SuperSID Manual

Space Weather Monitors



Stanford University Solar Center

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Over 300 SID monitors have been placed around the world during the United Nations-sponsored International Heliophysical Year. More are being placed through the International Space Weather Initiative. Special thanks to Joe Davila, Barbara Thompson, and Hans Haubold for making these projects possible.

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SuperSID Users Manual

Sudden **I**onospheric **D**isturbance Space Weather Monitor

http://solar-center.stanford.edu/SID



Society of Amateur Radio Astronomers
http://Radio-astronomy.org

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Chapter 1 - The Space Weather Monitoring Program



Stanford University's Solar Center has developed inexpensive space weather monitors that students can install and use at their local high schools. The instruments detect changes to the Earth's ionosphere caused by solar flares and other disturbances. Students "buy in" to the project by building their own antenna, a simple structure costing little and taking a few hours to assemble. Data collection and analysis is handled by a local PC, which need not be fast or elaborate. Stanford provides a centralized data repository where students can exchange and discuss data. Considerable accompanying educational guides are provided with the monitors.

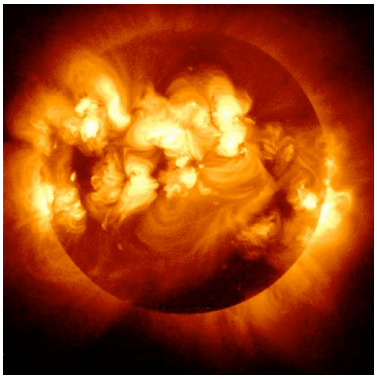
Two versions of the monitor exist – the original SID Monitor, distributed throughout the world for the International Heliophysical Year[1], and SuperSID, a lower-cost, more powerful upgraded instrument being distributed through the International Space Weather Initiative[2]. This manual describes the upgraded, SuperSID monitor.



What is a Space Weather Monitor?

Our space weather monitors measure the effects on Earth of solar flares by tracking changes in very low frequency (VLF) radio transmissions as they bounce off Earth's ionosphere. The VLF radio waves come from transmitters set up by various nations to communicate with their submarines. Signal strength of these VLF waves changes as the Sun affects Earth's ionosphere, adds ionization, and thus alters where the waves bounce. Our monitors track these changes in signal strength.

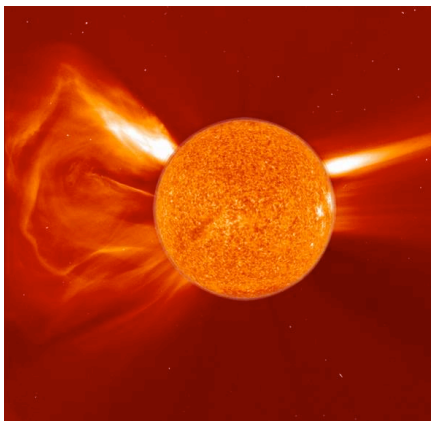
The Sun affects the Earth through two mechanisms. The first is energy. Whenever the Sun erupts with a flare, it is usually in the form of X-ray or extreme ultraviolet (EUV) energy. These X-ray and EUV waves travel at the speed of light, taking only 8 minutes to reach us here at Earth, and dramatically affect the Earth's ionosphere.



Solar flares, seen in X-ray, as captured by the Hinode spacecraft. Image from NASA/JAXA

[1] United Nation's sponsored IHY: http://ihy2007.org/ , UNBSSI program: http://ihy2007.org/)
[2] http://www2.nict.go.jp/y/y223/sept/ISWI/090615_SWIs.pdf

The second mechanism of affecting Earth is through the impact of matter from the Sun. Plasma, or matter in a state where electrons have been separated from the nuclei of their atoms, can also be ejected from the Sun during a flare. This "bundle of matter" is called a Coronal Mass Ejection (CME). CMEs flow from the Sun at over 2 million kilometers per hour. Thus it would take a CME 72 hours or so to reach us. These CMEs primarily affect the Earth's magnetosphere and one would need a magnetometer to track changes.

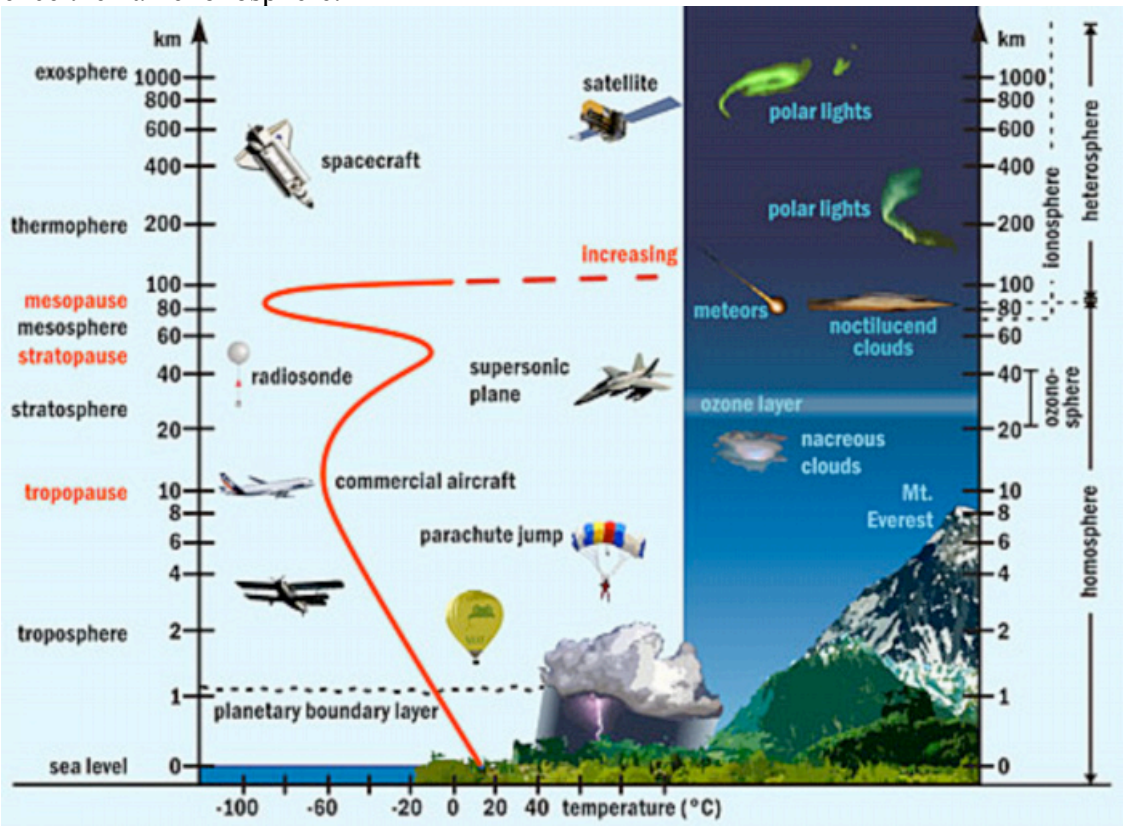


CME ejection. Image from NASA/ESA SOHO

Both energy and matter emissions from the Sun affect the Earth. Our space weather monitors track only the **energy** form of solar activity.

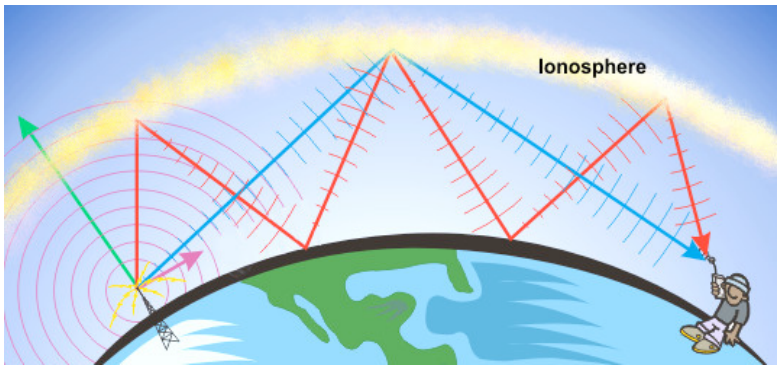
What is the Ionosphere?

Energy from the Sun constantly affects the Earth's ionosphere, the highest level of Earth's atmosphere, starting some 60 km above us. When solar energy strikes the ionosphere it strips off electrons from their nuclei. This process is called ionizing -- hence the name ionosphere.



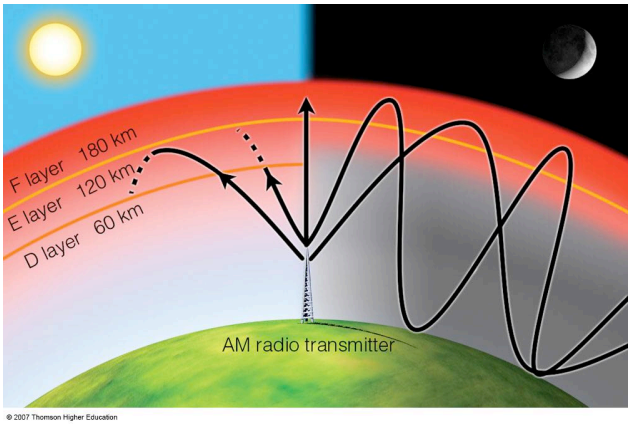
The Earth's ionosphere begins about 60 km above the Earth's surface.

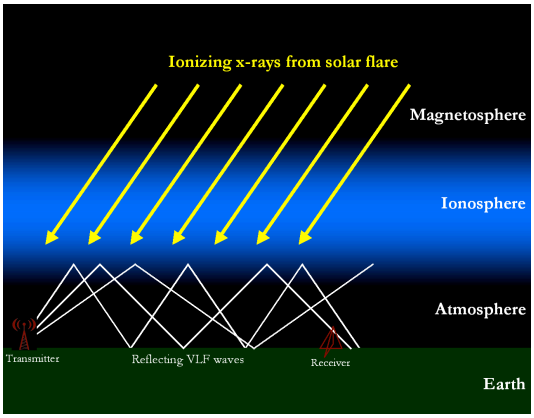
It is the free electrons in the ionosphere that have a strong influence on the propagation of radio signals. Radio frequencies of very long wavelength (very low frequency or "VLF") "bounce" or reflect off these free electrons in the ionosphere thus, conveniently for us, allowing radio communication over the horizon and around our curved Earth.



Radio waves bounce off the ionosphere

The ionosphere has several layers created at different altitudes and made up of different densities of ionization. Each layer has its own properties, and the existence and number of layers change daily under the influence of the Sun. During the day, the ionosphere is heavily ionized by the Sun, creating the (arbitrarily-named) D, E, and F layers. During the night hours there is no ionization caused by the Sun since it has set. However, there is some small ionization caused by cosmic rays, which creates only the higher, F layer. Thus there is a daily cycle associated with the ionizations.



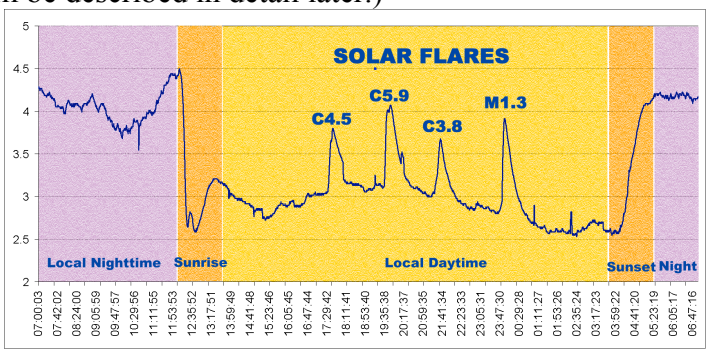


In addition to the daily fluctuations, activity on the Sun can cause dramatic sudden changes to the ionosphere. When energy from a solar flare reaches the Earth, the ionosphere becomes suddenly more ionized, thus changing the density and location of layers. With the increased ionization, the VLF signals now bounce from the lower, D layer. Hence the term "**Sudden Ionospheric Disturbance**" to describe the changes we are monitoring.

The strength of the received radio signal changes according to how much ionization has occurred, at what level of the ionosphere the VLF wave "bounces" from, and how much additional ionization the wave must penetrate on its way to or from a bounce.

What Will SID Data Look Like?

Below is a sample SID data graph (we added the colors to make it easier to read). The y-axis of the graph indicates signal strength, and the x-axis time, in this case 24 hours. Note the change of the signal strength at sunrise and at sunset. Also note the 4 solar flares. (These will be described in detail later.)

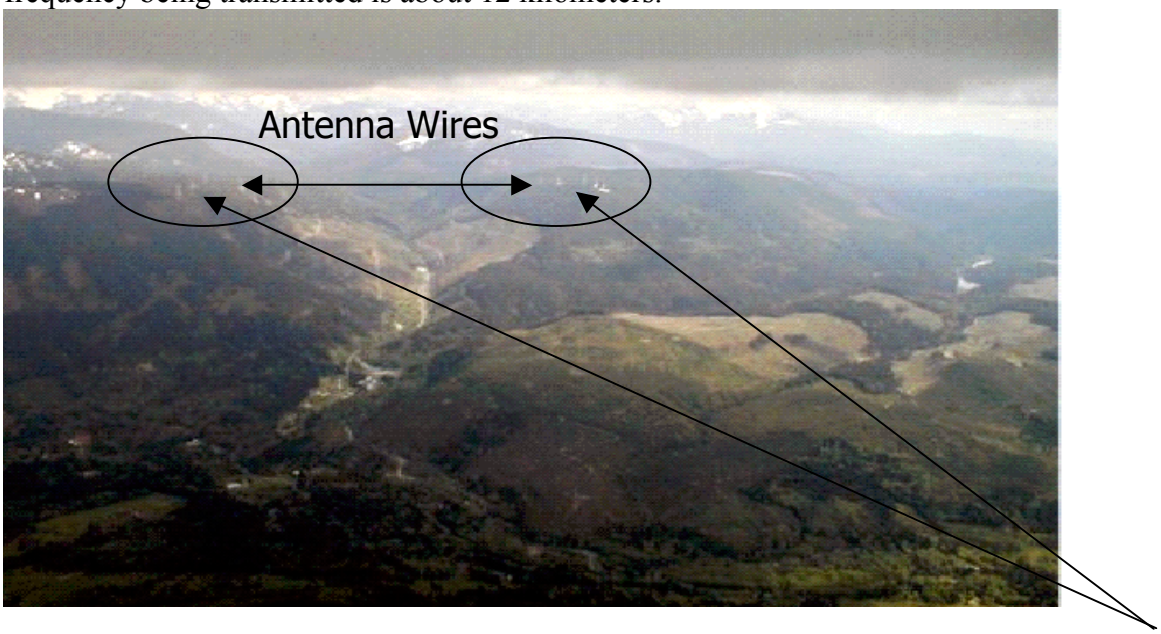


Where do the "bouncing" VLF radio waves come from?

