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ICOM IC-746 MF/HF/VHF Transceiver

Ten-Tec T-Kit Model 1340 Transceiver Kit

Product Review

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ICOM IC-746 MF/HF/VHF Transceiver

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The ICOM IC-781 has had a lot of staying power and remains the flagship of ICOM's HF fleet. Is there a ham out there who has looked at an ICOM IC-781 and not dreamed of owning one? Apparently not, given ICOM's latest family of radios. This time, we consider the IC-746—which ICOM has cleverly positioned between the IC-706MkII and the IC-756. Don't be misled by its compact size. This radio has enough bells and whistles to satisfy most operators.

Advances in technology over the decade since the IC-781's introduction have yielded unique capabilities and features with each successive radio. While the '781 still reigns supreme as ICOM's top performing HF transceiver, its latest incarnations present more economically motivated ICOM buyers with some hard choices. The IC-746 gives you 100 W out on SSB, CW, FM and RTTY (40 W on AM) on HF, plus general coverage receive starting at 300 kHz. But it doesn't stop there. General coverage receive extends all the way to 60 MHz, plus 108 to 174 MHz, *and* the radio offers 100 W on both 6 and 2 meters! The addition of all-mode 2-meter capability is something the IC-756 doesn't even have.

Let's see how the whole package stacks up.

Feature Highlights

For a mid-priced radio, the IC-746 has a great deal to offer—quite a bit more than the '706MkII, of course, but also including features found on the '756 too, like DSP and a built-in automatic antenna tuner for HF and 6.

The generous display window—characteristic of this '781 descendent—takes up nearly a quarter of the front-panel space. This results in large numbers, easy-to-read meter scales, and a clear view of active functions (such as operating mode, antenna 1 or antenna 2 connector in use, VOX, preamp, AGC setting and active DSP modes). The display is striking. (Some users liked it better than the IC-756 display.) The screen background, similar to that on the IC-756, is a light blue. Text, numerals, and graphics appear in dark blue and both the display contrast and the intensity of the backlighting are menu adjustable. At first glance, the IC-746 is almost a dead ringer for the IC-756. But when the ICOM Funmobile stopped by HQ back in June, we got a chance to see both radios side by side. The most noticeable difference is the separate analog meter on the '756. The '746 metering is all on the LCD display. One scale shows signal strength or power output, and two additional meter sections indicate ALC and SWR levels.

The "band scope"—a popular feature on the IC-781—helps you quickly spot band activity. A wide variety of filter options allows you to tailor the receiver's characteristics to your preferred modes. Other features include a CW keyer with four message memories, twin passband tuning, true FSK RTTY capability, dual selectable HF/6-meter antenna ports (there's a separate dedicated antenna connector for 2 meters), speech compression, adjustable transmit tone, and a transmit audio monitor just to name a few.

The large main tuning dial has a very nice rubber grip, and the finger dimple for quickly spinning up and down the band is great. In addition, a feature ICOM calls "SmarTune" automatically increases the tuning rate as you spin the knob faster for even more rapid frequency excursions. A small screw on the front panel allows adjustment of the "tuning dial brake." Beyond these, you'll notice a few knobs and lots of buttons. Operation of the frequency keypad is obvious. Hit a button with the band frequency you want, and you'll jump right there. There are three "band-stacking registers, so you can recall three previously used frequency/mode settings in each band with successive presses of that band's button. This is perfect for keeping a favorite CW, RTTY and SSB frequency set for each band. Start with the **F-INP** button, though, and the keys become number buttons for direct frequency entry.

This radio is pretty easy to figure out. Select a mode, switch between VFO A and VFO B or between the VFO and the memory channels, set split operation, turn on the RIT or transmit offset feature and clear the selected offset—everyone was up and running with the '746 while the manual remained in its plastic wrapper. The **ANT** button lets you select between the two HF/6-meter antenna connectors and the **TUNER** button activates either the built-in automatic antenna tuner or an optional random wire external tuner. There are also buttons to read and write the five (or 10, your choice) scratch-pad memories (more on these later) and the 99 regular memory channels, two programmed-scan-limit channels, and the priority call channel.

The **M-CH** (memory channel) and **RIT/ΔTX** knobs are individual single-function controls. The **AF** (audio gain) and **RF/SQL** (RF gain and squelch) control is a dual, concentric control. The audio gain is the

BOTTOM LINE

An impressive transceiver for HF, 50 MHz and 144 MHz work. With loads of those features considered most desirable to the serious HF operator *and* all modes at 100 W on both 6 and 2 meters, the IC-746 is a fine choice in a mid-priced rig.

center knob. In the factory default setting, the outer ring provides increasing RF gain through about the first 170° of rotation. The remaining 180° of rotation increases the squelch setting. A menu setting allows you to change this control to behave as either an RF gain control or a squelch control through its entire range.

The concentric **TWIN PBT** (twin passband tuning) controls allow you to electronically vary the IF passband to reduce interference from adjacent frequencies. A graphic representation in the lower right of the display window shows the relative width and position of the passband with respect to your desired signal.

Another dual control is the **NR** (DSP noise reduction) and **APF** (audio peak filter) control. The **NR** knob controls the amount of noise reduction that is applied when the DSP is activated with the **NR** button. **APF** only works in the CW mode. It provides an additional interference-fighting tool. With this control (the outer ring of this concentric pair) you can adjust the audio frequency response to boost a particular frequency, between about 300 Hz to 900 Hz. What isn't so obvious (we had to go to the manual for this one) is that if you hold the **APF/ANF** button in for two seconds, you can change the boost-frequency bandwidth from 320 Hz to 160 Hz to 80 Hz. Talk about being able to pick a single signal out of a crowded band!

There is an additional row of small knobs and buttons along the bottom of the front panel. Unfortunately, you may have to crouch down in front of your operating table to read the labels under those controls. Fortunately, these are not ones that you'll have to adjust very often, once they are set to your operating preferences.

