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Icom IC-7300 HF and 6 Meter Transceiver

Icom's software defined radio (SDR) in a box with knobs.

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Calling a piece of technology a "game-changer" is to invoke a cliché of the highest order, but it's difficult to avoid when discussing the Icom IC-7300. A game-changer is usually defined as a product that has the potential to disrupt a market. When a game-changer appears on the scene, competitors are challenged, buying preferences change, and the market veers off in a new direction (the introduction of the Apple iPhone is a classic example).

The game-changing aspect of the IC-7300 is not the fact that it is a software defined radio (SDR). Hams have been exposed to SDR technology for more than a decade, and *QST* has reviewed several highly competent SDRs from other manufacturers. Instead, what makes the IC-7300 disruptive is that it offers the performance and flexibility of SDR with a touchscreen in a user-friendly package that is unlike any other — and it does this at a price point that is guaranteed to be attractive to a large segment of the amateur community. It's similar in concept and price point to Icom's previous generation IC-7410, but offers more features and better performance in many areas.[1]

SDR with Knobs

For those who may be unfamiliar with the technology, a software defined radio takes the analog signal arriving at the antenna input and "samples" it at an extremely high rate, effectively converting the analog signal into a stream of digital information. Once a signal has been converted to data, it can be processed by software in ways that are not possible — or at least practical — with analog technology. Any form of modulation can be decoded, noise can be removed (or greatly suppressed), and extraordinarily sharp filters can be applied to the result.

To transmit, the process is essentially reversed. Software massages the desired signal, which is then converted to analog and amplified.

In the early days of Amateur Radio SDR, a receiver board performed quadrature mixing on the incoming RF signal, creating in-phase (I) and quadrature (Q) analog

[1]R. Lindquist, WW3DE, "Icom IC-7410 HF and 6 Meter Transceiver," Product Review, *QST*, Oct 2011, pp 49 – 54.

Bottom Line

Icom's IC-7300 is a 160 – 6 meter, 100 W, software defined radio (SDR) in a conventional package. Aimed at the "entry level" segment of the market, it offers a wide range of features and excellent performance often found in higher-priced transceivers.

Figure 1 — The IC-7300's rear panel has connections for a CW paddle for the internal keyer or external key/keyer; an external speaker; ALC and TR switching for an amplifier; remote control via the optional *RS-BA1* software or an Icom CI-V device; a USB port for radio control and digital mode operation; an ACC socket for connecting a TNC or PC for digital modes, and a jack for connection to any of Icom's accessory antenna tuners or tuned antennas.

Key Measurements Summary

Icom IC-7300 HF and 6 Meter Transceiver

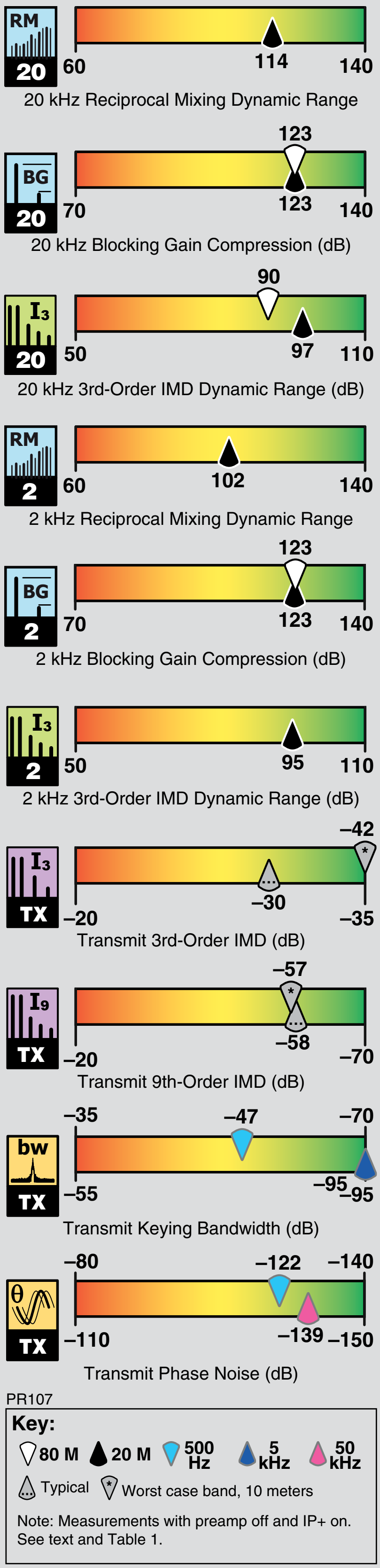

Table 1
Icom IC-7300, serial number 02001161

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: Receive, 0.03 – 74 MHz; transmit, 160 – 6 meter amateur bands.	Receive and transmit, as specified; (5.255 – 5.405 MHz, 60 meters).
Power requirement: Receive, 0.9 A (standby), 1.25 A (maximum audio); transmit, 21 A at maximum power output at 13.8 V dc ±15 %.	At 13.8 V dc: Receive, 1.05 A (maximum volume); transmit, 18.5 A (typical); 5 mA (power off).
Modes of operation: SSB, CW, AM, FM, RTTY.	As specified.
Receiver	**Receiver Dynamic Testing**
CW sensitivity, <0.16 µV (1.8 – 29.999 MHz, preamp 1 on), <0.13 µV (50 MHz preamp 1 on), <0.16 µV (70 MHz, preamp 1 on).	Noise floor (MDS), 500 Hz bandwidth: *With IP+ (Dither) Off (See text)* *Preamp* — *Off* / *1* / *2* 0.137 MHz — –85 / –83 / –82 dBm 0.475 MHz — –96 / –116 / –118 dBm 1.0 MHz — –114 / –123 / –125 dBm 3.5 MHz — –133 / –141 / –143 dBm 14 MHz — –133 / –141 / –143 dBm 28 MHz — –132 / –141 / –143 dBm 50 MHz — –130 / –139 / –141 dBm *With IP+ (Dither) On (See text)* 3.5 MHz — –123 / –135 / –139 dBm 14 MHz — –124 / –136 / –140 dBm 28 MHz — –122 / –135 / –138 dBm
Noise figure: Not specified.	14 MHz, IP+ off, preamp off/1/2: 14/6/4 dB; 50 MHz, 17/8/6 dB.
AM sensitivity: 10 dB S/N, <12.6 µV (0.5 –1.8 MHz preamp 1 on); <2.0 µV (1.8 – 29.999 MHz, preamp 1 on); <1.0 µV (50 and 70 MHz preamp 2 on).	10 dB (S+N)/N, 1-kHz, 30% modulation, 9 kHz bandwidth: *Preamp* — *Off* / *1* / *2* 1.0 MHz — 12.20 / 4.16 / 3.71 µV 3.8 MHz — 1.64 / 0.61 / 0.56 µV 29 MHz — 1.82 / 0.66 / 0.58 µV 50.4 MHz — 2.19 / 0.76 / 0.66 µV
FM sensitivity: 12 dB SINAD, <0.5 µV (28 –29.990 MHz, preamp 1 on), 0.25 µV (50 and 70 MHz, preamp 2 on).	12 dB SINAD, 15 kHz bandwidth: *Preamp* — *Off* / *1* / *2* 29 MHz — 0.50 / 0.17 / 0.16 µV 52 MHz — 0.62 / 0.21 / 0.17 µV
Spectral sensitivity: Not specified.	Preamp off/1/2: –100/–114/–118 dBm.
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range, 500 Hz bandwidth†: — *20 kHz offset Preamp off/1/2* / *5/2 kHz offset Preamp off* 3.5 MHz — 123/118/116 dB / 123/123 dB 14 MHz — 123/118/116 dB / 123/123 dB 50 MHz — 122/118/116 dB / 122/122 dB
Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/5/2 kHz offset: preamp off, IP+ off: 114/107/101 dB; preamp off, IP+ on, 114/108/102 dB.

