

How to observe and report Sudden Ionospheric Disturbances

Paul Hyde

Observing Sudden Ionospheric Disturbances is one of the easiest ways to observe astronomical phenomena in the radio part of the electromagnetic spectrum. The aerial is simple to build, you do not need any specialist receiving equipment and the software needed to analyse the data is freely downloadable from the internet. SIDs are the result of X-ray flares erupting on the Sun and releasing vast amounts of X-ray and Ultra Violet energy which drive up the ionisation levels in the Earth's ionosphere which, in turn, affects the strength of signals received from distant transmitters in the Very Low Frequency (VLF) part of the radio spectrum.

Building a SID detector is the subject of one of Sky at Night magazine's 'How to ...' articles and the following provides further information on a selection of low cost USB Sound Cards and how the Spectrum Lab software application can be used to observe and record SID events.

Using an external Sound Card

It is possible to use the Microphone input of a computer for observing SIDs. However there is a small risk that static electricity can be conducted into the computer and damage the sound card. An alternative option is to use a low-cost USB external sound card which can easily be replaced if there is a problem.



Fig 1

Four external sound cards were checked for suitability for monitoring SIDs. Their performance in handling ordinary audio signals was not checked. There's a variety of these devices available via the Internet and their performance (as well as pricing) can vary, even amongst devices that claim the same specification, so it is not possible to be sure that every card will be suitable.

- **Syba USB 2.0 Stereo Sound Card Adapter with Optical SPDIF Output SD-AUD20101**

Purchased from Novatek for £15.70 including post and packaging

www.amazon.com/Syba-External-Adapter-Optical-SD-AUD20101/dp/B006SF68P2

This card was the only one that supported a 96 kHz sampling rate, making it capable of receiving radio signals up to around 44 kHz in frequency. This adds the Icelandic transmitter at Grindavik (37.5 kHz) to the list of transmitters that can be observed, but this isn't critical as the Cutler transmitter in Maine, USA (24 kHz) was observable (though weak) with all of the external cards tested. As this is even further west, it extends the daylight hours during which SIDs can be observed. This device did not work with the 'active' USB extension cable, presumably because of the higher data rate from the 96 kHz sampling.

- **PC Laptop USB to Mic/Speaker & Headphone 7.1 Channel 3D Audio Sound Card Adapter**

This was purchased from PLUSBEE for £2.49 including post and packing and worked quite satisfactorily.

www.ebay.co.uk/itm/390883605864

- **USB 5.1 Stereo Sound Card Adaptor - Windows 7 Compatible**

This was purchased from Dynamode for the princely sum of £0.78, including post and packaging. There were evident noise 'spikes' in the audio part of the spectrum and it produced a lower output than the other cards.

www.amazon.co.uk/dp/B003UR9B8M/ref=pe_385721_37038051_TE_3p_dp_1

- **Creative Soundblaster Play Sound Card**

This was purchased from NORDPC in Germany for £20.59 including post & packaging. Although a better engineered product than some of the others, there was no significant difference when monitoring SIDs.

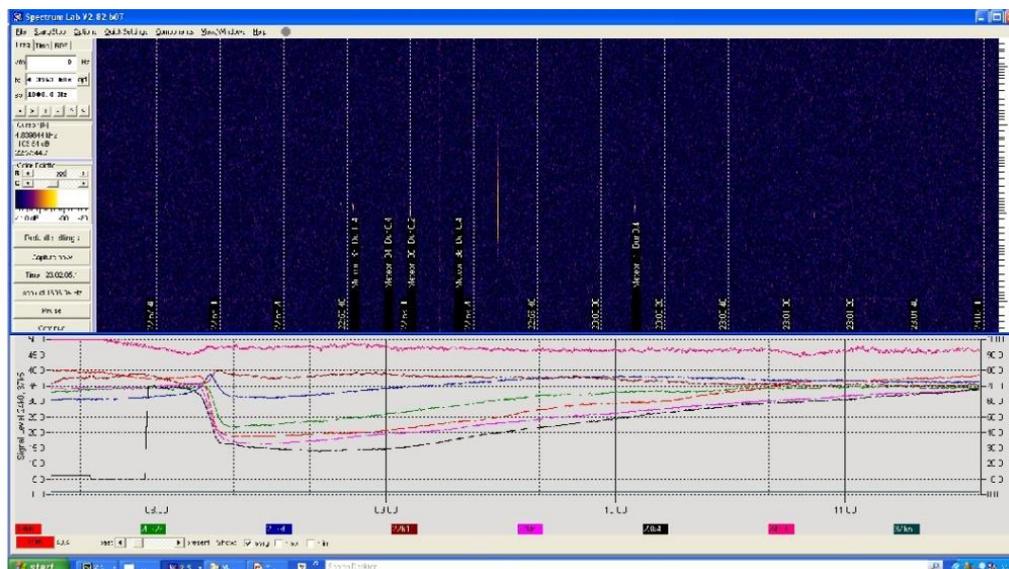
www.amazon.co.uk/dp/B0028RZ231/ref=pe_385721_51767431_TE_dp_1

