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Product Review

FlexRadio Systems FLEX-6400M HF and 6-Meter SDR Transceiver

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The FLEX-6400M is a 100 W nominal SSB, CW, AM, FM, and digital-mode transceiver for 160 to 6 meters. Unlike previous FlexRadio SDR transceivers, the FLEX-6400M can be operated as a standalone radio that doesn't require a computer or separate control head for operation. Thus the FLEX-6400M — with its front panel that includes switches, knobs, and a high-definition color display — can fit into the traditional transceiver spot in a ham shack.

FlexRadio Signature Series Transceivers

Martin Ewing, AA6E, reviewed earlier versions of the direct-sampling Signature Series transceivers in *QST*.[1, 2] The FLEX-6400 is now the entry point instead of the FLEX-6300, while the middle ground includes the new FLEX-6600 rather than the FLEX-6500. The FLEX-6700 is still at the top of the lineup. The FLEX-6400 and FLEX-6600 are available in two configurations — a standalone model as in the FLEX-6400M reviewed here, and a blank front-panel model (without the M suffix) that requires an external control system. As with the earlier FlexRadio models, the control system can be a Windows-based PC, iPad, or iPhone running the appropriate *SmartSDR* software, or FlexRadio's Maestro control panel.

The Maestro is a thin front panel that looks very much like the front of the FLEX-6400M, but it can be mounted separately from the FLEX-6400 and interconnected via a built-in wireless link or via an ethernet cable. The Maestro can also be used for remote operation of the FLEX-6400 or FLEX-6400M over the internet, should you want to have a similar-looking front panel from a remote location. It provides the functionality of a PC running *SmartSDR*, but is independent of the PC. The price of the base FLEX-6400 starts at $1,999. With the Maestro, it is $199 more than the standalone FLEX-6400M.

Bottom Line

The FLEX-6400M expands FlexRadio's line of high-performance, direct-sampling transceivers to include a traditional front panel, allowing operation without the need for a computer for control and display. It can also be controlled locally or remotely from a Windows-based PC, iPad, or iPhone running the appropriate *SmartSDR* software, or from FlexRadio's Maestro control panel — perhaps offering the best of both worlds.

Other options for the FLEX-6400 include an internal automatic antenna tuner at $299 and a GPS-based frequency standard that will control the radio's frequency, as well as provide an accurate 10 MHz reference for other station and test equipment at $699. The review radio included the antenna tuner.

How It Works

As with the other *Signature Series* transceivers, this transceiver is based on a direct digital-sampling architecture with no conversion steps in front of the analog-to-digital converter (ADC). The radio samples and digitizes the entire spectrum from 0.03 to 55 MHz, thus information from any frequency range is immediately available. As shown in Table 1, the FLEX-6400M's performance is right up in the top tier of current HF transceivers.

The selected portion to be decoded is called a *slice*, and the FLEX-6400M can process two such slices from anywhere within the received spectrum, but both slices must come from the same antenna port. The

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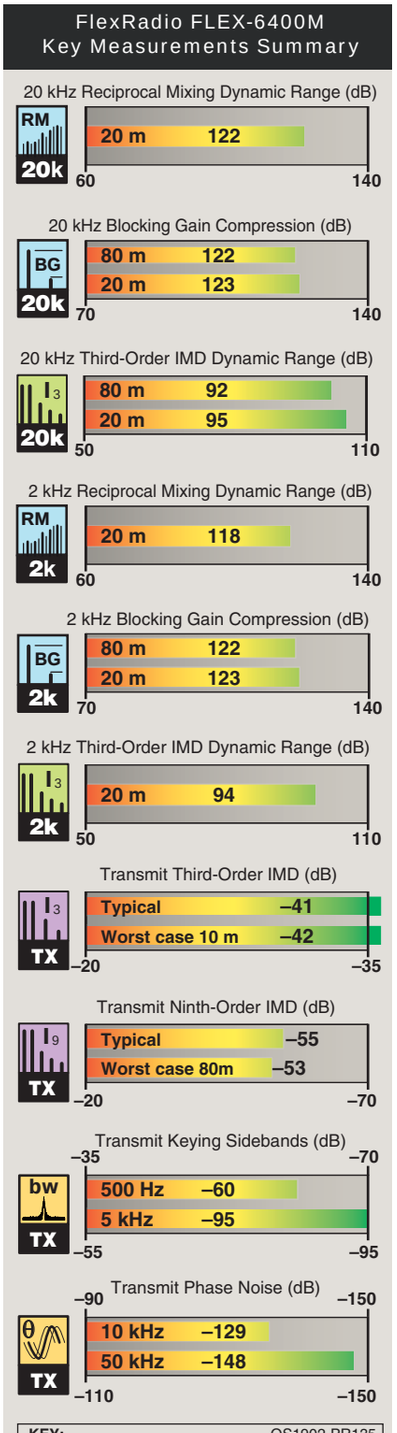

