

PRODUCT REVIEW

WiNRADiO WR-G31DDC Excalibur Software Defined Receiver



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The march of technology is relentless. Less than a decade ago we marveled at first-generation software defined receivers that sampled a small slice of RF spectrum and sent the resulting information to a computer sound card as analog I and Q (In-phase and Quadrature) signals for subsequent conversion and demodulation. The hardware simply mixed the RF to baseband audio and the computer took it from there. The result was the ability to demodulate just about anything you could receive. Better still, you could process it with razor-sharp filtering well beyond what any hardware receiver could hope to achieve.

Within five years technology had advanced to the point where it was possible to sample a wide swath of RF spectrum and instantly convert the analog signals to digital data. The data was then passed directly to the computer for processing — no sound card analog-to-digital conversion required. This came about as high-speed analog to digital converters (ADCs) and digital downconvert-

ers (DDCs) became available at reasonable prices. One product that benefitted from this advance was the Microtelecom Perseus software defined receiver, which we reviewed in these pages back in December 2008.¹ At that time the Perseus retailed for about \$1300. Today it sells for just under \$1000.

The WiNRADiO WR-G31DDC Excalibur receiver takes advantage of the technological refinements that have occurred since then. The \$899.95 price tag may seem intimidating when compared to most

¹S. Ford, WB8IMY, "Microtelecomm Perseus Software Defined Receiver," Product Review, *QST*, Dec 2008, pp 40-44. *QST* Product Reviews are available to ARRL members online at www.arrrl.org/product-review.

Bottom Line

WiNRADiO's WR-G31DDC Excalibur software defined receiver offers excellent performance. Despite the wealth of features found in the accompanying software, it's easy to set up and enjoy.

consumer-grade analog desktop receivers, but the performance and features may justify the difference for many.

Features and Functions

The Excalibur is housed within a shielded $6\frac{1}{2} \times 3\frac{3}{4} \times 1\frac{1}{2}$ inch box encased in translucent plastic and powered by a 12 V dc supply. At the business end you'll find an SMA antenna connector. (WiNRADiO thoughtfully includes an SMA-to-BNC adapter.) That's where the story of the Excalibur's signal processing technology begins.

The antenna jack is connected to a hardware stage that includes a bit of analog preamplification and filtering. The output of this stage is fed to a high-speed ADC at which point the entire RF spectrum, from about 5 kHz to almost 50 MHz, is chopped to bits (so to speak). Let that idea sink in for a moment — nearly 50 MHz of RF bandwidth, and everything contained within, rendered to data in tiny fractions of a second!

Now it follows that you'd want to immediately funnel all that data right to your computer for processing, but that isn't possible with current technology, or at least with technology that doesn't require the net worth of Bill Gates to purchase. So, the Excalibur gets around this limitation by using a digital downconverter to channel only up to 2 MHz worth of spectral data to your computer at any given time. The Excalibur sends the downconverted data to the computer through a USB 2.0 connection at which point the WiNRADiO software takes the final step of demodulating the desired signals.

The layout of the WiNRADiO software interface reflects this process (see Figure 1). The large window along the bottom shows the complete RF spectrum all the way to either 30 or 50 MHz (selectable). The window at the upper left displays the output of the DDC, the bandwidth of which is adjustable from 2 MHz down to 20 kHz. The window at the upper right is devoted to the software demodulator. Here the bandwidth is continuously adjustable from about 62 kHz down to just 10 Hz.

The current version of the WiNRADiO software will demodulate USB, LSB, CW, AM, synchronous AM, FM and FSK. You can also receive and decode Digital Radio Mondiale (DRM) signals if you purchase a license key from WiNRADiO. More about DRM reception later.

You can tune the Excalibur in a number of ways. You can enter the frequency directly via the keyboard, tweak the virtual tuning knob found in the upper portion of

the user interface, or click and drag a filter window. Tuning in 1 kHz steps is the norm, but 1 Hz, 10 Hz or 100 Hz tuning steps are available if you press and hold the CNTRL, SHIFT or ALT keys respectively.

