

Yaesu FT-650 6/10/12-Meter Transceiver

Reviewed by Jon Bloom, KE3Z

Even though it covers only the amateur 12, 10 and 6-meter bands (plus continuous receive-only coverage from 24.5 to 56 MHz), the FT-650 has most of the features you'd expect to find in an all-band HF transceiver, including the benefits of digitally controlled frequency synthesis: memories, split-frequency operation and scanning. If you're in the market for a radio covering these bands, the FT-650 offers you quite a bit. And it's the only 100-watt 6-meter transceiver available to US hams.

Standard Features and Options

The FT-650 transceives in AM, CW, FM and SSB modes. Although it doesn't have separate RTTY or packet modes, it does have a connector for attaching 1200-baud AFSK packet modems. The '650 requires 13.8 V dc at 18 A on transmit and 2 A on receive; the FP-22 ac-operated switching power supply slips easily into a cavity in the rear of the transceiver. This design makes changing from home-station to mobile operation a snap.

The '650's receiver includes IF shift, a noise blanker and a notch filter. The notch filter can be operated manually or in an auto-tracking mode, in which it seeks, notches and tracks offending carriers. In place of a continuously variable IF-bandwidth control, the FT-650 allows selection from several IF bandwidths. The FT-650 manual states that, "In addition to standard IF bandwidths, fine tailoring of the IF passband is made possible by two of the DDSs [direct digital synthesizers], providing selectable IF bandwidths of 1.8, 2, 2.2 and 2.4 kHz in SSB modes, 300, 600, 1200 and 2400 Hz in CW mode, 2.4 and 6 kHz in AM and 8 and 15 kHz in FM modes (the two narrowest CW modes require an optional filter)." Of these, only the 600-Hz and 2.4, 6, 8 and 15-kHz choices reflect the actual bandwidths of single IF filters. The FT-650 uses two filters to implement the 300-Hz and 1.2, 1.8, and 2.2-kHz selectivities with a form of programmable, stepped variable bandwidth tuning (VBT).¹

The FT-650's triple-conversion receiver has intermediate frequencies of 13.69 MHz, 455 kHz and 8.215 MHz. Its front-end sensitivity can be varied by selection of a 10-dB attenuator or a 10-dB-gain preamplifier. The radio's AGC circuit has fast- and slow-decay modes; it cannot be turned off.

The transmitter includes an RF speech



processor. When you're transmitting, the built-in meter can indicate ALC voltage, SWR and output power (peak or average, selected by an internal switch). The FT-650's RF output is continuously variable from less than 5 watts to about 100 watts (50 watts in AM mode). VOX operation is *not* included, although semi-break-in CW is provided with an internally adjustable hang time.

FT-650 options include Yaesu's DVS-2 digital voice recording/playback unit and FTS-8 tone-squelch encoder/decoder. (The reviewed unit didn't include these options; see the FT-1000D review in March 1991 *QST* for a review of DVS-2 operation.)

The combination of direct digital synthesis and microprocessor control make for a good set of frequency control features, including RIT (or *clarifier*, as Yaesu calls it), 105 memories, split-frequency operation, repeater-offset selection and several scanning modes. Keypad frequency entry is not included. The FT-650 is also computer-controllable (frequency/memory/mode/PL-tone selection, TR switching) via Yaesu's CAT protocol.

The radio's fluorescent display brightness can be adjusted to one of eight levels. The brightest of these isn't adequate for operation in strong sunlight, but the control range is wide enough to handle most other lighting conditions.

Installing the optional 600-Hz IF filter in the FT-650's 455-kHz IF requires removing the radio's top cover and one of its plug-in circuit boards, and soldering the filter to the board. Once this is done, you flip a switch to enable the new filter and reinstall the board in the radio. The whole process takes

only 15 minutes or so to complete.

The Manual

Yaesu continues to produce superior manuals. I especially appreciate the manual's photographs of each of the connectors that can be attached to the radio, with labeling to show the proper connection point for each signal on the connector. You need not squint to read the embossed black-on-black pin numbers on those tiny DIN connectors when making cables for the FT-650! And the FT-650 manual contains—surprise!—*examples* of how to perform the more complex memory and scanning operations. Having a lot of control operations is only useful when they're properly documented—and Yaesu addresses this need nicely in the FT-650 manual.

Operation

The FT-650 includes a host of well-thought-out control features. It's obvious that Yaesu designers actually *operate* ham radios! Two of the three bands covered by this radio allow FM operation (6 and 10 meters), and FM is well-integrated into the FT-650 design.

