QST

Product Reviews

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COMPACtenna 2M/440+

Product Review

Yaesu FTM-6000R VHF/UHF Mobile Transceiver

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The Yaesu FTM-6000R is a compact, dual-band, one band at a time, analog (FM) mobile transceiver. The maximum RF output power is 50 W on both the 2-meter and 70-centimeter bands, but it also has a significant extended range on receive, from 108 MHz to 999.995 MHz (with cellular blocked; see Table 1). The control head is detachable and can be connected to the main unit remotely using the included 10-foot cable. Yaesu also includes a control head mounting bracket, a radio main unit mounting bracket, a USB cable, a dc power cable, and a DTMF microphone (SSM-85D). The radio can support Bluetooth wireless with the optional BU-4 unit. There are 1,100 programmable memory channels. Programmable scanning functions include the VFO scan, memory scan, and Primary Memory Group (PMG) scan. A 3 W audio power speaker provides good, loud audio output. The unit features a Funnel Air-Convection Conductor (Wind Tunnel) that gathers cool air from the front and side intakes and directs it to the radio final amplifier, and out of the unit through the fan located on the rear panel (see Figure 1).

A new Easy to Operate – III (E2O-III) system implements a three-tier list that calls up the function settings in order of the frequency of priority and use. The PMG allows calling up a group of registered frequencies regardless of the band. A Memory Auto Grouping (MAG) calls up memory channels that are automatically categorized in each band for quick and easy recall.

Basic Operation

The radio turns on by pressing and holding the **POWER/LOCK** switch located in the upper left-hand portion of the controller. Press and hold it again to turn off the radio. Adjust the volume by rotating the **VOL** knob just below the **POWER/LOCK** switch. To adjust the squelch level, push the **SQL/BACK** key in the upper right-hand corner of the control head, and turn the **DIAL** knob below it to mute the background noise. Pushing the **SQL/BACK** key again (or waiting 2 seconds) will return the **SQL** level screen to the normal operating screen.

To select a frequency band, press the **BAND GRP** key repeatedly to cycle through five band choices. Unwanted frequency bands can be set so they are not displayed on the rotation of bands. To tune to a specific frequency, the **DIAL** knob on the right-hand side of the controller changes the frequency. To change the frequency in 1 MHz steps, press the **DIAL** knob first, then rotate it to the desired frequency. To change the frequency in 5 MHz steps, press the **DIAL** knob and hold down while rotating the knob. You can also press the numeric keys on the microphone to select a frequency.

For transmission, press the standard microphone **PTT** button. If it is pressed when a non-amateur band is selected, an alarm sounds, **INHBT** (inhibit) is displayed on the screen, and transmission is disabled. According

Bottom Line

The FTM-6000R may look like a basic dual-band mobile radio, but it's not. The new operating features were implemented with the operators in mind, and that's where the technical advancements reside.

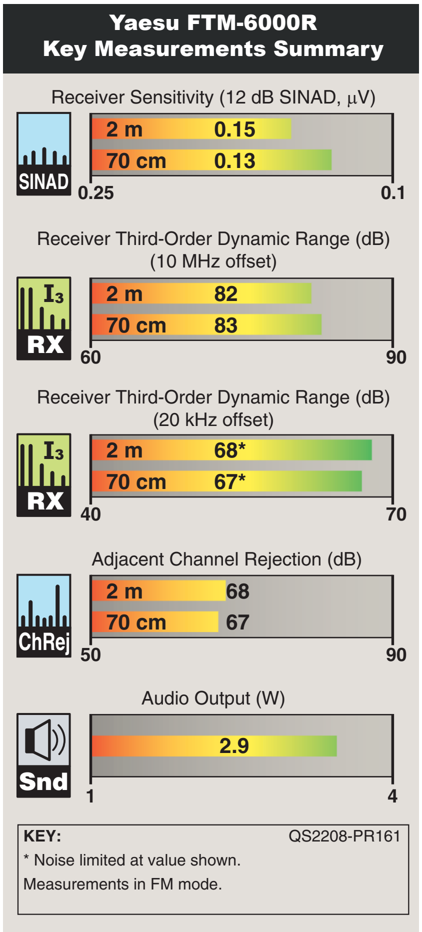


Table 1
Yaesu FTM-6000R, serial number 1L020743, FCC ID# K6620795X40

Manufacturer's Specifications	Measured in ARRL Lab
Frequency coverage: Receive, 108 – 999.995 MHz (cellular blocked); transmit, 144 – 148, 430 – 450 MHz.	Receive: 108 – 823.995, 849.1 – 868.995, 894.1 – 938.295, 965.2 – 983.295 MHz. Transmit: as specified.
Modes: FM, FM-N (FM-Narrow), AM (receive only).	As specified.
Power requirements: Transmit, 10 A at 50 W RF output; receive, 0.5 A at 13.8 V dc. (No operating voltage range was specified.)	At 13.8 V dc: Receive, no signal, max. audio and backlights, 510 mA; lights at min, 275 mA. Power off, <0.1 mA. Transmit (hi/med/low): 146 MHz, 7.2/5.2/2.7 A; 440 MHz, 9.5/6.1/2.9 A.
Receiver	**Receiver Dynamic Testing***
Sensitivity: FM 12 dB SINAD: 137 – 150 MHz, 0.2 µV; 150 – 174 MHz, 0.25 µV; 174 – 222 MHz, 0.3 µV; 222 – 300 and 336 – 420 MHz, 0.25 µV; 420 – 520 MHz, 0.2 µV; 800 – 900 MHz, 0.4 µV; 900 – 999.99 MHz, 0.8 µV. AM: 10 dB S/N, 108 – 137, 300 – 336 MHz, 0.8 µV.	FM 12 dB SINAD: 146 MHz, 0.15 µV; 223 MHz, 0.42 µV; 440 MHz, 0.13 µV; 902 MHz, 0.21 µV. AM: 120 MHz, 0.74 µV.
FM two-tone, third-order IMD dynamic range: Not specified.	20 kHz offset: 146 MHz, 68 dB,† 440 MHz, 67 dB;† 10 MHz offset: 146 MHz, 82 dB, 440 MHz, 83 dB.
FM two-tone, second-order IMD dynamic range: Not specified.	146 MHz, 89 dB; 440 MHz, 111 dB.†
Adjacent-channel rejection: Not specified.	20 kHz offset: 146 MHz, 68 dB;† 440 MHz, 67 dB.†
Squelch sensitivity: Not specified.	At threshold: 146 MHz and 440 MHz, 0.11 µV, 0.28 µV (maximum).
S-meter sensitivity: Not specified.	For 5 bars: 146 MHz, 1.7 µV; 440 MHz, 1.5 µV.
Audio output power: 3 W into 8 Ω at 10% THD.	2.9 W; THD at 1 V_{RMS}, 3.3%.
Transmitter	**Transmitter Dynamic Testing**
Power output: High/medium/low power, 50/25/5 W.	At 13.8 V dc, high/medium/low power: 146 MHz, 49/24/5.1 W; 440 MHz, 55/28/5.5 W.
Spurious signal and harmonic suppression: ≥60 dB.	146 MHz and 440 MHz, >70 dB. Meets FCC requirements.
Transmit-receive turnaround time (PTT release to 50% of full audio output): Not specified.	Squelch on, S-9 signal: 146 MHz and 440 MHz, 25 – 60 ms.††
Receive-transmit turnaround time (tx delay): Not specified.	146 MHz and 440 MHz, 43 ms.