This row includes the **MIC GAIN**, **RF PWR**, **CW PITCH** and **KEY SPEED** controls. To the right of these four knobs are six buttons. The **P.AMP/ATT** button activates either of two preamplifiers or an attenuator. Preamp 1 is a 10-dB amplifier for 1.8 through 54 MHz. Preamp 2 is a 16-dB amplifier for 21 through 60 MHz. These preamplifiers, though optimized for specific frequency ranges, can be engaged outside of their intended ranges and did seem to add some usable gain over the entire range. The data in Table 1 in some cases represent measurements taken *outside* the preamp's intended range. On 2 meters, the **P.AMP/ATT** button activates a single-stage VHF preamp for 108 to 174 MHz. If you push and hold it for two seconds, it enables a 20 dB attenuator for all frequencies.

There is also a button here to control VOX and CW break-in operation. When using voice modes, pressing this button activates and deactivates the VOX. Hold it in for two seconds and a VOX menu pops up, allowing you to adjust the VOX gain, delay, and anti-VOX. When in the CW mode, this same button allows you to select between full and semi-break-in, and there's a similar pop-up menu for adjusting break-in delay. The next two buttons are on/off controls for the noise blanker and the transmit audio monitor.

If you have the optional speech synthesizer installed, pressing a **SPEECH** button located just to the lower left of the main tuning knob will announce the frequency and mode, and if desired, the S-meter level. Located to the lower right is the **LOCK** button, which disables the tuning knob.

CW ops will appreciate the fact that the sidetone tracks the CW pitch setting, so if you adjust the offset frequency between 300 to 900 Hz, the sidetone frequency will change too. Your straight key or paddle plugs into a 1/4-inch stereo jack on the front panel. There is also a separate jack available on the back panel for a straight key or external keyer.

Standard accessories with the radio are a hand mike with **UP/DN** frequency buttons, a 9 1/2-foot-long fused dc power cable, spare fuses, and a 1/4-inch stereo phone plug for your keyer paddle or headphones, if needed.

What's on the Menu Tonight, Dear?

The IC-746 uses a menu system to change operating parameters and control various features during operation. Users of other members of this ICOM family, such as the '706, will feel right at home with this system. The bottom edge of the LCD display window provides an additional electronic label for each of the five function keys (labeled **F1** through **F5**) arranged in a horizontal row just below. Their purpose changes depending on the mode in use and whether you are in Menu 1 or Menu 2. (Pressing the **MENU** button toggles between the two menus.)

Let's start with Menu 1, active in sideband mode. The **F1** button now controls AGC level. A quick press of this button toggles between fast and slow AGC action. Hold the button in for two seconds, and you turn off the AGC. **F2** toggles between duplex off and the selected + and – offsets. **F3** turns the speech compressor on and off (a small knob on the back of the radio allows you to adjust the compressor's gain) and **F4** allows you to adjust the tone of your transmitted audio. **F5** activates the band scope display. You can select between seven different sweep step sizes—from 0.5 kHz to 25 kHz—by pressing the **F5** key after activating the display. **F1** now toggles between sweeping the spectrum and normal receive. (Received signals cannot be heard during sweeping.) When you hit **F1** to stop the sweep, the scope retains the spectrum display shown at that instant, and you can use the main tuning knob to move up and down the spectrum to check out the indicated activity. A small cursor on the bottom of the graph shows where you are in relation to the displayed trace. Pressing the **MENU** button again takes you back to the normal display.

If you are in RTTY or CW mode, pressing the **F3** key slows the tuning rate to 1/4 the normal rate. This is handy for fine-tuning a signal, as the normal rate is a bit fast for real fine tuning. In RTTY mode, the **F4** key brings up a special RTTY menu, where you can set the mark tone, the frequency shift, and the FSK keying polarity. This is a handy feature. When I first tried RTTY operation with my KAM, I couldn't get anyone to answer my calls, even if I answered their CQ. Eventually OM5XX came back to tell me I was transmitting upside down! The FSKINV command in the KAM could change the KAM's polarity, but it was actually easier to change the keying polarity in the radio using this menu!

In CW mode, **F4** selects the CW memories. The four message buffers hold up to 50 characters each. Programming them is fun, and you don't even need to know the code. Just press the **F3** (**EDT**) key to edit, then select M1 through M4 with the **F1** key and move through the message using the **F2** and **F3** keys, which now serve as left and right arrows. Spin the tuning dial, and you will see the letters of the alphabet change in the selected position. When you've dialed in the character you want (numbers are entered using the numeric keypad), just move to the next character and dial again! What could be easier? When you are done editing, hit the **MENU** button to go back to the keyer menu. The **SET** menu (**F5**) allows you to change various keying parameters, including sidetone volume level, dot/dash ratio, paddle polarity (in case your plug is wired "backwards" or if you want to switch from right to left-handed keying) and—get this—whether you want to use the **UP/DN** buttons on your microphone as the paddle input. The **F2** button brings up the **SND** menu, and again you can select between the four memories. Just hit the appropriate button, and your message is on its way. There's even a feature that can automatically increment a contest QSO serial number in your message. Neat, huh?

It may seem a bit awkward to have to "dig down" all those levels to get at the menu item you want, but it is really quite intuitive. The key labels and text that appear in the display window above the function keys lead you each step of the way.

All of this is available with a few key presses from Menu 1. If you switch to Menu 2, you will find a few more selections. Here you can set up the scanning parameters, add memory name alpha/numeric labels up to nine characters long to your memory channels, or change the contrast and backlighting on the display.

If you can't find enough options on these menus to satisfy your radio appetite, there is one more selection to try. That is the **F5** key to SET various radio parameters. Here you control how loud the beep sounds when you press a button, turn on the calibration marker, tell the radio which optional filters you have installed and so on. There is a total of 30 items you can change in the SET menu.

