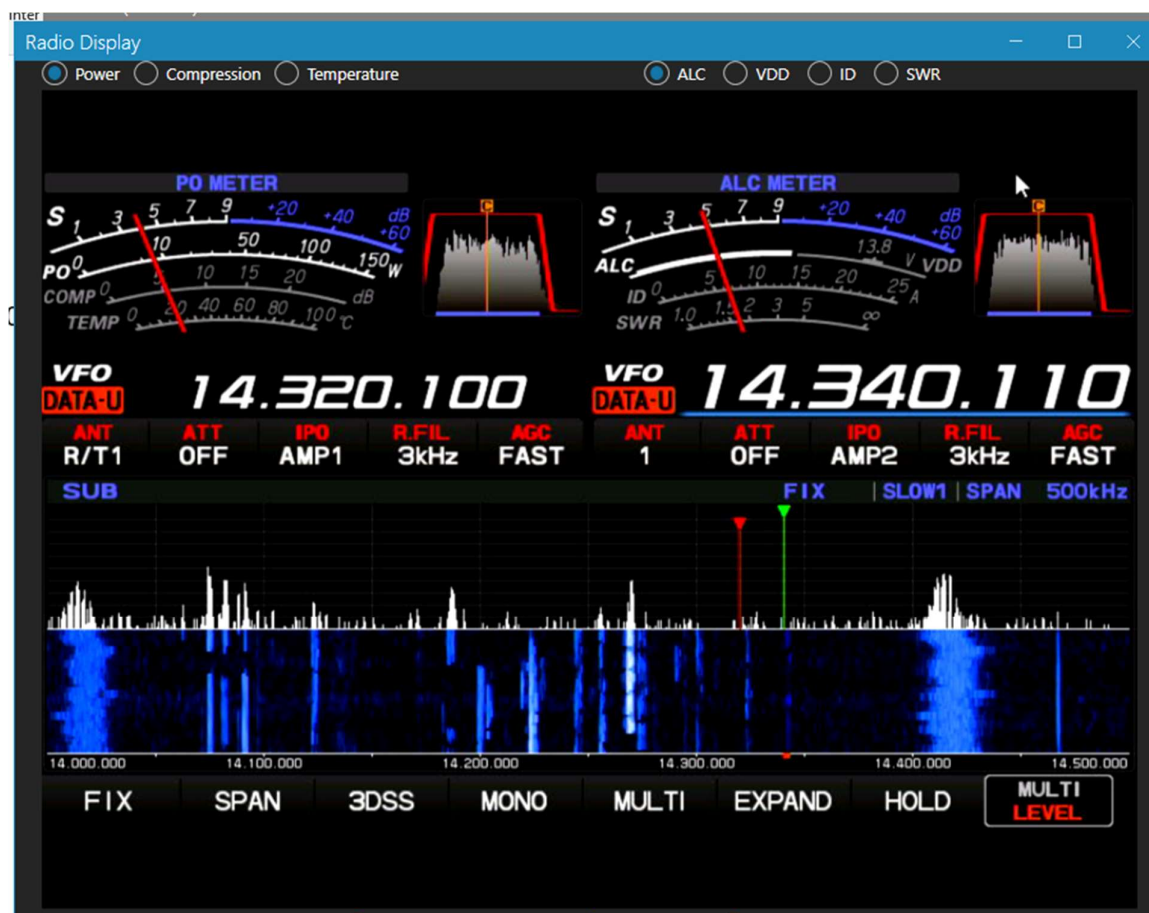


# Diversity Reception with an RSPDuo and FTdx101D

## Introduction

The FTdx101 series of radios has some excellent tools built-in to combat interference, but many modern hams living in urban environments are faced with massive levels of QRN generated by thousands of cheap switch mode PSUs driving LED lighting and a multitude of other domestic appliances plus noise from VDSL internet services and solar panel installations. A screen capture from my FTdx101D illustrates the problem about twenty miles north of London :