Size (height, width, depth): Control head: 1.6 × 5.51 × 1.38 inches, without knob. Radio body: 1.66 × 5.47 × 5.2 inches, without fan.

Weight 2.43 pounds (radio body, control head, and control cable).

*Test results shown are for standard FM mode. Sensitivity, adjacent channel selectivity, and dynamic range increased by 1 dB in FM narrow mode.
†Measurement was noise limited at the value indicated. See the Lab Notes on page 43.
††Timing fluctuated over this range. The turnaround times are faster than most transceivers, so this should present no problems in typical use.

to the manual, if transmission is continued for a long period of time, the radio overheats and the high temperature protection function is activated. The power output level is automatically reduced to the low power setting. If transmission continues with the high temperature protection function engaged, the radio will forcibly return to the receive state, a feature that is appreciated when the transmitter remains engaged without the knowledge of the operator (which happens occasionally in the field — for example, when an operator accidentally

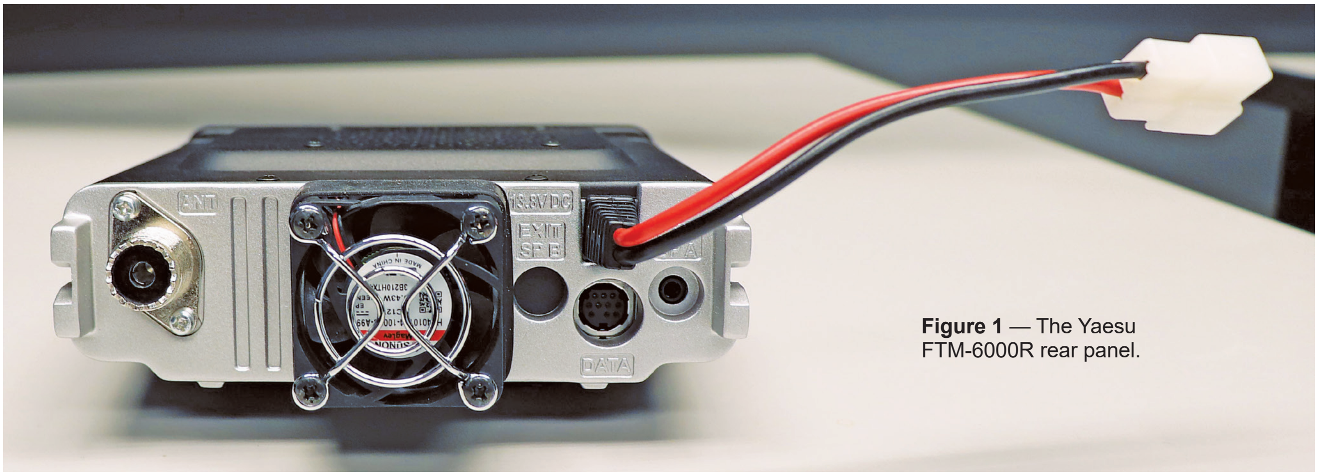


Figure 1 — The Yaesu FTM-6000R rear panel.

pushes or sits on the microphone's **PTT** button). For the purpose of this review, this feature was not tested.

To lock the keys and **DIAL** knob, press the **POWER/LOCK** key briefly. The word **LOCK** will display on the screen. The **PTT** button and the **VOL** knob cannot be locked. Pressing the **POWER/LOCK** button again will unlock the system, and the word **UNLOCK** will appear briefly on the screen. If you are unaware that the system is locked, an error message will appear on the screen when the **PTT** button is pushed. For example, **LOCK** is a reminder that the system is locked and needs to be unlocked prior to changing frequency.

The E2O-III System for Assigning Functions and Settings

The E2O-III provides a three-tier system of operating modes for assigning functions and settings, such as the CTCSS tone frequency. There are three lists of functions in order of frequency and priority of use. The Menu list contains all settings and functions not registered to the next level (the frequently used Function list). Thus, the Menu list contains all of the settings that are of the "set and forget" type, such as the microphone gain setting. To view the Menu list, hold down the **F/MENU** button while rotating the dial to cycle through the items.

The Function list contains the settings that are more frequently used, such as the CTCSS tone frequency, plus or minus frequency shift for repeater use, and repeater reverse (which flips the receive frequency to the transmit frequency, allowing access to the repeater incoming signal strength and readability on the repeater's input frequency — information used to set up a simplex communication off the repeater frequency, for example).

To register (move) a frequently used function or setting to the Function list, select the function or item from the Menu list and then press and hold the **F/MENU** key. It is then moved to the Function list. To cancel a function's registration on the Function list, select it and then press and hold the **SQL BACK** key; the function is then moved back to the Menu list. To call up a function in the Function list, press the **F/MENU** button momentarily, and then rotate the **DIAL** knob to the desired function/setting.

