This Review is reproduced with kind permission of the RSGB

It appeared in the April 2017 edition of RadCom

RadCom is the monthly magazine of the UK's Radio Society of Great Britain

For more about joining the RSGB—go to

www.rsgb.org

Review

SDRplay RSP2

The new RSP-2 Radio Spectrum Processor from SDRplay builds on the features of the popular RSP-1 to deliver an even more powerful low-cost SDR receive system. We take a close look at the new features.

Overview

The new RSP-2 provides uninterrupted frequency coverage from 1kHz to 2GHz and now includes three software selectable antenna inputs along with additional preselection filters and a bias tee power feed. A software adjustable low noise preamplifier has also been added, along with a switchable notch filter for the medium wave and VHF FM bands. The reference clock oscillator has been upgraded to a 0.5ppm TCXO device and this can be further trimmed to 0.01ppm. Those with access to an external reference clock will be able to lock the RSP-2 to a local 24MHz source by using its external clock input. The provision of a clock output also enables several RSP-2s to be daisy-chained so they can all be locked to the same reference source. Software support for the RSP-2 is also looking good and it's currently supported by SDRplay's own SDRuno plus SDR-Console V3 and HDSDR plus any other software that supports operation via the standard ExtIO interface.

Antenna connections

Multiple antenna inputs are essential for a receiver with such a wide frequency range and the RSP-2 now has three separate antenna inputs, each with a different role. The two 50Ω SMA connectors are labelled A and B and follow similar RF paths into the tuner, as seen in the simplified block diagram of **Figure 1**, but input B has a 4.7V bias tee facility included. This can be used to power a masthead preamp or active antenna, providing they are compatible with a 4.7V supply. The bias tee power is also software controlled, which is helpful. The provision of the third, high impedance (Hi-Z) port is very welcome and makes an ideal connection point for the random wire antennas that are so often used for general listening on the lower frequency bands. This port is suitable for use from 1kHz through to 30MHz and has a nominal input impedance of 1000Ω. If you want to use this port with a 50Ω coax fed antenna, SDRPlay suggest using a reverse 9:1 balun to handle the connection. As you can see from **Photo 1**, the Hi-Z input is fitted with a three-terminal block for connecting the wire antenna. In most configurations, the antenna is connected directly to the P terminal with the N and GND terminals looped together and connected to the station ground. When using antennas with a ribbon feeder, the ribbon is connected directly to the P and N terminals. The Hi-Z terminal block can also be unplugged from the main board and a custom plug can be used to make a more permanent connection.

PHOTO 1: SDRplay RSP-2 general view. The two SMA sockets are the main antenna connections and the green block is a detachable high impedance (1000Ω) input.

Reference clock

The reference clock in SDR hardware provides the heartbeat that controls the overall frequency accuracy of the receiver. Because of this, it has become standard practice to use good quality, temperature controlled crystal oscillators (TCXO). For the new RSP-2, the previous 10ppm (parts per million) crystal oscillator has been replaced with a new and much more accurate 0.5ppm TCXO. For many, this will provide sufficient accuracy, especially as most of the SDR software packages include calibration utilities that allow a clock correction factor to be applied. In addition to providing better absolute accuracy, the new, tighter controlled, TCXO has lower drift than its predecessor.

An important enhancement for the RSP-2 is the addition of a pair of MCX miniature coax

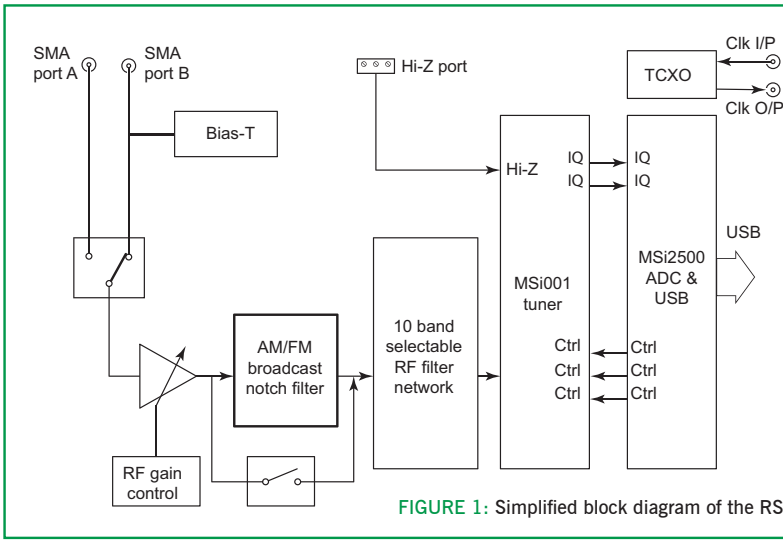

FIGURE 1: Simplified block diagram of the RSP-2.