Conveniently for us, several nations use VLF (very low frequency) waves to communicate with their submarines because these wavelengths can penetrate water. There are transmitters scattered around the world. The VLF signals bounce off our ionosphere from many kilometers away and can be picked up almost anywhere. A list of known stations is in Appendix A and also maintained by the American Association of Variable Star Observers (AAVSO) at

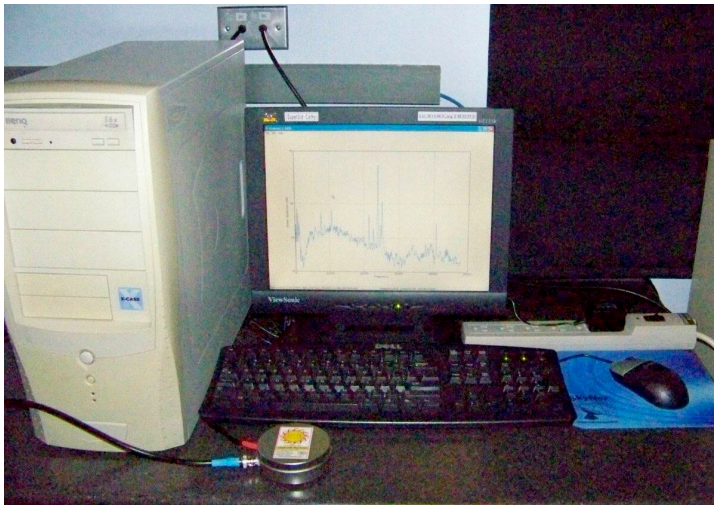
http://www.aavso.org/observing/programs/solar/vlfstati.txt

The transmitter stations are usually very large, covering many kilometers. The site in the picture below is the US Navy Radio Station in Jim Creek, Washington, USA. Note that the antenna wires span from mountain top to mountain top, since the wavelength of the frequency being transmitted is about 12 kilometers.



"NLK" 24.8 kHz US Navy Radio Station, Jim Creek, WA Transmission Towers
wavelength 12 km (7.5 miles)

Chapter 2 - Installation



Required to Host a SID Monitor

1. Access to power
2. A SuperSID monitor (preamp) plus instructions on how to install it
3. A PC computer with the following minimal specifications:
   - **For sites in North and South America, a High Definition (HD) sound card that can record (sample) up to 96 kHz, or the ability to insert such a sound card** *(required for America only)* For sites in Europe, Asia, Africa, and Australia, an HD sound card is optional, since transmitters in those areas transmit at a lower frequency. However, you can choose to install an HD soundcard if you wish to receive even more stations at higher frequencies.
   - MS Windows operating system (Windows 2000 or more recent)
   - A CD reader
   - Standard keyboard, mouse, monitor, etc.
   - 1 GHz CPU with 128 mb RAM
   - Ethernet connection & internet browser *(desirable, but only necessary for accessing centralized data)*
   - External speakers (*desirable*)
4. An inexpensive antenna that you will build yourself
5. An antenna location that is relatively free of electric interference; can be placed indoors or out, but never high enough to be at risk from lightning.

You may also need

1. Power strip (otherwise known as plug board, power board, power bar, distribution board, or multi-box), extension cords, other electrical support
2. An assortment of basic tools such as screwdrivers, hammer, knife, pliers, etc.
3. Materials to build your antenna (wood, PCV pipe, wire, etc.)

How SuperSID Works



A loop antenna to pick up VLF signals reflected from the ionosphere





A PreAmp to raise very small signals to a level can be captured by a PC sound card.



A sound card to convert signal from analog to digital.



A PC to process data and estimate signal strengths though a day. Sudden Ionosphere Disturbance indicates Solar Flare on the SUN.

The primary parts of your SuperSID instrument are an antenna, a preamplifier, and a computer with a sound card. SuperSID needs a loop antenna to pick up radio signals reflected from the ionosphere. These signals typically are very small, only ~0.1 milli-volts[3], so a preamplifier is needed to boost or amplify the signal about a thousand times, to the level that can be captured with a PC sound card. The sound card's task is to convert the signal from analog to digital. Then, a program we provide, running on your PC, tracks the VLF transmission signal strengths and processes the data. Since the reflected radio signals are strongly influenced by the Sun's radiation, plotting the signal strengths over time should tell us when there is a solar flare on the Sun.

Installation Steps

Quick Overview. Each step will be described in more detail below.

1. Get prepared – familiarize yourself with the concepts, collect materials, find a site for your antenna and for your computer & SuperSID
2. Construct your antenna
3. Install and connect your hardware, perhaps including a new sound card
4. Install your software
5. Test your system; collect data, and debug
6. Send data back to Stanford for sharing with your colleagues (if you wish)

Step 1. Get Prepared

- Read this entire installation chapter before you begin.
- Familiarize yourself with SID concepts. What is a SID event? Why do you need to monitor a VLF station to detect SIDs in the ionosphere? How does the monitor detect them?
- Obtain and familiarize yourself with each SID hardware component (SuperSID preamp, sound card, power adaptor, etc.)

[3] It takes 10,000 of the 0.1 milli-volts to make 1 volt. The common light bulb uses 120 volts (120,000 milli-volts), so you can see why we need to amplify this signal.

- Find an indoor, secure place for the SID monitor and computer that has access to power. Is there an internet connection nearby?
- Find a place for the antenna. It does not need to be high, it can be indoors or out, but it must be as far away as possible from electrical interference *(see Appendix F on common sources of interference)*. **It should not be high enough to attract lightning.**
- Obtain the supplies you need for constructing your antenna and hooking up your hardware

Step 2. Construct Your Antenna



A SuperSID antenna is called a "**wire-loop antenna**" and is nothing more than a frame that holds up "wraps" or big loops of wire. There is no "standard size" or shape of antenna for a SuperSID. The antenna does not need to be built to precise dimensional specifications nor its wire wound to exact tolerances, nor does it have to be assembled or constructed exactly as shown in this document. You are encouraged to experiment and adjust the construction of your antenna for the parts and supplies you can acquire easily. More ideas are available in Appendix B – Sample Antenna Designs.

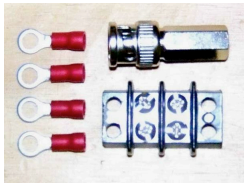
You can either build a **small (about 1 meter wide**) antenna with lots of wraps of wire, or a **large** antenna (**2 or more meters wide**) with fewer wraps, or something in between. Larger antennas are more sensitive, but are difficult to carry around and mount outside because of wind, rain, and space requirements. Smaller antennas are easier to build but require more wire to pick up the signal and are not as sensitive as big antennas. The larger in diameter, the better your antenna will be, e.g. 25 turns on a 2 meter frame is better than 50 turns on a 1 meter.

Collect your antenna materials

- About 120 meters (400 feet) of **insulated** wire. Solid, large wire gives a better signal. Stranded wire may be easier to wrap and keep straight and could work. Magnet wire is inexpensive but fragile and needs to be kept inside. You can use anything from #18 AWG (1.02362mm) to #26 AWG (0.40386 mm) size wire depending on the size of your antenna. A small antenna will require about 50 turns/winds of the smaller diameter wire, a larger one about 25 of the larger diameter wire. We have built antennas with different types of wires using wire

gauge from AW 22 – AW 322, single or multiple strands, with 20 turns to 40 turns.

- Coax Cable RG-58 of sufficient length to attach your antenna to your computer
- BNC connector; 4 terminal connectors, terminal block
- 1 meter or longer sticks, PVC pipes, broom handles, drift wood, or something similar to make a simple frame. You'll need 3 sticks for the frame in the photo.
- Screws and nails to assemble your sticks and wire, plus simple tools such as a hammer, screwdrivers, perhaps a drill.

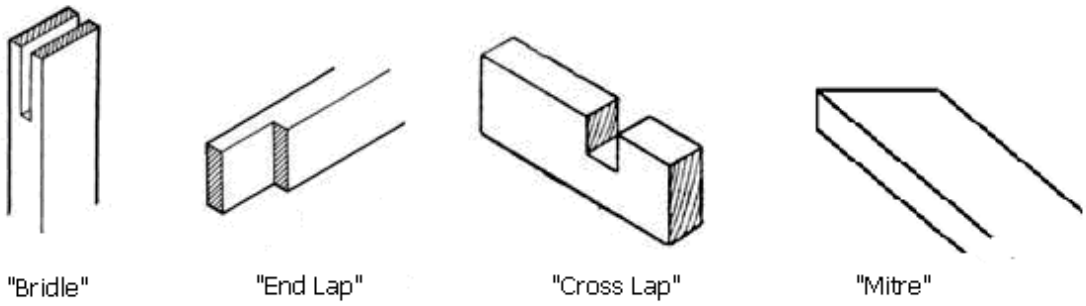


Assemble the Frame

For our example, we'll build a 1+ meter (4') antenna. You can use similar steps to build a 2-meter or larger antenna. Our sample antenna frame is made of three wooden sticks:



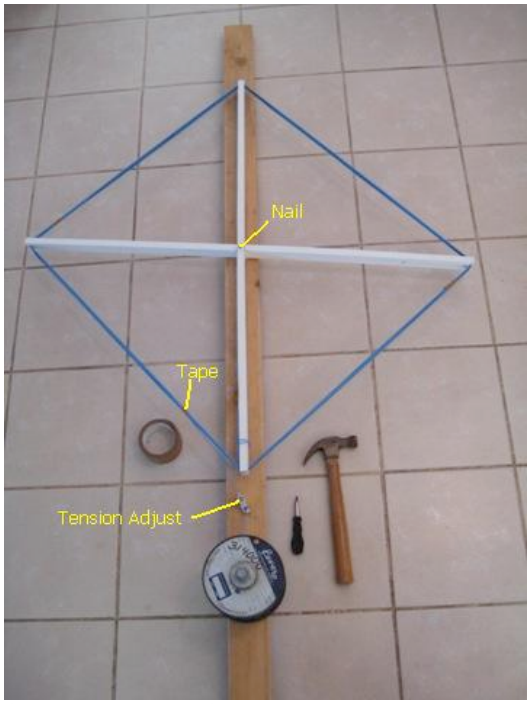
1. Horizontal Arm (*top*): has "bridle" cuts on both ends to hold the wires and a "cross lap" cut in the middle to be joined with the Vertical Arm.
2. Vertical Arm (*middle*): has a "bridle" cut (to be on the top), and "end lap" cut (to be on the bottom) and a "cross-lap" cut in the middle to be joined with the Horizontal Arm. The "end lap" at the bottom is for sliding the wire loop into/out of the antenna as needed.
3. Antenna Stand (*bottom*): has a "mitre" cut at the bottom to go into the ground and 2 screws about a foot apart at the top for later attachment to the Vertical Arm.



Basic Wood Cuts, referred to above

Assemble your frame with nails, screws, glue, leather straps, twine, or whatever you have.

Wind Your Antenna



To wind or "wrap" an antenna means to string wire around the outside of your frame. Here is a simple fixture we used to keep the wire straight and uniform when winding. It requires a long 2x4, hammer, tape, and a little wire holder like the ADR21 connector in the photo.

We drilled a little hole in the middle of our antenna and used a nail to temporarily secure it to a 2x4 frame. We used a small piece of paper to wrap around the wire and feed the wire through a little wire holder like the connector below. We used the connector to adjust the wire tension as we rotated the frame, winding the wire into a loop. We added small pieces of tape here and there to hold the wire together, flat, and in place.

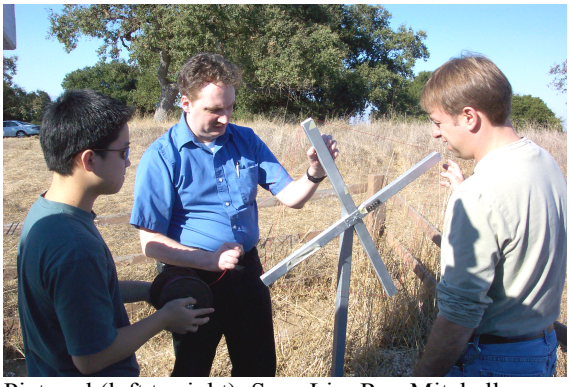
Make sure you leave enough wire at the end to connect to the terminal block.



See http://www.drillspot.com/products/42540/Colorkey_ADR21_1_Conductor_Connector).

You could also wind your antenna by turning it like a windmill as a friend feeds wire out to it. If you use this method be sure to tape your wire bundles together occasionally.

Wind your antenna, but TAKE YOUR TIME… a fast job will produce sloppy results and could break something. Expect that it will take about 20 - 40 minutes to complete this step.



Pictured (left to right): Sean Liu, Ray Mitchell, and Eric Havel

Little precautions can help improve the signal quality significantly:
1. Keep the wire straight and of uniform tension
2. Have good wire contacts for the crimped ends of the antenna wires and connectors

3. Protect your wire from shorting out from rain by using electrical tape to cover the connection from the wire to the connectors
4. Use coax cable to shield the signal from electrical interference from buildings.

Antenna Completion and Packaging

You will put two terminal connectors on one end of the coax and attach that to the terminal block. Then you'll add a BNC connector to the other end of the coax (details below). This will eventually connect to a SuperSID. You can stand up your antenna by placing it in a bucket of sand or rocks, digging a hole, or by attaching it to something permanent in your environment. However, we'll be using your antenna to set up your SuperSID, so do not place the antenna in its permanent spot yet.

If you need to de-assemble your antenna for shipping, lay it down on the ground and use a small screwdriver to "glide" the wires into or out of the frame. Work on one wire at a time because using a lot of force could break the antenna arms. Make sure you have sufficient tape holding the wires together. The antenna can now be wrapped up to ship.



Preparing an antenna for transport or shipping

Antenna Site Selection

Because the signals you are attempting to pick up are very small, you will need to locate your antenna in an area relatively free of electric interference. It can be indoors or out, but should be away from generators and other large electric equipment, not under power lines, not in large metal-framed buildings, not near microwave ovens, etc. Unlike a TV antenna, **your antenna does not need to be up high, and it should not be placed where it could get struck by lightning**. Your monitor and computer will need to be relatively nearby, indoors. Place your monitor and computer in a place that can be secured from being tampered with. A lockable closet works well. You will need access to power and, hopefully, an internet connection.

Connecting the Antenna to the Preamp

Now it is time to prep the coax cable for use. "Coax" is short for coaxial, meaning the cable has two conductors in the same axis, one center connector, and a ground shield

around the center connector. The RG-58· is a standard cable used by ham radio people and available at electronics outlets (similar to Radio Shack if you are in the U.S.). Determine the length of wire you will need to run from your antenna to your SID monitor, plus some slack. Shorter cable gives a better signal and picks up fewer noises along the way. Do not loop extra cable near the computer (where it will work as another antenna!)

Detailed information on how to strip coax cable is available in Appendix C. Basically, you should carefully strip off about 2 inches of the outer sheathing of the coax cable with a sharp pocket knife or straight edged blade. Cut only deep enough to pierce the sheathing but **not** any deeper or you will cut the ground wire (see Figure 1). Then separate the center connector and ground shield wires (Figure 2).