Lastly, the **F1** key calls up the one function that is the highest priority for the individual operator. Examples include "Home" (the operator's home repeater) or the CTCSS tone frequency selection setting (if the operator travels out of their home area frequently). From the Function list, select the desired function/setting, and then press and hold the **F1** key. Then, all you have to do is push the **F1** key briefly to pull up your home repeater, for example. You can readily change the assignment of the **F1** key by selecting another function/setting from the Function list and then pressing and holding down the **F1** key. Figure 2 shows a diagram representing the layered structure of the E2O-III system.

MAG (Memory Auto Grouping)

Memory channels can be grouped and recalled by band. When you press the **BAND GRP** key while the radio is in memory mode, the bands switch from air, VHF, UHF to all memory channels. Then, only the memory channels in the selected band can be recalled, for efficient memory channel selection. For example, I programmed three local repeaters into memory channels, and an active local aircraft fre-

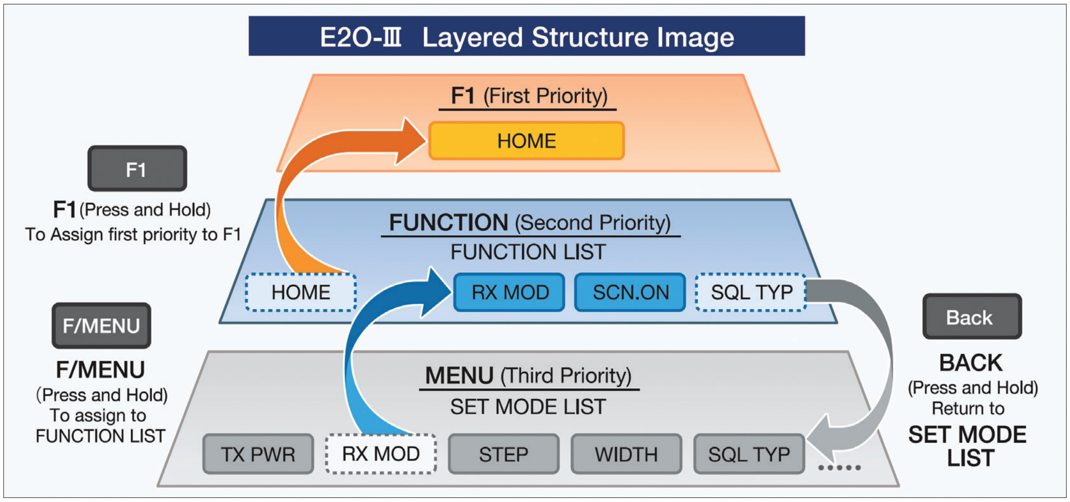


Figure 2 — This diagram represents the layered structure of the E2O-III system. [Graphic courtesy of Yaesu]

quency (118.175 MHz). Pressing the **BAND GRP** key brought up the air band memory channel. Pressing it again brought up the VHF band memory channels with my three local repeater memory channels.

PMG (Primary Memory Group)

Frequently used frequencies and up to five memory channels that have been programmed into the PMG can be displayed for easy selection/operation. For example, if 25 memory channels are programmed into the radio, up to five of them can be registered in the PMG. I registered three repeater channels in the PMG. Subsequently, when I pressed the **PMG PW** button, only those three repeater channels were available to cycle through and use, adding another aspect to the efficient operation.

VFO Band Skip

Also adding to the efficient operation, unused bands can be skipped in the rotation of bands. For example, if you have no need for monitoring the air band, you can skip it by selecting the **BND.SEL** (band select) function in the main Menu list and changing its state to **OFF**.

Other Functions

The frequency and other parameters in a memory channel can be transferred into the VFO register by simply pressing and holding the **SQL/BACK** key while the memory channel is displayed.

Scanning

The radio supports the following scanning functions: VFO scan, memory channel scan, PMG scan, and Programmable Memory Scan (PMS). To find active frequencies, press the **V/M MW** key to switch to VFO mode or memory mode, or press the **PMG PW** key for the PMG mode, and then press and hold the microphone **UP** or **DWN** button to start scanning up or down. When the VFO scan is active, **VFO.SCN** appears on the screen. **MEM.SCN** appears during a memory scan, and **PMG.SCN** appears during a PMG scan. Turn the **DIAL** knob and scanning will move up or down in frequency based on the direction of the knob rotation. When a busy frequency comes up, the scan pauses, the frequency flashes, and the scan starts again after 3 seconds (other options are discussed below). Press the **PTT** switch or **UP** or **DWN** button to cancel the scanning. If the scan has paused on a busy frequency, rotate the **DIAL** knob to resume scanning.

PMS (Programmable Memory Scan)

The PMS function scans only the range of frequencies between the lower and upper limits set by the user in a pair of PMS programmable memory channels. Fifty pairs of frequencies (L01/U01 to L50/U50) are available.

To resume scanning after the scan stops on a busy frequency, bring up the **SCN.TYP** (scan type) function in the Menu list. Use the **SCN.RSM** (scan resume) function to select what happens. **BUSY** means the signal is received until the signal fades out, and after two seconds, scanning resumes. **HOLD** means scanning stops and does not resume. **1 SEC / 3 SEC / 5 SEC** means the signal is received for a specified time, and then scanning resumes. Each memory channel can be selected to be skipped during a memory scan.