Operating Modes

The FT-650's CW operation is smooth, but its keying is hard, resulting in considerable key clicks. The CW offset and sidetone pitch are fixed. Also, the FT-650 suffers from the all-too-common problem of "dot swallowing"—that is, in semi-break-in mode, the first keyed element of each transmission is shortened—by about 14 milliseconds, according to our lab tests—and

¹G. C. Collins and D. Newkirk, "Transceiver Features That Help You Beat Interference," *QST*, Mar 1991, pp 16-21.

Table 1**Yaesu FT-650 6/10/12-Meter Transceiver, Serial Number 0M050123****Manufacturer's Claimed Specifications**

Frequency coverage: Receive, 24.5-56 MHz; transmit, 24.5-25, 28-29.7 and 50-54 MHz.

Modes of operation: AM, CW, FM, LSB, USB.

Power requirement: 110-125 or 220-234 V ac or 13.8 V dc. Receive, 55 W max; transmit, 500 W max.

Receiver

Receiver sensitivity (preamp on, bandwidth not specified): 0.125 μ V (–125 dBm).

AM (10 dB S/N, preamp on): 0.5 μ V (–113 dBm).

FM (12 dB SINAD, preamp on): 0.16 μ V (–123 dBm).

Receiver dynamic range: Not specified.

Third-order input intercept: Not specified.

S-meter sensitivity (for S9 reading): Not specified.

CW/SSB squelch sensitivity: Less than 0.2 μ V.

FM squelch sensitivity: Less than 0.125 μ V.

Notch-filter attenuation: More than 40 dB.

Receiver audio output: More than 1.5 W at 10% distortion with an 8- Ω load.

Receiver IF/audio response: At least 400-2600 Hz at –6 dB.

Transmitter

Transmitter power output: SSB/CW/FM, 10-100 W; AM, 50 W carrier.

Unwanted-signal suppression (below 30 MHz/above 50 MHz; Harmonic, >50 dB/70 dB below peak output; nonharmonic, >40 dB/60 dB below peak output.

Carrier and opposite sideband suppression: >40 dB below peak output.

Third-order intermodulation distortion products: Better than –31 dBc at 80 W PEP output at 51 MHz.

CW-keying waveform: Not specified.

Transmit-receive turnaround time (PTT release to 90% audio output): Not specified.

Size (height, width, depth): 4.33 \times 11.2 \times 10.3 inches; weight, 18 lb with internal power supply, 15 lb without.

†Unless noted otherwise, blocking dynamic range and third-order IMD dynamic range measurements were made at the ARRL Lab standard signal spacing of 20 kHz.

††Test-equipment limitations inhibit ARRL Lab measurement of notches deeper than about 30 dB.

Measured in the ARRL Lab

As specified.

As specified.

Not measured.

Receiver Dynamic Testing

Minimum discernible signal (noise floor) with 300-Hz IF bandwidth:

Frequency	Preamp off	Preamp On
24.9 MHz	–132 dBm	–138 dBm
28.0 MHz	–135 dBm	–139 dBm
50.0 MHz	–133 dBm	–139 dBm

10 dB S + N/N (6-kHz IF filter, signal 30% modulated with a 1-kHz tone, preamp off): 28 MHz, –119 dBm; 50 MHz, –120 dBm.

12 dB SINAD, preamp off: 29 MHz, –111 dBm; 50 MHz, –112 dBm.

Blocking dynamic range (300-Hz IF bandwidth):†
Preamp off: 28 MHz, 140 dB; 50 MHz, 109 dB.
Preamp on: 28 MHz, 114 dB; 50 MHz, 104 dB.

Two-tone, third-order intermodulation distortion dynamic range (300-Hz IF bandwidth):†

Preamp off: 28 MHz, 84 dB; 50 MHz, 86 dB.
Preamp on: 28 MHz, 82 dB; 50 MHz, 82 dB.

Preamp off: 28 MHz, –9 dBm; 50 MHz, –4 dBm.

Preamp on: 28 MHz, –16 dBm; 50 MHz, –16 dBm.

At 28 MHz: preamp off, –88 dBm; preamp on, –98 dBm.

As specified.

As specified.

More than 30 dB.††

2.1 W at 5% total harmonic distortion with an 8- Ω load.

2.4-kHz IF bandwidth: 120-2532 Hz.

Transmitter Dynamic Testing

Output power: 24 and 28 MHz, 95-115 W (CW, SSB, FM—output is typically more than 110 W and varies slightly by mode and band); 50-54 MHz, 88-93 W; AM, as specified. Minimum output: 3-4 W on each band.

As specified. See Fig 1.

