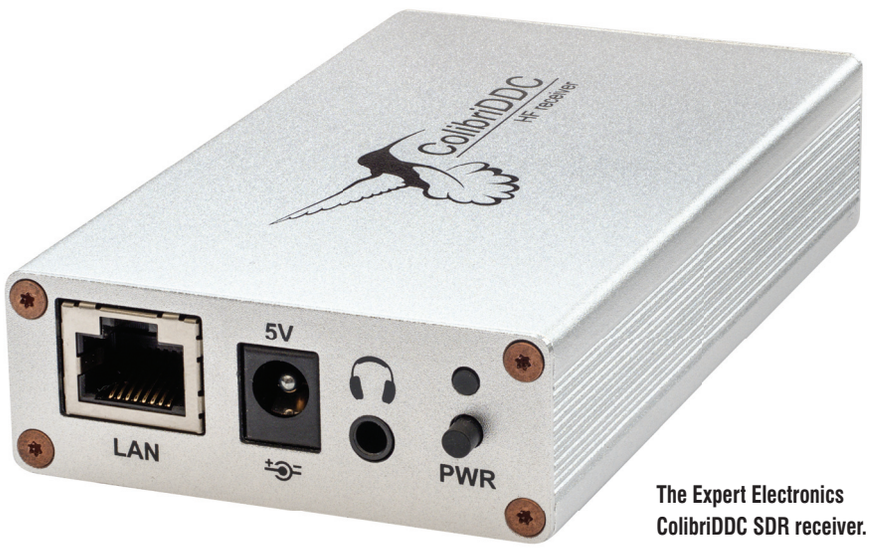
Mike Richards reviews the Expert Electronics ColibriDDC SDR receiver

Expert Electronics ColibriDDC

Mike Richards looks at a new, networked, direct digital conversion SDR receiver that covers from 10kHz to 55MHz. What's more, the receiver's frequency range can be extended up to 800MHz using undersampling.



The Expert Electronics ColibriDDC SDR receiver.

The software defined radio (SDR) receiver market place is busy with new designs and the camp is clearly split between the lower cost units that feature an analogue front-end and the direct digital conversion (DDC) designs that digitise the signal close to the antenna. The new, Russian designed, Expert Electronics ColibriDDC is a very compact, network connected, DDC SDR receiver offering a primary frequency range from 10kHz to 55MHz. What's more, the frequency range can be extended up to 800MHz using undersampling.

In the Box

The ColibriDDC was very well presented in a smart box, with a physical diagram of the receiver on the top cover. Everything I needed to get started was included and comprised the receiver, a 1.5m Ethernet cable, an SMA to SO-239 adaptor cable, a CD-ROM containing the software and *User manual*, and a 2-pin mains to 5V DC power unit. One rather nice touch was the use of protective covers for all the external connectors both front and rear (**Fig. 1**). It is not a big deal but does indicate a degree of extra care on the part of the manufacturer.

Fig. 1: The ColibriDDC front and rear panels with all sockets protected.

External Connectors

As you can see from the photographs, there are very few external connectors. Therefore, getting hooked-up was simple. The power requirement is 5V at 640mA, which is provided by the supplied 2-pin mains power unit. The power socket was a standard coaxial type, so it could easily be powered by an alternative 5V DC power source. A female 50Ω SMA socket provided the antenna connection and a handy SMA to SO-239 socket adapter cable was supplied. With such a wide frequency coverage, you might also need an external antenna switch because most operators use more than one antenna to cover the very wide, 10kHz to 55MHz range of the receiver. The ColibriDDC is controlled exclusively via the receiver's Ethernet port and that used a standard RJ-45 connector. Those are all the connections required to get on the air. Also included is a headphone jack and sockets for external control (EXT CTRL) and an external reference clock (REF), each of which are covered later.

Software Installation

The next step was the installation of the ExpertSDR2 software that controls the receiver. The supplied CD-ROM included a copy of the software as a RAR (.rar) file that needed to be extracted

to create the executable (.exe) file for Windows installation. I used the freeware 7-Zip software to extract the .exe but it struck me that it would be better to use a standard .zip or .msi file or avoid zipping the software altogether because it only saved about 1MB of disk space. Once extracted, the software installed on my 64-bit Windows 7 systems with no problems.