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

Band (Preamp/IP+)	*Spacing*	*Measured IMD Level*	*Measured Input Level*‡	*IMD DR*
3.5 MHz (off/off)	20 kHz	–133 dBm	–53 dBm	80 dB
		–97 dBm	–16 dBm	
3.5 MHz (off/on)	20 kHz	–123 dBm	–33 dBm	90 dB
		–97 dBm	–16 dBm	
14 MHz (off/off)	20 kHz	–133 dBm	–56 dBm	77 dB
		–97 dBm	–16 dBm	
14 MHz (two/on)	20 kHz	–140 dBm	–38 dBm	102 dB
		–97 dBm	–38 dBm	
14 MHz (off/off)	5 kHz	–133 dBm	–56 dBm	77 dB
		–97 dBm	–16 dBm	
14 MHz (two/on)	5 kHz	–140 dBm	–40 dBm	100 dB
		–97 dBm	–39 dBm	
14 MHz (off/off)	2 kHz	–133 dBm	–56 dBm	77 dB
		–97 dBm	–21 dBm	
14 MHz (off/on)	2 kHz	–124 dBm	–29 dBm	95 dB
		–97 dBm	–21 dBm	

Manufacturer's Specifications		Measured in the ARRL Lab		
14 MHz (one/off)	2 kHz	–141 dBm –97 dBm	–63 dBm –34 dBm	78 dB
14 MHz (one/on)	2 kHz	–136 dBm –97 dBm	–36 dBm –34 dBm	100 dB
14 MHz (two/off)	2 kHz	–143 dBm –97 dBm	–64 dBm –34 dBm	79 dB
14 MHz (two/on)	2 kHz	–140 dBm –97 dBm	–40 dBm –39 dBm	100 dB
50 MHz (off/off)	20 kHz	–130 dBm –97 dBm	–41 dBm –15 dBm	89 dB
50 MHz (two/on)	20 kHz	–139 dBm –97 dBm	–41 dBm –30 dBm	98 dB

Second-order intercept point: Not specified.	Preamp off/1/2:‡ 14 MHz, +69/+45/+41 dBm; 21 MHz, +65/+67/+67 dBm; 50 MHz, +71/+71/+71 dBm.
DSP noise reduction: Not specified.	15 dB (maximum).
Audio Output: >2.5 W into 8 Ω at 10% THD.	At 10% THD, 2.4 W into 8 Ω. THD at 1 V_{RMS}, 0.2%.
FM adjacent channel rejection: Not specified	29 MHz, 82 dB; 52 MHz, 79 dB.
FM two-tone third order dynamic range: Not specified.	20 kHz spacing, 29 MHz, 82 dB*; 52 MHz, 79 dB.* 10 MHz spacing, 29 MHz, 97 dB; 52 MHz, 99 dB.
Squelch sensitivity: SSB, 5.6 µV, FM, <1 µV.	At threshold: 1.58 µV 14 MHz (SSB, preamp off); 0.08 µV (29 MHz, p2 on).
Notch filter depth: Not specified.	Manual notch, 52 dB; auto-notch, 52 dB (45 dB two tones). Attack time, 198 ms (single tone), 2080 ms (two tones).
S-meter sensitivity: Not specified.	S-9 signal, (preamp off/1/2): 14 MHz, 70.7/31.2/18.8 µV; 50 MHz, 78.4/37.5/24.5 µV.
Audio filter response: Not specified.	Range at –6 dB points:** CW (500 Hz): 342 – 860 Hz (518 Hz); Equivalent Rectangular BW: 514 Hz; USB (2.4 kHz): 234 – 2632 Hz (2398 Hz); LSB (2.4 kHz): 250 – 2656 Hz (2406 Hz); AM (9 kHz), 166 – 4477 Hz (8622 Hz).

Transmitter	Transmitter Dynamic Testing
Power output: 2 – 100 W; 1 – 25 W (AM).	HF, 0.7 – 104 W typical; 50 MHz, 0.5 – 97 W. 70 W typical at minimum specified dc voltage input.
Spurious-signal and harmonic suppression: >50 dB (1.8 – 28 MHz); >63 dB (50 MHz).	HF, typically 64 dB, 57 dB (worst case 160 m), 50 MHz, 76 dB.
SSB carrier suppression: >50 dB.	>70 dB.
Undesired sideband suppression: >50 dB.	>70 dB.
Third-order intermodulation distortion (IMD)	3rd/5th/7th/9th order, 100 W PEP: HF, –42/–38/–46/–57 dB (typical) –30/–37/–44/–58 dB (worst case, 10 m); 50 MHz, –26/–37/–39/–44 dB (100 W); 50 MHz, –33/–37/–44/–62 dB (80 W)
CW keyer speed range: Not specified.	6 to 48 WPM, iambic mode B.
CW keying characteristics: Not specified.	See Figures 2 and 3.
Transmit-receive turn-around time (PTT release to 50% audio output): Not specified.	S-9 signal, AGC fast, 15 ms. QSK transmit to receive time, 35 ms.
Receive-transmit turn-around time (tx delay): Not specified.	SSB, 14. ms; FM, 15 ms (29 MHz and 52 MHz).
Composite transmitted noise: Not specified.	See Figure 4.

