February 2020

FlexRadio Systems FLEX-6600M HF and 6-Meter SDR Transceiver and *SmartSDR* Software Version 3

FlexRadio Systems FLEX-6600M HF and 6-Meter SDR Transceiver and *SmartSDR* Software Version 3

Reviewed by Martin Ewing, AA6E
aa6e@arrl.net

The FLEX-6600M is a top-performing software-defined radio (SDR) transceiver covering the ham bands from 137 kHz to 54 MHz, handling the common voice, CW, and data modes, and transmitting at 100 W on 160 through 6 meters. The FLEX-6600M has many features in common with the FLEX-6400M, which was reviewed by Joel Hallas, W1ZR, in the February 2019 issue of *QST*.

This review will focus on the differences between the FLEX-6600M and the FLEX-6400M. If you're not familiar with the FLEX-6400M, please consult Joel Hallas's review to get a good orientation before diving into the FLEX-6600M's specifics here. Note that a very similar model, the FLEX-6600, is available at a lower cost without the front-panel controls. The FLEX-6600 requires you to supply a separate FlexRadio Maestro controller (reviewed in the November 2016 issue of *QST*) or a Windows PC, iPad, or iPhone running FlexRadio's *SmartSDR* (*SSDR*) software. In this review, when I write "FLEX-6600" or "FLEX-6400," it will apply to both the panel-less model and the "M" model, unless otherwise noted.

Compared with the FLEX-6400, the FLEX-6600's most notable features are the dual spectral capture units (SCUs) and the number of panadapters and simultaneous audio outputs — four instead of two. (FlexRadio uses the term "spectral capture unit" [SCU] to refer to the combination of a single antenna input, preselector and preamp, and an analog-to-digital converter.) Having dual SCUs permits you to receive from two different antennas at the same time. This allows diversity reception, where you can combine signals from antennas located away from each other or from antennas with different polarization or directivity. With diversity reception, you can reduce the effects of fading, as you can choose whichever channel has the stronger signal. This is not automatic, however. You would probably listen to one channel with your left ear and the other with your right — assuming you're using headphones. Your hearing readily focuses on the better channel.

Each FLEX-6600 SCU operates at double the sampling frequency (245.76 MHz) of the FLEX-6400's single unit. All told, the dual FLEX-6600 SCUs internally generate four times the data of the FLEX-6400.

Bottom Line

The FLEX-6600M offers top-tier performance and, with its built-in seventh-order band-pass filters, is easily capable of operating full duplex on two bands at a time. *SmartSDR* Version 3 offers the opportunity for two operators to share the radio with some limitations. The transceiver can 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.

That implies substantially higher computing power inside the radio. One benefit is that you can use four independent panadapter displays and waterfalls at one time, where the FLEX-6400 provides only two. The maximum bandwidth of a single panadapter display is also doubled, to 14 MHz. With only two such panadapters, you can continuously monitor all the HF amateur bands.

Another benefit of the FLEX-6600's high sampling rate is higher frequency resolution. With maximum zoom at 10 MHz, I noted (by eye) that the frequency bin size was about 4 Hz. The same test on the FLEX-6400 showed a bin size of about 8 Hz. When you're trying to pick out a very weak unmodulated carrier, the FLEX-6600's panadapter might provide approximately 3 dB better sensitivity, which could be important for VHF and higher bands.

Figure 1 — MultiFlex operation with a Maestro (top) and FLEX-6600M transceiver connected to a single antenna. The Maestro receives 30 and 20 meters, while the FLEX-6600M receives 80 and 40 meters.

Single-Operator, Two-Radio (SO2R) Operation

If you are careful to minimize cross coupling of your antennas, you can operate the FLEX-6600 in full-duplex mode (FDX) — receiving on one antenna at the same time as you transmit on the other. This capability supports so-called SO2R contesting (single operator, two radios) in which a skilled operator can find the next contact with one SCU while completing a contact that was started on the other. (There are a number of online resources giving details of SO2R setups and operations.[1]) This way, avid contesters can use a single FLEX-6600 to replace the dual-transceiver installation they might have needed before. FDX is also important when you are using the dual-operator "MultiFlex" mode, described below.

Two-Operator, Single-Radio (2OSR) — MultiFlex

FlexRadio's operating software for the FLEX-6000 series is known as *SmartSDR* (*SSDR*). Some components of *SSDR* run in the radio itself, while other parts (including the user interface) run in various devices that can serve as a "control surface" — the collection of knobs and buttons that make up FlexRadio's operator interface. The control surface can be the front panel of an "M" model, or a PC, an iPad/iPhone, or a Maestro, as mentioned above. Version 3 of *SSDR* was recently introduced. Its major new addition is multiplexing two operators onto one radio, a mode called "MultiFlex."

MultiFlex supports two control surfaces at once — called 2OSR for two operators with a single radio (see Figure 1). The second control surface can be connected locally (in the same room) or remotely over the internet.

Each MultiFlex control surface can control one to three receiver panadapters (receiver slices). There is only one transmitter, however, and either attached controller can transmit on a first-come first-served basis. Both control points are "live" for transmitting, so you need to take care if one of the operators is not licensed.

It happens that the Maestro and the "M" model's front panel, which are very similar, are both limited to two panadapters, while the FLEX-6600 radio supports four. So the combination of a Maestro and a FLEX-6600M in MultiFlex mode neatly makes use of all four control slots. Of course, a single PC running *SSDR* for Windows can show all four on one screen, if you prefer.

[1]One good explanation of SO2R contest operation is: R. Farmer, W8FN, "Basics of SO2R Operation," a paper presented at Ham-Com 2014, available as **www.dfwcontest.com/uploads/8/1/1/0/8110093/so2r_v2.pdf**.