>62 dB at 28.2 MHz.

As specified. See Fig 2.

See Fig 3.

S1 signal, 34 ms; S9 signal, 28 ms.

hardened. This occurs because of the delay between the time the radio is keyed and when it first puts out RF. The FT-650's CW transmit performance leave considerable room for improvement.

SSB operation with the '650 is straightforward, requiring only microphone-gain adjustment, with the aid of the multimeter's ALC scale. RF speech processing is available at the touch of a push-button switch. On-the-air reports indicated that the proces-

sor provides a modest amount of compression with no noticeable distortion. Curiously, Yaesu rates the radio at 100 watts output, but specifies its transmitter IMD as –31 dBc (decibels relative to the carrier) at 80 watts PEP output at 51 MHz. This is acceptable IMD performance, but isn't particularly impressive for a 1990s transceiver. Our review FT-650 meets that specification at 51 MHz and does slightly better in the 24- and 28-MHz bands; at 100 watts

PEP output, however, transmitted IMD products are typically 4-5 dB worse than they are at 80 watts, reaching a maximum of –26 dBc. In other words, operated at 100 watts PEP output, this radio produces objectionable distortion products (splatter) on adjacent frequencies. These IMD products can be especially bad if the FT-650 is used to drive an external power amplifier that requires more than 80 watts of drive. In sum: Keep the FT-650's SSB output at

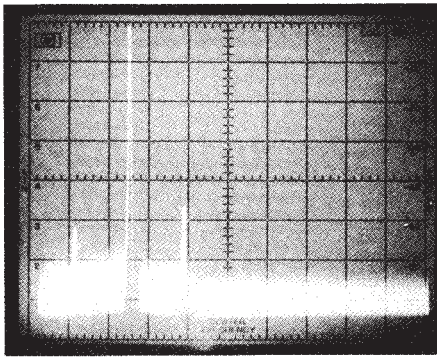


Fig 1—Yaesu FT-650 worst-case spectral display. Horizontal divisions are 10 MHz; vertical divisions are 10 dB. Output power is approximately 3 W at 24.5 MHz. All harmonics and spurious emissions are at least 46 dB below peak fundamental output. The FT-650 complies with current FCC specifications for spectral purity for equipment in this power-output class and frequency range.

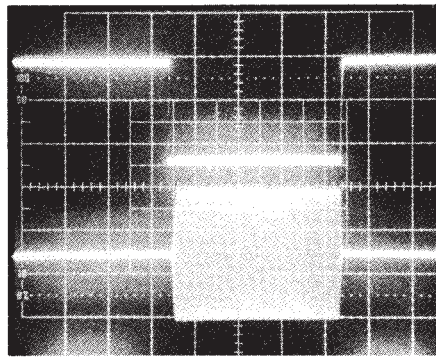


Fig 3—CW-keying waveforms for the Yaesu FT-650 in the semi-break-in mode. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 5 ms. The transceiver was being operated at 100 W output on 28.25 MHz. The FT-650's CW keying is hard; clicks are audible on the keyed signal. The first keyed element, not visible in this photograph, is shortened by approximately 14 ms.

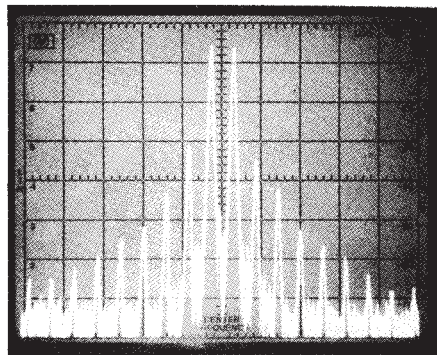


Fig 2—Worst-case spectral display of the FT-650 transmitter during two-tone intermodulation distortion (IMD) testing. Third-order products are approximately 31 dB below PEP output, and fifth-order products are approximately 42 dB down. Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The transceiver was being operated at 80 W PEP output at 51 MHz. Transmitter IMD performance at 100 W PEP output is considerably worse than that at 80 W; see the text for details.

or below 80 watts PEP, whether you're operating with or without an external power amplifier.

The FT-650's lack of a separate RTTY mode makes it difficult to use the optional 600-Hz filter for RTTY or packet operation. This is a serious drawback for anyone considering use of the FT-650 for the digital modes on HF. For 1200-baud operation, though, the FT-650 should prove quite acceptable for FM-AFSK operation on 6 meters (such operation isn't legal on 10 meters in the US), 1200-bit/s PSK, and 2400-bit/s operation using the SSB mode.

