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NEW Expanded Product Review Section

SSB Electronic Zeus ZS-1 Software Defined MF/HF Transceiver

A compact 15 W SDR from Germany with good performance.

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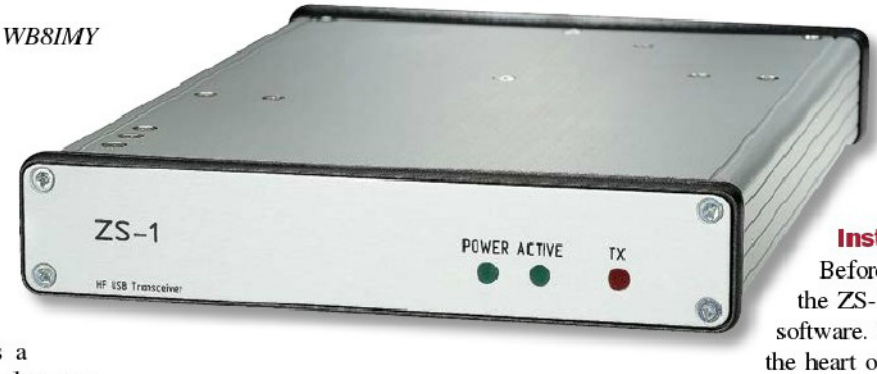

The Zeus ZS-1 from SSB Electronic is among the first German entries in the software defined transceiver (SDR) market. Like most modern SDRs, the receiver is a direct-sampling design that converts analog signal energy directly to digital data for subsequent processing within the computer. When transmitting, the process is reversed, with the required signal being generated by the computer and then converted to analog for amplification and transmission.

The ZS-1 generates a maximum of 15 W output on all bands from 160 through 10 meters, with two exceptions. On 30 meters, output is limited to 8 W, and there is no 60 meter transmit capability. The output level is adjustable down to 1 W. The ZS-1 also has the ability to generate an adjustable 1 – 40 mW signal for use with VHF+ transverters.

Data flows between the ZS-1 and your computer via a USB 2.0 connection; there are no other cables connecting the computer and the Zeus. The transceiver requires more dc power than a USB port can supply, so you need to connect the ZS-1 to a 13.8 V dc power supply capable of providing about 4 A of current. Other than the SO-239 antenna port on the back panel and a few other miscellaneous jacks, the connections are minimal, as shown in Figure 1.

Because most of the signal processing takes place in the computer, you'll need a certain amount of processor "muscle" to enjoy the best experience with the ZS-1. The proprietary SSB Electronic software (supplied on CD-ROM) requires a *Windows XP*, *Vista*, *7* or *8* computer with at least a 1.5 GHz dual-core processor and 2 GB RAM. For this review I used the ZS-1 on a *Windows 7* machine with 8 GB RAM with no difficulty. It may also be possible to run the ZS-1 software on a Mac with a *Windows* emulator such as *CrossOver* (**www.codeweavers.com**), but I didn't have an opportunity to test it.

Installation

Before you do anything with the ZS-1, you must install the software. Because software is at the heart of any SDR, make sure you are using the most recently updated version. I downloaded and installed Version 2.6, but by the time you read this review there may be an even newer version available.

The installation routine loads the ZS-1 operating software, along with the *IQ Player* and the necessary *Windows* drivers. Once everything is loaded and ready, you can plug in the ZS-1's USB cable. When you double-click your mouse cursor on the ZS-1 icon, the software immediately searches for the transceiver. In most instances this search should require no more than a few seconds.

On my first attempt the software failed to find the transceiver. At the time, I had

Figure 1 — The ZS-1 rear panel has connections for interfacing with a computer, external power amplifier, antenna, and station accessories.

Bottom Line

The Zeus ZS-1 software defined transceiver offers excellent performance in a small package. Its clean 15 W transmitter can be used as-is, or it would be easy to add an external power amplifier.