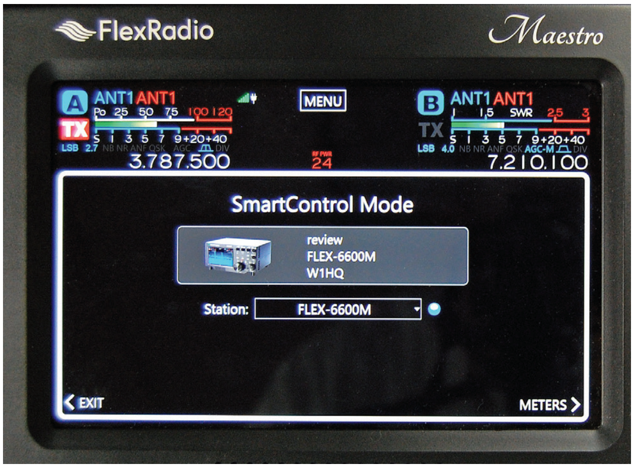

Figure 2 — A Maestro in SmartControl mode controls and monitors a remote FLEX-6600.

Operating with the MultiFlex capability can be useful in a number of situations. For example, a mentor and a new ham can collaborate to learn how to make contacts. You can also support two separate operating positions in your own station. It's great for ham radio demos, too. Contesters can simplify and economize on the hardware needed to support multiple operators. Two operators on separate bands (with good antenna isolation) can share a single FLEX-6600. Occasionally, they may want to transmit at the same time, and one of them will have to wait.

MultiFlex does a good job of making the radio seem like a computer server with two independent users, but under some circumstances, it is possible for one operator to change the configuration in a way that could upset the other operator. FlexRadio says that "some means of coordination may be helpful." It's probably best to have an off-air way to talk with your remote colleague. At least you need to know who's going to be transmitting on what band, using what antenna.

More Features

SSDR Version 3 adds support of a new "Smart Control" mode, in which a Maestro can control a remote FLEX-6000 series transceiver (see Figure 2). It should be particularly useful as a controller for a "headless" (non-M) radio that otherwise is controlled via a PC. The SmartControl is effectively an enhanced version of the older FlexControl tuning knob product.

The FLEX-6600 includes an automatic antenna tuning unit. (This was optional on the FLEX-6400M). It also offers dual-transverter output and external receiver inputs that help with more complex VHF+ situations (see Figure 3 for the rear-panel layout).

Lab Notes: FlexRadio Systems FLEX-6600M

Bob Allison, WB1GCM,
ARRL Laboratory Test Engineer

FlexRadio Systems FLEX-6600M can handle high signal levels at the antenna jack. Its lowest dynamic range, at 2 kHz spacing, at 14 MHz, is 104 dB (third-order IMD dynamic range). Blocking and reciprocal mixing dynamic ranges are even better.

On the other end of the equation, the FLEX-6600M offers a wide range of receiver gain settings, starting with 0 dB, which provides the receiver with just enough gain to match an average background noise level of –115 to –110 dBm. If your background noise is at this level, or higher, set the gain to **0 dB**. This is equivalent to adjusting the RF gain on a traditional receiver so that the background noise is just audible, providing a better signal-to-noise ratio and easier copy of received signals. On the higher frequency amateur bands, where background noise levels are much lower, the additional receiver gain of the FLEX-6600M will allow reception of weak signals. AM sensitivity is adequate, especially on the higher bands, where signal levels at 1 μV or less can be heard. The panadapter and waterfall display are very sensitive. A watchful eye will not miss weak signals.

Transmit quality is very important. The best receivers cannot remove transmitted distortion products, wide CW sidebands, or high transmitted phase and AM noise. Laboratory tests showed low transmit phase noise at 14 MHz, and somewhat higher phase noise at 50 MHz. Transmit IMD products are acceptably low at all RF output levels. In CW mode, the CW sidebands are very low, making the FLEX-6600M a good neighbor for those listening close to its transmitted frequency.

Signal latency is an important consideration with software-defined radios. Receiver processing delay time is the time it takes from when a signal arrives at the antenna jack to when the signal comes out of the speaker. The more signal manipulation and processing, the longer the delay (latency) is. As shown in Table 1, adjusting the filter edges to **SHARP** takes slightly longer to process than when the filters are set to **LOW LATENCY**, where filter edges have a more tapered response.

The preselector filters on the "contest bands" (160, 80, 40, 20, 15, and 10 meters) have been upgraded to seventh order (>50 dB rejection), compared with third-order filters on the FLEX-6400. This improves rejection of interference from other transmitters operating in a multi-transmitter environment. We do not routinely measure cross-band isolation at the ARRL Lab, but we did a few checks on the FLEX-6600M compared with the FLEX-6400.

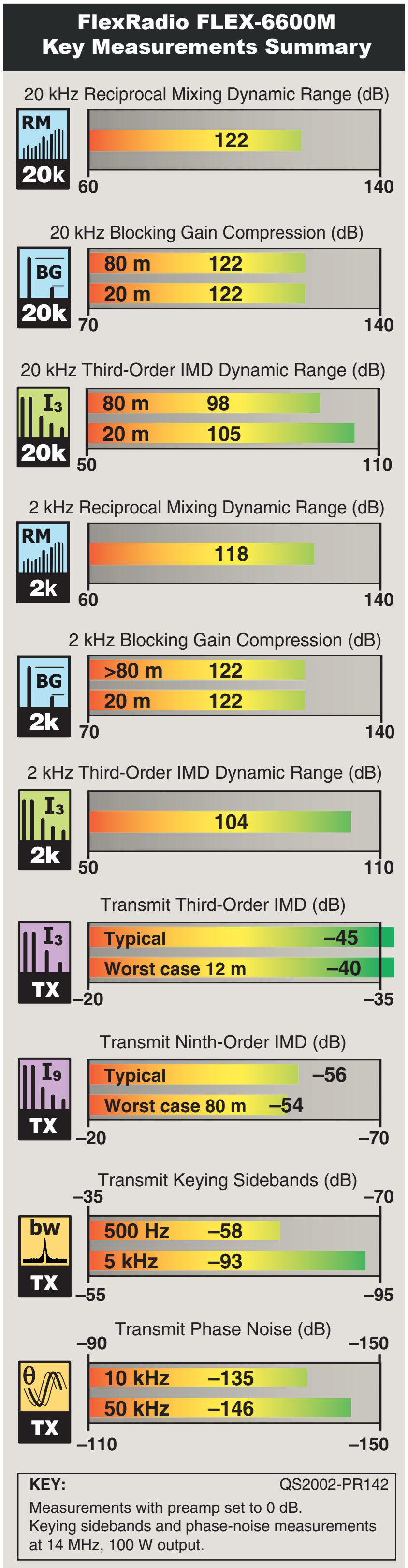

Table 1
FlexRadio Systems FLEX-6600M, serial number 0525-6601-4585, *SmartSDR* V3.1.8.145