Table 1
FlexRadio Systems 6400M, serial number 1618-2097-6401-2120, v2.3.9

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: Receive, 0.03 – 54 MHz. Transmit, 160 – 6 meter amateur bands only.	Receive, 0.03 – 55 MHz. Transmit, 160 – 6 meter amateur bands including five 60-meter channels.
Power requirement: Transmit, 23 A (maximum). Receive, 1.7 A (typical) at 13.8 V dc (±15%).	At 13.8 V dc: Transmit, 22 A (typical), 12 A (AM) at maximum RF power output; 6.0 A at minimum RF output. Receive, 2.16 A (maximum backlight), 2.10 A (minimum backlight). Power off, 25 mA.
Modes of operation: SSB, CW, AM, FM, RTTY, digital.	As specified.

Receiver	Receiver Dynamic Testing
SSB/CW sensitivity: Not specified.	Noise floor (MDS), 400 Hz bandwidth, AGCT = 60: *Preamp* *0* *+16* *+32 dB* 0.137 MHz –115 –104 –98 dBm 0.475 MHz –117 –113 –115 dBm 1.0 MHz –115 –130 –127 dBm 3.5 MHz –113 –127 –132 dBm 14 MHz –114 –129 –138 dBm 50 MHz –115 –131 –138 dBm
Noise figure: Not specified.	Preamp 0/16/32 dB: 14 MHz: 33/18/9 dB; 50 MHz, 31/16/9 dB.
AM sensitivity: Not specified.	10 dB (S+N)/N, 1 kHz tone, 30% modulation, 6 kHz BW: *Preamp* *0* *+16* *+32 dB* 1.0 MHz 10.0 2.63 3.39 µV 3.88 MHz 18.0 3.46 2.11 µV 29.0 MHz 21.9 3.16 0.59 µV 50.4 MHz 14.8 2.21 0.81 µV
FM sensitivity: Not specified.	For 12 dB SINAD, 3 kHz deviation, 15 kHz BW: *Preamp* *0* *+16* *+32 dB* 29 MHz 21.9 3.16 0.59 µV 52 MHz 0.59 0.26 0.20 µV
Spectral sensitivity: Not specified.	Panadapter display, preamp 0/16/32 dB: 14 MHz, –127/–141/–149 dBm 50 MHz, –123/–139/–147 dBm Waterfall display, preamp 0/16/32 dB: 14 MHz, –130/–144/–154 dBm 50 MHz, –126/–142/–151 dBm
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range, 400 Hz BW: *20 kHz offset Preamp 0/16/32* *5/2 kHz offset Preamp 0 dB* 3.5 MHz 122/120/110 122/122 dB 14 MHz 123/122/115 123/123 dB 50 MHz 121/123/118 121/121 dB
Reciprocal mixing dynamic range: 115 dB at 2 kHz.	14 MHz, 20/5/2 kHz offset: 122/120/118 dB.

ARRL Lab Two-Tone IMD Testing (400 Hz bandwidth), AGCT = 60:

Band/Preamp	*Spacing*	*Measured IMD Level*	*Measured Input Level*	*IMD DR*
3.5 MHz/0	20 kHz	–113 dBm –97 dBm	–21 dBm –8 dBm	92 dB
14 MHz/0	20 kHz	–114 dBm –97 dBm	–19 dBm –6 dBm	95 dB
14 MHz/+16	20 kHz	–129 dBm –97 dBm	–33 dBm –15 dBm	96 dB
14 MHz/+32	20 kHz	–138 dBm –97 dBm	–44 dBm –29 dBm	94 dB
14 MHz/0	5 kHz	–114 dBm –97 dBm	–19 dBm –6 dBm	95 dB
14 MHz/0	2 kHz	–114 dBm –97 dBm	–20 dBm –6 dBm	94 dB

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Band/Preamp	*Spacing*	*Measured IMD Level*	*Measured Input Level*	*IMD DR*
50 MHz/0	20 kHz	–115 dBm –97 dBm	–20 dBm –10 dBm	95 dB
50 MHz/+32	20 kHz	–138 dBm –97 dBm	–42 dBm –15 dBm	96 dB

