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# A Review of the Flex 6600M Software Defined Radio

*By Paul Staupe WØAD*


Paul, WØAD in his new station built around the Flex 6600M

I passed the Novice test in WØAIH's basement in Virginia, MN 48 years ago. Still in junior high I started on a lifelong journey of interest in DXing on Top Band as well as DXing on the BCB (Broadcast Band) and below. In high school, upgrading to a Drake R-4A/T-4X was a giant leap forward in technology from my original HQ-110A/Ranger Novice rigs. Moving to a Drake C-line was a natural evolution and I became friends with Rob Sherwood and modified several R-4Cs with Rob's kits to improve low band and close signal performance. However, I always wondered if I was missing signals due to weak tubes or misalignment. When solid state rigs came along I was aware that they left much to be desired in terms of strong signal capabilities, so I held off until eventually settling on a YaesuFT-1000D with all the filters and sub-receiver. Space diversity reception had intrigued me on TopBand and I could achieve it on the FT-1000D to some extent, but the sub-receiver was not phase locked to the main receiver and was an inferior design. W8JI had published his project on phase locking R

-4Cs together, but I knew something better was coming along.

**Transitioning to SDR Technology**

Fast forward to 2015. I'd been in touch with Glenn Johnson WØGJ over the years and visited his Iowa QTH after he had moved from Bemidji. Glenn had been using conventional transceivers so I was very interested when I discovered that he had switched to Flex Radio. After his K1N DXpedition to Navassa which showcased the Flex's capabilities in a DXpedition, I took him up on his offer to lend me a Flex 6500. Considering a radio without knobs was an easy concept for me to absorb since I've spent my career in IT and telecommunications. When I installed the software and booted up the loaner Flex 6500, I immediately realized the power of the design.

The Flex "ingests" the entire HF spectrum and immediately converts it from analog signals to digital 0's and 1's. It then manipulates the data into readable signals without the traditional mixing approach of superhetrodyne methods used since the 1930s. The massive amount of data that is produced by taking snapshots of the whole HF spectrum many times per second takes a tremendous amount of computing power.

Early SDRs (Software Defined Receivers) required a fast computer with a lot of RAM and multiple CPU cores to decode the vast amount of data. Flex's approach with their Signature Series (6300/6500/6700 and now the 6600) is to offload the data processing to an internal specialized solid state device called a Spectral Capture Unit, (SCU). The radio itself does the massive processing and the computer provides the control and video functions. As a result, the brute force requirements for a ham's PC was eliminated. The sheer amount of data that's decoded by the SCU is incredible. An Intel i7 hex core processor is capable of decoding between 4-8 gigaflops, (a gigaflop is a unit of computing power equivalent to 1 billion floating point operations per second). The specialized SCU in the Flex is capable of decoding 121 gigaflops per second or about 20 times the speed of the most expensive PC. In the Flex, the entire HF radio spectrum is sampled over 245 million times per second !!! When the actual slice receivers in the Flex select a "slice" of the spectrum and provide the analog to digital conversion on the frequency of interest, the rest of the data is discarded.

It was after reading a presentation about how SDR technology had finally eclipsed traditional superhetrodyne radio that I finally gained the insight as to what a Flex could do:

http://www.ke4ham.com/club-information/modern-radio-sdr-101/

The bottom line is that there has been a paradigm shift in receiver technology from analog (superhet) to digital (SDR) analogous to the shift from spark technology to continuous wave (CW). This is described in Aitkin's excellent book "The Continuous Wave: Technology and American Radio 1900-1932" (Princeton Press 1985).

Aitkin's book explores the quantum leap in technology from spark to CW which eventually rendered spark transmission obsolete even though the incumbent providers such as the Marconi Company made significant advances in later years. CW was an entirely new way to transmit RF and was clearly superior.

This was on my mind as I tried out WØGJ's loaner Flex 6500. Its ability to get next to a strong signal without receiver de-sensing as the digital filtering literally emulates a 1000 pole crystal filter with no loss of quality of the received signal or ringing. It is only manipulating 1s and 0s and not the RF signal itself as in a superhetrodyne radio. This is the equivalent of copying audio CDs - the copy is an exact duplicate of the original no matter how many copies are made. The original waveform is preserved while eliminating adjacent QRM. It can also be digitally enhanced to become more readable which is helpful on both CW and SSB.