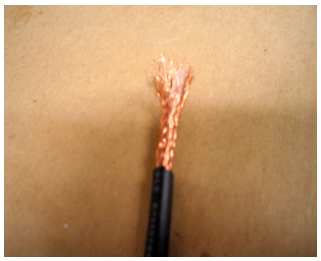


Figure 1

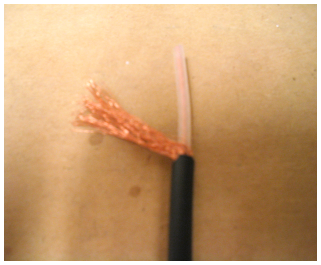


Figure 2

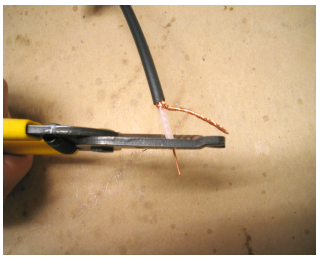


Figure 3

Pull the center conductor and sheathing through the ground wire and twist the ground wire as shown in figure 3. Next, strip the center conductor back about ½ inch as shown in figures 3 and 4. We recommend using spade connectors (figure 4) and a crimp tool to make the attachment to the terminal block easy (figure 5).

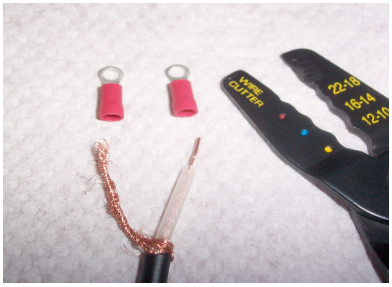


Figure 4



Figure 5

To attach the spade (ring) connected coax wires to the terminal block, unscrew the two screws on the opposite side of the connected antenna wires. Slip the ring over the screw and tighten back down (figures 6 and 7).

· Note: RG-59 could be used as well, although different terminators are needed. The two types have similar electrical characteristics, but different impedance. The RG-59 is used in cable systems and has a 75 ohm impedance; RG-58 is 50 ohms. Again, each needs a specific terminator.

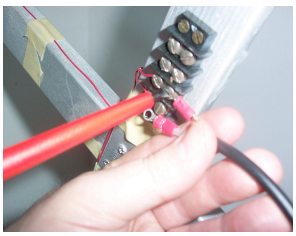


Figure 6

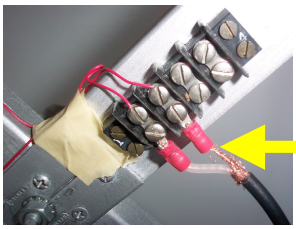


Figure 7

If your antenna will be outside, you will want to wrap electrical tape to cover the bare wire and the center conductor to protect from rain.

On the other end of the coax you need a BNC (Bayonet Neill-Concelman) connector to mate with your SID Monitor.



A BNC connector

Strip the coax about 21 mm from the end. Figure 1 shows a wire stripping tool, but you can do as well with a knife. (Again, see Appendix C.) Cut or scrunch the ground wire so that it sticks out about 6.35 mm from the covered coax and strip the center conductor about 14.3mm, as shown in figure 2. Now place the center conductor into the hole in the connector (at the end of the shaft). Twist the shaft in a clockwise direction until the screws are tight and it covers any exposed ground wire as in figures 3 and 4. If you are having trouble, cut a little bit off your center conductor and try again.

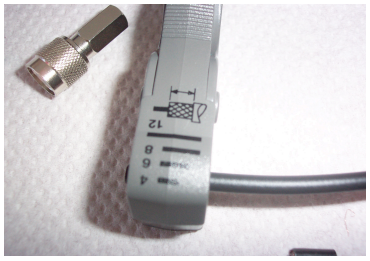


Figure 1

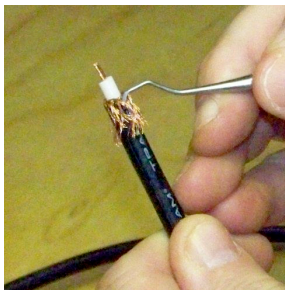


Figure 2



Figure 3



Figure 4

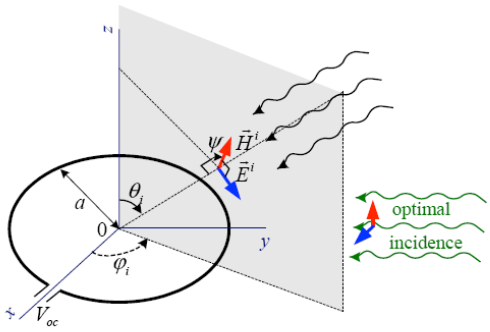


When your connector is finished it will connect to the monitor as shown here.

How these antennas work

The type of antenna that can pick up VLF radio signals is called a loop antenna. Fundamentally, a loop antenna is an LC (inductor capacitor) circuit which resonates at some frequency. An inductor concentrates and stores magnetic energy, while a capacitor concentrates charge and thereby stores electric energy. The inductance is formed by the wire loop. The capacitance is formed by the wiring metal surface, running in parallel along the loop. Wire resistance is small, though always present in a wire and increases as the length of the wire increases. As the electromagnetic field from a VLF station passes by the loop, a very small (~0.1 mili-volts) electrical current is induced in the wire.

You can improve your chances of picking up this tiny signal by increasing the number of turns or enlarging the size of the antenna. As the number of turns increases, the distributed capacitance also increases, which lowers the resonant frequency. Also, when the number of turns increases, the resistance of the wire increases too, causing the amplitude of the signal to drop.



The open-circuit voltage at the loop terminals is induced by the time-varying magnetic flux through the loop.

the open-circuit voltage can be expressed as:

$$V_{oc} = j\omega\mu SH^i \cos\psi \sin\theta_i = j\beta SE^i \cos\psi \sin\theta_i$$

V_{oc} is maximum for $\theta_i = 90^\circ$ and $\psi = 0^\circ$.

From http://www.ece.mcmaster.ca/faculty/georgieva/antenna_dload/current_lectures/

There is a lot of information on the Internet regarding various techniques to improve the signal to noise ratio by using larger wire gauge, adding tuning capacitance, etc. Perhaps you can design the “ultimate” SuperSID antenna!

Fortunately, VLF stations are operating at very low frequencies and the availability of new electronic amplifiers can magnify little signals hundreds or thousands of times. These operate at very low voltage and are low cost. These technologies have allowed us to build antennas using simple materials found at local hardware stores.

Step 3. Install and Connect Your Hardware

Move all your hardware components, including your antenna, to the room where the computer is to be located. The VLF signal can penetrate deep into the Earth and seas so it can easily enter the room. Now, you are going to:

a. Install your sound card
b. Collect and hook up your system components -- antenna, SuperSID, power transformer, and computer

Sound Card Selection & Installation

From the SuperSID perspective, there are 2 types of sound cards:

1. AC97 -- samples at 48 kHz
2. HD (high definition) – samples at 96 kHz

If you live in North or South America, you will need to have an HD sound card that can sample audio signals at 96 kHz. Most computers come with a sound card as part of the mother board. These typically are AC 97, which will only record or sample at 48 kHz. You can see what sound card is installed on your system by doing[4]:

Start ->	**Settings->**	**Control Panel ->**	**Sounds and Audio Devices ->**	**Audio (TAB) ->**	Check the drop-down menu to see if more than 1 sound card is installed

If your sound card includes "HD" in its name, you have what you need. You may have to google your soundcard name to learn more about it. We highly recommend using a High Definition (HD) sound card for capturing SID data. An inexpensive sound card like the Sound Blaster's Audigy SE ($29 in the US) can sample (record) audio signals at 96 kHz, giving us the full VLF range.

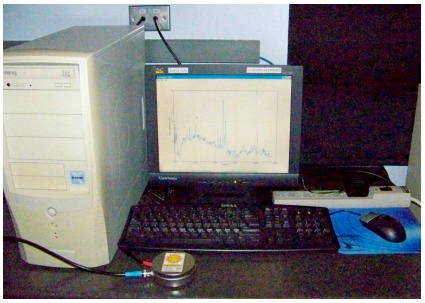
Many VLF stations in Europe and Asia are transmitting at frequencies lower than 22 kHz. These stations can be monitored with earlier sound cards (AC97 standard). These sound cards are widely available on PCs and laptops.

Appendix D shows you how to install a sound card, if you need to. If you do install an HD sound card, be sure to install the driver software that came with the sound card CD (and skip other bundled applications, which you won't need). If you run into trouble installing your sound card, check Appendix E for troubleshooting tips.

Note: There may be more than one sound card installed on your PC. There may be multiple audio input channels like CD ROM, microphone, line-in which can be enabled and muted independently. Double check to make sure you enabled Line-in of the newly installed Audigy sound card and that it is not being muted.

[4] Something like this should work for Windows XP to see what device is installed, but it will not show a sampling rate on the AC97.

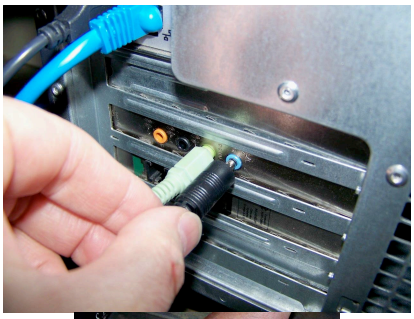
Hook up your system components



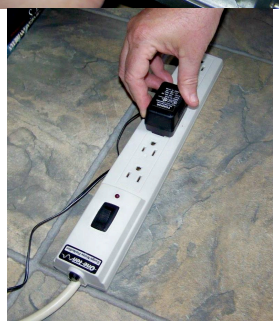
1. Collect your computer and SuperSID preamp. Temporarily set up your antenna near your SID and computer



2. Plug your coax cable from the antenna into the antenna input on the SID monitor



3. Plug the SuperSID cable into the AUDIO INPUT port on your computer.



5. Plug in the SuperSID power transformer.

6. If you have them, connect the powered speakers to Line-out (green) of the Audigy sound card. Check "mute" settings and try a lower frequency tone (like 2 KHz) into Line-in (high frequency tones > 20 kHz are not very audible).

Step 4. Install Your Software

Quick overview:

1. You will need to collect some specific information about your site, its location, your monitor ID, and your time zone. Details are below.
2. Copy SuperSID files from your distribution disk

3. Adjust the configuration file for your site

Collect your Site Information

a. Site name _____
(your site's 3-10 letter identification or site name; **no spaces**; you probably chose this, and can find it on your order form)

b. SuperSID serial number _____
(Your instrument's serial number. It is in the form of 3 or 4 digits and is written on your monitor.)

c. Your site's location: latitude: _____ **longitude** _____
(The latitude and longitude of your site, in decimal form (ddd.ff). See Appendix G for how to obtain these.)

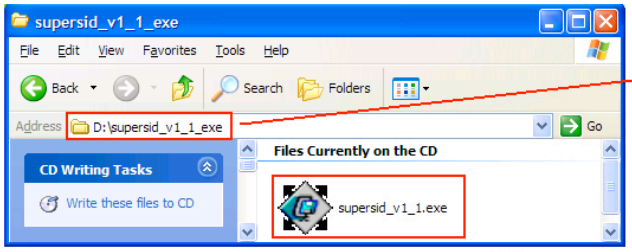
d. Time Zone: _____
(See Appendix K and http://www.worldtimezone.com/wtz-names/timezonenames.html)

e. Number of hours you are before or after Universal Time (UTC):
_____ (See http://www.worldtimezone.com/)

Copy SuperSID files from your Distribution Disk

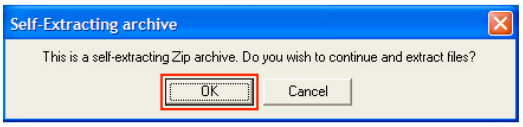
a. Load your SuperSID Installation CD into your computer. Bring up a Windows Explorer window to access it (this may happen automatically).
b. On the CD there is only 1 file: **supersid_v1_1_exe** (*or a similar name*). Double-click on the filename.
c. This should bring up a window with a message similar to: "This is a self-extracting Zip archive. Do you wish to continue and extract files?"
Click "OK".
d. Next a window will ask to where you want to extract the files. Make sure this is set to something like **C:**. Then click "**OK**".
e. Once your files have been extracted, familiarize yourself with the directory structure and files of the installed software. These should include:

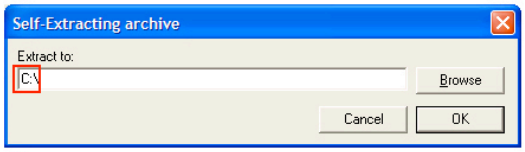
C:\supersid_v1_1	**\Config**	Location of the configuration file – supersid.cfg
	\Data	Your data files will go here. We put some samples there for you to look at.
	\Doc	A collection of various documentation that might be useful for working with your SuperSID and understanding your data. **Teachers – there are 2 guides for you here!**
	\Program	A collection of scripts, programs, and files that you will need to run your SuperSID.

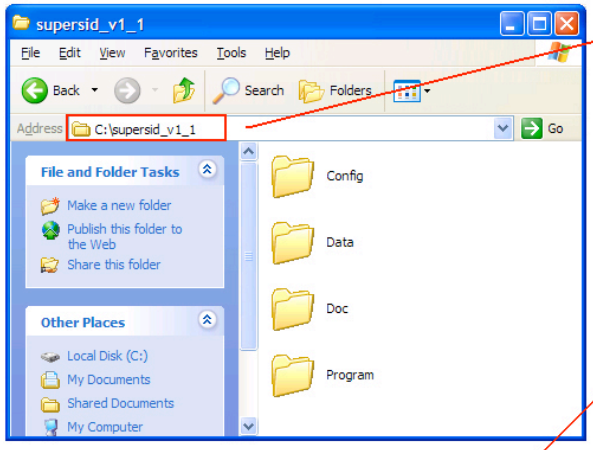


SuperSID Software Installation:

1. On CD, there is 1 file called 'supersid_v1_1.exe'
   Double click on it to unzip the file to C:\

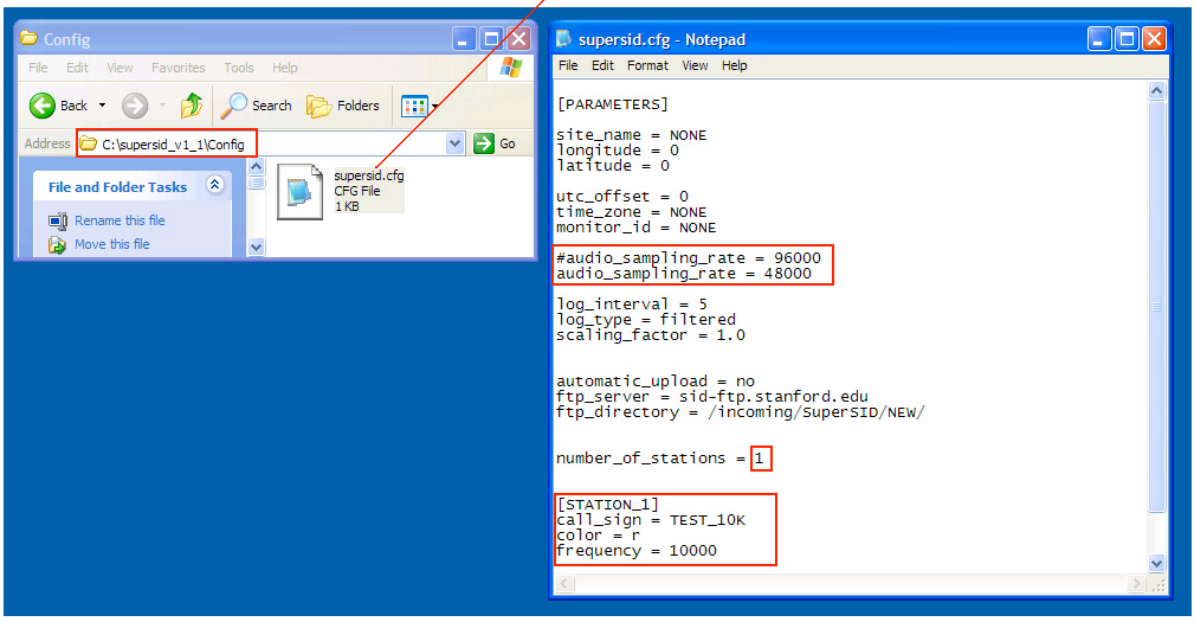






2. There should be 4 folders under C:\supersid_v1_1
   - Config
   - Data
   - Doc
   - Program

3. We can modify C:\supersid_v1_1\supersid.cfg
   to minimal to test run the software.
   (without antenna, preamp, HD sound card)
   Simplest config file looks like this.