Lab Notes: Yaesu FTM-6000R

In measuring dynamic range, lab tests put strong off-channel signals into a receiver input and look for unwanted responses. The difference between the noise floor of a receiver and the level of off-channel signals that cause unwanted receiver responses is generally known as "dynamic range," typically expressed in dB. The higher the dynamic range, the better the receiver. One unwanted response can be intermodulation between two or more off-channel signals, causing a mix of those two signals to appear in the receiver passband. Another unwanted effect can be for the receiver to lose gain, effectively decreasing its sensitivity. The dynamic range of a receiver can also be limited by the phase noise of the receiver internal oscillators. When this noise predominates, the measurement is reported to be noise limited at the value shown. A receiver measurement being "noise limited" is not any different from any of the other effects, so a noise-limited dynamic range measurement is still a valid measurement of the receiver's dynamic range. What counts is the actual number. A receiver that is noise limited at 80 dB of dynamic range is just as good as a receiver that has gain compression measured at 80 dB. In fact, if the design of the receiver is robust, the gain compression performance could be so good that a low level of phase noise dominates. What counts is the dynamic-range number, not the actual cause of the dynamic-range limit. — *Ed Hare, W1RFI, ARRL Lab Manager*

Impressions

Just when you think the ubiquitous dual-band VHF/UHF FM synthesized transceiver can't be improved upon over its 45-year history, along comes the FTM-6000R. Much of the evolution of these radios involves improvement of the human operator interface, and the FTM-6000R is no exception. I especially like the E2O-III algorithm for assigning functions and settings.

There is plenty of audio output from the small speaker, which fires straight up. Audio quality reports from repeater users have been fine. I've never seen a **MUTE** button on any microphone keypad before this one, but it seems like a convenience when needing to quiet the radio instantly. The microphone fits comfortably in the hand. I like that if I were to accidentally sit on the microphone and cause transmission, the radio's protocol is to force the receiver.

The Basic Manual

Despite the common tendency of many hams (including myself) to intuitively operate a radio without reading the manual, I recommend studying the basic manual for this radio, as you will learn its wide range of functioning. A good example of this is the scanning function. I tried a VFO scan, and the screen display read **VFO.SCN**. Although it seemed like it wasn't working, it was, and a frequency would not pop up until the scan came across an active frequency. Traditional scanning usually involves the rapid increase or decrease of the actual frequency numbers being scanned. The manual explains this well.

The basic operating manual is well written and succinct, and it includes large graphics showing which buttons to push or dials to rotate. It is in large print, good for my 70-year-old eyes. The manual is 40 pages, but that includes all of the fine print that no one ever reads!

The Advanced Manual (for Advanced Features)

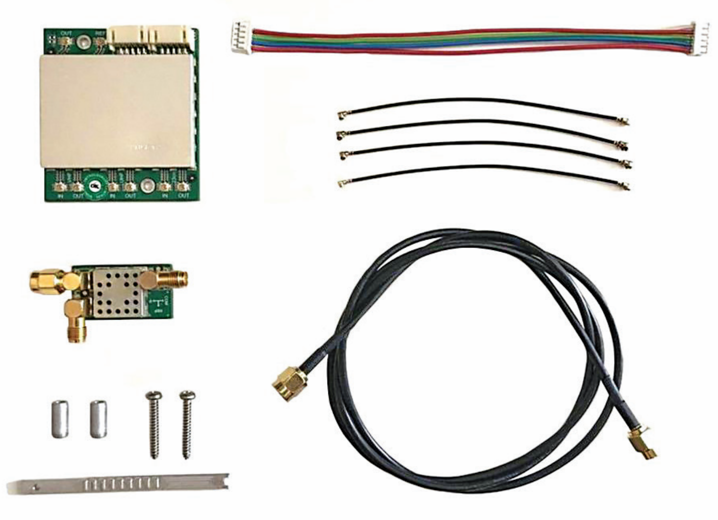
The supplied basic manual covers more than needed to get started with this radio. The radio's advanced manual (available for download under the product heading on the Yaesu website) covers more advanced operations in detail: selecting squelch type, scanning for the CTCSS frequency, Digital Code Squelch (DCS) operation, Enhanced Paging and Code Squelch (EPCS), DTMF operation, Dual Watch feature, weather broadcast channels and functions, Automatic Range Transponder System (ARTS), and a complete explanation of every Menu list function. Additionally, a 10-pin data port on the rear panel allows connection of a terminal node controller (TNC) for packet operation. It can also be used to access the Yaesu WIRES-X network as an analog node when connected to an HRI-200, and this is discussed in the advanced manual.

Conclusion

This is a solid, basic but feature-laden, compact, high-power, dual-band FM mobile transceiver that is modestly priced. The ultimate litmus test for any product review is whether or not the reviewer would consider purchasing the product themselves. In my case, I am purchasing one for my vehicle.

Manufacturer: Yaesu USA, 6125 Phyllis Dr., Cypress, CA 90630; **www.yaesu.com**. Price: FTM-6000R, $320.

Radio Analog PTRX-9700 SDR Adapter Add-On



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Like its HF sibling (the IC-7300) has done on 160 – 6 meters, Icom's IC-9700 has taken the VHF/UHF world by storm. The IC-9700 covers the 144 – 148, 430 – 450, and 1240 – 1300 MHz amateur radio bands. It also shares the form factor, intuitive front panel layout, multifunction display, and many other features that make the IC-7300 so popular. The IC-9700 has quickly become the go-to radio for many serious VHF/UHF operators, including those who operate the most demanding modes, such as EME.

In early 2020, I found a great deal on a new IC-9700. This radio quickly replaced the high-performance transverters I had been using for all three bands for several years. It's seen service in VHF contests, portable operations such as the microwave sprints, day-to-day MSK144 meteor scatter activity on 2 meters, and JT65 and Q65 EME operations on 144, 432, and 1296 MHz. It's a radio that does many things quite well, and despite its small size, relatively spartan front-panel control layout, and limited rear-panel control capabilities, it has drawn in many demanding operators.

Turbocharging the IC-9700 Receiver

Radio Analog first developed enhanced SDR functionality for the IC-7300 and followed that up with the PTRX-9700 for the IC-9700. Fundamentally, the PTRX-9700 allows for the connection of an external SDR to the IC-9700. Installing this product is a simple, nonintrusive, and easily reversible change to the radio.

The PTRX-9700 uses the existing 10 MHz reference input (SMA) connector on the radio's rear panel, along with a splitter provided with the kit, to allow that connector to be used for its original function and the SDR output. You attach an SDR of your choosing to the IC-9700 to reap the benefits of SDR receiver operation in parallel with the IC-9700's own receiver.

