

Mike Richards looks at the brand new Airspy wideband software defined radio receiver, which offers continuous coverage from 24MHz to 1.8GHz and (with a suitably powerful PC) allows you to view and record up to 10MHz of RF spectrum.

Airspy

The appearance of the FUNcube Dongle and RTL-based software defined radio (SDR) receivers has allowed many listeners to gain access to wideband coverage at a reasonable price. However, designers are now looking at how to make use of the vast amount of new, low-cost technology that is currently available to build the next generation of SDR receivers. The new Airspy certainly fits into that category because it is extremely compact and offers a 10MHz receive bandwidth over a tuning range from

24MHz to 1.80GHz with no gaps. What is more, it lacks the central spur that has been a feature of many of the cheaper designs. The Airspy is closely linked with the SDR# project and has been designed and produced by **Youssef Touil** and **Benjamin Vernoux**. As you will see, the construction quality is excellent thanks to the team at Itead Studio.

Setting Up

The Airspy was supplied with a Micro USB lead and a small printed instruction sheet. The construction quality was excellent, with the electronics housed in an extruded alloy case with alloy end plates. Input and output connections comprised an SMA antenna connector, a Micro-B USB socket and an MCX connector for an external clock.

The antenna connection was a standard 50Ω type. However, the Airspy can also be configured to supply 4.5V (at up to 50mA) as a bias tee feed via this socket, which is a very useful feature that could be used to power an antenna amplifier, an antenna switch or an HF upconverter.

Power for the Airspy is delivered via the USB connection, along with all the control and in-phase and quadrature (IQ) sample data for the receiver. On the review model, the power consumption (while running at full speed with the bias tee switched off) was 320mA. When operating at the sample rate of 10 mega samples per second (MSPS), the Airspy makes a heavy demand



The Airspy wideband SDR receiver.

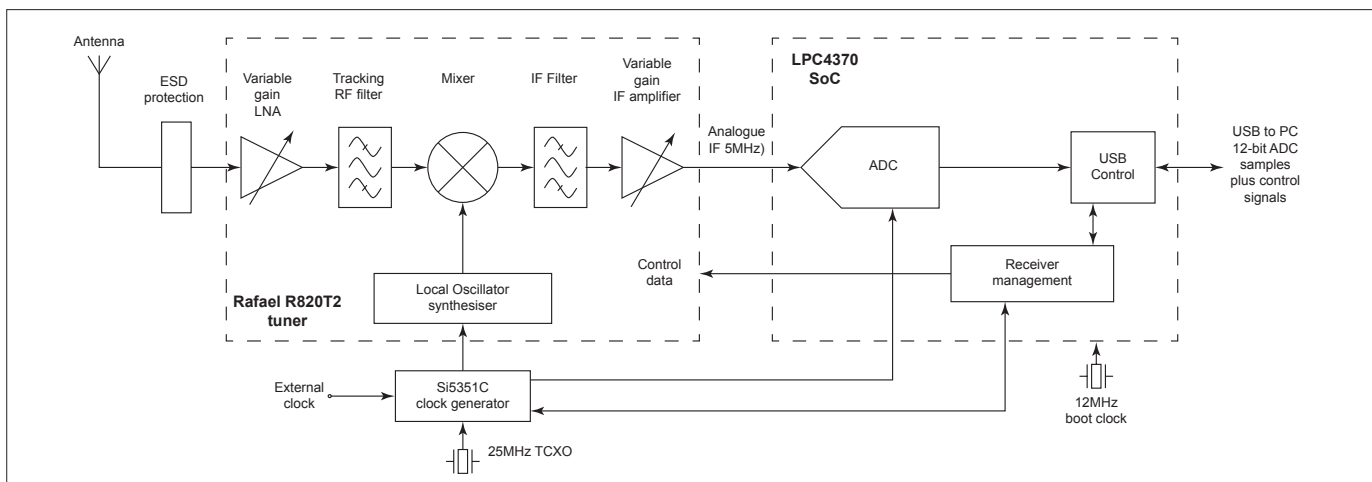


Fig. 1: A simplified block diagram of the Airspy hardware.