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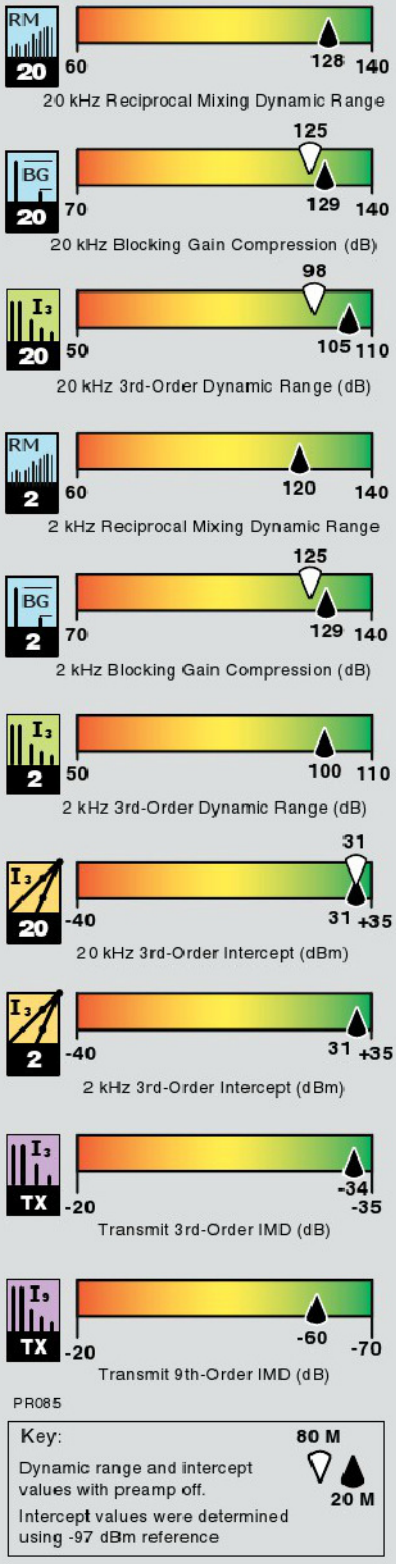
Key Measurements Summary



another device connected to the same USB hub, so I wondered if there might be a conflict. I disconnected the other device and tried again. Sure enough, the software found the transceiver right away.

When the software locates the Zeus you'll hear a click of relays and see the front panel LED labeled ACTIVE spring to life. The radio still isn't fully operational, though. As the Zeus software interface appears on your monitor, you have to use your mouse to click the POWER button in the upper left corner.

Keep in mind that your computer is providing much of the magic, including the audio. So, you'll need to have speakers plugged into your computer's sound output jack if you expect to hear anything from the Zeus. You will also need a microphone plugged into the computer's microphone input to operate AM or SSB. Initially I used a handheld studio microphone during the early portion of the review, but then switched to a microphone/headset.

Receiving

The ZS-1 offers general receive coverage from 300 Hz to 30 MHz. Changing frequency is as easy as scrolling with the wheel on your mouse, using direct keyboard entry, or by simply "dragging" the bar at the very bottom of the window for large, rapid changes. I found myself switching from one method to the other, depending on how impatient I was at the time. After a while, I settled on scrolling the numeric display to get to the frequency I wanted and then dragging the spectral display to home in on particular signals.

I typically operated the ZS-1 in a configuration that allowed the receiver to display 20 kHz of spectrum above and below the center frequency. If something piqued my interest, I merely clicked in the spectral display (or the waterfall below) to move the receiving "window" to that signal; see Figure 2.

Like all software defined radios, you can do fascinating things with the Zeus's ultra-sharp adjustable filters. In addition, AGC is continuously adjustable and there are the requisite notch and noise filters as well.

If you enjoy CW, you'll be pleased to know that the ZS-1 offers binaural audio, or "pseudo stereo," as SSB Electronic calls it. If you are wearing headphones, the effect can be startling. CW signals at different frequencies seem to almost float in space between one ear and the other. You soon find yourself picking out signals by their "positions." It is something one simply has to hear to appreciate.

The Zeus software can generate standard WAV audio recordings of your selected signals, and it can also save the entire selected bandwidth as an in-phase/quadrature (I/Q) recording. For the sake of discussion, consider an I/Q file as a data dump of everything the ZS-1 is hearing. As you can probably guess, this could become a very