Why might you want to add an SDR to the IC-9700, which already offers panadapter functionality? For one thing, you can use it to monitor two frequencies and/or modes on the same band at the same time. For another, you can monitor and/or control the IC-9700 from your preferred SDR software and hardware of your choosing. Or you can use an external SDR to independently drive a larger display, which allows you to monitor a large segment of a band. And you can use it to do things the IC-9700 can't do natively.

For example, an EME operator may use the PTRX-9700, feeding another SDR along with *HDSDR* software and *MAP65* software (provided with *WSJT-X*) to decode 90 kHz — the entire EME band segment — at once, something the IC-9700's own receiver cannot do. Another application for two receivers might be to operate two instances of *WSJT-X* on one band at the same time, with one running MSK144 and the other on Q65. Or you might run CW or SSB on the IC-9700 and decode meteor scatter signals using MSK144 on the SDR. Or perhaps monitor the beacon subband while making contacts in the weak-signal portion of the band, or during an FM contact.

Architecture

The PTRX-9700 is a small module that mounts to existing screw locations on the IC-9700 main board. It sits inline with the three receive signal paths, one per band, providing buffering, filtering, and multiplexing.

Bottom Line

The PTRX-9700 is a high-quality add-on for the IC-9700 that provides an easy way to integrate an external SDR receiver, opening the possibility to demodulate 90 kHz of a band simultaneously or monitor two in-band frequencies at once, using your choice of SDR software.

Functionally, it breaks out each band's receive RF signal and feeds the signals from the IC-9700's currently selected band to the internal receiver and to an external SDR that you provide, with no loss in signal such as you'd have with a receive splitter. The board's architecture is shown in Figure 3.

One important caveat: The PTRX-9700 can operate only on the currently selected band of the IC-9700. If you're operating, say, 144 MHz, it feeds only the 144 MHz signal out to the external SDR. It doesn't offer the ability to use the external SDR to watch a second band while using the IC-9700's built-in waterfall display on the currently selected band.

Installation

Installing the PTRX-9700 took me about 20 minutes. The biggest part of the job is removing and then reinstalling all of the bottom cover screws on the radio — it has a dozen of them. Once you have the bottom cover off the radio, there's plenty of room to work, and installing the board is straightforward. The key steps are:

1) Disconnect power from the radio, and remove the bottom cover.
2) Remove two of the screws that hold the main board to the radio, and replace them with standoffs and longer screws, mounting the PTRX-9700 to the standoffs.
3) Disconnect the three receive signal cables (one per band), and connect the PTRX-9700 board in series with them using the provided cables.
4) Insert the PTRX-9700 into the external reference signal path with the provided cable.
5) Insert the PTRX-9700 into the power path to the main board by moving a power connector and inserting the provided wiring harness.

The most intrusive part of the installation is cutting a few plastic wire ties to facilitate moving the last section of the radio's power wiring harness to the PTRX-9700.

Figure 4 shows the PTRX-9700 installed in the IC-9700. At this stage, the RF connections on the PTRX-9700 input are completed, and the cables supplied with the PTRX-9700 route RF back to the radio's main RF board. Figure 5 shows the board after the installation is completed.

Radio Analog makes installation easy by providing an L-shaped tool with properly placed tabs for removing and installing the tiny U.FL RF connectors that Icom uses to attach cables to the board. These are difficult to manipulate and securely attach without this tool — props to Radio Analog for including it.

Once I had installed the board, buttoning up the radio and testing it were all that remained. For level of difficulty, I'd give this a 1 out of 5. Very straightforward.

Options

If you are using the IC-9700 without an external reference, then all you need to do after the installation is connect your external SDR with the provided SMA male-to-male cable. If you plan to use an external reference with the radio, you have a couple of options: Use the provided splitter board to inject the reference signal, or upgrade the radio's external reference functionality using a Leo Bodnar Reference Injection Board (see the next review in this issue of *QST*) and accompanying 49.152 MHz reference oscillator.

The Reference Injection Board fits inside the radio side by side with the PTRX-9700 and uses the provided cable and splitter. Radio Analog provides a connection diagram for this option on their website. Both options fit into the radio easily, and the interconnections are no more challenging than either one by itself.

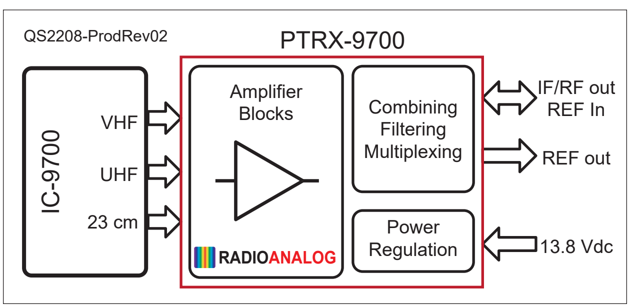

Figure 3 — Functional block diagram of the PTRX-9700.

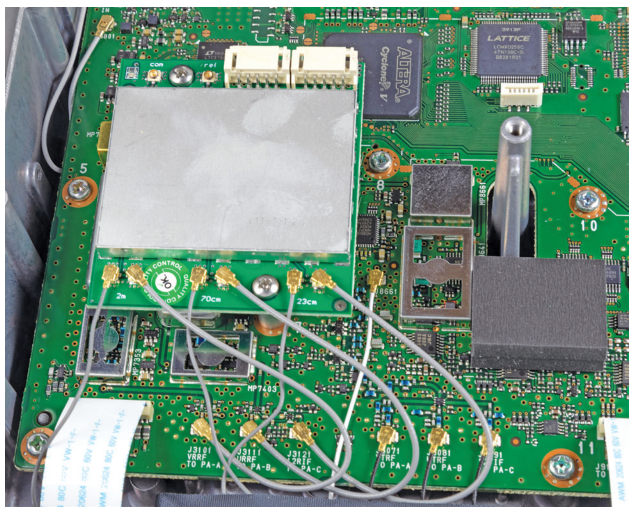

Figure 4 — PTRX-9700 installed in the IC-9700. RF connections on the near side of the board are completed. The IC-9700's internal cables now route to the PTRX-9700, and the PTRX board routes connections back to the radio's main RF board after filtering and buffering.

