



Product Review and Short Takes from *QST* Magazine

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Product Reviews:

ICOM IC-7000 HF/VHF/UHF Transceiver
Heil Sound Traveler Dual Side Headset

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MFJ Model 4116 Bias Tee Power Injector

PRODUCT REVIEW

ICOM IC-7000 HF/VHF/UHF Transceiver

Reviewed by Mark Wilson, K1RO
QST Product Review Editor

It's hard to believe that 10 years has passed since *QST* first reviewed the IC-706, calling it "one of the most exciting new products to come along in years."¹ The package proved a huge hit, and ICOM kept the radio fresh by following on with the IC-706MkII and IC-706MkIIG. By the time the G version rolled out in 1999, ICOM had added 70 cm, bumped up the power on 2 meters, made DSP noise reduction and notch filter standard, and made quite a few improvements. Meanwhile, ICOM has been busy doing extreme makeovers on the rest of the product line, moving to DSP-based receivers and sophisticated display screens.

Which brings us to the IC-7000. Although the '7000 is similar to the '706 in many ways, it also shares features with the IC-756PROIII. ICOM touts the IC-7000 as a mobile transceiver, but, like the '706, it will find its way into many a suitcase for DXpeditions and Field Day outings. For a lot of hams, it has everything they want and need in a home station radio.

Feature Overview

The IC-7000 covers 160 meters through 70 cm except for 1.25 meters. Power output is 100 W on 160 through 6 meters, 50 W on 2 meters and 35 W on 70 cm. The radio works on the five 60 meter channels available to US operators, and it transmits only when one of those channels is *precisely* dialed in. The receiver covers 30 kHz to 200 MHz and 400 to 470 MHz. Modes include SSB, CW, AM, FM and RTTY. The receiver has WFM for listening to FM broadcast stations and TV audio.

DSP features include selectable IF filters, adjustable AGC, noise blanker and noise reduction, passband tuning, an automatic notch filter and a two point manual notch



filter. In addition, the '7000 offers a CW memory keyer, RTTY demodulator and digital voice keyer. FM features include scanning, automatic repeater offset, subaudible tones, DTMF memories and other familiar features. Gadget junkies will love this radio.

Hooking it Up

The package is compact and feels quite solid. It's the same height and width as the IC-706 but not quite as deep. There's a folding bale on the bottom for desktop use, and the speaker and small fan are both on top. The front panel detaches and ICOM offers several different brackets and separation cables for mobile use.

The radio needs about 22 A at 13.8 V dc. The supplied HM-151 mic plugs into one of two modular jacks — one on the bottom edge of the front panel, the other on the back of the main unit. (You can't use two microphones simultaneously, though.) A PHONES jack on the right edge of the front panel works with stereo or mono headphones or an external speaker thanks to a SPEAKER/PHONES switch behind the front panel.

The rear panel will be familiar to IC-706 users. There are two antenna jacks, one for 160 to 6 meters and the other for 2 meters and 70 cm. There's a ¼ inch stereo phone

jack for connecting a CW paddle or external keyer. Several ¼ inch phone jacks handle ICOM's CI-V computer interface (sorry, no USB jack), external speaker and RTTY (FSK keying and PTT). The VIDEO jack is new (more on this later).

The 13-pin ACC jack provides control, band data and audio signals and is used for digital modes, amplifier connections, external tuners or antenna switches. A matching plug is wired with short pigtailed — no soldering to minuscule pins! The 6-pin DATA jack can also be used for connecting a TNC or sound card for digital modes. Note that the IC-7000 can handle amplifier key lines up to 16 V dc at 200 mA. Some amplifiers will require a separate keying interface with higher ratings to avoid relay damage.

That Colorful Display

Everyone who used the review radio raved about the '7000's color TFT display screen. It measures 2.5 inches diagonally, and is about 2 inches wide by 1.5 inches tall. Before the radio hit the streets there was some trepidation about the readability of such a small, busy display. Let's face it — many hams (including me) are at the age where things look a little fuzzy and we need to break out the reading glasses when *QST* arrives.

¹The original IC-706 review appeared in March 1996 *QST*. The IC-706MkII was reviewed in March 1998, the '706MkIIG in July 1999 and the '756PROIII in March 2005. Reviews are available for download from the Members Only section of the ARRL Web site, www.arrl.org/members-only/prodrev/.

Those fears were completely unfounded. The incredible resolution, bright colors and excellent contrast make the display easy to read under a variety of lighting conditions and viewing angles. The characters are crisp and clear, and everyone who used the radio could easily see and use the screen labels and graphics. Sure, in a mobile environment or outdoors on a bright day it's occasionally difficult to see the display, but I found it perfectly readable under most conditions.

One of the menus allows you to change display characteristics such as brightness and contrast. Most photos show the default black background with white lettering, but you can change it to a bright blue background with white letters or a white background with blue letters.

The rear panel VIDEO jack mentioned earlier is an analog video output. For grins I plugged it into the composite video input on my TV, and the IC-7000's display immediately filled the screen. While this might be useful for a presentation, you're more likely to hook up one of those small video screens made for portable DVD players or automobile entertainment systems. Note that the composite video output isn't as crisp as the internal display.

