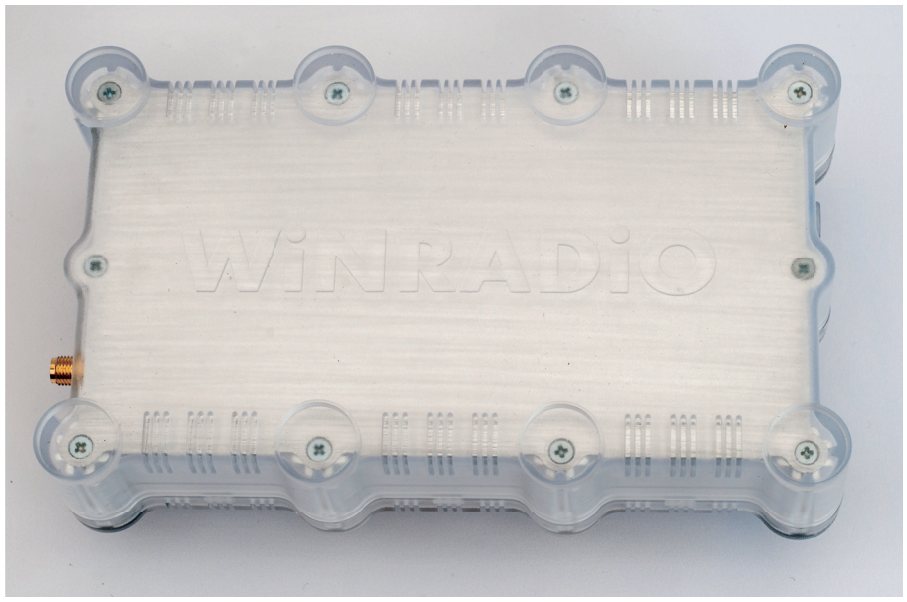
■ The latest software defined radio from WiNRADiO reviewed by Mike Richards

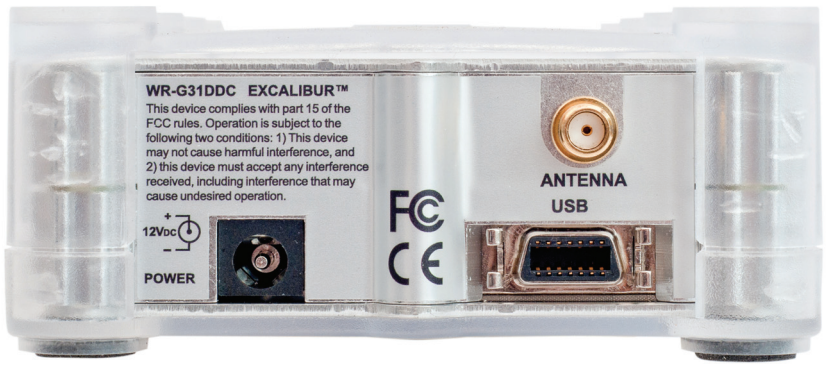
WiNRADiO Excalibur

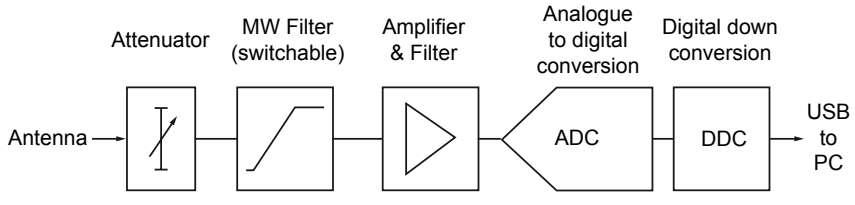
Mike Richards has been testing the very latest model from WiNRADiO, a company that is well established in the world of software defined radio.

Excalibur is the latest in a pedigree line of digital radio receivers and it is bristling with new features and more power than ever. The incoming RF spectrum (up to 50MHz wide) is converted to digital right at the front end and then decimated down to 2MHz chunks for final processing in the PC. Digitising the signal very early in the receiver completely eliminates any analogue tuning and everything can be controlled digitally. The filtering options are a joy and you can process up to three different receive channels simultaneously within the selected 2MHz chunk.



The Excalibur.





Excalibur block diagram.