Size (height, width, depth, including protrusions): 4.0 × 9.4 × 10.7 inches. Weight, 9.3 lbs.
Price: $1500.

†Blocking occurs at ADC overload threshold. Blocking level is same for IP+ on or off.
‡There was no intercept of the IMD input signal and receiver IMD at the S5 (–97 dBm) level. Figures are at threshold of ADC overload or spurious receiver response. Second-order intercept points were determined using S5 reference.
*Measurement was noise limited at the value indicated.
**Default values; bandwidth is adjustable.

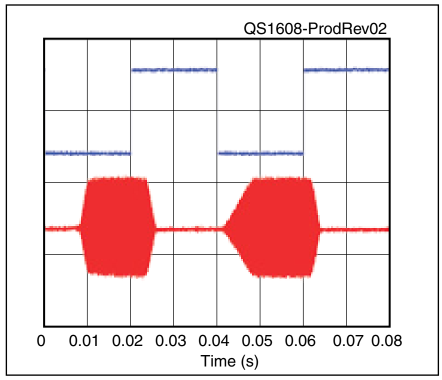

Figure 2 — CW keying waveform for the Icom IC-7300 showing the first two dits using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. (Note that the first key closure starts at the left edge of the figure.) Horizontal divisions are 10 ms. The transceiver was being operated at 100 W output on the 14 MHz band.

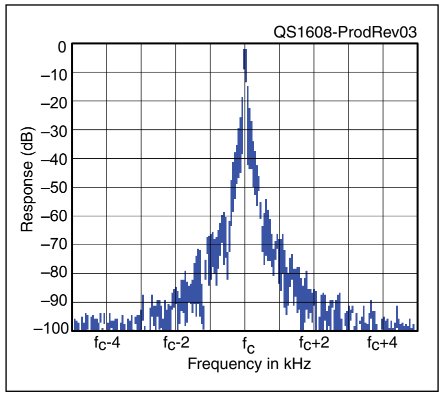

Figure 3 — Spectral display of the Icom IC-7300 transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 100 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is 10 dB/division.

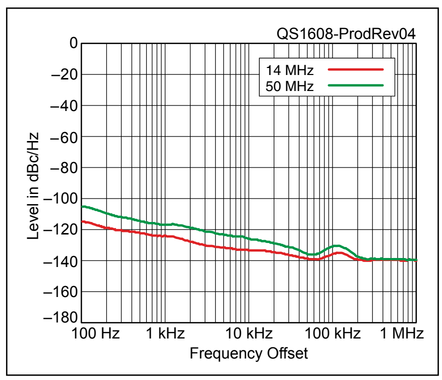

Figure 4 — Spectral display of the Icom IC-7300 transmitter output during phase noise testing. Power output is 100 W on the 14 MHz band (red trace) and 50 MHz band (green trace). The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 100 Hz to 1 MHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dBc/Hz.

baseband signals. This IQ baseband signal was converted to digital information by a computer sound card, and software was used to demodulate the received signal. As technology improved, the signal mixing and IQ digital conversion stages were combined in a single box, and the resulting data was streamed to the computer for processing, typically over a USB connection.

Today, most software defined transceivers do not rely on outboard computers for processing; all conversion and processing takes place within dedicated circuitry that functions as a complete transceiver. The computer merely functions as an interface between the transceiver and its human operator.

The IC-7300 takes the next step by eliminating the computer interface completely and substituting knobs, buttons, and a highly responsive touchscreen. As a result, if you are comfortable operating a conventional transceiver, you can operate an IC-7300 just as easily. You'll find buttons and knobs that are entirely familiar. Best of all, the complicated menu systems found in other transceivers have been greatly streamlined in the IC-7300 through the use of the touchscreen. Navigation is as simple as tapping your finger on a screen icon or "button."

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Some amateurs may miss the ability to directly tap into the IQ stream (the IC-7300 does not offer an IQ output), but the IC-7300 is clearly designed to appeal to a different audience. The hams who embrace the IC-7300 are those who desire the performance of an SDR, yet are put off by the need to have a computer or some other interfacing device between them and the radio.

The Basics

The IC-7300 is a 100 W output, 160 through 6 meter transceiver capable of operating SSB, CW, FM, AM, and digital modes. The chassis is compact at 9.4 inches wide, 3.7 inches high, and 9.4 inches deep. It is somewhat light at only 9.3 pounds, of interest for portable operation as well as home station use. All of the knobs and buttons have a high-quality feel.

The transceiver comes with a handheld microphone and a printed "basic" manual. An accompanying CD-ROM contains a much more detailed manual and a complete set of schematic diagrams.

Looking over the schematics, it's obvious that the IC-7300 wastes no time getting from analog to digital. Received signals are filtered, amplified, and then sent to an analog-to-digital converter (ADC). Then they are fed to an FPGA (field programmable gate array) for conversion and processing. All of this is transparent to the user, though...if you sat down in front of an IC-7300 without knowing about its architecture, you'd never guess that you were looking at an SDR.

The "No Manual Test"

When a transceiver makes the claim of being "user friendly," that's my cue to perform the No Manual Test. I simply leave the manual in the box and attempt to set up and operate the radio without any assistance other than my own experience.

It took less than 5 minutes to plug in the dc power cord (the radio draws 21 A maximum) and connect the coaxial cable from my antenna to the IC-7300's single SO-239 port. That antenna port is used for all bands from 160 through 6 meters, and also 4 meters — 70 MHz — in other markets. There's no provision for a separate receiving antenna such as a Beverage for the low bands.

The rear panel (see Figure 1) also has connections for a CW paddle for the internal keyer or external key/keyer, an external speaker, digital mode interfaces, and other accessories. I pressed the POWER button and the large touchscreen came to life with a frequency display and a bright spectrum scope and waterfall. The audio and RF gain knobs operated as expected, as did the passband tuning.