FM operation is simple with the FT-650, and the 100-watt 6-meter output makes for a big signal among the FM crowd. The '650's selectable repeater offset allows use

of nonstandard-offset repeaters, and its memory system has all the control features you could want for FM. Access to most repeaters is possible with the optional CTCSS encoder. (The optional FTS-8 tone unit supports all but one [97.5 Hz] of the ARRL-recommended 10-meter access tones.)

Two "VFOs" (really tuned memories) are available in the FT-650. The primary use of the second VFO is for split-frequency operation. The FT-650 puts no limitation on the split: transmit and receive operation may be on different bands or even different modes. VFO contents can be stored in memory at any time. The memories store operating frequency, mode, IF-bandwidth selection, RIT setting and repeater offset. The main tuning knob selects memories during memory-storage and -recall operations. A recalled memory setting can be changed—you can tune around, for example—without affecting either the memory contents or the VFO settings. The modified memory information can, of course, be rewritten to memory (the same one or another) or to the selected VFO.

The FT-650's scanning function can be programmed to continuously step through the transceiver's memories or to stop when a signal is detected. During its mode-specific scanning, the radio scans only the memories set to a selected mode—handy for scanning only stored FM channels, for instance. You can program the '650 to skip individual channels; this programming can be overridden with the microphone PTT switch.

Of the FT-650's 105 memories, 99 are general-purpose, and the remaining six are devoted to specialized scanning modes. Two band segments can be selected for use in the programmed-scan mode. This mode scans the selected segments in selectable frequency steps, stopping when signals are detected. During scan pauses in this mode, you can

manually tune the radio's frequency within the programmed limits.

The FT-650 can also perform priority-channel monitoring, in which up to two stored channels can be checked for activity once every 5 seconds.

A Novel Notch

The FT-650's tracking notch filter uses a phase-locked loop to lock onto a single steady signal such as a heterodyne or carrier, and adjusts itself to minimize that signal. This filter is similar in action to the j-Com Magic Notch reviewed elsewhere in this column, except that the j-Com version works at audio and Yaesu's works at IF. The FT-650's notch filter works well, too, although it has trouble eliminating weak carriers. (Weak signals aren't as much of an interference problem as strong signals, anyway.) In the US, heterodyne interference isn't often encountered on the bands covered by this transceiver—but we understand that higher band occupancy makes the FT-650's automatic notch filter potentially very useful in Japan. (Yaesu, how about working this feature into US-bound radios that cover 20 and 75 meters?) You can also switch the notch to manual control and adjust it the old-fashioned way.

Noise Blanker

The FT-650's noise blanker works well. A neighbor's old rattletrap car provided me with an excellent source of test signals, which the FT-650 noise blanker all but eliminated. (The noise, that is, not the source!) The FT-650 is a natural for mobile operation, and an effective noise blanker is essential for that application.

Pros and Cons

In spite of the many control features built into the FT-650, its uncluttered front panel makes the radio easy to use—and to learn to use. A few rough edges exist, though.

The F key selects the transceiver's fastest tuning rate and selects a second set of commands on the control keypad. Because the F key is right next to the tuning knob, it's all too easy to brush the tuning knob and experience a large jump in frequency when all you want to do is select a keypad function. A bit more physical separation would have been nice—or how about an UNDO key? Another complaint: The FT-650 displays its operating frequency in 100-Hz steps, even though it tunes in 10-Hz steps. Although you may not often need to know your exact frequency for casual QSOs, setting up frequencies for skeds, channelized operation and digital modes would be much easier with 10-Hz display resolution.

Senior Assistant Technical Editor Dave Newkirk, WJ1Z, considers the FT-650's dynamic receiver performance to be out of keeping with the radio's pedigree and expense. With a third-order-IMD dynamic range (DR) measured as 82 to 86 dB (depending on the frequency and whether its preamp is on or off), the FT-650's ability to handle strong signals without gener-

ating spurious signals of its own is about 10 dB (and thus about 10 years) behind the times below 30 MHz, and on the low edge of okay at 50 MHz. (More WJ1Z opinion: Third-order-IMD-DR figures in the 90s—at least—are appropriate below 30 MHz for radios of the 90s that cost this much. At 50 MHz, 1990s radios of this pedigree and expense should exhibit third-order DRs no lower than the high 80s.) The FT-650's strong preamp-off blocking-DR performance at 28 MHz (140 dB) is marred by much worse performance with the preamp on (114 dB); at 50 MHz, its blocking-DR performance is just okay. On the other hand, the FT-650's composite-noise perfor-

mance is good enough to allow us to measure its 28-MHz, preamp-off blocking DR as 140 dB—a very respectable number.