PHOTO 2: Side view of the RSP-2 showing USB connector and MCX coax clock in and clock out ports.

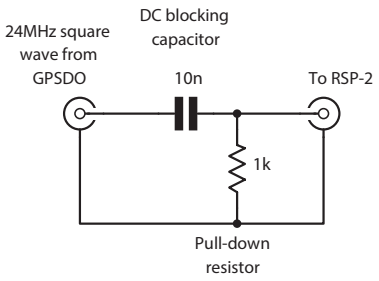

FIGURE 2: Minimum circuit for using the GPS-DO with the RSP-2.

connectors (**Photo 2**) that provide a clock-in and clock-out facility. For those using multiple RSP-2s, the clock-in/out enables receivers to be daisy-chained in a master/slave configuration so that they can all be synchronised to a single clock source. That source can be the internal reference clock of the first receiver in the chain or an external 24MHz sine wave reference oscillator with a signal level of 1 to 2V p-p. To use the RSP-2 with an external clock or the clock from another RSP-2 you must power up the RSP-2 with the reference clock already connected. This is because the external clock input is scanned for a valid signal during start-up and cannot be activated later. In addition to being available during power-up, the external source must provide a DC path to ground (1kΩ is ideal) to enable the switch-over from the internal reference. For the review, I used the excellent GPS-DO (GPS Disciplined Oscillator) from SDR-kits, **Photo 3**. This compact, dual output, reference clock can be set to deliver a wide range of clock frequencies. Its only limitation is that the range of frequencies available from the second output are mathematically linked to the frequency supplied by output 1. Fortunately, with output 1 set for 10MHz (as used by other kit in my shack), the second output could be configured to provide the required 24MHz. To use the GPS-DO with the RSP-2, a small interface is required. The minimum is a 1k resistor to ground and a 10nF capacitor to provide a DC block, shown in **Figure 2**. Don't be tempted to connect the square-wave output of the GPS-DO directly to the RSP-2, as it doesn't work properly! The specification suggests a 1 to 2V p-p sine wave is the ideal clock source. I built a simple in-line low pass filter to tidy up the GPS-DO output, shown in **Figure 3**.

RF filtering

With all wideband receivers, good filtering is essential to help prevent strong out-of-band signals from overloading the tuner front end and the analogue to digital converter (ADC). Like the RSP-1, the RSP-2 uses software switched RF preselection filters ahead of the tuner, but this has been enhanced from 8 to 10 bands in the new model, as shown in Figure 1. In addition, switchable RF notch filters have been added to attenuate the MW and VHF/FM broadcast bands. When activated, MW signals are attenuated by around 40dB and the VHF/FM band by approximately 60dB. This will be a big help for those who suffer overload from very strong broadcast signals. One important point to note here is that the new broadcast notch filters and the 10-band RF preselection filters are only available when using the SMA antenna ports A and B. When using the Hi-Z port, the signal is applied directly to the LF port of the Mirics MSi001 tuner with minimal filtering.

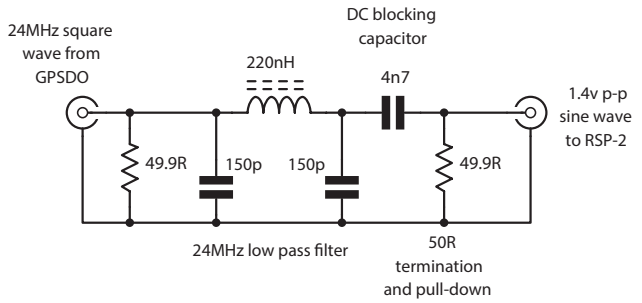

FIGURE 3: Suggested low-pass filter for use with square-wave external clocks.

