

SDRplay RSPduo Review by Mike Richards

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SDRplay RSPduo

The new RSPduo from SDRplay was released at this year's Hamvention in Dayton and provides a dual tuner SDR receiver.

Each of the two tuners can operate independently and on any frequency between 1kHz and 2GHz, with no coverage gaps! Based on the same Mirics chipset as previous models, the new RSPduo employs new filter combinations and retains the signal level measurement facility introduced last year. To complement the new receiver, a new version of their SDRuno software is available for free download from the SDRplay site.

Dual tuners

The provision of dual tuners is an interesting idea that opens up many new possibilities. Fairly obviously this means you can monitor any two frequencies between 1kHz and 2GHz with the same receiver. However, the more exciting prospect is the potential for noise cancellation using diversity reception techniques. For those unfamiliar with the concept, this is where your main antenna is connected to one receiver and a secondary (noise) antenna is connected to the second receiver. The outputs from each receiver are then mixed using an adjustable phase shifting network. In a practical system, you alter the mixing parameters until you achieve the best null in the noise level. The benefits can be significant, and I've seen 20dB of noise reduction reported by ANAN users. For this system to work, you need a two channel, phase-coherent receiver – and the RSPduo fits the bill. Whilst the RSPduo has the hardware to support diversity reception, there is currently no supporting software available. However, the SDR Play team are working on a diversity enhancement for SDRuno, although there is no release date available. I'm sure other 3rd party SDR software developers will be exploring the opportunities for diversity reception once they've had a chance to get to grips with the new API (Application Programming Interface).

Let's now look in a bit more detail at the architecture of this twin tuner receiver. I've shown a simplified block diagram of the tuner sections in **Figure 1**. Here you can see that the 50Ω inputs follow identical paths to each of the two Mirics MSi001 tuner chips. The tuner itself is an analogue device with



PHOTO 1: The strong RSPduo enclosure has two SMA connectors and a plug-in screw terminal block.

several band-defined input channels and a dual mixer designed to provide analogue I and Q outputs. The mixers can operate in direct conversion mode with an IF bandwidth of 8MHz or in low-IF mode with a bandwidth of 1.536MHz. Each tuner has its own fractional-N synthesiser, but both are driven by the same, high stability, on-board, TCXO reference. For critical applications an external 24MHz reference can be used and daisy-chained to other SDRplay RSPs. One very useful enhancement here is its direct compatibility with the popular Leo Bodnar GPS Referenced Clock. The previous RSP-2 required a sine-wave input so the square wave output of the GPS source needed filtering to round off the waveform. The change means the RSPduo is now directly compatible with any reference source that can deliver a 24MHz, 3.3V CMOS level output signal.

A silicon RF switch handles the connection between the two tuner outputs and the analogue to digital converters (ADC) in the Mirics MSi2500 chip. When used in single channel mode, this switch connects the appropriate tuner's I and Q outputs directly to the MSi2500's dual ADCs, see **Figure 2**. When used in dual-channel mode, the tuners are operated in low-IF mode with



PHOTO 2: The rear panel carries the USB connector and 24MHz reference in and out sockets.

a 1.536MHz bandwidth. In this mode the low IF signal from tuner 1 is routed to ADC 1 and tuner 2 routed to ADC 2, as seen in **Figure 3**.

Connections

The new RSPduo is housed in a very sturdy steel case (the same as the RSP2 Pro) with SMA connectors for the 50Ω antenna inputs, see **Photo 1**. The High-Z input is fitted with a pluggable, screw-terminal block and can