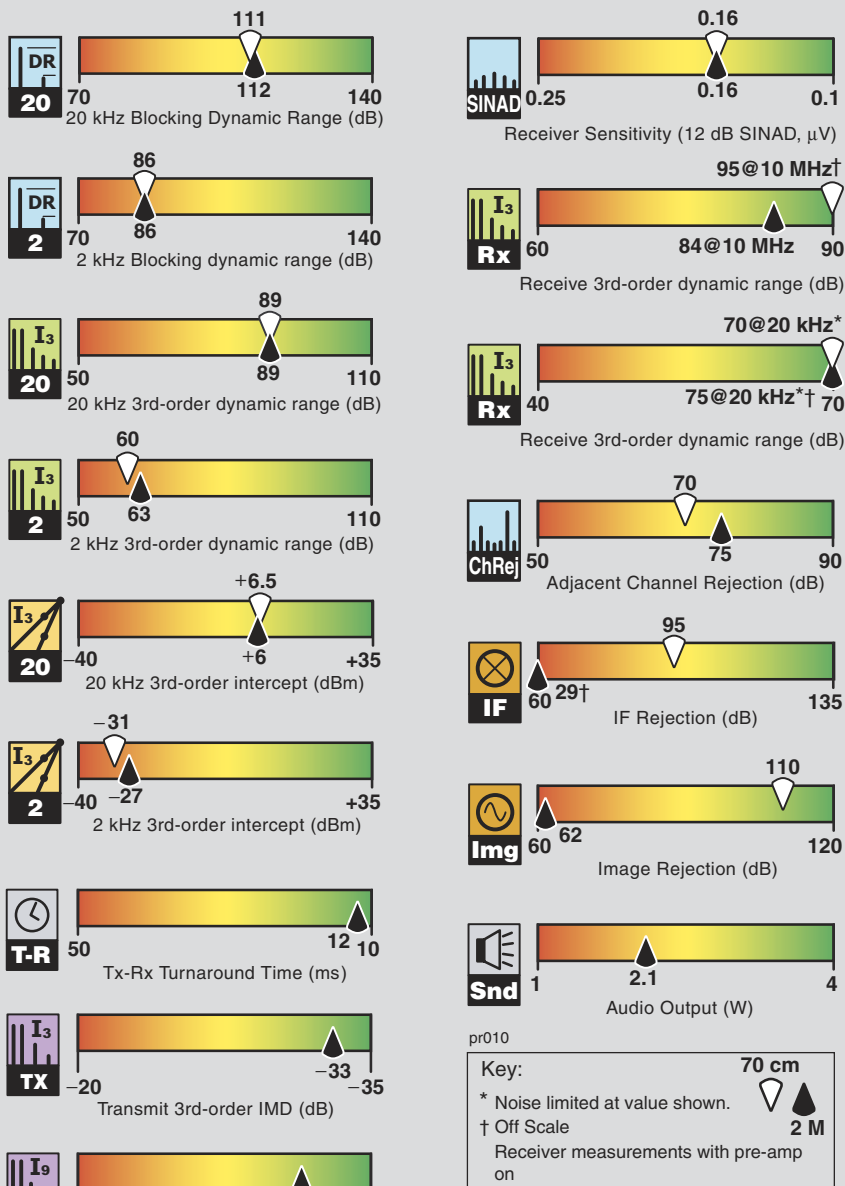
Controls and Menu

Although the '7000 takes some getting used to, ICOM did a good job with the human interface despite a minimum of buttons and panel space to work with. Most buttons have multiple functions, and some menus and controls change according to mode of operation. For the most part I was able to figure out the functions, but I kept the manual close during initial operation.

The main tuning knob has a nice feel. The BAND up and down switches are at the right-hand corners. Pressing one or the other will bring you to the last-used frequency on each band. I like to chase DX on various bands and modes and have grown fond of the band stacking registers on my desktop radio. Repeatedly pressing a band button on the keypad jumps me from SSB to CW to RTTY subbands with filter selection and other settings ready to go. ICOM has added this convenience to the IC-7000 through the HM-151 microphone. The mic's keypad resembles the keypad found on the front panel of larger radios and works the same way. There's a button for each band, and repeated pressing steps you through three band stacking registers. The keypad also works for direct frequency entry. Other HM-151 buttons control common functions.

As mentioned before, there are two mic jacks but you shouldn't plug in two microphones at the same time. For home station operation with a desk mic or headset it would be nice to plug in a keypad with the HM-151 functions, or else be able to disable the HM-151 mic element and use it as a keypad.

Key Measurements Summary



Bottom Line

The IC-7000 puts compact radio performance and features in a new package. It builds on the IC-706 line, while adding IF DSP features from ICOM's PRO series. It has what you need to enjoy operating on 13 amateur bands with many of the conveniences found in the full-size boxes.

A Note about the Key Measurements Summary

The Key Measurements Summary shows a specific product's performance relative to other radios we've tested. It's important to remember that the comparison is to all radios, not just those in the same class as the one tested for this month's column. Numbers in the "red zone" for a given radio *do not* mean that performance is "bad" or "unacceptable." Radios can be expected to fall anywhere in the range, and more expensive radios often score better. See January 2006 QST, page 69, for more details.



Figure 1 — The IC-7000 display screen is small, but the incredible resolution and use of color make it easy to see and use.



Figure 2 — Here's the IC-7000 display with the RTTY decoder screen.



Figure 3 — The display showing the VHF FM repeater screen.

Pressing and holding MODE toggles between USB or LSB, CW or CW-R (reverse sideband), RTTY and RTTY-R, and AM, FM and WFM. Other buttons alongside the display are for preamplifier and fixed 12 dB attenuator, optional autotuner control, menu navigation, noise blanker, noise reduction, manual notch filter and automatic notch filter.

The '7000 retains the '706's M (menu), S (submenu) and G (graphic menu) labels to help you find things. The arrangement is a bit simpler than the IC-706, but there are still nine menus. The M1 to M3 menus control functions like filter selection, split operation and memories. Menus S1 to S3 include metering, scanning, memory settings and other secondary items. S1 and M3 functions change with mode. Graphic menus G1-3 are for the band scope, multifunction meter and SWR meter.

There's also an extensive SET MODE menu for adjusting 51 radio parameters. The

Table 1 ICOM IC-7000, serial number 0501552

Manufacturer's Specifications

Frequency coverage: Receive, 0.03-199, 400-470 MHz; transmit, 1.8-2, 3.5-4, 5.3305, 5.3465, 5.3665, 5.3715, 5.4035, 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, 144-148, 430-450 MHz.

Power requirement: Receive, 1.6 A (max audio); transmit, 22 A (max).

Modes of operation: SSB, CW, AM, FM, RTTY (AFSK, FSK), WFM (receive only).

Receiver

SSB/CW sensitivity, bandwidth not specified, 10 dB S/N: 1.8-30 MHz, 0.15 μ V; 50-54 MHz, 0.12 μ V; 144-148, 430-450 MHz, 0.11 μ V.

AM sensitivity, 10 dB S/N: 0.5-1.8 MHz, 13 μ V; 1.8-30 MHz, 2 μ V; 50-54, 144-148, 430-450 MHz, 1 μ V.

FM sensitivity, 12 dB SINAD: 28-30 MHz, 0.5 μ V; 50-54 MHz, 0.25 μ V; 144-148, 430-450 MHz, 0.18 μ V.

WFM sensitivity, 12 dB SINAD: 76-108 MHz, 10 μ V.

Blocking dynamic range: Not specified.

Two-tone, third-order IMD dynamic range: Not specified.

Third-order intercept: Not specified.

Second-order intercept: Not specified.
FM adjacent channel rejection: Not specified.

QS (quick set) menu is mode-sensitive. It includes things like mic gain on SSB, keyer speed on CW, and shift width on RTTY.

PRO-style DSP Features

If you've used any of ICOM's "PRO" radios, the IC-7000's DSP-based receiver

Measured in ARRL Lab

Receive, as specified (sensitivity degrades below 500 kHz); transmit, as specified.

Receive, 1.5 A; transmit, 19 A.
Tested at 13.8 V.

As specified.