Second-order intercept point: Not specified.	Preamp 0/16/32 dB: 14 MHz, +71/+71/+71 dBm 21 MHz, +71/+71/+69 dBm 50 MHz, +83/+83/+71 dBm
DSP noise reduction: Not specified.	12 dB.
FM adjacent channel rejection: Not specified.	Preamp +32 dB: 29 MHz, 97 dB; 52 MHz, 95 dB.
FM two-tone third-order IMD dynamic: range: Not specified.	20 kHz offset, preamp +32 dB: 29 MHz, 84 dB; 52 MHz, 90 dB; 10 MHz spacing, preamp +32 dB: 29 MHz, 86 dB; 52 MHz, 99 dB.
Squelch sensitivity: Not specified.	FM, preamp +32 dB: 29 MHz, 0.32 µV to 1.58 µV; 52 MHz, 0.14 µV to 0.71 µV.
S-meter sensitivity: Not specified.	S-9 signal, preamp 0/16/32 dB: 14 MHz, 38.4/38.4/36.3 µV 50 MHz, 26.3/23.4/23.4 µV Scaling: 6 dB per S-unit.
Notch filter depth: Not specified.	Tunable notch filter: normal, 29 dB; deep, 61 dB; very deep, >70 dB.
IF/audio response: Not specified.	Range at –6 dB points:‡ CW (400 Hz BW): 400 – 800 Hz; Equivalent Rectangular BW: 402 Hz; USB (2.4 kHz BW): 90 – 2,500 Hz; LSB (2.4 kHz BW): 90 – 2,500 Hz; AM (6 kHz BW): 31 – 5,491 Hz.
Receive processing delay time: Not specified.	165 ms.
Transmitter	**Transmitter Dynamic Testing**
Power output: 1 – 100 W (SSB, CW, FM), 1 – 25 W (AM).	SSB, CW, FM: 1.8 – 30 MHz, 0.9 – 100 W; 50 MHz, 0.6 – 85 W. AM: 1.8 – 30 MHz, 0.17– 23 W; 50.4 MHz, 0.1 – 17 W.
RF power output at minimum specified operating voltage: Not specified.	At 11.7 V dc: 14 MHz, 92 W; 50 MHz, 77 W.
Spurious-signal and harmonic suppression: 55 dB (HF); 65 dB (50 MHz).	HF, >68 dB typical; 61 dB worst case (5.330 MHz); 50 MHz, 73 dB. Complies with FCC emission standards.
Third-order intermodulation distortion (IMD) products: Not specified.	3rd/5th/7th/9th order, 100 W PEP: –41/–40/–49/–55 dB (HF typical) –42/–39/–46/–53 dB (worst case, 10 m) –42/–37/–46/–55 dB (50 MHz) At 50 W RF output: –35/–43/–50/–55 dB (14 MHz) –32/–40/–50/–55 dB (50 MHz)
CW keyer speed range: Not specified.	5.5 to 100 WPM, iambic mode A & B.
CW keying characteristics: Not specified.	See Figures 1 and 2.
Transmit-receive turnaround time (PTT release to 50% audio output): Not specified.	S-9 signal, AGC fast, SSB, 200 ms; CW (full break-in), 186 ms.*
Receive-transmit turnaround time (TX delay): Not specified.	SSB, 47 ms; FM, 26 ms (29 MHz), 25 ms (52 MHz).
Transmit phase noise: Not specified.	See Figure 3.
Amplifier key line closure to RF output: Selectable, 0 to 30 ms.	As specified. RF off to key line open, variable, 0 to 3 seconds.

Size (height, width, depth, including protrusions): 7.0 × 14.0 × 12.9 inches; weight, 10.5 lbs.

Second-order intercept points were determined using S-5 reference.

‡Default values; bandwidth is adjustable.

*Default settings. Turnaround time is affected by the Filter Options menu to optimize filter sharpness versus turnaround time.

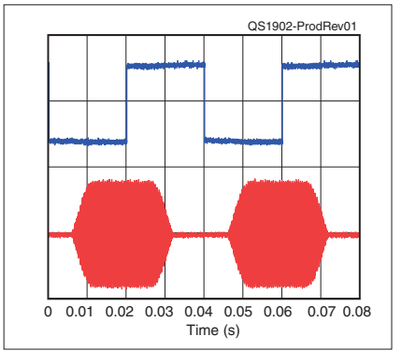

Figure 1 — The CW keying waveform for the FlexRadio FLEX-6400M, showing the first two dits in full-break-in (QSK) mode using external keying and the default rise time setting. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure, and the lower trace is the RF envelope. (Note that the first key closure starts at the left edge of the figure.) Horizontal divisions are 10 ms. The transceiver was being operated at 100 W output on the 14 MHz band.