Powering Up

With everything connected and installed, it was time to power up the hardware. There was no need to worry about internet protocol (IP) addresses because the ColibriDDC is pre-configured to use your router's dynamic host configuration protocol (DHCP) server. Should you need to alter this, there are options in the SDR software to customise the IP settings. When you start the ExpertSDR2 software, it automatically searches and locates the ColibriDDC receiver on the local network. The IP management of the ColibriDDC was particularly impressive and really helped to smooth the setup process. While you can use a WI-Fi connected laptop to access the receiver, you will need a very fast link or you will struggle with lost packets.

Although I started by installing the ExpertSDR2 software from the CD-ROM, I also checked the ColibriDDC website and downloaded the latest version (v1.0.1).

http://goo.gl/Yac4GL

When I subsequently ran the software, it quickly found the ColibriDDC and automatically started a firmware update. The first time this ran it failed with an 'unable to enter bootloader' message. Nevertheless, re-booting the receiver hardware soon fixed that and the firmware upgrade proceeded without issue.

Under the Cover

Fig. 2 shows a simplified block diagram of the ColibriDDC receiver hardware. Starting with the antenna, the single SMA connector feeds a 55MHz low-pass, anti-aliasing filter followed by a switchable 20dB attenuator to help deal with strong signals. Digitisation occurs next and the ColibriDDC uses the LTC2261 analogue to digital converter (ADC) to provide 14-bit resolution sampling at a frequency of 125MHz, slightly more than twice the highest receive frequency of 55MHz. The high-speed serial data stream from the ADC is then fed to an Altera Cyclone IV field programmable gate array (FPGA). The FPGA's prime role is to decimate or under-sample the incoming 125 million samples per second (MSPS) data stream to produce a more manageable in-phase and quadrature (IQ) data stream that can be fed over the 100 million bits per second (Mbps) Ethernet link to the receiver software. The ColibriDDC's FPGA is configured to produce one or two independent IQ streams, each of which can provide up to 312kHz of receive bandwidth. Controlling the ADC, FPGA and other receiver hardware is handled by an LPC4078, M4 based microcontroller.

Modern SDR receivers need a good quality reference clock and the ColibriDDC employs a 20MHz, 0.5 parts per million (ppm) temperature controlled crystal oscillator (TCXO). This feeds into an Analog Devices AD9526 clock generator that provides all the reference clocks for the receiver. To support applications requiring critical accuracy, the ColibriDDC can also accept an external 10MHz reference clock via the 50Ω SMA socket marked REF. To provide headphone level audio direct from the receiver's hardware, the ColibriDDC includes an additional 24-bit audio digital to analogue converter (DAC).

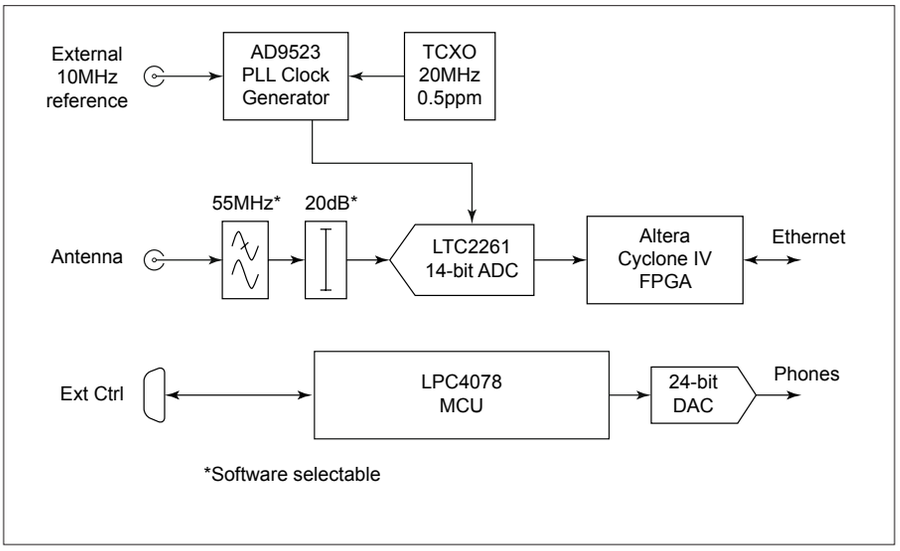
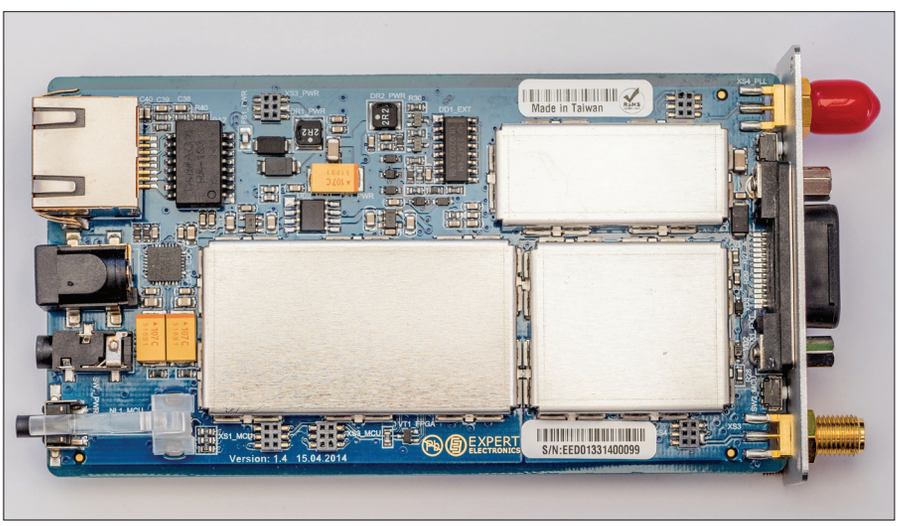