One noteworthy feature of the Excalibur is the ability to receive three signals at once. In this sense you can say the Excalibur offers three independent receivers. The receivers are selected via three buttons in the upper

left corner above the frequency display (see Figure 2). If the signals in question all fall within the selected bandwidth of the digital downconverter (as shown in the DDC BW window), you can do some creative things with the Excalibur audio mixer. For example, one receiver can be sent to the left audio channel and another to the right channel. For the ultimate in listening madness, you can listen to all three receivers at once in both channels!

The S meter is calibrated in dBm, μ V or S units and can be set to show the peak, RMS or average values. The meter will alert you to strong signals that result in ADC clipping. Should this happen, you can configure the Excalibur to automatically activate an input attenuator.

In addition, you have a fully adjustable AGC system with fast, medium and slow presets as well as three user presets. You can set the attack and decay times together with a reference level and maximum gain. Or, you can disable the AGC altogether and ride the gain manually.

As I mentioned previously, you can set up some astonishingly sharp filters. A software function known as *filter length* determines the sharpness of the filter edges. The default setting is 200, but you can take it all the way to 5000 and create true “brick wall filtering” if your computer has the processing muscle to support it. With my 3 GHz dual-core PC, I was able to take the range to 5000 without sluggishness, but slower processors will likely be limited to a much lower range. It was a fascinating exercise to create ultra-narrow filters to pull weak CW signals out of crowded bands.

The Excalibur includes a notch filter with adjustable frequency and width, and a noise blanker with adjustable threshold. They’ve even thrown in an audio filter with adjustable low and high cut and selectable deemphasis.

With the Excalibur you have the ability to store and recall an almost limitless number of frequencies. The memory storage is limited only by the size of your hard drive. You can tag each memory with a label (such as VATICAN RADIO, for example) and the label will appear on the spectrum display whenever you tune near the frequency. You can also download and store the free HFCC (www.hfcc.org) or EiBi (www.eibispace.de) broadcast frequency databases.² This is particularly handy for shortwave broadcast browsing.

With the built-in recording feature (Figure 3) you can record the entire DDC

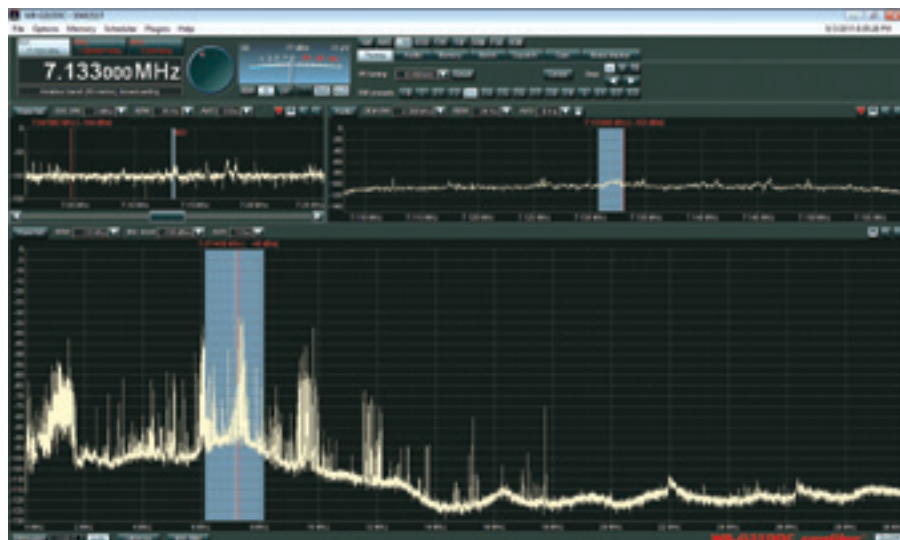


Figure 1 — The Excalibur main screen. The entire received spectrum is shown in the lower window. The DDC spectrum appears in the upper left window and the demodulated spectrum is displayed in the upper right window.



Figure 2 — The bar along the top allows you to select from one of three receivers and includes the frequency display, S meter and the mode and demodulator bandwidth controls.