I was amazed to discover the high resolution visual display, showing each signal on the panadaptor as well as the time characteristics of each signal in the waterfall. I purchased a 40" ultra-high definition TV with a HDMI input from MicroCenter and mounted it on my wall so I could see not only N1MM+ and my other computer applications, but a crisp view of the Flex panadaptor and control functions. I was no longer just listening the band, I was now able to see the band.

In a way, this was disappointing as I could now see every signal on the band, and if there was a spot with no signal visible on my display, I wasn't going to hear it and it wasn't going to be worked, no matter how hard I hoped it would be there. So, some of the excitement of tuning blindly up and down the band hoping to hear DX was diminished but replaced with the knowledge that if I saw a DX station on the band-scope, I most likely could work it. (I solved that issue by getting back to "old school radio" with a refurbished Drake B line, the radios I couldn't afford in high school that I now use quite often!)

The Flex display made working DX stations in split mode far easier as I could see both the DX station and the pileup, and many times by "coat tailing" the last station he worked after he signed (which also would be visible on CWSkimmer), I would soon be in his log. This is far more efficient and effective than hoping you would land on the right spot, as I experienced by working VKØEK on 20 meters in April 2016 with my Kenwood TS-590 in the last two hours of their DXpedition after a week of fruitless blind calling.

The challenge with the Flex 6500, when using it with the SmartSDR software, is a lack of knobs to change frequencies. This is done by either using the mouse wheel, dragging the receiver frequency to the desired spot, or typing the frequency in the window. This is somewhat alleviated by using a multifunction Flex Control knob which plugs into the computer and emulates a VFO tuning knob. However, not having real knobs was still an issue for rapid QSY, as well as precision tuning. Being forced to use a mouse to change receiver settings although intuitively laid out on the screen, is still slower than having a button to push on radio front panel.

Even more important than knobs and front panel buttons was the fact that the upcoming 6600M also would have two spectral capture units; separate yet equivalent receivers that could be phase locked. At long last, I could utilize space diversity with different antennas such as verticals and Beverages for low band and BCB DXing.

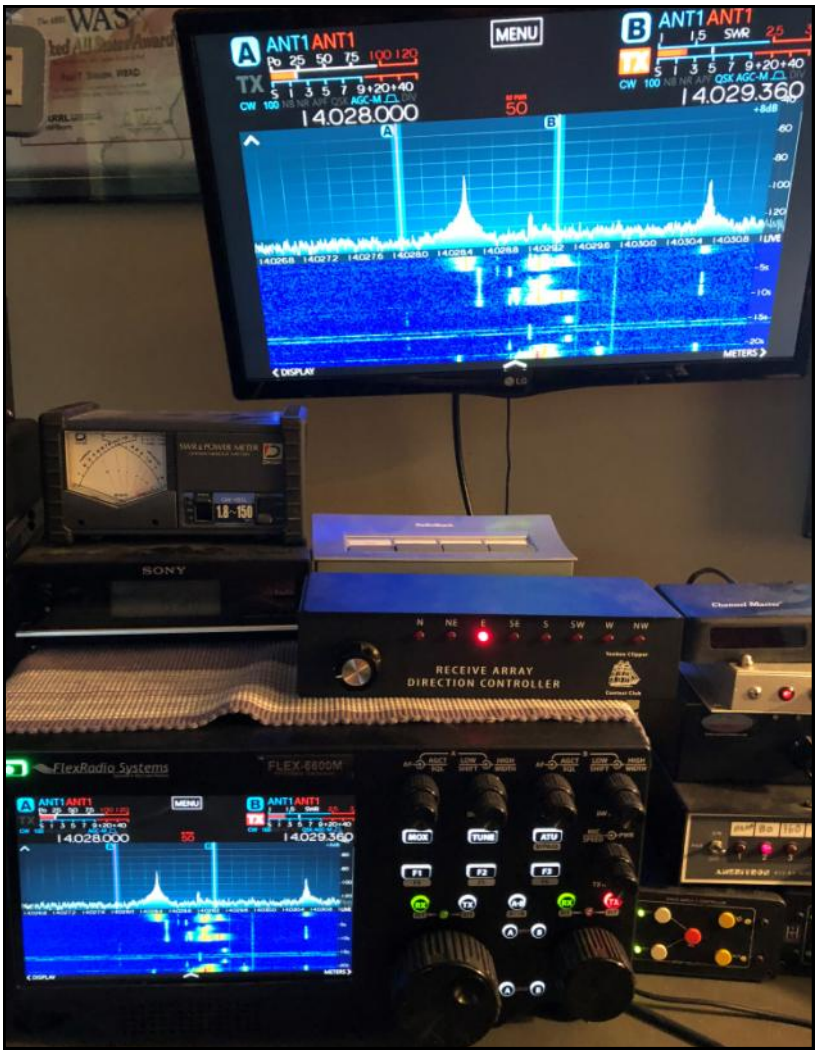
**Taking Delivery of the Flex 6600M**

With these features in mind, when the Flex 6600M was announced at Dayton 2017, I sent in my deposit a day after the conven-


A close-up of the new Flex 6600M

tion ended and waited. Flex sent out periodic updates, and it soon became clear that they were not going to be rushed into releasing a radio before it had been totally beta tested. My hopes for winter contesting with the new radio were put on hold.