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: Receive, 0.03 – 54 MHz; transmit, 160 – 6 meter amateur bands.	Receive, 0.03 – 55 MHz. Transmit, 160 – 6 meter amateur bands including five 60-meter channels.‡
Power requirement: 13.8 V dc (±15%).	At 13.8 V dc: Transmit, 22 A (typical), 12 A (AM) at maximum RF power output; 5.8 A at minimum RF output. Receive, 2.8 A (maximum backlight), 2.8 A (minimum backlight). Power off, 114 mA.
Modes of operation: SSB, CW, AM, SAM, FM, Free-DV, RTTY, digital.	As specified.
Receiver	**Receiver Dynamic Testing**
SSB/CW sensitivity: Not specified.	Noise floor (MDS), 500 Hz bandwidth, AGCT=65.
Noise figure: Not specified.	Preamp off/+16/+32: 14 MHz: 33/19/12 dB; 50 MHz, 31/13/7 dB.
AM sensitivity: Not specified.	10 dB (S+N)/N, 1 kHz tone, 30% modulation, 6 kHz BW:
FM sensitivity: Not specified.	For 12 dB SINAD, 3 kHz deviation, 15 kHz BW:
Spectral sensitivity: Not specified.	Panadapter and waterfall display: 14 MHz, –144 dBm; 50 MHz, –154 dBm (maximum sensitivity).
ADC overload level: Not specified.	With preamp 0/+16/+32: +8/–7/–24 dBm
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range, 500 Hz BW:*
Reciprocal mixing dynamic range: 115 dB at 2 kHz offset.	14 MHz, 20/5/2 kHz offset: 122/120/118 dB

Noise floor (MDS), 500 Hz bandwidth, AGCT=65:

Preamp	*0*	*+16*	*+32*
0.137 MHz	–115	–102	–94 dBm
0.475 MHz	–117	–113	–113 dBm
1.0 MHz	–117	–125	–121 dBm
3.5 MHz	–114	–126	–129 dBm
14 MHz	–114	–127	–136 dBm
50 MHz	–116	–134	–140 dBm

AM sensitivity, 10 dB (S+N)/N, 1 kHz tone, 30% modulation, 6 kHz BW:

Preamp	*0*	*+16*	*+32*
1.0 MHz	15.5	4.67	6.60 µV
3.88 MHz	21.4	4.26	2.98 µV
29.0 MHz	18.8	2.66	1.00 µV
50.4 MHz	15.1	2.29	0.81 µV

FM sensitivity, for 12 dB SINAD, 3 kHz deviation, 15 kHz BW:

Preamp	*0*	*+16*	*+32*
29.0 MHz	6.23	0.93	0.31 µV
52.0 MHz	5.01	0.81	0.26 µV

Blocking gain compression dynamic range, 500 Hz BW:*

	20 kHz offset Preamp 0/16/32	*5/2 kHz offset Preamp 0*
3.5 MHz	122/120/112 dB	122/122 dB
14 MHz	122/120/112 dB	122/122 dB
50 MHz	124/120/112 dB	124/124 dB

ARRL Lab Two-Tone IMD Testing (500 Hz bandwidth), AGCT = 65:

Band/Preamp	*Spacing*	*Measured IMD Level*	*Measured Input Level*	*IMD DR*
3.5 MHz/0	20 kHz	–114 dBm	–16 dBm	98 dB
		–97 dBm	–6 dBm	
		–86 dBm	0 dBm	
14 MHz/0	20 kHz	–114 dBm	–9 dBm	105 dB
		–97 dBm	–3 dBm	
		–89 dBm	0 dBm	
14 MHz/+16	20 kHz	–127 dBm	–27 dBm	100 dB
		–97 dBm	–14 dBm	
14 MHz/+32	20 kHz	–140 dBm	–42 dBm	98 dB
		–97 dBm	–29 dBm	
14 MHz/0	5 kHz	–114 dBm	–9 dBm	105 dB
		–97 dBm	–3 dBm	
		–89 dBm	0 dBm	
14 MHz/0	2 kHz	–114 dBm	–10 dBm	104 dB
		–97 dBm	–6 dBm	
		–89 dBm	0 dBm	

Manufacturer's Specifications	Measured in the ARRL Lab

Band/Preamp	*Spacing*	*IMD Level*	*Measured Input Level*	*Measured IMD DR*
50 MHz/0	20 kHz	–116 dBm –97 dBm –76 dBm	–16 dBm –9 dBm 0 dBm	100 dB
50 MHz/+32	20 kHz	–135 dBm –97 dBm	–35 dBm –27 dBm	100 dB

Second-order intercept point: Not specified.	Preamp 0/+16/+32 dB: 14 MHz, +71/+71/+71 dBm 21 MHz, +71/+71/+71 dBm 50 MHz, +85/+81/+77 dBm
DSP noise reduction: Not specified.	12 dB.
FM adjacent channel rejection: Not specified.	Preamp +32 dB: 29 MHz, 81 dB; 52 MHz, 80 dB.
FM two-tone third-order IMD dynamic: range: Not specified.	20 kHz offset, preamp +32 dB: 29 MHz, 81 dB; 52 MHz, 80 dB. 10 MHz offset, preamp +32 dB: 29 MHz, 127 dB; 52 MHz, 115 dB.
Squelch sensitivity: Not specified.	FM, preamp +32 dB: 29 MHz, 0.17 µV to 0.85 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, 50.1 µV (all preamp settings) 50 MHz, 50.1 µV (all preamp settings) Scaling: 6 dB per S-unit.
Notch filter depth: Not specified.	Tunable notch filter, normal, 45 dB; Auto-notch, >70 dB.
IF/audio response: Not specified.	Range at –6 dB points:† CW (500 Hz BW): 335 – 865 Hz; Equivalent Rectangular BW: 508 Hz; USB (2.4 kHz BW): 280 – 2718 Hz; LSB (2.4 kHz BW): 281 – 2718 Hz; AM (6 kHz BW): 28 – 4484 Hz.
Receive processing delay time: Not specified.	Auto, 170 ms; low latency, 56 ms; sharp filter, 167 ms.