Digital Receiver

I'll start with a basic primer on Direct Sampling and Digital Down Conversion because they are at the heart of the Excalibur. The key to this type of receiver is the availability of fast Analogue to Digital converters (ADC) and Field Programmable Gate Arrays (FPGAs). Because the Excalibur covers a frequency range from 9kHz to 50MHz, it requires an ADC that can sample at twice the rate of the highest frequency you want to be able to receive – that's 100 million samples per second. To help explain what an ADC does, you can think of it as being rather like a programmable digital voltmeter. It monitors the input signal and takes/stores voltage readings at a rate of 100 million every second. In the case of the Excalibur, the voltage is measured to 16 bit accuracy. That means each time the signal is sampled, the voltage can be any one of a possible 65,536 different voltage steps.

Once this stage is complete, the output is a high-speed stream of data with a 100 million new, 16 bit, values appearing every second.

In order to give the user lots of configuration options, the data stream is sent to the PC for the final part of the signal processing. However, with such a high sample rate, the data rate on the link to the PC would need to be at least 1.6Gb/s, a lot faster than any of the common interfaces or PCs can manage. The solution is to use a process called Digital Down Conversion (DDC) or decimation to select a segment of the full bandwidth and send just that to the PC. This conversion is handled by Excalibur's high speed FPGA, which uses thousands of logic blocks that are interconnected to create sophisticated digital filters and re-samplers to extract a segment of the spectrum (up to 2MHz wide). DDC is the digital equivalent of a conventional mixer where the incoming RF signal is converted to a more manageable

intermediate frequency. In the Excalibur, DDC reduces the data rate to about 64Mb/s, which is well within the capacity of a standard USB 2.0 link.

Once the 2MHz data stream is in the PC, the WiNRADiO software takes over and provides all manner of goodies. The Excalibur implements this technique seamlessly and despite the underlying use of 2MHz chunks, you can freely move around the entire 50MHz spectrum without having to pre-select the chunk you want – the software does all that for you.

Getting Started

As with all WiNRADiO receivers, installation is very simple. You load the CD-ROM first because this installs the receiver software and the vital drivers so that the Excalibur hardware will be recognised when you plug it in. System requirements were reasonably modest with a 2GHz dual-core Pentium and 1GB RAM as the starting point.

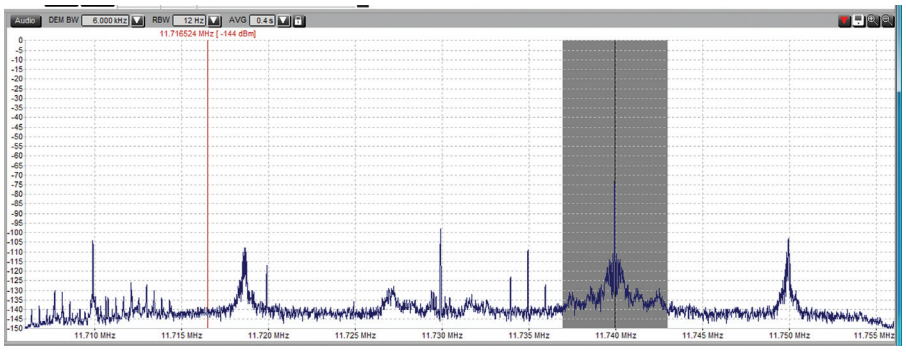
The receiver itself is housed in a solid die-cast case that is enclosed in a translucent plastic cage and connections are simple, with all the necessary leads provided in the box. The antenna uses a miniature 50Ω SMA connector but a BNC adaptor is included in the box, which is very thoughtful. The USB lead has a bespoke WiNRADiO connector at the receiver end and a standard USB plug at the other. Power is supplied via a linear external power unit, which avoids the RF interference problems often associated with some switch-mode power units. That's it for connections but the receiver case also has a push-button power on/off switch and a blue LED indicator that can be used for power/status indication.

Once the installation is complete, the Excalibur receiver unit can be tucked away out of sight because all the functionality is controlled from within the software.

