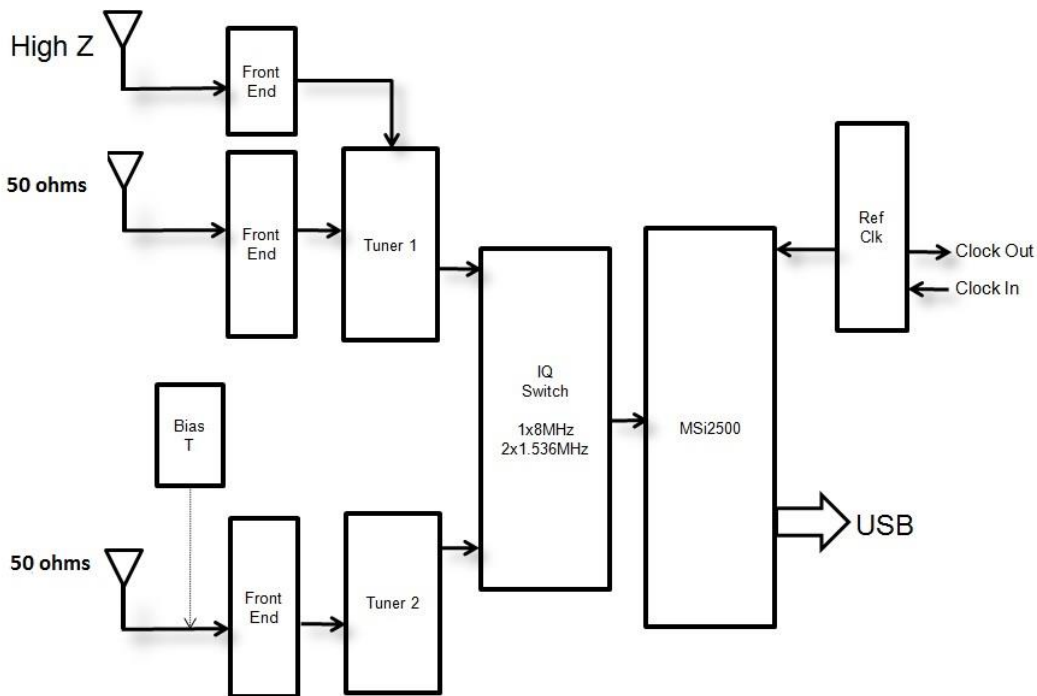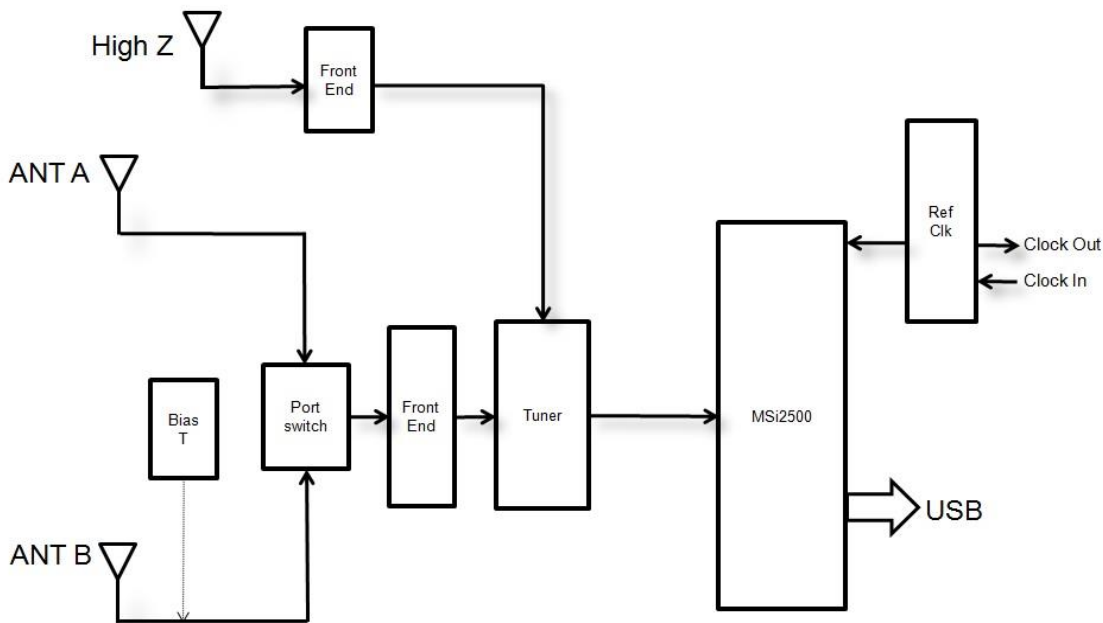# RSPduo
Dual tuner 14 bit 1kHz – 2GHz SDR

The RSPduo is a radical new product that will shortly be introduced as part of the RSP line of SDR receivers from SDRplay. Architecturally, it is different from any previous RSP in that it features dual independent tuners, both piped through a single USB 2.0 interface. Superficially the RSPduo will look virtually identical to the RSP2pro and will be able to operate in a very similar way, but it also allows a completely new and unique set of usage scenarios.