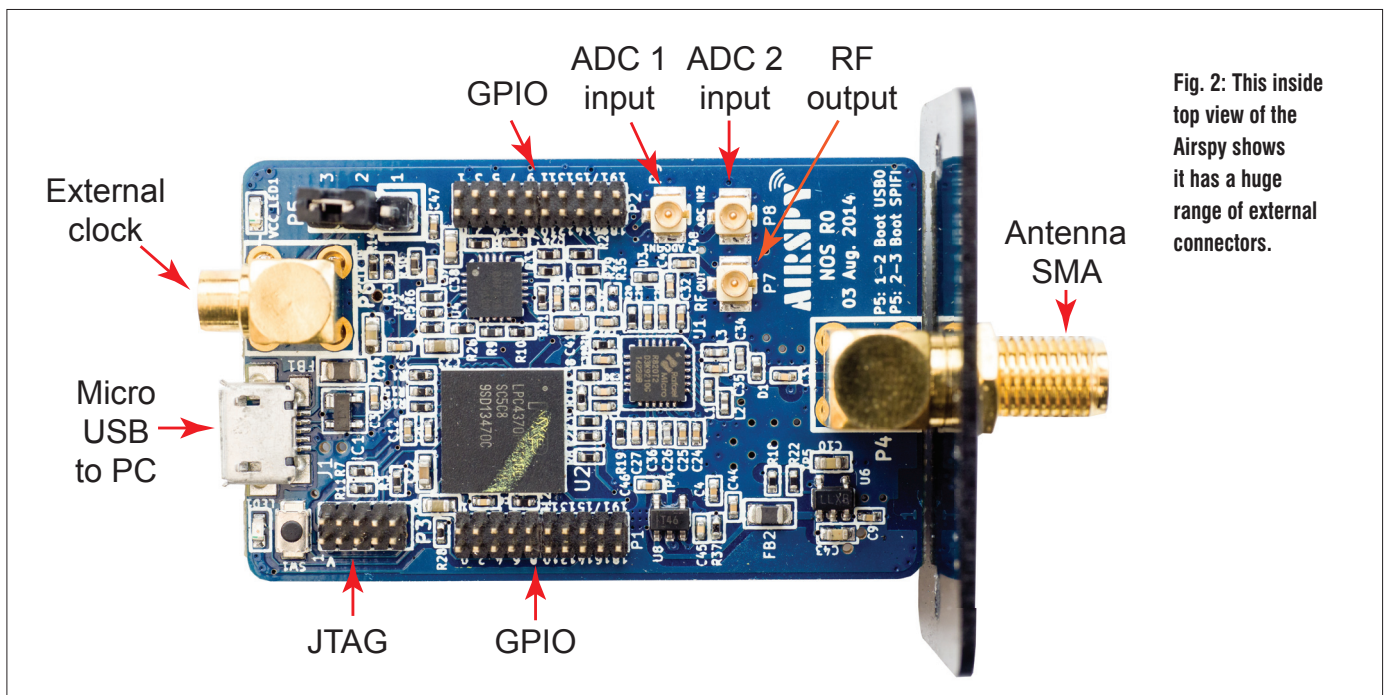


Fig. 2: This inside top view of the Airspy shows it has a huge range of external connectors.

on the USB port and a PC with a third generation Intel i3 2.4 GHz CPU is recommended. Nevertheless, the Airspy is still very attractive for use with slower PCs, providing it is switched to its lower sample rate of 2.5MSPS. The provision of an external clock port is something of a rarity on this type of receiver and certainly increases the receiver's flexibility. While the internal clock accuracy is more than adequate for most purposes, the provision of a separate clock input might still be useful for some specialist applications.

A Look Inside

As you can see from the photos, the Airspy is a very nicely made compact receiver that is bristling with technology. Like many receivers, the Airspy makes use of an integrated tuner chip that was designed originally for the set-top box market. The Rafael Microelectronics R820T2 tuner is the latest version of a comprehensive radio frequency (RF) tuner system, with a continuous frequency coverage from 24MHz through to 1.8GHz. For this reason, the first big plus point is no gaps! The R820T includes a variable gain low noise amplifier (LNA) in the front-end that feeds a software controlled tracking RF filter. This is another advantage because many other designs employ banks of switchable filters. The output from the tracking filter feeds the mixer, where the incoming signal is mixed down to the 5MHz intermediate frequency (IF) or 1.25MHz when using the 2.5MSPS

sample rate. It is the use of a 5MHz IF that overcomes the spur in the centre of the display that is a characteristic of zero-IF designs. The final stages of the R820T comprise an IF filter and a variable gain IF amplifier. In addition to acting as an IF filter; this section doubles as an aliasing filter for the analogue to digital converter (ADC). The local oscillator chain is integrated with the R820T chip. However, instead of using the usual low-cost resonator, the Airspy employs a Si5351C high-quality clock generator chip combined with a temperature controlled crystal oscillator (TXCO). The Si5351C is a very capable clock generator and is used to provide all the clocks for the receiver and the processor.