I noticed the TUNER button and assumed that it operated the built-in antenna tuner. I held it down for about a second and was rewarded with rapid clicking noises as the tuner went to work. A few seconds later, the IC-7300 had tuned to a flat 1:1 SWR.

You can't miss the large VFO knob, so I gave it a spin across the signal peaks appearing in the spectrum scope. Being in the SSB mode at the time, I marveled at how good the received audio sounded.

But how would I change bands? There were no mechanical band buttons to be found, so I knew I had to resort to the touchscreen. Being on 20 meters, I tapped my index finger on "14" on the frequency display. Sure enough, an array of band-button icons appeared. I tapped on "7" and was immediately transported to 40 meters. Through this exercise, I also discovered that tapping on various portions of the frequency display also effectively altered the tuning rate of the VFO. Direct frequency entry is also possible through the same window.

I plugged in the microphone, and within a couple of minutes I found a fellow calling CQ. I answered and received an outstanding signal report (he remarked that my audio sounded particularly good). The elapsed time from power application to conversation was less than 10 minutes. The IC-7300 had passed the No Manual Test with high marks.

Of course, you will probably want to peruse the full version (PDF format) of the manual at some point to look a bit deeper into what the IC-7300 can do. The manual is well organized and well written, with illustrations and helpful hints throughout. The manual is also available for download from Icom's website.

On the Air in Depth

The SDR aspects of the IC-7300 become apparent as you spend more time listening to signals and using the various features. The sensitivity and selectivity of the radio never failed to impress. Even in crowded conditions, the IC-7300 clearly outperformed my older analog transceiver.

The manual warns that the IC-7300 could distort in the presence of very strong signals. The receiver is indeed very "hot" — so hot that I found myself turning off the dual preamps and even switching in the attenuator on occasion. Receiver sensitivity without the preamps is adequate virtually all of the time.

The IC-7300 has an IP+ feature, which inserts a *dither signal* when you activate it. You could say this is somewhat like adding a strong signal off frequency, which has the clever effect of reducing the intermodulation distortion (IMD) products. The dither signal is noise and it raises the noise floor a bit. As shown in Table 1, the best possible measured performance is with IP+ and Preamp 1 on. However, as with other radios,

Lab Notes: Icom IC-7300

By Bob Allison, WB1GCM
Assistant Laboratory Manager

Starting with this review, the ARRL Lab will offer comments and observations about HF transceivers tested. The Icom IC-7300 uses an RF direct sampling system. Analog signals are picked up via the antenna and go through the appropriate band-pass filter. Then all incoming analog signals are digitized, processed, and manipulated by software and then converted back to analog audio for listening with the speaker or headphones. This is quite different from current traditional receiver architecture, in which the signal path stays analog until the digital signal processing stage is reached.

A key component of an RF direct sampling system is the analog-to-digital converter (ADC). The digitization of an analog signal is done in small steps. These steps are a type of non-linearity that forms intermodulation (IMD) products at low signal levels that can coherently add up.† To prevent this unwanted effect, a dither signal (random noise) is added. The result is an improved two-tone third-order intermodulation distortion dynamic range (3 IMD DR). The dither signal inside the IC-7300 can be turned on and off by using the IP+ key. With IP+ on, the sensitivity is reduced by the dither signal, but the overall 3 IMD DR is improved. Table 1 shows the minimum discernible signal level and the 3 IMD DR with and without the dither signal.

All ADCs have an input signal limit. If a high enough signal level is present at the antenna jack, the ADC can go into an overload state. The signal level at which the overload state is attained is known as the *ADC threshold*. At this signal level, the receiver is not usable. Fortunately, the ADC threshold is high in the IC-7300 — an in-passband signal does not overload, even at >10 dBm. No signal blocking appears until the ADC threshold level from an *adjacent* signal is reached.

The reciprocal mixing dynamic range (RMDR) and gain compression (blocking) dynamic range figures are very good. RMDR in particular shows the benefit of Icom's new synthesizer design. At 2 kHz spacing, it is nearly 25 dB better than the previous generation IC-7410. Note that these dynamic ranges are measured with the AGC off. With the AGC on, no blocking is observed, but the background noise *increases* as the ADC threshold level is approached with an adjacent signal 2 kHz away. Still, overall performance is excellent for an entry-level transceiver.

For decades, it's been generally accepted that an S-meter reading of S-9 corresponds to an input signal level of 50 µV (–73 dBm), and that each S unit represents a change of 6 dB (S-8 = –79 dBm, S-7 = –85 dBm, and so on). Our measurements indicate that some manufacturers do a good job of hitting the S-9/50 µV level, but many ARRL members have told me that they wish there were more uniformity with the rest of the S-meter scale. Unfortunately, in most transceivers the S-meter scale does not accurately report 6 dB/S unit. The Icom IC-7300 uses a 3 dB/S unit scale, for example. I hope that manufacturers will improve upon this by adding a dBm signal level scale for more accurate reports, and also make the meter read the same level with the preamp(s) on or off. Turning the preamp on does not magically add voltage at the antenna jack!

The transmitter of the IC-7300 is clean, with low phase noise and reasonable keying sidebands. On most HF bands, the transmit IMD third-order products are excellent, among the best we've tested in 13.8 V transceivers, but the fifth and seventh order products are on the high side. On 6 meters, all transmit IMD products are high at full RF power output. Reducing the RF output to 80 W PEP reduces odd order products considerably.

I did not see any power overshoot in CW mode but did find some in SSB mode. It happens very quickly, for less than 2 ms, and can only be seen on a scope with screen persistence. I tested the IC-7300 with an amplifier that has protection circuitry that is sensitive to overshoot. The amplifier's peak power meter does indicate a higher power on the first syllable — 1800 W — then it settles down to 1500 W. This very brief overshoot did not trip the amplifier's protection circuitry, and appears to be of no concern. Icom recommends operating the IC-7300 with the speech compressor off to minimize the probability of overshoot when using an external power amplifier.

A concern pointed out by a member is the appearance of RF output at the antenna jack for 3 ms, after the amplifier key line opens (confirmed in the ARRL Lab). If used during QSK (full break-in) CW operation with an amplifier with very fast PIN diode TR switching, it is possible that the amplifier could switch back to receive mode while RF is still flowing from the IC-7300. In such a case, hot-switching can cause key clicks.