About Spectrum Lab

Spectrum Lab is a freely downloadable application developed by Wolfgang Buescher that started out as a software tool to look at the frequency spectrum of an audio signal. Development has continued over the years, adding in support for a range of applications, from testing audio equipment, capturing 'Natural Radio' signals created by thunderstorms, to listening to bat calls. It was even filmed being used in the search for the missing Malaysian Airlines flight MH370. For amateur radio astronomy Spectrum Lab can be used to observe the VLF radio spectrum up to 24 kHz, and often 48 kHz, depending upon the specification of the computer sound card. This means that it can be used to detect and measure Sudden Ionospheric Disturbances (SIDs) created by solar flare emissions.

Spectrum Lab has a huge range of configuration options and finding your way around these is daunting for a newcomer. However it is possible to load a configuration file which will set up the system for a particular application.

There is an extensive Help file available for Spectrum Lab and this has been converted to an Acrobat file which can be downloaded from www.ql.net/dl4yhf/speclab/SpecLab_Manual.pdf. Like the application itself, it can be a struggle to find your way around this document given the vast amount of information it contains, so below you will find a summary of the most important screens and the main parameters to get you started. You can then use the Help file to find out further detail as needed, or to explore the full capabilities of this very flexible application.



Setting up Spectrum Lab

- Loading the SID configuration file

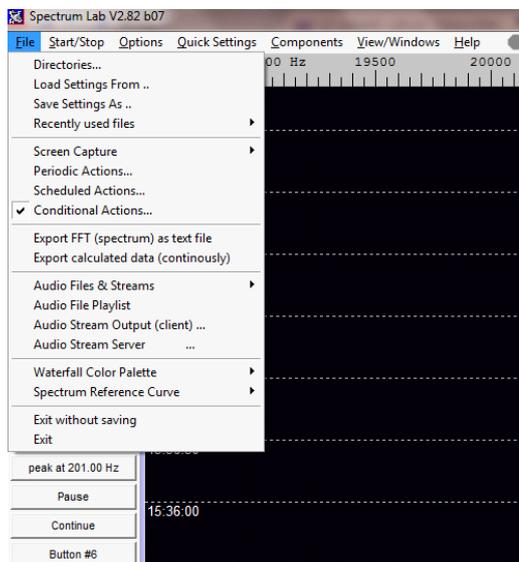


Fig 3

The configuration file for supporting SID monitoring is called RAG_SIDv1.usr. It should be loaded using the 'File' and 'Load settings from...' options in the Main toolbar.

Note that Spectrum Lab will save its current configuration when you exit or close down the application, so it is worth keeping a 'clean' copy of the original configuration file in a separate directory if you are going to make changes.

- Selecting the external USB sound card

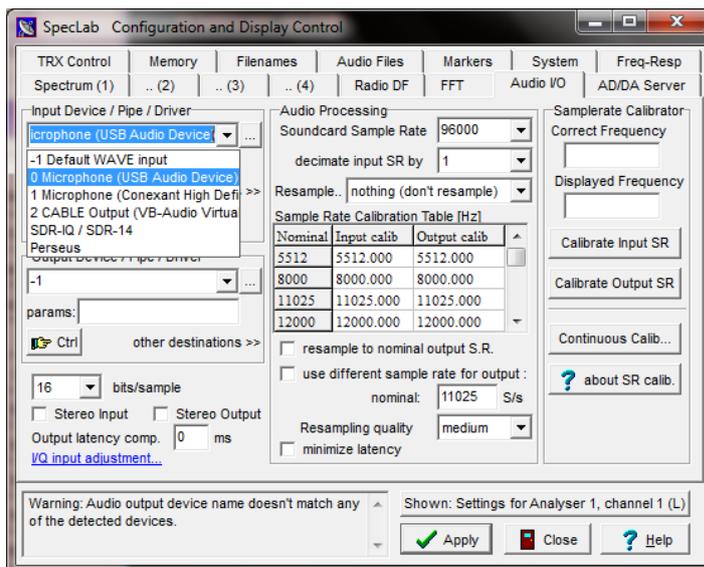


Fig 4

Provided that you have installed the sound card before starting the Spectrum Lab application, the device should appear in the pull down list of Input Devices.