Adjust the Configuration File for Your Site

If you wish, you can test your configuration file before you change it. See the instructions in the previous image.

Before starting the software you **must** configure it. This means you must tell it some specific information about your site. You now need the information you gathered at the beginning of this step (your site name, you SuperSID's serial number, etc.) Bring up Windows NOTEPAD, or whatever editor you prefer, and edit the file:

C:\supersid_v1_1\Config\supersid.cfg

(Note – the file name versions may be slightly different as we update the SuperSID software.)

Start -> **Programs** -> **Accessories** -> **Notepad**

When the Notepad window shows, do **File** -> **Open** -> then maneuver to the CONF directory above. Set the pull down menu **"Files of type"** to "**All Files.** Then double click on **supersid.cfg**

As distributed, your configuration file should look something like this:

```
[PARAMETERS]

site_name = NONE
longitude = 0
latitude = 0

utc_offset = 0
time_zone = NONE
monitor_id = NONE

audio_sampling_rate = 96000

log_interval = 5
log_type = filtered
scaling_factor = 1.0

automatic_upload = no
ftp_server = sid-ftp.stanford.edu
ftp_directory = /incoming/SuperSID/
number_of_stations = 6

[STATION_1]
call_sign = NAA
color = r
frequency = 24000

[STATION_2]
…
```

The various fields in the configuration file are described in Appendix H. You only need to change some of them. Using the information you collected earlier, make the changes necessary for your site. Right now, only adjust the first 6 parameters (in bold above).

Here is an example for a site in Africa:

```
…
site_name = ETHIOPIA-2      [remember – no spaces]
longitude = 38.42
latitude = 9.02

utc_offset = +03:00
time_zone = East Africa Time (EAT)
monitor_id = 149
…
```

Now, you will need to set the audio_sampling_rate to whatever your sound card's rate is, either 48000 or 96000. This is an important parameter, which MUST match with what the installed sound card is capable of (and you cannot change its sampling rate by changing the value here)**.**

audio_sampling_rate = 48000 *If you have an older AC97 sound card.*
or **audio_sampling_rate = 96000** *If you have an HD sound card or purchased one from us*

Reminder: **Sites in North and South America are required to have HD sound cards** (and to set audio_sampling_rate = 96000) Sites in Europe, Asia, and Africa can get by with the smaller rate (set audio_sampling_rate = 48000) but they will be able to pick up more transmitters if they install an HD sound card.

After you've made the changes to the configuration file, save your file
in **Notepad, File -> Save**

Later, once you are sure of your data, you may go back to change automatic_upload = yes to enable the sending of your data files to Stanford. More on this later.

Check Appendix H for an explanation of the various other fields in the configuration file. However, most of these you will not need to change.

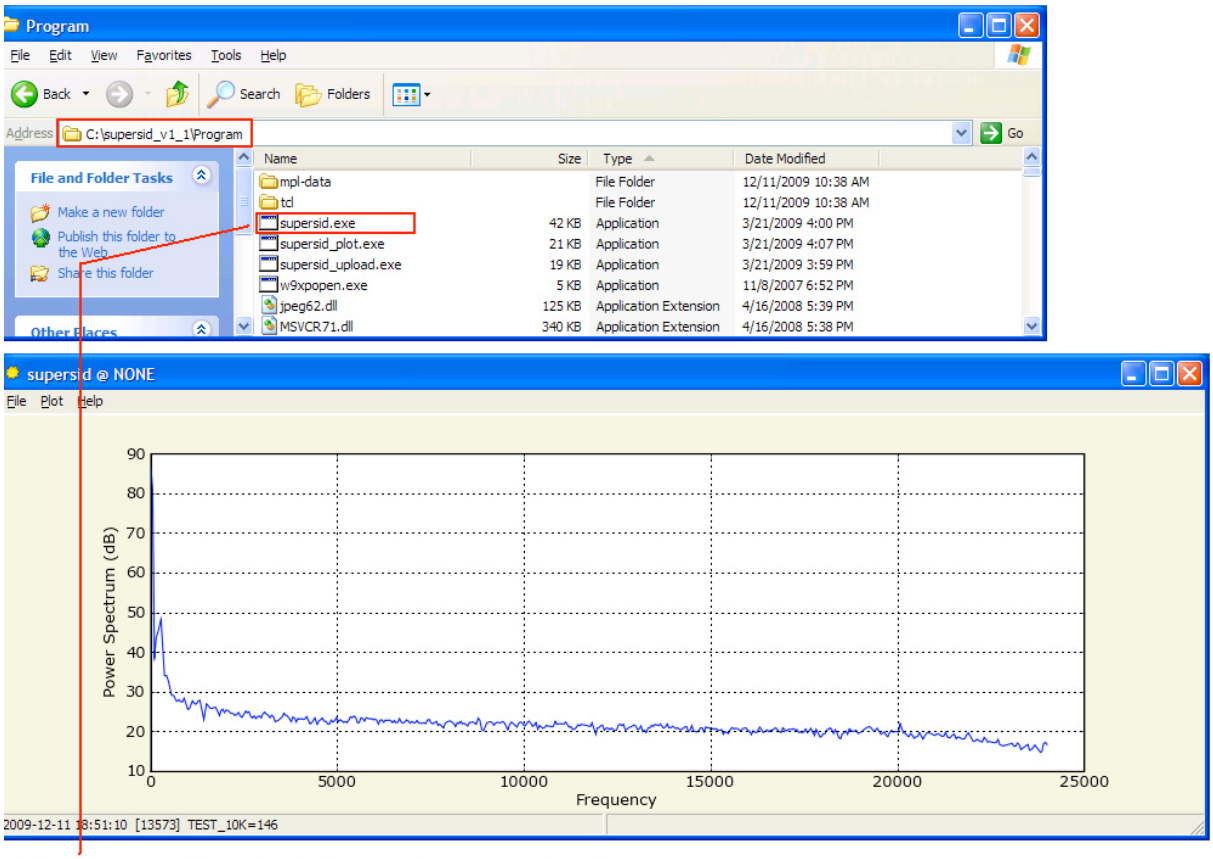
Step 5. Test, Collect Data, and Troubleshoot

Once your hardware, software, and antenna are installed, you are ready to try to get your system to work. You are going to:

1. Start your system
2. Look at your data files
3. Troubleshoot your data files

Start your SID

After configuring your supersid.cfg file, go to **C:\supersid_v1_1\Program** and double click on **supersid.exe:**

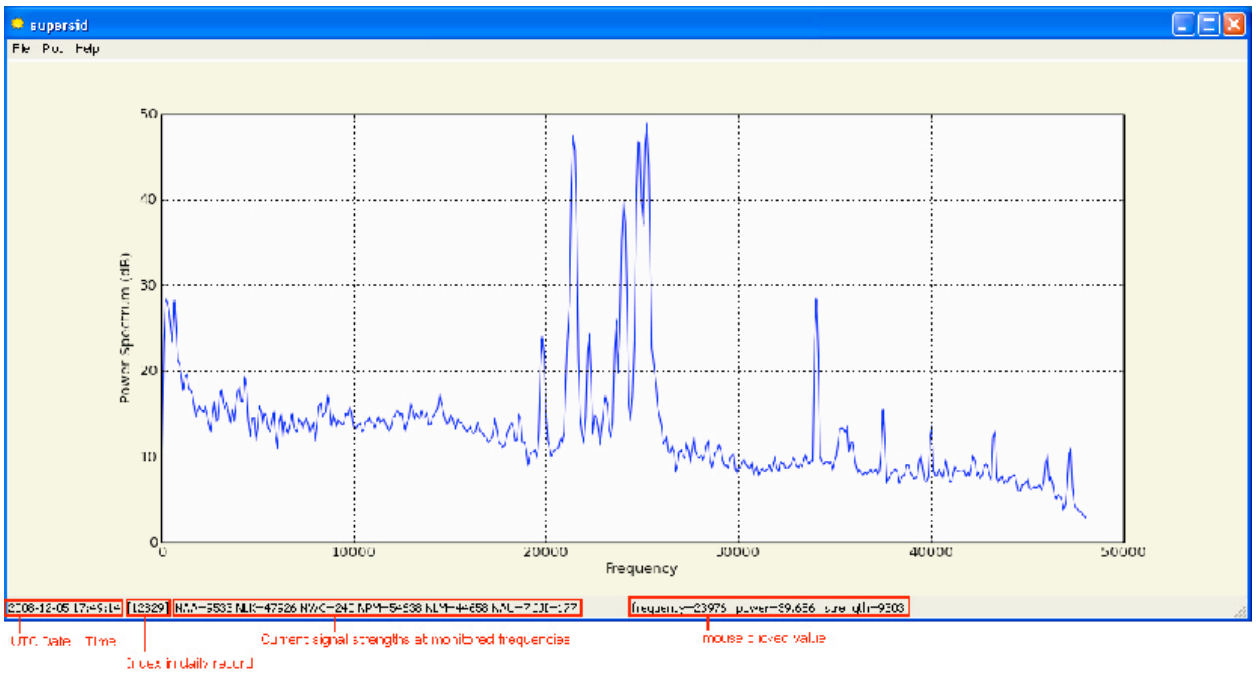


4. Double click on C:\supersid_v1_1\Program\supersid.exe to run the program and here how the spectrum would look like.

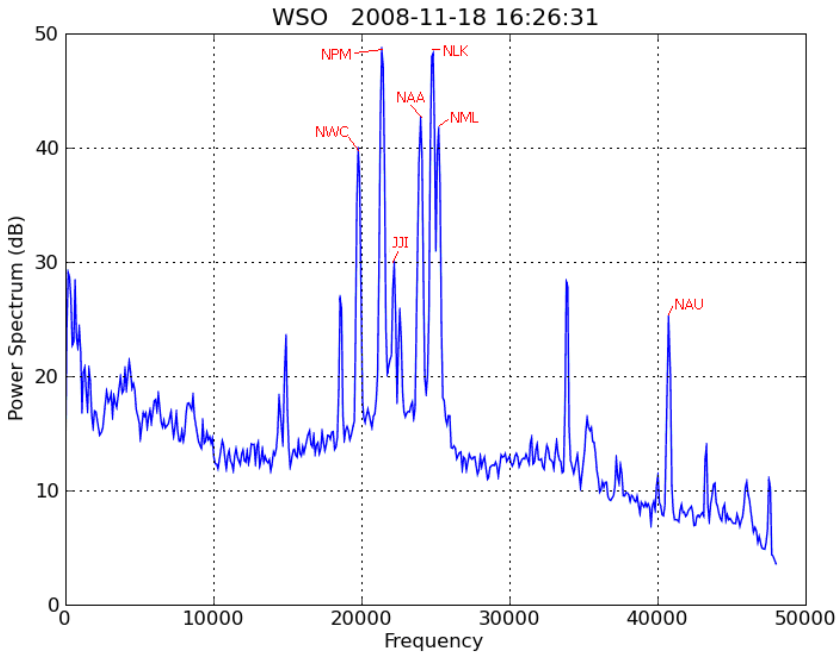
The main window from the supersid application should automatically come up (see above). Amongst other things, it allows you to:

- Click on a graph to inspect spikes which represent various transmitters
- Generate a testing tone to see if it appears on the system
- Sample data files

Below is a sample plot showing how a VLF spectrum might look with real data. The signal strengths of the radio stations appear as vertical spikes standing in the noise floor. While the noise floor raises and drops very wildly from one second to the next, these spikes stand solemnly. These spikes slowly rise at night and lower to a stable level during the day. Although your SID instrument collects data all day (24 hrs), we are only interested in monitoring the peaks' values, or signal strength variations through the daytime.



To inspect the frequencies at the peaks, click on the peak and the program should show the transmitting station's call letters (e.g. NAA). This is very handy since when you first set up an antenna, you don't know exactly which VLF stations will be available in your area. We've labeled the peaks for you here:



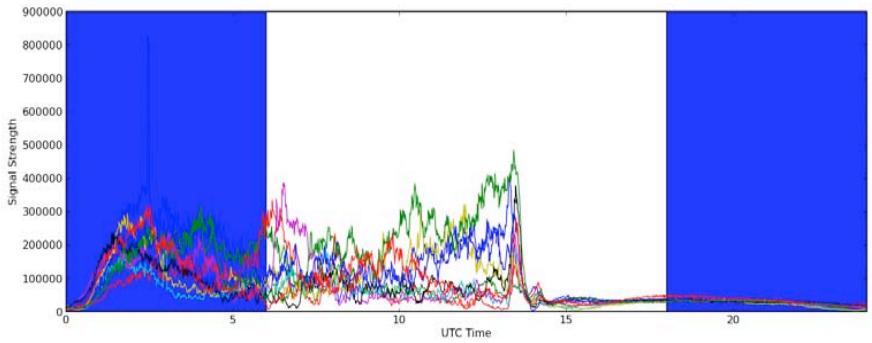
You can rotate your antenna around to see which VLF stations seem to be consistently high above the noise level during the day. These are good candidates to monitor. Your goal is to have the peaks as high as possible and the noise floor as low as possible (this is

called the signal-to-noise ratio). The daily plot will be cleaner when you have a good signal-to-noise ratio. If you cannot find any peak that seems to be consistently raised above the random noise level, you probably need to relocate the antenna to a better location further away from power lines and building electric interferences, realign (repoint) the antenna, build a larger antenna, or shorten the antenna cable. See Appendix F for common sources of electrical interference.

If you are in North or South America, the configuration file already lists the major transmitters you may be picking up. However, if you are elsewhere, you may need to adjust your configuration file to add transmitters. See Appendix H.

If your system is working, every 5 seconds supersid wakes up, collects 1 second of signal strength data for each of the peaks, calculates the power spectrum density (using Welch's method[5]), and (re)displays the spectrum on its main window. That collected information eventually becomes your SID data.

Below is an example plot of one particular VLF transmitter's signal strength variation over several days. The Sun was not very active when these data were taken, so the daytime patterns (right half of the graph) are very flat.