Transmitter	Transmitter Dynamic Testing
Power output: 1 – 100 W (SSB, CW, FM), 1 – 25 W (AM).	SSB, CW, FM: As specified; 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: 1.8 MHz, 85 W; 14 MHz, 95 W; 50 MHz, 80 W.
Spurious-signal and harmonic suppression: >60 dB.	HF, >70 dB typical; 60 dB worst case band (1.8 MHz); 50 MHz, 75 dB. Complies with FCC emission standards.
Third-order intermodulation distortion (IMD) products: Not specified.	3rd/5th/7th/9th order, 100 W PEP: –45/–40/–50/–56 dB (HF typical) –40/–38/–48/–54 dB (worst case, 12 m) –47/–38/–45/–53 dB (50 MHz) At 50 W RF output: –36/–43/–51/–53 dB (14 MHz) –32/–40/–51/–57 dB (50 MHz)
CW keyer speed range: Not specified.	4.2 to 100 WPM, iambic mode A & B.
CW keying characteristics: Not specified.	See Figures 4 and 5.
Transmit-receive turn-around time (PTT release to 50% audio output): Not specified.	S-9 signal, AGC fast, SSB, 200 ms; (sharp filter), 82 ms (low latency). CW (full break-in), 190 ms (sharp filter), 82 ms (low latency).
Receive-transmit turnaround time (TX delay): Not specified.	SSB and FM, 53 ms (sharp filter), 49 ms (low latency).
Transmit phase noise: Not specified.	See Figure 6.
Amplifier key line closure RF output: Selectable, 0 to 30 ms.	As specified. RF off to key line open, variable, 0 to 3 seconds.

Size (height, width, depth, incl. protrusions): 7.0 × 14.0 × 13.2 inches; weight, 11.9 lbs.
Second-order intercept points were determined using S-5 reference.

‡Adjustable low-level RF output for 137 and 475 kHz appears at the transverter jack: 137 kHz, –12 to +8 dBm and 475 kHz, –12 to +10 dBm.
*No signal blocking occurred up to the point of ADC overload.
†Default values; bandwidth is adjustable.

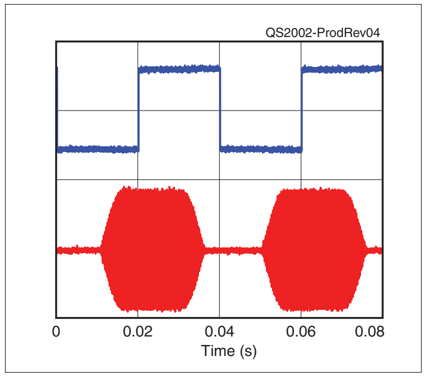

Figure 4 — A CW keying waveform for the FLEX-6600M, showing the first two dits in full-break-in (QSK) mode using external keying and the default 4-millisecond rise time setting. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. (Note that 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.

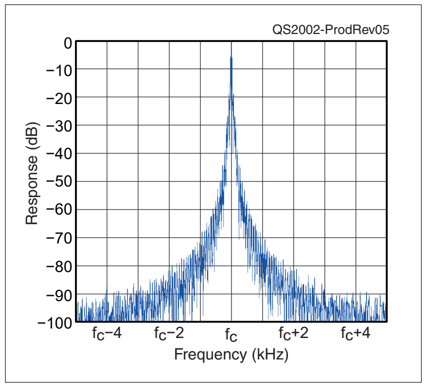

Figure 5 — The spectral display of the FLEX-6600M transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying and the default rise time setting. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated 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 dB.

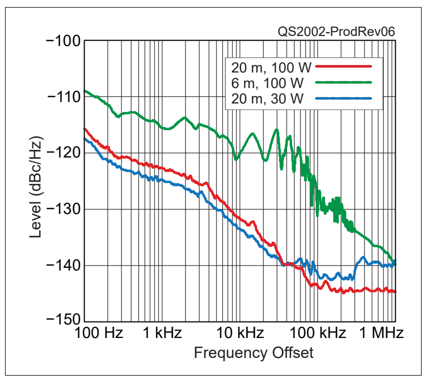

Figure 6 — The spectral display of the FLEX-6600M transmitter output during phase-noise testing. Power output is 100 W on the 14 MHz band (red trace), 30 W on the 14 MHz band (blue trace), and 100 W on the 50 MHz band (green trace). The carrier, off the left edge of the plot, is not shown. This plot shows phase noise 100 Hz to 1 MHz from the carrier. The reference level is –100 dBc/Hz, and the vertical scale is 10 dB per division.

When we listened to a signal generator on 7.15 MHz (S-5 signal level), we added a variable-strength “interference” signal at 14.2 MHz. With the FLEX-6400 (controlled by a Maestro), we noted that the radio tripped out at +17 dBm into its self-protect mode. (The FLEX-6000 series radios automatically disconnect the antenna if an excessive signal is put into the antenna jack. This will hopefully save your radio from harm, but you are not encouraged to test this limit.) With the FLEX-6600M, we saw no evidence of overload, even with +27 dBm “interference” input (½ W). This result shows that the FLEX-6600’s improved preselector filter, at least for this particular test, was at least 10 dB better than the FLEX-6400’s and most likely even better than that, but our normal safety guidelines prevent the use of very high signal levels.

Figure 3 — The FLEX-6600M rear panel.

In addition to operation on 160 through 6 meters, the FLEX-6600 supports operation on 630 meters (475 kHz) and 2200 meters (137 kHz). The receiver has usable sensitivity on those bands, and a low-level output, suitable for driving an external power amplifier chain, is available at the transverter jack. The radio could also be used with an external transverter, such as those from Monitor Sensors.