At the beginning of the transmission, there is an adjustable transmit delay for RF to start flowing after the key line closes. The delay is 6 ms with the default setting. If you use the IC-7300 with an amplifier, check the amplifier switching time. You will probably need to set the delay to 10 or 15 ms (or longer), to avoid hot-switching and subsequent damage to amplifier switching circuitry.

†See *QST*, February 2010, page 52 for more information.

it is best to leave the preamp off unless needed. For the weakest signals, I would turn off the IP+ for maximum sensitivity.

Speaking of noise, the IC-7300's noise blanker is a thing to behold. I've never experienced this level of noise blanker performance in a radio in this price class. All but the worst clicks and pops were completely eliminated. The noise reduction feature was equally impressive. It manages to greatly reduce background hiss and static without introducing excessive distortion of its own.

AGC is highly adjustable. FAST, MID, and SLOW settings are available with separate settings for SSB, CW/RTTY, and AM modes. Time constants are adjustable from 0.1 – 6 seconds for SSB and CW/RTTY, and up to 8 seconds for AM. FM is fixed at a 0.1 second FAST setting. At the default setting of 6 seconds, on SSB the AGC is very slow to recover in the presence of a strong signal. As noted in the manual, a faster setting works better when receiving weak signals if strong signals are also present. As with many current transceivers, any kind of impulse noise captures the AGC when the noise blanker is off.

As with all SDR rigs, you can adjust the filtering to whatever parameters you desire. In the IC-7300, this is accomplished through the touchscreen. Each operating mode provides three filter selections and

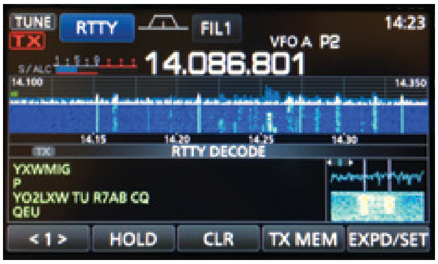

Figure 5 — The built-in RTTY decoder features a window on the lower right with a visual tuning aid — just line up the mark and space signals with the vertical bars. Up to four lines of decoded text are displayed at the lower left.

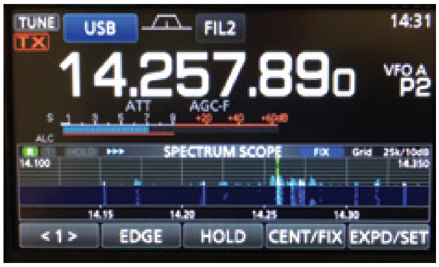

Figure 6 — The IC-7300's real-time spectrum scope shows both panadapter and waterfall displays. The frequency span is adjustable in several steps and can be set to show a fixed portion of the band or centered around the operating frequency.

Figure 7 — The SWR graphing function offers a visual indication of antenna system SWR over an adjustable frequency range.

you can change the bandwidths of each one, as well as the shape between "sharp" and "soft."

When operating CW, it was a pleasure to select a sharp 250 Hz filter and just slowly tune through crowded bands, listening to individual signals without a hint of ringing. When it comes to sending CW, earlier SDRs occasionally had latency issues (a lag between pressing the key and sending or receiving the CW), but none of this is present in the IC-7300. I quickly found that I could send CW every bit as well as I could with my analog rig. Break-in operation is selected by a front panel switch, either with full break-in (QSK) or an adjustable delay for semi break-in. Note that in QSK operation, the turnaround time is 35 ms, which is slower than, for example, the IC-7100, which is 29 ms. This limits QSK operation at higher speeds. The AUTO TUNE button can help you to tune in a CW signal to the proper pitch.

The IC-7300 includes a CW keyer with adjustable speed, weighting, and so forth. You can program up to eight memories to send your call sign, signal reports, contest exchanges, and other information. Once recorded, memories can be played back using buttons on the lower portion of the screen or with an external keypad. (Icom doesn't offer a keypad, but the manual shows the connections needed.) There's a similar "voice keyer" provision for recording and sending up to eight short voice messages.

Split frequency operation is similar to other Icom transceivers. With QUICK SPLIT enabled, simply press and hold the SPLIT button. The transceiver turns on the split function and sets VFO A and B to be equal. The VFO B frequency (which will be used for transmitting) is displayed near the bottom of the screen. Use the XFC button to set your transmit frequency, or to listen on the transmit frequency.

Audio can be tailored with the TONE CONTROL menu. Bass and treble are adjustable separately for each voice mode (SSB, AM, and FM), with separate adjustments for receive and transmit. Other adjustments include high-pass and low-pass filter cutoff frequencies for receive audio for each mode and transmit bandwidth for SSB.

The rear panel includes TR switching and ALC connections for using an external power amplifier. Transmit delay is adjustable in several steps up to 30 ms to allow amplifier relays to settle and avoid hot switching. The Lab did observe that RF output appears at the IC-7300's antenna jack for about 3 ms after the amplifier key line opens so hot-switching an amplifier is possible at the end of transmission during full break-in (QSK) operation if the amplifier uses fast switching (see the accompanying sidebar).

Once you have the IC-7300 configured to your liking, you can save the configuration to the SD memory card (the memory card is not included). In this way, you can store different configurations for different types of operating. The SD card will also store many other types of information, including received audio and transmit voice keyer audio.

Digital Modes

The IC-7300 offers a built-in RTTY decoder (see Figure 5). I tested this function, along with the "twin peaks" RTTY filtering, and it performed quite well. The text appears in a small window within the main display. The radio can also save the decoded text to the SD card for later review.

The RTTY feature includes transmit memories for various "canned" messages. These would be highly useful for DX hunting, especially in pileup situations. You could program your call and response, and simply tap the touchscreen to send.

For most digital operating generally, the IC-7300's USB connection is the way to go. Transmit and receive audio, and transmit/receive keying, are all handled smoothly over a single cable between the radio and your computer — no hardware interfaces required. You only need to keep in mind that the IC-7300 presents itself as a "sound device" (USB Audio CODEC), which you'll have to select in your software setup. For transmit/receive keying, the IC-7300 appears as a virtual serial COM port. To hunt down the assigned COM port number, I had to access Device Manager in *Windows 10* and open the list of ports. In my computer, the IC-7300's interface appeared as "Silicon Labs CP210x USB to UART Bridge" and had been assigned to COM 9 (the COM port number will likely be different in your computer). So, once I configured my software to use COM 9 for rig keying, all was right with the world. I operated the IC-7300 on several digital modes with ease — exactly as I would with a conventional transceiver.