Figure 3 — The Excalibur recording function includes a full-featured scheduler.



Figure 4 — Close-up of the demodulator window showing the drop-down audio recording window.

²See www.hfcc.org and www.eibispace.de for more information about these databases.

Table 1
WiNRADiO WR-G31DDC, serial number 10K02117

Manufacturer's Specifications

Frequency coverage: Receive only, 9 kHz-49.975 MHz.
 Power requirement: 11-13 V dc, 500 mA, 45 mA (power save on).
 Modes of operation: SSB, CW, FM, AM, AMS (synchronous AM), UDM (user defined mode), DRM (optional).

Measured in the ARRL Lab

5 kHz to 49.975 MHz.
 416 mA (on screen power switch on), 50 mA (power switch off) at 12 V dc. Drop out voltage, 7.7 V dc.
 As specified.

Receiver

Sensitivity: CW, -123 dBm at 10 dB S+N/N, 500 Hz bandwidth; SSB, -116 dBm at 10 dB S+N/N, 2.1 kHz bandwidth.

Receiver Dynamic Testing

Noise floor (MDS), 500 Hz BW:*

0.010 MHz	-108 dBm
0.137 MHz	-127 dBm
0.505 MHz	-130 dBm
1.0 MHz	-130 dBm
3.5 MHz	-130 dBm
14 MHz	-130 dBm
28 MHz	-129 dBm

Noise figure: 14 dB.

14 MHz, 17 dB

AM sensitivity: 2.0 µV at 10 dB S+N/N.

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

1.0 MHz	2.00 µV
3.8 MHz	2.00 µV
29.0 MHz	2.980 µV

FM sensitivity: 0.56 µV at 12 dB SINAD, 3 kHz deviation, 12 kHz bandwidth.

For 12 dB SINAD, 3 kHz deviation, 15 kHz BW: 29 MHz, 1.15 µV

Spectral display sensitivity: -140 dBm.

-141 dBm.

Blocking gain compression: Not specified.

Gain compression, 500 Hz BW:†

	20 kHz offset	5/2 kHz offset
3.5 MHz	127 dB	127/127 dB
14 MHz	128 dB	128/128 dB
28 MHz	129 dB	129/129 dB

Reciprocal mixing (500 Hz BW): Not specified.

20/5/2 kHz offset: better than 128 dBc.††

Spurious free dynamic range: 107 dB.

Third order IMD dynamic range: Up to 107 dB.†

Third order intercept point: +31 dBm.

Up to +27 dBm at MDS, +32 dBm at S5 (-97 dBm).†

Adjacent channel rejection: Not specified.

20 kHz spacing, 80 dB.

FM two-tone, third-order IMD dynamic range: Not specified.

20 kHz offset: 29 MHz, 80 dB (noise limited).

S-meter sensitivity: Not specified.

S9 signal at 14.2 MHz, 69.6 µV.

Squelch sensitivity: Not specified.

29 MHz, 0.4 µV.

IF/audio response: Not specified.

Range at -6 dB points (bandwidth):‡

CW (500 Hz):	296-799 Hz (503 Hz).
Equivalent Rectangular BW:	519 Hz.
USB: (2.4 kHz):	295-2712 Hz (2417 Hz).
LSB: (2.4 kHz):	295-2712 Hz (2417 Hz).
AM: (6 kHz):	300-3283 Hz (5964 Hz).

Size (height, width, depth): 1.6 × 3.8 × 6.5 inches; weight, 1.15 lbs.

Price: WR-G31DDC receiver, \$899.95. DRM license, \$49.95. Virtual Sound Card s/w, \$49.

*Filter length set to 3000. An MDS of -134 dBm with a noise figure of 13 dB was achieved with longer filter lengths and deemphasize set to -1.0 dB/octave.

**Blocking level exceeds the threshold of ADC clipping.

†Dynamic range dependent on total RF power at receiver jack. See February 2010 QST, page 52.

††No reciprocal mixing occurred up to the threshold of ADC clipping (-2 dBm at 14 MHz).