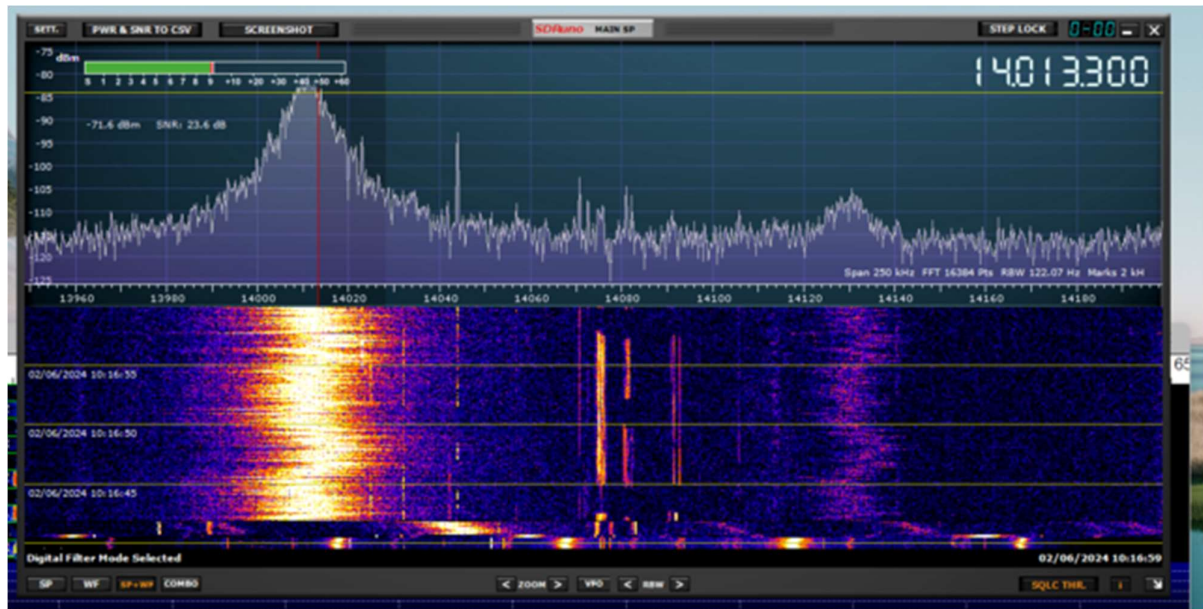


The noise peaks at just above 14MHz and 14.4MHz are present continually. They are repeated every 400kHz up the band to 6m – and probably beyond. The FTdx101D's filtering and noise reduction can do nothing about them.

Following research on the internet, I decided to try out diversity reception. There were several sources that indicated that it was likely to make a useful difference, but there was little definitive information and the instructions for setting it up were not particularly detailed. The cost of implementation was non-trivial and I was concerned that I might have been about to waste my

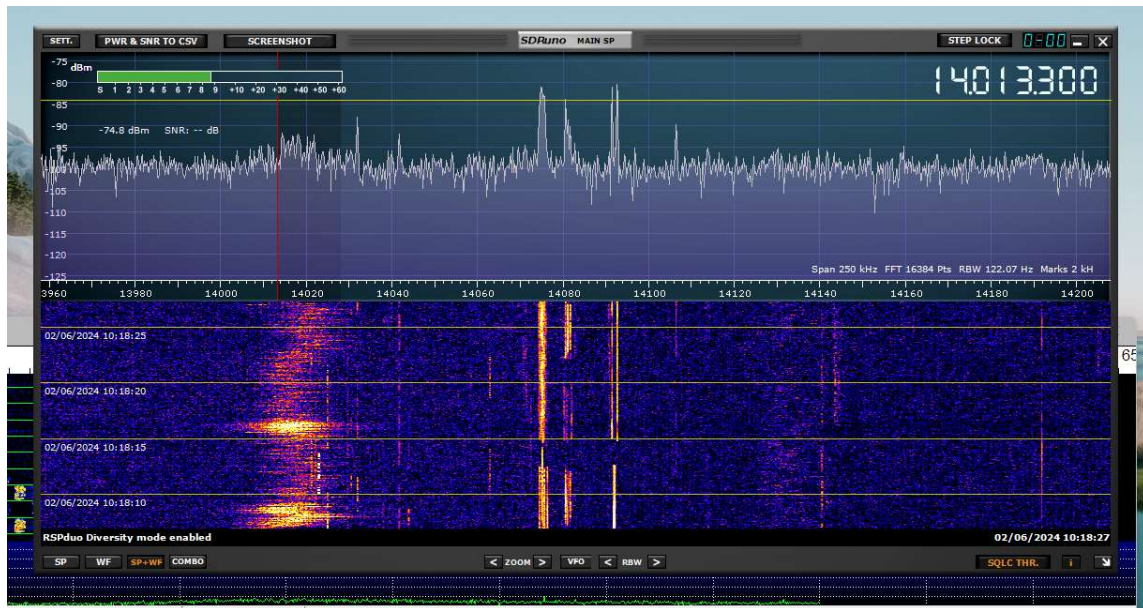
money. The result has been very successful from my point of view and I'm writing this in order to help others decide whether or not it is appropriate for them.