Control of the R820T's gain and tuning is done via a simple I2C data link from the processor unit – see Fig. 1 for a simplified block diagram.

The 5MHz IF signal from the R820T2 tuner is passed to the LPC4370 processor chip for digitisation and further processing. The LPC4370 is a system on a chip (SoC) rather than a simple microcontroller and is packed with all manner of goodies. The main processor is an ARM Cortex-M4 running at up to 204MHz. Supporting this is a Cortex-M0 processor that can also run at up to 204MHz and can be used to off-load work from the M4 processor. In addition, there is another Cortex-M0 sub-system processor that looks after communications and peripherals. As if all that was not enough, the LPC4370 includes a three-channel, 12-bit,

high-speed ADC that can run at up to 80MSPS. Also very important for high-speed digital signal processing is the hardware floating-point maths unit.

In addition to providing all the control functions for the receiver and USB port, the LPC4370's ADC digitises the 5MHz analogue IF from the R820T tuner. The ADC normally runs at 20MSPS with 12-bit samples that are fed to the host PC via the USB port. The use of 12-bit per sample is worthy of note because most of the lower priced SDR receivers use 8-bit samples and therefore have a lower dynamic range than the Airspy. The host software on the PC is used to generate the IQ data and to manage the decimation, filtering and demodulation. When set to 2.5MSPS, the ADC sample rate is changed in the Airspy hardware, thus giving a lower throughput on the USB link.

Expansion

In addition to being an excellent SDR receiver, the Airspy has a host of expansion options along with an open source application programming interface (API) that makes it an excellent choice for the experimenter. If you are interested, the firmware can be downloaded via the Airspy Firmware page on GitHub.

<https://github.com/airspy/firmware>

A look inside the case shows a number of connectors waiting to be used (Fig. 2). On the RF side, there is an RF loop output, as well as two ADC inputs and lots of general-purpose input/output (GPIO) connections. Using the API, the

ADC can be set to run at any sample rate up to a maximum of 80MSPS. This, combined with the GPIOs, makes it an ideal platform for radio experimenters. Once the Airspy is established, I am sure there will be many interesting applications to come.

On the Air

Because the Airspy was designed with SDR# in mind, most of my testing was undertaken using that software. Recently, having changed my PC to a 64-bit Intel i5-4960K processor running Windows 7, I did not have any problems handling the 10MSPS IQ rate. I did also try running Airspy on my old 32-bit Intel Q8300 based system but it did struggle. After a couple of exchanges with Youssef, I overlocked the old PC by 15 per cent using its basic input/output system (BIOS) settings, which solved the problem. I also tried fitting a modern high-speed USB-2 PCI card to the old PC. This also provided enough speed increase to cope with the Airspy's 10MSPS rate without having to overclock the processor. If you do have any problems with stuttering audio, Youssef provides a handy set of measurement tools free that can be downloaded from the Airspy website.

<http://airspy.com>

These tools use the Airspy hardware to exercise your PC's USB and processor to see if it can cope. One of the best ways to ensure you have the maximum capacity available is to download the latest drivers for your USB ports. The manufacturers own drivers are usually superior to the generic Windows drivers, so it is worth trying. It is also worth experimenting with other USB ports on your PC and avoid using a USB hub.

Installing SDR# is very easy. I just followed the instructions on the SDR# website. One of the nice points about the software is that it is completely self-contained, so you can store it on any drive or directory you like and it does not mess with the Windows Registry. SDR# is also frequently updated, so it is worth topping up with the latest version. The version I used for the review was 1.0.0.1331.

The first task when operating SDR# was to select Airspy One as the source. The Airspy module includes a software control panel that is accessed by clicking the cogs symbol in SDR#. This opens a pop-up menu (Fig.3), where you can adjust various tuner gain and ADC

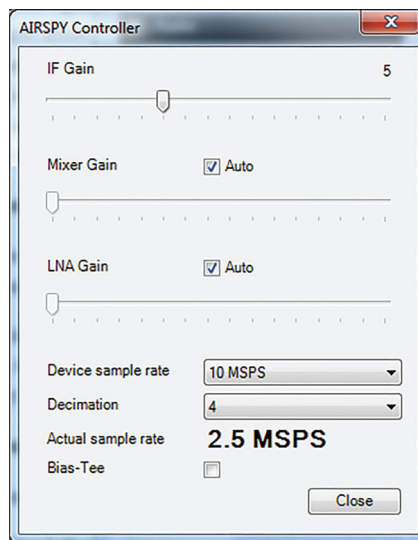


Fig. 3: The SDR# cogs pop-up allows you to control the Airspy hardware.

sample settings. The recommended start point was to set the IF gain to 5, Mixer gain to 10 and then manually adjust the LNA gain to put the noise floor at around -80dB on the scale.

