Draft: 01 September 2014 (WFD)

Readme: Sudden Ionospheric Disturbances (SIDs) – AAVSO Database

The Sudden Ionospheric Disturbance (SID) Database lists all events identified in the AAVSO Solar Bulletin. These results are provided monthly by the worldwide network of SID observers in the AAVSO Solar Division. Individual results are correlated with other observers' reports and reduced to a list of events with high definiteness ratings.

The database is organized as ASCII files, each containing only the SID events recorded in the listed month. The file format begins with a list of observer IDs to recognize the observers who contributed to that monthly report. The list of SID events follow with the date, event peak time (UT), and the importance rating for each event on consecutive lines. The events are ordered chronologically. The bottom lines of each file provide a distribution of the SID events in terms of importance rating. A monthly total is also listed.

The SID Database is a work in progress. Hardcopy lists published in the AAVSO Solar Bulletin are manually entered and formatted to create each file. As each month is converted and verified, the files will periodically be added to the database webpage. The work is time-consuming, but worthwhile since the final product will allow efficient electronic searches and more detailed statistical analyses of the SID program results going back to 1958. Many SID observers have contributed to this data set over the years. The final database serves to recognize their efforts and honor their diligence in providing this scientifically valuable data on a voluntary basis.

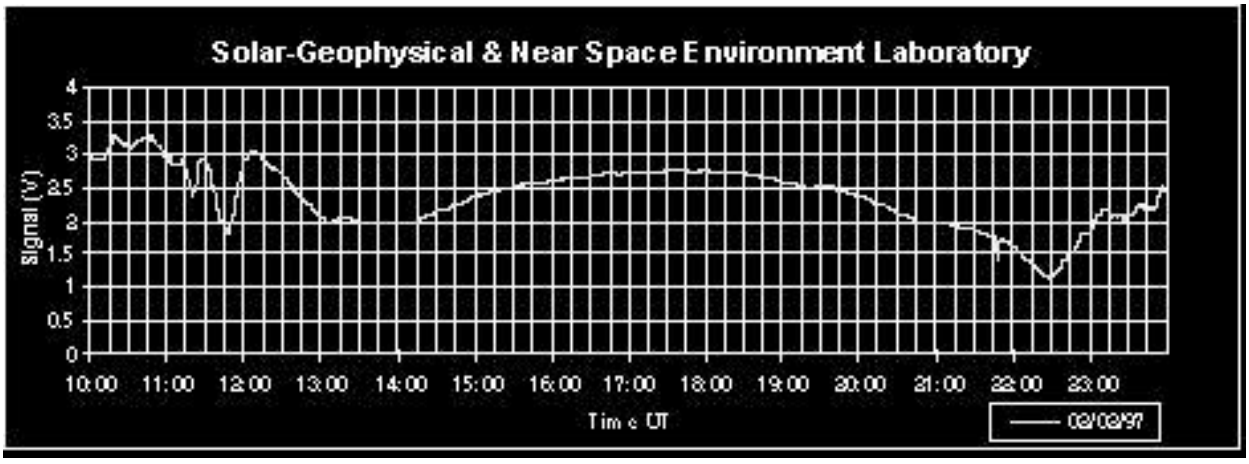
Data provider: American Association of Variable Star Observers (AAVSO)

AAVSO SID Analyst: Rodney Howe (ahowe@frii.com)

See http://www.aavso.org/solar-sids

Sudden Ionospheric Disturbances (SIDs)

The AAVSO SID Program consists of solar observers who monitor very low frequency (VLF) radio stations for sudden enhancements of their signals. Earth's ionosphere reacts to the intense X-ray and ultraviolet radiation released during a solar flare. The ionospheric disturbance enhances VLF radio propagation. By monitoring the signal strength of a distant VLF transmitter, sudden ionospheric disturbances (SIDs) are recorded and indicate a recent solar flare event.



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Typical SID Data (quiet day)

All SID monitoring stations are homebuilt by the observers. Instructions for constructing the VLF receiver and antenna are available on this website under the SID Monitoring Overview section. Additional assistance can be obtained from the SID Program Chairman. Some experience with electronics is required, as well as access to certain electronic apparatus in order to build and tune an SID receiver.