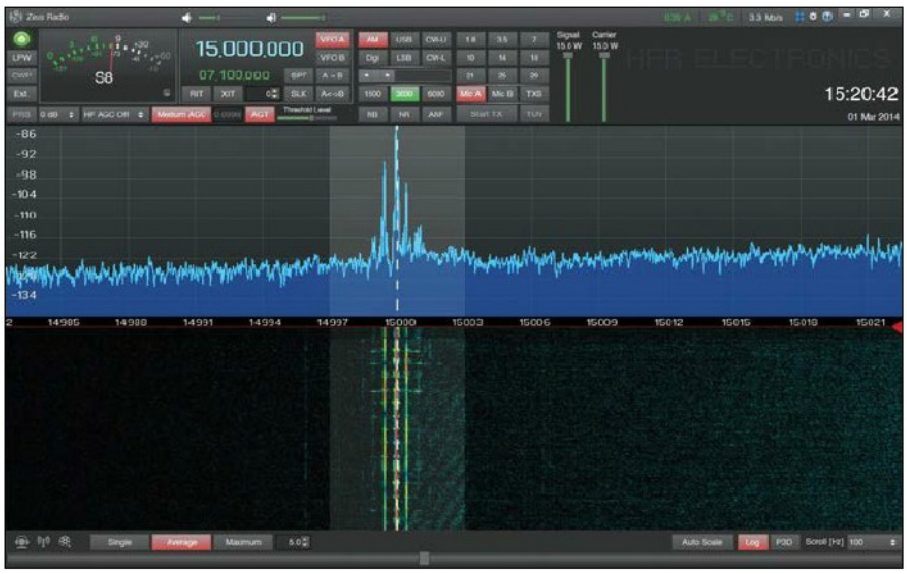


Figure 2 — Listening to WWV on 15 MHz.

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large file, so you have to use this feature carefully lest you fill a substantial portion of your hard drive in short order. The *I/Q Player* software allows you to open an I/Q file and listen to signals while tuning from one to the other, applying various filters and so on.

Time Shifting

One remarkable reception feature is the ability of the ZS-1 to "time shift." To understand the time shift function, think of the ZS-1 receiver as being analogous to a digital video recorder (DVR). If you're among the majority of Americans who own one of these devices, you know that you can choose to watch a TV show in real time, or you can wait until the DVR has captured, say, 15 minutes and then begin watching. By watching the show 15 minutes "in the past," you can easily fast forward through the commercials (at least until the recording catches up to real time).

Like a DVR, the ZS-1 records and temporarily stores all the signal activity within the bandwidth you've selected. "Temporarily" translates to about 2.5 minutes. If, for example, you miss something that was said and need to hear it again, just click the red arrow in the upper right corner of the waterfall and drag it downward. Release your mouse cursor and you will hear the signal exactly as it was 2½ minutes ago. Like the DVR, the ZS-1 software will continue to "play" the signal from that point in the past. If you fail to pay attention to the display, you may be unsure whether you're listening to a signal in the present or the past!

Transmitting AM and SSB

The ZS-1 software includes a sophisticated transmit audio equalization function, but I opted for the default settings. At a mere 15 W output, I wasn't working the world, but I did make a number of contacts and received good audio reports.

The ZS-1 offers dual VFOs and a split-frequency function. With linear transponder satellites in mind, there is also a split-frequency "tracking" feature as well. When you change the frequency of VFO A, VFO B changes by the same amount.

To place the ZS-1 into the transmit mode, you simply click your mouse cursor on the START TX button; click it again to return to receive. Alternatively, you can plug a foot switch into the PTT jack on the real panel and use it to key the radio. There is no VOX.

The software meter instantly displays your output power (peak or RMS) when you are in the transmit mode. According to SSB Electronic, future versions of the software will implement an SWR meter as well. The hardware is already present in the Zeus; it is just a matter of making the necessary software changes.

Transmitting CW

Because of latency issues, CW operation has been problematic with a number of software defined transceivers. Not so with the ZS-1. I plugged a set of paddles into the rear-panel KEY jack and I was on my way. The CW transmit window displays the iambic keyer settings including speed (in characters per minute) and weight. Within this same window you also find the ability to send "canned" CW messages as well as a feature for sending CW with your keyboard (for those times when you don't have paddles handy).

The ZS-1 seemed to handle CW well; if latency was present, I didn't notice. You can operate full break-in (QSK), or set a slight return-to-receive delay.

Digital Operating

The ZS-1 software displays a DIGI button among the available mode selections, which made me hope for some kind of integrated digital mode, such as PSK31 or RTTY. In reality, it switches the audio input and output sources and disables all sound processing functions that would degrade digital signals. So, only one mouse click is needed to switch from SSB operation with microphone and headphones to digital modes with the necessary audio routing.