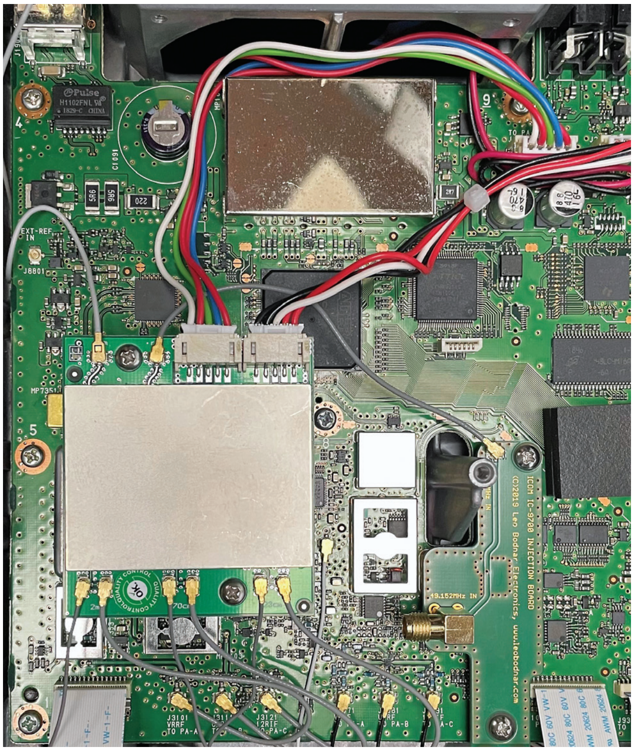

Figure 5 — Adding the Leo Bodnar external reference board to the IC-9700 alongside the PTRX-9700. The two options seem almost made to go together. The Bodnar board is visible just to the right of the center support post and connects to the PTRX-9700 using a cable provided with the PTRX-9700.

For digital mode operation on 1296 MHz, especially for EME, I like option 2. You can add the PTRX-9700 before or after you install the Leo Bodnar kit, if you go that route. It doesn't add any time to the installation process, so I recommend doing both at the same time. Figure 5 shows the two options installed inside the IC-9700.

Operation

Once you've installed the PTRX-9700 and, if appropriate, connected the external reference to the provided splitter board, connect your SDR and select appropriate SDR software for your computer. With my setup, I use HDSDR. I did initial testing with a HackRF One and then moved to an Airspy HF+. Since the Airspy HF+ also works well with MAP65 for 144 MHz EME, that's the SDR on which I settled. I've also tested with a FUNcube Dongle Pro+, which is another good choice.

To use the PTRX-9700, you'll need an SDR that covers your bands of interest, such as 144 – 148 and 430 – 450 MHz. For 1240 – 1300 MHz operation, the IC-9700 uses 311 – 371 MHz as its IF range, so 1296 MHz is equivalent to 367 MHz at the rear-panel SMA connector, where the SDR connects. Based on that, to cover the entire 144 – 1300 MHz range of the IC-9700, you'd need an SDR that covers 144 – 148, 311 – 371, and 430 – 450 MHz. Even a simple SDR like an RTL-SDR dongle can do the job, but you'll be rewarded with better performance if you choose a higher-performance SDR.

For EME operators, MAP65 (which is part of the WSJT-X installation) is a great way to go with the PTRX-9700. MAP65 supports multiple SDR options, including the FUNcube Dongle, SDR-IQ, Perseus, IQ+, WSE, SoftRock, and others. The key to covering the full EME band is being able to sample at 96000 or 95238 Hz.

Manufacturer: Radio Analog, **www.radioanalog.com**. Price: $329.

Leo Bodnar IC-9700 Reference Injection Board and Mini Precision GPS Reference Clock

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When it was released, the Icom IC-9700 received criticism, especially in the digital communications community, for its frequency accuracy and stability. Icom released a firmware update (version 1.10) that made it easier to set the radio's internal oscillator to match an external 10 MHz reference. Both topics were discussed in the Product Review of the IC-9700 in the January 2020 issue of *QST*. That adjustment is a manually applied setting, not a dynamic tracking feature that those familiar with the use of GPS-disciplined oscillators (GPSDOs) might expect.

Some good news for enthusiasts of optimal frequency accuracy and stability comes from UK-based Leo Bodnar Electronics, who introduced a nonintrusive, fully reversible, and affordable method of adding an external reference with tracking to the IC-9700. The Reference Injection Board is a small PC board that installs easily inside the IC-9700 and connects to an external reference oscillator running at 49.152 MHz. See the figures in the PTRX-9700 review in this issue for more details on the board's location and connections.

49.152 MHz is not exactly a common reference frequency. That said, TCXO and OCXO modules are available that can provide this frequency, but GPS-disciplined options are also readily available. Leo Bodnar offers GPSDOs that are programmable to work at nearly any frequency between 400 Hz and 810 MHz, including the Mini Precision GPS Reference Clock (miniGPS, as labeled), reviewed here. Paired with the Reference Injection Board, the miniGPS provides a great solution for GPS-locking the IC-9700, and one that works seamlessly with the Radio Analog PTRX-9700 that's also reviewed in this issue of *QST*.

Installation

The Reference Injection Board installs easily inside the radio. The process is simple; the most time-consuming part is taking the bottom cover off the radio. Follow these installation steps:

1) Remove all connections from the radio. Remove the bottom cover.
2) Peel off the black spongy cover on the reference input shield. Leo Bodnar recommends affixing it elsewhere inside the radio, but I removed it from my radio.
3) Remove the screws on the main board that are marked 10 and 11. Install them in the two blank holes on the Reference Injection Board.
4) Install the Reference Injection Board using the supplied hardware.
5) Install the supplied SMA extension cable between the injection board and the rear panel 10 MHz reference input. Alternatively, connect it using a supplied cable with the PTRX-9700 board.
6) Reinstall the bottom cover.