Receiver Dynamic Testing

Noise Floor (MDS), 500 Hz filter:

	Preamp off	Preamp on
1.0 MHz	-123 dBm	-134 dBm
3.5 MHz	-128 dBm	-139 dBm
14 MHz	-128 dBm	-138 dBm
50 MHz	-135 dBm	-141 dBm
144 MHz	-133 dBm	-142 dBm
430 MHz	-131 dBm	-142 dBm

10 dB (S+N)/N, 1-kHz tone, 30% mod:

	Preamp off	Preamp on
1.0 MHz	4.1 μ V	1.0 μ V
3.8 MHz	2.4 μ V	0.61 μ V
50 MHz	1.0 μ V	0.48 μ V
144 MHz	1.4 μ V	0.45 μ V
430 MHz	1.6 μ V	0.5 μ V

For 12 dB SINAD:

	Preamp off	Preamp on
29 MHz	0.94 μ V	0.26 μ V
52 MHz	0.39 μ V	0.17 μ V
146 MHz	0.52 μ V	0.16 μ V
440 MHz	0.57 μ V	0.16 μ V

Blocking dynamic range, 500 Hz filter:

	20 kHz Preamp off/on	5 kHz/2 kHz Preamp off
3.5 MHz	111/109 dB	88/86 dB
14 MHz	112/109 dB	88/86 dB
50 MHz	112/107 dB	88/84 dB
144 MHz	113/109 dB	89/85 dB
430 MHz	112/103 dB	88/84 dB

Two-tone, third-order IMD dynamic range, 500 Hz filter:

	20 kHz Preamp off/on	5 kHz/2 kHz Preamp off
3.5 MHz	89/88 dB	78/60 dB
14 MHz	89/88 dB	79/63 dB
50 MHz	90/87 dB	77/62 dB
144 MHz	88/90 dB	78/63 dB
430 MHz	83/80 dB	73/63 dB

	20 kHz Preamp off/on	5/2 kHz Preamp off
3.5 MHz	+6.5/-8.0 dBm	-11/-31 dBm
14 MHz	+6.0/-6.5 dBm	-12/-27 dBm
50 MHz	0.0/-12 dBm	-16/-36 dBm
144 MHz	-2/-9 dBm	-16/-35 dBm
430 MHz	0/-13 dBm	-12/-33 dBm

Preamp off/on, +57/+57 dBm.

20 kHz offset, preamp on:

29 MHz, 78 dB; 52 MHz, 79 dB;
146 MHz, 75 dB; 440 MHz, 70 dB.

Manufacturer's Specifications

Receiver (continued)

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

S-meter sensitivity: Not specified.

Squelch sensitivity: SSB, 5.6 μ V;
FM, 0.3 μ V.

Receiver audio output: 2 W into 8 Ω at 10% THD.

IF/audio response: Not specified.

Spurious and image rejection: HF & 50 MHz,
(except IF/2 rejection on 50 MHz): 70 dB;
VHF & UHF, (except IF rejection): 65 dB.

Transmitter

Power output: HF & 50 MHz: SSB, CW, FM,
100 W (high), 2 W (low); AM, 40 W (high),
1 W (low); 144 MHz: SSB, CW, FM, 50 W
(high), 2 W (low); AM, 20 W (high), 2 W
(low); 430 MHz, SSB, CW, FM, 35 W (high),
2 W (low); AM, 14 W (high), 2 W (low).

Spurious and harmonic suppression: >50 dB
on HF, >60 dB on VHF & UHF.

SSB carrier suppression: >50 dB.

Undesired sideband suppression: >50 dB.

Third-order intermodulation distortion (IMD)
products: Not specified.

CW keyer speed range: Not specified.

CW keying characteristics: Not specified.

Transmit-receive turn-around time (PTT release
to 50% audio output): Not specified.

Receive-transmit turn-around time (tx delay):
Not specified.

Composite transmitted noise: Not specified.

Size (height, width, depth): 2.3 \times 6.6 \times 7.3 inches; weight, 5.1 pounds.

Third-order intercept points were determined using S5 reference.

*Measurement was noise-limited at the value indicated.

**Measured with 500 Hz filter. Varies with PITCH control setting.

Measured in ARRL Lab

Receiver Dynamic Testing

20 kHz offset, preamp on:
29 MHz, 78 dB; 52 MHz, 75 dB;
146 MHz, 75 dB*; 440 MHz, 70 dB*;
10 MHz offset: 52 MHz, 95 dB; 146 MHz,
84 dB; 440 MHz, 95 dB.

S9 signal at 14.2 MHz: preamp off, 120 μ V;
preamp on, 24 μ V; 50 MHz, preamp off,
50 μ V; preamp on, 15 μ V;
144 MHz, preamp off, 58 μ V;
preamp on, 13 μ V; 430 MHz, preamp off,
47 μ V; preamp on, 6.9 μ V.

At threshold, preamp on: SSB,
14 MHz, 1.4 μ V; FM, 29 MHz, 0.23 μ V;
52 MHz, 0.14 μ V; 146 MHz, 0.15 μ V;
430 MHz, 0.15 μ V.

2.1 W at 10% THD into 8 Ω .

Range at -6dB points, (bandwidth):

CW: 339-850 Hz (511 Hz);**

USB: 341-2475 Hz (2134 Hz);

LSB: 335-2450 Hz (2115 Hz);

AM: 207-3050 Hz (2843 Hz).

First IF rejection, 14 MHz, 114 dB;
50 MHz, 122 dB; 144 MHz, 29 dB;
430 MHz, 95 dB; image rejection,
14 MHz, 96 dB; 50 MHz, 103 dB;
144 MHz, 62 dB; 430 MHz, 110 dB.

Transmitter Dynamic Testing

HF: CW, SSB, FM, typically 110 W high,
<1 W low; AM, typ 39 W high, <1 W low;
50 MHz: CW, SSB, FM, typ 97 W high,
<1 W low; AM, typ 38 W high, <1 W low;
144 MHz: CW, SSB, FM, typ 49 W high,
<1 W low; AM, typ 19 W high, <1 W low;
430 MHz: CW, SSB, FM, typ 33 W high,
<1 W low; AM, typ 13 W high, <1 W low.

HF, 59 dB; VHF, 67 dB; UHF, 74 dB.
Meets FCC requirements.

68 dB.

70 dB.

3rd/5th/7th/9th order (worst case):

HF, 100 W, -33/-50/-57/-58 dB PEP;

VHF, 50 W, -35/-28/-32/-37 dB PEP;

UHF, 35 W, -22/-36/-54/-57 dB PEP.

6 to 60 WPM.

See Figures 4 and 5.

S9 signal, 24 ms.

SSB, 12 ms; FM, 11 ms. Unit is suitable
for use on ARQ modes.

See sidebar.

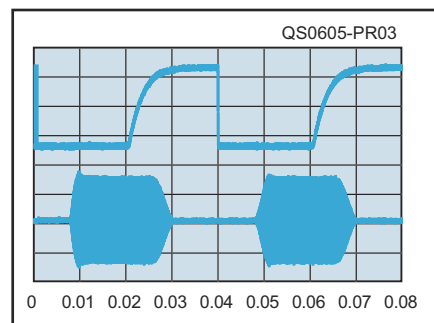


Figure 4 — CW keying waveform for the IC-7000 showing the first two dits in full-break-in (QSK) mode using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transceiver was being operated at 100 W output at 14.2 MHz.

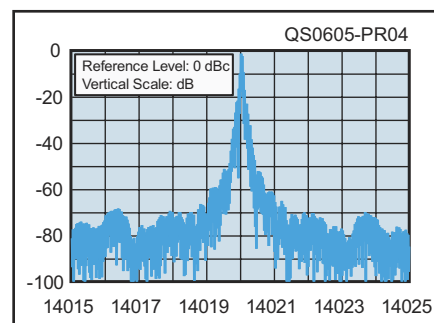


Figure 5 — Worst-case spectral display of the IC-7000 transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 100 W PEP output at 14.2 MHz.

depth at 40 dB for one tone or two.