With RTTY contesting in mind, I used the IC-7300's USB connection to handle receive audio and FSK keying with the popular *MMTTY* RTTY software and did a little searching and pouncing during the Alessandro Volta RTTY competition. Once again, the IC-7300 performed perfectly. Rich Donahue, KØPIR, has a video on YouTube at **https://youtu.be/ZCkiuzAMuZI** that shows you how to set up *MMTTY* for use with the IC-7300.

If you already own a digital interface, and prefer to continue using it instead, don't worry. The IC-7300 still offers a multi-pin accessory port on the rear panel to accommodate your interface connections.

About that Screen

I quickly learned to love the IC-7300's touchscreen. It is bright and easy to read, including the waterfall and spectrum scope (see Figure 6). Both scopes are adjustable and you can even zoom in for a closer look at individual signals, or select an additional display of the audio characteristics of the signal. (This was particularly helpful when sending PSK31. I could see the modulation characteristics of my transmit signal right there on the screen.) Tapping a signal on the scope tunes the transceiver to that frequency. Even passband tuning is rendered graphically. When you twist either of the passband tuning knobs, you see the result as an animated graphic that shows the effect of what you are doing.

While exploring the myriad features, I also ran across a very cool SWR graphing function that behaves like an antenna analyzer. You set your frequency parameters and then repeatedly press the TRANSMIT button. With each press, the SWR is measured and plotted on the graph (see Figure 7). This is a good time to mention that while the built-in antenna tuner is designed for mismatches that result in a maximum 3:1 SWR, it offers a so-called "Emergency Mode" that allows it to grapple with SWRs as high as 10:1, albeit at reduced RF output.

Overall, the screen was well suited to my needs, even with my aging vision, but if you want something bigger, Icom offers the optional $100 RS-BA1 remote control software. With this software you can control the transceiver and display the entire screen on your computer monitor. You can even control the IC-7300 remotely via the Internet.

Conclusion

So is the IC-7300 really a game-changer? In my opinion, it clearly meets the criteria. The IC-7300 takes the familiar ergonomic design of an analog transceiver and blends it seamlessly with software defined radio technology — all at a moderate price. I have a feeling that this approach to amateur transceiver design is likely to spread rapidly, even to lower-end models. Years from now we may look back at the IC-7300 and see its introduction as the moment when everything changed.

Manufacturer: Icom America, 12421 Willows Road NE, Kirkland, WA 98034; tel 800-872-4266; **www.icomamerica.com**.

See the Digital Edition of *QST* for a video overview of the Icom IC-7300 HF and 6 meter transceiver.

JYE Tech Ltd Capacitance Meter DIY Kit

Reviewed by Paul Danzer, N1II
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Microprocessors have made a big difference in electronics in general and in ham radio in particular. For around $10, you can get a kit for a capacitance measuring device that covers 1 pF to 500 µF and is microprocessor based, with a digital readout and automatic operation. The manufacturer is the same one who makes the $34 oscilloscope kit reviewed in the January 2016 issue of *QST*, so it was not a surprise that the small shipping box contains a large number of parts for the money, as shown in Figure 8.[2]

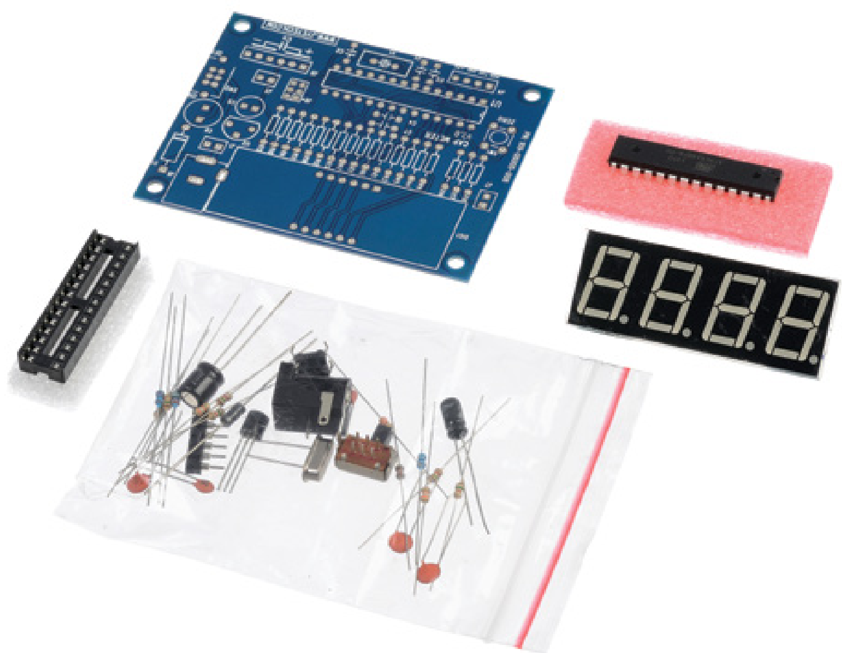

Figure 8 — A four-digit LED display and a preprogrammed microprocessor (ATmega48) form the heart of the circuit. This microprocessor is listed as having an eight-bit CPU, 4 kbytes of memory, and a built-in A/D converter. This kit uses no surface mount components.

Bottom Line

For around $10 and an evening or two of careful work, you end up with a perfectly serviceable device to measure a wide range of capacitors.

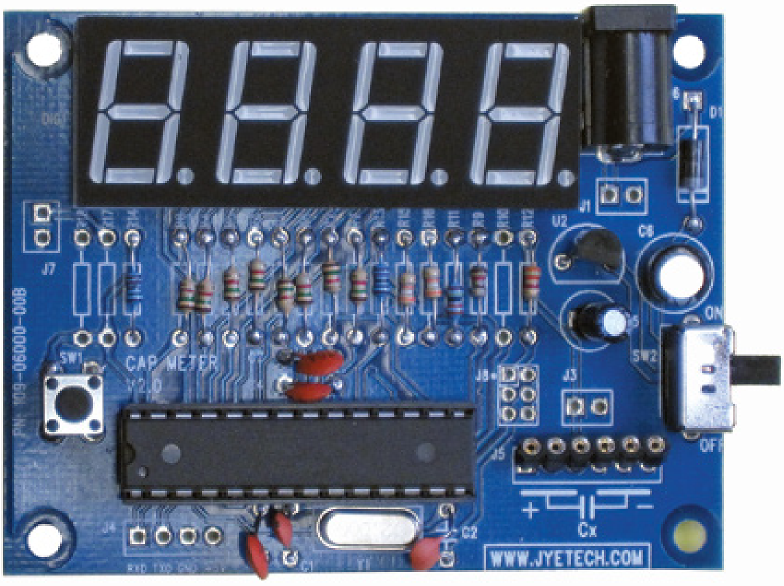

Figure 9 — Most of the resistors in the center of the board are the current limiting resistors for the LED display. Pushbutton switch SW1 on the left edge zeroes the circuit before use, and the slide switch (SW2) on the right edge turns the power on and off.