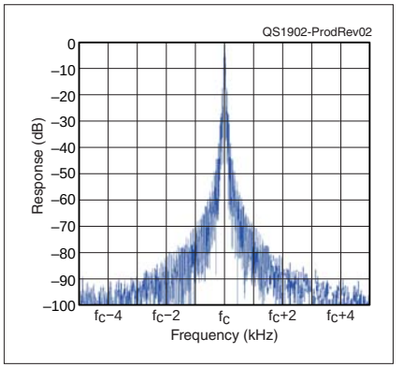

Figure 2 — The spectral display of the FlexRadio FLEX-6400M transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying and the default rise time setting. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 100 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is in decibels.

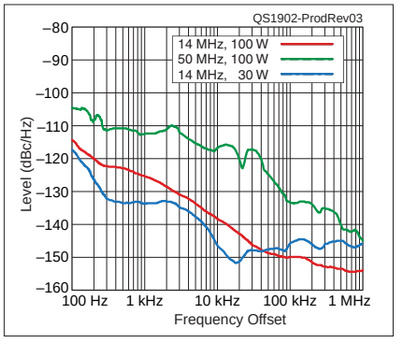

Figure 3 — The spectral display of the FlexRadio FLEX-6400M transmitter output during phase-noise testing. Power output is 100 W on the 14 MHz band (red trace), 30 W on the 14 MHz band (blue trace), and 100 W on the 50 MHz band (green trace). The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 100 Hz to 1 MHz from the carrier. The reference level is –80 dBc/Hz, and the vertical scale is 10 dB per division.

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higher-featured FLEX-6600M operates in a similar way, but has the capability to process a total of four slices. Any of the four slices can be pointed to any two antenna ports for receive, and each has independent transmit antenna selection, thus supporting fully independent dual-receive systems.

Computer Connectivity

The transceiver interconnects with your PC via its CAT 6 ethernet port. While a computer connection is not necessary to operate the FLEX-6400M, it is needed to exchange digital information with the PC (such as for a logging program), or to use transceiver audio to operate via sound-card digital modes, such as FT8. The ethernet connection can be direct to the PC or over your LAN, or even a remote connection to another location (more on this later).

While the direct connection to the FLEX-6400M must be to a device with a CAT 6 port and connected via an eight-wire CAT 6 cable in order to operate, the rest of the station or home network can be older technology.

In order to connect to my antiquated household LAN (which can transfer data at up to 50 Mbps), I found that using an inexpensive five-port gigabit switch with CAT 6 connectors and CAT 6-wired jumpers (one is provided with the FLEX-6400M) allowed my PC and the FLEX-6400M to connect together at high speed, as well as to interface with my LAN.[3] USB ports on the radio can be used to interface with other radio hardware, such as an amplifier or automatic antenna switch.

The FlexRadio *SmartSDR* software includes three major functions, each accessible through its own desktop icon. We were working with version 2.3.9 at the start of the review, and it included *SmartSDR v2.3.9*, *DAX*, and *CAT*. The *DAX* software is the *digital audio exchange* that can connect to your Windows PC's audio system, either for remote operation or to run sound-card digital modes using software on your PC. The *CAT* software can support computer automated radio operation for interfacing with logging software and other applications independent of other *SmartSDR* functions. The *DAX* and *CAT* modules can be brought up independently of *SmartSDR* if you are operating from the FLEX-6400M front panel.

If you bring up the full *SmartSDR* program, it allows your local or remote PC to take over the complete functioning of your transceiver and brings up the *CAT* and *DAX* modules as part of the process. Your PC first indicates that the radio is in use, then you tell it to turn off that user (the local FLEX-6400M display) and connect. The local FLEX-6400M screen is then replaced by an indication that the radio is in use by your PC.

SmartSDR shows the full panadapter and waterfall displays, along with all the other transceiver functions, although operation is slightly different from the transceiver front panel. For example, the radio's touchscreen functions are operated by the PC mouse, and some other controls are different in appearance and position.

To operate your FLEX-6400M from *SmartSDR* remotely, you will need to set up an account with the *SmartLink* software from FlexRadio. This software is available from the *SmartSDR* startup page. Registering as a *SmartLink* user provides you with security and authentication so that only a *SmartSDR* user with knowledge of your email address and password can access your FLEX-6400M remotely.

Note that *SmartSDR* requires a license to operate. Purchase of the radio includes a license for a single copy of *SmartSDR* that is assigned to the particular radio and goes with it if sold. The original license includes access to any minor updates, but a fee is required to obtain a new license for a major update.