What's different on the '7000 is a manual notch filter (MNF) with *two* adjustable notch points. We measured notch depth at 50 dB for one tone or two, and more than 70 dB with both manual notch filters working together. After some trial and error, I found that I could make signals pop out of the crud by setting points above and below the operating frequency.

The noise blanker is intended for automobile ignition noise and electrical line noise. Level and width are adjustable over a wide range, and I found it effective most of the time. As usual, there's a penalty in strong signal handling. Noise reduction (NR) lowers the background noise while letting signals through. At times I noticed some distortion with the NR engaged, but adjusting the level helps. We measured the noise reduction at typically 20 dB maximum, similar to most DSP radios we've tested.

SSB, CW, AM and RTTY all have three AGC settings (fast, medium, slow). You can set the time constants for each mode independently in 13 steps plus off. FM is fixed.

between "sharp" and "soft" filter shapes. I preferred the sound of the soft settings. They didn't sound as harsh and helped with ringing on CW at narrower bandwidths.

The concentric passband tuning (PBT) controls in the lower left corner let you narrow or shift the passband to help eliminate

interfering signals. When PBT is engaged, a little window pops up in the display to show you the settings as you adjust the controls.

The automatic notch filter (ANF) effectively zaps those annoying carriers, revealing desired signals underneath. It works on multiple tones and we measured the notch

Some Operating Impressions

Although I've used a number of ICOM radios, the IC-7000 is sufficiently different that for the first few hours of operation it seemed like I was always pressing the wrong buttons. Although the designers did a good job of grouping similar functions and maintaining a consistent way of doing things, it took practice to navigate the features like a pro.

CW Operation: Improved Keying

For CW operation the '7000 includes a 6-60 WPM keyer with four memories and contest serial numbers. Loading the memories is a bit tedious using the function keys and tuning dial, but once it's done, it's done. The manual shows how to make an external keypad with four push buttons to send the CW (or voice) memory keyer contents so that you can use the radio's screen for other functions. The keyer is easy enough to use, but it sure would be nice to have easier access to the SPEED control. It's a setting on the QS menu, and you have to press a few buttons to get to it.

CW keying was an issue with all of the IC-706s and to varying degrees with other ICOM radios. In semi-break-in mode on the '706, the first transmitted dit was noticeably shortened. In QSK mode, the keying sounded choppy, particularly above 30 WPM. The IC-756PROIII review reported that ICOM had finally licked this problem, and as shown in Figure 3, the IC-7000 works correctly as well. The only drawback to using QSK is the sound of the relay clicking, but it didn't bother me with headphones on.

Voice Operation: Can Sound Good, But...

For SSB operation I found the default mic gain settings to be on track but usually dialed the compressor back a few notches. The IC-7000 includes adjustable SSB transmit bandwidth (TBW), which we first saw on the IC-756PROIII. TBW allows you to adjust the SSB transmit filter bandwidth by attenuating frequencies on the high and low side. On the low side, choices are 100, 200, 300 and 500 Hz. On the high side, it's 2500, 2700, 2800 or 2900 Hz. You can store three combinations — wide, mid or narrow — for quick access from the M3 menu. Default settings are 100/2900, 300/2700 and 500/2500 Hz.

Two of the operators who borrowed the '7000 received poor audio reports on SSB. Others received favorable reports. After some experimentation, we found two issues. First — not surprisingly — the HM-151 hand mic is adequate, but if you're looking for hi-fi audio you'll want to consider a different microphone. According to ICOM, the HM-151 is tailored for mobile operation and is designed with restricted response to attenuate road and wind noise. We tried a Heil Handi Mic and Traveler headset, and they sounded good.

A more serious issue is proper adjustment

of the TBW settings. We found that the radio sounded fine with TBW at its widest setting, but most people said that the audio at mid and narrow sounded distorted and rough. Sort of like you're talking through a cardboard tube. It was difficult to listen to and not something you'd want to use on the air.

Adjustments on the high side make the audio sound restricted, as you would expect. On the low side, though, the 300 Hz and 500 Hz settings made the radio sound "broken." Even at 200 Hz you can hear something going on, especially with the compressor turned on. Note that the SSB transmit quality monitor does not provide a true representation of what the transmitted signal sounds like. If you want to hear what it really sounds like, you need to listen to yourself in a second receiver.

In the end, I just used the widest TBW settings and received good audio reports from everyone I asked. Nobody found the stock mic objectionable. With my voice, some listeners thought that the Heil mic sounded better, while others couldn't tell much difference. ICOM says that they have no plans to address the TBW issue and recommend using the widest settings. Although this will disappoint some users, my other transceivers have no TBW-type controls and I've never felt deprived.

On FM with the HM-151 mic, the radio sounded very much like other FM mobile radios with a hand mic. On AM, the modulation sounded a bit "light." You can make contacts with it, but consider something else if hi-fi AM is your main interest.

RTTY and Digital Modes

AFSK RTTY and sound card modes are straightforward once you're made the hardware connections. FSK RTTY requirements are a little more complicated, but the IC-7000 is ready. MARK frequency, shift width and keying polarity are menu-adjustable. With the IF filter flexibility you can dial in the optimum bandwidth, often something other than the usual fixed voice and CW options. RTTY operators have the option of using a special twin peak filter (TPF) that boosts the MARK and SPACE frequencies.

Like the '756PROIII, the IC-7000 has a built-in RTTY decoder. Press DECode and everything below the frequency display changes into a miniature RTTY screen. The text display on the left has room for six lines of text about 15 characters each. On the right is a compact tuning display complete with a waterfall, mark/space indicator bars and tuning arrows. It's quite easy to use. You'll still need an external RTTY unit of some kind to transmit.

Steve Ford, WB8IMY, used the '7000 in the CQ WPX RTTY contest. As he operated, he compared the internal decoder to the popular *MMTTY* sound card RTTY soft-

ware. Although the internal decoder at times couldn't keep up with *MMTTY*, it did just fine with signals in the clear. Steve praised the twin peak filter, noting that it does wonders for copying signals in heavy QRM.

The radio offers 1200 and 9600 baud packet operation, but we didn't try those modes.

Other Features

With PBT off, the concentric knobs in the lower left corner are used for memory channel selection (inner knob) and for RIT/ Δ TX (outer knob). RIT range is ± 9.99 kHz in 10 Hz steps. I didn't really care for the RIT implementation for two reasons. First, you have to crank and crank on the little clicky knob to tune in stations that are a few hundred Hz off frequency. The tuning rate could be faster, or the range narrower, or something. Second, for CW and SSB operation the RIT would be more convenient on the inner knob — it sticks out farther and is easier to grab. Maybe someday you'll be able to assign different functions to the knob.