Fig. 2: A simplified block diagram of the ColibriDDC SDR receiver.



Inside the ColibriDDC, complete with internal screening.

Operation and Performance

The full software manual was not ready in time for the review, so I was working from an early draft document. I hope that should be rectified by the time this issue of *RadioUser* is published.

The supplied ExpertSDR2 software provided a conventional and easy to use interface for the receiver. As you can see from the screenshots, in its initial configuration the ExpertSDR2 software provides an interface that is dominated by full-width spectrum and waterfall displays (**Fig. 3**). The divider between the spectrum and waterfall displays can be dragged with the mouse to extend or restrict the visibility of either trace.

The ExpertSDR2 software supports conventional mouse click tuning and the cursor also doubles as a handy measurement system because it displays the current frequency and signal level at the cross-hair marker. I could also zoom the spectrum scale by right-clicking/drag on the spectrum display. The central tuning ribbon can also be moved by right-clicking and dragging the display, which was useful. Major frequency changes were best achieved using the frequency readout, where you could hover the mouse over any digit and use the mouse wheel to scroll the setting. A similar tuning effect could be achieved by hovering and clicking the left or right mouse buttons.

One unusual and helpful addition to the tuning tools was the memory stack. This automatic memory system keeps a record of any frequency you pause on for more than a second. This is great if you have been tuning around and want to return to a recent frequency. The last 16 frequencies are held in the stack and can be found using the down arrow just above the main frequency display. The ExpertSDR2 software also has a more conventional memory system that was very easy to use. Each entry provides storage for the frequency, mode and a text comment.

As is common with DDC receivers, the ColibriDDC supports multiple receivers. This is achieved through the use of two independent IQ streams from the FPGA. These two IQ streams can be located anywhere in the receiver's 10kHz to 55MHz coverage. In the ExpertSDR software, each of these IQ streams can support two receivers. That gives four simultaneous receivers as illustrated in **Fig. 4**. The two receivers associated with each IQ stream have to remain within the 312kHz band delivered by that IQ stream.

To support the four receivers, the ExpertSDR software allows you to control the audio routing from each receiver. For example, if you wanted to leave one receiver monitoring NAVTEX on **518kHz**, you could route that receiver's audio to a virtual audio cable (VAC) that is connected to your NAVTEX decoder. You could then use a second receiver on that IQ stream to connect to a second NAVTEX decoder and tune the receiver to the inshore NAVTEX frequency on **490kHz**. You are then free to use the other IQ stream to monitor other traffic (**Fig. 5**). When using multiple receivers to monitor voice traffic, you can use a built-in mixer to decide where on the sound stage you want the signal to appear. This is a really useful facility that lets you quickly identify a signal to the correct receiver.