Table 1

ICOM IC-746, serial number 001674

Manufacturer's Claimed Specifications	*Measured in the ARRL Lab*
Frequency coverage: Receive, 0.3-60, 108-174; transmit, 1.8-2, 3.5-4, 7-7.3, 10.1-10.15, 14-14.35,18.068-18.168, 21-21.45, 24.89-24.99, 28-29.7, 50-54,144-148 MHz.	Receive, 0.3-57,† 108-174 MHz; transmit, as specified.
Power requirement: Receive, 2 A; transmit, 20 A (max).	Receive, 2 A; transmit, 20 A. Tested at 13.8 V.
Modes of operation: SSB, CW, AM, FM, FSK, AFSK.	As specified.
Receiver	*Receiver Dynamic Testing*
SSB/CW sensitivity, bandwidth not specified, 10 dB S/N: 1.8-30 MHz, <0.16 μV; 50-54 MHz, <0.13 μV; 144-148 MHz, <0.11 μV.	Minimum discernible signal (noise floor), 500 Hz filter:

	Preamp off	*Preamp one*††	*Preamp two*††
3.5 MHz	–132 dBm	–140 dBm	–143 dBm
14 MHz	–132 dBm	–139 dBm	–143 dBm
50 MHz	–129 dBm	–138 dBm	–141 dBm
144 MHz	–134 dBm	–139 dBm	N/A

AM sensitivity, 10 dB S/N: 0.5-1.8 MHz, <13 μV; 1.8-30 MHz, <2 μV; 50-54, 144-146 MHz, <1 μV.

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

	Preamp off	*Preamp one*	*Preamp two*
1.0 MHz	4.1 μV	N/A	N/A
3.8 MHz	1.4 μV	0.6 μV	0.5 μV
50 MHz	1.9 μV	0.8 μV	0.5 μV
120 MHz	1.1 μV	0.6 μV	N/A
144 MHz	0.7 μV	0.4 μV	N/A

FM sensitivity, 12 dB SINAD: 28-30 MHz, <0.5 μV; 50-54 MHz, <0.25 μV; 144-148 MHz, <0.18 μV.

For 12 dB SINAD:

	Preamp off	*Preamp one*	*Preamp two*
29 MHz	0.5 μV	0.2 μV	0.2 μV
52 MHz	0.7 μV	0.3 μV	0.2 μV
146 MHz	0.3 μV	0.2 μV	N/A

Blocking dynamic range: Not specified.

Blocking dynamic range, 500 Hz filter:

	Preamp off	*Preamp one*	*Preamp two*
3.5 MHz	123 dB	121 dB	115 dB
14 MHz	122 dB	120 dB	113 dB
50 MHz	125 dB	122 dB	116 dB
144 MHz	122 dB*	116 dB	N/A

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

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

	Preamp off	*Preamp one*	*Preamp two*
3.5 MHz	99 dB	97 dB	96 dB
14 MHz	99 dB	97 dB	92 dB
50 MHz	97dB	88 dB	96 dB
144 MHz	89 dB*	93 dB	N/A

Third-order intercept: Not specified.

	Preamp off	*Preamp one*	*Preamp two*
3.5 MHz	+17 dBm	+5.1 dBm	–4.5 dBm
14 MHz	+14 dBm	+4.2 dBm	–7.3 dBm
50 MHz	+21 dBm	–5.0 dBm	–0.3 dBm
144 MHz	–2.8 dBm	–2.4 dBm	N/A

Second-order intercept: Not specified.

Preamp off, +60 dBm; preamp one, +60 dBm; preamp two, +47 dBm.

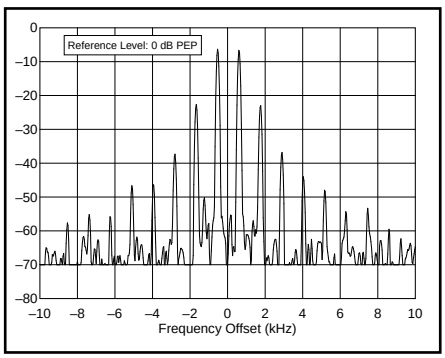

Figure 1—Worst-case spectral display of the IC-746 transmitter during two-tone intermodulation distortion (IMD) testing on HF. The worst-case third-order product is approximately 23 db below PEP output, and the worst-case fifth-order product is approximately 37 dB down. The transmitter was being operated at 100 W output at 28.350 MHz.

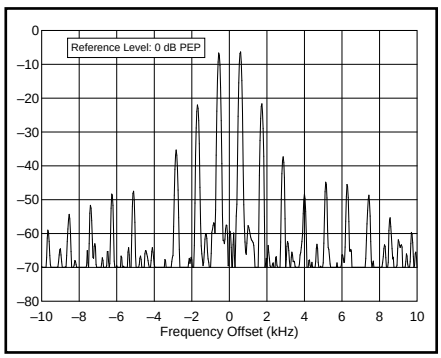

Figure 2— Worst-case spectral display of the IC-746 transmitter during two-tone intermodulation distortion (IMD) testing on VHF. The worst-case third-order product is approximately 22 dB below PEP output, and the worst-case fifth-order product is approximately 36 dB down. The transmitter was being operated at 100 W output at 144.200 MHz.

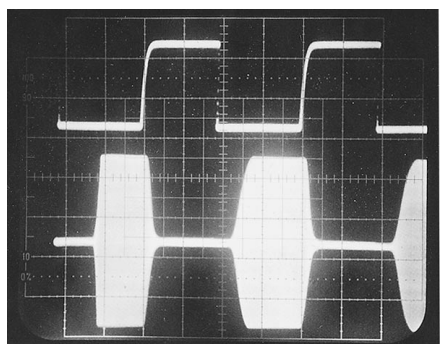

Figure 3— CW keying waveform for the IC-746 showing the first two dits in semi-break-in mode. The equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transmitter is being operated at 100 W output at 14.2 MHz. Note that the first dit is slightly shortened. Full-break-in operation (QSK) results in a nearly identical shape for the first dit, with slight shortening indicated on subsequent dits.