The basic block diagram of the RSPduo is:

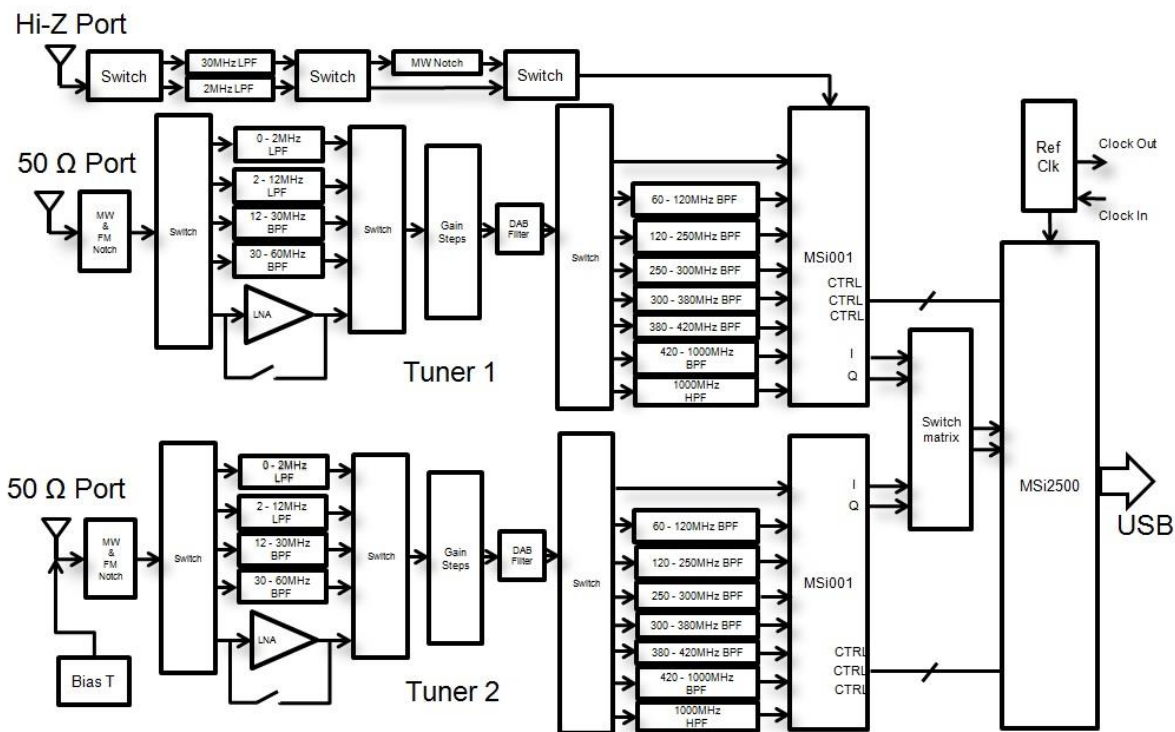In contrast the RSP2 block diagram is shown below:

As can be seen, the principle difference is that the RSPduo contains two tuners as opposed to the RSP2 which has a single tuner and switched antenna ports.

The MSi2500 contains dual ADCs. This allows the sampling of I/Q analog baseband signals when the tuner is used in Zero IF mode. However, the tuner can also operate in a Low IF mode, where a single ADC is used to sample the output from the tuner. This opens up the possibility of having two independent tuners operating simultaneously, but this is ONLY POSSIBLE IF BOTH TUNERS ARE OPERATING IN LOW IF MODE. In Low IF mode, the maximum flat pass-band bandwidth of the IF filters in the tuner is 1.536MHz (giving 2MHz visible spectrum), whereas in ZIF mode, it is possible to widen these filters to 8 MHz (giving 10MHz visible spectrum). This is the approach used in the RSPduo. The receiver can either operate each tuner individually (one at a time) in zero IF mode with a visible bandwidth of 10MHz or both tuners simultaneously with a maximum visible bandwidth of 2MHz each.