During the review period, the radio indicated that v2.4.9 had become available, so I selected that and let it download and upgrade. After indicating that it was downloading properly, as shown on the progress indicators, it seemed to hang during the update phase. After a couple of restarts, it eventually came up in v2.4.9, with all memorized conditions still intact.

On the Air

I enjoyed using the FLEX-6400M as my main station transceiver for more than a month and had an opportunity to test it in most modes. While getting started was simple, as with most full-featured radios, expect to spend some time with the manuals to be able to fully appreciate and learn to operate all the advanced features. You can assume that any feature or function you've encountered on any transceiver is also supported on this radio.

This radio is a bit different from other transceivers I have used in some minor ways that struck me as I was getting started. While the radio includes a single small front-facing speaker, it has lower audio output than I am used to. The rear stereo speaker jack is designed to drive powered computer-type speakers. I found suitable speakers in my bottomless basement, and even found a wall transformer that could run them.

The other unusual item is that there are no front-panel jacks on the FLEX-6400M. This may be a blessing for those who like to hide all of their station wiring, but because there is only one **KEY** jack, and one **MIC** jack, I found the arrangement a bit cumbersome at times while trying different accessories.

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Figure 4 — A screenshot of the FLEX-6400M display showing a single panadapter display, with waterfall below, including the frequency tuned by VFO A.

Figure 5 — Same as in Figure 4, except a second spectrum and waterfall display are added below the first. Note that the second is on a different band, bandwidth, and mode. Either can be anywhere within the FLEX-6400M's tuning range, but both must be from the same antenna.

Frequency memories also store the mode, selectivity choice, and other mode-specific parameters, such as repeater offset and CTCSS tones needed for FM. The memories are added, loaded, or deleted from the main menu, with each selected from the list by a push on the touchscreen. To eliminate the two pushes needed to get to the memory list, I set the **F1** function button to **OPEN MEMORY**, which made memories easier to use.

The spectrum scope is quite useful and flexible. It can observe a portion of the spectrum near the tuned frequency, as shown in Figure 4. If set to cover a particular portion of a band that includes both the A and B receiver channels, they are both shown on the same scan. Alternately, the B channel could be on a different portion of the band, or even a different band and mode, and can be shown on a separate span below the first — each with its own width and tuning rate, as shown in Figure 5. The width can be adjusted from 6 kHz to 7 MHz, either by using the **+** and **–** buttons that appear when the display is tapped, or by squeezing or stretching the screen with your fingers. The display is crisp and sharp, and it offers a high enough resolution that the use of a larger display (available via an HDMI connection) might be useful.

The front panel also shows two bar graph meters, one for each VFO, as shown in Figures 4 and 5. The default settings are transmit power and receive signal strength, but each can be cycled through a number of other indications by pushing the scale that you would like to change. Push the **METERS** tag on the screen, and all the meters are presented.

The internal antenna tuner quickly tunes an antenna system with up to a specified 3:1 SWR to near 1:1, and it remembers the tuner settings for that frequency. I found that it could tune some antennas with a higher SWR, but the internal SWR meter only shows up to a 3:1 value, so it can be hard to tell. Attempting to use an antenna with more than the specified mismatch can be risky. While the radio cuts back to 10 W out during tuning (adjustable in the **TRANSMIT** menu), if you try to operate with full power, you could damage tuner components if ratings are exceeded.

Voice Operation

Voice modes all worked well, with good audio reports received on SSB and AM. Conditions did not allow me to make any FM contacts on 10 or 6 meters — not unusual here. The transceiver is supplied with a handheld FHM-2 PTT electret microphone that plugs into the 3.5-millimeter, rear-panel jack. The jack can supply electret bias voltage on the **MIC** line, or it can be set to **OFF** by a menu item in order to use dynamic microphones or electrets that require bias on a separate pin. In addition to the supplied hand mic, I tried a professional-quality dynamic and an amateur electret desk mic and received good reports on all.

For 10- or 6-meter FM operation, the FLEX-6400M provides easy split-frequency offsets, as well as CTCSS tone encoding for repeater access. The repeater frequency offset is displayed in MHz, with a decimal point, rather than kHz (for example, 0.1 MHz rather than 100 kHz on 10 meters). Note that the frequency offset shown does not change after pushing the **PTT** button, continuing to show the receive frequency.

On SSB, the transmit voice bandwidth can be set from 1,600 to 4,000 Hz in eight steps using touchscreen buttons. The selection can be immediately overridden by using **BW SELECT** knobs, either by setting the **LOW – HIGH** or **SHIFT – WIDTH** choices. The transmit and receive audio response can be set via separate eight-channel equalizers with octave frequency bins starting with one centered at 63 Hz and going to 8 kHz, each adjustable for 10 dB cut or boost. The transmit equalizer settings are used for all voice modes.

