QST Product Review

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Icom IC-R8600 Communications Receiver

A high-performance broadband receiver, with SDR versatility.

Reviewed by Martin Ewing, AA6E aa6e@arrl.net

Amateurs of a certain age will remember operating with separate receivers and transmitters. At one time, this was the only option. Since the 1970s, however, we generally purchase integrated transceivers. These combine the receiver and transmitter in a single box, simplifying station setup and saving cost.

Why would you consider a standalone communications receiver today? Advanced amateur-friendly models, such as the IC-R8600, cover a very wide frequency range and support a variety of signal modulations and operating modes. They allow you to scan wide swaths of spectrum, looking for interesting signals and diagnosing interference. In one compact box, you get a very good receiver for ham communications, a fine scanning monitor and shortwave listening (SWL) radio, and an excellent piece of test equipment. A receiver in this category will probably not be your first radio, but it can round out the capabilities of any ham shack.

I used the earlier IC-R8500 for many years. Produced between 1996 and 2004, that radio covered 100 kHz to 2 GHz.¹ When it departed my shack, it left quite a gap — and seller’s remorse! Now, after 13 years, Icom’s R8000 series resumes with the IC-R8600. The latest advances in software-defined radio (SDR) have brought many high-end features into the R8600’s price range. This radio compares favorably with Icom’s IC-R9500, now 11 years on the market and aimed at professional users at a higher price point.²

In addition to the classic communications receiver and spectrum analyzer that monitors specific channels or bands, the R8600 is also a “scanner” radio, where the emphasis is on rapid scanning across wide bandwidths, searching for signals of interest that may have unknown frequencies.

Technical Overview

The IC-R8600 receiver covers the RF spectrum from 10 kHz to 3000 MHz, with the usual US cell phone exclusions.

Figure 1 shows a simplified block diagram. Frequencies between 10 kHz and 30 MHz are direct sampled for SDR processing. Above 30 MHz, the radio converts the signal frequency two or three times in a double or triple superheterodyne scheme. To reduce spurious responses, some 11 RF band-pass filters (BPFs) are provided for HF bands, and 13 filters for the VHF/UHF bands. The analog/digital converter (A/D) samples at 122.88 MHz. A field programmable gate array (FPGA) converts the time samples to the frequency domain, for display on the spectrum scope (aka panadapter/waterfall display) or for further digital signal processing (DSP) and digital/analog conversion to produce a demodulated audio signal.

As shown, there are three available antenna inputs. A type-N connector supports the radio’s full frequency range. When you are operating below 30 MHz, you can instead select a UHF or a phono connector. The N and UHF

Bottom Line

Covering 10 kHz through 3 GHz and demodulating many popular analog and digital modes, the IC-R8600 can be used as a high-quality ham band receiver, or for listening to many other radio services. Its dynamic performance rivals top-tier amateur transceivers.
Table 1
Icom IC-R8600, serial number 02001068

<table>
<thead>
<tr>
<th>Manufacturer’s Specifications</th>
<th>Measured in the ARRL Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency coverage: 0.01 – 821.999.999, 851 – 866.99999 MHz, 0.896 – 3.0 GHz.</td>
<td>As specified.</td>
</tr>
<tr>
<td>Power requirement: 13.8 V dc, ±15%.</td>
<td>At 13.8 V dc: 1.49 A (maximum volume, no signal), Off, 8 mA.</td>
</tr>
<tr>
<td>Modes of operation: SSB, CW, AM, FM, WFM, FSK, D-STAR, P25, NXDN, dPMR, and DCR.</td>
<td>As specified.</td>
</tr>
</tbody>
</table>

