EMC Advice Leaflet EMC 17
Identifying VDSL interference using Lelantos

Introduction

VDSL (Very-high-bit-rate Digital Subscriber Line) is the pre-eminent means used to deliver broadband internet services to millions of residential and business customers in the UK. VDSL uses spectrum up to 17.664MHz and because it is carried over unscreened, twisted-pair, subscriber lines, originally designed just to carry telephone speech up to 3.4kHz, it widely leaks out, causing interference across the amateur radio HF bands up to and including 20m.

VDSL uses spread spectrum digital coding and is therefore very difficult to positively identify, since on an HF receiver it appears as wideband background noise with no easily discernible characteristics. For this reason, a software tool called Lelantos has been developed which can positively identify VDSL interference, even in the presence of other interfering signals.

This leaflet describes how to use a Software Defined Radio (SDR) HF receiver and the Lelantos software running on a Windows PC to identify the presence of VDSL interference in the HF spectrum.[1]

Identifying VDSL interference using Lelantos software

Lelantos is a software application that has been developed by Dr Martin Sach G8KDF, a member of the RSGB EMC Committee. It uses sophisticated digital processing to identify the VDSL Cyclic Extension waveform, a signal unique to VDSL, to positively identify whether or not VDSL interference is present in a sample radio spectrum recording.

Lelantos is a stand-alone Windows application which can be downloaded here.

On the download page are the Lelantos executable file, a detailed Lelantos Instruction Manual and two example recordings that can be used to test the application once it has been installed. It is recommended that you read the manual before proceeding further.

To use Lelantos, a short recording of the HF spectrum in which VDSL interference is suspected, is made in standard I/Q format and is then uploaded to the Lelantos application. The recording can be made using virtually any SDR receiver. The Lelantos application then searches within this recording for the VDSL Cyclic Extension waveform to positively identify whether or not VDSL interference is present. Further details of how Lelantos works can be found in the Instruction Manual and in an article in the November 2018 edition of RadCom, page 28 onwards.

To install and use Lelantos

Download the Lelantos application (the current version is Lelantos119-Setup.exe) and the Instruction Manual (current version Lelantos119 Manual.docx) to a suitable folder on a Windows PC.

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[1] For those without an SDR receiver and / or a Windows PC, an alternative means to identify VDSL interference can be found at the end of this leaflet.

Install Lelantos by double-clicking on the application, then click Install on the screen shown in figure 1. During the install process you may need to answer "Yes" to the question "*Do you want to install this app from an unknown publisher to make changes to your system?*".

By default, Lelantos will install shortcuts to the start menu and on the desktop.

Figure 1. Lelantos Install screen

Making a suitable I/Q format file recording

Before running Lelantos, you need to make a raw RF recording in standard I/Q format using an SDR receiver. This recording is of the radio spectrum that you believe may contain VDSL interference. Most SDRs can be used to make this type of recording.

The recording must have a minimum bandwidth of 192kHz of spectrum, although much wider bandwidths can be used, at the expense of creating a larger wav file. In practice most SDRs will allow bandwidth recordings up to many MHz wide. We recommend making a recording of around 2MHz of bandwidth. Higher bandwidths can be used but will create larger files and will not make a significant improvement to the detection of VDSL by the software.

Note that a raw RF recording is needed in standard I/Q format, and that audio recordings cannot be used.

If you want to be able to observe the size of any changes in the background noise around the VDSL guard bands then the recording spectrum should be centred on one of the guard bands. The most suitable guard bands are at 3.75MHz, 5.2MHz, 8.5MHz and 12MHz. Alternately, if you suspect you are suffering from VDSL interference on a particular amateur band then you could centre your recording on that particular band. Any amateur band between 160m and 20m could be affected by VDSL interference. Identifying interference in one or more of the primary amateur bands [2] is important because these are the bands that we can legitimately complain to Ofcom about loss of service.