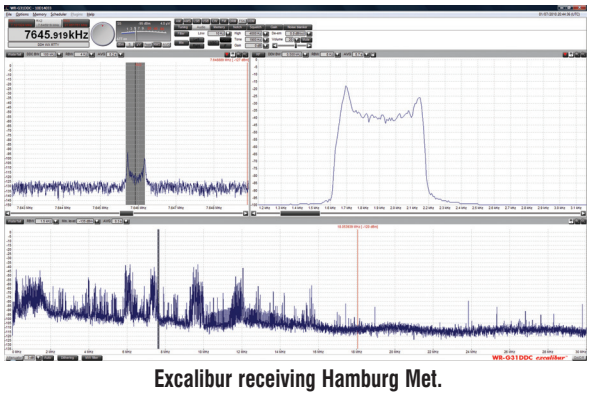
Spectrum Analysis

When the software starts, you are presented with a busy screen. There's a full-width spectrum display at the bottom, another top left, a third top right and general receiver controls at the top. This might seems a bit daunting but the displays are easy to master and do provide a very comprehensive view of the entire spectrum. Having visibility of the entire 0-30MHz or 0-50MHz spectrum changes the way you operate.

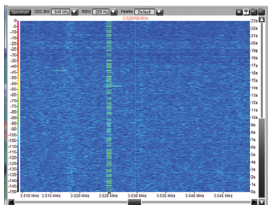
The large spectrum display at the bottom of the screen can be set to show the entire receiver bandwidth from 9kHz to either 30MHz or 49.95MHz. For most, 30MHz will be the best bet and provides clearer analysis of the spectrum but the full 50MHz is available if you want it. However, the performance declines close to 50MHz due to the use of anti-alias filters to improve ADC performance.



Excalibur monitoring the 11MHz broadcast band.



Excalibur receiving Hamburg Met.



A waterfall display of a CW signal.

A grey vertical bar on the display shows the size and location of the DDC chunk that's being passed to the other sections of the receiver. This can be placed anywhere in the spectrum by a simple mouse click and you can alter its size simply by stretching the sides with the mouse! This was an incredibly quick and easy way to get around the bands and look for activity. By looking at the entire spectrum, you can quickly assess band conditions and jump straight to an interesting section. I found this particularly useful for keeping an eye on the higher frequencies as conditions are extremely variable currently. When a band becomes active, you see the noise floor rise and an increasing number of active peaks popping up and down.

In addition to providing a general overview of band activity, the spectrum display has a vertical marker that follows the mouse pointer and shows the precise frequency and signal level at any point in the spectrum.

Immediately above this full spectrum display are a number of controls that can be used to fine tune the performance. The RBW control sets the bandwidth of each measurement point on the spectrum display and ranges from 1.5kHz through to 98kHz. At the 1.5kHz end you will get a very fine resolution, spiky, display whilst at 98kHz the display is smoothed right out. In practice, the fine resolution is great for spotting individual station activity whilst the higher settings allow you to view the levels of an entire sub-band more easily.

The next adjustment is for the minimum level that will be displayed. This effectively moves the trace up or down on the display and the default setting of -135dBm is likely to suit most situations. To help make some signals more visible, it's worth making use of the Averaging control. This specifies the period over which the signal is averaged for display and it has the effect of smoothing out the display and makes rapidly varying signals more visible. A good example is a RTTY signal as with no averaging it's difficult to spot the classic two-peak shape of the signal. However, if you bring the averaging up to 0.3 or 0.4 seconds all becomes clear.

If you want a better view of a section of the spectrum, you can use the zoom control and there's even a snapshot button so you can save a screenshot of the spectrum to disk as a bitmap.

If you prefer waterfall displays to conventional spectrums because they

are very effective for spotting continuous signals, you have that option with the waterfall button.

At the bottom of the main spectrum are a few additional controls that provide adjustment of the main signal path. First is the attenuator that provides adjustment from 3 to 21dB in 3dB increments. This can be set manually or by pressing the auto button, which causes the attenuator to switch in automatically if any signal exceeds 0dBm.

Dithering is a method of reducing minor ADC artefacts but these are very low in the Excalibur so this probably won't get much use.

Finally, there is the MW filter that switches in an attenuator for all frequencies below 1.8MHz, which should reduce the risk of overload from strong medium wave signals.

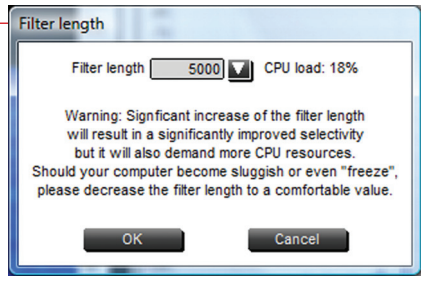
DDC Spectrum

This display is located at the top left and provides analysis of the DDC segment of the overall spectrum. This can be set to any value between 20kHz and 2MHz by using the DDC bandwidth control on this display.