Receiver Dynamic Testing

| Sensitivity (MDS): Preamp on, 500 Hz BW, 0.1 – 1.8 MHz, –113 dBm; 1.8 – 30 MHz, –121 dBm; 30 – 2.000 MHz, –117 dBm; 2 – 3 GHz, –115 dBm. | Noise floor (MDS), 500 Hz bandwidth: Preamp on 0.137 MHz –126 dBm –136 dBm. Preamp off 0.475 MHz –128 dBm –138 dBm. |
| Sensitivity: For 12 dB SINAD, 12 kHz bandwidth: Preamp on 1.020 MHz 1.74 µV, 0.65 µV. Preamp off 3.885 MHz 1.82 µV, 0.60 µV. 29.0 MHz 1.78 µV, 0.50 µV. 50.4 MHz 1.64 µV, 0.68 µV. 120 MHz 1.64 µV, 0.68 µV. 144 MHz 1.64 µV, 0.68 µV. 432 MHz 1.74 µV, 0.68 µV. For 10 dB (S+N), 6 kHz bandwidth: Preamp on 29 MHz 0.50 µV, 0.21 µV. 52 MHz 0.51 µV, 0.22 µV. 70 MHz 0.76 µV, 0.29 µV. 100 MHz 0.94 µV, 0.41 µV (WFM). 146 MHz 0.53 µV, 0.22 µV. 162 MHz 0.54 µV, 0.24 µV. 223 MHz 0.57 µV, 0.23 µV. 440 MHz 0.56 µV, 0.23 µV. 902 MHz 0.71 µV, 0.29 µV. 1,296 MHz 0.41 µV, 0.23 µV. For 12 dB SINAD, 12 kHz bandwidth: Preamp on 29 MHz 0.50 µV, 0.21 µV. 52 MHz 0.51 µV, 0.22 µV. 70 MHz 0.76 µV, 0.29 µV. 100 MHz 0.94 µV, 0.41 µV (WFM). 146 MHz 0.53 µV, 0.22 µV. 162 MHz 0.54 µV, 0.24 µV. 223 MHz 0.57 µV, 0.23 µV. 440 MHz 0.56 µV, 0.23 µV. 902 MHz 0.71 µV, 0.29 µV. 1,296 MHz 0.41 µV, 0.23 µV. |

| AM sensitivity: For 10 dB (S+N), 6 kHz BW, 0.1 – 30 MHz, 7.96 µV; 1.8 MHz – 3 GHz, 6.32 µV. | Noise figure: Not specified. |
| FM sensitivity: For 12 dB SINAD, 15 kHz BW, 28 MHz – 2 GHz, 0.5 µV; 2 – 3 GHz, 0.8 µV. | For 10 dB (S+N), 6 kHz bandwidth: Preamp on 1.296 MHz 0.48 µV, 0.20 µV. Preamp off 1.44 MHz 0.50 µV, 0.22 µV. 432 MHz 0.52 µV, 0.23 µV. 222 MHz 0.41 µV, 0.18 µV. 432 MHz 0.52 µV, 0.23 µV. 1,296 MHz 0.48 µV, 0.20 µV. For 12 dB SINAD, 12 kHz bandwidth: Preamp on 1.296 MHz 0.48 µV, 0.20 µV. Preamp off 1.296 MHz 0.48 µV, 0.20 µV. 432 MHz 0.52 µV, 0.23 µV. 222 MHz 0.41 µV, 0.18 µV. 432 MHz 0.52 µV, 0.23 µV. 1,296 MHz 0.48 µV, 0.20 µV. |

| Blocking gain compression dynamic range: | Blocking gain compression dynamic range, 500 Hz bandwidth: Preamp on 20 kHz offset 1.9 dB. 52 kHz offset 1.4 dB. Preamp off 3.5 MHz 123/113 dB. 14 MHz 124/124 dB. 50 MHz 122/114 dB. 144 MHz 121/114 dB. 440 MHz 122/116 dB. 14 MHz, 20/5/2 kHz offset: 122/122 dB. 50 kHz offset: 122/114/108 dB. |

| Reciprocal mixing dynamic range (500 Hz BW): | Not specified. |

| ARRL Lab Two-Tone IMD Dynamic Range Testing (500 Hz bandwidth)† | |
| Band/preamp | Spacing | Measured IMD Level | Measured Input Level | IMD DR |
| 3.5 MHz/Off | 20 kHz | –131 dBm | –97 dBm | –7 dBm†† | 99 dB |
| 14 MHz/Off | 20 kHz | –132 dBm | –97 dBm | –9 dBm†† | 103 dB |
| 14 MHz/On | 20 kHz | –142 dBm | –97 dBm | –33 dBm†† | 103 dB |
| 14 MHz/Off | 5 kHz | –132 dBm | –97 dBm | –19 dBm†† | 99 dB |
**User Interface**

A key feature of any modern radio gear is the user interface. With SDR techniques, you can control and monitor operation through a full complement of buttons, knobs, touchscreens, or even from remote computers. The R8600 controls closely resemble other recent Icom products, such as the IC-7300, so many users will find the scope, memory, and scan system very familiar.