Receiver design has progressed remarkably as the SID program participants have been inspired to improve signal sensitivity and noise rejection. Recent SID station receivers follow a design developed by past SID Technical Coordinators, Art Stokes and Cap Hossfield. A small indoor loop antenna captures the radio wave for amplification and rectification by the receiver. Many of the early receiving systems used simple 1 inch/hour Rustrack strip chart recorders to collect a month's worth of SID data. Recordings were then analyzed manually for the beginning, end, and duration of SID events. With computers becoming more available at reasonable cost, most SID program participants have switched to digitally recording and archiving the signal values for later processing. A simple A/D converter design for specific use with the VLF receivers must be built in order to do this. Plans are available for this as well.

SID observers must reduce their own data to produce a list of SID events they have detected for the month. The results are put into a SID report that follows a pre-defined format. Reduced data are submitted via e-mail to the SID Analyst for final analysis and correlation with other observers' results. Monthly SID event results are published in the Solar Bulletin and archived in the AAVSO SID Database. They are also sent to the National Geophysical Data Center (NGDC) for publication in the Solar-Geophysical Data Report where they are accessed by researchers worldwide.

The AAVSO Solar Committee welcomes advanced amateur astronomer participation in the SID program. The cost of the equipment is minimal and can be built fairly easily. There is also a lot of room for personal innovation in the design and construction of the observing equipment and monitoring software. The equipment and software available here on the web is by no means the only way of monitoring SIDs. The only requirement is in the final report format sent in to the SID Analyst. How you get to that point is up to you.

See: http://www.aavso.org/sid-monitoring-overview

SID Monitoring Overview

SID Monitoring Overview
AAVSO SID Program

Rodney Howe, Solar Section chair & SID leader

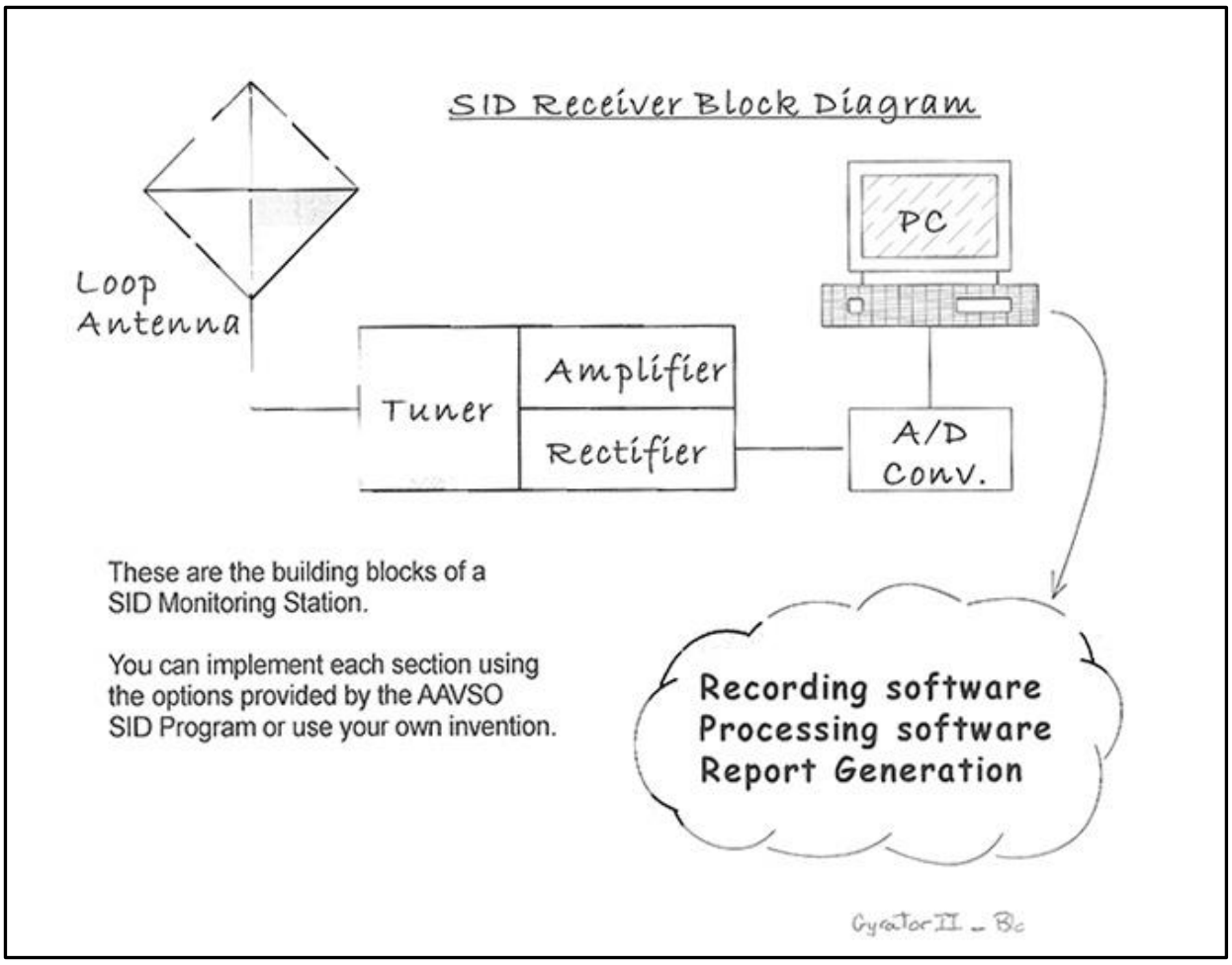
So, what are we looking for? Here are a couple references of SID events and their influence on the ionosphere:

Grubor, D., D. Sulic and V. Zigmane (2005), Influence of solar x-ray flares on the earth-ionosphere waveguide, *Serb. Astro. J., 171*, pp. 29 -35.
http://www.spaceweather.eu/publications/Solar%20X-Ray_in%20english%20for%20slovenia.pdf

Sulic, D., V. Cadez, D. Grubor and V. Zigman (2006), Space weather signatures on VLF radio waves recorded in Belgrade, *Publ. Astron. Obs. Belgrade, 80*, pp. 191-195 http://adsabs.harvard.edu/full/2006POBeo..80..191S

The Hardware

The setup for monitoring solar flare activity is made up of four basic building blocks and a computer to record data.



SID receiver block diagram

The **ANTENNA** most commonly used for SID monitoring is a small Loop Antenna that consists of many turns of small gauge wire wound on a square frame a little larger than the size of a dinner plate. The antenna, acting as an inductor, is tuned with a capacitor sufficient to cause the loop to resonate at the frequency of the station being monitored.

The **TUNER**, much like the antenna, must be tuned to the appropriate frequency based on which station you are monitoring.

The **AMPLIFIER** is used to boost the strength of the signal so that it can be converted to a Direct Current signal and recorded.

The **ANALOG to DIGITAL CONVERTER (A/D)** is a separate device from the receiver which converts the continuous voltage quantity to a discrete time and digital number, which can be graphed on the computer.

Recording Software → **data format** →Reporting Software → **report format**

Data Collection

For folks who use a data logging device from DATAQ Instruments, Data Acquisition Starter Kits can be found here: http://www.dataq.com/data-acquisition-starter-kits/data-acquisition-starter-kits.htm. These have a USB interface for their data acquisition unit. You can use the software provided by DATAQ to log data but must take the format into consideration for processing recording the start, maximum and end times for SIDs.

For folks who use a soundcard there is easy to use software on this web site: http://www.radiosky.com/skypipeishere.htmlt. This also requires consideration of data format for report generation.