The recording needs to be only about a half second long, irrespective of the bandwidth. A half second long recording of 2MHz wide spectrum will create a wav file with a size of around 4 Mbyte. Increasing either the length of the recording or the bandwidth recording will lead to larger files.

Making the recording using an SDRplay RSP1A receiver with SDR Uno software
As an example, here are the instructions for making the necessary recording using an RSP1A receiver. Connect the RSP1A receiver to the main station antenna and to your PC and run the SDR Uno software.[3] Full details of how to do this can be found on the SDRplay website at www.sdrplay.com.

Launch the SDRuno software. On the main console, click "Play!" to start the software running. See Figure 2.

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[2] The bands in which amateur radio has primary status and which are potentially susceptible to VDSL interference are 160m, 80m, 40m and 20m (1.8MHz, 3.5MHz, 7MHz and 14MHz)

[3] The examples here use the SDR Uno software version 1.42

Figure 2. SDRuno Main Console

Then set the IF mode to "ZIF" (Zero Intermediate Frequency) and the display bandwidth SR (MHz) to 2.0 in order to display 2MHz of spectrum. (see Figure 3)

Figure 3. Bandwidth setting on SDRuno Main Console

On the RX Control console set the main VFO to your chosen centre frequency e.g. 8.5MHz, as shown in Figure 4.

Figure 4. Main VFO setting in the RX Control console

Then back on the main console, adjust the RF Gain control to maximise the receiver signals relative to the background noise as seen on the spectrum display on the main SP console. See Figure 5.
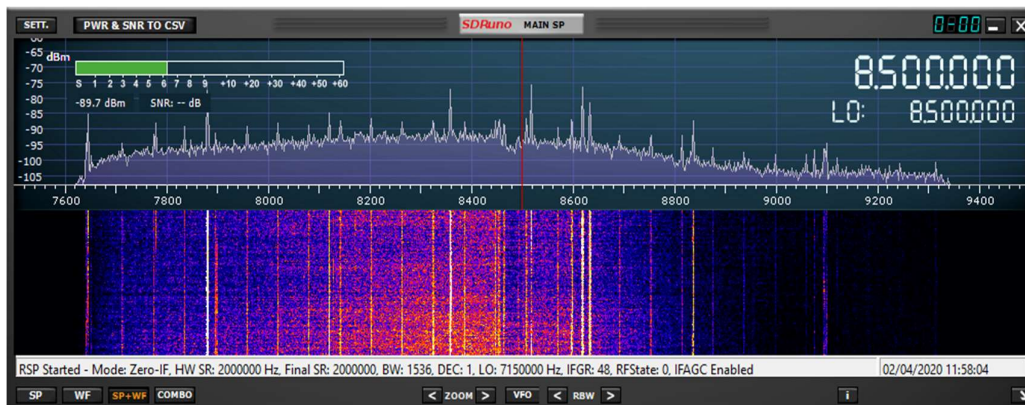

Figure 5. Main SP console showing spectrum and waterfall display

For the purpose of making the recording, you can ignore all the other settings (e.g. mode, noise blanking, squelch, AGC etc.) since these all occur after the raw IQ output.

To make the recording, open the recorder by clicking "Scheduler" on the Main Console. This will open the screen shown in Figure 6.

Figure 6. Scheduler Console

Click on the "Rec. Folder" button and select an appropriate folder where the recording will be saved. Then click record (the red button with a white centre circle), wait for at least 0.5 seconds then click stop (the button with a white square centre). This will record the file and save it in the chosen folder. During the recording, the panel will display the size of the file being created.

The recorded file has a file name in the format SDRuno_DDDDDDDD_TTTTTTZ_FFFFkHz.wav where DDDDDDDD is the date, TTTTTT is the time and FFFF is the centre frequency of the recording. This file is now suitable for use with the Lelantos software.

A similar process will be required to make the necessary recording with other types of SDR receiver.

Running Lelantos with the recorded spectrum file
Once a recording has been made, open and run Lelantos, for example by clicking on the desktop icon.