To operate digital modes, such as PSK31, I had to jump through several hoops. First, I had to download and install *Virtual Audio Cable* from **software.muzychenko.net/eng/vac.htm**. (There is a trial version that nags you with an annoying voice every few seconds until you purchase the full version, which costs $25 to $50, depending on support options.) *Virtual Audio Cable* allows the ZS-1 software to share receive and transmit audio with another program such as *DigiPan*. To transmit, however, you have to install and configure a null modem emulator known as *com0com* (**com0com.sourceforge.net/**) so it can pass the COM port keying commands from your digital mode program to the ZS-1 software. This can be a bit tricky, so I chose to key the rig

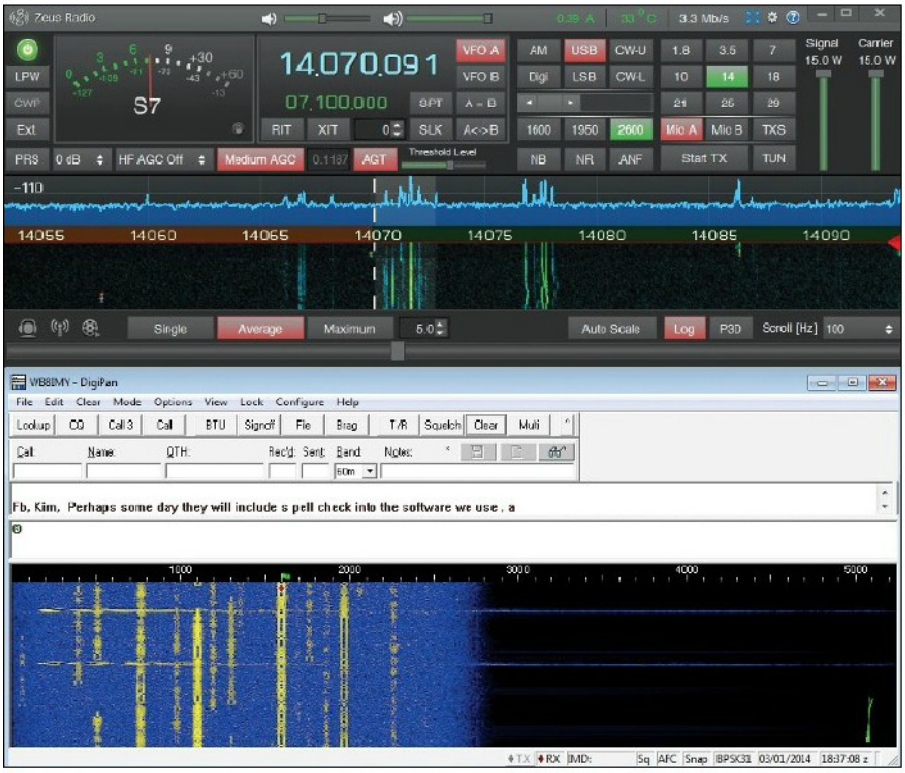

Figure 3 — Operating PSK31 with *DigiPan*. *Virtual Audio Cable* was used to share transmit and receive audio with the ZS-1 software.

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manually. It wasn't a very elegant solution, but it worked. Figure 3 shows the ZS-1 working with *DigiPan* during a PSK31 contact. Considering the complexities, I have a feeling that only the most computer-savvy hams will be using the ZS-1 for digital operating for the time being.

If you attempt digital operating with the ZS-1, it is important to note that the 15 W output rating is not for 100% duty cycle modes such as RTTY. I tried it and my Zeus became warm fairly quickly. The manual warns that you should reduce output by at least 50% when operating RTTY and similar modes.

In the Lab

ARRL Lab test results are shown in Table 1. Receiver sensitivity and dynamic ranges are excellent. As we have observed with other software defined receivers, the IMD and blocking gain compression dynamic range is equally good at wide and narrow signal spacings. The spectral display sensitivity is excellent, which has not always been the case in other transceivers.

One interesting feature is that the receiver gain adjusts automatically when the AGC is on. The GAIN control does nothing if the user clicks on it, but indicates if attenuation is switched in if there is a need for improved performance. Attenuation kicks in with higher received signal levels, for example when W1AW fires up across the parking lot from the Lab. With the AGC off, you can switch in the preamp or several levels of attenuation manually.

The ZS-1's transmitter stands out for the cleanliness of its transmitted signal. The CW keying waveform produces a good sounding signal with low CW keying sidebands. On SSB, transmitter IMD products are low. Transmitter composite noise is also very good.

Our initial review unit had low transmitter power, 8 to 9 W on each band. SSB Electronic replaced that ZS-1 with a new one that easily met specifications.