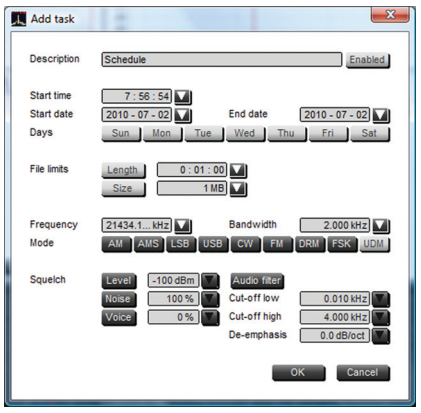
As with the main display, there are controls for the display bandwidth, averaging, waterfall and zoom. However, this display provides finer analysis of the spectrum because it only has to deal with the 2MHz DDC section. In fact, this display is so fine that on full zoom you can see the dots and dashes of a CW signal!

This display also includes a grey shaded section that shows the demodulator bandwidth that's set up in the next section. The main factor in determining what DDC bandwidth to use is how many of the three receive channels you are using and what frequency span they have to cover. If you are using three channels to monitor or record three stations in the same broadcast band, then 500kHz would probably be fine. However, I suspect most listeners will only be using one receive channel at a time in which case a 20-50kHz DDC bandwidth would be fine.

Another little gem in this section is the record option that lets you record the entire DDC data to disk for replay later.



Excalibur's Filter length control panel.



Scheduler for unattended recording.

This is great for signal analysis as you can capture a chunk of spectrum and repeatedly examine it. The replay includes a pause and loop control to help with this process.

Demodulator Spectrum

Finally, we come to the demodulator spectrum that provides a view of the signal we're monitoring. There's no waterfall option but instead there's the choice between the audio and RF demodulator spectrums along with similar display bandwidth and averaging controls.

A new addition is the demodulator bandwidth, which can be adjusted in 100Hz steps from 10Hz through to 62.4kHz wide!

The quality of the filtering is excellent and is primarily determined by the filter length setting. Having fine control of such good quality filters means you can really pluck your wanted signal out of the noise. This worked superbly well for me during the review and made utility monitoring so much easier.

As with the DDC section, the demodulator also includes a data recorder so you can capture and replay the demodulator spectrum!

Filter Length

Digital filtering is an iterative process and the longer the cycle of repeats, the better the filter becomes – think of it like cascading conventional filters one after another but without the insertion loss.

Excalibur includes an option to determine the length of the filter chain, which can be between 10 and 5000 taps. At the lower end, the filters are very soft with gentle rolling curves whilst at 5000 taps, the filters are so sharp you could cut yourself!

The reason for not fixing the setting to 5000 is resorces because running the Excalibur with a 2MHz DDC and a filter setting of 5000 requires a lot of processing. The recommendation is that you set the filter length as high as you can whilst keeping the processor load below 30% – there's even a processor load meter in the setting panel. However, I was pleasantly surprised to find that my Intel Q8300 quad core processor PC was fine and could easily handle 2MHz DDC and a 5000 filter setting with a processor load of only 20%.

Tuning

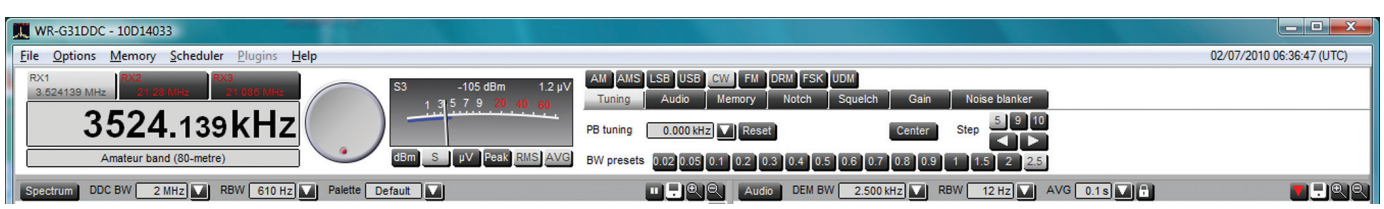
Tuning has been made very simple with several different methods available. If you know the frequency you want, then the best way is to tap it into the numeric keypad. You can also use the mouse with the spectrum displays to click on the approximate frequency that you want.