Manufacturer's Claimed Specifications	*Measured in the ARRL Lab*
FM adjacent channel rejection: Not specified.	20 kHz channel spacing, both preamps on: 29 MHz, 60 dB; 52 MHz, 72 dB; 146 MHz, 71 dB.
FM two-tone, third-order IMD dynamic range: Not specified.	20 kHz channel spacing, both preamps on: 29 MHz, 64 dB*; 52 MHz, 72 dB*; 146 MHz, 71 dB*. 10 MHz channel spacing, preamp on: 146 MHz, 82 dB.
S-meter sensitivity: Not specified.	S9 signal at 14.2 MHz: preamp off, 78 μV; preamp one, 24 μV; preamp two, 7.0 μV; 50 MHz, preamp off, 143 μV; preamp one, 28 μV; preamp two, 14 μV; 144 MHz, preamp off, 32 μV; preamp on, 10 μV.
Squelch sensitivity: SSB, CW, RTTY, <5.6 μV; FM, <1 μV.	At threshold, preamp on: SSB, N/A; FM, 29 MHz, 0.1 μV; 52 MHz, 0.1 μV; 146 MHz, 0.1 μV.
Receiver audio output: 2 W into 8 Ω (THD not specified).	2.3 W at 10% THD into 8 Ω.
IF/audio response: Not specified.	Range at –6dB points, (bandwidth): CW-N (500 Hz filter): 320-848 Hz (528 Hz); CW-W: 284-2589 Hz (2300 Hz); USB-W: 297-2549 Hz (2252 Hz); LSB-W: 283-2587 Hz (2304 Hz); AM: 83-2889 Hz (2806 Hz).
Spurious and image rejection: HF and 50 MHz, (except IF rejection on 50 MHz): 70 dB; 144 MHz, 60 dB.	First IF rejection, 14 MHz, 100 dB; 50 MHz, 75 dB; 144 MHz, 72 dB; image rejection, 14 MHz, 120 dB; 50 MHz, 117 dB; 144 MHz, 90 dB.
Transmitter	*Transmitter Dynamic Testing*
Power output: HF, 50 and 144 MHz: SSB, CW, FM, 100 W (high), 5 W (low); AM, 40 W (high), 5 W (low).	HF: CW, SSB, FM, typically 115 W high, 1.5 W low; AM, typically 43 W high, 2 W low; 50 MHz: CW, SSB, FM, typically 105 W high, 1.7 W low; AM, typically 40 W high, 2.4 W low; 144 MHz: CW, SSB, FM, typically 95 W high, 1.2 W low; AM, typically 42 W high, 1.7 W low.
Spurious-signal and harmonic suppression: ≥50 dB on HF, ≥60 dB on VHF.	HF, 58 dB; 50 MHz, 64 dB; 144 MHz, 73 dB. Meets FCC requirements for spectral purity for equipment in its power output class and frequency range.
SSB carrier suppression: ≥40 dB.	44 dB or greater.
Undesired sideband suppression: ≥55 dB.	70 dB or greater.
Third-order intermodulation distortion (IMD) products: Not specified.	See Figures 1 and 2.
CW keyer speed range: Not specified.	6 to 67 WPM.
CW keying characteristics: Not specified.	See Figure 3.
Transmit-receive turn-around time (PTT release to 50% audio output): Not specified.	S9 signal, 21 ms.
Receive-transmit turn-around time (tx delay): Not specified.	SSB, 8 ms; FM, 36 ms. Unit is suitable for use on AMTOR.
Composite transmitted noise: Not specified.	See Figures 4 and 5.

Size (height, width, depth): 4.7×11.3×12.5 inches; weight, 19.6 pounds.

Note: Unless otherwise noted, all dynamic range measurements are taken at the ARRL Lab standard spacing of 20 kHz.
*Measurement was noise-limited at the value indicated.
†Sensitivity no better than –115 dBm between 57 and 60 MHz.
††See text.
Third-order intercept points were determined using S5 reference.

Expanded Product Review Report Available

The ARRL Laboratory offers a detailed test result report on the ICOM IC-746 that gives in-depth, technical data on the transceiver's performance, outlines our test methods, and helps you to interpret the numbers and charts. The report even includes a summary of how the radio stacks up with similar, previously tested units. Request the *IC-746 Test Result Report* from the ARRL Technical Department, 860-594-0278; e-mail **mlevesque@arrl.org**. It's $7.50 for members and $12.50 for non-members, postpaid.

Filter Options

The IC-746 accepts two optional filters in the 9-MHz IF and one optional filter in the 455-kHz IF. These include 250, 350, and 500 Hz CW and data-mode filters and 1.9 and 2.8 kHz SSB filters for the first IF, and 250 and 500 Hz CW and data-mode and 1.8, 2.8, and 3.3 kHz SSB filters for the second IF, for a total of 10 different optional filters! We installed one 500-Hz CW filter in each. The actual installation takes only a few minutes, and is quite simple. Just remove the bottom cover, locate the appropriate socket, and pop in the filter. Before you can actually use your new filter though, you must go into the SET menu and tell the radio which filter or filters you've installed. (I accidentally changed that setting while dialing through the menus, and then had to remove the bottom cover just to see which filters we had installed.)

Pressing the **FILTER** button turns the NAR display icon on and off. Hold this button in for two seconds and you will see a display that shows which filter bandwidth is selected for the 9-MHz IF and which is selected for the 455 kHz IF. Pressing the **FILTER** button again toggles between the wide and narrow selection, and you can use those wonderful function keys to change your choices. Be sure you check each operating mode, and choose the appropriate filters for the wide and narrow filter position in each.

Some Operating Impressions

I used the IC-746 during the ARRL June VHF Contest on 6 and 2 meters. It was great fun to operate all modes on those bands during the contest. While my compromise antennas and low elevation didn't provide an abundance of signals, there were still quite a few stations to work.