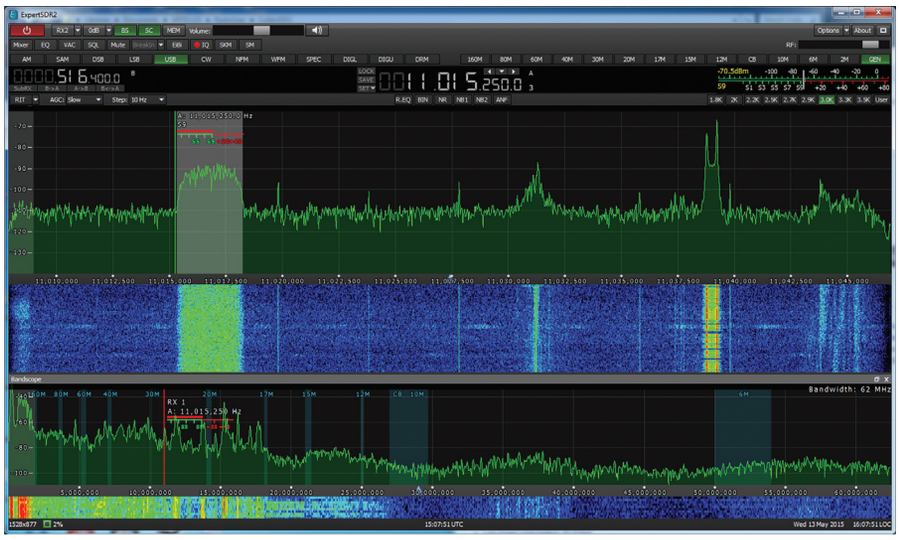


Fig. 3: The ExpertSDR2 software main screen.

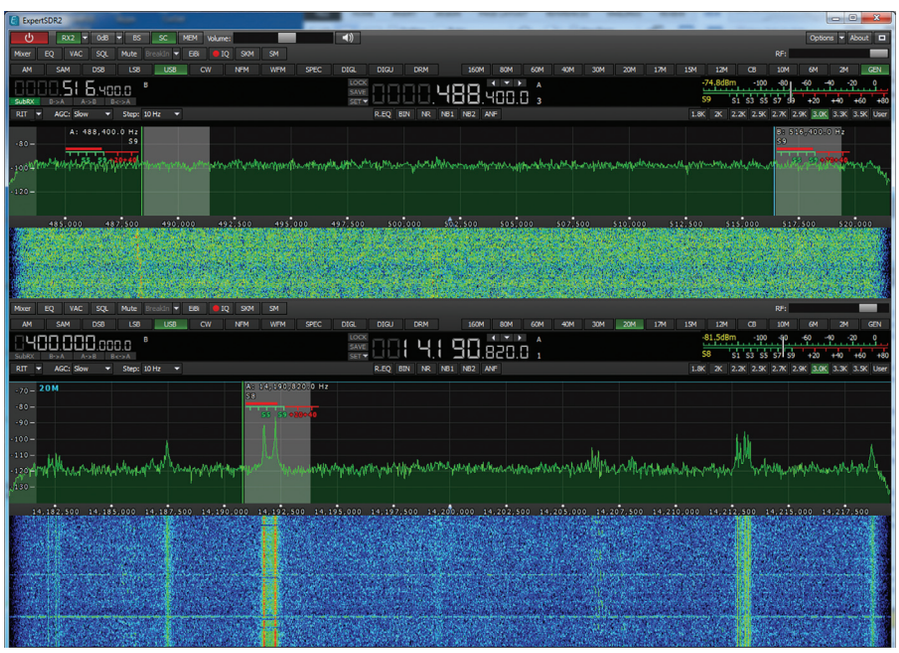


Fig. 4: An example of a multiple receiver layout using the ExpertSDR2 software.

When activating the second receiver, I could choose its screen location but the default was to show it immediately below Receiver 1. The second receiver has the same set of controls as Receiver 1, so was very easy to use. However, to make the most of the multiple receivers you need a large screen, 22in is recommended and it certainly looked fine on my 24in monitor.

In addition to the multiple receiver displays, the ExpertSDR2 software can display a full spectrum plot covering the entire 10kHz to 55MHz spectrum. This gives a useful overview of the entire spectrum and includes facilities to zoom, scroll and tune using just the mouse. While some full spectrum displays are more novelty than practical use, the ColibriDDC and ExpertSDR2 software combination is a very useful tool for spotting and pouncing on activity.

Mode selection was very straightforward using a row of buttons immediately above the frequency display. In addition to the normal amplitude and frequency modulation (AM/FM) and single sideband (SSB) modes, there was a Digital Radio Mondiale (DRM) setting that gave a flat 10kHz bandwidth suitable for sending to a DRM decoder such as Dream. Wide FM was also included, which is useful for operating the receiver in undersampling mode on the VHF FM broadcast band.