There are 495 memory channels in 5 banks of 99 channels, 3 pairs of scan edge memories and 2 meter/70 cm call channels. Each memory stores frequency, mode and filter selections. VHF memory features are described below. Memory contents are easy to review via a menu screen and you can add an alphanumeric label. Scanning options include frequencies between selected scan edges, all memories or selected memories.

The "simple band scope" is an improvement over the one found in the IC-706 series, primarily because of the color display. The IC-7000's band scope is like a miniature version of the one on the '756PROIII. It offers fast and slow sweep speeds with steps from ± 10 to ± 250 kHz. In the fast "one sweep" mode, I expected the band scope to take a single fast sweep and stop, but it went right back to continuous slow-speed sweeping after the fast sweep. I would have liked it better with a setting to take a sweep and pause without having to press HLD (hold) each time I wanted a snapshot.

As noted in the manual, the receiver and band scope sweep functions use the same receive circuit, and "the switching sound may be irritating to listen to." Refreshingly frank, eh? A menu choice attenuates or mutes the audio during fast sweeping so you don't have to listen to it. I used the band scope during the ARRL DX Contest. It helped to locate the pileups when the band was opening and closing.

The IC-7000's built-in digital recorder is similar to the one in the '756PROIII but is *much* more capable on receive. The recorder in the 'PROIII stores four receive channels of up to 15 seconds each. In the '7000, you can record and store up to 25 *minutes* of whatever interesting signals you hear on the air. There

are 99 different memories, with a maximum of 120 seconds per memory. It's very easy to use — just press and hold the front panel ANF/REC button and it will start recording in the next available memory. The MIC MEMO feature allows you to include comments with the recorded audio by speaking into the microphone. There's a menu screen that allows you to scroll through and play back or clear the recorded memories. Each one is labeled with the date, time, frequency, mode and recording length.

For transmit the IC-7000 voice keyer has four message memories that store up to 90 seconds total, very attractive for storing CQ messages for DXpedition or Field Day use. Again, the menu makes it easy to program and label the memories, and you can adjust the recording level and play them back until you're happy with the result.

In addition to the usual SWR meter, the IC-7000 can generate a bar graph showing your antenna SWR over a selectable range of frequencies. The bars turn from green to red whenever the SWR is above 1.5:1. The IC-706MkIIIG had a similar feature, but once again the '7000's color display brings it to a new level. Although I couldn't find it specified in the manual, the SWR meter and graphing function appear to work only on 160 through 6 meters (ANT1).

VHF/UHF

Strip away the IC-7000's HF features, and you have a multimode VHF/UHF transceiver. Standard repeater offsets can be programmed for each band via one of the menus, and you can dial in nonstandard splits using the two VFOs. You can set the shift direction manually or let the radio do it automatically according to frequency range. Transmit and receive frequencies are both displayed.

The '7000 includes CTCSS encoding and decoding, as well as digital tone coded squelch. Although the HM-151 keypad doesn't support DTMF dialing, you can program and store up DTMF strings (up to 24 characters) in four memories.

Note that the IC-7000 receives on one band at a time. There is no sub receiver for satellite operation or monitoring your local repeater while you're talking on HF. You can set the VFOs to transmit on one band and receive on another, though.

Of course you can store your favorite repeaters in memory, including standard or nonstandard offset and tone settings. Unlike some VHF/UHF FM radios, you can't program the memories via computer software. They need to be entered manually. It's not complicated, just tedious if you have a lot.

The receiver covers up to 200 MHz, and thus you can listen to weather channels, the FM broadcast band, AM aircraft frequencies, some TV audio and VHF public service

If You Could Only Have One Radio...

My first impression of the IC-7000 is that it answers the question "if you could only have one radio, what would it be?" The answer could be this radio.

To see if my first impressions were lasting ones, I took it home for a weekend to try it out. The first thing that struck me is its size. It was no bigger than my 2 meter mobile transceiver and yet it runs a full 100 W on HF. It fits comfortably in my Samsonite attaché case

The most striking feature of this radio is the high resolution color display. The display is, simply, stunning. The twenty something year olds in the household were very taken with the IC-7000's looks. They never paid much attention to my "standard" size transceiver, but the razor sharp color display on IC-7000 caught their eye. They're used to cell phones and iPods, so, to them, it looked like a modern consumer electronic device. The display, while small, is perfectly readable in all light levels. I could read it easily without having to lift my head to use the close-up lenses in my bifocals.

I must be the exception to the rule, but, before I turn on a new radio, I read the manual. A tradeoff of a software-controlled radio is that you can control nearly every function you can imagine, but you have to *find* the function first on a menu. The IC-7000's menu tree is complex because the radio has many functions but only a few buttons and knobs on the front panel. There are two or more ways to control some functions, so it was confusing to determine the best method. A suggestion for ICOM: Include an index in the back of the manual.

The knobs themselves are fine and I especially liked the feel of the large tuning knob with its indented "dimple." Ergonomically and visually, the radio controls felt right.

I connected the '7000 to my G5RV, anxious to see what my friends on a Sunday morning 40 meter sked thought of the audio quality. My friends know what I sound like and said that, compared to my normal audio, my voice was "hollow" and "lacked bass." I consulted the manual and adjusted the audio bandwidth and compression to different settings, but the reports were still not very complimentary. My friends commented that while it lacked bass, the signal had a lot of "punch." I would guess that these conditions are a function of the digital audio processing and compression parameters.

I also tried the IC-7000 on 20 meter CW with its internal keyer and full CW break-in capability. You need to go three menus deep to adjust keying speed, not the easiest arrangement for quickly changing speeds unless you left this menu on the display while operating. I could not find any way to lock the radio in transmit to manually adjust my antenna tuner using both hands.

With the keying functions set to my liking, the radio performed flawlessly. I worked a number of a number of stations and received excellent signal reports. I tried working a DX station operating split, but it took me some time to figure out how. The manual suggested three different ways to do it! Once you master it, it is easy to do.

I enjoyed using the IC-7000 and that display really grows on you. There are so many capabilities that it will take a while to feel totally comfortable with it, but it's worth the effort. — *Harold Kramer, WJ1B, ARRL Chief Operating Officer*

channels. The receiver is quite sensitive in this range and provides some enjoyable listening when the HF bands are dead.

Small Radio, Big Manual

At 156 numbered pages, the IC-7000's manual is twice as thick as the IC-706MkIIIG's. I found the manual to be easy on the eyes, well written and well illustrated, no small trick with a radio that covers this much ground. I noticed a couple of minor errors, but nothing that prevented me from using the radio.

The format is generally consistent, with major sections for installation and receiving and transmitting on the various modes. A

number of tables detail the various menu settings. I downloaded the PDF version from ICOM's Web site and used Adobe *Acrobat's* search feature when I couldn't find what I was looking for in the printed book. An added bonus: The PDF version has color illustrations.

Lab Testing

Lab tests showed the IC-7000 to be more like the IC-706 than the IC-756PROIII. It's a competent performer, but ICOM didn't endow this do-everything radio with the competition-focused 'PROIII's receiver performance.