A more detailed block diagram of the RSPduo is shown below:

Hi-Z Port

Switch — 30MHz LPF / 2MHz LPF — Switch — MW Notch — Switch

50 Ω Port — MW & FM Notch — Switch — 0 - 2MHz LPF / 2 - 12MHz LPF / 12 - 30MHz BPF / 30 - 60MHz BPF — LNA — Switch — Gain Steps — DAB Filter — Switch — 60 - 120MHz BPF / 120 - 250MHz BPF / 250 - 300MHz BPF / 300 - 380MHz BPF / 380 - 420MHz BPF / 420 - 1000MHz BPF / 1000MHz HPF — MSi001 — CTRL CTRL CTRL — I Q

Tuner 1

Ref Clk — Clock Out / Clock In

50 Ω Port — MW & FM Notch — Switch — 0 - 2MHz LPF / 2 - 12MHz LPF / 12 - 30MHz BPF / 30 - 60MHz BPF — LNA — Switch — Gain Steps — DAB Filter — Switch — 60 - 120MHz BPF / 120 - 250MHz BPF / 250 - 300MHz BPF / 300 - 380MHz BPF / 380 - 420MHz BPF / 420 - 1000MHz BPF / 1000MHz HPF — MSi001 — I Q — CTRL CTRL CTRL

Bias T

Tuner 2

Switch matrix — MSi2500 — USB

As can be seen from the diagram above, Tuner 1 contains both a 50Ω port and a Hi-Z port. Unlike the RSP2, the 50Ω ports on both tuners now operate down to 1 kHz and deliver significantly improved dynamic range when compared to the RSP2. In addition, like the RSP1A, there is a 0-2 MHz low pass filter on both 50Ω ports, which helps reduce the number of spurious mixing products that appear at LF and MW. Unlike the RSP2, the Hi-Z port on the RSPduo now incorporates both a MW notch filter and a 0-2 MHz low pass filter, which should help reduce overload from strong MW AM signals and spurious mixing products from HF. The Hi-Z port should deliver the best performance for LF, MW operation and ought to be far superior to that on the RSP2. The 50Ω ports on Tuner 1 and 2 deliver very good performance from LF to 2GHz, but deliver the best performance for HF and above due to the extra preselection filters which are not available on the Hi-Z port above 2 MHz.
The 50Ω ports on Tuners 1 and 2 should deliver similar performance to the RSP1A, but with improvements in both the MW and VHF FM notch filter rejection and also a reduction in spurious mixing products from UHF appearing in Band 3 (120 – 250 MHz)
The reference clock circuitry has been significantly enhanced and can now interface to a GPSDO delivering a 0-3v output without any interface circuit. It is capable of operating as a clock master to other RSPduos or RSP2s and will also operate as a clock slave when using a RSP2 as a clock master. In tests, we find that we can 'hot swap' between an internal and external clock without hanging the MSi2500, which is not possible on the RSP2.

Finally, like the RSP1A, the RSPduo also features 14bit ADC performance for sample rates of 6 MHz or below.

The simultaneous use of two independent tuners (albeit with reduced bandwidth) makes certain key usage scenarios possible:

1. Simultaneous monitoring of two widely spaced bands – e.g. 40m and 2m
2. Mixing and matching applications simultaneously – e.g. ADS-B and ATC scanning
3. Phase and time coherent demodulation of two receivers

Scenario 3 is very difficult to achieve with two separate USB devices because of the uncertainty of USB latency. So whilst it is possible to phase lock the clocks of multiple RSP2s, the uncertainty of USB latency meant that the timing of the two units would not be aligned when it came to demodulation. The only way to overcome this was to apply timing correlation in software which requires a 'training sequence' to be simultaneously applied to both devices. The RSPduo overcomes this limitation because all traffic goes through a single USB interface, it opens up the possibility of the development of various types of diversity demodulation such as: spatial, frequency and polarisation which can bring huge benefits in terms of improved performance.

Operating with two tuners simultaneously

Whilst the tuners can be controlled completely independently in terms of gain and frequency, there is one common factor that cannot (indeed should not) be separated and that is the ADC sample rate.
Because of this, whichever tuner is set up first will dictate the sample rate of the second receive path. To make it clear, we designate the first receiver to be set up as the 'Master' and the second one the 'Slave'.

In low IF mode, there will only be two sample rates available:

1. 6 MHz – This will deliver 14 bit ADC resolution, but with slightly inferior anti-aliaising performance at the widest bandwidth
2. 8 MHz – This will deliver 12 bit ADC resolution, but with slightly better anti-aliaising performance at the widest bandwidth

6 MHz operation should result in a slightly lower CPU load.

A new API concept

The problem with the existing API concept is that when starting the application with embedded API, it is simply not possible to determine in advance what is available in terms of receivers. We have therefore completely changed the concept behind the API.