The microphone connection to the computer's internal sound card will also be shown and you can use this if you decide not to use an external sound card. Note that the Stereo input box is not checked as we are working in Mono mode.

- **Setting the Waterfall frequency scale and brightness**

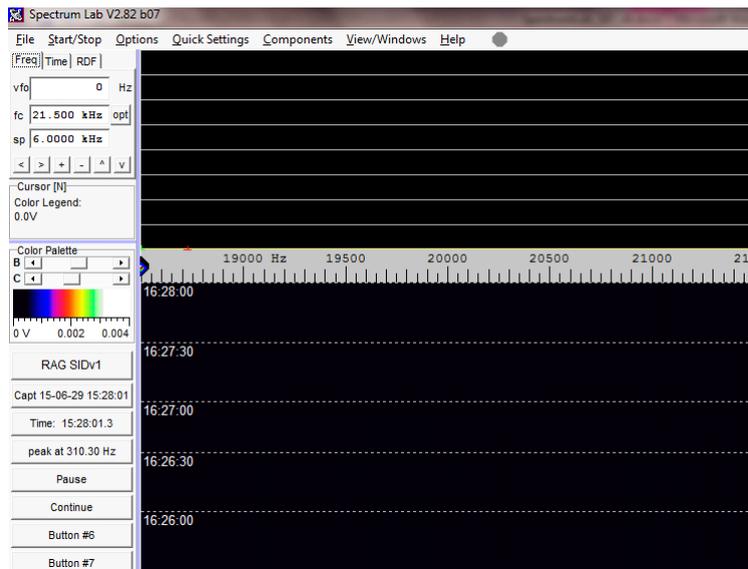


Fig 5

The frequency scale for the Waterfall window is adjusted by first setting the required centre frequency (fc) and then the required span (sp). You can also use the buttons underneath to zoom in and out or change the frequency range.

In this case the Waterfall covers 18500 to 24500 Hz which includes the radio signals most useful for SID monitoring.

The Colour Palette sliders provide fine control over the Brightness (B) and Contrast (C) for the Waterfall display, but you may need to adjust the coarse range via the Spectrum Display Settings Part 2 screen to be found under the OPTIONS tab on the main menu.

- **Spectrum Display Settings Part 2**

The Amplitude Range sets the range covered by the Colour Palette slide bars on the left of the main Waterfall display. Once you have found the normal operating range for your system it is better to adjust these limits accordingly and use the sliders on the main screen for fine control.

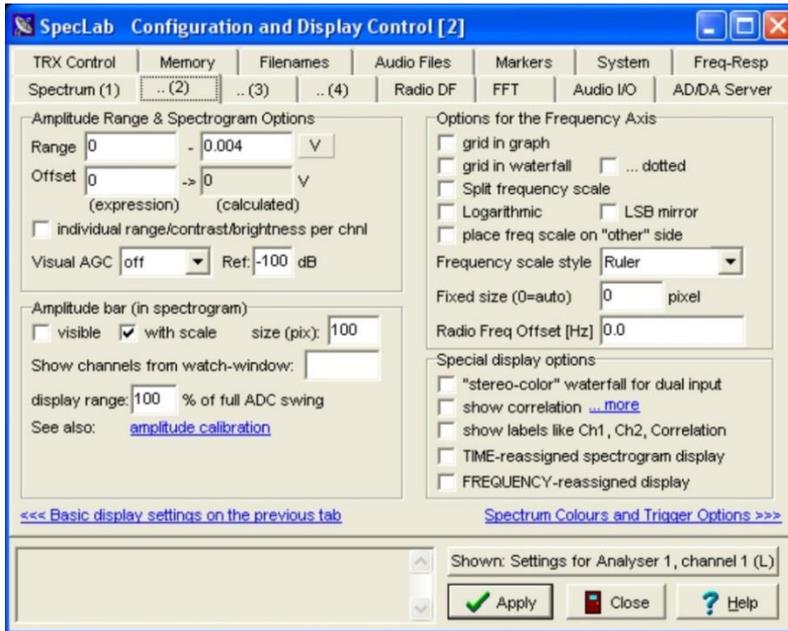


Fig 6

- **Setting up the Watch List and Plot Window**

The Watch List is reached via the View/Windows tab in the Main Menu. This feature allows you to define the frequencies to be monitored with the results charted in the Plot Window. You will need to modify the multiplier in the Expression field to produce a value of around 60 to 80 in the Result column so that the signal traces fall about two thirds of the way up the Plotter chart at around midday. Don't worry if your signal levels then go off the top of the Plotter chart at night time. This will not harm the system and you cannot obtain any useful information after sunset. The levels should fall back into range at sunrise the following day.