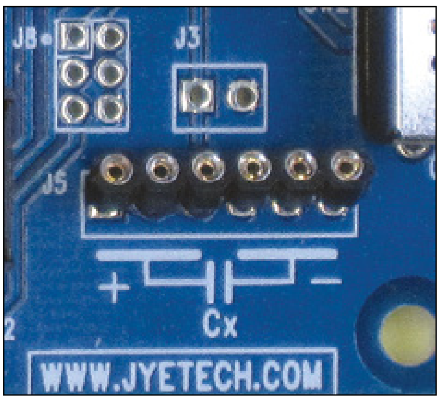

Figure 10 — An unknown capacitor plugs into the jack labeled Cx on the lower right — one lead into any of the group of three left-hand pin sockets, and the other lead into any of the three right-hand sockets. The board is marked to show how to connect the positive and negative leads of electrolytic capacitors. J3 and J8, seen at the top of the figure, are not used.

End line: Does it work? Yes. Does it work well? Yes. Does the automatic range selection work? Yes.

The only similarity between this kit and a classic Heathkit is that when you are finished, your workbench is littered with clipped-off resistor leads. Although assembly is probably only a one or perhaps two-evening project, instructions are sparse and it is not a beginner's kit.

Putting It Together

The resistors are very tiny, and sneezing near your workbench is not a good idea. However, using the same technique described in the previous *QST* review, one good approach is to measure each resistor, place it on a strip of double-sided tape mounted on a piece of paper, and write the value next to it.

The electrolytic capacitors are easy to identify. Three ceramic caps are clearly marked as "104," corresponding to the three caps in the parts list with a value of 0.1 µF. Two smaller caps are marked with "22," corresponding to the parts list value of 22 pF. Components are not in numerical order on board.

You will need a 20 to 40 W soldering iron with the tip filed to a point, and if you can find #28 gauge solder, that will make soldering points in close proximity easier. The board is clean and has a coating that helps resist solder bridges. The components are mounted in plated through holes, which makes soldering much easier. To better locate part placement, you can copy the PC board solder mask on a copy machine set to 150% or more. The only assembly guidance the manufacturer gives you is a note that the positive lead of electrolytic capacitors goes in the hole marked with a square.

There are component mounting holes for components that are not supplied or used, so just ignore these places. SW2, the "zeroing" switch, is not symmetrical and will fit the four mounting holes only when correctly oriented, although you may have to straighten out its leads. The finished capacitance meter is shown in Figure 9.

Using the Meter

First, turn it on. No, that's not a joke. It is very easy to overlook the setting of SW1 on the right side of the board that turns power on and off — and the single assembly and instruction sheet never mentions it. Power is applied through J1, anywhere between 8 and 16 V at less than 30 mA. I tried 9 V and 12 V with no notable difference. The board power connector is compatible with a 5.5 mm coaxial plug. A 5 V regulator (U2) steps down the voltage for most of the circuit.

When you first turn it on, you can ignore the pattern. Before attaching the capacitor to be measured, press SW2 to set the zero. A few seconds after you release the switch the LED will read 000. Ignore the fourth digit; it is not a numerical readout but is used to show the units of capacitance with "sort of" letters. "P" (which looks like a rectangular capital "P") is for "pF." The "n" for "nF" looks like a small inverted "u" using three segments of the LED. The "u" for microfarads looks like a "u," also using three segments.

After the zeroing process the display will read 000P; then you can the insert the capacitor leads. Unfortunately J5, to which you connect the capacitor to be measured, only accepts a narrow range of leads (see Figure 10). Heavy capacitor leads will not fit, so you will have to tack on smaller wire to fit the jack.

Theory of Operation

As with many microprocessor-based devices, there is no theory of operation supplied. The microprocessor is reprogrammable; J8, J3, and J4 are not used under normal operation, but according the schematic appear to control the programming ports. As a ham you may be curious as to what is going on. Placing an oscilloscope across the capacitor being measured results in a set of voltage spikes with their interval varying with the capacitor value. The smaller the capacitance, the higher the spike frequency. The instruction sheet has a limited troubleshooting guide, and an on-line forum at the JYE website may help to answer questions.[3]

Measurements and Accuracy

The JYE unit is rated by the manufacturer as being accurate to less than 2%. As with all digital units, this specification is always ±1 in the last (right-hand) digit. Sometimes this effect is not serious. For example, a capacitor that shows a value of 743 pF might, depending on how the meter rounds off, actually be 742.6 or 743.4. However, sometimes this rounding error is a larger percentage of the capacitance value. Suppose the measurement shows 12 pF. It might actually be 11.6 or 12.4 pF, which alone exceeds the 2% rating. These small discrepancies won't matter for most applications.

In order to confirm the 2% rating on the JYE unit, you would probably need either a capacitor standard or a measuring instrument good to an order of magnitude better, say 0.2% accuracy. Because this accuracy is hard to come by outside a specialized laboratory, I decided to measure several capacitors with four different instruments and compare the average to measurements taken with the JYE kit. While this does not confirm the claimed accuracy, it at least verifies the ability of the JYE unit to measure as well as units costing five to ten times as much.