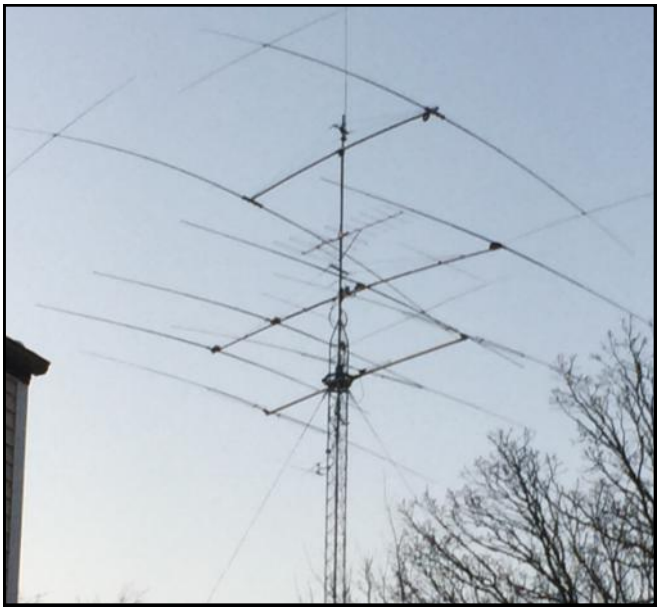
However, I received a notice in late January 2018 that the Flex (M) models were shipping, and a week later, my radio was ready to ship. I immediately sent my Flex 6500 as a trade-in and received the 6600M just in time for the February ARRL DX CW contest after paying for overnight shipping to make sure it arrived!




The Flex 6600M has an HDMI Port allowing the radio front panel to be displayed on an external monitor

My learning curve was very short as the 6600M behaved very much like my previous no knobs 6500. Surprisingly, it took a while to get used to knobs and buttons again. A nice touch was that the 6600M has its own HDMI port rather than using a video display card on the computer. I purchased a second UHD TV with a HDMI input and mounted it on the wall. I could now view the radio display all by itself and the rest of the station functions on the big 40" monitor.

The smaller monitor is dedicated to the Flex display which is a more convenient way to watch what's happening on the bands. As an added bonus, I can DX the DTV spectrum with a Yagi on my mast at 90 feet.



WØAD's antenna stack on 80' of Rohn 45G

Both the 6500 and the 6600M have up to four software defined receivers called "slices" that can be used on the same band, for split operation in DXing. In the case of the 6600M with its two SCUs, true full duplex cross band operation anywhere between 160M and 6M with two antenna outputs is possible. There is no signal degradation between any of the slice receivers as they are simply software decoding digital data. For example, one slice can be monitoring 6M openings while another two slices can be chasing DX on 20 meters.

**Integrating the Flex 6600M Into My Station**

The Flex 6600M integrates into the station much differently than my previous Kenwood TS-590. A HP quad core computer running Windows 10, the Flex 6600M, the Flex Control, my German made solid state amplifier, (more on this later) and my 4O3A antenna switch (which follows the Flex automatically changing antennas during band changes) are all connected. They communicate to each other via a standard commercial (Cisco Meraki) gigabit Ethernet switch.

My prop pitch rotating a W6NL 2 element 40M Moxon at 90', a 9 element FM BCB Stereo Probe 9 at 85' and a 4 element SteppIR at 80' is controlled by a Green Heron RT-21pp. A Tic-Ring at 70' rotating a 3 element KLM 30M Yagi is controlled via a Green Heron RT-21D. A Ham-IV rotating a 4 element SteppIR at 35' on a swinging gate is controlled by a Hy-Gain DCU-1. An Array Solutions 80M 4 square and an Array Solutions StackMatch II switch for the SteppIR completes the interfaces. All are controlled by USB connections to the computer. My objective is to someday be able to operate the entire station remotely. At this point, the only functions that are not remote controllable are Beverage selection and direction selection on my YCCC 5 element receive array.