Report Generation

There is a program called **SIDEntry** to manually enter the event times. This program works like a spreadsheet and allows you to write out the results to a file that has the correct AAVSO SID Report format and can be emailed to the SID Analyst at the end of each month. This is the recommended method for manual report generation: http://www.aavso.org/solar-program-reducing-data-and-email-format. The format adheres to the required guidelines. Contact the SID analyst for a copy of this software: *Rodney Howe, SID Analyst (ahowe@frii.com)*

I would recommend the Gyrator III as an easy to build receiver. http://www.aavso.org/gyrator-iii-vlf-receiver (This document has instructions on the Antenna, Tuner and Amplifier). The Gyrator III was originally designed by Art Stokes for the AAVSO SID program and eliminates an inductor in the input tuning circuit by using a couple of Op-Amps in what is known as a Gyrator configuration. This design is based on inductor based receivers, used by past SID Observers, and is similar to the Gyrator I and II. There is also what is known as a minimal Gyrator circuit which was an attempt to make the circuit as simplistic as possible and hence cheaper, (see SID Equipment).

You can purchase the Gyrator III PC Board from Far Circuits:

Gyrator III PC Board
Far Circuits
18N640 Field Ct.
Dundee IL 60118
web: http://www.farcircuits.net/receiver1.htm
847-836-9148 (7-10 CST- weekdays)

See other hardware options by going to the SID Equipment section of the AAVSO web site (see below).

See: http://www.aavso.org/solar-program-reducing-data-and-email-format

Solar Program, Reducing Data and Email Format

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Solar Program, Reducing Data and Email Format

Reducing Data Gathered by VLF Monitoring Systems

(Extracted from SID Technical Bulletin Vol. 3, Number 4, Oct. 1992)

The reduction process is quite simple, and consists of the steps which follow. First, the universal time for each of three event-phases must be measured for each SID. Examples are indicated on the recording at the end of this report.

Event Start: The moment when an event begins. Be aware that the amplitude of different events varies considerably, and some may appear in inverted form. If it is obvious that an event began before the first definable start time, an 'E' (before) is appended to the recorded time.

Event End: Of the three times, the end time is the most difficult to determine. It is defined as the moment when the trace returns to the diurnal trend line, or is interrupted by the onset of a new event. In the latter situation, the letter 'D' (after) is appended to that time, which in turn becomes the start time for the following event.

Event Maximum: The moment when the ascending (descending in the case of inverted events) branch slows its sharp rise. Note that this generally does not coincide with the event's peak amplitude.

If the trace goes off-scale as maximum is approached, or is interfered with in some other manner such as the onset of sunset, device failure, etc., we append a 'U' (uncertain) to the last identifiable time. For example, if the SID maximum occurs somewhere off-scale and the last determinable time is fourteen hours, ten minutes (1410), the time is recorded as 1410U.

Duration	Importance
< 19 minutes	1-
19-25	1
26-32	1+
33-45	2
46-85	2+
86-125	3
>125	3+

After each of these times have been recorded, the event's 'Importance' and 'Definiteness' ratings can be determined. Importance generally refers to the length of an event, found by subtracting the start time from the end time. The table at right associates the Importance rating with event duration.

With respect to the observer's typical daily trace, a class 1 SID is an event with small intensity change and a relatively short duration. Class 2 is a moderate intensity event with a fairly long duration, and a class 3 describes a SID with a 'great' change in intensity and long duration.