**Manufacturer’s Specifications**

<table>
<thead>
<tr>
<th>Band/preamp</th>
<th>Spacing</th>
<th>Measured IMD Level</th>
<th>Measured Input Level</th>
<th>IMD DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 MHz/Off</td>
<td>2 kHz</td>
<td>–132 dBm</td>
<td>–43 dBm</td>
<td>99 dB</td>
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<tr>
<td></td>
<td></td>
<td>–97 dBm</td>
<td>–19 dBm†️</td>
<td></td>
</tr>
<tr>
<td>50 MHz/Off</td>
<td>20 kHz</td>
<td>–133 dBm</td>
<td>–50 dBm</td>
<td>83 dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–97 dBm</td>
<td>–24 dBm</td>
<td></td>
</tr>
<tr>
<td>50 MHz/On</td>
<td>20 kHz</td>
<td>–141 dBm</td>
<td>–55 dBm</td>
<td>86 dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–97 dBm</td>
<td>–35 dBm</td>
<td></td>
</tr>
<tr>
<td>144 MHz/Off</td>
<td>20 kHz</td>
<td>–133 dBm</td>
<td>–56 dBm</td>
<td>85 dB</td>
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<td>–97 dBm</td>
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<td>432 MHz</td>
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<td></td>
<td></td>
<td>–97 dBm</td>
<td>–33 dBm</td>
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</tbody>
</table>

**Spectral sensitivity:** Not specified.

**Tuning dial accuracy:** Not specified.

**Second-order intercept point:** Not specified.

**FM adjacent channel selectivity:** Not specified.

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

**Squelch sensitivity:** Not specified.

**Signal strength meter accuracy:** Not specified.

**DSP noise reduction:** Not specified.

**Notch filter depth:** Not specified.

**IF/audio response:** Not specified.

**Audio output:** 2 W at 10% THD, 8 Ω load.

**Signal processing delay time:** Not specified. 15 ms.

**Size (height, width, depth):** 4.0 x 8.6 x 10.5 inches (including protrusions). **Weight:** 9.5 lbs. **Price:** IC-R8600, $2,499; AD-55NS power supply, $59; CS-R8600 programming software, $80.

†Third-order IMD dynamic range data taken with IP+ on. See Lab Notes sidebar.

‡Default values; bandwidth and cutoff frequencies are adjustable.

You can direct audio output to a built-in or external speaker, a headphone jack, a constant-level “line” output, or as digital audio to your computer or other device over USB or Ethernet. You can view digital mode decoded text output on screen, or you can direct output to an external device COM port over USB. You may also store up to 32 GB of video screenshots, audio, or decoded data on an SD memory card.

The R8600 will internally decode FSK (RTTY) signals, along with a number of data modes. For ham use, the radio’s main data mode of interest is probably D-STAR. Other modes (P25, NXDN, dPMR, and DCR) are generally used by other radio services. Unfortunately, there is no support for the digital voice modes DMR or C4FM (Yaesu System Fusion) or other common data modes, such as PSK31.

The radio offers a number of extra signal output options. An analog 10.7 MHz IF output with 10 MHz fixed bandwidth, allows you to connect alternative back-end equipment. There is a dedicated USB jack for output of complex I/Q IF data, and a 12 kHz digital IF output can be taken from a ¼-inch phone jack or either a front or rear USB connection.
tions. There is also a spectrum scope/ waterfall that will show up to 5 MHz of spectrum typically centered on the current operating frequency. You can narrow the spectrum display range down to 5 kHz, giving a useful frequency resolution of about 10 Hz, which is the minimum VFO step size. (VFO resolution is actually 1 Hz, but 10 Hz is the step accessible from the normal controls. You can get 1 Hz settings via the touchscreen “zoom” function.)

If you want to preserve a screen display, there is a convenient screenshot option to store .png or .bmp files with 480 × 272 resolution on an SD card. Alas, there is no support for an external video display. There is, however, an output to drive an external signal strength meter.

Three multifunction (turn/push) controls are assigned to scanning control (Dial A), audio/RF gain and squelch (Dial B), and memory selection (Dial C). Other functions are selected either by screen touches or by physical buttons. The main tuning knob has a good feel with three rather different settings — low friction, high friction, and (my favorite) a step detent action.