With the current API approach, if one application has already set up a SDRduo receiver as the ADC 'Master' and another application attempts to set up the second receiver in a way that is not possible, then the application will error and (most probably) crash out. Instead of the API either being embedded within the application (such as with SDRuno) of a separate DLL (as with HDSDR and SDR Console), it is therefore necessary to operate the API as a background 'service' within Windows and a 'daemon' under Linux and Mac OS. In this way, the service constantly monitors what is available in terms of receiver hardware and communicates this to the application at startup. That way, it is possible to avoid the application attempting to configure a tuner on startup into a mode that is simply not possible because another tuner is already designated as the 'Master' by a different application.

The matrix of available hardware options (for a single RSPduo) to the various applications will be as follows:

Operating mode	Tuner 1 Available RF ports	Tuner 2 Available RF ports	Master sample rate	Slave Sample rate	Tuner 1 IF Bandwidth	Tuner 2 IF Bandwidth	Tuner 1 frequency range	Tuner 2 frequency range
Single receiver (Tuner 1)	50 Ω/Hi-Z	Not available	2-10 MHz	N/A	200 kHz – 8 MHz	N/A	1 kHz – 2 GHz	N/A
Single receiver (Tuner 2)	Not available	50 Ω with Bias T	2-10 MHz	N/A	N/A	200 kHz – 8 MHz	N/A	1 kHz – 2 GHz
Dual tuner (tuner 1 master)	50 Ω /Hi-Z	50 Ω with Bias T	6/8 MHz	Determined by Tuner 1	200 kHz – 1.536 MHz	200 kHz – 1.536 MHz	1 kHz – 2 GHz	1 kHz – 2 GHz
Dual tuner (tuner 2 master)	50 Ω /Hi-Z	50 Ω with Bias T	6/8 MHz	Determined by Tuner 2	200 kHz – 1.536 MHz	200 kHz – 1.536 MHz	1 kHz – 2 GHz	1 kHz – 2 GHz

For the avoidance of doubt, when the service based API operating correctly, when operating a single instance of SDRuno, the RSPduo will operate in exactly the same way as the RSP2 if single tuner mode is selected from the main panel. Selecting either the 50Ω or the Hi-Z port, associate with Tuner 1 will enable Tuner 1 and selecting the 50Ω associated with Tuner 2, will enable Tuner 2. If dual tuner mode is selected from within main panel of the first instance of SDRuno, then a second instance of SDRuno will automatically designate the remaining tuner as the 'Slave' tuner.

The following diagram illustrates how SDRuno will work with the RSPduo:
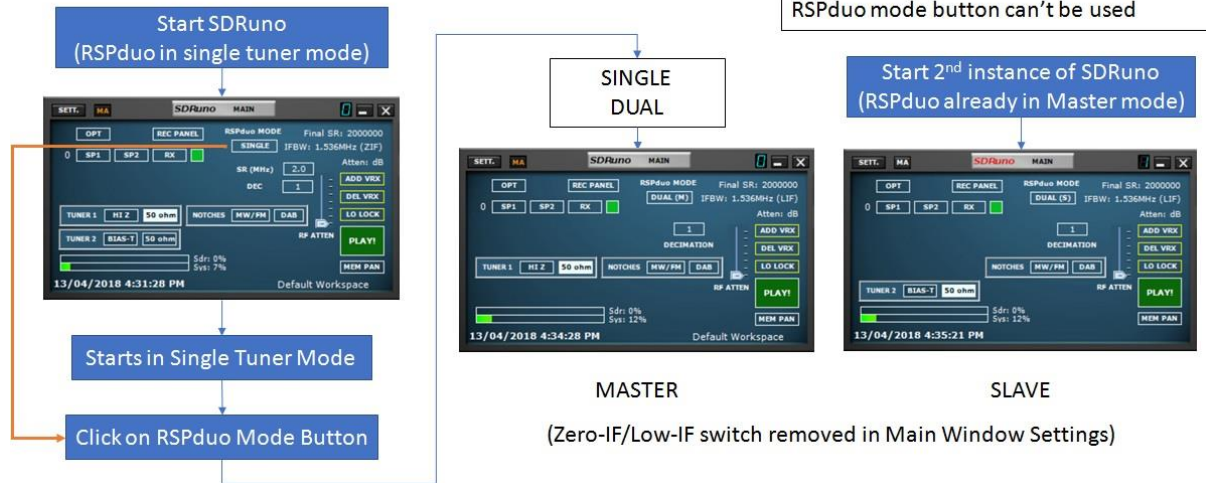
If a different application has already set up the RSPduo as a dual tuner and is using one of the tuners as a 'Master' then the service will tell SDRuno what is available to it upon startup and in this case, the Main Panel will be configure for Slave mode only. Similarly if an application is already using the RSPduo in single tuner mode, then the service will inform any subsequent applications that no additional tuners are available unless other RSPs are also plugged in.

We believe that the dual tuner capability will prove to be a real differentiator in the market place and add momentum to the popularity already established by the RSP1, RSP1A, RSP2 and RSP2pro.