View Your Data

When the supersid software is running, it will produce signal strength data files. Typically, the signal strengths are kept in memory and written to text files at the end of the day (at 24 UTC, in the /Data folder). For each station/transmitter listed in the configuration file, the software will produce a separate data file in the data directory. Your SID data files should be located in:

C:\supersid_v1_1\Data

You can plot a data file by clicking the Plot pull-down menu on the SuperSID window, or by using:

C:\supersid_v1_1\Program\supersid_plot.exe

by dropping a data file onto its short-cut icon. If you wish to compare data from different

[5] http://en.wikipedia.org/wiki/Welch's_method

files, you can click on Plot again without closing the previous graph window. On the graph window, there are handy tools for Zoom/Pan, Scale/Drag, Go Back, and Crop and Save image. Refer to Appendix I for other options on viewing SID data.

Data File Names
Information is stored both in the data files and in their names. The filename is based on your sitename, the transmitter being monitored, and the timestamp for the first entry in the data file. A sample SuperSID filename is:

SARA_NAA_2009-11-10.csv

Parsed as this:

SiteName		*Station/Transmitter*		*Year*		*Month*		*Day*	.	*cvs*[6]
SARA	**_**	**NAA**	**_**	**2009**	**_**	**11**	**_**	**10**	**.**	**cvs**

The file format:
Here is what a sample data file might look like (viewed in Notepad):

```
# Site = SARA
# Longitude = -84.88
# Latitude =35.25
#
# UTC_Offset = -5
# TimeZone = Eastern Standard Time
#
# UTC_StartTime = 2009-11-10 00:00:00
# StationID = NAA
# Frequency = 24000
# MonitorID = 179
# SampleRate = 5
# This is a comment
2009-11-10 00:00:00, 0.0907684922409
2009-11-10 00:00:05, 0.0901194958269
2009-11-10 00:00:10, 0.0894704994129
2009-11-10 00:00:15, 0.0888215029988
… and so on
```

The file begins with a collection of header lines, each starting with a '#' and most having a keyword=value pair. The keyword-value pairs are taken from your SuperSID configuration file. You can also include whatever comments you want by preceding them with "#".

[6] cvs stands for "Comma Separated Values." Calling a file .CSV makes it easy to open as an **MS Excel®** file. However, you can use any data graphing / processing program you like including the one we provide or ones that you write yourself!

After the header is completed there should not be any more comment lines, then the data follows. Timestamps are always in UTC time:
<Timestamp 1>, <Data 1>
<Timestamp 2>, <Data 2>
<Timestamp 3>, <Data 3>
etc.
Once your system is generating data files, you should **move your antenna to its permanent location**. Then double-check that you are still getting a good signal.

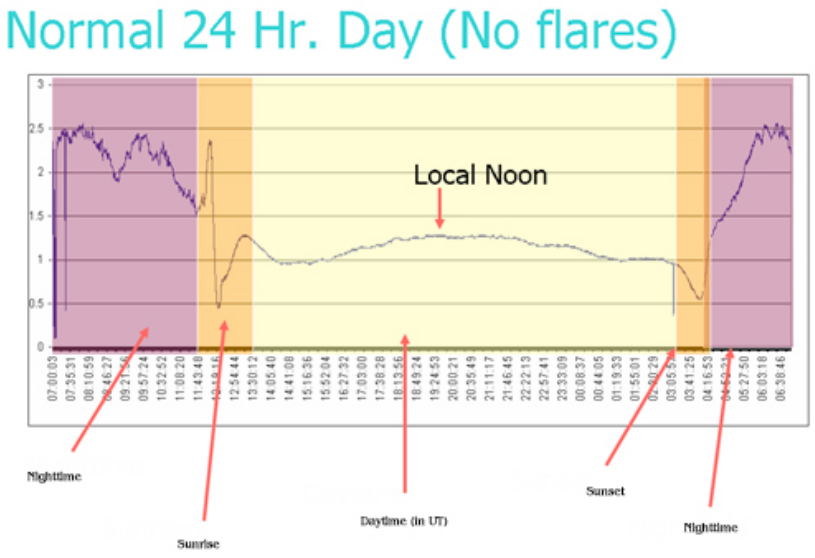
Trouble-Shooting Your Data

Much can go wrong when setting up your SID monitor. The best way to diagnose the problem is run the data log for at least 24 hours to see if you get what we call the "sunrise and sunset effects".

Look for Sunset and Sunrise Signatures

Once you have at least 24 hours-worth of data, try producing a data graph (as described above). If you can, look at graphs from several days at first to see what patterns emerge. Every day should have a distinctive sunset and sunrise pattern. Look for a graph that slopes sharply downward at sunrise and sharply upward at sunset. The area between them is where we will be doing our flare hunting. Remember that SID data is kept and labeled in UTC time, so you will need to compute when your local sunrise and sunset times are.

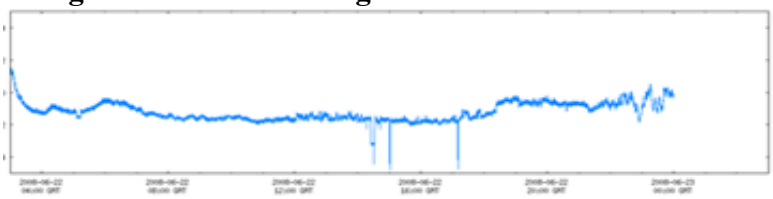
If everything is fine, the data should look roughly like below, with a normal low-signal-strength daytime period, specific sunrise and sunset signatures, and a high-signal-power nighttime period. (If you have fewer than 24 hours of data, it will be hard to diagnose.)



We added the colors, arrows, and labels to help you understand the chart.

Comparing a few graphs, what patterns in the data can you see? Is there a sharp spike every day at the same time or is the graph really spiky all the time? Get a "feel" for what your SID monitor data are like. Sometimes data are more rounded and sometimes they spike sharply, it depends on what other "noise" your detector is picking up. Noise can't always be helped so it's a good idea to learn what the background signature of your SID monitor is.

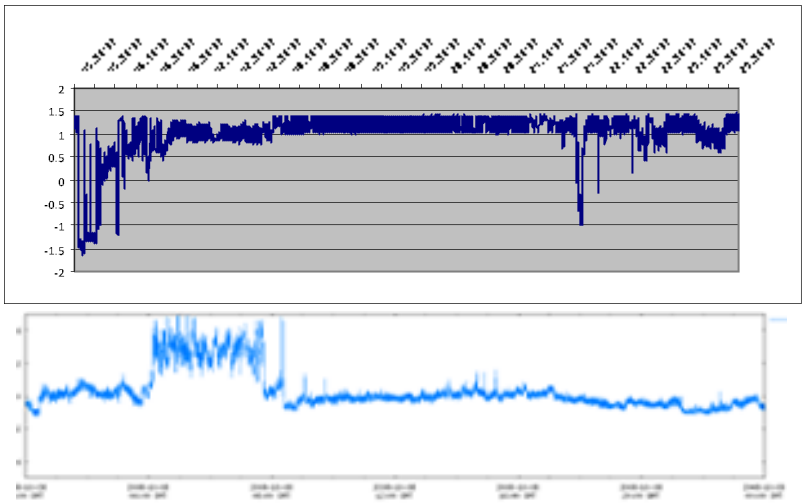
No Sunrise/sunset Signature Means No Signal



If you cannot find any sort of day-night pattern, then you are probably not picking up a signal from any of the transmitters. This usually indicates an antenna problem:

a. Recheck that all the antenna cables and connectors are properly installed (see earlier sections of the manual).
b. Adjust the antenna bearing, i.e. repoint your antenna to a different direction.
c. Move the antenna to a more electrical-noise-free location.
d. Shorten the coax connecting your antenna and monitor.
e. Build a larger antenna.

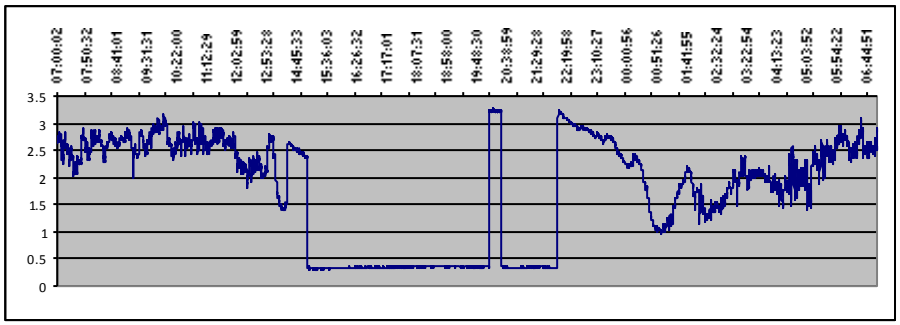
Noisy Signals - Interference



Above are two graphs taken from very "noisy" environments. The problem is interference from some local electric device(s). Whatever is causing the noise completely swamps out the signal and, in the upper case, even the sunrise / sunset effects. Although isolated spikes on your graph can show ionospheric response to solar flares, the frequent appearance of spikes generally indicates electrical interference. See our list of common sources of interference in Appendix F. Solutions for dealing with noise include:

1. Move the antenna to another location further away from building electrical interference (elevator, microwave oven, computer terminal, power lines, old fluorescent light ballasts....)
2. Attempt to realign/repoint the antenna.
3. Build a larger antenna. We have worked with square antennas with a diameter 1-2 meters, with 25-30 wire-loops.

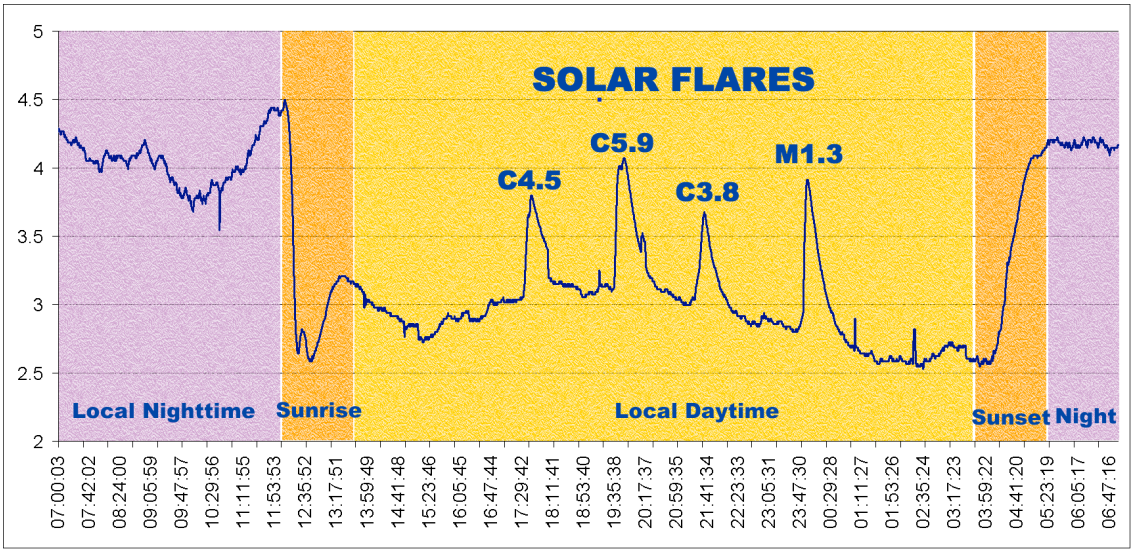
Transmitter Down (for Maintenance?)



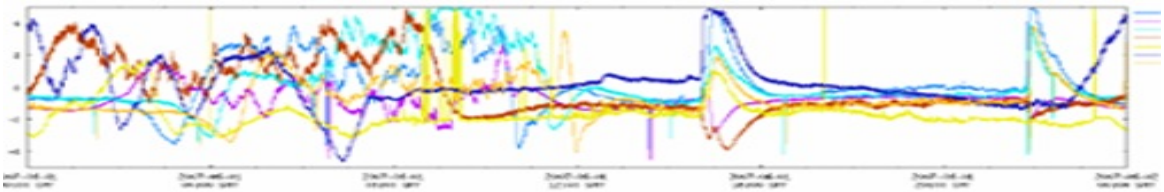
Are there places in your data where the graph "flat lines?" If you have several weeks of data, you might see a pattern to the timing of those flat lines. Each of the VLF transmitting stations goes down for maintenance about once a week, usually on a regular (albeit unpublished) schedule. The graph above shows such a period. After a few weeks of data collection, you should see a pattern that responds to your station's maintenance schedule.

Identifying Solar Flares

Solar flares have a very characteristic shape – a swift increase in signal strength followed by a slower decrease:



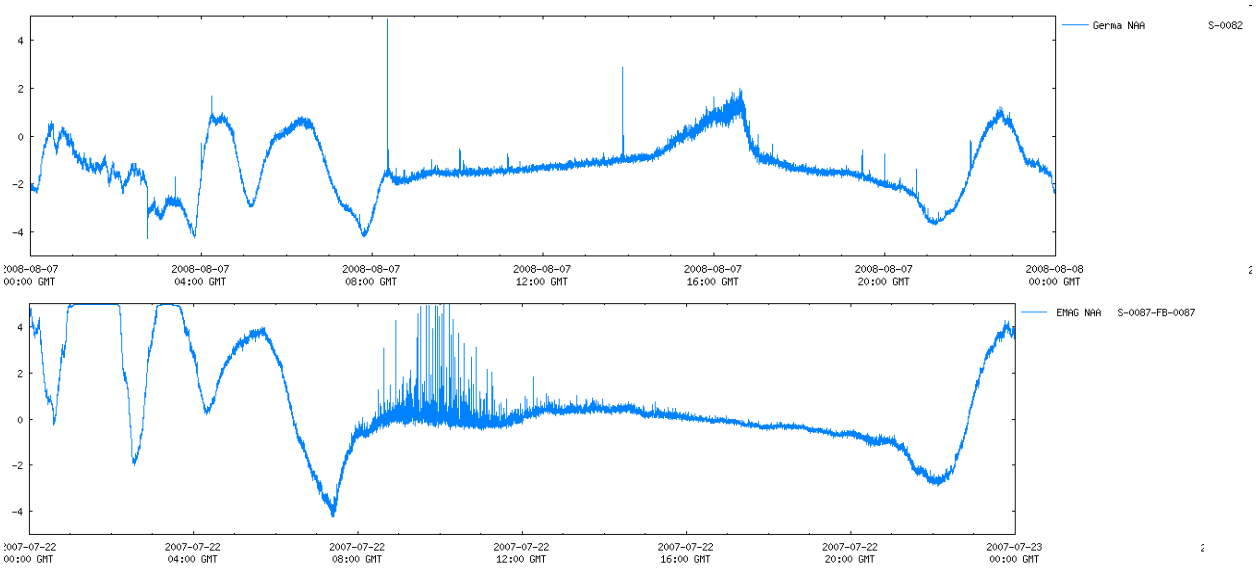
Occasionally, flares can show up as a decrease in signal strength:



The above SID chart, from our SID data browser, shows an M2.8 class solar flare on 1 June 2007. Seven sites picked up this flare (the 7 different colored lines). Note that 2 sites picked up the flare as a decrease, rather than increase, in signal strength. This is due to destructive interference of the VLF waves between those sites and the transmitters. So, your data may show either dramatic increases, or dramatic decreases, in signal strength to indicate a solar flare.