Calibrated signal level

This is a particularly useful enhancement that brings the RSP one step closer to being a measuring receiver. The calibrated receive level allows the RSP-2 to indicate true signal input levels in dBm. This may sound simple but it's not really. In a modern SDR, the signal level measurement occurs at the ADC. In this stage, the incoming analogue signal voltage is measured at high speed, typically, a rate that's twice the highest IQ bandwidth. So, a receiver that's displaying a 10MHz bandwidth will be taking ADC measurements at a rate of at least 20 million samples per second (MSPS). The accuracy of each measurement is defined largely by the accuracy of the ADC's reference voltage. Thanks to developments in technology these reference voltages are extremely good. As a result, we can have confidence in the accuracy of the signal measurement at the ADC. However, looking at the block diagram, Figure 1, you can see that there are a number of analogue stages before the signal reaches the ADC and some of these have gain control settings that can either be changed manually or by the automatic gain control (AGC). To produce an accurate signal level representation in the spectrum display, the ADC measurement needs to be corrected for the current gain settings. The SDRplay team have tackled this problem by using a complex set of data tables that show the gain effect of all the analogue stages over a wide range of settings and frequencies. As a result, the displayed signal level will remain largely static when you alter the gain controlled stages. I'll show you how

Mike Richards, G4WNC
mike@photobyte.org

PHOTO 3: Leo Bodenar GPS-DO reference clock used during the review.

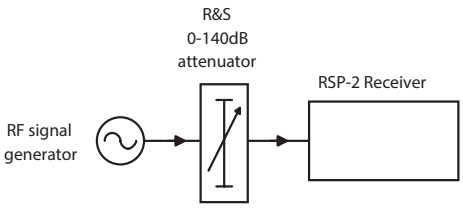

FIGURE 4: Test setup for checking the signal level tracking.

well it does later. This is a new feature and the SDRPlay team are continuing to gather data and refine the data set with each software release.

RF low noise amplifier

Also new to the RSP-2 is an adjustable RF low noise amplifier (LNA). The main benefit here will be seen with higher frequency signals. The amplifier gain is adjustable in 8 steps and uses the same principle as the other gain controls in the RSP series. Both RSPs provide all their gain adjustment stages as gain reduction, ie the starting point is to assume full gain and performance is tailored by reducing the gain to optimise performance for the current receiving conditions. This might seem a bit odd at first but it's easy to master.

Standard vs Pro option

The new RSP-2 is available in two options, standard and Pro. In both instances the electronics are identical but the changes are in the enclosure. The standard version uses a new ABS enclosure that has conductive plating on the inside to provide some additional screening to help keep stray RF out, as seen in **Photo 4**, whilst the Pro version uses an all-metal enclosure. In addition to providing improved screening, the Pro version is more robust.

One the air

The general performance of the RSP-2 is very similar to the popular RSP-1, as most of the electronics at the core of the receiver remain the same. Here I'll look at the improvements that come with the new features.

The software switchable antennas are a big step forward as few people will attempt to cover 1kHz to 2GHz with a single antenna! With 3 antenna inputs, many of the common antenna installations can be covered. I found that the best way to apportion the inputs was to use the Hi-Z for long and medium wave listening but then switch over to SMA input A for the HF bands. This is because the Hi-Z input connects to the LF input of the Mirics tuner and this is optimised for LF/MF performance. The new RF pre-selection and notch filters are only available to SMA inputs A and B so, by using Input A for HF we get the dual benefit of improved pre-selection filtering and the MW/VHF FM notch filters. A few measurements of the notch filter shows attenuation of just over 40dB at 1MHz and 60dB at 98MHz. In most installations, Input B is best kept for VHF/UHF operation as it has the benefit of the additional filtering and includes a bias tee power feed that could be used to power a masthead preamplifier. For those that use active antennas for HF reception the opposite is true, so SMA input B would be used for HF and SMA input A for VHF/UHF.

As mentioned earlier, I used the Leo Bodenar GPS Disciplined Oscillator to provide the 24MHz frequency reference for the RSP-2. This provides an extremely accurate reference that allows the RSP-2 to be used for very precise frequency measurement. When connected to a good external GPS antenna, the GPSDO can approach an accuracy of 1 part per billion (ie within 1Hz at 1GHz), which is very impressive.