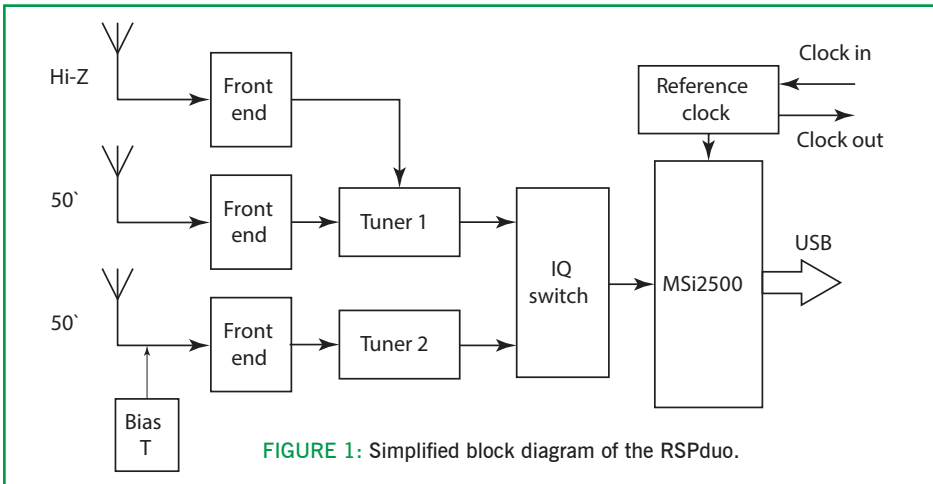


FIGURE 1: Simplified block diagram of the RSPduo.

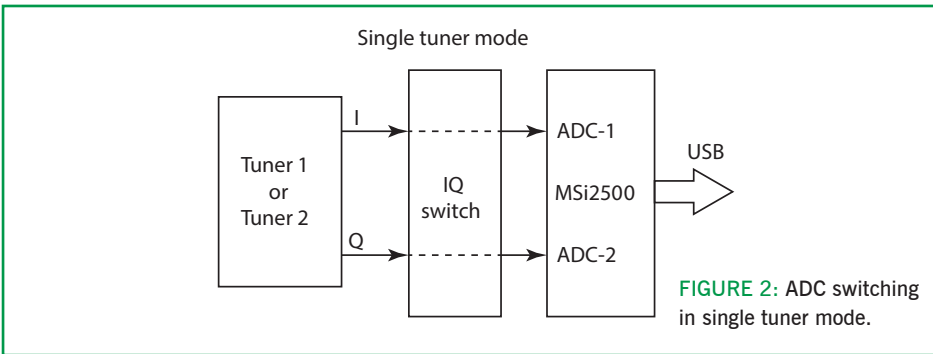


FIGURE 2: ADC switching in single tuner mode.

be used for both balanced and unbalanced high-impedance antennas. The connection back to the computer uses a standard USB-B connector and you will need a high-speed USB-2 adapter to handle the higher sample rates. Whilst the frequency accuracy of the RSPduo is very good, you can enhance this by adding an external frequency reference, as mentioned before. It is also interesting to note that the reference can be hot-plugged without causing the receiver any stability problems.

New filters

Wideband receivers represent a significant design challenge and this is particularly true for receivers in the sub-£250 bracket. Most of these receivers use analogue tuners to mix down the incoming RF to a low frequency intermediate frequency (IF) or direct to baseband ('zero IF'). The challenge for these designs is protecting the analogue mixer from strong out-of-band signals that will cause intermodulation products. The standard solution is to employ pre-selection filters to tame the troublesome signals before they reach the mixer. The SDRplay team has been very active in this area and have been fine-tuning their designs in response to customer feedback. However, for the RSPduo, they decided to use their accumulated knowledge

to create a new set of filters. Both tuners have identical filter banks in their 50Ω ports and I've shown the architecture in Figure 4. Here you can see that the filters have been split into two groups with the 1kHz to 60MHz filters located before the RF gain stage and the higher frequency filters placed between the gain stage and the tuner inputs. In addition to the split location for the filters, a new 0-2MHz low-pass filter has been included in both 50Ω paths and the Hi-Z port to improve the LF performance. The main filter switching is fully automated but there are some manually controlled filters available to deal with specific problem areas. For the two 50Ω inputs there is a switchable and combined MW and VHF/FM notch filter designed to knock out these strong signals before they can cause any problems. Similarly, there is a VHF/DAB notch filter located after the gain stage to tame the strong signals in that band. The balanced Hi-Z input has also benefitted from an upgrade with two new, automatically switched, filters. The first is a 30MHz low-pass filter which is automatically replaced with a 2.0MHz low-pass filter when tuning the lower frequencies. There is also a manually controlled MW notch filter on this input to attenuate the strong medium wave broadcast signals that can easily cause overload. The new filtering makes the RSPduo a much better prospect for LF work.