As with most SDR receivers, the ExpertSDR2 software allowed fine

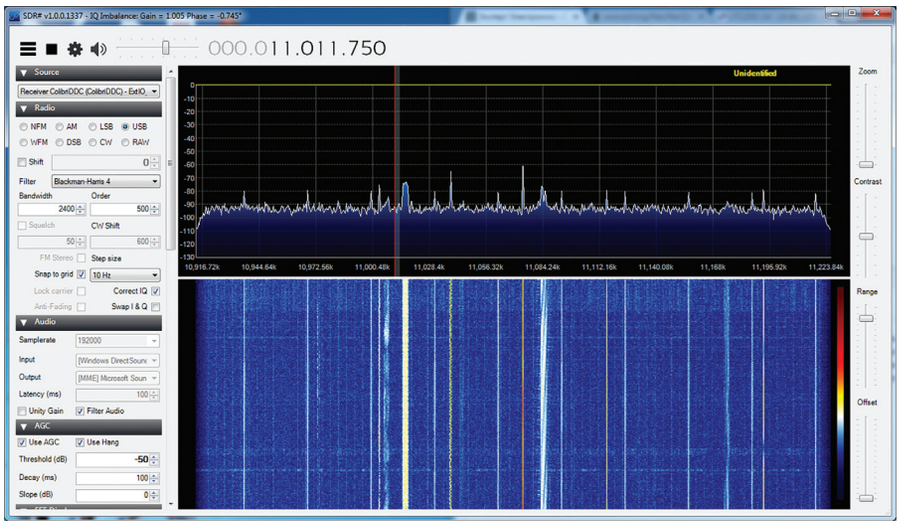


Fig. 5: SDR# working with the ColibriDDC SDR receiver.

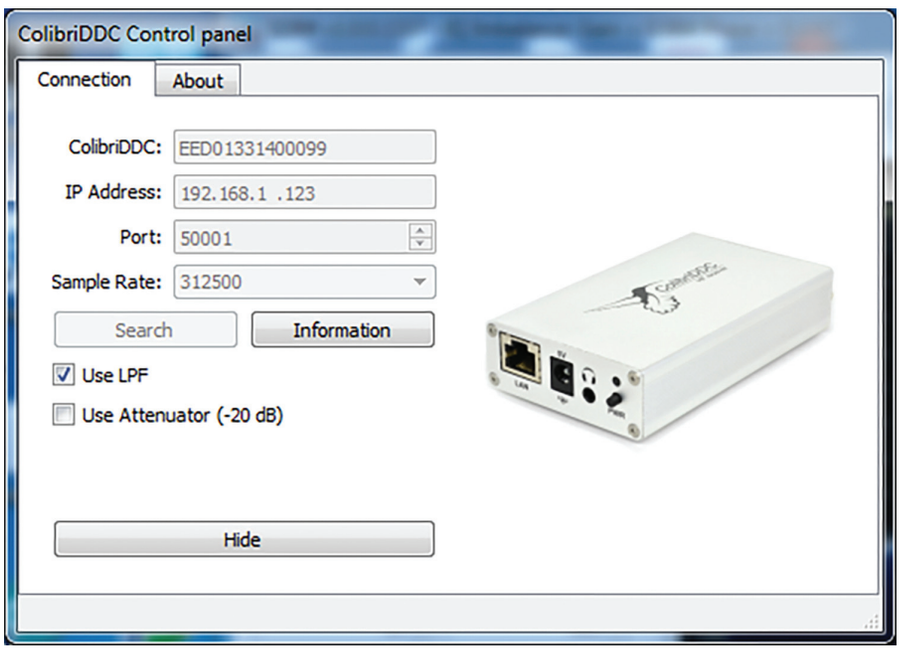


Fig. 6: The ColibriDDC Control panel opened using the SDR# 'cogs' icon.

adjustment of the receive bandwidth by dragging the filter passband on the spectrum display.

The ExpertSDR2 software also provides a useful range of signal conditioning tools that includes an audio equaliser, noise reduction, noise blankers and an automatic notch filter. This latter filter proved to be very good and it identified and dealt with interfering carriers very quickly.

Other SDR Software

With many DDC designs, you are restricted to using the manufacturer's proprietary SDR software. However, the ColibriDDC has an ExtIO library available. The ExtIO library system was developed to support Winrad SDR and allow the software to work with different hardware systems. You can think of ExtIO as a command translator so when you tell the SDR software to select upper sideband (USB), the library translates the request into the appropriate command to make the hardware select USB. In addition to translating the general operation of the receiver, ExtIO also provides a simple set up panel that is used to configure the hardware. As a result, any SDR software that is ExtIO compatible will be able to use the ColibriDDC hardware. I tried it with SDR# because that is currently one of my favourite packages. All I had to do was download the ExtIO_ColibriDDC library from the Expert Electronics website and unzip the contents to my SDR# directory. When I started SDR#, ColibriDDC was in the drop-down list of receivers and pressing the 'cogs' icon opened up the Control panel (**Fig. 6**). In the panel, there was a search button to locate the receiver on the network automatically and tick boxes for the 20dB attenuator and the low-pass filter (LPF) selection. I also tried using the ColibriDDC with HDSDR, which also worked without a hitch.