The calibrated signal level was a very welcome addition and I did a number of tests to check the accuracy of the reported levels. The test setup comprised an RF signal source connected to the RSP-2 (SMA A) input via a Rohde & Schwarz variable attenuator, shown in **Figure 4**. I adjusted the input level to read -50dBm on the RSP-2 and then used the attenuator to adjust the level over the range -50dBm to -120dBm in 10dB steps. This is roughly equivalent to an S-meter range of S1 to S9+20dB, so represents the main working range of the receiver. To simulate normal use

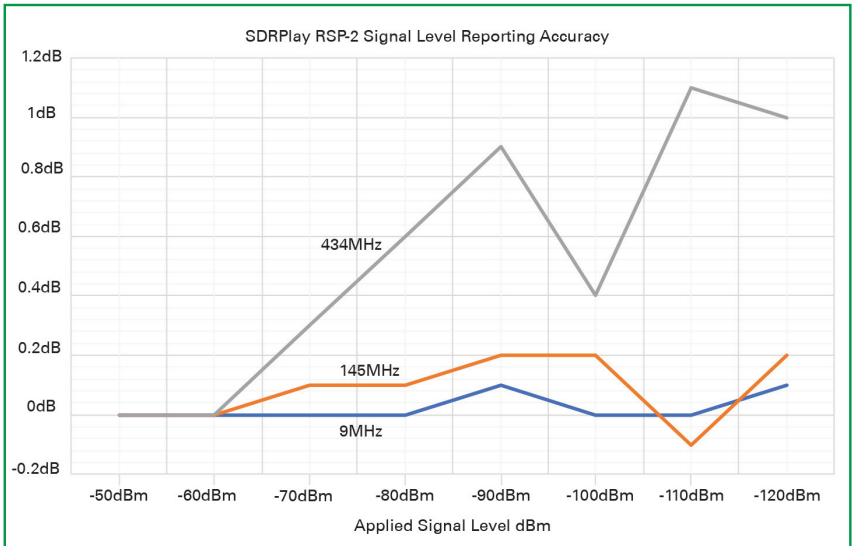

FIGURE 5: Graph showing the small measurement error in dBm at three test frequencies with the signal level varied between -50dBm and -120dBm.