Nr	Title	Expression	Result (Value)	Format	Scale Min	Scale Max
0	19k6	60000*avg(19525,19675)	64.9	0.0	0	100
1	20k27	150000*avg(20195,20345)	9.5	0.0	0	100
2	20k9	25000*avg(20825,20975)	73.5	0.0	0	100
3	22k1	50000*avg(22025,22175)	64.4	0.0	0	100
4	22k6	30000*avg(22525,22675)	86.4	0.0	0	100
5	23k4	80000*avg(23325,23475)	65.8	0.0	0	100
6	24k0	400000*avg(23925,24075)	58.2	0.0	0	100
7	37k5	500000*avg(37425,37575)	0.7	0.0	0	100

Modify these values to place the Plotter traces between 60 and 80 at midday

Fig 7

Measuring those SIDs

SID events are quantified by their Start time, the time at which the maximum deviation occurs, and the time at which the signal returns to its normal level. These provide an indication of the rise time of the flare event and its importance as defined by the total duration. You can use the mouse and cursor to obtain these timings directly from the Plotter window, but the system also archives a daily text file in the Spectrum folder (labelled vlf_logYYYYMMDD.txt) which can be imported into a spreadsheet application for analysis at a more convenient time.

The text file is comma delimited and consists of a timestamp followed by the signal levels of each of the monitored radio stations.

```
UT,19k6,20k3,20k9,22k1,22k6,23k4,24k0,37k5
00:00:08,71.9,34.2,101.6,137.2,68.1,62.6,20.2,0.8
00:00:18,72.1,35.0,102.3,138.2,68.6,62.1,20.3,3.8
00:00:28,72.1,34.4,102.2,138.5,67.5,61.8,20.3,1.9
00:00:38,72.1,33.6,102.2,137.9,66.7,62.1,20.1,1.2
00:00:48,71.8,33.8,102.7,137.8,65.9,64.1,20.5,0.9
```

The standard configuration file monitors eight different stations:

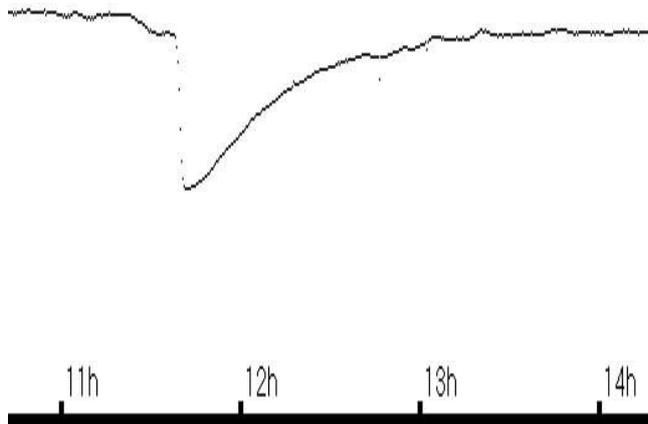
Call sign	Frequency (Hz)	Location
GBZ	19580	Anthorn, UK
ICV	20270	Isola di Tavolara, Italy
FTA	20900	Sainte-Assise, France
GQD	22100	Skelton, UK
HWU	22600	Rosnay, France
DHO38	23400	Rhauderfehn, Germany
NAA	24000	Cutler, Maine, USA
NRK/TFK	37500	Grindavik, Iceland

You may wish to reduce the number of stations monitored, but you need at least two and preferably three stations to be sure that a change in signal level is due to a SID, rather than a change in power level at the transmitter, or a burst of interference. Some of the transmitters are also off-air for periods of the day or during maintenance work.