Identifying Anomalies

Strange occurrences on SID graphs are not uncommon. Most are difficult to track down. Below are 2 graphs, from 2 separate occasions, where lightning during a local thunderstorm has produced anomalies on the graphs:



Lightning-induced fluctuations

We are not sure what causes other anomalies. Gamma Ray Bursts have been implicated, but as yet we have not verified a GRB on a SID graph. Meteors or meteor showers? Local electrical anomalies? Nuclear tests? Earthquakes? What else do you think they could be?

Step 6. Send your data files to the Stanford data-server

When you are sure your monitor is set up and your data being accurately recorded, you can arrange to send your data files to the Stanford data repository, where students all over the world can share each other's data:

http://sid.stanford.edu/database-browser/

The supersid application contains code to ftp[7] (electronically send) your data to Stanford every day. You must have access to the internet for this to work.

To have your SuperSID system automatically send your data to Stanford every day, edit (via Notepad) your configuration file:

C:\supersid_v1_1 \Conf\supersid.cfg

and set **automatic_upload = yes** (the default was "no").

To turn off automatic data ftp to Stanford, simply reset automatic_upload = no.

[7] File Transfer Protocal – see http://en.wikipedia.org/wiki/File_Transfer_Protocol

Chapter 3 – Safety and Maintenance



Photograph by Alan Moller
NOAA / NWSFO

Stanford is not responsible for accidents or injuries related to monitor use. You are responsible for safety in the installation of your antenna and securing the antenna so that it cannot cause damage should it be blown around, the cable be yanked by a curious person, or it being struck by lightning. If you cannot ensure a proper installation, then find someone who can professionally install your antenna for you.

Antenna Placement

1. The loop antenna is intended for picking up electromagnetic waves from the sky. Since the signal is very small, the antenna needs to be far away from building electrical interferences. Also, **the antenna should NEVER be placed higher than surrounding trees or structures where it can be potentially hit by lightning!** The antenna can be placed inside, in a wooden structure, house, barn, or on a wooden wall -- anywhere there is not too much electrical interference. This will also help protect the wire loop from the weather, UV light, and lightning.

2. The antenna should be placed in a location where it will not be disturbed. If the antenna were blown around or off a roof would anyone get hurt or would property get damaged? Take extra steps to secure the antenna. The cable should have some strain relief to prevent the coax from being pulled or tugged.

3. Does the coax cable cause you to have an open window or door? Does this pose a security risk of a break-in, or allow outside weather to enter the building?

4. What wiring codes or policies does your local government have? The antenna wire is passive and itself does not have any power on it, but still, there might be some rules to observe. For instance, the exposed terminal block may need to be covered according to your local laws.

5. And last, but not least, use common sense – each installation will be unique and of course we can't cover everything you may encounter, but you should take the time to research and plan this installation.

Antenna Maintenance

Your antenna needs very little maintenance if construction and installation are done properly. Periodic checks of the antenna should be made for signs of corrosion or deterioration. If the signal should suddenly drop out, the antenna should be checked to make sure it has not been moved or turned or the wire become disconnected.

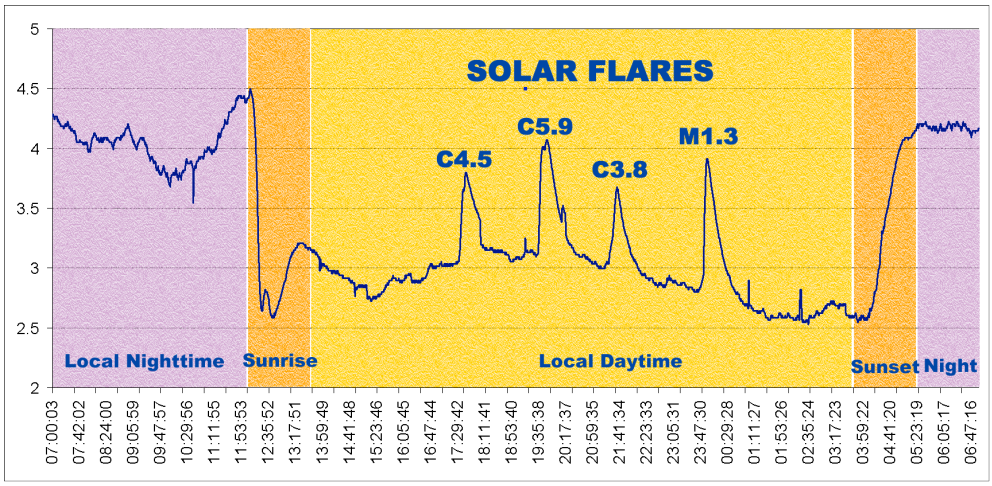
If any maintenance is to be done it is important to mark the location and orientation of the antenna with something such as paper, tape, or chalk before touching the antenna. This will assure that the antenna can be returned to the exact same orientation and will produce similar results as before.

Monitor Maintenance

You should not need to adjust your monitor. Its internal adjustments were not designed for student use. If you have a problem with your monitor, contact the SuperSID Monitor team:

SuperSID@radio-astronomy.org

Chapter 4 – Interpreting Your Data and Looking for Flares



Data for August 2 (colors and labels added)

SuperSID data graphs yield information about the Sun and how it is affecting the Earth. You have already been introduced to the SID data formats in Chapter 2. You will now learn how to interpret your SID data and identify solar flares. Then, you will be confirming your data with the GOES satellite data found in the Space Environment Center (SEC) online database. If you wish, you can even track the event you located back to the sunspot or active region on the Sun that produced the flare! You may also find other more "local" events that interfere with the data but also provide us with information that is useful.

Identify Potential Solar Flares in Your Data

This step is fun, rather like a treasure hunt. Look at your graphs to see if there are any large spikes in the data. The spikes will rise (or drop) very steeply, come to a peak, and then taper off, as in the example above. These are possible flare signatures. For SID monitors, our nemesis is "noise", interference from sources other than the Sun. Sometimes noise is very clever and tries to look like a flare but there is a way to know for sure.

If you don't have access to the internet, skip the next section.

Compare Your Potential Flare to Satellite Data

You can check your SID data with the data from the GOES[8] satellites. These satellites circle the Earth in a geosynchronous orbit, high enough to monitor a full-disc Earth and also watch the Sun for sudden flares. They don't get the same interference that we do because they are in space. The GOES satellites are tracking emissions directly from the Sun, while your SID monitor is tracking the Earth's response to those emissions. However, the shape of flare data on each of the graphs is similar.

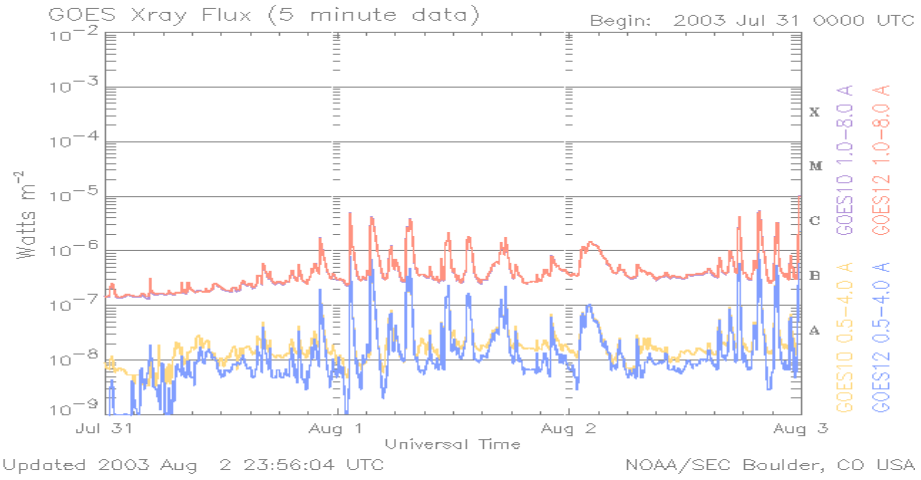
[8] See http://www.oso.noaa.gov/goes/

If you find a potential flare on one of your recent graphs, you can check the current GOES data:

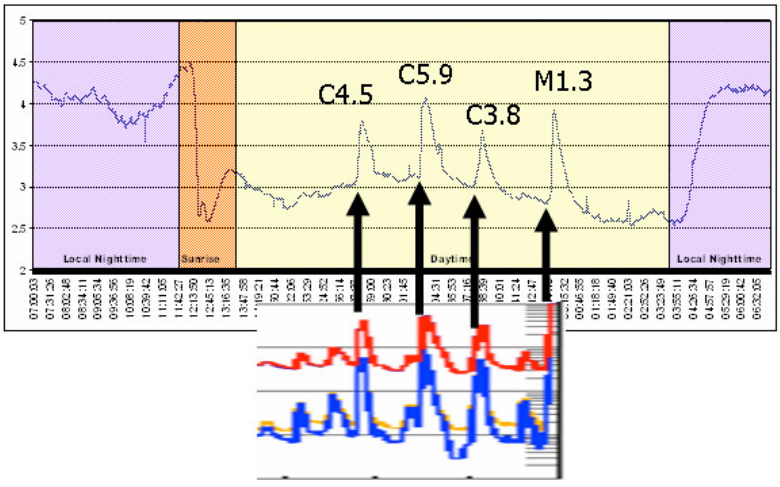
http://www.sec.noaa.gov/rt_plots/xray_5m.html

This site shows data similar to yours, as a graph, though taken from the GOES series of satellites. The graph usually shows data for the last few days. Note that the times are given in UT times. It is updated every 5 minutes, so if a solar flare is happening in real time, you can see the changes in the graph!

A sample GOES graph is below. The different colored lines represent data from different channels and different satellites. You only need to pay attention to the uppermost (in our example, the red) line. The x-axis is time, the y-axis (as labeled on the right) indicates the strength of the flare. See Appendix J for information on how solar flares are classified.



Now you can compare your graphs and match up potential flares with those taken by GOES. Notice that the GOES graph above shows 3 (actually 4) flare indications at the end of the day on August 2. The timing of these matches the SID flare data for August 2, the chart we used at the beginning of this chapter:



If the timing of the spikes on your graph match up well with spikes on the GOES data graphs, you have most likely found flares!

If more than a couple days have passed since a potential flare showed up on your graph, you will need to check the GOES catalog of flares at

http://www.sec.noaa.gov/ftpmenu/indices/events.html

The GOES flare catalog will show a list of dates -- links to a particular day's solar data. The dates are in UTC time, as is your SID data.

In the GOES catalog, find the day you want to investigate and click on the link. You will find a page that looks similar to the chart below:

```
:Product: 20050831events.txt
:Created: 2005 Sep 01 2102 UT
:Date: 2005 08 31
# Prepared by the U.S. Dept. of Commerce, NOAA, Space Environment Center.
# Please send comments and suggestions to SEC.Webmaster@noaa.gov
#
# Missing data: ////
# Updated every 30 minutes.
#                    Edited Events for 2005 Aug 31
#
#Event   Begin   Max      End  Obs  Q  Type  Loc/Frq   Particulars      Reg#
#--------------------------------------------------------------------------------
7520 +    0018   0023     0033  G12  5   XRA  1-8A     B1.6    1.3E-04   0806
7520      0024   0024     0024  G12  5   XFL  S18E35    5.0E+01 8.4E+01   0806

7530 +    0052   0110     0123  G12  5   XRA  1-8A     B5.0    5.9E-04   0806
7530      0055   0111     0122  G12  5   XFL  S18E34    8.5E+02 2.1E+03   0806

7540      0155   0156     0156  PAL  G   RBR  410      480

7550 +    0952   1002     1008  G12  5   XRA  1-8A     B3.2    2.2E-04   0806
7550      0958   1003     1007  G12  5   XFL  S17E32    6.5E+02 1.6E+03   0806

7560 +    1026   1151     1251  G12  5   XRA  1-8A     C2.0    1.2E-02   0803
7560      1028   1028     1031  SVI  U   RBR  606      320             0803
7560      1028   1028     1028  SVI  G   RBR  2695     21              0803
7560      1030   1218     1250  G12  5   XFL  N13W13    4.8E+03 1.1E+04   0803
7560 +    1042   1042     1042  SVI  G   RBR  245      75              0803
7560 +    1042   1042     1042  SVI  G   RBR  410      80              0803
```

If you would like detailed information on the contents of the GOES catalog reports, see: **http://www.sec.noaa.gov/ftpdir/indices/events/README.**

Note that the top three lines of the catalog will show you both the date this particular table was created (Created: which you can ignore), and the date of the data (:Date:). **Check that the ":Date:" is the one you want to be looking at** (not the "Created" date)**.**

The event reports include 10 columns:

<table>
<tr><td>Event</td><td>This column is a way that SEC uses to catalog solar events in their own system, so we can ignore it.</td></tr>
<tr><td>Begin</td><td>Time in UT that the event started. For instance, in California any time before about 1200- 1400 is in the night time (depending on what season it is since the Sun rises at different times) so when you are looking for your events start further down in the 1300's.</td></tr>
<tr><td>Max</td><td>This is when the event has hit its peak X-ray flux (its highest output). This is useful when dealing with a flare whose beginning has been lost in interference or sunrise/sunset.</td></tr>
<tr><td>End</td><td>This is when the flare or event officially ends.</td></tr>
<tr><td>Obs</td><td>This column stands for observer, and tells you which of the GOES satellites is reporting the event. Different satellites report different types of events. We are most interested in the G12 and G10 satellites, which report solar flares.</td></tr>
<tr><td>Q</td><td>This is for radio bursts, sweep frequencies, storms and optical flares. It's a way of categorizing the quality of the data they received. Since SID can pick up some radio bursts and optical flares you may want to read more about the Q column in the README file listed above.</td></tr>
<tr><td>Type</td><td>This column is very important -- it tells you what type of event has occurred. Remember SID can only pick up things that disturb our ionosphere but there a lot of other things going on out in space! Solar flares are listed as XRA for X-ray event. These are the events that you will pick up on your SID.</td></tr>
<tr><td>Loc/Frq</td><td>This stands for Location or frequency. Ignore this.</td></tr>
<tr><td>Particulars</td><td>This column tells how big a flare GOES detected. To understand it, you need to know how solar flares are classified. Appendix J gives more detailed information, but here is an overview:
<table>
<tr><td>B class flares</td><td>The smallest flares, which occur frequently. SID is not sensitive enough to detect them.</td></tr>
<tr><td>C class flares</td><td>Some of the C class flares can get pretty big. SID is able to detect flares Class C2.0 or above, although there have been incidents where we have picked up C1.0 flares.</td></tr>
<tr><td>M class flares</td><td>Are larger yet and occur less frequently. These should be very apparent on your SID graphs.</td></tr>
<tr><td>X class flares</td><td>These are huge and easy to detect. If aimed at the Earth, they can cause major disruptions in cell phone communication, radio, and power grids. In October of 2003 an X25 flare was captured, the largest flare recorded in history! Some X class flares are too much for SID to handle and they will peak off the charts, causing a plateau effect.</td></tr>
</table></td></tr>
<tr><td>Reg#</td><td>This column tells you which active region of the Sun produced the event.</td></tr>
</table>

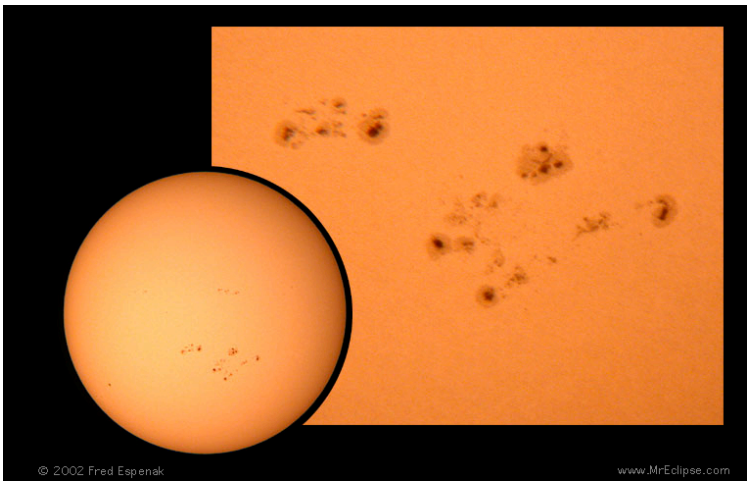
Compare the information in the GOES catalog with your potential flare detection. If the GOES catalog indicates a flare at the time your graph shows a spike, you have most likely detected a flare!