Two reviewers had '746s going during Field Day, and that event provided some pretty crowded band conditions. At a club Field Day station, the radio drew quite a crowd, with plenty of operators willing to try it in the VHF station as well as on HF after we moved it to one of those positions.

This Field Day operation highlighted one important aspect of the radio—it is simple to operate! The front panel doesn't look intimidating, and—as we've noted already—you can make use of many of the radio's features without reading the manual. Opening the manual does help, however, when it comes to some of those more subtle controls. For example, you can turn off the AGC by holding in the button for two seconds. A quick press simply toggles between fast and slow AGC attack. You might miss the fact that you can control the CW sidetone level or select the opposite sideband for CW operation (CW reverse) by holding in that mode button.

This radio is a pleasure to operate on CW. Some operators noted that if you send faster than about 30 WPM in QSK mode, however, the dits are slightly shortened. This made the keying sound a bit "choppy" at very high speeds. This does not occur in

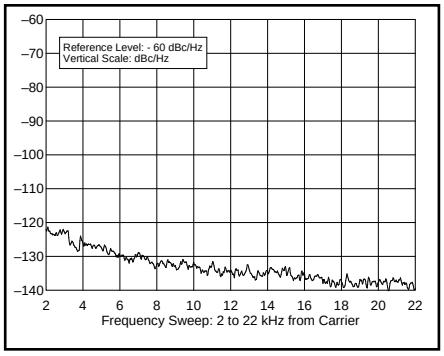

Figure 4—Worst-case tested spectral display of the IC-746 transmitter output during composite-noise testing on HF. Power output is 100 W at 14.020 MHz. The carrier, off the left edge of the plot, is not shown. The plot shows composite transmitted noise 2 to 22 kHz from the carrier.

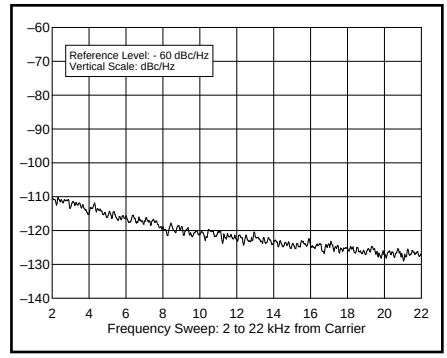

Figure 5—Worst-case tested spectral display of the IC-746 transmitter output during composite-noise testing on VHF. Power output is 100 W at 144.020 MHz. The carrier, off the left edge of the plot, is not shown. The plot shows composite transmitted noise 2 to 22 kHz from the carrier.

semi-break-in. We have seen similar shortening with other radios, so this is not unique to the '746. We do wish the manufacturers would find a way around this, though!

The DSP noise reduction system works well. It even reduces some pulse-type noise. You can adjust the amount of noise reduction that is applied via the **NR** knob. The auto notch filter also did a very effective job of eliminating carriers in SSB mode. I could tune the 40-meter band in the evening and not be bothered by shortwave broadcast heterodynes with ANF active. There is no manual IF notch filter, however, a feature many CW ops find comes in handy.

The noise blanker did not seem as effective on pulse-type noise as other blankers we have used. One reviewer lamented the lack of any adjustment on the noise blanker. He also commented that it introduced its own array of pops and snaps that sounded somewhat like static, apparently generated by nearby activity.

Another feature that was effective at eliminating some interference was the twin passband tuning (**TWIN PBT**). This control wasn't as effective at eliminating very strong signals on a nearby frequency as we might have hoped for, but it *was* effective for signals that weren't quite as strong as the desired signal. Depending on which other menu items are displayed, you may have to hit the **MENU** button one or more times to get back to the main display, where the display section that shows the setting of the pass band tuning appears. (The controls are effective at all times—you just may not see the graphic all the time.)

The built-in antenna tuner was able to optimize the impedance match for any near-resonant antenna I tried with it, maintaining a low SWR well beyond the normal bandwidth of my antennas. In addition, it was able to match several makeshift antennas on 6 meters. I used my 2-meter beam on 6 during the VHF contest and made a number of contacts. I also tried my 40-meter dipole, and it had no trouble matching that on 6 meters as well. In automatic mode it retunes the network as you tune up and down the band, and is able to reset the proper match quickly when you return to a band that was used previously.

On SSB, we received excellent reports on transmitted audio. Several operators liked the ability to tailor the transmitted audio to their individual voice characteristics or operating circumstances. You can easily dial up "contest" audio or "broadcast" audio.

The VOX circuit performed flawlessly and is easy to adjust using the menus. The speech compressor is effective, too, without distorting the transmitted audio.

FM operators will find a full array of features designed for repeater operation on 10, 6, and 2 meters. For US 2-meter repeater operation, you can even set up a default repeater offset feature to automatically select the plus or minus shift according to the band plan. There is a tone encoder and decoder for repeaters that use CTCSS for access. You can even let the radio detect the proper tone by listening to signals on the repeater's input. The tone decoder will also allow you to monitor a frequency, hearing only those signals that include your selected "call" tone. These are becoming standard features on the FM-only radios, so it is nice to see them built in to the '746. It only took a few minutes to program several of the memories with the data for my favorite repeaters. The memories store the proper offset, CTCSS tones, and other operating parameters.

RTTY operators will enjoy true FSK operation as well as the ability to select narrow filters at the touch of a button. Menu settings allow you to control many important RTTY parameters. Pressing and holding the RTTY mode button selects the reverse mode, in case you want to work a station that is transmitting "upside down."

The scratch pad memories are really handy during contest operating or chasing DX. If you are having difficulty breaking through the pile-up, simply store the frequency in the scratch pad by hitting the **MP-W** (memory pad write) button. The last 5 (or 10, if you change it in the setup menu) frequencies with all operating conditions are stored. This is a first-in, first-out buffer, so the oldest data will be deleted as you use the scratch pad. When you are ready to go back and try that station again a little later, just hit the **MP-R** (memory pad read) button to recall the frequency. You can step through the scratch pad memories with successive presses of the **MP-R** button.