My Wish List

The great thing about software defined radio is that an upgrade is as close as the next software version. With that in mind, this is my wish list for future versions of the ZS-1:

- Make it easier to interface with third

Table 1
SSB Electronic Zeus ZS-1, serial number 000143, v.2.6 software

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: 0.3 to 30 MHz.	Receive, 0.1303-32.0198 MHz; transmit, 1.8-2.0, 3.5-4.0, 7.0-7.3, 10.1-10.15, 14.0-14.35, 18.068-18.168, 21-21.450, 24.89-24.99, 28.0-29.7 MHz.
Power requirements: 12 to 15 V dc.	Receive, 420 mA; transmit 2.9 A at max RF output. Minimum operating, voltage 11.7 V dc (12 W RF output).
Modes of operation: SSB, CW, AM, digital.	As specified.
Receiver	**Receiver Dynamic Testing**
Sensitivity: –141 dBm maximum (see text).	Noise floor (MDS), 500 Hz DSP bandwidth:

	Preamp off	*Preamp on*
0.137 MHz	–124 dBm	–126 dBm
0.475 MHz	–129 dBm	–137 dBm
1.020 MHz	–130 dBm	–138 dBm
3.5 MHz	–130 dBm	–138 dBm
14 MHz	–133 dBm	–138 dBm
28 MHz	–131 dBm	–136 dBm

Noise figure: Not specified.	14 MHz, preamp off/on, 14/9 dB.
AM sensitivity: Not specified.	10 dB (S+N)/N, 1-kHz, 30% modulation, 6 kHz DSP filter:

1.0 MHz	5.95 µV	2.14 µV
3.8 MHz	5.12 µV	2.11 µV
29.0 MHz	4.15 µV	2.51 µV

Spectral display sensitivity: Not specified.	At 14 MHz, –141 dBm.
Blocking gain compression dynamic range: Not specified.	Gain compression, 500 Hz DSP bandwidth:*

	20 kHz offset Preamp off/on	*5/2 kHz offset Preamp off*
3.5 MHz	125/122 dB	125/125 dB
14 MHz	129/122 dB	129/129 dB

Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/5/2 kHz spacing, 128/123/120 dB

ARRL Lab Two-Tone IMD Testing (500 Hz DSP bandwidth) **

Band/Preamp	*Spacing*	*Input Level*	*Measured IMD Level*	*Measured IMD DR*	*Calculated IP3*
3.5 MHz/off	20 kHz	–32 dBm	–130 dBm	98 dB	+17 dBm
		–12 dBm	–97 dBm		+31 dBm
14 MHz/off	20 kHz	–28 dBm	–133 dBm	105 dB	+25 dBm
		–11 dBm	–97 dBm		+31 dBm
14 MHz/on	20 kHz	–35 dBm	–138 dBm	103 dB	+17 dBm
		–25 dBm	–97 dBm		+11 dBm
14 MHz/off	5 kHz	–28 dBm	–133 dBm	105 dB	+25 dBm
		–11 dBm	–97 dBm		+31 dBm
14 MHz/off	2 kHz	–33 dBm	–133 dBm	100 dB	+17 dBm
		–11 dBm	–97 dBm		+31 dBm

See the Digital Edition of *QST* for a video overview of the SSB Electronic Zeus ZS-1 Software Defined MF/HF Transceiver.

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Manufacturer's Specifications	Measured in the ARRL Lab
Two-tone second order intercept point: Not specified.	At 21 MHz, preamp off/on, +53/+43 dBm.
IF/audio response: Not specified.	Range at –6 dB points, (bandwidth):† CW (500 Hz): 300-800 Hz (500 Hz); Equivalent Rectangular BW: 506 Hz; USB (2.4 kHz): 350-2755 Hz (2405 Hz); LSB (2.4 kHz): 350-2756 Hz (2406 Hz).
Spurious and image rejection: Not specified.	14 MHz, 115 dB.
Transmitter	**Transmitter Dynamic Testing**
Power output: 15 W (8 W on 30 meters) typical, at 13 V dc.	13.8 V dc external supply, 0.6-15 W 10.2 W at 10.1 MHz.
Spurious-signal and harmonic suppression: Not specified.	62 dB (worst case 12 meters), typically >65 dB. Meets FCC requirements.
Third-order intermodulation distortion (IMD) products: Not specified.	15 W PEP, 3rd/5th/7th/9th order: –34/–51/–50/>–60 dBc (worst case, 10 m); –36/–54/–53/>–60 dBc (typical).
CW keyer speed range: Not specified.	6 to 48 WPM, 24 WPM default; iambic mode A or B.
CW keying characteristics: Not specified.	See Figures 4 and 5.
Receive-transmit turn-around time (tx delay): Not specified.	68 ms (SSB); 8 ms (CW).
Transmit-receive turn-around time (rx delay): Not specified.	344 ms (SSB); 10 – 1000 ms (CW).††
Composite transmitted noise: Not specified.	See Figure 6.
Size (height, width, depth): 1.4 x 6.7 x 9.5 inches, incl protrusions. Weight: 2.6 lbs.	
Price: $1700.	