Discussion

Bench tests of the MultiFlex feature using the FLEX-6600M, a Maestro, and a Windows PC mostly worked as expected, but occasionally we ran into odd conditions where control appeared to end up with the “wrong” device. The situation was tricky to figure out, but a power reset will cure it. It would be handy if the control surfaces could show who is attached and how they are operating. As it is, all you get is an alert when the other station goes into transmit mode.

We also encountered some issues with MultiFlex and CW. Break-in CW can consist of a short transmit cycle for each code element. If operator 1 and operator 2 are trying to send CW at the same time, you will get confusing results as control flips between them between code elements or words. You might think that slowing down the break-in switching would help, but we were unable to find a foolproof way to handle this situation. Eventually, you and the other operator will try to transmit at nearly the same time. Even using non-break-in (MOX control), there are problems. If you hit your key when the other person is sending, you will often interfere with their transmission. We hope these issues will be addressed in a future software release.

You may want to disconnect a control surface if you’re trying to switch MultiFlex setups. To turn off the FLEX-6600M’s front panel and free up a slot for MultiFlex, you can go to the “radio” menu and select **SWITCH VERSION**, but on the Maestro you would go to **NETWORK** and select **WIFI SETTINGS**. A **DISCONNECT** button would have been more intuitive.

FlexRadio supplies a lot of good documentation for this radio and *SSDR* software — more than 400 pages weighing in at more than 4 pounds, single-sided. But, because the documentation often changes with software updates, it isn’t practical to keep a fully updated hard copy. They are available as PDFs for downloading as needed. In addition, the FlexRadio community on FlexRadio’s website can answer questions and provide assistance.

As we have come to expect from leading SDR products, software updates come along frequently. We worked with three separate releases during the course of this review. We ended up with *SmartSDR* version 3.1.8. If you have an older FlexRadio FLEX-6000 series radio, you may need to purchase a $200 license to upgrade to version 3 software. However, you can stay with an earlier version at no cost.

Final Thoughts

The FLEX-6600 and FLEX-6600M are the high-end transceivers of the current generation of FlexRadio FLEX-6000-series products. You can get higher performance (eight slices and panadapters) and support

MultiFlex and Remote Operation at the ARRL Lab

Bob Allison, WB1GCM,
ARRL Laboratory Test Engineer

FlexRadio's *SmartSDR* V3 software allows two operators to share one radio. We tried this feature while operating the FLEX-6600M remotely, using a Maestro at the ARRL Lab, and the FLEX-6600M connected to a router in the home station of ARRL RFI Engineer Paul Cianciolo, W1VLF, some 17 miles distant. It was a new experience for me to be able to share a radio with another operator without sitting next to them. Paul and I could listen on the same band or on separate ham bands simultaneously, and operation was seamless. For transmitting, FlexRadio gives its users a traffic-light system, with obvious indicators that the other is transmitting. Once one user finishes transmitting, the other may transmit. Whoever transmits first has priority and blocks the other user from transmitting. (Some limitations of this are explained in more detail in the main review.)

When the operator and control surface are separated from the transceiver, some latency is added by the signal path over a local area network or over the internet in the case of remote operation. To test latency, we used a keying generator to turn on the FLEX-6600M's CW transmitter, with the generator's keying action viewed on one trace of a dual-trace oscilloscope. The other trace viewed an analog receiver speaker output. When the key closed, I could measure the time it took from when the key was pressed on the Maestro in the Lab to when the signal was transmitted remotely from the FLEX-6600M at Paul's station and heard in the speaker (there is no significant latency in an analog receiver). This one-way path took 50 milliseconds and was confirmed with FLEX-6600M's internal latency metering, which stated a two-way latency of 100 milliseconds.

We found that latency increased if the router used at Paul's station was shared with other devices. For example, if he turned on another remote receiver connected to his home router, latency with the Maestro in the Lab controlling the FLEX-6600M at his station increased to about 300 milliseconds. (In addition, we note that some users have reported unusual latency problems using CW over remote connections with recent SSDR versions. See **community.flexradio.com**. It is not clear if our experience is related to this issue.)

We asked FlexRadio's Vice President of Engineering, Steve Hicks, N5AC, for his thoughts on latency, and here is his response:

> For remote operations, the two key things that affect latency are the degree of filtering in the radio itself and the latency observed in the network. The operator of a FlexRadio has tremendous control over the latency inside the radio. Each mode (CW, voice, and digital) has a control that can be set for lowest latency, highest degree of filtering, or a balance of these. The latency observed in the network can affect operations, but a number of strategies with the radio have been employed to minimize the effects of latency including using multiple different internet protocols and measuring which are faster, given your particular network connection. Also, to reduce latency when using SmartLink, the SmartLink server initially establishes connections to both the radio and the operator's device (Maestro, PC, etc.), but then brokers a final connection directly between the radio and the operator. By brokering the connection, the SmartLink server ensures that the network can find the quickest path between the operator and their radio without standing in the middle of the connection…Ultimately, all operators using their radios remotely will have some latency from the network which is unavoidable, but much of the time it is minimal and is not a hindrance to operations.

for the 2-meter band with the older FLEX-6700 that is still in production. But it's likely that most amateurs would be satisfied with the FLEX-6600 and its lower price point.

The MultiFlex dual-operator feature appeared to work well in our Lab tests described above and in the sidebar, "MultiFlex and Remote Operation at the ARRL Lab." Features such as MultiFlex and remote operation are hard to evaluate in the Lab, because we would need to explore all the edge cases of marginal internet service, long latency, along with various operating modes, band conditions, and so on. We verify that things work nicely on the bench, but the community will have to see how these features fare in real life.

SSDR version 2 gave us an easy-to-use remote capability. Version 3 now extends that to dual-operator access. These important extensions to the FLEX-6000 series validate one of the selling points of software-defined radio — that an SDR hardware investment can be continually improved through software development.

Manufacturer: FlexRadio Systems, 4616 W. Howard Ln., Suite 1-150, Austin, TX 78728; **c**. Price: FLEX-6600M, $4,999; GPS disciplined 10 MHz oscillator, $699.