Reconnect and test the radio. Its operation should be unaffected by installing the board. It's not until you connect the 49.152 MHz reference that you'll see a difference in operation.

The board is held in place with two screws and two spacers. The screws are longer than the factory ones to accommodate positioning the board above a perforated shield, where the injection board couples 49.152 MHz energy into the radio.

Leo Bodnar's attention to detail is evident in the board's design. The factory screws thread into two holes in the board for permanent storage. Should you ever decide to remove the Reference Injection Board, you can remove those screws from it, remove the board, and place the screws back into the main board — a nice touch.

Setup and Operation

You don't need any test equipment to align and use the Reference Injection Board with the miniGPS receiver. You'll need to configure the miniGPS to supply the correct reference frequency, using the configuration software available from the Leo Bodnar product page. It's available for Windows or Mac OS X (see Table 2).

Connect the miniGPS to a USB port using the supplied mini USB cable, and the supplied GPS antenna to the SMA GPS port. Then open the software and you should see a display similar to the one shown in Figure 6. If you're using the Mac application, the view is different but includes the same information, plus additional graphical elements, including a satellite map of the current GPS position.

Set the frequency to 49152000, and then click the **UPDATE** button in the right-hand pane. This saves the

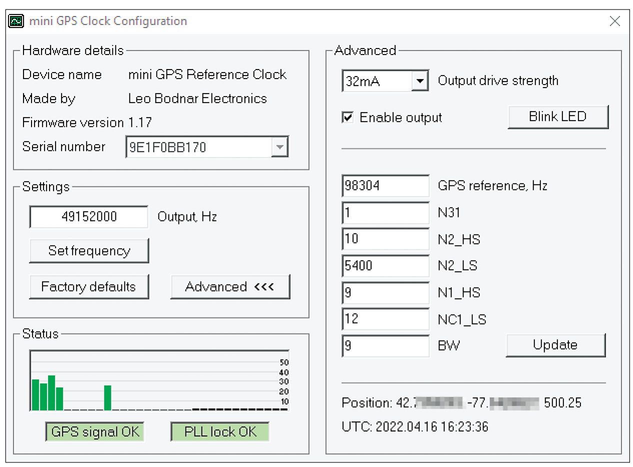

Figure 6 — The 32 mA output setting is recommended by Leo Bodnar for driving the IC-9700 Reference Injection Board. The utility (available from the miniGPS product page for Mac and Windows) requires only setting the output frequency, as shown.

Bottom Line

The Leo Bodnar miniGPS and Reference Injection Board provide a simple, affordable method of locking your IC-9700 to a GPS referenced clock for improved frequency stability and accuracy. High stability really matters, especially for digital mode operating, and this setup provides it in a small, well-designed package.

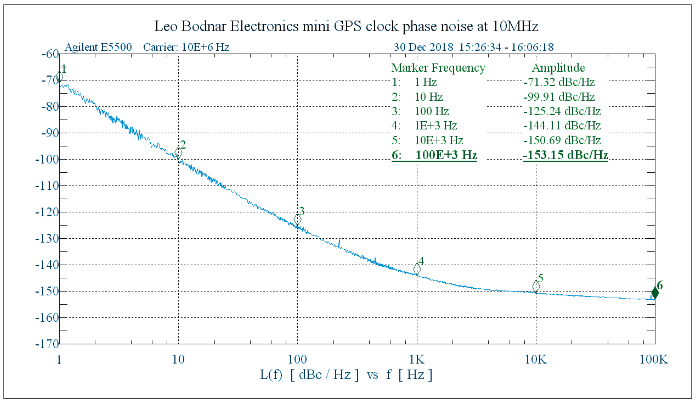

Figure 7 — Phase noise at 10 MHz output. [Graphic courtesy of Leo Bodnar]

Table 2 — miniGPS Specifications

Manufacturer Specifications

Input power:	5 V, 250 mA.
Output signal:	Square wave, configurable for 6.4, 9, 9.9, or 10.3 dBm (approximately 4 – 10 mW). SMA connector.
Output frequency:	400 Hz – 810 MHz, configurable through Mac or Windows software.
GPS antenna:	SMA connector, supports active or passive GPS antennas. Active antenna with magnetic base and 3-meter cable included with the miniGPS.
Phase noise:	Figure 7 shows the phase noise graph provided by Leo Bodnar.

configuration. Make sure that the output is set to 32 mA (about +10 dBm), as shown in Figure 6.

Connect the miniGPS output to the IC-9700 reference input SMA connector, and use the checkbox in the upper right-hand corner of the software window to enable the output. Your IC-9700 is now GPS-locked. If you're tuned into a signal, you'll be able to toggle the miniGPS output on and off and hear any difference in the radio in its reference-locked and unlocked states. Leo Bodnar provides the easy-to-follow process for adjusting the radio's internal reference oscillator to match the miniGPS on the product page.

What's remarkable about Figure 6 is that I took this screenshot while using the miniGPS in my ham shack, which is in the basement. The GPS antenna, supplied with the miniGPS, was sitting next to the GPS receiver at the time. I wasn't expecting to receive any GPS satellites — let alone acquire a position fix — until taking the antenna outdoors. Ultimately, as many as 10 GPS satellites were part of the fix. It took only a few minutes of powered-up time to reach a GPS fix, even though this was the first time the unit had been powered up since before it shipped from England. I was impressed.

Other Applications

I use a second miniGPS with my portable, tripod-mounted station for 10 and 24 GHz. In that setting, the miniGPS is configured for a 10 MHz output. It drives both transverters (Down East Microwave for 10 GHz, DB6NT for 24 GHz).

A significant advantage of the miniGPS is that it locks quickly. From a cold start, it achieves lock in about 1 second, even after sitting for weeks at a time. Fast lock time is important because time spent waiting for the GPS receiver to lock is time lost from making QSOs. By contrast, my previous 10 MHz OCXO solution took about 20 minutes for the oven to stabilize, and it consumed a lot more power. The miniGPS runs from a USB adapter and adds only about 85 mA of current drain at 14 V. By comparison, the OCXO drew more than 800 mA until the oven stabilized, and then dropped back to about 250 mA. Current drain is an important consideration for portable work, and the Leo Bodnar miniGPS is a definite win in that category. Its fast lock time is another important benefit.