Sometimes SID monitors pick up flares that do not appear in the GOES catalog. Then you have found an "undocumented" flare! It doesn't appear on the charts because the charts are reduced from the graph data by humans, who sometimes make mistakes. We are looking into the possibility of having flares detected by students be incorporated into the general GOES catalogs.

Remember that the GOES satellites are detecting solar flares as they are emitted from the Sun. Your SID monitor is detecting changes to the Earth's ionosphere caused by those same flares. So while your monitor and the satellites are tracking different effects, they are based on the same phenomena.

Track a Solar Flare to its Source on the Sun

Active regions are places on the visible surface of the Sun containing strong magnetic fields in complex configurations. They are often associated with a particular sunspot or sunspot group. You can think of them as magnetic storms, in constant change and flux. These active regions are usually the source of the solar flares you have detected.



Solar active regions

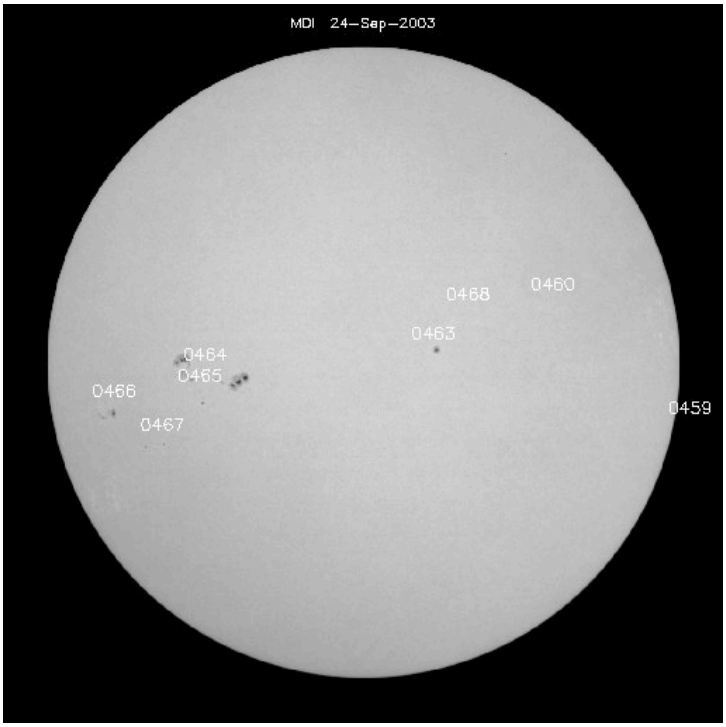
Active regions are given consecutive numbers by scientist/watchers as they appear on the disk. If you have detected a flare and want to know where on the Sun it came from, look at **REG#** in the GOES catalog listing (above).

To see the region numbers identified on the Sun, go to:
http://sohowww.nascom.nasa.gov/
and hit **"Sunspots"** in the upper right corner.

The current day's solar active regions will be shown there. If you need to check for previous

days' images, hit the "**List of all available daily images**" on that same page.

The images of active regions come from the great Solar and Heliospheric Observatory (SOHO), a spacecraft circling the Sun and on which our Stanford team has an instrument, MDI. Below is a sample image of the Sun listing the "active regions" from which solar flares or other events might have emanated. Note that each new sunspot or active region will receive a new number so these images change frequently. Find the image for the day you think you found a flare, and look up the image to find the active region.



Active regions identified (image from SOHO/MDI)

Find the Birth of Active Regions in "Farside" Data

Your SID monitor only picks up flares from the side of the Sun facing Earth. But often, the sunspots or active regions that eventually produced flares actually originated on the back side, or "farside" of the Sun and rotated into view over several days. With some fancy science called helioseismology[9], scientists can virtually "see through" the Sun to track an active region before it gets to the front side! To understand how this works, look at:

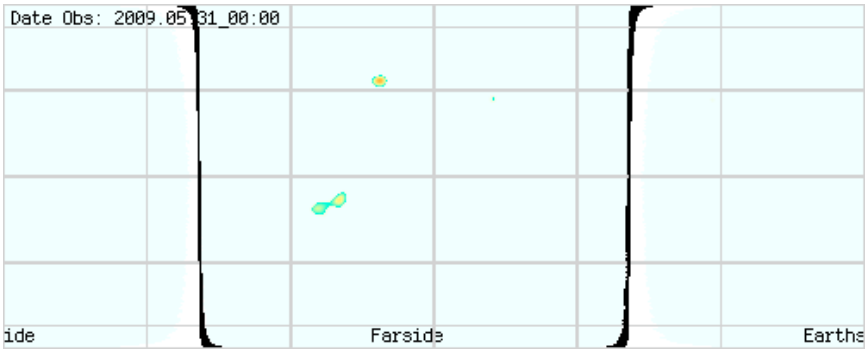
http://www.nasa.gov/vision/universe/solarsystem/soho_xray.html

To see farside images, go to:

http://soi.stanford.edu/data/full_farside/

[9] See http://soi.stanford.edu/results/heliowhat.html

Scroll down the page until you see a list of dates. Pick the date range in which you found your flare. It should provide you with a number of images from the time period, similar to that below.



The layout of this chart is similar to a Mercator Projection map of the world:



Active regions will show up as bright spots on the farside images. Search through the farside charts to see if you can recognize the active region which produced your flare, then track it back in time. Perhaps that active region formed on the back side of the Sun, then rotated into view and produced a flare!

You can look at both farside and front side images of the Sun every day at

http://spaceweather.com

Predicting Flares

Now you have identified a solar flare in your data, found it in the GOES database, and tracked it down to the active region/sunspot group that produced the flare. You can also watch the progress of active regions on the Sun and try your hand at predicting which groups might generate what size of flares, then use your monitor to track your predictions.

The SOHO spacecraft, orbiting 1 million miles from the Earth, takes images of the Sun every day, 24 hours a day. For the most recent images of the Sun, check out:

http://sohowww.nascom.nasa.gov/ and hit "**The Sun Now**" button

Since the Sun rotates on its axis in about 27 days (at its equator), over a period of time you will see the sunspots and active regions move and rotate on or off the visible disk.

Now that you have the tools to investigate your data it should be fun! It will become easier and faster with practice. You may find events that GOES data has not posted or maybe you found an event other than a solar flare. You may be able to make predictions about potential flares and track your accuracy. You are part of a network of people watching the sky and looking for solar flares. If you have found something new or strange let us know. Share your findings with other people in this program.

Teacher Resources

We have prepared a guide for working with SID data -- *Research with Space Weather Monitor Data – Classroom Activities and a Guide for Teachers*. This should have been provided with your SID distribution (in \Docs). If not, it is available online:

http://solar-center.stanford.edu/SID/educators/ForTeachers.pdf

For more activities relating to solar flares, see our Space Weather Forecast curriculum for high school students. This should also have been provided with your SID distribution (\Docs). If not, it is also available online:

http://solar-center.stanford.edu/SID/educators/SpaceWeatherForecast-v.070507.pdf

Chapter 5 - Resources



Photo by David Fritts

More Information about SID Monitors

http://solar-center.stanford.edu/SID

Teaching Aids

Research with Space Weather Monitor Data – Classroom Activities and a Guide for Teachers: **http://solar-center.stanford.edu/SID/educators/ForTeachers.pdf**

Space Weather Forecast – A Space Weather Curriculum for High School Students
http://solar-center.stanford.edu/SID/educators/SpaceWeatherForecast-v.070507.pdf

SID Information for Educators
http://solar-center.stanford.edu/SID/educators/

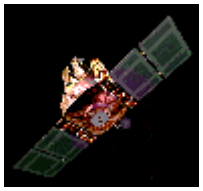
More About Space Weather

For most of human history, the only detectable manifestation of "space weather" was the beautiful auroras. Now, our technological civilization is often perturbed by invisible but powerful blasts from the Sun that have the potential to seriously affect us on Earth. We call this "space weather" – conditions caused by violent transfers of matter and energy from the Sun. The sources can include radiation storms, solar flares, and ejections from the Sun as well as disturbances in the Earth's magnetic field caused by the Sun. Through the SID program, you are already familiar with solar activity's effects on the Earth's ionosphere. Besides those, solar storms not only trigger beautiful auroras, but also damage or kill satellites, disrupt power grids and electrical systems, interfere with cell phones and other communications, and disturb animal movements. They can even threaten astronauts and high-flying airplanes with their radiation!

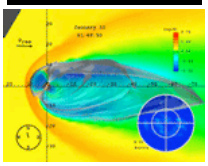
To learn more about space weather on the web:



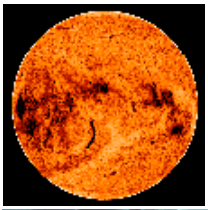
SpaceWeather.com -- http://spaceweather.com
Daily science news, images, and information about the Sun-Earth environment. Find out about recent solar flares, spots on the Sun, current solar wind speed, potential auroras, and spots currently on the front side and back side of the Sun! Check this site daily.



Space Weather Research Explorer – http://www.exploratorium.edu/spaceweather
Produced by the Exploratorium in San Francisco, CA, USA, this website explains space weather concepts and provides links to live data. Hear interviews with scientists who study space weather.



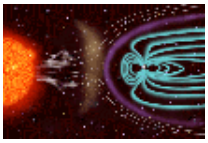
Space Weather Today http://www.windows.ucar.edu/spaceweather/
For students and educators. A treasury of resources on what is happening today in space and on space weather itself. These pages are part of the famous Windows to the Universe project.



Space Weather Center -- http://www.spaceweathercenter.org/
A site designed especially for younger kids. You can learn more about space weather, and even play games like Magneto Mini Golf!



Dr. Sten Odenwald's Space Weather Site http://www.solarstorms.org/
Tells you about space weather's impact on technology and what we can do about it.



Space Weather Now -- http://www.sec.noaa.gov/SWN/
Primary site to provide information about current space weather conditions and predictions. Developed by NOAA/National Weather Service of the USA.



To get started on the topic of space weather, see the Stanford Solar Center -- **http://solar-center.stanford.edu/solar-weather/**



Space Weather for Pigeon Racers and Fanciers http://solar-center.stanford.edu/solar-weather/pigeons.html
Space weather conditions interfere with racing pigeons' ability to navigate.

Books on Space Weather:

1. **The 23rd Cycle: Learning to Live with a Stormy Star** by Sten Odenwald, Columbia University Press, 2000.
   Also available on the web at http://www.solarstorms.org/S23rdCycle.html

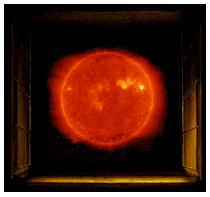
2. **The Role of the Sun in Climate Change** by Douglas V. Hoyt and Kenneth H. Schatten. Oxford University Press, USA, 1997. ISBN: 019509414X
   Mostly of interest to students in climate studies, this book focuses on solar variations as a driver for climate change.
3. **Sentinels of the Sun: Forecasting Space Weather** by Barbara B. Poppe, Kristen P. Jorden. Johnson Books, 2006. ISBN**:** 1555663796
   Takes a look at space weather and the Space Environment Center, an American federal agency devoted to the study of the Sun. The numerous players in the story have brought this science to the forefront of space physics and solar forecasting because they understand that Earth systems will be increasingly affected by the Sun.
4. **Storms from the Sun: The Emerging Science of Space Weather** By Michael Carlowicz and Ramon Lopez. National Academies Press, 2002. ISBN 0309076420.
   Written for a general audience, this book provides colorfully written descriptions of major solar storm disruptions of communications satellites, power grids, and all the technological devices dependent on them. Also contains some discussion of the basic science behind space storms.
5. **Storms in Space** by John W. Freeman Cambridge University Press, 2001. ISBN: 0521660386
   A very readable account of space weather storms and their effects. Provides a new understanding and appreciation of how seemingly insignificant disturbances on the Sun can have major effects here on Earth.

More About the Sun

http://solar-center.stanford.edu *and*
http://solar-center.stanford.edu/about/
A general introduction to the Sun, its science, culture, music, art, and even folklore. Includes classroom activities and information for educators.



If you would like to observe the Sun yourself:
http://solar-center.stanford.edu/observe/



http://www.windows.ucar.edu/tour/link=/sun/sun.html
Windows to the Universe website on the Sun.

http://sunearthday.nasa.gov/
This NASA website brings together the rich expertise of scientists, educators, and museums to develop innovative products and programs that share the exciting discoveries and knowledge from NASA Sun-Earth Connection missions and research programs with the public.

Books and articles about the Sun:

1. **Sun Observer's Guide**, Pam Spence, Firefly Publishers, 2004.
   Best quick introduction to the Sun we know about! Excellent for students interested in doing their own observing.

2. **The Sun – Living with a Stormy Star,** *National Geographic* July 2004, pp. 2-33.

3. **SOHO Reveals the Secrets of the Sun**, by Kenneth R. Lang; *Scientific American,* March 1997, pp. 40-47.

4. **The Complete Idiot's Guide to the Sun** by Jay M. Pasachoff. Alpha Books, 2003. **ISBN:** 1592570747
   General book about the origin and history of the Sun, including information on the Sun's physical properties; how solar flares, sunspots, and winds on its surface affect Earth's atmosphere and environment; solar and lunar eclipses, transits, and occultations, and early astronomers' discoveries about the Sun.

5. **Journey from the Center of the Sun**, by Jack B. Zierker. Princeton University Press, 2002. ISBN 0-691-05781-8

6. **Nearest Star – The Surprising Science of Our Sun,** by Leon Golub & Jay M. Pasachoff. Harvard University Press, 2001. ISBN 0-674-00467-1

7. **Sun, Earth and Sky** by Kenneth R. Lang, Springer 1997. ISBN 3-540-62808-8
   A visually dramatic and lavishly illustrated book that introduces the Sun, its physics, and its impact on life on Earth.

8. **Sunquakes – Probing the Interior of the Sun**, by J. B. Zirker Johns Hopkins University Press, 2003. ISBN 0-8018-7419-X

Appendices

Appendix A - VLF Station List[10]

See http://sidstation.lionelloudet.homedns.org/stations-list-en.xhtml for a current version of this list.