Anomalies

We purchased two IC-746s for our review and flipped a coin to determine which would be our "product review" radio for ARRL Lab data purposes. While measuring the receiver's dynamic range characteristics, Test Engineer Mike Tracy, KC1SX, encountered a notable performance anomaly. Typically, there's only a few dB difference between the high side and the low side of our two-tone, third-order IMD dynamic range measurements. We report the worse of the two. In our IC-746, however, the high side and low side differed by as much as 10 dB. The resulting "worst case" IMD dynamic range numbers were in the vicinity of 80 dB.

We repeated our receiver tests using our second IC-746 and a third unit and concluded that the original IC-746 was somehow defective or possibly misaligned. Our second radio, very close in serial number sequence to our review radio, performed considerably better and showed no evidence of the imbalance we'd seen. The third unit (borrowed from a local distributor) also worked properly. So that we could report numbers we believe to be representative of the IC-746, we have included the dynamic range measurements from our second unit in Table 1.

And A Few Minor Complaints

A few minor shortcomings deserve mention. Some of these items may be insignificant to most operators and major issues for others. For example, the **MODE** keys and the function keys are close together and aligned one row above the other. I frequently looked at a **MODE** key, read it as a label, and hit the button above that label. That means I was really hitting the function key instead, so the resulting radio reaction varied depending on the menu condition at the moment. Other reviewers also commented on this problem.

The minimum tuning range seems too fast for some tastes. On RTTY and CW you can slow it down to one-quarter the normal rate, and that seems better on those modes. The tuning step (**TS**) button allows you to tune the kilohertz digit for even faster excursions up and down the band, though, and that is nice.

VHF operators may have a complaint when they try to work cross-mode contacts,

because the CW signal will be offset from the phone signal by about 800 Hz. This means an inconvenient retuning between transmit and receive modes.

Conclusion

The number of features ICOM has packed into the IC-746 is amazing. The inclusion of the 2-meter band is a real plus. If you've always wanted more than an FM box on that band, this radio gives it to you, along with a very nice HF rig. It won't cost you the price of an *extra* HF rig to add it, either.

I would like to thank Rick Lindquist, N1RL; Emil Pocock, W3EP; Joe Bottiglieri, AA1GW; plus Mike Tracy, KC1SX, and Ed Hare, W1RFI, of the ARRL Lab, for their assistance with this review.

Manufacturer: ICOM America, 2380 116th Ave NE, Bellevue, WA 98004; tel 425-454-8155; fax 425-454-1509; **http://www.icomamerica.com**. Manufacturer's suggested list price: $2280, UT-102 voice synthesizer unit, $74; optional IF filters, $105-$249; CR-282 high-stability crystal unit, $168.

Ten-Tec T-Kit Model 1340 Transceiver Kit

Reviewed By Dan Miller, K3UFG
Educational Activities Correspondent

It's been many years since the days of Heathkit, Eico, WRL, and Knight Kit. Most present-day hams haven't experienced the indescribable pleasure of communicating with equipment they've actually assembled themselves! While kit building was once very popular, in recent years smaller outfits like Oak Hills Research, Small Wonder Labs, Wilderness Radio, EMTECH, A&A and a handful of others cater to a relatively small number of hams, primarily members of the QRP community, who still enjoy "rolling their own."

A couple of years ago, Ten-Tec launched its T-Kit line. Offerings now include mobile FM transceivers for 6, 2 and $1^1/_4$ meters, 6 and 2-meter transverters, some SWL and ham band receivers, and an assortment of station accessories. Recently, the company returned to its QRP kit roots (remember the Power Mite PM1 and PM2 of the late 1960s?) by introducing a line of low power CW transceivers. The 1320, 1330, and 1340 cover any 50 kHz of the CW section of the 20, 30, or 40-meter bands respectively with an output power of about 3 W. Earlier plans to include a version for 80 meters have been shelved. The receiver is a single conversion superhet and features include RIT, QSK, ALC, and a 4-pole crystal filter. Priced under $100, they are proving to be very popular. We purchased the 1340 to see what the excitement was all about.

A Little Help Please!

I haven't attempted to build anything in quite some time, so I asked my Russian friend, Oleg Ashmarov, KØTF (formerly UQ2GTF), to help out. At half my age, he has the necessary dexterity for winding coils and soldering small components, and sharper vision for identifying parts and reading fine print. He has had little opportunity for any ham equipment construction since he came here from Latvia five years ago and was thrilled at the chance to get back into building.

We began our project by reading through the *Reference* section of the 1340's instruction manual. This includes a short Ten-Tec company history, a primer on QRP operating, a description and block diagram of the various stages of the transceiver, and a glossary of terms and abbreviations. In addition, you'll find lists of the included parts and components, required and optional tools and test equipment, a section on modifications, and tips on alignment, operation, and troubleshooting.

An important first step when building any kit is to go through the parts list and sort out all the materials and components. Be sure to check any included *T-Kit Technical Bulletins*. These single page addendum sheets may explain any variations. There are lots of parts in this kit, so be sure to keep things well organized to make them easy to locate during assembly. The kit uses just one double-sided circuit board. It's silk-screened with white lettering and outlines to indicate the parts numbers and locations of the board-mounted components.

BOTTOM LINE

The Ten-Tec T-Kit 1340 QRP transceiver is attractively priced, rugged, and simple to operate. Its well-written instruction manual and "test-as-you-build" assembly procedure puts this project within the capabilities of almost anyone with a moderate amount of kit-building experience.

The holes where component leads pass through the board are plated through. Plating through simply connects the circuit traces on the top and bottom side of the board. Without through plating, some component leads must be soldered on both the trace side *and* the component side. Very early versions of this kit included a circuit board that was not plated through. This led to some challenging soldering in areas already crowded with installed components. All currently available 1300 series kits now include a plated through board.