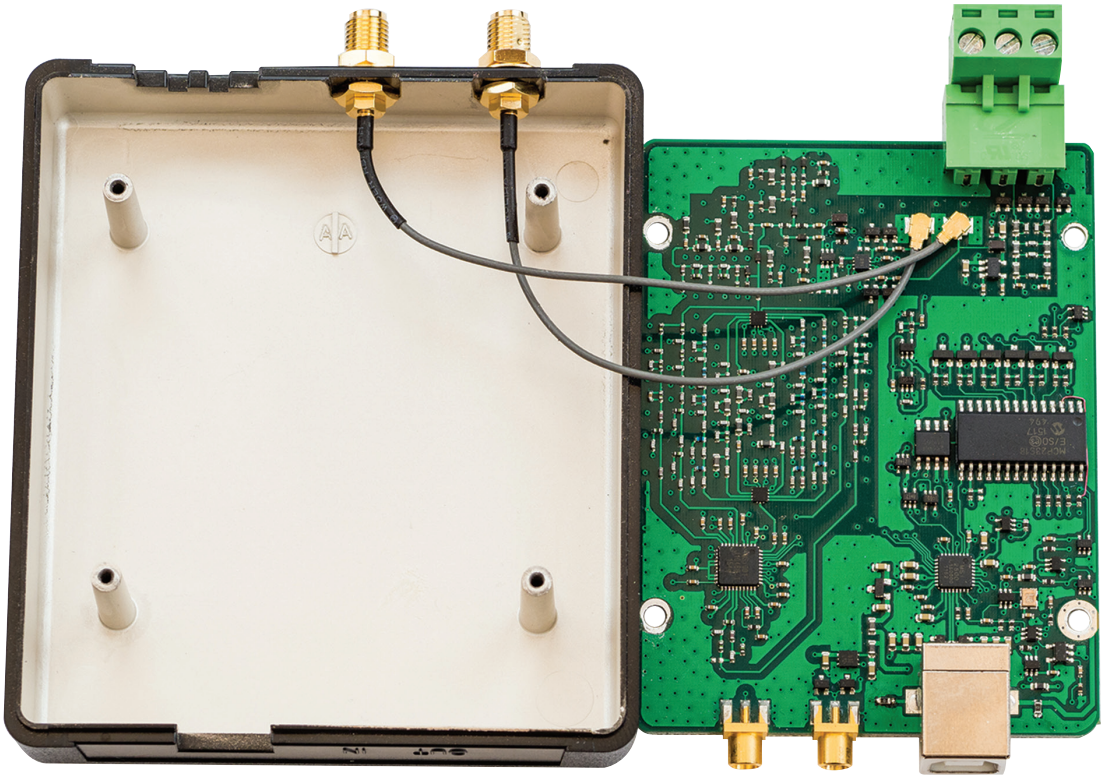

PHOTO 4: Inside the RSP-2, showing the conductive plating inside the ABS case. The filter banks on the left of the main PCB are quite distinctive.

of the receiver, I had the AGC switched on and the RF LNA at gain reduction 3. To check the RSP-2's level tracking, I noted the RSP-2 signal level whilst increasing the attenuation in 10dB steps. The results are shown in **Figure 5**. Whilst the absolute signal accuracy is currently only good to within 1-2dB, the tracking accuracy over the 50dB level range was excellent. The 9MHz and 145MHz tests remained within 0.2dB but, as you might expect, the 434MHz result was not quite so good although it remained within 1.1dB of the true value. The increased error at higher frequencies is due to the difficulty predicting the precise gain of the system at these frequencies. However, the accuracy will improve as the SDRPlay team refine their dataset. One final test was to check the gain reporting whilst adjusting the RF gain setting. This showed excellent tracking that was within 0.5dB across the three test frequencies (9MHz, 145MHz and 434MHz).

The adjustable gain LNA was a very welcome addition but, in practice, I found it needed careful monitoring as the full gain was rarely required (particularly on HF). I used the RSP-2 with my Wellbrook ALA1530 Imperium Pro loop that delivers a relatively high output level to the receiver. When using this on the HF bands, I frequently had to back off the LNA gain to prevent ADC overload.

I found it hard to quantify the benefit of the improved RF preselection filters but they will no doubt help in receive locations that are plagued by strong out-of-band signals. The combined MW and VHF/FM notch filter was easier to quantify and provided useful attenuation of the broadcast signals.

Summary

The SDRPlay team have clearly listened to their customers and enhanced the RSP-2 with a host of well-chosen improvements. Like all wide band SDRs, care is needed when strong signals are around as it's easy to overload the ADC, especially if you don't keep control of the new RF gain adjustment. The addition of the calibrated signal level reporting and the new TCXO plus the external reference option makes the RSP-2 a very useful measuring instrument to have around the shack.

Not only are the RSP-2 hardware improvements very welcome but their development team are very active and their in-house SDRuno software and the driver APIs are under constant revision, so we can expect more improvements will be seen over time. The RSP-2 is £164.40 inc VAT and tracked courier delivery in the UK and can be purchased direct from the SDRplay website (www.sdrplay.com/purchase/) or, alternatively, ML&S are a direct distributor. My thanks to SDRPlay for the loan of the review model.

SPECIAL EVENT STATIONS

These callsigns are valid for use from the date given, but the period of operation may vary from 1-28 days before or after the event date. The details published here were kindly provided by Ofcom on 20 February 2017.

Date	Callsign	Event Phonetics	Location
01/04	GB2M	Marconi	Isle of South Uist, Outer Hebrides
	GB0MPA	MPA	Sully
07/04	GB0LAF	Lissett Air Field	Driffield
13/04	GB0RM	GB0RM	Dudley
21/04	GB4GM	Marconi Day	Caernarfon
22/04	GB0AA	Caister Marconi Station	Caister
	GB1STG	Saint George	Chelmsford
	GB5LT	Luttrell's Tower	Southampton
	GB0IMD	International Marconi Day	North Somerset
	GB0CMS	Caister Marconi Station	Caister
	GB4MDI	Marconi	Sully
23/04	GB4TDY	Tour de Yorkshire	Lancaster