The next adjustment was the Device sample rate and Decimation. If your PC can handle it, you will get a better signal to noise ratio (SNR) by sticking with 10MSPS. However, if your PC is struggling at that speed, then switch the sample rate to 2.5MSPS. As well as reducing the data rate to the USB port, the 2.5MSPS sample rate also changes the tuning bandwidth to just under 2.5MHz. Just below the Device sample rate adjustment is a Decimation control, which can be used to reduce the effective sample rate by powers of 2 between 2 and 64. This has a similar effect to the display zoom control because the tuning width reduces as you increase the decimation rate. If you select the 10MSPS sample rate and set the decimation to 8, the resulting sample rate becomes 1.25MSPS and the tuning range changes to just under 1.25MHz. You might be wondering why use this two-step process; why not just change the main sample rate? By maintaining the ADC sample rate at 10MSPS and decimating to the lower rate, Airspy can maintain the SNR advantage of the higher sample rate while providing a narrower tuning band. Decimating the 10MSPS sample rate also provides a reduction in quantization noise from the conversion process.

One of the great things about the 10MSPS sample rate is that you get to see just under 10MHz of spectrum on the display. This is extremely helpful for spotting activity, particularly on the VHF/

UHF bands where transmissions are often very brief. With the excellent combined spectrum and waterfall display of SDR#, you can spot a transmission by the vertical blip on the spectrum and then use the corresponding vertical line on the waterfall to double click and tune in ready for the next transmission (Fig. 4).

With the full 10MHz bandwidth displayed, accurate point and click tuning was quite difficult. However, I found that if I clicked close to the required signal, I could then set the decimation to 64 to get in close and complete the tuning. An alternative technique was to use the SDR# Zoom control. However, to use this technique you need to change the display fast Fourier transform (FFT) from its default setting of 4096 and increase it to 32768 or higher. You have to be careful with this setting because too high a value will smear the waterfall display. As I explained earlier, for best signal to noise performance you should leave the device sample rate set at 10MSPS because this provides a 6dB signal to noise ratio improvement over the 2.5MSPS rate, which is always useful. To demonstrate the difference, I made an audio recording of a local air traffic information broadcast. You can access the recording via the link below. The recording provides 10 seconds at 10MSPS followed by 10 seconds at 2.5MSPS. This sequence is repeated until the end of the recording. As you will hear, the 10MSPS setting provides a very obvious improvement.

<http://goo.gl/hsyPSp>

The performance of the Airspy was very impressive on the VHF and UHF bands and the SDR# software made tuning around and searching for activity very straightforward. In addition to being good for general purpose VHF/UHF listening, the Airspy did very well on the FM broadcast band. The sensitivity was excellent and the stereo sound quality was also very good. I use a Cambridge Audio DAC (DACMagic XS) for Hi-Fi listening and this worked extremely well with SDR#.

The Airspy appeared to handle strong signals very well on VHF because I have a couple of local paging transmitters a couple of miles away and they can cause havoc with some receivers.

When tuning around, I usually started with the sample rate set to 10MSPS and no decimation because this provided the widest spectrum view. When I spotted some activity I wanted to monitor, I used the decimation setting to narrow the tuning

range and complete the tuning. To get the very best results, I experimented with the gain settings to give the best signal to noise ratio. I found that as I increased the LNA gain, it would reach a point where the signal level stopped increasing but the noise continued to rise. The sweet spot was just prior to that changeover. An alternative gain adjustment technique was to leave the mixer and LNA gains on Auto and adjust the IF gain for best results. In general this worked well. However, if you have lots of strong signals around, you need to back off the LNA to avoid front-end overload.

I do not have the facilities to measure the technical performance in depth. However, **Leif Asbrink SM5BSZ** undertook some very detailed comparisons that show the Airspy is a very capable receiver. For more information, see Lief's post on the RTL-SDR.COM website titled, *Comparison of several SDRs on degradation from nearby strong signals at broadcast FM frequencies*. <http://goo.gl/HjZlfi>

HF Reception

Because I had an Opendous upconverter to hand; I also tried the Airspy on HF. The 10MHz tuning bandwidth was very useful for checking band conditions because I could very quickly gauge the entire segment from LF to 30MHz. The upconverter has an insertion loss of 10dB, which is no bad thing because it helps to tame some of the very high signal levels that can appear on the lower HF bands in the evenings.