New API

The API (Application Programming Interface) is an essential part of most computer hardware as it provides the mechanism for software applications to communicate with the hardware. In an SDR, the API would be used for all the control functions required to make the hardware behave as an SDR. In previous SDRplay models, the API has been embedded in the SDR software or supplied as a separate dynamically linked library (DLL) file. However, with two tuners and the flexibility of having each tuner accessed by a different application, a new approach was required. For example, if SDRuno is active using tuner 1 and a second SDRuno instance is started, the second instance needs to know which tuner to use. A similar situation would arise if you wanted to use the other tuner with an entirely different SDR software package. The solution developed by the SDRplay team is to run the API as a Windows service (it runs as a daemon under Linux and Mac). Whenever an application needs access to an RSP device, it communicates via the API service to determine which tuner is available along with any other critical information such as sample rates, etc. With this configuration, you can easily operate with two different SDR software packages, the first connected to tuner 1 and the second to tuner 2. The change to a new API may cause a delay whilst 3rd party developers adapt their code, but the added flexibility will be worth the wait.

Sample rates and decimation

I think this area of the SDRplay warrants an explanation as sample rates and decimation are often misunderstood. Let's begin with sample rates. When we digitise an analogue signal, we need to convert the incoming analogue signal into a series of numbers that can tell us the strength of the signal and the rate at which it is changing. The standard technique for this is to take voltage readings of the signal at regular intervals. The conversion device is the analogue to digital converter (ADC) but, to capture a realistic representation of our incoming signal, we need to take frequent measurements. This is where the familiar Nyquist theorem comes in play as this shows us that we need to sample a signal or a bandwidth at a rate that's twice as fast as the highest frequency or bandwidth we want to capture. From that you would expect to sample at 20MHz to digitise a 10MHz bandwidth. Whilst that is true for a single channel, the situation is slightly different

Mike Richards, G4WNC
mike@photobyte.org

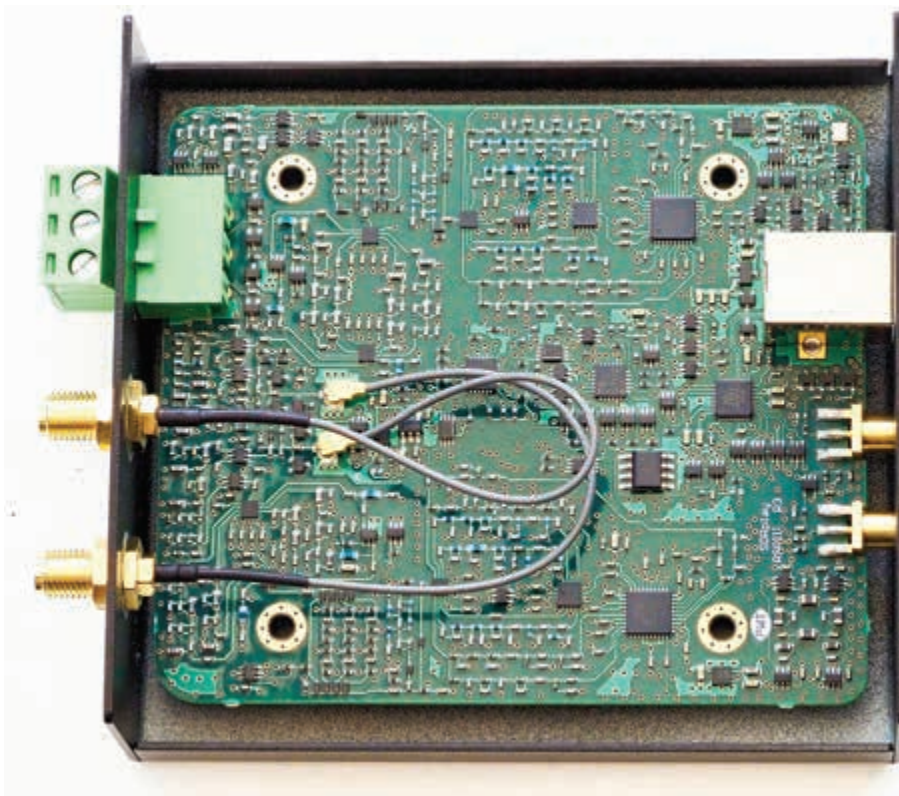


PHOTO 3: Neat, tidy modern construction techniques are employed throughout.