Let's start by looking in more detail at the results I've achieved here. If they spark your interest, then read on to understand how to reproduce my solution. The following screen capture shows the situation at my QTH in more detail:



This is a capture from the SDR Uno application running on the shack PC connected to an SDRPlay RSPDuo receiver running in Single Tuner mode. The SDR Uno spectrum display is accurately calibrated and you can see that the QRN peak reads in excess of S9 (that is the yellow line across the spectrum display) and pretty much wipes out more than 40kHz of bandwidth centred around 14.010MHz. There's another lesser band of QRM centred around 14.130MHz and, out of range of this screen capture, the pattern is repeated all the way up past 30MHz with large peaks around 400kHz apart.

The following capture shows what is possible with diversity reception following a bit of configuration:



The noise peak at 14.010MHz is dramatically reduced and the lesser one around 14.130MHz is almost gone – but the FT8 signals at 14.074 and 14.080 MHz are not reduced to any noticeable extent. You can see a CW signal at significant strength around 14.025MHz which would have been buried under the QRN in the first screen shot. Now, for diversity to work, it is necessary that the noise has a small number (preferably just one) source. If you look at the shape of my QRN in the waterfalls above, it is obvious that it is coordinated and from a single source – the frequency drifts around in a fairly predictable manner and the various bands of QRN on the waterfall mirror each other quite closely. My QRN is a good candidate for diversity reception. If you don't already have all the necessary equipment, take a long look at your local QRN on the 101's waterfall and try to satisfy yourself that you are also a good candidate before you lay out upwards of £300 on equipment.

## Requirements

So, what do you need to set this up? Well, the most fundamental requirement, other than a decent PC, is a dual tuner SDR. Unfortunately, this really does have to be a single SDR with two tuners – two single tuner SDRs will not hack it. The obvious choice is an SDRPlay RSPDuo – this is a well-built, high performance device that sells for around £240 (2024 prices). None of the other SDRPlay devices and none of the other USB SDR “dongles” on the market at the moment are suitable. High-end SDR transceivers like the Flex devices may be able to do it, but not with the software I’m describing here. Dual receiver transceivers like the FTdx101 and IC7610 make some attempt at diversity, but without the levels of control necessary to achieve the results shown above.

In addition to the SDR, you are going to need two antennae. Diversity reception is totally dependent on combining the signals from two different antennae with complex signal processing to selectively delete the QRN without impacting on the signals that you actually want to hear. A single antenna will quite simply not cut it. Your two antennae need to be selected to meet the needs of diversity reception – they need to be sufficiently different and sufficiently far apart that they will receive a significantly different view of the RF environment, but they need to be sufficiently similar in their gains for the SDR software to be able to match their outputs and null out the QRN. Your antennae do not need to be anything particularly exotic – look at what you have available and look at the capabilities of the FTdx101 and use it to its full capabilities. In my case – and the results above are generated from this – I use a simple doublet antenna that is resonant on 20m (more or less) and an

active loop receiving antenna from Cross Country Wireless. The loop is about 1m diameter and mounted at the end of my garden just a few feet above the ground. Obviously, there would be a big discrepancy in gain between these two, but the low noise amplifier at the feedpoint of the loop makes up for a lot of that discrepancy and the amplifiers in the FTdx101 complete the job.