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For AM, the receive bandwidth can be set from 5.6 to 20 kHz in eight steps, again overridden by the front-panel **BW SELECT** knob set, if desired. In addition, synchronous AM reception (**SAM**) can be selected. That mode provides better reception during fades by using an internally generated carrier instead of the one received over the air, which will not always stay constant in amplitude.

Voice-operated transmit control (**VOX**) worked flawlessly, as did the anti-VOX function, which kept the VOX from triggering off loud received stations, even with the mic pointed at the speakers. Adjusting VOX parameters is accomplished via the **TX MENU**, not to be confused with the **TRANSMIT** menu. This took a bit of study, but the documentation does refer to them differently.

For split-frequency operation, pressing the **TX** button for slice B can initiate split-frequency mode. In order to have the two audio channels appear on separate sides, it is also necessary to adjust the unidentified **L – R** slider to the right of the **AGC** selector on each **SLICE** menu (initiated by tapping the receive frequency), one to the right, one to the left. Remember to move the slice A slider back to the middle if not running in split mode.

A monitor function is provided, along with a recording function that can be used to record and playback audio signals. It can be used to record either transmitted audio or received signals, depending on the state of the transceiver when the red button on the **SLICE** menu is engaged. You can listen to the audio recording offline, or you can transmit it on the air. You can also integrate the radio with voice messaging from third-party software, such as *N1MM Logger+*.

CW Operation

The FLEX-6400M includes many useful features for the CW operator, like full break-in (QSK) or adjustable delay, and semi-break-in operation is supported with the transmit-receive switchover noise, just barely audible with my ear on the cabinet top. A single 3.5-millimeter stereo jack in the rear can be used for paddles, a straight key, or connections to an external keyer. In addition, Pin 4 of the rear-panel **ACCESSORY** connector provides another input for a straight key, external keyer, or computer-generated keying interface. The built-in iambic (mode A or B) electronic keyer can be adjusted from 5 to 100 words per minute. CW messages can be programmed with CWX in *SmartSDR* for Windows, and function keys of the FLEX-6400M front panel can be used to send canned messages.

Activating the **TX MENU** (by pushing the **MIC/SPEED** button) while in **CW** mode opens the **CW TRANSMIT** menu. Here, you can set a slider to change from 0 to 2,000 milliseconds of transmit-receive delay, with 0 resulting in full break-in, so you can receive between transmitted code elements.

The two receivers can be set independently to default CW bandwidths of 50, 100, 250, 400, 500, 800, 1,000,

Lab Notes: FlexRadio Systems FLEX-6400M

Bob Allison, WB1GCM, ARRL Assistant Laboratory Manager

Some HF transceivers, such as this FLEX-6400M, are a joy to test, with predictably good performance. The receiver test results are presented a little differently from our usual format. FlexRadio Systems provides several sensitivity settings, and for test purposes, we chose three: 0, +16, and +32 dB. With an antenna hooked up, the 0 dB gain setting provides enough sensitivity to match the background noise floor in a relatively quiet location. Much of the time on HF, adding more sensitivity simply makes the background noise higher and does not increase the signal-to-noise ratio for the listener, so it's important to match the gain setting to band conditions.

The FLEX-6400M's dynamic ranges are quite good overall. Third-order IMD dynamic range is about 95 dB, regardless of gain settings. Signal blocking is excellent, and reciprocal mixing is kept to a minimum — both of these dynamic ranges are excellent. Second-order IMD products are very low with the gain settings to either +16 or +32 dB. This type of performance is most welcome to those who live in close proximity to strong shortwave broadcast stations, where the mixing of strong 6 and 15 MHz signals can create phantom 21 MHz signals.

On 6 meters, where the noise floor is typically much lower, users of the FLEX-6400M will enjoy using the very sensitive spectral display, with a waterfall that can detect very weak signals on a quiet band. Though AM sensitivity could be better on HF, it is quite adequate for the 6-meter AM crowd on 50.4 MHz. FM sensitivity on 6 meters is also good.

On the transmit side, initially our FLEX-6400M greatly exceeded the FCC requirements for harmonic and spurious emission suppression on most bands, except for a spurious emission when transmitting on 6 meters. FlexRadio fixed that under warranty. Transmit IMD exhibits very low third-order products, desirable for good transmit audio quality. The seventh- and ninth-order products are about average, compared to other transceivers tested at the ARRL Lab. The FLEX-6400M has excellent keying characteristics, with complementary excellent keying sidebands. Low transmit phase noise makes this transceiver a friendly neighbor to others operating on nearby frequencies.