When Lelantos launches, it starts with a menu bar with a large blank grey area below, as shown in Figure 7.

Figure 7. Lelantos opening screen

On Lelantos, go to File – Open, then point at the saved spectrum wav file and click "Open".

After a few seconds of processing time, Lelantos should produce four graphs showing its analysis of the wav file. An example display of the four graphs is shown in Figure 8 (here an 8MHz bandwidth has been used).
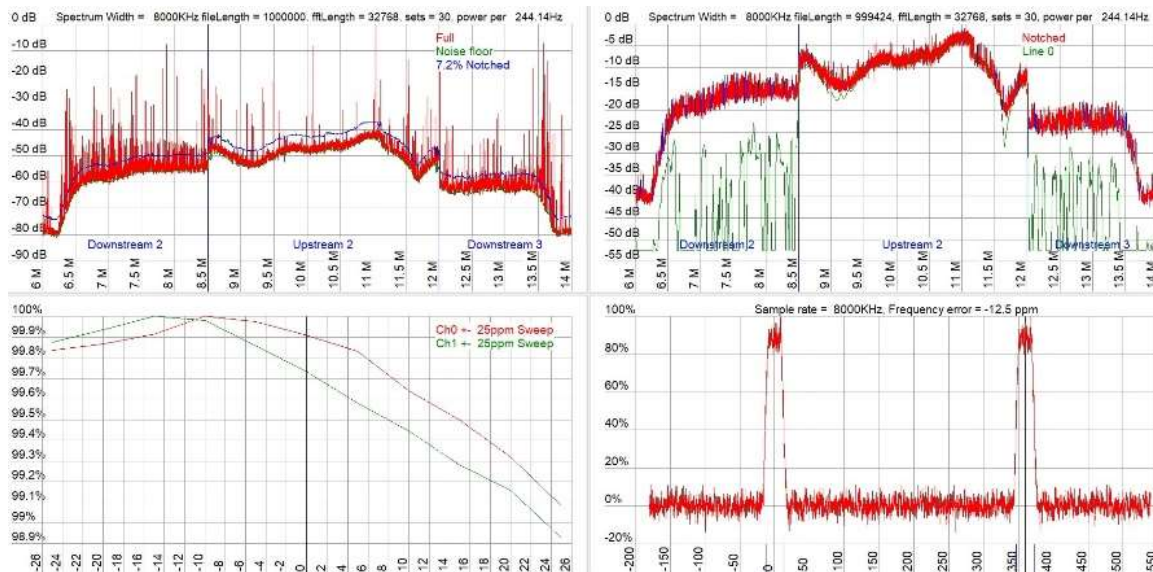
Figure 8. Typical Lelantos screen display

The top 2 graphs show the spectrum from the wav file. In the example in Figure 8 the spectrum is centred on 10MHz and the SDR's filtering rolls the spectrum off at each end. The top left graph shows in red the spectrum of the wav file.

There are several upward red spikes on the top left graph which are narrow band signals such as individual radio signals. The top right graph shows the same spectrum with these narrow band signals suppressed.

Now look at the bottom right graph on the Lelantos display. If VDSL interference is present it will show the timing of the VDSL Cyclic Extension symbols being detected.
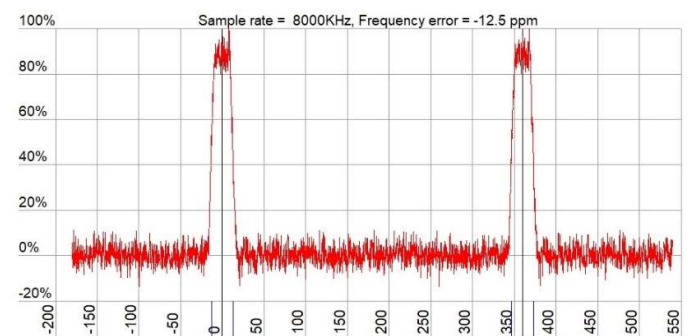

Figure 9. Lower right graph on Lelantos showing detection of VDSL timing signals

Figure 9 shows the lower right graph with Lelantos detecting VDSL timing signals proving the presence of VDSL interference in the spectrum recording. The X-axis on this graph is in degrees, with 360 degrees representing one symbol time in the VDSL signal.