In addition to the miniGPS, Leo Bodnar Electronics also offers a larger model with the same output frequency range, and two BNC output connectors, for 165 GBP (around $200 USD). They also offer a number of other interesting products, some of which are available in the US at **https://v3.airspy.us/**.

The Leo Bodnar miniGPS and Reference Injection Board make great additions to your IC-9700. The improvement in frequency accuracy and stability — with such a small, affordable setup — makes a worthwhile improvement to the IC-9700's functionality, and one that is especially important to digital mode operators on the 432 and 1296 MHz bands. The miniGPS has many applications thanks to its flexible frequency and power-level settings. Both have long-term homes in my ham shack.

Manufacturer: Leo Bodnar Electronics, **www.leobodnar.com**. Available in the US via **https://v3.airspy.us**. Price: MiniGPS, $160; IC-9700 Reference Injection Board, $49.95.

COMPACtenna 2M/440+

Reviewed by Michael Fluegemann, KE8AQW
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For anyone looking for a low-profile mobile or station antenna for 2 meters and 70 centimeters, the 2M/440+ made by COMPACtenna may be right for you. I had the pleasure of using the 2M/440+ antenna for more than several weeks and found it to work well. At only 9 inches tall, it is ideal for cars that park in garages with low clearances. COMPACtenna also sells the CompacCounterpoise, which turns this antenna into a great base-station antenna with the benefit of being small, perfect for those who need to conceal their antennas from view.

Hardware Details

The 2M/440+ antenna looks like a black cylindrical tube that is about 9 inches tall and 1.5 inches wide. It has an NMO connector with a leaf spring as the center connector. The manufacturer specifications say the antenna can handle 100 W on the 2-meter band and 75 W on the 70-centimeter band, with an SWR of less than 2:1 on both bands (see Table 3). My SWR tests show that the antenna performed as specified or better. With the mag mount on my vehicle, I got an average of 1.8:1, and the station installation with the ground plane was even better, with an average of 1.5:1. Unlike other antennas that are shortened with a loading coil, this antenna has a patented design "with a special design construct of spiraled and cylindrical metal sheeting." Even though this antenna seems small, it is advertised with 5 dB-MEG gain. The geometry of the antenna provides the matching network, and because the antenna has a strong magnetic near field, local noise is reduced.

I used this antenna with a Larsen NMO magnetic mount on my Ford Focus and with the CompacCounterpoise at my house. The counterpoise kit came with a bracket that has an NMO connector for the antenna and an SO-239 connector for the coax. There are four ground-plane elements that are 18 inches long. After attaching them with the provided screws, washers, and nuts, I was able to attach the mount to my deck with the provided hose clamps (see Figure 8). The kit also came with lube for the threads, as well as a rubber gasket.

Road Trip

Shortly after receiving the 2M/440+ antenna, I took a road trip from Detroit, Michigan to Huntsville, Alabama

Bottom Line

At only 9 inches tall, the COMPACtenna is an ideal low-profile, dual-band antenna for cars that need low clearances or for a stealth station installation without compromising on performance.

Table 3 — COMPACtenna 2M/440+
Manufacturer's Specifications

Frequency Coverage: 144 – 148 MHz, 430 – 450 MHz

(V)SWR: Nominal <2:1, 144 – 148 MHz; 430 – 450 MHz

Maximum Power Rating: 100 W for the 2-meter band; 75 W for the 70-centimeter band

Connector: NMO

Gain: Nominal 5(+) dB-MEG

Antenna Type: Unique Electric/Magnetic Field Diversity Science & Technology Patented Design (Patent No. US 9,407,001)

Maximum Duty Cycle at Maximum Power Rating: 1 minute in any 2-minute period

Dimension: Length, 9 inches × 1.5 inches diameter

Figure 8 — The COMPACtenna 2M/440+ balcony station installation with CompacCounterpoise ground plane.

to visit my friends for their wedding. This was the perfect opportunity to test the antenna. I connected it to my Kenwood TM-V7A and positioned the antenna on the roof of my Ford Focus in the rear passenger corner (see Figure 9), as the instructions suggested better omnidirectional performance on a corner. Throughout my 10-hour trip, I tried hitting several 2-meter and 70-centimeter repeaters. I found I was able to hit several of them. Specifically, while I was near Nashville, I was able to hit NE4MA at 442.800 MHz with a good signal from 21 miles away. Then on my trip home, I was able to hit WC8OH at 145.110 MHz with a good signal from over 25 miles away, and I could still hear it faintly at 40 miles away.

Figure 9 — The COMPACtenna 2M/440+ vehicle installation with the Larsen NMO magnetic mount.

Satellites

Satellite operation was one of the other use cases suggested in the instructions. While using the radio in my car, I tried a couple of FM satellite passes with the new ISS repeater and SO-50. On both occasions I was able to get into the satellites and make a couple of contacts. This could be a good option for those without a handheld Yagi or those who would prefer a simple setup that does not require moving an antenna.

Base Station

With the antenna mounted on the CompacCounterpoise on my deck and plugged into my Kenwood TM-V7A, I was able to hit several of my local repeaters with ease. I have not had a base-station antenna for VHF/UHF and have relied on a Diamond NR22L dual-band 5/8-wave vehicle-mounted antenna in the past to call into nets on repeaters that were too hard to hit with a handheld. The performance of the COMPACtenna 2M/440+ installed at low height was comparable to the performance of my Diamond antenna mounted on the vehicle.

Final Thoughts

The COMPACtenna 2M/440+ antenna performed well for its small footprint. I highly suggest this antenna for anyone who needs the short form factor but doesn't want to compromise on the performance.

Manufacturer: COMPACtenna, **www.compactenna.com**. COMPACtenna 2M/440+ Antenna, price: $109.95. COMPACtenna CompacCounterpoise NMO Mount Base Station Ground Plane, price: $99.95. Larsen NMOMMRPL Mobile Antenna Magnet NMO Mount, price: $69.99.