DX Engineering RX Share Audio Switch

Reviewed by Mark Wilson, K1RO
k1ro@arrl.org

There are times when two operators might want to listen to the same radio, or one operator might want to listen to two radios. The RX Share from DX Engineering offers a convenient and flexible way to share audio. It's a passive device requiring no power source (no internal amplifiers or signal processing). Audio quality and volume are controlled by the transceiver(s).

Cables connect to the rear panel (see Figure 7). The Radio 1 and Radio 2 inputs are silver ¼-inch stereo jacks. Headphones connect to either the black ¼-inch stereo jacks or the ⅛-inch stereo jacks. No cables are supplied with the unit. I had a couple of suitable shielded audio cables in my junkbox to connect to the headphone jacks of my transceivers.

RX Share is set up for a typical 8 Ω system, but can change the impedance to 600 Ω by swapping some internal jumpers. Each audio channel uses an isolation transformer to prevent ground-coupled crosstalk or RF pickup. The transformers are specified to handle up to 1 W of audio. There's also an internal ground jumper that can be used to connect the input common or the output common to the enclosure, or it can be removed. The manual suggests experimenting with this jumper if you experience RF pickup in the headphone audio.

Using the RX Share

For the **SHARED RADIO** mode, connect the transceiver to the **R1 INPUT** jack and headphones to **HEAPHONES OPERATOR 1** and **HEADPHONES OPERATOR 2**. It's not mentioned in the instructions, but I found that the transceiver has to be connected to the **R1** input, and not the **R2** input, for **SHARED RADIO** operation.

Set the center rocker switch to **SHARED RADIO** and the transceiver audio will be heard in both headsets. Some transceivers have two receivers with separate main and subband audio outputs. In that case, each operator can use their rocker switch (see Figure 8) to select main receiver audio in both ears, sub receiver audio in both ears, or main in one ear and sub in the other.

Figure 7 — The RX Share connections include two sets of ¼- and ⅛-inch stereo headphone jacks, and a ¼-inch stereo jack for connection to each receiver.

Because the volume for both operators is controlled by the transceiver, this device works best when both headsets have similar impedance and sensitivity, and both operators have similar hearing sensitivity. If there is a significant difference, the manual suggests moving the internal impedance jumpers to reduce the volume on one side or the other.

For the **SEPARATE RADIOS** mode, connect audio from a second transceiver to the **R2 INPUT** and switch the center rocker switch. Now, each operator can use their rocker switch to select Radio 1 audio in both ears, Radio 2 audio in both ears, or one radio in each ear (or a single operator can listen to these combinations for SO2R contesting).

Bottom Line

The DX Engineering RX Share offers a safe and convenient way for two operators to share the audio from a transceiver, or for one operator to listen to audio from two transceivers.

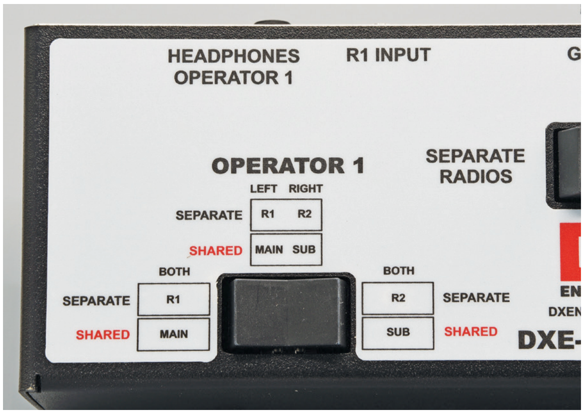

Figure 8 — Large rocker switches are used for selecting the various audio streams heard in the headphones.

The RX Share is well made. It weighs nearly 4 pounds, and with its large rubber feet, it stays put on the operating desk. The rocker switches operate smoothly, and after a few minutes, I was able to operate them by feel while looking at my radio or computer.

Manufacturer: DX Engineering, 1200 Southeast Ave., Tallmadge, OH 44278; **www.dxengineering.com**. Price: $189.99.

Workbench "Third Hand" Circuit Board Holders

Reviewed by Paul Danzer, N1II
n1ii@arrl.net

While assembling small projects on printed circuit (PC) boards, it can be helpful to have something to hold the board while you work. Oftentimes, you feel like you need a third hand. We checked Amazon and chose several PC board holders that looked useful, and also ordered a unique one from a ham radio kit supplier. Each design has advantages and disadvantages, and picking one depends largely on the features you prefer. The units shown were available as of mid-November 2019.

For this review, I used each unit to install components on a small board (3 × 5 inches). I also used my normal soldering tools — a 40 W pencil-tip soldering iron, a good light, and a magnifying device, unless there was one built into the board holder.

Helping Hand Magnifier

This small, inexpensive unit is a classic design offered by many companies. The one we ordered carried the model number MZ101B, but identical devices are available under various brand and model names. There are two versions — one with an integrated magnifying glass, as shown in Figure 9, and one without. The unit shown here has a 2½-inch lens with 4× magnification. All joints are friction fit, and the various clips and arms are secured in place by tightening thumb screws. Two alligator clips are mounted on the end of the horizontal bar to hold the PC board.

After inserting a component on the top side of the PC board, you usually have to take the board out of the clips to turn it around and solder the reverse side. Then you remount the board to repeat the process for the next component. The base is heavy enough to support small PC boards without tipping over. While

Figure 9 — The classic and inexpensive Helping Hand design is available with and without a magnifier.

Figure 10 — The LED Light Helping Hands Magnifier Station includes several soldering aids and two magnifying lenses. It uses the same two alligator clips to hold your work as the device shown in Figure 9.

the Helping Hand Magnifier is not the most convenient to use, it's the least expensive one tested.

Available from Amazon (search for "SE MZ101B" or "Helping Hand Magnifier"). Similar devices are available with other model names. Price: about $7.95.