‡Adjustable with audio filter settings.

modulated signal audio with other software applications such as a PSK31 or RTTY decoders. However, this requires the separate purchase of the WiNRADiO *Virtual Sound Card* (VSC) software at a cost of \$49.

Hands On

Excalibur software is provided on a CD-ROM for *Windows XP, Vista* or *7*. On my 64 bit *Windows 7* system it installed smoothly and quickly. Setting up the Excalibur receiver itself was as easy as connecting the dc power cable, plugging in the antenna system coax and connecting the USB cable. When I double clicked on the EXCALIBUR icon, the radio instantly sprang to life.

As you'll see in the accompanying screen images, the user interface is well designed and easy to navigate. That said, it pays to read the Excalibur manual before diving in. Topping out at 108 pages, the manual is well written and informative.

With so much RF at my fingertips, more than an hour sped by as I browsed the bands for the first time. Every time I saw a portion of the spectrum spike with unknown activity, I'd click on that portion of the screen and listen to whatever I found.

Listening to shortwave broadcasts with *synchronous AM* was a rare pleasure. If you're unfamiliar with the term, synchronous AM is a reception technique in which the receiver creates a stable RF carrier to replace the fluctuating received station carrier, thereby reducing or eliminating the distortion caused by selective fading. If you click the AMS button you may hear a heterodyne tone. Simply click and slide the demodulator bandwidth window until the tone goes to zero beat and — *voilà!* — the signal is suddenly clear. Yes, it can still fade, but it will do so without the irritating distortion. This does wonders for casual shortwave listening.

A number of shortwave broadcast stations today transmit digital signals using the Digital Radio Mondiale (DRM) format. You'll recognize these signals from their "square" appearance in the demodulator display as well as their characteristic roaring sound. Unlike other software defined receivers, DRM reception is fully integrated into Excalibur software; you don't have to purchase a separate decoding application. However, you *do* have to purchase a DRM license key from WiNRADiO at a cost of \$49.95.

With the license key installed I was able to receive DRM broadcasts with little difficulty. It is remarkable to hear clean, FM quality audio from a shortwave broadcast signal. You often receive streams of text at the same time. The Excalibur offered the best DRM performance I've experienced to

spectrum and play it back later for analysis. For instance, you could set the DDC bandwidth to cover the entire 20 meter band and record it for several hours. Later, you can tune through the signals just as though you were listening in real time. Bear in mind, however, that wide-bandwidth recording will eat through a considerable amount of

hard drive space. Alternatively, you can record selected signals in the demodulator window as standard WAV audio files.

A scheduler (Figure 4) is available to set up recordings in advance. You can program the Excalibur to record broadcasts while you sleep or when you are away from home.

The Excalibur is capable of "sharing" de-

date. It even managed to maintain a decoding “lock” during signal fades.

Overall, the Excalibur offered outstanding performance, albeit with lower IMD dynamic range at very weak signal levels as noted in Table 1. That notwithstanding, I was fascinated to see that the Excalibur did a superb job way down at 5 kHz with an MDS of -100 dBm. The “basement” of radio is very noisy at my location, but I have a feeling at the Excalibur would be an excellent receiver for listening to “natural radio” (Dawn Chorus, whistlers, and others) in quiet environments.

Conclusion

The WiNRADiO WR-G31DDC Excalibur is an astonishing piece of technology.

WINRADIO WR-G31DDC Excalibur

If you own a tablet or smartphone with the appropriate application, scan this QR Code to see a video overview of the WinRadio Excalibur. You can also watch this video on your computer by going to (case sensitive):

<http://www.youtube.com/watch?v=UuiySRhgHRk>



From a user standpoint, I'm tempted to compare the Excalibur experience to working with a lump of unformed clay on a potter's wheel. The radio makes a vast range of RF spectrum (the “clay”) available to you and by carefully tweaking the functions in the Excalibur software you can create whatever reception characteristics you desire. Best of all, as the software improves over time,

you'll be able to upgrade the Excalibur's features and performance by simply downloading the latest version.

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