For general tuning around you can use the mouse wheel, up/down keys or put your mouse over the tuning knob. For all these options, the default tuning rate is 1kHz per click but that can be reduced to 100Hz, 10Hz or 1Hz. You can also hover the mouse over the frequency display, press shift and then spin the numbers with the mouse.

All the tuning options are live all the time, so you can mix and match as you please. With such a comprehensive range of options, tuning was very easy.

Three Receivers in One

Excalibur has three separate receive systems that can process any frequency



Excalibur's main receiver controls.

within the selected DDC band. Although the receivers are created in software, they are completely independent with their own analysis windows and demodulators. You can record the output from each one and there is even the facility to mix the demodulated audio between the left and right channels so you could listen to all three at once!

Whilst simultaneous operation of all three receivers is only possible within the limits of the DDC band, you can tune any of the three receivers to any frequency in the 50MHz spectrum and use it as a preset – just click on the receiver and everything changes over to the new frequency.

Demodulation

Excalibur can demodulate AM, Synchronous AM, LSB, USB, CW, FM, DRM and FSK signals. There's even a User Defined Mode where you can make up your own receive settings. Also in this section are a set of seven tabs with additional controls covering tuning, audio, notch filter, squelch, gain/AGC and a noise blanker.

Within the audio section is an excellent audio filter that you can use to optimise the audio bandwidth.

Excalibur also comes with a comprehensive memory system where you can store all your favourite stations along with detailed receiver settings.

summary

This is great receiver that will change the way you monitor the HF bands. Being able to see the entire spectrum on one display and jump to any point with the click of a mouse is a very powerful tool. The receiver performance is extremely good and it's helped by the filters, which were magnificent.

The Excalibur cost £649.95 and my thanks to WiNRADiO for the loan of the review unit.

Scheduler

Unattended recording of signals is supported using a scheduler that has access to all the important demodulator functions and it can make digital recordings to your hard drive. You can set file size limits to make sure you don't use up all your free space.

Masterstroke

The masterstroke is that WiNRADiO have done a brilliant job with the Excalibur user interface and this receiver is an absolute breeze to use once you've spent a bit of time finding your way around it. Whilst it may sound as though you have to carefully set the DDC width and so on, in practice, you can point and click your way around the bands in a flash. It really does change the way you operate because the entire spectrum is at your fingertips and available at the click of a mouse.

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Specifications

Receiver type:	Direct-sampling, digitally down-converting software-defined receiver
Frequency range:	9kHz to 49.995MHz
Tuning resolution	1Hz
Mode	AM, AMS, LSB, USB, CW, FMN, FSK, UDM, DRM mode optional
Image rejection	90dB typ.
IP3	+31dBm min.
Attenuator	0 - 21dB, adjustable in 3dB steps
SFDR	107dB min.
Noise figure	14dB
MDS	-130dBm @ 10MHz, 500Hz BW
Phase noise	-145 dBc/Hz @ 10kHz
RSSI accuracy	2dB typ.
RSSI sensitivity	-140dBm
Processing and recording bandwidth	(DDC bandwidth) 20kHz - 2MHz (selectable in 21 steps)
Demodulation bandwidth	10Hz - 62.5kHz (continuously variable in 1Hz steps)
Spectrum analyzers Input spectrum/waterfall	30 or 50MHz wide, 1.5kHz resolution bandwidth
DDC spectrum/waterfall	max 2MHz wide, 1Hz resolution bandwidth
Channel spectrum	max 62.5kHz wide, 1Hz resolution bandwidth
Demodulated audio	16kHz wide, 1Hz resolution bandwidth
ADC	16 bit, 100 MSPS
Sensitivity (@ 10 MHz)	AM -101dBm (2.00µV) @ 10dB S+N/N, 30% modulation
	SSB -116dBm (0.35µV) @ 10dB S+N/N, 2.1kHz BW
	CW -123dBm (0.16µV) @ 10dB S+N/N, 500Hz BW
	FM -112dBm (0.56µV) @ 12dB SINAD, 3kHz deviation, 12kHz BW
Tuning accuracy	0.5 ppm @ 25°C Tuning stability 2.5 ppm (0 to 50°C)
MW filter Cut-off frequency	1.8MHz @ -3dB Attenuation 60dB min @ 0.5MHz
Antenna input	50Ω (SMA connector)
Output	24-bit digitized I&Q signal over USB 2.0 interface
Power supply	11-13 V DC @ 500mA typ.
Consumption	11-13V DC @ 45mA typ. (power save)
Operating temperature	0 to 50°C