in most SDRs because we use two samples that are 90° out of phase. These are the I and Q signals. When used with a direct conversion tuner such as the Mirics MSi001 the two 10MHz I/Q samples let us tune up to 5MHz above and 5MHz below the central tuning point, thus giving us a 10MHz bandwidth with a 10MHz sample rate. In practice, the usable bandwidth is slightly less than the overall sample rate. This also helps explain why direct conversion (zero IF) designs suffer from a spike at the central (DC) tuning point. Once we have a digitised signal we will want to reduce the sample rate/bandwidth to home in on a specific band. This is where decimation is used and the first step is to apply a digital low-pass filter and then drop samples to achieve the desired sample rate.

The ADCs used in the RSPduo use sigma-delta architecture where the ADC includes a sampler and a decimation stage. Instead of taking full resolution readings at the specified sample rate, these ADCs sample using a lower bit resolution but at a much higher sample rate. This high-speed sample stream is then internally decimated to produce the target resolution and sample rate. One of the many benefits of sigma-delta ADCs is a significant reduction in quantisation noise, which is the primary noise source in the conversion process.

Now that we have an overview of the digitisation process, we can look at the RSPduo. The default resolution of the MSi2500 ADCs is 12 bits but it can be switched to 14-bit resolution when the sample rate is 6MHz or less. 14-bit operation doesn't increase the dynamic range of the ADC but it does reduce digitisation artefacts because the digitised samples are a better fit to the original signal. Because of this, it's worth using the lower sample rates when you zoom in on a band. The RSPduo has selectable decimation in the

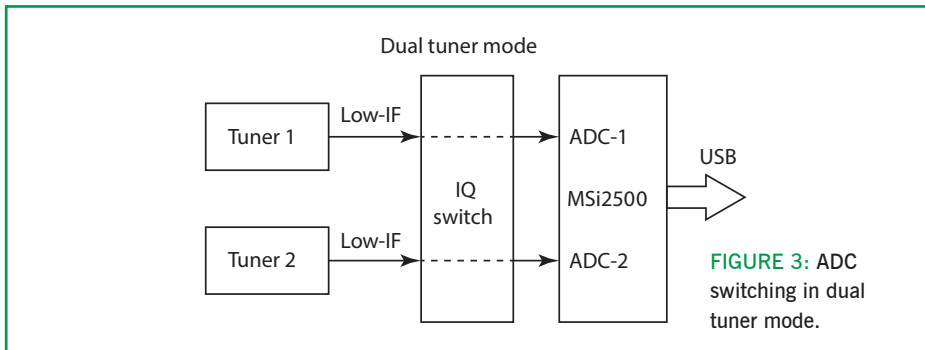


FIGURE 3: ADC switching in dual tuner mode.