The FT-650's frequency synthesizer—and the realities of amateur operation between 24.89 and 54 MHz—merit a stronger receiver front end.

Along slightly different lines, NJ2L notes that the FT-650 has no provisions for use with transverters as an IF transceiver (no low-level transmitted signal is available at the rear panel, and the only place to connect a receive-converter output is the FT-650's antenna jack).

Overall, the FT-650 provides good performance. Its control features are well

designed for operator convenience and flexibility. Its 100-watt 6-meter output is attractive, too. If your interest lies in the upper-HF and lower-VHF spectrum, consider the FT-650 a contender, especially if FM operation is in your plans.

Thanks to Dave Newkirk, WJ1Z, for contributing to this review.

Manufacturer: Yaesu USA, Inc, 17210 Edwards Rd, Cerritos, CA 90701, tel 213-404-2700. Manufacturer's suggested retail prices: FT-650 with internal power supply, \$1599; XF-455M601-01 600-Hz CW IF filter, \$159; DVS-2 digital voice recorder/player, \$289.95; FTS-8 CTCSS encoder/decoder, \$55.

Audio-Filter Roundup

Audio filters have long been popular accessories in the ham shack. The following reviews take a look at three relatively new and unique audio filters for Amateur Radio use. Although this is not a comprehensive overview of currently available audio filters, it spotlights some interesting and promising developments.

As you read these reviews, keep in mind that audio filters have one major performance handicap (when compared to IF filters): They do their work outside the receiver AGC loop. Therefore, any audio filter, no matter how effective, can't keep strong signals in or adjacent to the receiver passband from actuating the receiver AGC. At best, this effect can be annoying; at worst, it pushes desired signals below the AGC threshold, where no audio filter can revive them.—Ed.

THE j-COM MAGIC NOTCH AUTOMATIC AUDIO NOTCH FILTER

Reviewed by Jim Kearman, KR1S

Readers of *QST*, *The National Contest Journal* and other ham magazines have probably noticed j-Com's Magic Notch advertisement. The ad features a cartoon of a hapless ham bemoaning the fact that all the DX nets are on the national tune-up frequency. Hearing stations tuning up all over the HF bands shows that j-Com has stepped in to fill a real, if aggravating, need.

The Magic Notch is small (3 × 1.25 × 5.5 inches HWD), and requires 10-14 V dc at a maximum of 200 mA. The Magic Notch's single control, a front-panel switch, is labeled OFF, BYPASS, and ON. You connect the Magic Notch between your headphone or speaker jack and your headphones or speaker via 1/8-inch jacks. The headphone jack is wired for stereo headphones; you'll need an adapter to use headphones with a 1/4-inch, two-conductor plug. (Such adapters are available from many sources, including Radio Shack [p/n 274-047].) You set the front-panel switch to ON, and forget about single-heterodyne interference. Period.

A device this clever deserves a few more

words, though. The little blue-and-gray box contains a switched-capacitor audio filter (SCAF), which constantly scans through the its speech-audio passband (the manual defines its "active range" as 200-4000 Hz). Speech signals vary in frequency and amplitude and are ignored by the filter. It notices continuous tones, however. Frequency information from the scanning circuit is passed to the notch filter, which slices out a sliver of the passband, attenuating the interfering signal.

So, you ask, suppose the interfering signal starts to wobble in frequency? Well, once the filter detects a carrier, it phase locks to it, so the "swishers" are also sliced out (figuratively, that is).

Best of all, if you leave the filter turned on, you might never know it's operating. Yes, it responds *that* quickly. Having sold you a neat gadget, the manufacturer would, of course, like you to know how much your life has been improved by purchasing it. So, the green LED on the Magic Notch's front panel turns red to tell you when the Magic

Notch is doing its job. I didn't notice any effect on received-signal intelligibility; the notch is narrow.

When operating CW, you'll probably have to place the filter in bypass mode. Otherwise, you'll find that it seeks out and attenuates signals you're trying to copy. Effectiveness against CW signals is necessary for the SSB operator, and not always to prevent careless or malicious interference. For example, on the 40-meter band, most SSB DX stations transmit on frequencies used for CW in the US.

The *Magic Notch* works extremely well against one undesired continuous tone in the passband. *Two* tones? That's a different story. I guess if you're really dedicated, you can connect two Magic Notch filters in series. Leave one on and the other in bypass mode. When you hear a carrier, you know there are two; the first one's been attenuated in the first filter, letting the second one sneak through. Just turn on the second filter and the carriers are neutralized. Of course, if you're dealing with more than two carriers