On the main 40" monitor, I use CWSkimmer, N1MM+ which logs, spots and controls the rotors, VNC to remote control the solid-state amp, and the Hamation (Array Solutions) ShackLAN which controls the 80M 4square and the StackMatch for the SteppIRs. I also run DDUtil, a helper application that remote controls my SteppIR control boxes as they change frequencies. Additionally, I can still run SmartSDR on the big screen as I did before with the Flex 6500 (which remote controls the Flex 6600M and utilize the FlexControl knob). I was somewhat surprised to discover that since using SmartSDR on my PC rather than on the Flex itself, the PC becomes a remote controller even though the Flex is next to the computer and the front knobs and display on the Flex are disabled. Likewise, if I'm using my iPad to control the Flex or if I use a software package SmartLink distributed

by Flex. This allows remote control of the Flex from anywhere, even though my corporate network. The front knobs and display are disabled as a different computer's IP address is controlling the Flex.

SSB/AM/SAM/FM on the Flex uses either a high impedance mic jack or a balanced audio connector for microphone inputs.

A 40" Ultra High Definition TV provides plenty of screen real-estate for applications used with the Flex 6600M

There is no need for an external equalizer since voice is immediately turned into data and can be manipulated as discussed previously. Voice can be studio quality or highly processed and even downward expanded to eliminate background noise. On SSB reception, automatic notch filters can be introduced to eliminate heterodynes as well. One of the benefits of using the Flex is that no external boxes are required for RTTY or digital modes. Since everything is already digital, the signals can be manipulated by software so that the necessary tones and timing are all internal. The Flex is essentially a computer; a purpose built specialized computer eliminating the delays associated with general use computers and issues of CPU interrupts and delays. The signal generation is accurately timed without the need for anything external.

The Flex software emulates serial ports with a CAT helper application, and audio/control information with a DAX helper application that are included with Flex's SmartSDR package. These two applications eliminate the jumble of wires and boxes required for digital modes in standard transceivers. Many of the devices such as rotor controls and helper applications are identified and controlled by the Flex software.

Rather than purchasing the solid-state companion linear amplifier from Flex, I chose to purchase a LDMOS amplifier called a B26-RF2K+ which was an outgrowth of the DARC in Germany marketed as RF-KIT. https://rf-kit.de/en/2k_Kit.php

This relatively inexpensive amplifier covers 160-6M and is extremely quiet at 1500 watts. It has an internal antenna tuner which follows the Flex using a serial USB cable. It is also remote controllable using a shareware application called VNC. The RF-KIT also has its own touch screen. In order to protect the LDMOS devices from overdrive, I keep the Flex at 50W maximum and the amp has a 16 dB attenuator plus other protective circuitry. Without the attenuator, the LDMOS has such high gain that I couldn't stay legal on 30M even driving it with only 1 watt output from the Flex. With 50 watts attenuated, the RF-KIT puts out 1500W on all bands,

with slightly lower output on 6M. The ease of controlling the amp through the VNC software makes it an excellent step toward my goal of operating remotely.


Decoding KCHK AM in New Prague, MN in diversity mode on the Flex 6600M

**Performance**

So how does this all fit together? The Flex has performed well in several contests since receiving it six months ago. The overload characteristics are superb. I can easily receive a weak DX signal 100 Hz away from a 20+9 local with ease. When DXing, I set my passband to 50 Hz wide and hear no ringing or artifacts even though the passband is extremely narrow. Also, I've been able to enjoy BCB and beacon DXing without the image and overload problems that I have experienced in every other receiver I've ever owned due to high power levels on the BCB. I'm just beginning to get familiar with utilizing the space diversity mode on the BCB and as autumn approaches I'll be using it more frequently on 160 and 80 meters with the transmit antenna and either Beverages, a loop or the YCCC 5 square RX array.


The new B26-RF2K+ amplifier now interfaces with the Flex 6600M in WØAD's station

The figure above shows the Flex decoding KCHK AM in New Prague, MN in diversity mode right next to the strongest local signal in my area WLOL on 1330. The left signal is coming from my 80M 4 square, and the right side is coming from one of my Beverages. This is similar to what I'd do on CW on 160 or 80M. With the headphones on, the fades will equalize and a weak signal will be much more readable.

To sum it up, the investment I've made in the Flex 6600M and state of the art technology has vastly improved my station. Although it's no substitute for a good antenna farm and a good operator, it provides the means to work DX in a much easier manner than previous technology and I believe is well worth it.

73,Paul WØAD