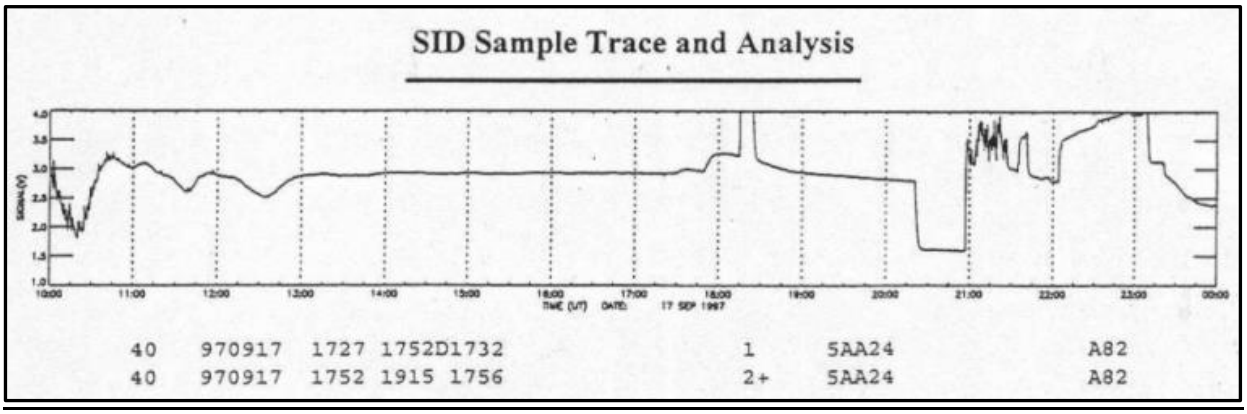
Confidence	Definition
Questionable	0
Possible	1
Fair	2
Reasonable	3
Reasonably Definite	4
Definite	5

Definition is a subjective estimate of an observer's confidence in the event. Normally, the events which are included in our reports have Definitions equal to 3 or greater. Use the right-hand scale as a guide to Definition. Careful study and experience teaches observers how to recognize false SID events caused by man-made interference. Beginners should not hesitate to assign high Definition values to those events which are not correlated with known noise sources. Other observers' results will be compared to eliminate suspect events before a final report is submitted to the NGDC.

Email Format for SID Event Reports

The format prescribed by the NGDC always begins with the '40' NOAA SID identifier code. The AAVSO SID Coordinator assigns observer codes after the station is operating correctly and data is received regularly from that observer.

Column	Description
1-2	Data code; always 40
3-5	Blank
6-7	Year
8-9	Month
10-11	Day
12-13	Blank
14-17	Start time; UT hours and minutes event began
18	Start time qualifier; D = after, E = before, U = uncertain
19-22	End time; UT hours and minutes event ended
23	End time qualifier; D, E, U
24-27	Maximum time; UT hours and minutes of event maximum
28	Maximum time qualifier; D, E, U
29-44	Blank
45-46	SID Importance; sign in column 46
47-50	Blank
51	Definiteness
52-55	Code for monitored transmitter. The field consists of the final two station call letters and the two numbers which represent the frequency (kHz). The latter is rounded to the nearest integer. Example; the code for NSS at 21.4 kHz is recorded as SS21
56-69	Blank
70-72	Observer code; Example A82



SID Sample Trace and Analysis

See: http://www.aavso.org/sid-monitoring-group-faq

SID Monitoring Group FAQ

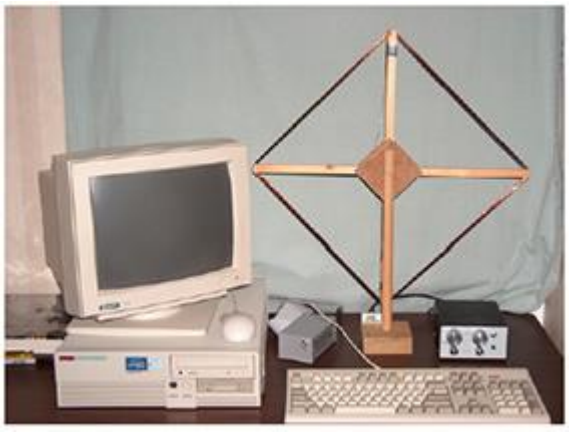
When the ultraviolet rays from the Sun hit the Earth's atmosphere the energy they possess work to knock electrons off of the atoms and molecules that the atmosphere is made up of. These free electrons make up a region of the atmosphere known as the ionosphere. The region is strongest on the daytime side of the earth since it is dependent on the energy from the solar ultra violet rays.

Very Low Frequency (VLF) radio waves reflect quite well of the underside of this region as they travel from their source, a VLF radio station, to a receiver of the signal. If you monitor the "strength" of the received signal, you will see the strength rise from minimum in the morning to a peak at noon when the sun is highest, and then fall back to a lower level towards sunset. This is a normal quiescent daytime pattern.