If there is no VDSL interference present in the spectrum recording, then the bottom right graph on the Lelantos display will show only random noise, with no discernible symbol pattern. An example of this is shown in Figure 10.
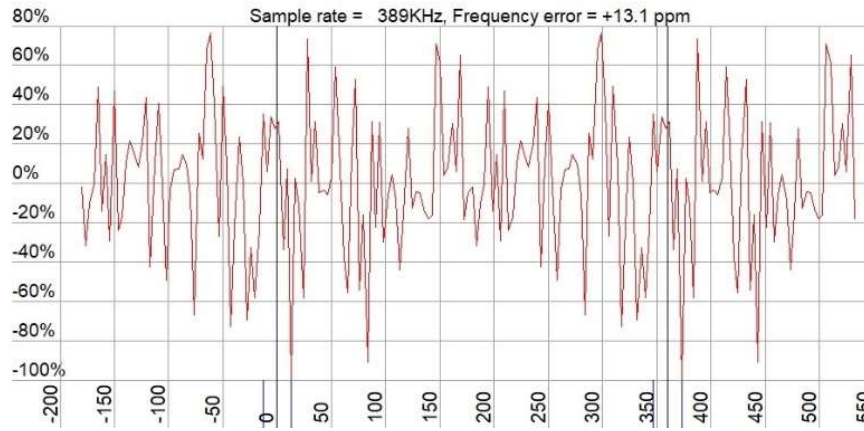

Figure 10. Lower right graph on the Lelantos screen display showing no VDSL interference present in the spectrum recording

For additional confirmation of the presence of VDSL interference, look at the top left graph on the Lelantos screen showing the radio spectrum. With VDSL interference present, it should be possible to see one or more of the VDSL guard bands. The positioning of these guard bands on the graph will depend upon the bandwidth that you record. If you cannot see any guard bands then this indicates that either VDSL interference is not present, or that it is below the background noise level. Nevertheless, Lelantos may still show the presence of VDSL interference in the bottom right graph.

If Lelantos detects interference from more than one VDSL system within the spectrum recording (for example from VDSL systems serving neighbouring houses) then the graph at the bottom right will show timing peaks for each system. Figure 11 shows Lelantos detecting at least 3 separate VDSL systems from within a single spectrum recording. Notice that the timing signals for the individual VDSL systems typically occur at different points in the overall frame, determined by the moment each VDSL
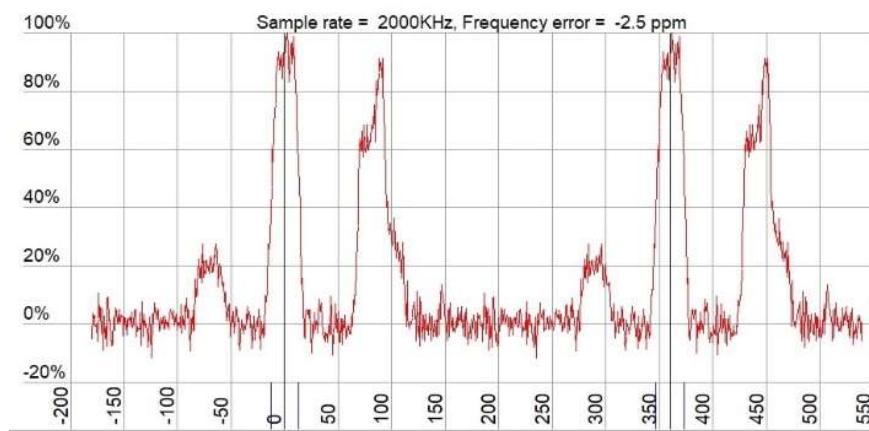

Figure 11. Lower right graph on the Lelantos screen display showing the presence of at least 3 individual VDSL systems within a single recording

system was started up. Once started, because the network uses timing signals derived from a national frequency standard, then the phase relationship between individual systems should remain constant over a long period of time.