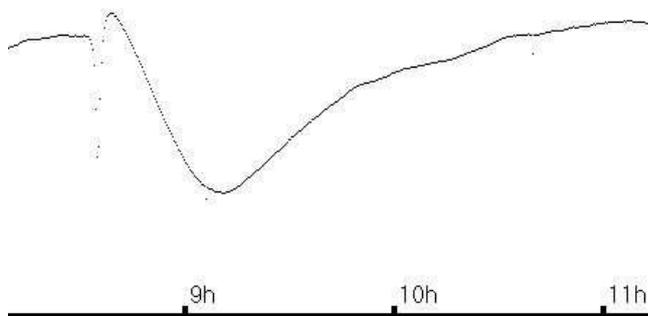
How to interpret SID events

The shape of recorded flares will vary from one observer to another, but a little experience while the sun is active will allow most events to be isolated from other interference. The text-book SID has a sharp rise to a definite peak, followed by a longer recovery period. In practise, many SIDs do not look that simple, and may have multiple peaks. SIDs may also appear inverted. This variation in shape is due to a combination of the path from transmitter to receiver and the varying state of the ionosphere. The sun often produces multiple flares over a short period, leading to superimposed SIDs that can create confusion.

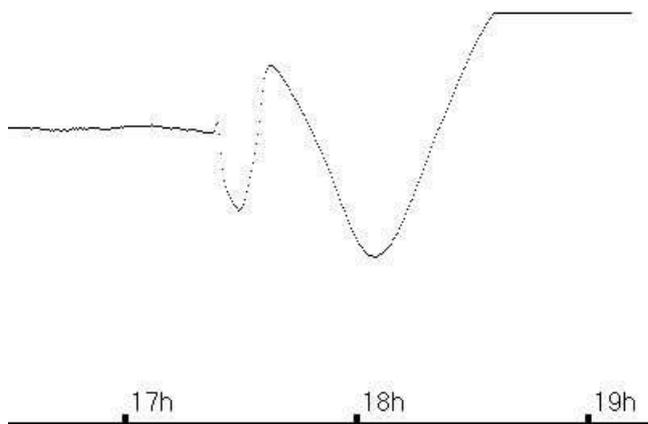
The following illustrations show some typical events:



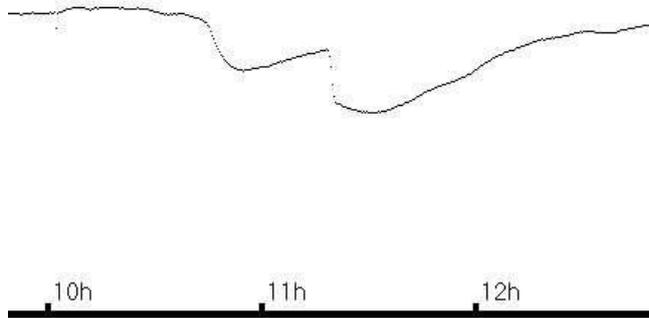
This is typical of an ordinary SID here measurement is fairly easy. It is inverted relative to 'normal', but is clearly the correct shape.



This is typical of a much more energetic solar flare, producing a SID that has a double peaked structure. The start and end times can be measured as usual; the peak time I measure at the maximum point, in this case at 08:37UT.



This is much more difficult, as the flare occurred during the sunset dip in signal strength. The result is a combination of the two effects. The start is easily measured, and the peak is also clear (as above). The end time cannot be measured, and would be left blank.



This recording shows 2 flares in rapid succession, such that the SID's overlap. An end time for the first event cannot be measured.

These sudden ionospheric disturbances might be recorded thus:

Date	Start	Peak	End	Importance
2005 March 10th	11:39UT	11:42UT	12:42UT	2+
2005 September 15th	08:33UT	08:37UT	10:33UT	3
2005 September 7th	17:23UT	17:28UT	?	-
2005 September 13th	10:45UT	10:55UT	?	-
2005 September 13th	11:18UT	11:32UT	12:05UT	2+

Note that all times are recorded in Universal Time (UT). The importance of an event is determined by its duration, the difference between the Start and End times.

Duration	Importance	Duration	Importance
Less than 18 mins	1-	19 to 25 mins	1
26 to 32 mins	1+	33 to 45 mins	2
46 to 85 mins	2+	86 to 125 mins	3
More than 126 mins	3+		

You can find the archive of past monthly reports on the BAA RAG website at www.britastro.org/radio/vlfrereports.html

If you would like to contribute observations to this programme, please send them to jacook@jacook.plus.com. Observations should be in the format described above and submitted on a monthly basis, with a deadline of the 15th of the succeeding month.