Note that with the power switched off, the FLEX-6400M draws 25 mA — a consideration if a battery is used for the supply voltage.

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or 3,000 Hz. As with other modes, both the filter width and center frequency can be adjusted using the front panel concentric knobs, independent of the menu starting point. I heard just the slightest trace of ringing at the 50 Hz setting.

Data Modes

The FLEX-6400M has a number of options for data mode operation. The ethernet connection to my PC can use the FlexRadio *DAX* software to interchange data between PC and radio, without any additional audio interconnections. Of course, the **MIC** and **SPKR** connections could also be used, with extra cables to a physical sound card, but it's not worth bothering.

There is no capability for direct frequency-shift keying (FSK) for RTTY, but audio frequency-shift keying (AFSK) works fine. There are multiple other ways to do any of the popular computer-based digital modes. All the selectivity and audio-filtering options are available in data modes.

DSP Noise Reduction

The FlexRadio designers worked hard on the various noise reduction processes. The first thing I noticed is that instead of an **RF GAIN** control, the FLEX-6400M offers a front panel receive AGC threshold (**AGCT**) that is on the same concentric shaft as the **AF GAIN** control. The **AGCT** sets the maximum gain available so that signals will not have excessive loudness. By setting the threshold to just below the point at which the background noise starts to decrease, strong signals will be limited, with a reduction in noise, while weak signals will still be heard. The AGC attack/release time can be set to fast, medium, slow, or off, with separate settings for each slice receiver. The threshold should be adjusted for band changes or changes in noise level.

The FLEX-6400M has two different noise blankers. A wideband blanker (**WNB**) is designed to eliminate pulse-type noise and is applied before any selectivity that would tend to stretch out the noise pulses. This blanker is applied to any signals within the panadapter width. A separate noise blanker (**NB**) is applied to each slice separately. Both blankers are available and adjustable on each **SLICE** menu.

Noise reduction processing can reduce background "white" noise. Engaging and advancing the slider results in a dramatic improvement in signal-to-noise ratio, with minimum distortion until set to the highest level.

An effective automatic notch filter (**ANF**) is provided for use in voice modes. The button changes to a narrow audio peaking filter (**APF**) in CW mode, so you won't inadvertently notch out your desired CW signal.

An interesting feature is engaged by pressing the panadapter or waterfall screen, near where you would like to eliminate a carrier. A menu appears with a choice to **CREATE TNF**, which will enable a tracking notch filter that can be moved to the offending carrier. Unlike the usual **ANF**, it will stay at that frequency even as you tune up and down the band. Additional tracking filters can be established if there are multiple carriers. This is very slick and well described in the manual.

Operating Impressions

This radio has a lot going for it. The large, high-resolution display is helpful, particularly while using the spectrum scope, and the controls are easy to reach and operate. If you need an even larger display, the HDMI video connector on the rear can be used to drive a compatible monitor or even a TV set, so you can monitor band activity from across the room — or just impress visitors.

It did take me a while to get used to the concentric front-panel knobs. They turn easily, and initially, I sometimes turned both while attempting to turn just one. The large and small **FREQUENCY** tuning knobs are easy to operate and nicely weighted, so you can easily spin across large segments of the band. The tuning step is adjustable, with a separate button for each slice. A short tap advances the step size, while a longer push reduces it — easy to deal with.

My amplified computer speakers worked nicely during receive, but I suspect they were not designed to operate in an RF environment and made a lot of noise while transmitting on some bands. This is not a fault of the radio, but is something to be aware of as you set up your FlexRadio station. At least one manufacturer offers a pair of reasonably priced amplified computer speakers that are designed to minimize RF pickup.[4] Usually, such problems can be resolved by wrapping the speaker wires around some ferrite toroid cores, but I didn't bother for this temporary test. Just moving the wires away from my linear amplifier helped quite a bit.

I was operating the FLEX-6400M with my 500 W linear amplifier and auto tuner, just using the radio's **TX1** keying-out connection. There are actually three such dedicated connections that key upon the FLEX-6400M's switchover to transmit. Thus, for example, in addition to keying an amplifier, you could have connections in place for your transverter and mast preamp sequencer — a helpful arrangement. My amplifier requires just 20 to 30 W drive, depending on the band. The FLEX-6400M also thoughtfully remembers the power out setting for each band, so you don't need to tweak it as you change bands, or risk driving your amplifier into alarm, or worse. Changing bands also goes back to the mode, frequency, and bandwidth selected when you were last there.