The unit's jacks, knobs, cabinet parts, and the power switch are included, although the builder supplies RCA plugs for the dc power connections and CW key. The quality of the parts and components that make up this kit are quite good. The slightly textured satin black cabinet, the silk-screened white lettering and scales on the front and back panels, and the grooved black plastic knobs give the finished unit a very professional look.

After making sure we had a low-wattage soldering pencil, a good regulated 12-14 V dc power supply (rated at 1 A or higher), a 40-meter antenna with a 50-Ω coax feed line, and the hand tools needed for assembly, we started gathering test

Table 2

Ten-Tec 1340

Manufacturer's Claimed Specifications	***Measured in the ARRL Lab***
Frequency coverage: Receive and transmit, any 50 kHz between 7-7.15 MHz.	As specified.
Power requirement: Receive, 35 mA (no signal); transmit, 800 mA (max output).	Receive, 32 mA; transmit, 840 mA. Tested at 13.8 V.
Modes of operation: CW.	As specified.
Receiver	*Receiver Dynamic Testing*
CW sensitivity, bandwidth not specified, 10 dB S/N: <0.25 μV.	Minimum discernible signal (noise floor): –123 dBm.
Blocking dynamic range: Not specified.	Blocking dynamic range: 108 dB.
Two-tone, third-order IMD dynamic range: Not specified.	Two-tone, third-order IMD dynamic range: 75 dB
Third-order intercept: Not specified.	–10.1 dBm.
Receiver audio output: 300 mW into 4 Ω, distortion not specified.	856 mW at 10% THD into 4 Ω.
IF/audio response: Not specified.	Range at –6dB points, (bandwidth): CW: 598-1237 Hz (639 Hz).
Spurious and image rejection: Not specified.	First IF rejection, 79 dB; image rejection, 130 dB.
Transmitter	*Transmitter Dynamic Testing*
Power output: CW, 3 W typical.	Typically 4 W.
Spurious-signal and harmonic suppression: Not specified.	47 dB. Meets FCC requirements for spectral purity for equipment in its power output class and frequency range.
CW keying characteristics: Not specified.	See Figure 6.
Composite transmitted noise: Not specified.	See Figure 7.

Size (height, width, depth): 2.8×6.0×6.0 inches; weight, 2.3 pounds.

Note: Unless otherwise noted, all dynamic range measurements are taken at the ARRL Lab standard spacing of 20 kHz.

Third-order intercept points were determined using MDS reference.

equipment. My Radio Shack VTVM (built from a kit many years ago) would be fine for the dc voltage measurements. My Kenwood TS-450S HF transceiver would be perfect for receiving and generating test signals. A borrowed Oak Hills Research WM-1 QRP wattmeter for power output testing rounded off the list. We were ready to begin.

Hitting the Books

The *Assembly* section of the 1340's manual (and most of the other T-Kit manuals as well) includes instructions for testing most of the stages of the unit as construction progresses. This can greatly simplify troubleshooting and provides reassurance to novice builders that they're on the right track. Experienced builders may prefer to skip these steps, as some temporary installation and subsequent removal of parts is sometimes required. We decided to make these tests, and added solder wick and a desoldering bulb to the tool complement.

The *Kit Manual Supplement* is a addition to the documentation and proved to be very beneficial. One side of this 11×17-inch worksheet gives a complete schematic, the other shows the component location diagrams (duplicates of those in the manual) for each of the seven phases of circuit board assembly. Using this supplement eliminates the need for turning the manual's pages back to those diagrams during the assembly process. Although the original manual provides schematics for each of the subsections, it does not include a single page schematic of the completed unit. This could come in very handy if any troubleshooting were required. (A review of this kit elsewhere, by Chuck Adams, K5FO, noted these shortcomings in the original documentation. Thanks to Chuck and to Dan F. Onley, K4ZRA, who was responsible for the original manual's text and design, for today's improvements.—*Ed.*)

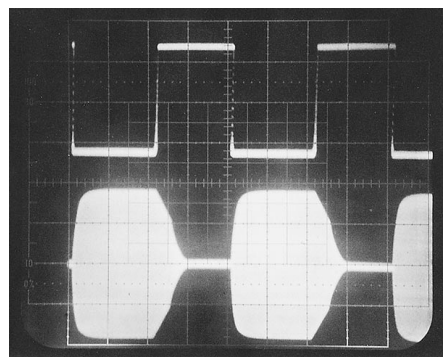

Figure 6—Keying waveform for the Ten-Tec 1340 showing the first two dits. The equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transmitter is being operated at 4 W output at 7.020 MHz.

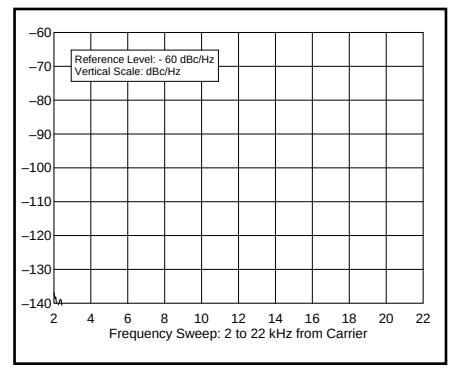

Figure 7—Spectral display of the Ten-Tec 1340 transmitter output during composite-noise testing. The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 2 to 22 kHz from the carrier. Note that the only noise on this plot is the two small "pips" near the left edge of the graph. This level of composite noise is lower than any transmitter that has been previously tested in the ARRL Lab. The transceiver is being operated at 4 W PEP at 7.020 MHz.

I would consider the 1340 to be an intermediate-level kit. With the installation of 216 components on the circuit board alone, the winding of five toroidal coils, and several situations where soldering in fairly close quarters is required, the novice builder may find this kit a bit challenging. The instruction manual is excellent, however. With the manual's well-organized sections, very good diagrams, step-by-step checkbox format, and the extensive additional information provided, this project should be within the capabilities of just about anyone with even a moderate amount of kit-building experience. True first-timers may want to consider cutting their teeth on one of Ten-Tec's easier and less-expensive accessory or receiver kits, or relying on the assistance of an experienced "Elmer."