When a solar flare occurs on the sun it generates vast quantities of x-rays that race out at the speed of light (300,000 Km/sec) and reach the earth eight minutes later. These x-rays, even more energetic than the ultra violet rays, also work to ionize the upper levels of the atmosphere. They do so more rapidly and with greater strength but the effect is short lived as the x-ray blast subsides.

The effect on the received VLF radio signal is for its' strength to quickly become greater and then gradually return to normal. This is known as a Sudden Ionospheric Disturbance or SID. They are sometimes referred to as an SES which stands for Sudden Enhancement of Signal. Monitoring the VLF signal provides a way to indirectly detect solar flare activity on the sun and its direct effect on the propagation of radio waves by the ionosphere.

What Kind of Equipment Do I Need to Monitor SIDs?



You will need an antenna, and a VLF receiver that converts the signal strength to a DC output. You then need to record the signal for later analysis. In the past this was done with paper strip chart recorders, which some observers still use. But more recently we have moved over to computerized monitoring which requires an Analog to Digital (AD) converter, and an input device by which the computer can read the signal. One option to use a commercial Data Acquisition module which has the A/D Converter built in or you could build a simple AD Converter yourself that could be accessed via the parallel printer port of your computer.

In addition to these pieces of equipment that you will build yourself, you also need to have or have access to an oscilloscope and a signal generator that will produce a signal in the 15 to 60 Khz range. Of course you will also need software to drive the processing. Some of the commercial DAQ Modules come with their own software. Some of the software in use has been developed by some of our observers. You could even develop your own software if you are

adept at computer programming. That is all part of the fun of getting involved with the SID program. You have many opportunities for your own creativity and options to pursue this in whatever way you are best able to do so.

What Kind of Skills Do I Need to Get Involved?

If you are going to get involved with SID Monitoring there are some basic skills you will need to effectively set up a monitoring station and begin acquiring meaningful data. A basic understanding of electronics is needed in order to build the receiver from the schematic circuit diagrams provided. You will also need to be able to do light electronic assembly work with a soldering iron on a PC board. You don't have to make the PC board. This can be purchased for a very reasonable price. You need to understand how to work with signal generators, voltmeters, and oscilloscopes. These are needed when tuning the circuit for best reception. Lastly you will to build the antenna which involves some simple woodworking and mechanical assembly.

Computer programming is not necessary unless of course you want to create your own software, but one must be familiar with computers for implementing the computer monitoring. Access to the Web and email is important as most communication among observers is done via this medium.

The AAVSO SID Monitoring Program

The AAVSO Solar Committee SID Group serves to collect observations of SID events made by many observers located across the United States and overseas and correlated to one another, in order to monitor and archive the level of solar flare activity as it affects the ionosphere. Monthly counts of SIDs have been made since the 1950. Originally the data was used in connection with Radio Signal propagation forecasting and modeling which was heavily dependent on current flare activity. Today with spacecraft continuously monitoring for solar flares, the SID event data serves more as a gauge of solar activity, similar to the sunspot number, which has a historical past for comparison and will be continued into the future.

Once a prospective observer has put together an observing station and verified its operational status to the SID Analyst, he/she is given an Observer ID code which will be used when reporting data. After that, monthly reports of SID events are submitted in a standard file format and then correlated to other observers' data. The end result is a compilation of correlated events for the month which is archived at the AAVSO and sent to the National Geophysical Data Center (NGDC) where it is archived with many other solar related data.

Further References

The AAVSO web site is the best place to start: Sudden Ionospheric Disturbances

From this page look under the heading "More Information" to access other pages with more detailed information. The following pages should be viewed first.

- SID Equipment
- SID data reduction guidelines
- AAVSO Solar and SID Forum

For more information you can contact the SID Group Chairman and Data Analyst Rodney Howe (ahowe@frii.com)

Or contact the AAVSO directly:

American Association of Variable Star Observers
49 Bay State Road
Cambridge, MA 02138

Phone: (617) 354-0484