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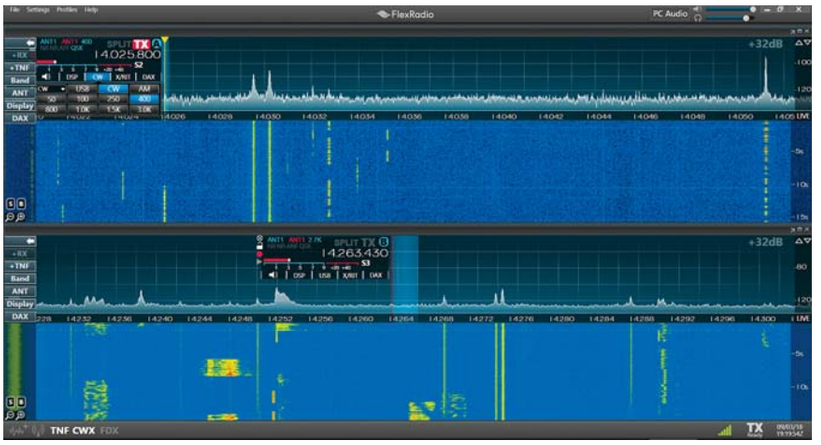

Figure 6 — *SmartSDR* on a locally connected PC running the FLEX-6400M. The setup menus are closed, and we are looking at signals on 20-meter CW and SSB.

Remote Operation

The FlexRadio Signature Series transceivers are a natural for remote operation. While the built-in display on the FLEX-6400M becomes redundant if you are operating from elsewhere, it doesn't cause any problems, and it allows an easy return to local operation if desired. I think that if I expected to do a lot of remote operation, I would be more inclined to go with the base FLEX-6400 and the Maestro separate front panel, which allows remote operation without the need of a PC. A typical *SmartSDR* screen on my locally connected PC is shown in Figure 6.

While attending the New England Division Convention in Boxborough, Massachusetts, I visited a booth operating with a Maestro onsite. The operation was sponsored by the Nashua (New Hampshire) Area Radio Society with Donald Bartlett, N1OKD, operating as N1T via a remote internet link to the station of Fred Kemmerer, AB1OC, in Hollis, New Hampshire. It was very impressive — especially considering how busy the shared internet connection must have been at the show venue. I couldn't tell the difference between the remote operation and operation locally at the show — except the antennas were a lot better from the remote site.

Documentation

Our FLEX-6400M did not include a printed manual, but two versions are provided on the FlexRadio website. One is a 165-page *FLEX-6400M / FLEX-6600M Users Guide*, while the other is a 218-page *SmartSDR Software User Guide*. While you might think that the software guide would only be needed for remote operation, the standalone version operates with the same software, so some operational details are described more fully in the software manual. The FlexRadio Customer Service support function via their website was responsive any time I struggled while becoming familiar with this transceiver. There's also a very active online community of FLEX users to answer questions and offer advice.

Wrapping Up

The FLEX-6400M is a very effective, full-featured transceiver that would work well in most stations, whether at home or operated from a remote location with internet connectivity. It provides all the advantages and capabilities of the traditional "blank-panel" SDR, but adds a serious front panel with all needed controls, indicators, and a stunning panadapter/waterfall display.

Manufacturer: FlexRadio, 4616 W. Howard Lane, Suite 1-150, Austin, TX, 78728; **www.flexradio.com**. Price: FLEX-6400M, $2,999; internal automatic antenna tuner, $299; GPS-synchronized 10 MHz oscillator, $699.

Notes

[1]M. Ewing, AA6E, "FlexRadio Systems FLEX-6300 Transceiver, FLEX-6700 Transceiver, and *SmartSDR for Windows* Software," Product Review, *QST*, April 2015, pp. 47 – 58.

[2]M. Ewing, AA6E, "FlexRadio Systems FLEX-6500 SDR Transceiver and Updated *SmartSDR for Windows* Software," Product Review, *QST*, Feb. 2017, pp. 53 – 59.

[3]I used a Linksys LGS105 unmanaged five-port gigabit switch. This compact unit, not much bigger than a deck of cards, is available for about $25 from a number of online retailers. It came up without any hassle, connecting to the FLEX-6400M, my PC, and my old LAN, and it made everything work together.

[4]West Mountain Radio COMspkr Computer Speaker System, **www.westmountainradio.com**.

Visit https://youtu.be/VKOYSQx-ESE to see our review of the FlexRadio Systems FLEX-6400M HF and 6-Meter SDR Transceiver on YouTube.

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