You will also need to protect the SDR from the high RF fields generated by the transceiver when you transmit. This is one of the ways in which the FTdx101 really shines at diversity – it has excellent antenna management and support for an external receiver. If you try to apply this solution to a different transceiver, you will almost certainly have to spend more money on external T/R switches like the MFJ-1708.

You will also need a suitable SDR application to run on your shack PC. While there are many SDR applications around, I'm only aware of two that implement diversity reception – SDR Uno and SDR Connect, both from SDRPlay. SDR Uno has been their flagship for many years. It's a mature application and very functional, but its user interface is very non-standard – like Marmite, you'll either love it or hate it. SDR Connect is a new application – the current version (June 2024) is still described as a beta release. It is already a very functional application, but it is missing a few features that are pretty critical to use in a ham radio context. SDRPlay are promising to address these issues in the future and it seems likely that SDR Connect will become the application of choice, but the development process has been very slow and I'm not optimistic that it will be ready for us before 2025. Note that SDR Uno is a strictly Windows program and attempts to run it under the various Windows emulation layers on Linux or MacOS have not been met with much success. SDR Connect is a multi-platform application and, reportedly, runs well on all three major OSes.

While you are using diversity reception, the audio you listen to will be coming from your PC, not the FTdx101. Some PCs include excellent sound systems, some have little more than a basic beeper. You must make sure that your PC is capable of outputting an audio signal that is adequate for long-term operation – you may need to install an additional sound card and/or connect an external amplifier and speakers. With the move towards digital streaming of entertainment, there is a lot of perfectly serviceable HiFi equipment no longer in use – I rescued an redundant Sony AV amplifier and a pair of Kef bookshelf speakers and they have been doing excellent service.

Finally, by the time you get this all configured, you are going to have a lot of audio sources. If you are only interested in CW and telephony, then you probably don't need to worry about this final component but if you are also going to operate digital modes like FT8, you are going to have to address the signal routing problem. Add in a selection of applications such as WSJT-X, FLDigi and JS8Call, and you may have a lot of signal routing to do. Diversity reception can work wonders eliminating QRN, but it is certainly not a “click-and-forget” solution. The diversity parameters need frequent adjustment to meet changing local conditions and longer-range propagation conditions. You certainly could just turn it on and leave it on, but that will be a real pain on the bands where you are not plagued by QRN. You will have a significantly better operating experience if you configure your system to permit rapid repatching of the various audio paths. I strongly recommend that you include two audio applications – Voicemeeter and VB Matrix in your configuration. These are both products of VB Audio (<https://vb-audio.com/>) and are very good value for money. They are sold as “Donationware” meaning that you effectively pay what you think they are worth to you! You will also need some “virtual audio cables” to interconnect the various applications. VB-Audio offers solutions that are built into Voicemeeter and VB-Matrix as well as a stand-alone version. If you decide to not go with Voicemeeter, then VAC is a perfectly good solution (<https://vac.muzychenko.net/>), but it is not free.



## Installation and initial configuration

In terms of the physical setup, connect your antennae to the sockets on the back of the FTdx101 and link the inputs of the RSPDuo to the two RX Out sockets also on the back. To do this, you'll need two SMA to RCA cables – not a combination that is commonly sold, so you'll probably need to get the soldering iron out. There are usually some minor differences in sensitivity between the Tuner 1 and Tuner 2 inputs on the RSPDuo and the standard instructions for configuring diversity reception include provision for physically swapping the antennae between the two inputs in order to find the best match between antenna gain and tuner sensitivity. In this context, we'll be making use of the antenna switching in the FTdx101 to route antennae, so we will not need to move cables – just connect tuner 1 to the RX Out of Main and tuner 2 to the RX Out of Sub. Diversity reception depends on receiving and processing a wide RF bandwidth, so don't use the IF Outputs of the FTdx101 – the signals there are too highly processed and filtered to be of any use to us.