As with VHF/UHF monitoring, the best results were obtained by experimenting with the Airspy's gain control settings. During testing on HF, the Airspy compared favourably with a Yaesu FT-897 and the new Elad FDM-DUO.

You might have seen that there is soon to be a matching HF upconverter called the Spyverter. At the time of writing, this is in final development, so it should be on the market soon. I have not seen any details but I will report back as soon as I can get my hands on one to test.

Other Software

In addition to working with SDR#, a number of other SDR software packages have been updated to support Airspy. These include SDR-Console, HDSDR (via extIO) and Studio 1 (via extIO). For more details on Airspy developments, it is worth looking at their user forum, which can be accessed via the Airspy website.

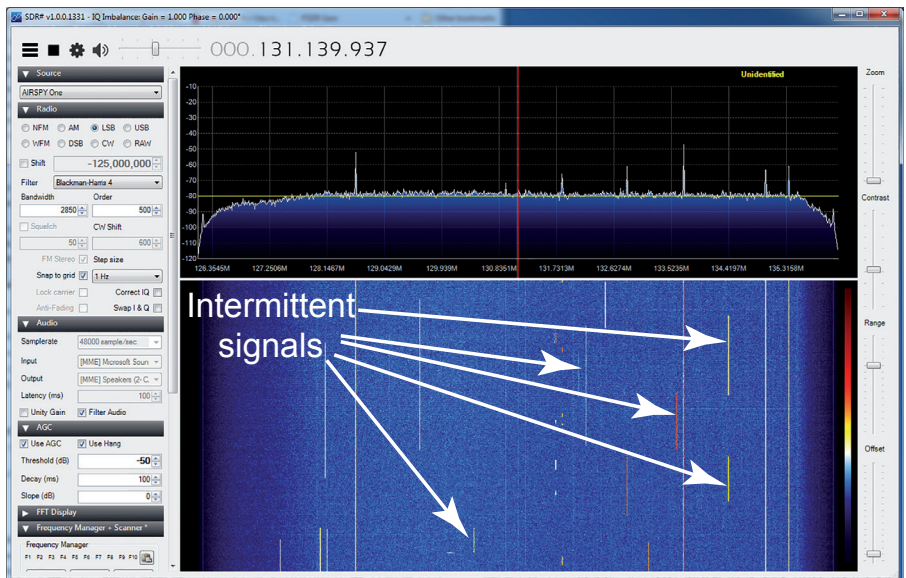


Fig. 4: Using SDR# to spot intermittent transmissions.

Airspy Specification

- Continuous coverage from 24MHz to 1.8GHz with no gaps
- 3.5 dB NF between 42MHz and 1.002GHz
- Tracking RF filters
- 35dBm third-order intercept point (IIP3) RF front-end
- 12-bit ADC at 20MSPS (80dB dynamic range, 64dB SNR and 10.4 effective number of bits)
- Up to 80MSPS for custom applications
- Cortex-M4F at up to 204MHz with multi-core support (dual M0)
- 1.5ppm high precision, low phase noise clock
- Real-time clock (RTC) for packet time-stamping
- External clock input (10 to 100MHz via MCX connector) – ideal for phase-coherent receivers
- 10MHz panoramic spectrum view with 9MHz alias/image free
- IQ or Real, 16-bit fixed or 32-bit float output streams
- No IQ imbalance, DC offset or 1/f noise at the centre
- 16 x SGPIO extension ports
- 1 x RF Input (SMA)
- 1 x RF Output (Loop through, U-FL)
- 2 x High speed ADC inputs (up to 80MSPS, U-FL)
- 4.5V software switched bias tee to power LNAs and up/down-converters

summary

The Airspy is a very welcome new SDR receiver that is backed with a host of advanced features. The combination of the 10MSPS sample rate and a 12-bit ADC makes the Airspy a particularly attractive proposition. Even if you do not have a fast enough PC for the 10MSPS rate, the 2.5MSPS setting still provides very good performance and a 2.5MHz tuning band, which is more than most SDR receivers.

The Airspy combined with SDR# gives you an immensely powerful receive system at your fingertips at a very attractive price. It is available via the Airspy website and, at the time of writing, the Airspy cost \$199.00 on pre-order.

<http://airspy.com>

My thanks to Airspy for the loan of the review model.