Table 2
JYE Capacitance Meter DIY Kit Measurements

Marked Value	JYE Meter	Average of 4 Other Meters
470 µF	481 µF	Out of Range
100 µF	146 µF	121.0 µF
1.0 µF	1.1 µF	1.04 µF
0.47 µF (470 nF)	517 nF	508.5 nF
0.22 µF (220 nF)	259 nF	227.33 nF
0.1 µF (100 nF)	104 nF	100 nF
0.1 µF (100 nF)	925 nF	900 nF
0.075 µF (75 nF)	76.2 nF	70 nF
0.047 µF (47 nF)	42.7 nF	42.75 nF
0.01 µF (10 nF)	18.2 nF	18.58 nF
47 pF	46.5 pF	45.90 pF
45 pF	52 pF	46.55 pF
10 pF	10.2 pF	8.48 pF

Table 2 summarizes the result. None of the four other instruments were capable of measuring the 470 µF capacitor, and only two could measure the 100 µF capacitor. They all used an impedance technique — that is, an ac voltage of known frequency is applied and the reactance measured, then converted to capacitance and displayed digitally. At the bottom of the table, a low value capacitor (10 pF) was very sensitive to lead length.

My results suggest that this $10 measuring instrument compares favorably with other, higher priced (and not auto ranging) units. In other words, if you need to measure capacitance, the JYE unit will do as well on your workbench as other, more costly units.

Manufacturer: JYE Tech Ltd, **www.jyetech.com**. *Distributor*: AccuDIY, 15 Heritage Rd, Unit 17, Markham, ON L3P 1W9, Canada. Order through **accudiy.com**. Look under "DIY Kits," then "Meters." Price: $9.80 kit, $12.80 assembled. Also available from SparkFun (**www.sparkfun.com**) and Amazon.

Notes

[2]P. Danzer, N1II, "JYE Tech Ltd DSO138 DIY Oscilloscope Kit," Product Review, *QST*, Jan 2016, pp 62 – 64.

[3]The forum at **www.jyetech.com/forum/index.php** covers the capacitance meter and other JYE products.

MyAntennas OCF-4010E-3K Off-Center Fed Dipole Antenna

Reviewed by Steve Ford, WB8IMY
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In the classic ½-wavelength dipole antenna, you have two equal lengths of wire, each ¼ wavelength at your chosen frequency. These two wires meet in the middle, where they attach to the center and braid conductors of your coaxial cable. The impedance at the center is reasonably close to 50 Ω, which creates an effective match to your "standard" 50 Ω cable. The other end of the coaxial cable is secured to your transceiver, which also is designed to work with a 50 Ω impedance. It's 50 Ω all around and everyone is happy.

But contrary to what you may have heard, a dipole antenna does *not* have to be fed at the center. You can move the feed point anywhere you like, as long as you can find a way to match the resulting impedance to your feed line.

For decades, many amateurs have embraced the off-center fed (OCF) dipole design as a means to enjoy multiband performance from a single antenna. An OCF dipole is fed at a point that corresponds to about 20% of its total length. The impedance at this point is approximately 200 Ω, so to create a match for 50 Ω coax, you need to attach the cable to the antenna through a 4:1 current balun (200 Ω / 4 = 50 Ω). Properly built, an OCF dipole has the advantage of offering a useable impedance match to 50 Ω coax on several bands rather than just one or two.

Bottom Line

The MyAntennas OCF-4010E-3K off-center fed dipole covers 40, 20, 15, and 10 meters with one feed line. It is well built and would be a good choice for home station or portable use.

The OCF-4010E-3K

The MyAntennas OCF-4010E-3K is an OCF dipole designed primarily for operation on 40, 20, 15, and 10 meters. Rated for full legal power, this antenna is built like a proverbial tank (see Figure 11). The OCF-4010E-3K uses a dual-core 4:1 current balun that is housed in a heavy polybutylene terephthalate (PBT) weatherproof plastic enclosure.

The antenna also offers heavy gauge wire that's insulated with a black ultraviolet-

Figure 11 — The OCF-4010E-3K arrives preassembled and ready for use.

Figure 12 — The feed point with balun/center insulator installed at a height of 30 feet. The 53-foot leg extends horizontally while the 13-foot leg slopes downward.

resistant material. Even the black end insulators are designed for high strength.

The OCF-4010E-3K arrives completely assembled. You simply remove it from the shipping box, clip off the cable ties, and you're ready to go.

I hauled the feed point about 30 feet into the branches of a pine tree (see Figure 12) that serves as my antenna "tower." I ran the 53-foot leg horizontally, but brought the 13-foot leg down at a shallow angle to a point about 7 feet above the ground. This arrangement is somewhat unconventional. I would have preferred to hang the entire antenna horizontally, but I had to make the best use of the space available.

Feeding the antenna with LMR-400 coaxial cable, I measured SWR below 2:1 on 40, 20, 15, and 10 meters. In addition, I measured SWR at 3.5:1 on 17 and 12 meters, well within the range of the antenna tuner in my transceiver (and with negligible SWR loss on either band thanks to the LMR-400). The surprise came when I tried the antenna on 6 meters. At 50.125 MHz, I measured an SWR of just 1.2:1. While MyAntennas doesn't specifically advertise the OCF-4010E-3K as having 6 meter capability, this was a pleasant bonus.

Without a professional test range, I can't speak to the performance of the OCF-4010E-3K in terms of actual measurements. Even so, from a purely subjective viewpoint, the antenna certainly seemed to "work" quite well, even during less-than-ideal propagation conditions. Considering the excellent craftsmanship of the OCF-4010E-3K and its durable design, this antenna should offer reliable performance for years to come. It's a good choice for home station or portable use.

Manufacturer: MyAntennas, 40415 Chancey Rd, Suite 105, Zephyrhills, FL, 33542; **myantennas.com/wp/**. Price: $139.99.

New Products

Siglent SSA3000X Series Spectrum Analyzers

The SSA3000X series of digital spectrum analyzers includes two new models with frequency ranges from 9 kHz to 2.1 GHz and 9 kHz to 3.2 GHz. These new spectrum analyzers incorporate all-digital intermediate frequency (IF) technology — frequency conversion and filtering is accomplished with digital signal processing earlier in the signal path. The SSA3000X spectrum analyzers include a 10.1-inch WVGA display with 1024 × 600 resolution. Key specifications: minimum resolution bandwidth (RBW), 10 Hz; average noise level displayed, –161 dBm/Hz; offset phase noise, –98 dBc/Hz @10 kHz; and total amplitude accuracy, < 0.7 dB. Initial calibration accuracy is < 0.2 ppm. Options include a tracking generator, advanced measurement package, EMI measurement function with quasi-peak detection, and reflection (VSWR) measurement kit. Prices start at $1595. For more information, visit **www.siglentamerica.com**.