The signal-strength meter displays as a bar graph that is notable because it supports four different scales. One is the classic “S-meter,” which displays S-1 to S-9 and up to S-9 + 60 dB. This is meant to observe the normal convention that S-9 is 50 µV, with a change of 1 S-unit corresponding to 6 dB, although the R8600 did not conform to this convention (see the “Lab Notes” sidebar). You can alternatively select a dBm scale that shows 0 dBm for a 1 mW input level. Unlike the S-meter, the dBm reading does not vary as you switch in the preamp or attenuators. It is meant to represent the actual power level at the input connector. You can also view absolute voltage (dBµ) in either 50 Ω terminated or open-circuit modes.

**Other Features**

The 10 MHz internal frequency reference is specified to be better than ±0.5 ppm. A back panel connector will supply this reference to external equipment. Optionally, this connector can accept a reference from an external 10 MHz source. Note that a 1 ppm offset at 3 GHz is 3 kHz, so a high-quality external reference may be needed if you want full accuracy and stability at the highest frequencies.

The R8600’s internal clock can be synchronized to an external internet NTP (Network Time Protocol) server through an ethernet connection. The same ethernet connection should support remote control operation, which Icom says is coming in a future software product.

If you set up the receiver’s antenna port and preamp, attenuator, and IP+ settings at a particular frequency, how far can you tune away from that frequency before the settings might change? This is not discussed in the Instruction Manual (but should have been), so I experimented and found that the radio
divides up the spectrum into “bands.” If you change any of those settings anywhere within a particular band, they seem to apply all throughout the band. I found band edges at 1.6, 2, 6, 8, 11, 15, 20, 22, 26, 30, and 1100 MHz. (The low band goes down to 10 kHz, and the high band goes up to 3 GHz.) Presumably, the radio is switching its filters and signal paths at these frequencies also.

You may run into unexpected changes in settings as you tune across a band boundary, but the panel display always shows the active values.

**Operating Modes**

The R8600 provides full support of the classical modulation modes along with some digital modes. Indirectly, you can supply your own DSP hardware or demodulation software (for example, Fldigi) to use the 10.7 MHz IF output, the 12 kHz IF output, or the SSB audio output.

AM operation is supported in four modes. There is AM and synchronous AM (SAM). SAM is provided for upper, lower, and double sideband operation. You can select an IF bandwidth from 200 Hz to 10 kHz. SAM is especially useful when selective fading of the AM carrier would cause audio distortion. The single sideband SAM options allow you to avoid interference that may appear on top of an AM signal in one sideband or the other.

CW operation is supported by IF bandpass adjustable from 50 Hz to 3.6 kHz, with sidetone frequencies (pitch at band-pass center) between 300 and 900 Hz.

SSB (LSB or USB) is supported with IF bandpass from 50 Hz to 3.6 kHz.

FM IF bandpass is fixed at 50 kHz, 15 kHz, or 7 kHz. You get a deviation indicator and an optional automatic frequency control (AFC) that can help you get on frequency (see Figure 2).

WFM (wide FM) is typically used for FM broadcasting. Its bandwidth is fixed at 200 kHz (see Figure 3).

With FSK, you get a tuning indicator and also a useful optional decode display that shows four to nine lines of decoded text alongside an audio spectrum scope that helps you tune in a RTTY station (see Figure 4). Default band-pass settings range from 2.4 kHz down to 250 Hz. Manually, you can set 50 Hz to 2.7 kHz. The decoder supports either 45 or 50 baud RTTY, with a range of standard mark/space tones and shifts. You can record decoded text as a text or HTML file on the SD device, or you can pass the data to your computer over USB.

There are default filter settings (FIL1, FIL2, FIL3) from wider to narrower, as appropriate for each mode. When you adjust filter settings manually, your new setting temporarily replaces one of the defaults.

The IF band-pass filter in these modes can be set to sharp or soft. Sharp filtering is best for eliminating nearby interference, while soft is preferred as a more traditional sound by some users.

The digital modes decode a number of signaling schemes, but only D-STAR is widespread among amateurs. It was simple enough to monitor a local D-STAR repeater, receiving both voice and text messages.

In addition to IF filtering, you can set different audio tone controls for each mode. That’s a lot of customization!