The software installation and configuration has the potential to become extremely complex – start simple, then build towards the full solution. Install your chosen SDR application on the PC. As of summer 2024, this really has to be SDR Uno, but monitor progress on SDR Connect – it could become the application of choice in the future. Connect your RSPDuo, power on the FTdx101, start SDR Uno and go through the setup procedures described in the manual – initially in single tuner mode. Audio routing can be a complex subject – even if you do intent to use Voicemeeter in the full solution, route the audio from SDR Uno directly to the PC speakers for the initial configuration.

At this point, you should be able to power up the FTdx101, start SDR Uno, set both Main and Sub on the FTdx101 to the same band and see something like this:

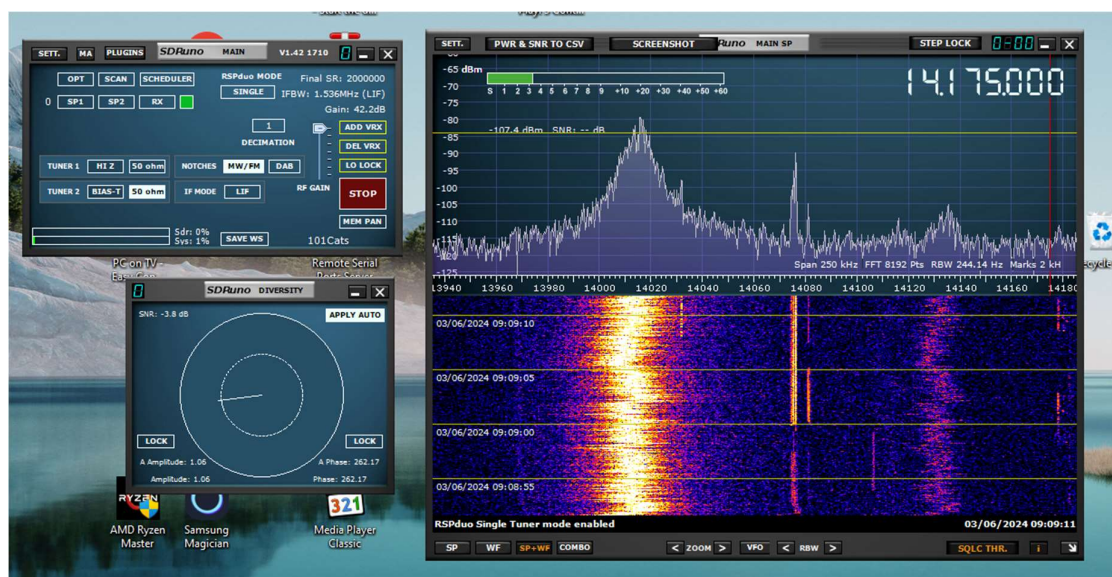


You should be able to tune to a signal by pointing to it and clicking in the waterfall and you should be able to hear it through the PC speakers. Choose one of your two antennae for Main on the FTdx101 and the other for Sub. Check that the RSP Duo can see both by switching between Tuner 1 (50 ohm) and Tuner 2 (50 ohm) in the SDR Uno Main window:

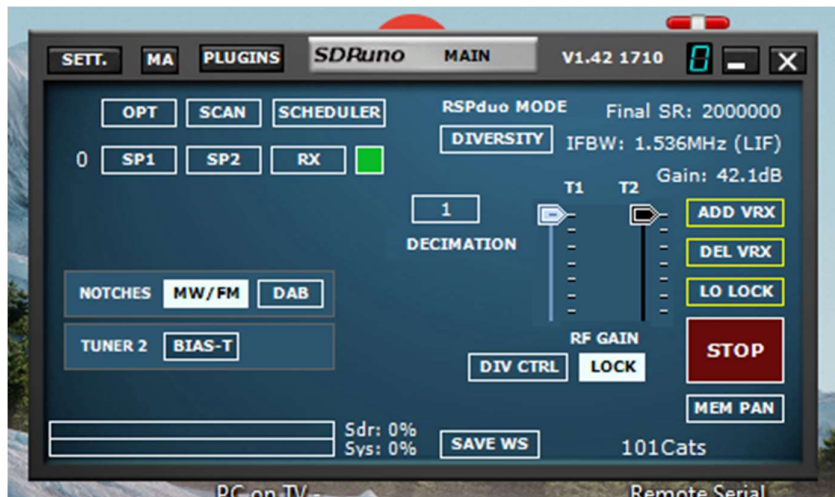


You need both tuners to see similar signal levels from their respective inputs. This can be a problem when the antennae are connected directly to the RSP Duo, but in our context, we have the FTdx101 to help us balance up the inputs. The RF Gain control will not do anything – the RX outputs are taken from an earlier point in the receiver chain – but the IPO and attenuator settings will adjust the signal level on the outputs. Experiment to ensure that you can find settings which will produce reasonably equal signal levels into SDR Uno for both tuners.

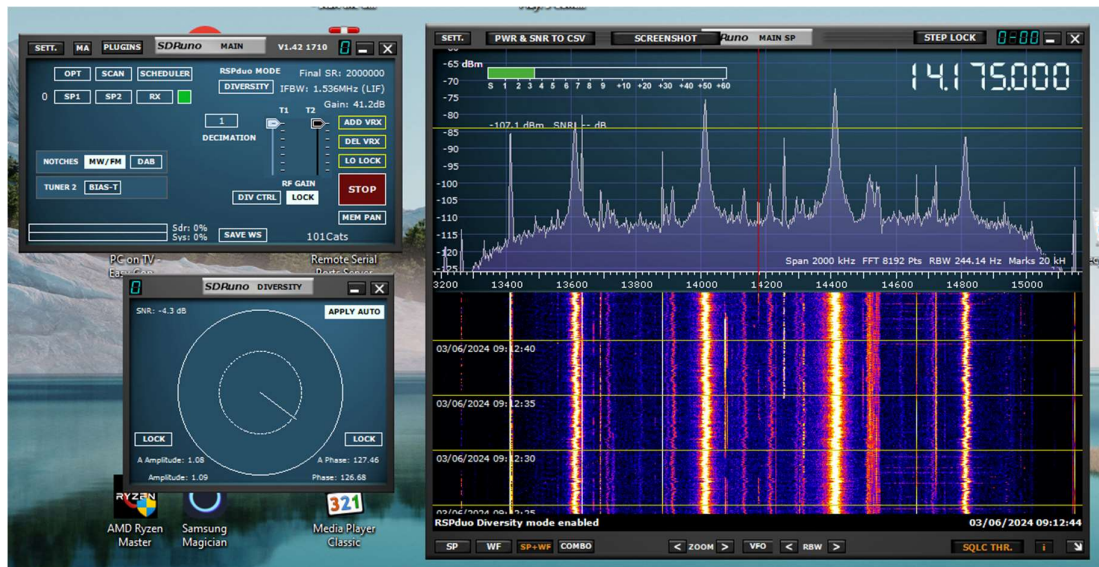
Now, try diversity reception. Select a band and frequency which demonstrates a significant QRN level :



Enable diversity reception by setting the “RSPduo MODE” in the SDR Uno main window :