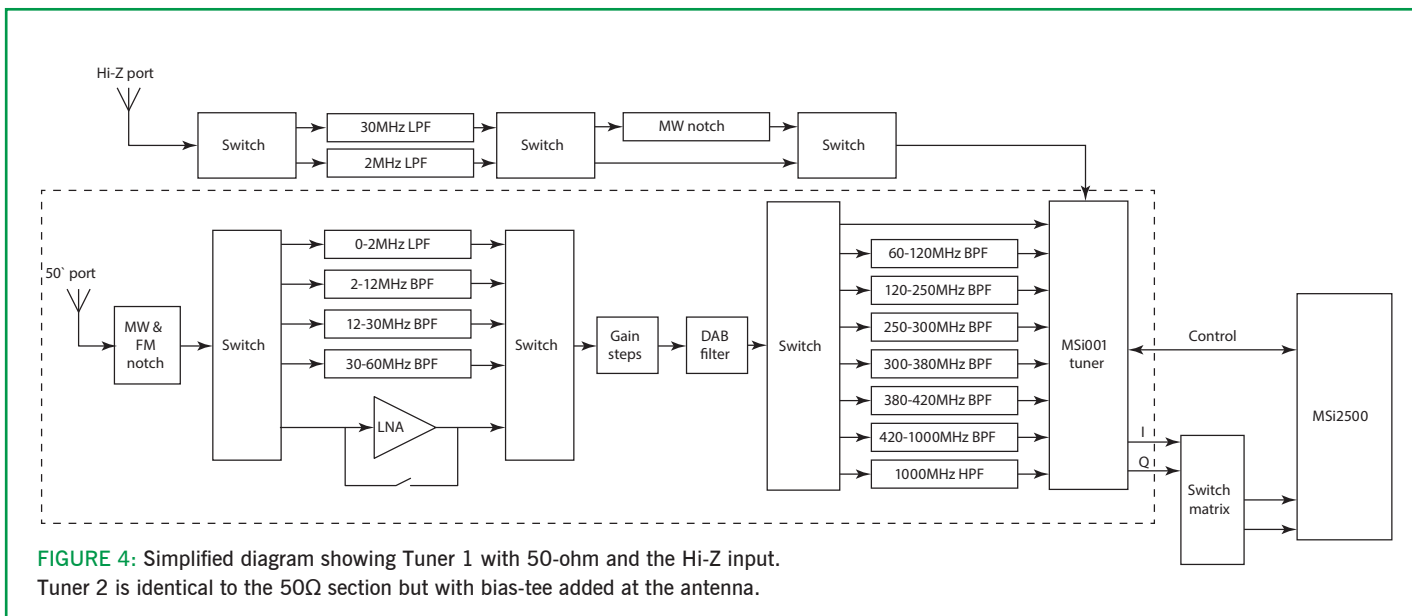


FIGURE 4: Simplified diagram showing Tuner 1 with 50-ohm and the Hi-Z input. Tuner 2 is identical to the 50Ω section but with bias-tee added at the antenna.



FIGURE 5: The new API receiver selection panel.



FIGURE 6: The SDRplay main panel in single tuner mode.

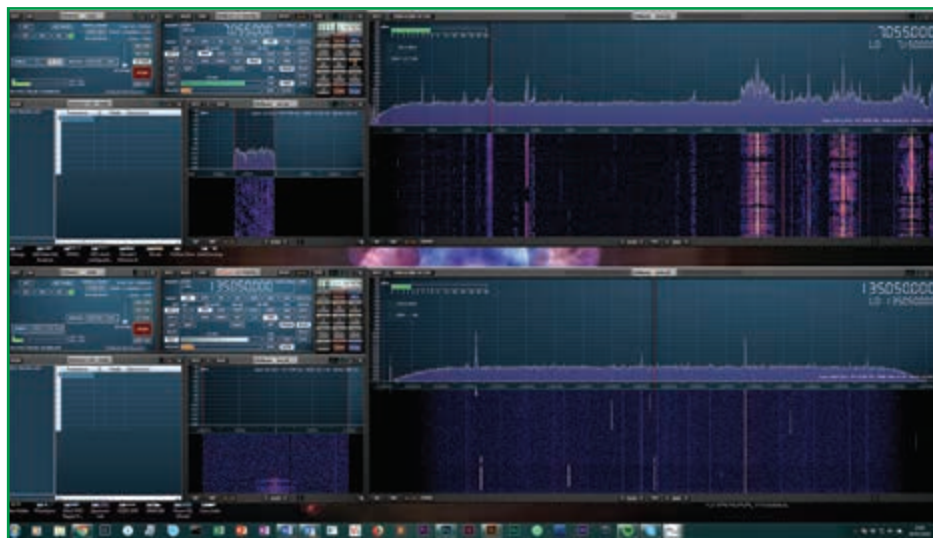


FIGURE 7: RSPduo operating in dual tuner mode with two instances of SDRplay.

main panel and the operation has been refined over successive SDRplay releases. The latest release inhibits decimation for sample rates above 6MHz, simply because you can get better performance by selecting a lower sample rate. Say you wanted a 5MHz bandwidth, if you use divide by 2 decimation on a 10MHz sample rate, you would get the desired 5MHz bandwidth but the resolution would be 12 bits. However, if you selected a 5MHz sample rate and no decimation, you would still get the 5MHz bandwidth but with 14-bit resolution. SDRplay has now been modified to steer you to the right settings by disabling decimation on all sample rates above 6MHz. The higher sample rates are still useful, particularly on VHF where you want to be able to see a wide bandwidth to check for activity. However, once you start to home in on a signal or band you should select sample rates of 6MHz or less and make use of decimation.