The IC-7000's synthesizer is a significant

improvement over the IC-706 and other small radios we've tested. The results can be seen in the transmitted composite noise testing and in the absence of "noise limited" receiver dynamic range measurements. See the accompanying sidebar, "Improved ARRL Lab Transmitter Noise Testing."

Compared to the '706MkIIIG, the '7000's sensitivity is a bit lower across the board, most noticeably on HF with the preamp off.

That's not a bad thing, as you don't always need the sensitivity on HF and you can always engage the preamp with a touch of a button. With the preamp on, the '7000's receiver sensitivity comes in around -140 dBm, typical of today's radios.

At 20 kHz spacing, with the preamp off, the blocking dynamic range is about 10 dB lower than the '706MkIIIG on HF, slightly lower on 6 meters, and slightly higher on

2 meters and 70 cm. The G's blocking measurements were mostly noise limited, but this wasn't the case with the '7000 and its cleaner synthesizer.

The IC-7000's IMD dynamic range at 20 kHz spacing is virtually identical to the '706MkIIIG, and third order intercept (IP3) numbers are better. With the preamp off, IP3 is a positive number on 80 and 20 meters, always a good sign. To keep things in

Improved ARRL Lab Transmitter Noise Testing

Product Review testing in the ARRL Laboratory has improved and expanded dramatically over the years, but especially so in the last decade. In March *QST* we introduced new close-in receiver dynamic range measurements and a new plot that displays transmitted CW keying sidebands.² We now introduce one of the most significant changes yet — a greatly improved transmitter sideband noise test.

Phase noise is the undesired, yet unavoidable, sideband noise produced by all oscillators. An excellent description of it can be found in the Oscillators and Synthesizers chapter of *The ARRL Handbook*.³ *Transmitted composite noise* is largely oscillator phase noise, but it also includes amplitude noise from later transmitter stages. Transmitted composite noise increases the background noise level received by nearby stations on the band while you are transmitting. It generally sounds like "white noise" rather than the discrete signals associated with interference from key clicks or transmitter IMD.

In receivers, oscillator phase noise effectively limits the useable dynamic range, as indicated by "noise-limited results" in ARRL Lab test data.

Since 1988, ARRL Product Reviews of SSB/CW transceivers have included a spectral plot showing transmitted composite noise over a range of frequencies. Beginning this month, the ARRL Lab has changed and improved the transmitter composite noise test procedure. The improvement was made possible by the donation of a Hewlett-Packard model 3048 Phase Noise Test System by Dr Ulrich L. Rohde, N1UL.

The new system provides accurate results over a wider range of frequency offsets than the ARRL

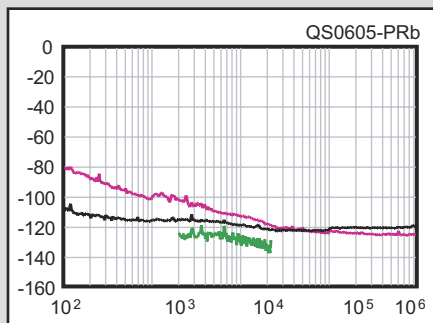


Figure 6 — Spectral display of the IC-7000 transmitter output during composite-noise testing at 14 MHz. The vertical scale is in dBc/Hz. The black trace shows HF composite transmitted noise 100 Hz to 1 MHz from the carrier as measured with the new HP model 3048 Phase Noise Test System. The red trace shows the worst case at VHF/UHF, measured at 430 MHz. For comparison, the green trace shows the HF composite transmitted noise at 14 MHz measured using the old test technique. The span is 2 to 22 kHz from the carrier.



Dr Ulrich Rohde, N1UL (left) and ARRL Test Engineer Michael Tracy, KC1SX, at N1UL's lab at Synergy Microwave. Dr Rohde donated the HP test equipment used for the ARRL Lab's new composite noise tests.

Lab's original setup, developed in 1987 using HP application notes.⁴ The original setup allowed measurement of transmitted noise at frequencies from 2 to 22 kHz away from the carrier. The HP 3048 Phase Noise Test System measures noise at frequency offsets from as low as 1 Hz to as high as 10s of MHz. We've selected the range from 100 Hz to 1 MHz for publication in this and future *QST* Product Reviews. Because of the greatly extended frequency range, the new data are displayed on a logarithmic scale instead of the linear scale formerly used. Figure 6 shows the IC-7000 tested using both the old and new test procedures.

All of the equipment in the new system can also be professionally calibrated. That means that the uncertainty of its test results is traceable to national standards. The prior composite-noise measurement method and the methods used by the new professional phase-noise measurement system are inherently different. Previous measurements of composite noise in the ARRL lab require an upward adjustment of 7.5 dB to account for opposite sideband noise in the measurement apparatus, an improved averaging technique, and correction for impedance differences. An update to our *Test Procedures Manual* (www.arrl.org/members-only/prodrev/test-proc.pdf) will be forthcoming.

— Michael Tracy, KC1SX, ARRL Test Engineer

²M. Tracy, "ARRL Lab Data Presentation Changes," *QST*, Mar 2006, p 64.

³R.D. Straw, Ed., *The 2006 ARRL Handbook for Radio Communications* (Newington: 2005), pp 10.5-10.12.

⁴A discussion of the ARRL Lab's original transmitter composite noise test setup can be found on pages 10.10-10.11 of *The 2006 ARRL Handbook*.

perspective, though, the numbers at 20 kHz spacing are all significantly lower than the 'PROIII. At 5 kHz spacing, which is more indicative of real-world conditions, the IC-7000 and '756PROIII are a lot closer. It's important to compare performance numbers to those of other radios in the same category when making purchase decisions.

On FM, the '7000 turned in adjacent channel rejection and dynamic range numbers that were in most cases better than the

'706MkIIG. Notable exceptions are image rejection and IF rejection on 2 meters, both degraded from the performance of the '706MkIIG. The measurements compare favorably with some of the better FM-only dual-banders we've tested. FM sensitivity is right up there, too.

Transmitter IMD performance on HF and 6 meters is noticeably improved over the IC-706. In particular, the higher order products (the ones that cause splatter on nearby

frequencies) are about 15 dB better. On 2 meters, though, the higher order products were out of line with the other bands — not even 40 dB down and 10-20 dB worse than the '706MkIIG. ICOM says that our IC-7000 is not typical in this regard and in fact the 2 meter IMD performance was much better on a second radio we tested.

About that 8 kHz Tone

Not long after the IC-7000 hit the streets, some users reported hearing a low-level 8 kHz tone in the receive audio. We were able to clearly see the tone with a spectrum analyzer. ARRL Test Engineer Michael Tracy, KC1SX, was able to hear the tone with a good pair of hi-fi headphones, but not in the speaker audio.

I couldn't hear the tone under any circumstances, but I know that my high frequency hearing is poor. My wife Jean, N1OJS, has excellent hearing. She's often annoyed by high frequency buzzes and whines that I'm oblivious to. When I asked her to listen to the '7000, with hi-fi headphones she could hear the 8 kHz tone on a quiet band but pronounced it "ever so faint." She could not hear it with the communications quality headphones in the Heil Traveler headset.