*No blocking occurred up to the threshold of ADC overload (–5 dBm at 3.5 MHz; –4 dBm at 14 MHz.)
**ARRL Product Review testing includes Two-Tone IMD results at several signal levels. Two-Tone, Third-Order Dynamic Range figures comparable to previous reviews are shown on the first line in each group. The "IP3" column is the calculated Third-Order Intercept Point. Second-order intercept points were determined using –97 dBm reference.
†Varies with adjustment of DSP settings.
††Turnaround time varies with processor speed and the sound card used. SSB turnaround measured with DirectSound; using the ASIO sound card driver it will be faster. CW turnaround/break-in time is adjustable.

party software for digital operating, or integrate a digital software package.

- Add synchronous AM reception and DRM digital shortwave broadcast reception.
- Add FM for use on 10 meters.
- Add VOX, SWR metering, and the ability to transmit on 60 meters.

But my wish list notwithstanding, the ZS-1 was a pleasure to operate. I found myself spending hours just exploring all the receive features, let alone transmitting. Even the S meter is a marvel — one of the best software emulations of a mechanical meter that I've seen.

SSB and AM is challenging at only 15 W output, but I made plenty of CW and digital contacts (which will come as no surprise to any QRP enthusiast). Fortunately, there are also amplifiers available from other manufacturers to boost the ZS-1's output to at least 100 W if you need it.

Considering its excellent characteristics, the Zeus ZS-1 could become the foundation of a high performance HF station, or a weak signal VHF+ station. With its relatively small size and light weight, the ZS-1 is also an attractive choice for operating in the field.

Manufacturer: SSB Electronic. Sold in the US and Canada by Vibroplex, 2906 Tazewell Pike #A2B, Knoxville, TN 37918; tel 865-309-5073; **www.vibroplex.com**.

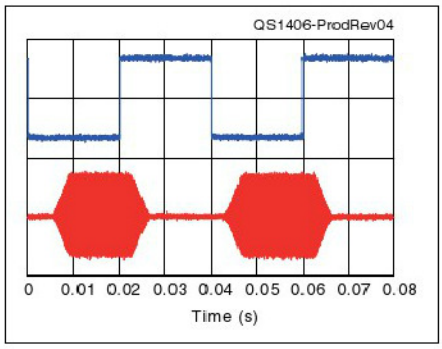

Figure 4 — CW keying waveform for the Zeus ZS-1 showing the first two dits in full break-in (QSK) mode using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. (Note that the first key closure starts at the left edge of the figure.) Horizontal divisions are 10 ms. The transceiver was being operated at 15 W output on the 14 MHz band.

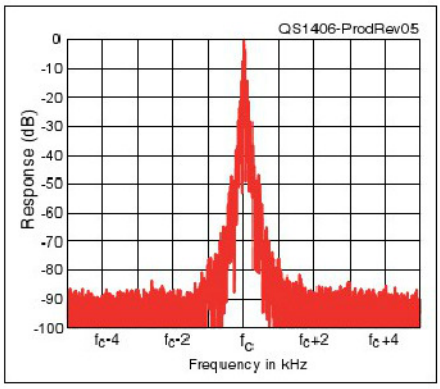

Figure 5 — Spectral display of the Zeus ZS-1 transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 15 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

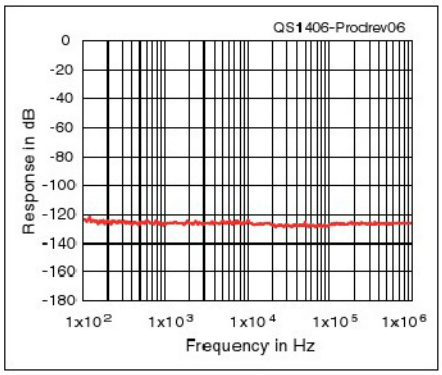

Figure 6 — Spectral display of the Zeus ZS-1 transmitter output during composite-noise testing. Power output is 15 W on the 14 MHz band. The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 100 Hz to 1 MHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

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