LED Light Helping Hand Magnifier

The circuit board holder shown in Figure 10 is available under several brand names, and we ordered the YOCTOSUN version. This device uses a horizontal bar with thumbscrew-mounted alligator clips, very similar to the Helping Hands Magnifier described above. The 7.5 × 3.5 inch base has a soldering iron holder on the back and a small tray on the front to hold a wet sponge for cleaning the soldering iron tip as you work. A small plastic vise can slide over the horizontal bar to hold small assemblies (see Figure 11), and at the very front are three drawers to hold small parts.

Two magnifying lenses mount on a pivoting arm. The larger lens (approximately 3-inch diameter) is a

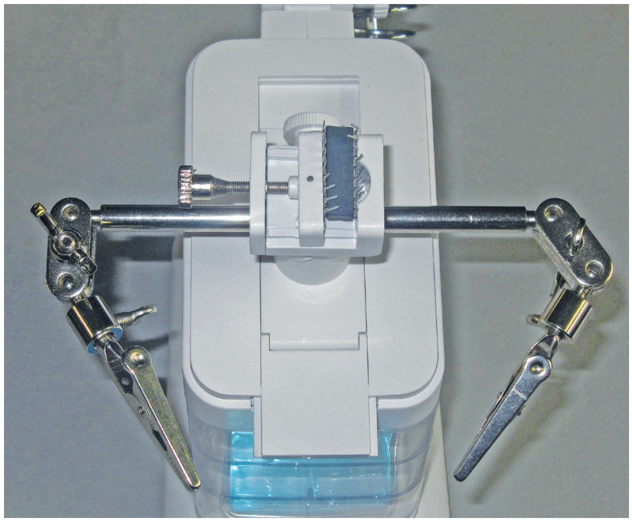

Figure 11 — A small vise, shown here holding an integrated circuit upside down to have its pins straightened, is included with the device shown in Figure 10.

3× magnifier, and has a 4.5× magnifying lens scribed inside. The smaller (¾-inch diameter) lens offers 25× magnification and can be used alone or in conjunction with the larger lens.

The large lens is surrounded with 10 LEDs, which I found to be bright enough to illuminate the work without excessive glare. The light can be powered from three AAA batteries or from a standard USB port (a matching USB cable is supplied). There may not be enough room to use your soldering iron with the magnifiers in place, but they easily pivot out of the way. A rectangular extension slides in and out to move the holding bar (and your work) backward and forward.

Available from Amazon (search for "YOCTOSUN Helping Hand Magnifier"). Similar devices are available with other model names. Price: about $16.99.

Helping Hands Third Hand Soldering Tool and Vise

Resembling a four-armed octopus with a magnifying head, the Helping Hands Third Hand by PSIVEN comes unassembled in a padded box weighing a hefty 4 pounds. A cloth bag and optical cleaning cloth for the 3¼-inch magnifying glass are included. Surrounding the 3× magnifier are 16 LEDs with two selectable levels of brightness, and the light is connected to a USB cord for power (power supply not included).

Assembly time is about 5 minutes, and it would have been easier if the screws connecting the arms to the base were longer. As shown in Figure 12, four flexible arms with alligator clips hold the circuit board. Two of the arms extend 14¼ inches from the base to the tip

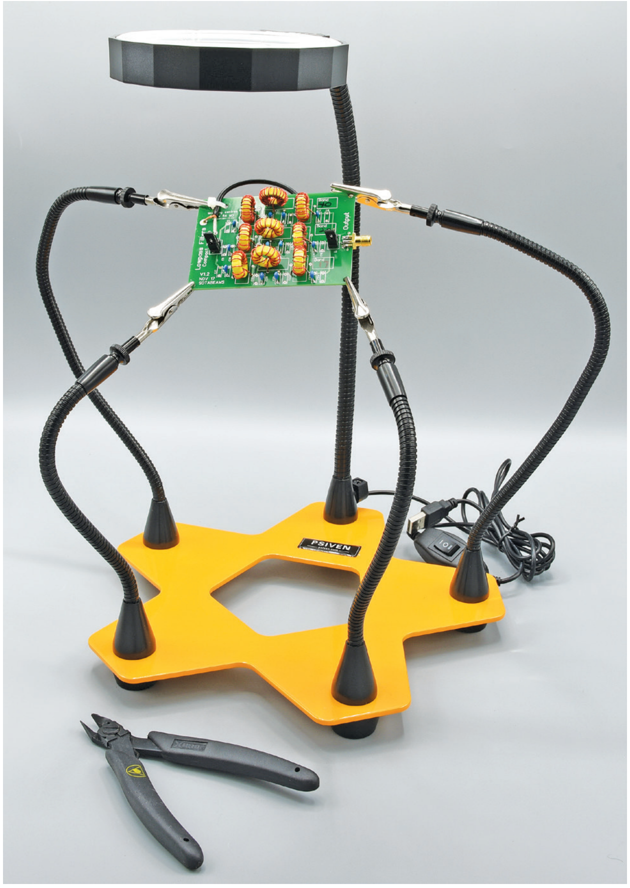

Figure 12 — The PSIVEN Helping Hands Third Hand Soldering Tool and Vise has four alligator clips and a magnifying lens with an LED light source, giving a lot of meaning to the word "flexibility."

of the alligator clip, and two extend 10½ inches. When it's used on a 36-inch-high workbench, you can work standing up with the holding arms extended.

Small rubber covers fit over the alligator clip noses to prevent scratching. The base of each alligator clip plugs into a plastic assembly on the tip of a flexible arm, and the alligator clips can be rotated. Turning the notched wheel locks the clip in place.

When holding the PC board with all four arms, I found it a bit awkward to bend the arms to the same level. In addition, if you want to work on the other side of the board, you have to unclip the board, turn it, and reset the clips. I found that using two alligator clips was sufficient to hold small boards firmly in place. If you use two clips and don't tighten the wheels completely, you can rotate the PC board from the component side to the solder side without unclipping the board.

The magnifying lens worked well, and its flexible stalk made it easy to move out of the way if needed. I also found that using the LED light source without using the magnifier was convenient.