If our experience is typical, users will have widely varying opinions about the importance of this 8 kHz tone. Most people won't notice, but it will be annoying to those blessed with exceptional hearing, particularly if they use hi-fi headphones. According to ICOM they are working on this issue.

Wrapping it Up

ICOM's latest compact radio extends the winning streak started with the IC-706 series 10 years ago. Equally at home in your car, base station or vacation spot, it has a boatload of features and competent basic radio performance. Although there are a few rough edges, none are show-stoppers for most operators. ICOM got most everything right with this radio, and it offers a lot of enjoyment in one compact package.

On a few occasions, I've referred to the IC-7000 as a "do everything and do it reasonably well" transceiver. If your focus is HF home station operation and you have the table space, check out the '746 or '756 series radios. For top-tier HF contest operation, particularly with big antennas, the '756 or '7800 offer better radio performance at a higher price. If you just operate VHF/UHF or satellites, there are better choices.

But if, like a lot of hams, you like to do a bit of all of the above, and particularly if you sometimes take your radio with you, the IC-7000 is worth a very close look.

Manufacturer: ICOM America, 2380 116th Ave NE, Bellevue, WA 98004; tel 425-454-8155, fax 425-454-1509; www.icomamerica.com. Price: \$1499.

DXpeditioning with the IC-7000

For several years I've been fortunate to visit Bermuda for the ARRL International DX Contest at the station of Ed Kelly, VP9GE. This year I brought along my new IC-7000 to hook up to a tribander and some simple wire antennas. I operated the IC-7000 for about 40 hours each mode and made 3500 contacts on CW and nearly 4000 on phone as VP9/W6PH.

I used the radio with CT contest software and an interface cable from K1NU to go between the radio and my laptop. It interfaced well. I found the on-board CW memory keyer a little cumbersome to program and use, so I used the one in CT. A Heil Traveler headset rounded out the setup.

The feature that most "grabbed" me was the on-board four channel voice keyer. For a DXpedition, this eliminates a peripheral I have brought along in the past. An Altoids tin is a nice size for building the outboard pushbutton interface shown in the manual to send the voice/CW keyer message memories. I used the voice keyer in the SSB contest. It is relatively simple to change the voice messages. For example, I reprogrammed a message when changing listening frequencies on 40 meters. On-air testing showed there was little or no difference between recorded and live voices.

During the CW contest I used the NR at all times with the default setting. There was a hint of DSP sound, but the reduction in noise level made it possible to copy call signs the first time. I would have needed to ask for fills without the NR. On phone I found that the NR distorted the audio, so I didn't use it.

Most of the time I used the default 500 Hz CW and 2.4 kHz phone filter settings. I tried both sharp and soft shape and didn't find any useful difference. When the CW QRM was lower, I opened to the 1.2 kHz filter. I found the 250 Hz CW filter setting too sharp for contesting. A couple of times on CW I used the MNF when someone opened up just below me. It does a good job. On phone, though, I tried adjusting it to eliminate some of the "growl" from a station a kHz below my frequency but couldn't get it to do what I wanted.

The RIT knob is tiny. It isn't really useful for tuning back and forth across the frequency to find callers. It would be nice if there were a way to make the "big knob" act as an RIT control. As a workaround, I used split VFO operation so that I could easily tune around the pileup of stations calling in.

I ran 100 W at all times. The set never got hot, even after hours of contest operating. I put my hand on the cabinet and on the heat sink fins many times and I would describe it as lukewarm.

Reports from distant stations showed no difference to speak of between the Traveler and the stock mic. Audio level was comparable, as well as intelligibility. Before the phone contest, I asked a few people to listen to the audio with the IC-7000 and Traveler headset. I ended up setting the TBW for 200 Hz on the low end and the compressor on because they thought it had more punch. During the contest I got a few reports of audio deficiencies, likely from the 200 Hz TBW setting. Based on my experience, I would call the audio "communications quality" but not "broadcast quality."

Coming from an IC-706 helps the learning curve. I call the IC-7000 an "IC-706PRO," but that term really diminishes its features. The enhanced features are proportional to the difference in the manual size. I have to also say that this is first time in my experience that the weight of the manual approaches the weight of the rig!

I would rate the receiver as excellent. Doing A/B testing next to my old TS-930S showed a significant difference in sensitivity. This IC-7000 could become my new home station radio! — *Kurt Pauer, W6PH*

Heil Sound Traveler Dual Side Headset

Reviewed by Mark Wilson, KIRO
QST Product Review Editor

We bought the Heil Traveler Dual Side headset to use with the IC-7000 reviewed in this issue, and it worked so well that we thought it was worth its own short review. The “Dual Side” moniker distinguishes this product from the Traveler Single Side headset, which has one headphone. Both are an improvement over the Heil HS-706 described in a Short Take in June 2001 *QST*.

I’ve been a fan of Bob Heil’s headsets since the original BM-10, a lightweight unit that traveled well and sounded good on transmit and receive. But the BM-10 had a lot of loose wire to tangle and sometimes tended to fly apart if you made the wrong adjustment. Over the years, newer models have offered improved construction, comfort and features to go along with the great sound.

Solid and Comfortable Construction

The Traveler’s construction reminds me very much of my old but faithful Heil ProSet, except it’s smaller and several ounces lighter. The headphones attach to an adjustable padded headband. The phones pivot slightly to conform to various head sizes and shapes. Unlike the ProSets, the headphones don’t cover your ears and clamp tightly to your head. Sturdy black cloth covers the headphone pads, rather than the smooth vinyl that I’m used to. They’re very comfortable, even after extended operating sessions, despite direct contact with the ears. The padded flex-steel headband can be bent to allow adjustment to fit wide or narrow heads or to change the pressure. The headphones sounded great during CW and SSB operation. You can crank the volume right up and they don’t sound distorted.

The Traveler’s microphone is covered with a foam windscreen and, like the ProSet, is mounted on a flexible stalk. You can bend it any which way and it holds position. If you’re not using the mic at the moment, you can swivel it up out of your way. All Travelers come with Heil’s full-range electret condenser mic element. The HC-4 and HC-5 dynamic elements available in other Heil products are not offered here.

Heil’s Web site offers suggestions on radio settings for getting the best performance from a particular radio/mic combination. On-air comparisons between the Traveler and the IC-7000’s stock mobile mic were interesting. Everyone thought that the Heil mic sounded good, but some listeners couldn’t tell much difference from the stock mic. Others thought that the Traveler sounded a bit cleaner and fuller.



Have More than One Radio?

Unlike the HS-706, which had a fixed modular plug and was designed specifically to work with ICOM’s IC-706, the Traveler headset cable terminates in an 8-pin round plug and works with a variety of radio-specific adapters. We ordered our Traveler with the HSTA 706, a 36 inch cable that mates with the Traveler’s 8-pin plug and terminates with a modular mic plug and 1/8 inch headphone plug. It’s compatible with the IC-706 series and ’703 as well as the IC-7000. Heil’s Web site lists 10 different Traveler adapters for a wide variety of popular mobile and base transceivers and handhelds. There are even adapters for use with cell phones and PC sound cards. Changing radios is as easy as changing adapters.