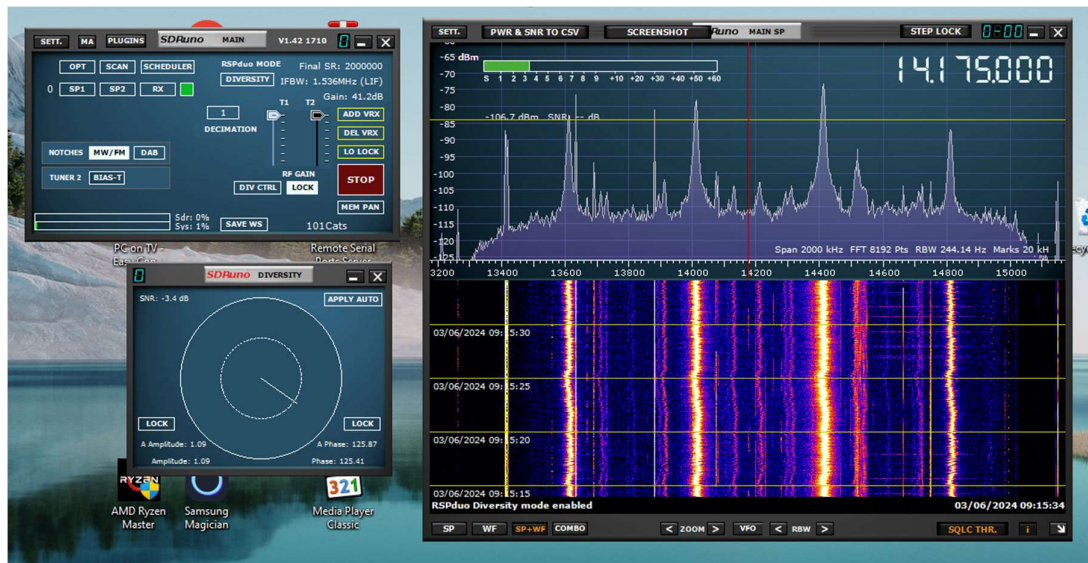


And make sure that you can see both the Diversity control panel and the spectrum at the same time :

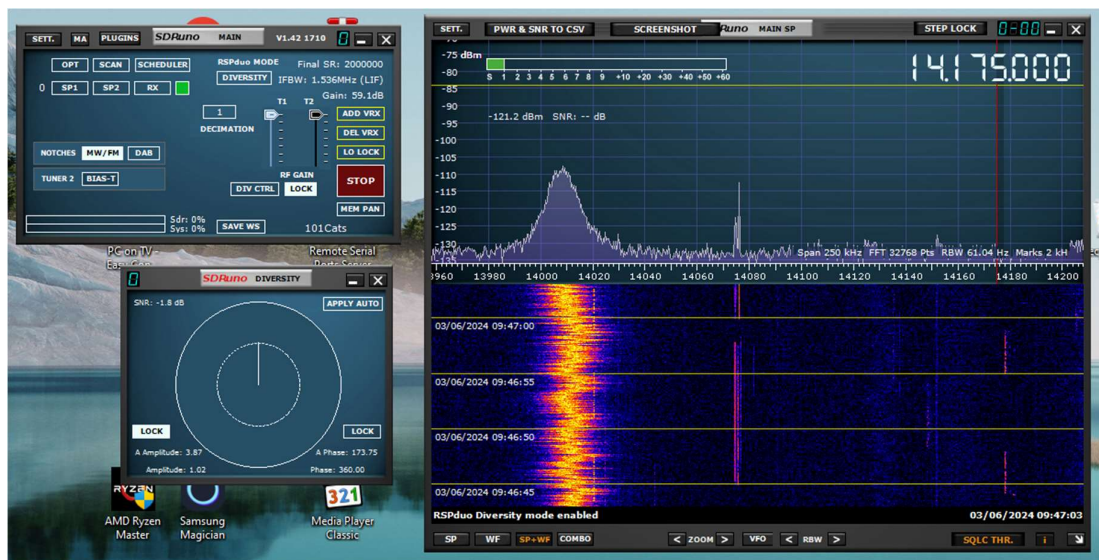


The “Auto Apply” function in SDR Uno is designed to maximise received signal strength to combat fading, not to remove QRN. By all means try it, but don’t expect it to magically delete your QRN. Instead, turn it off and drive it manually :