Please see the Lelantos Instruction Manual for additional details about the meaning and interpretation of all the graphs displayed by the software.

Using Lelantos to estimate the level of VDSL interference
Lelantos can also be used to estimate the size of the step in the background noise level around the VDSL guard bands.

To do this make a 2MHz wide spectrum recording centred around one of the guard bands (e.g. at 3.75MHz, 5.2MHz, 8.5MHz or 12MHz)

Feed this recording into Lelantos as described above.

View the top right graph displayed by Lelantos.

Expand this graph either by using pan and zoom, or by right clicking and then selecting "View params" (i.e. View parameters) to open the box shown in Figure 12.

Make sure that the "Spectrum Centre MHz" setting is set to the centre of the guard band that you wish to examine.

Set the "Spectrum Width kHz" setting to 200 and click OK.

This will expand the graph to show the spectrum around the guard band. Figure 13 shows an example of a recording centred around the 12MHz VDSL guard band.

Figure 12. "View params" box

Figure 13. Expanded Lelantos spectrum display showing the 12MHz VDSL guard band

In the example in Figure 13, the VDSL upstream band is that part of the spectrum that is below (i.e. to the left of) the guard band, while the downstream band is spectrum above (i.e. to the right of) the guard band. The plot in Figure 13 shows that the interference caused by the upstream band is about

9dB above the background noise level (as seen in the guard band), while the interference from the downstream band is about 5dB above the background noise level.

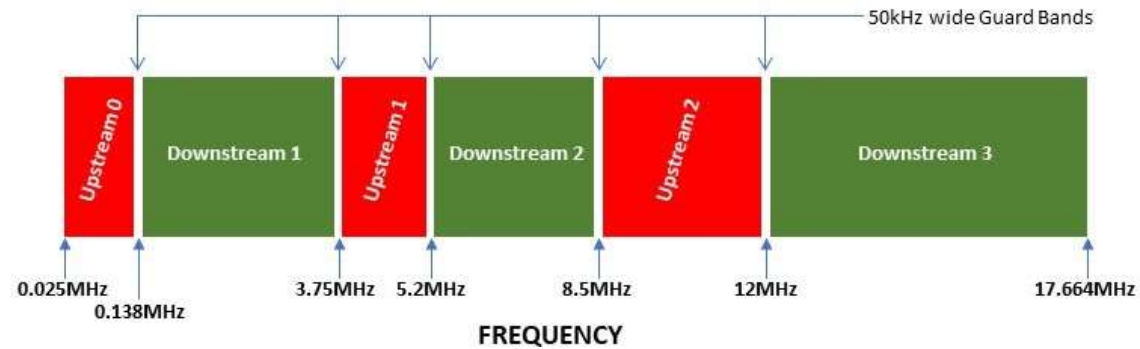For reference, the positioning of the VDSL upstream and downstream bands is shown in Figure 14.

Figure 14. VDSL spectrum showing the position of the upstream and downstream guard bands

Further information on Lelantos
For further information about Lelantos and how to use the software, including details of many additional features not described above, please see the Instruction Manual that is included on the download page.

An alternative way to identify VDSL interference
For anyone who does not have a suitable SDR receiver and / or a Windows PC, an alternative method to identify VDSL interference can be found in EMC leaflet 15. This describes how to search for the characteristic guard bands between the different upstream and downstream bands used by VDSL. EMC Leaflet 15 can be downloaded from here.

Conclusion
Using an SDR receiver and the Lelantos software will allow the positive identification of whether VDSL interference is present or not in a sample recording of HF spectrum, along with allowing an estimate to be made of the level of interference being experienced.

For those who are experiencing VDSL interference, leaflet EMC 15 (referenced above) contains a list of measures to help to reduce the effects of VDSL interference.