A “3-way inline pendant” in the headset cable has a red PTT button and \pm buttons for tuning the radio’s frequency up and down. These features worked with the IC-7000 but Heil’s literature warns that they don’t work with all radios. The pendant has a clip on the back, which proved to be a nice touch. The headset’s light weight and on-ear construction meant that at times the cable pulled the headset out of position when I moved my head or body (the tail wagging the dog...).

Bottom Line

Heil’s Traveler Dual Side is sturdy and sounds great. It’s the perfect accessory for your take-along station.

Clipping the PTT switch to something helps minimize that.

The on-ear headphones don’t seal out external sounds, so you can keep track of what’s going on around you. As mentioned in the manual, though, headset operation (dual or single) while driving may not be legal in some jurisdictions. Even if it is legal in your area, wearing headphones is sure to concern other drivers in these days of heightened awareness of distracted driving. The manual suggests putting the Traveler around your neck and using the headphones more as speakers. The set is flexible enough to do this.

Heil’s Traveler Dual Side is a useful and well thought out accessory for any radio, but it’s particularly well suited for use away from your home station. It’s the right size for your briefcase station but doesn’t give up much comfort and performance compared to the bigger headsets.

Manufacturer: Heil Sound Ltd, 5800 North Illinois, Fairview Heights, IL 62208; tel 618-257-3000; www.heilsound.com. Price: Traveler Dual Side, \$91; Traveler Single Side, \$71; HSTA/HTA series adapters, \$23 each.

Going Once, Going Twice...

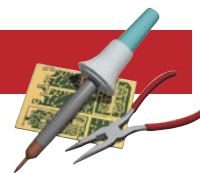
In order to present the most objective reviews, ARRL purchases equipment off the shelf from dealers. ARRL receives no remuneration from anyone involved with the sale or manufacture of items presented in the Product Review, Short Takes or New Products columns—*Ed*.

The ARRL-purchased equipment listed below is for sale to the highest bidder. Prices quoted on the Web page are the minimum acceptable bids, and are discounted from the purchase prices. All equipment is sold without warranty except as noted.

Details of equipment offered and bidding instructions can be found on the ARRL members’ Web page at www.arrl.org/prauction. The following items are available for bid in the May auction:

- Yaesu FTDX-9000D HF and 6 meter transceiver.
- ProSistel PST-641D antenna rotator and digital controller.
- LDG TW-1 “talking” wattmeter.
- LDG Z-100 automatic antenna tuner.
- Yaesu VX-120 2 meter handheld transceiver.
- Kenwood TM-V708A VHF/UHF mobile FM transceiver.
- Black & Decker Storm Station dc power system.

QST



MFJ Model 4116 Bias Tee Power Injector

Any product that promises to make my life easier grabs my instant attention. The new MFJ Bias Tee Power Injector claims to be one such product.

There is nothing revolutionary about the Bias Tee. Variants on this power injector concept (sometimes called a “dc power inserter”) have been around for decades. Author Phil Salas, AD5X, showcased his approach in the July 2004 *QST*.

The idea is simple. If you’re using coaxial cable to transport RF to and from your antenna, why not use it as a conduit for dc power at the same time? Think of the convenience. A single run of coax could make the RF connection to your antenna *and* supply dc power to run receive preamplifiers, remote automatic antenna tuners or other devices. There would be no need to string a separate set of wires.

The trick is to couple the dc voltage to the coax at the station and pick it off again at the antenna (or other location)—all without disturbing the RF path. The usual approach is to use a combination of radio-frequency chokes and high-voltage ceramic capacitors. The capacitors create a low-impedance path for RF, allowing it to flow through the bias tee as if the tee wasn’t even there. These same capacitors act as open circuits to dc, preventing it from going anywhere it shouldn’t.

For their part, the RF chokes couple dc power to the coax because a choke “looks” like nothing more than a piece of wire as far as dc is concerned. To RF, however, the choke looks like a brick wall, effectively blocking RF from getting onto the dc lines.

The MFJ Approach

So what makes the MFJ Bias Tee Power Injector different? The first part of the answer is that it is commercially available for Amateur Radio use. It is a bias tee you can buy off the shelf at an affordable price, ready to go. The second part is that the MFJ Bias Tee is designed for remarkably low insertion loss over a broad frequency range.

The MFJ Bias Tee is rated for use from 1 to 60 MHz. In the ARRL Lab, we discovered that the Bias Tee showed virtually no insertion loss up to 224 MHz. Even at that frequency, the



loss was a miniscule 0.03 dB. Below 224 MHz, the loss was so low it was essentially unmeasurable by the Lab equipment.

The MFJ Bias Tee is also rated to pass up to 50 V dc at 1 A. In my own tests, I pulled up to 3 A at 13.8 V with no ill effects. In terms of RF power, the Bias Tee is rated at 200 W.

Bias Tees in the Real World

You may need to purchase *two* Bias Tee Power Injectors for most applications. You need one unit to inject the dc power and another to “receive” it at the other end. I had a specific application for a pair of the

Bias Tees and I was eager to put them to use.

I use a vertical antenna for 20 through 6 meter operating and an inverted V dipole antenna for 40

meters. Until recently, I had a two-conductor wire running alongside my coaxial cable to the base of the vertical where I had installed a 12 V dc antenna relay. By applying dc in the shack, I could switch between the two antennas. This setup worked well — until I needed to reroute my cables to accommodate new siding for the house.

Re-stringing the coax was work enough, but I had to replace the relay wires as well. Or did I?

The MFJ Bias Tee Power Injector offered an elegant solution. I installed one Tee at the transceiver, connecting it to my dc power supply through a toggle switch. The second Tee found its resting place 60 feet away at the vertical antenna, where the

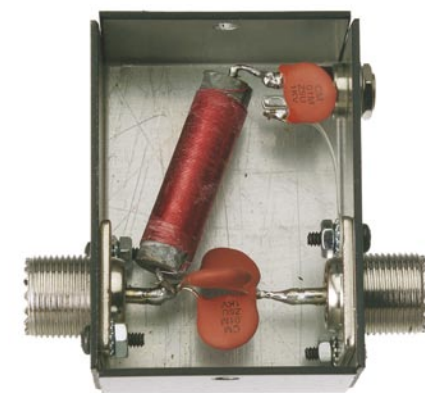
Tee’s dc jack was wired to the antenna-switching relay coil.

The Bias Tees worked perfectly. When I applied dc power in the shack, it flowed through the coax and closed the relay like magic. (Electronics are magic after all, aren’t they?) If I could improve the MFJ Bias Tee, I would make it weatherproof. The current model isn’t watertight, so you have to protect the Tee if you install it outdoors.

Bottom line? A single cable for dc and RF *does* make life easier!

Manufacturer: MFJ Enterprises, PO Box 494, Mississippi State, MS 39762; tel 800-647-1800; www.mfjenterprises.com. \$24.95.

QST



An interior view of the MFJ Model 4116 Bias Tee Power Injector.