Let's Get it Together

Assembly of the transceiver is broken up into eight phases. Here are some of the highlights and our observations.

Phase 1—Assembly of Keying and DC Input Circuitry, went without a hitch. Using jumper leads to make connections to our 12 V supply, simple voltage readings taken with the VTVM verified that this stage was okay.

Phase 2—4.00 - 3.85 MHz VFO Circuit. In the final assembly steps of this section the actual tunable range of the transceiver is set. Using my TS-450 as the test receiver for the generated signal, the initial VFO range before adjustment was determined to be 3975 to 3905 kHz. A chart in the manual indicated that this would result in operating frequency range of about 7025 to 7095 kHz. Adjustments in the number of turns or the spacing between turns on a toroid wound during this phase will allow the unit to cover any 50 kHz section of the 40-meter CW band (the usable limit later proved to be closer to 70 kHz). Since this range, covering the Advanced and General CW sections and the 7.040 QRP CW calling frequency, seemed to be perfect for our needs, no adjustments were necessary!

Phase 3—Transmit Mixer and 7 MHz Filter Circuit, Phase 4—1 MHz Receiver IF Stages, and Phase 5—Receiver BFO and Audio Amplifier Stages, all went according to the book. Progress tests using the power supply, a short length of wire for an antenna, and my Kenwood HF transceiver confirmed that everything was fine up to this point. The Phase 5 progress test includes some preliminary receiver alignment and peaking.

Phase 6—Receiver Audio Preamp/Filter and AGC. When installing the capacitors in this stage, we noted that the location of C43 was inadvertently left off the parts placement diagram in the manual. It is shown in drawing 6 on the *Kit Manual Supplement*, however. This completed the receiver section of the radio. With some temporary hookups we were able to test the transmitter's sidetone and do a bit of listening on 40 meters.

Phase 7—Transmit Driver, RF Amplifier and Output Filter. Here, longer wires for winding the three final output filter coils would have made life easier. Ten-Tec provides one piece of #24 enameled wire to cut into three equal lengths. Measure carefully and wind neatly or you'll come up short.

Phase 8—Final Assembly and Alignment. In this section, the final transistor and heatsink assembly is attached to the circuit board, the board is mounted in the cabinet, and connections are made to the jacks, controls, and speaker. Since most of the necessary alignment of each of the transceiver's previously completed stages was made during the earlier "progress tests," only checking for proper RF output and centering of the RIT control for the zero offset position was required. To maximize the RF output power, the spacings between turns in the output filter coils (wound during Phase 7 above) are slightly compressed while observing the output power on a wattmeter. Using a supply voltage of 13.8 V, we ended up with 4 W of RF.

Individual owners may want to consider some minor modifications (a long-time tradition among kit builders is to tailor the completed unit to their own preferences). The *Modifications* section of the manual recommends building and aligning the transceiver as described in the manual first, testing the unit for proper operation, and *then* making any desired changes. This is an excellent suggestion.

Here are some of my thoughts: I would prefer an alternative dc power connection, perhaps one of the coaxial-types used on H-Ts and low-voltage consumer electronics equipment. The exposed contacts of a disconnected RCA phono plug could easily short out a power supply or bridge a battery hookup if they inadvertently come in contact with a metal object. With any connector type, fuse your power lead to protect your source and keep spares on hand. I would install a 1/8-inch stereo jack for headphones and a 1/8-inch mono jack for the key on the front panel. An LED power indicator would be a nice addition, and may save me from running down a battery if I accidentally left the power on overnight. The front panel has a scale surrounding the main tuning knob labeled 0-10. Ten-Tec provides a table in the manual for converting this scale reading to frequency. I intend to make up an adhesive-backed overlay to cover the existing scale which will show the operating frequency directly.

Our total assembly time for the kit, from start to finish, was nine hours. The completed radio is very simple to operate, with just an on-off switch, a volume control, the main tuning knob, and an RIT control. A top mounted speaker delivers more than enough audio for most operating conditions and a 1/4-inch stereo jack on the front panel is included for headphones. The cabinet is extremely sturdy, bringing the weight of the completed unit up to just over a somewhat hefty 33 ounces. While this certainly does add to its ruggedness, I can almost hear the backpacking QRP buffs moaning. (Come on campers, it's not so bad, just skip the extra quart of water… just kidding, of course.) Backpackers have been known to drill holes in their toothbrush handles to save a few fractions of a gram.

The rear panel supports four connectors. An SO-239 antenna connector and three RCA phono jacks; one for the CW key, one for power input (12-15 V dc) and a dc output jack for running external accessories, such as an outboard CW keyer or logbook light.

On the Air

My first QSO with this radio is certainly worth mentioning. The signal reports, both ways, were good—559—for a contact to WS3C, Mike Sullivan, in Thomasville, Pennsylvania. Coincidentally, he too was using a 1340 with a G5RV antenna! This contact of several hundred miles was music to my ears.

I also had the opportunity to use the radio at W1AW's Field Day setup in a Connecticut state park. The crowded band conditions and the wide variety of weak and strong signals tended to overwhelm the unit's AGC circuit somewhat, but all in all the little transceiver proved to be a capable performer. In casual operation over a couple of hours, we easily added several dozen 40-meter QRP contacts to the logs, using a simple dipole strung about 15 feet above the ground. If you look carefully at the photo you may even see the scratches and scrapes our tough little unit now proudly wears.

Manufacturer: Ten-Tec Inc, 1185 Dolly Parton Pkwy, Sevierville, TN 37862; tel 423-453-7172; fax 423-428-4483; **http://www.tentec.com;** e-mail**: sales@tentec.com**. Price: $95.