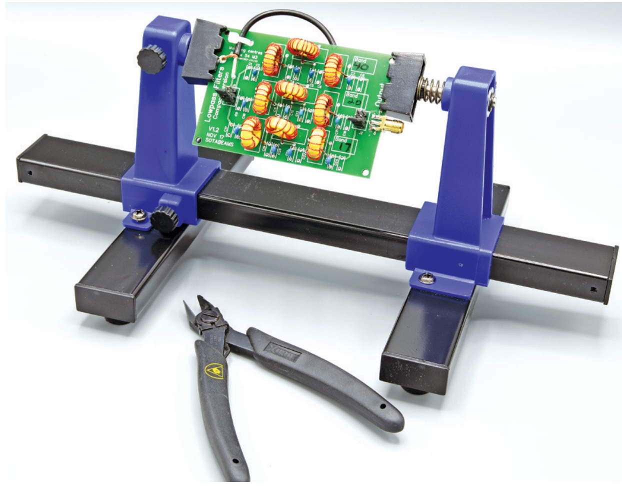

Figure 13 — The Aven Adjustable Circuit Board Holder resembles a lathe. The PC board is easily rotated.

Amazon carries several similar-looking devices with or without the magnifier and light. To find the one shown here, search for "PSIVEN Helping Hands." Price: $39.95.

Aven Adjustable Circuit Board Holder

The unit shown in Figure 13 resembles a small lathe with end posts to grab the edges of a PC board. It can be used with a board as long as 7¾ inches and as short as perhaps ¾ inch. The arms slide along the base and can be locked in place by thumbscrews with knurled knobs. Some simple assembly is required.

Each arm has a metal clamp that accepts the edge of a circuit board. The clamp on one arm is spring loaded, and the other is fixed. To use the device, set the arm with the fixed clamp at the desired position and lock it down. Place one edge of your circuit board in the fixed clamp and slide the arm with the spring-loaded clamp up to the opposite edge, compressing the spring enough to provide tension to hold the board in place. Lock that arm down and you're ready to work. Note that the clamp shafts also have thumbscrews that can be used to prevent the board from rotating if desired.

Once in place, the board is held solidly, but it does not take much to knock the board out of its mount. The clamps that hold the board rotate 360 degrees. If your PC board is less than 5½ inches wide and centered in the clamps, you can rotate it completely to work on the component side or solder side at any angle. If it's more than 5½ inches, you can still rotate it back and forth to get at both sides.

Figure 14 — The QuadHands Flip Circuit Board Holder resembles the Aven unit, but is much more rugged and holds a larger PC board.

Search for "Aven 17010" on Amazon. Price: about $12.95. Several similar-looking devices are also shown.

QuadHands Flip Circuit Board Holder

The QuadHands circuit board holder shown in Figure 14 is exceptionally rugged. Its hefty (2½-pound) base, with nonslip feet, holds two large end pieces with grooves to secure the PC board. It accommodates boards as long as 12 inches and as small as a fraction of an inch.

To use this device, loosen the wing nuts at the bottom of the end pieces and then move them so that the space between them is approximately ½ to ¾ inch smaller than the PC board. Then press the spring-mounted holder to compress the spring and insert the PC board. The spring tension is sufficient to hold the board firmly in place. The height of the end pieces allows rotation of a board as wide as 10 inches. Once the board is in place, it rotates easily to expose the opposite side or position it at any angle by turning the two end knobs simultaneously.

When tightening the wing nuts, the matching screw is kept from rotating by a rubber or plastic nut beneath the base plate. You may have to either tilt the end piece up slightly or pull on the wing nut to keep the screw from rotating. This holder is great for larger boards and won't move around on your workbench.

Search for "QuadHands Flip Circuit Board" on Amazon. Price: about $47.95.

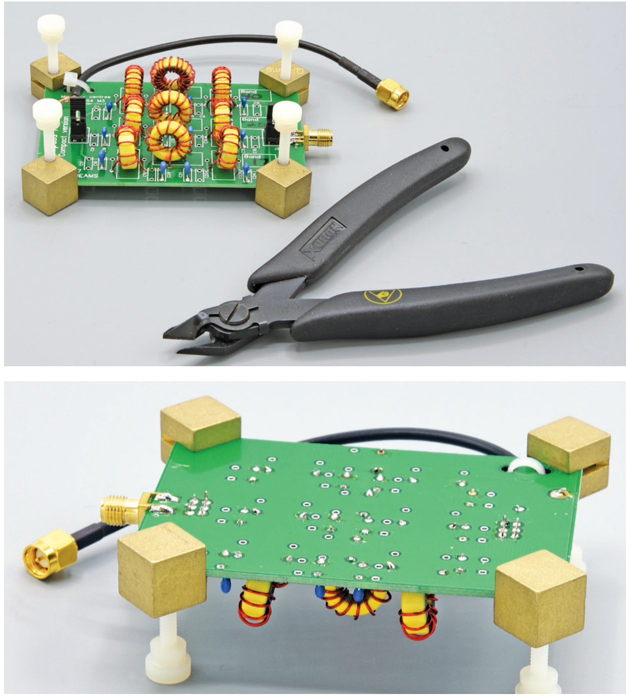

Figure 15 — A Brass Set from QRPme is quick to set up and is designed for small QRP projects. The nylon screw lengths give you room for protruding parts when the assembly is turned over.

A Brass Set from QRPme

Finally, we tried A Brass Set from Rex Harper, W1REX, at QRPme. This company supplies a wide range of kits, tools, and accessories of interest to hams. As you can see in Figure 15, this circuit board holder consists of four brass cubes, each measuring approximately ½ inch per side. Each cube is milled out to have a triangular slot through one corner, and it is threaded for a nylon screw. When the corner of a PC board is inserted in the slot, the nylon screw clamps the board in place.

With the brass cubes oriented as shown in the photos, with the component side down, the board is about an inch above the workbench surface. This gives clearance to protruding components. Turn it over, and the solder side is approximately ¼ inch from the workbench.

Of all the devices reviewed here, this one makes it most convenient to turn a small PC board over and position it at any angle as you work. The one issue I noted is that the nylon screws are slippery, so you may want to place it on a nonslip mat to keep the board with attached cubes from sliding as you work.

Available from QRPme, **www.QRPme.com**. Price: $17 for the set of four cubes.