Using the RSPduo

At the time of the review, the only software available with full support for the RSPduo was SDRplay version 1.23, so that was used for this review. However, you can expect to see updates for SDR-Console and HSDR appearing

soon. The PC used for the review was an Intel i5 based machine and this proved to have plenty of processing power to handle the RSPduo at all sample rates.

As explained earlier, the new API service provides a revised start-up sequence that opens a small RSP selection box, **Figure 5**, if you have more than one RSP (any model) connected or if you are opening up a second instance of SDRplay to access RSPduo tuner 2. When utilising both receive tuners of the RSPduo, the tuner opened first assumed the role of master with the other tuner automatically designated as the slave. The API service also provided continuity when I closed an application and prevented me from closing the master channel if another application was using the slave channel.

Once the SDRplay was up and running, receiver management was handled via the Main panel, **Figure 6**. The buttons toward the bottom left of that panel were used to select both the tuner you want to use along with the input connection and the Bias-Tee switching. In the review setup, I connected my Butternut HF vertical or a Wellbrook loop to channel 1 and VHF/UHF antennas to channel 2. The provision of a 5V 100mA bias-tee on channel 2 makes it ideal for use with a 5V powered VHF/UHF masthead preamplifier but, with a bit of homebrew, could

be used to drive an antenna switch. Next to the tuner selection buttons is the manual switching for the MW/FM and DAB notch filters. Although the on-screen buttons are lined up with tuner 1, the filters were applied simultaneously to both tuners when operating in single tuner mode.

Another useful improvement can be seen in the Main panel RF attenuator. In earlier versions of SDRplay, this was called Gain Reduction and users often found it difficult to get to grips with the idea of gain reduction controls where you increase the slider to get more gain reduction! Renaming this slider Attenuation seems to make a lot more sense.

For amateur band use, the band buttons, or band-bracketing worked very well. In addition to switching to the appropriate frequency, custom sample-rates and decimation are used to distribute the selected band neatly across the entire spectrum display width. All the bands from 135kHz through to 1.27GHz were included in two groups. I used the band-bracketing in both Zero-IF and Low-IF modes but Low-IF offered the best performance as it eliminated the central spur.

To activate both tuners, I started the first SDRplay instance as normal with the default panel layout then selected Dual mode from the Main panel. There are two dual modes on offer, one of which is specially configured to work with Dump1090 which is a specialist application for receiving ADS-B messages from aircraft. Next, I used the Options button in the Main panel to arrange the SDRplay panels in Master configuration. I then started a second instance of SDRplay and this opened directly on top of the first instance. This was easily resolved using the Options button in the Main panel to select the default layout for a slave tuner. This rearranged the panels as shown in **Figure 7**. At this point both tuners could be tuned anywhere between 1kHz and 2GHz, the only commonality being the sample rate which was fixed at 2MHz in Low-IF mode. However, decimation is available separately in each tuner as is the band framing.

Summary

The RSPduo represents the top end of the SDRplay RSP line-up and has lots of potential for the future. Given the high noise levels suffered by most of us, the opportunity to access diversity reception for noise cancellation is very appealing. This technique should be feasible with the RSPduo, though we will have to wait for the software developers before we can enjoy the results. The RSPduo is also one of the toughest receivers in this class thanks to the substantial steel enclosure. With continuous coverage from 1kHz to 2GHz and a signal level readout that's accurate to a couple of dB, this is a hugely versatile receiver with myriad uses in the shack. The RSPduo is available from SDRplay (www.sdrplay.com) or their authorised dealers and costs £239.94 including VAT. My thanks to SDRplay for the loan of the review model.