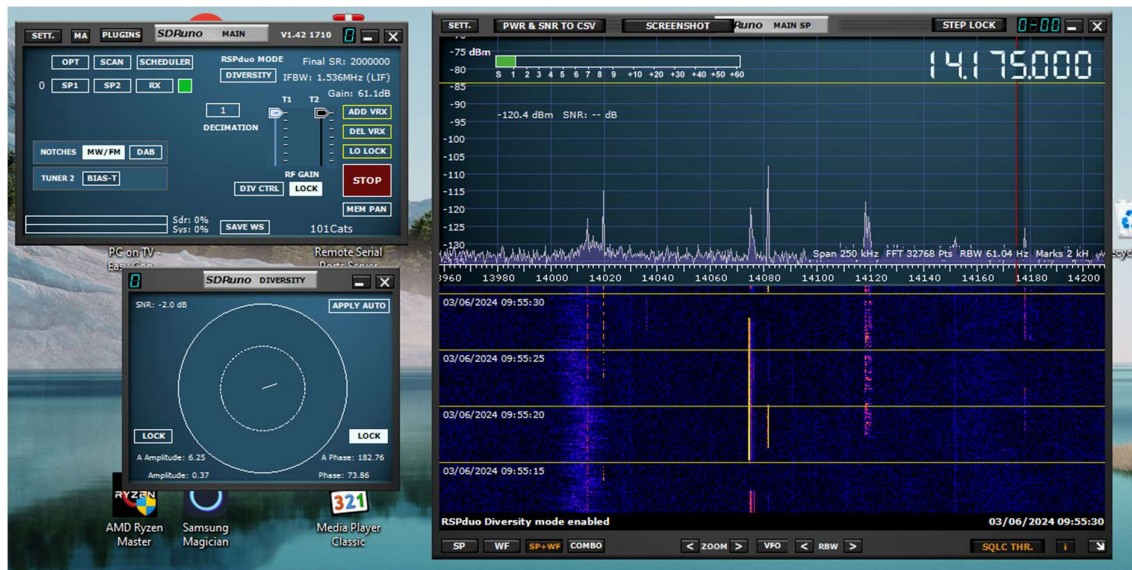


Point with your mouse into the outer circle in the Diversity window, press the left button and drag the straight line around while watching the waterfall and spectrum window. The length of the line indicates the relative signal strength between the two antennae in the mix and the angle indicates the phase shift introduced. The two “LOCK” buttons allow you to lock either the amplitude or phase shift – they are important, at least until you’ve got the hang of it. Search around a bit, just to get a feel for it, then make the search more methodical. Point to the 12 o/c point on the inner circle and click to set the end of the line, then lock the amplitude component :



Drag the line round the clock while watching the waterfall and spectrum display. Hopefully, you will see at least a small fluctuation in the strength of the QRN. Choose the angle that seems to reduce it most noticeably. Lock the phase there and unlock the amplitude, increase or reduce the length of the line and try to further reduce the QRN – hopefully, you’ll be able to reduce it significantly :





This is likely to be an iterative process – while you are learning, it can be frustrating, but you will soon get a feel for it and be able to zoom in on a solution quite quickly. If you find that spinning the phase dial has no noticeable effect, unlock the amplitude and move it in or out a bit before relocking and spinning the phase again. If you find that the noise minimum is either with the line at zero length or at maximum length, then this is an indication that the signal level balance between your two antennae is too poor for the software to find a solution – experiment with increasing or reducing the gain on either or both antennae or by swapping them over. This is a difficult task without the FTdx101 present, but routing the signals to the RSP Duo via the 101 makes it much easier – simply reverse the antenna selections between Main and Sub or adjust the relative gains with the IPO and attenuator settings.

The best settings for amplitude and phase are not fixed – they may wander about over time as local conditions change and global propagation conditions change. You are not necessarily searching for the lowest QRN level – in general, we are more interested in the overall signal to noise ratio. Diversity adjustments can also steer the effective radiation pattern of your compound antenna and you may find settings that do not reduce the QRN so much, but boost the strength of the signal of interest more. Use them, if necessary, rather than spending a long time looking for a completely noise free waterfall.

## Audio Routing and management

To follow!