Under Sampling

While the ColibriDDC is a very competent low frequency (LF) through to 55MHz receiver, it is also capable of receiving up to 800MHz. You will doubtless have heard of the **Nyquist** theorem that specifies the need to sample an analogue signal at twice the highest frequency you want to digitise. The theorem can be extended to say that the sampling frequency must be at least twice the bandwidth you want to sample. In a conventional sampling situation, you would be sampling from near DC to some higher frequency. However, if you wanted to sample a 1MHz wide bandwidth between 7MHz and 8MHz, then using the undersampling technique you could still sample at twice the bandwidth (2MHz) and capture the desired band. If you want to get to grips with more of the detail, an excellent tutorial titled *Section 5 Undersampling Applications* by **Walt Kester** can be accessed via the following link to the Analog Devices website.

http://goo.gl/0WJrhP

One other important point is that the band you want to cover using undersampling has to be within the frequency range of the ADC. In the case of the LTC2261 used in the ColibriDDC, the upper frequency limit is an impressive 800MHz.

To make use of undersampling, there are two main requirements. The first is to disable the internal 55MHz low-pass filter that is used to prevent aliasing when the ColibriDDC is in its normal baseband mode. The second is to provide external filtering to exclude everything except the band you want to receive. For example, if you wanted to add the civil airband, the VHF weather satellite band, the 2m amateur band and the marine band, you would need a band-pass filter that covers from about 118 to 170MHz. There are many filter calculators available on the internet, so it would not be too difficult to pull together a suitable design.

External Interfacing

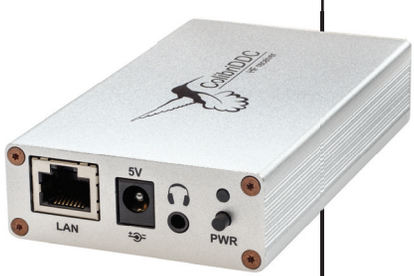
The ColibriDDC has a 15-pin D-sub socket on its rear panel marked EXT

CTRL. This is used to provide a number of external control points. There are six open collector outputs that can be controlled by the ExpertSDR2 software. The switching can be linked to band selection, so it could be useful to switch antennas or preamplifiers. The socket also has a 5V 100mA supply output along with two pins that can be configured as digital inputs.

The ExpertSDR2 software also includes an emulator that allows the receiver to be controlled using computer aided transceiver (CAT) commands. The connection is configurable in software and, when activated, the ColibriDDC can be controlled using standard TS-480 CAT commands. ●

Expert Electronics ColibriDDC Specifications

Modes	LSB/USB/DSB/CW/AM/SAM/NFM/WFM
Receiving bandwidth	0.01 to 55MHz (0.01 to 62.5MHz)
Receiving bandwidth in all Nyquist zones	0.01 to 800MHz
Spectrum scope bandwidth (up to)	62.5MHz
Number of independent receiving channels	2
Sensitivity	0.3µV
Blocking Dynamic Range (BDR)	110dB
IMD3 Dynamic Range	90dB
Image channel suppression	>110dB
Supply voltage range	4.5 to 5.5V
Maximum consumption current	0.64A
RF ADC clock frequency	125MHz
RF ADC resolution	14-bit
Local oscillator stability	± 0.5ppm
Built-in attenuator	0 and -20dB
Built-in audio DAC resolution	24-bit
Dimensions H x W x D	24 x 64 x 112mm
Weight	0.3kg



summary

The Expert Electronics ColibriDDC is an impressive, excellent value, DDC receiver with much potential. In addition to doing a fine job of its basic coverage, it could easily be extended to provide coverage up to 800MHz. The provision of the ExtIO library also gives the user the flexibility to choose their SDR software rather than being tied to the manufacturer's option. Having said that, the supplied ExpertSDR2 software is very easy to use and includes just about everything you need, including up to four receivers!

The Expert Electronics ColibriDDC is available from ML&S Martin Lynch & Sons Ltd. and, at the time of writing, cost £499.95 (including VAT at 20 per cent).

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