**Signal Processing**

For most signal modes, you have the usual receiver controls, resembling other Icom radios. There is an “IP+” mode that greatly increases IMD performance in certain situations — multiple signals in a low noise environment, such as in our Lab tests (see the “Lab Notes” sidebar). Controls for notch filtering, noise blanking, and noise reduction will be familiar. Icom’s digital twin passband tuning (TPBT) allows you to shift and narrow the passband as desired.

**Memory and Scanning**

The R8600 provides many memory channels that record frequency, mode, antenna setting, and other data associated with a particular receiving setup (a
Figure 4 — Spectrum and waterfall of 40-meter RTTY signals, showing decoded text and fine audio spectrum for precise tuning.

Figure 5 — Screenshots of CS-R8600 software: memory programming (below) and hardware settings (above).

station, in other words). You can set up 100 groups that can each contain 100 channels, up to the overall limit of 2,000 channels.

The R8600 scanning operation is similar to many other radios. You can scan predefined memory channels or defined frequency ranges. You can search for activity over a frequency range and store the active frequencies in memory channels.

It is interesting to note that the search function listens to one channel at a time, so it can take a long time to cover a wide band, stepping at a rate of 50 channels per second or less. If we made full use of the SDR’s FFT capability, we should be able to search hundreds of channels in parallel, cutting search time dramatically. Maybe in the future!

Cloning Software
You can manage the R8600 for routine tasks from the front panel. However, that gets tedious for such a complex radio with its 2,000 memory channels. To configure the radio and especially to “clone” the settings from one radio to another, you need computer assistance. Icom provides the CS-R8600 Cloning Software ($79.95) just for this purpose (see Figure 5). Any computer running Windows Vista or above with USB or SD card capability should support the software. I checked for alternative free cloning programs, but could find none that support the R8600 at this time.

Updates
There are several upgradable software components in the R8600. The manual gives clear update instructions that allowed us to update the main CPU using an external computer and SD card. (It would have been handier if the R8600 could update itself over its ethernet connection, but this is not supported.) For this review, we used the following firmware versions: Main CPU 1.10; Front CPU 1.00; DSP Program 1.02; FPGA 1.00, and DV DSP 1.00. If you have the CS-R8600 software, you will need to update it to the same level.

Note that you should check Icom’s Japan site (www.icom.co.jp/world/support/) for manuals and firmware updates. Icom’s American website (www.icomamerica.com) may not have the latest files.

The R8600 is ruggedly built, allowing Icom to claim MIL-STD-810 compliance.³ Dissipating up to 25 W, the radio can run warm to the touch, but requires no special ventilation.

Wrap-Up
As an ultra-versatile receiver, the Icom IC-R8600 may not be optimized for any particular service. For convenience and price, a fully integrated SDR transceiver will still be most amateurs’ choice for operating. If you want to use it on the higher UHF and microwave bands, you will need a more sensitive preamplifier.

Some of the more interesting features (ethernet, I/Q outputs) do not have support from Icom software as this is written. You will have to wait for remote control, for example, or start coding your own software.

Still, the R8600 is a remarkable radio that serves many applications beyond ham radio. In an amateur’s shack, the R8600 will provide access to a big swath of spectrum that includes all the ham frequencies from dc through the 13-centimeter band. It can be used as a high-quality ham band receiver, but it is much more than that. You can check out all the radio services up to 3 GHz. It is also excellent test equipment that will let you check spurious emissions and locate interference sources.

The receiver has a significant learning curve if you want to master all its features, but its similarity to other Icom
IC-R8600
10kHz - 3GHz SDR Communications Receiver

- Ultra-wide frequency coverage with RSSI
- Real-time spectrum scope
- Decodes multiple digital protocols
- Touch screen display
- Clear audio quality using FPGA/DSP base architecture
- I/Q signal output for use with third-party SDR software
- The SD card slot and voice recording
- Optional SP-39AD external speaker with integrated power supply
- Optional RS-R8600 remote control software

Listen to the World
products will help many users get in the swing pretty quickly.

Manufacturer: Icom America,
12421 Willows Rd. N.E., Kirkland,
WA 98034; tel. 800-872-4266;

Notes


3See en.wikipedia.org/wiki/MIL-STD-810. The ARRL Lab does many tests, but we do not check shock and vibration resistance.