Country	*Location*	*Name*	*Frequency*	*Power (kHz)*	*Latititude / Longitude*
USA	Cutler, ME	NAA	24.0	1000	44.65 N -67.3 W
	Jim Creek, WA	NLK	24.8	250	48.20 N -121.92 W
	Lualualei, HI	NPM	21.4	566	20.4 N -158.2 W
	LaMoure, ND	NML	25.2	500	46.35 N -98.33 W
	Aquada, Puerto Rico	NAU	40.75	100	18.40 N -67.18 W
Antarctica:	South Pole	VLF	20.0		-09 / 0
Australia	Harold E. Holt (North West Cape)	NWC	19.8	1000	-21.8 114.2 E
China[11]**:**	Changde	3SA (alternates 3SB)	20.6		25.03 111.67
	Datonge	3SB (alternates 3SA)	10.6		35.60 103.33
France:	Rosnay	HWU	20.9	400	40.7N 1.25E
	St. Assie	FTA[12]	16.8		
	LeBlanc (NATO)	HWV	21.75		40.7 N, 1.25 E
Germany:	Rhauderfehn	DHO	23.4	500	53° 10' N 07° 33'E
Iceland:	Keflavik (US Navy)	NRK	37.5	100	65N -18E
	Keflavic	TFK	37.5		
India:	Katabomman	VTX3	18.2		8.47 77.40
Italy:	Tavolara	ICV	20.27	43	40.88N 9.68E
	Sicily	NSC	45.9		38N 13.5E
Japan:	Ebino	JJI	22.2		32.04 130.81
Norway[13]**:**	Kolsas	JXN	16.4	45	59.51N 10.52E
Russia[14]**:**	Arkhanghelsk	UGE	19.7	150 input	64N24 41E32
	Batumi	UVA	14.6	100 input	
	Kaliningrad	UGKZ	30.3	100 input	
	Matotchkinchar	UFQE	18.1	100 input	
	Vladivostok	UIK	15.0	100 input	
Turkey	Bafa	TBB	26.7		37.43 27.55
United Kingdom	Anthorn	GBZ	19.6	500	52:71N -3:07W
	Anthorn (NATO)	GQD	22.1	500	52:4N -1.2W
	London	GYA	21.37	120	51 N 2 E

There is no transmitter below 18.3 kHz usable for SID monitoring in Europe.

[10] Info courtesy of Bill Hopkins, Technical Representative for Pacific-Sierra Research Corp., with updates from Chris Chapman, Morris Cohen, Peter Schnoor, and Deborah Scherrer

[11] There is evidence of two powerful transmitters being operated by China, only on for selected periods. These are at 21.1 kHz coming from the west of China, and 24.1 kHz from the east coast of China.

[12] Out of service for a number of years

[13] Off? Short transmitting time?

[14] Most of the Russian transmitters are either pooled (like the alpha transmitters around 11-13 kHz) or tend to alternate several frequencies between several sites. Transmitting times for Russian transmitters other than 66.7 are short. More information can be found at //www-user.uni bremen.de/~ews2/RDF_project.html

Appendix B - Sample Antenna Designs



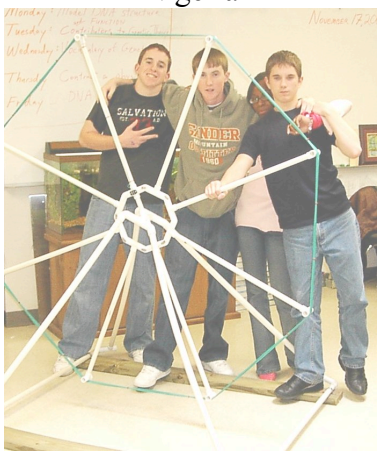
China



Nigeria



USA



USA



Netherlands



Canada



Croatia



Mozambique



Lebanon



USA



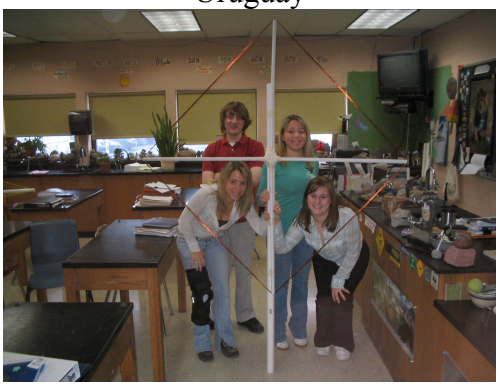
Germany



Uruguay



New Zealand



USA



Mexico



Romania



USA

Building a Horizontal Loop Antenna

By Tim Huynh

In some situations it is not possible to locate a large antenna in the field or it is too windy to set up one. A horizontal loop antenna may be an alternative option. Here are instructions on how to make one.

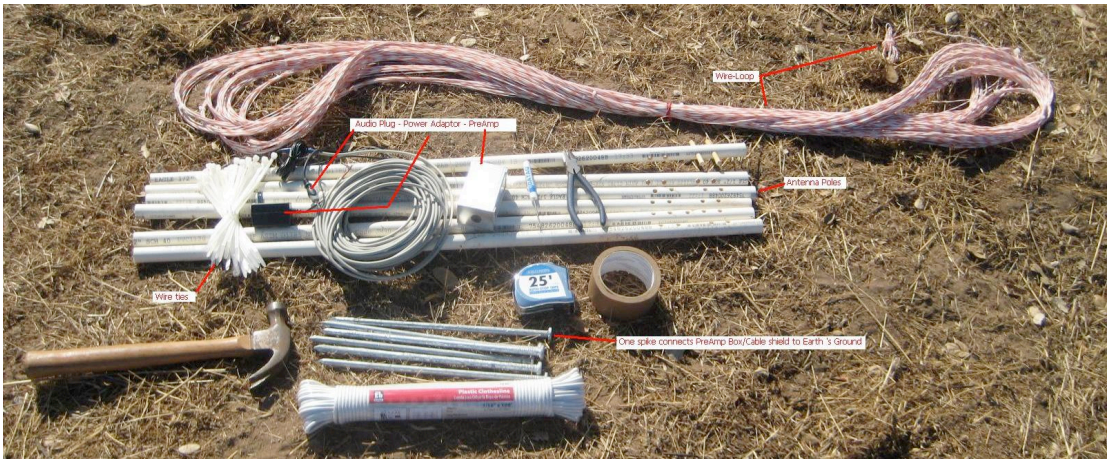


1. First, find or set up 2 poles (or 2 trees, a long wall, whatever) about 60 ft apart.
2. Put a nail on each of the poles.
3. Take a spool of wire and loop around the two nails, to make ~20 turns.
4. Use lots of wire-ties (or tape) to keep the wire straight, uniformly tensioned, and in a bundle.
5. Remove the nails and keep the wire-loop safe for transport.



6. Use small PVC tubing to make six antenna poles (~3ft)
   Drill a couple strategic holes, ready to hold the wire-loop and easy to tie down in the field

7. Here are the materials needed in the field.



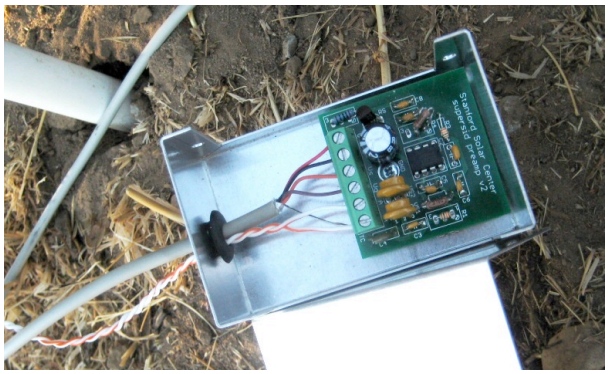
***** It is crucial to find a remote site, far away from electrical interferences *****
This is the most important factor for acquiring clean data. A large loop enables picking up small signals reflected from the ionosphere. A low-interferences site lowers the noise floor, making the small signals visible (see the spectrum plot).





8. To make a hexagonal shape antenna, fold the loop into three, mark 6 segments of equal lengths, and draw a hexagon on the ground.

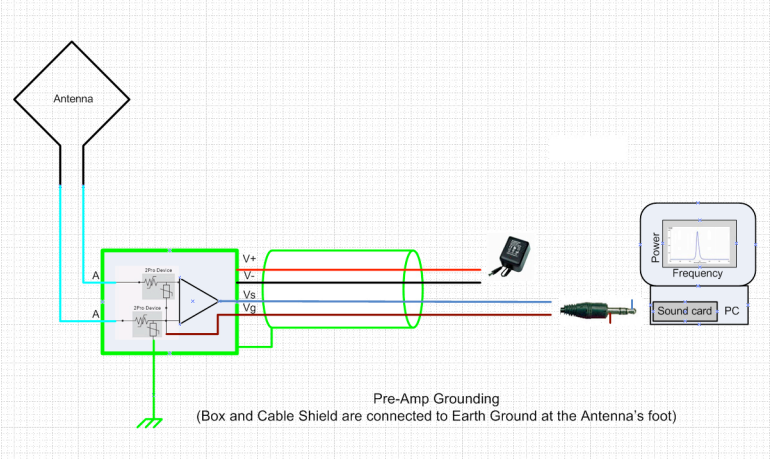
9. Set up the antenna poles at the corners, tie the wire loop to the poles and secure it to the ground.



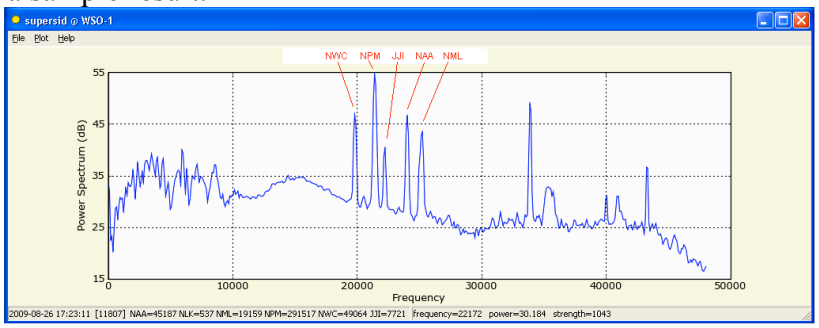
10. Connect the coax cable as described in Chapter 2. Or, if you wish, you can attach the antenna wire (orange/white) directly to the PreAmp.

    PreAmp connector has 6 terminals, or 3 pairs:
    Power Supply (V+ and V-): DC supply (5V-16V).
    Signal (Vs and Vg): to be connected Line-in of the sound card.

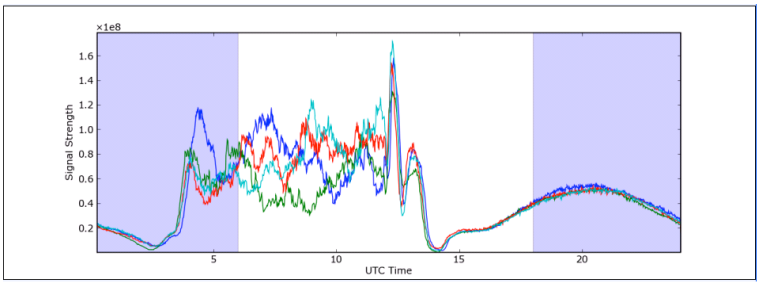
Antenna (A and A): are connected directly to the loop-wire. The metal chassis, cable shield and the PreAmp's GND are connected together and to one of the spikes going into the Earth ground.



Here is a sample result.



Horizontal hexagonal antenna with supersid preamp (production verision) at WSO-1

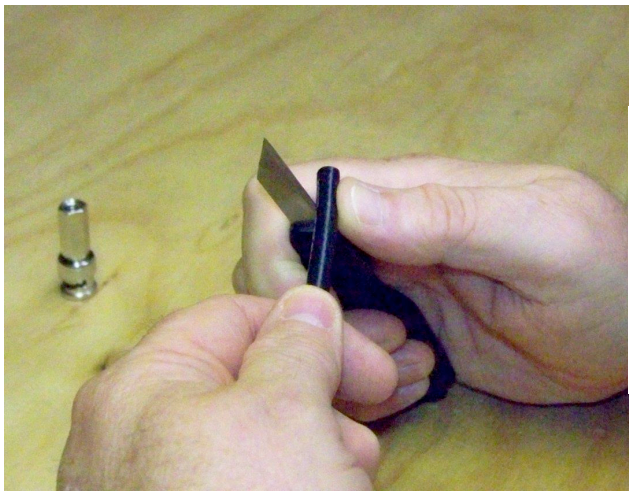


Monitoring NPM signal strength over 4 days

To decide which station to monitor, watch the spectrum plot over time to see which peaks seem to continuously stay high above the noise floor (>20dB). These are good candidates to monitor. In this case, we plot NPM signal strength over 4 consecutive days. It does show the characteristics of a signal reflected from the ionosphere.

Although a horizontal antenna might not be ideal (the wire loop is not aligned with any particular station, and the antenna is close to the ground which might attenuate some of the signals), its horizontal configuration makes it quite easy to build and setup. It might be a reasonable alternative to have at some sites.

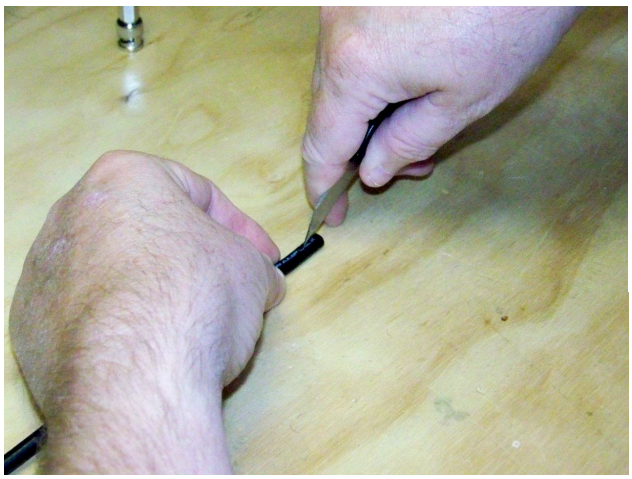
Appendix C – How to Strip Coax with a Knife



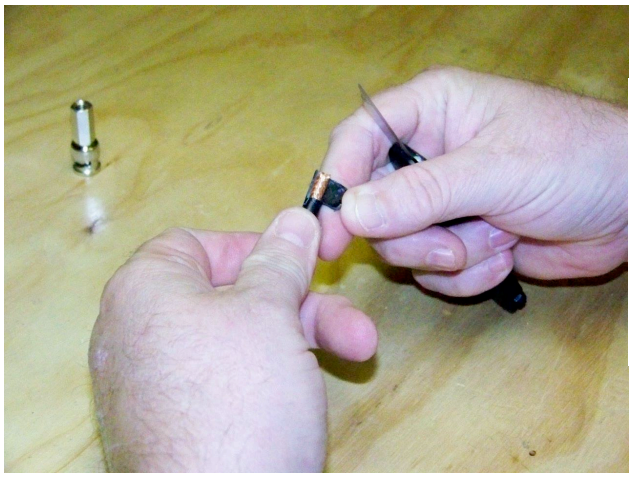
Carefully cut the outer cover of the coax cable.



Cut all the way around the cover.



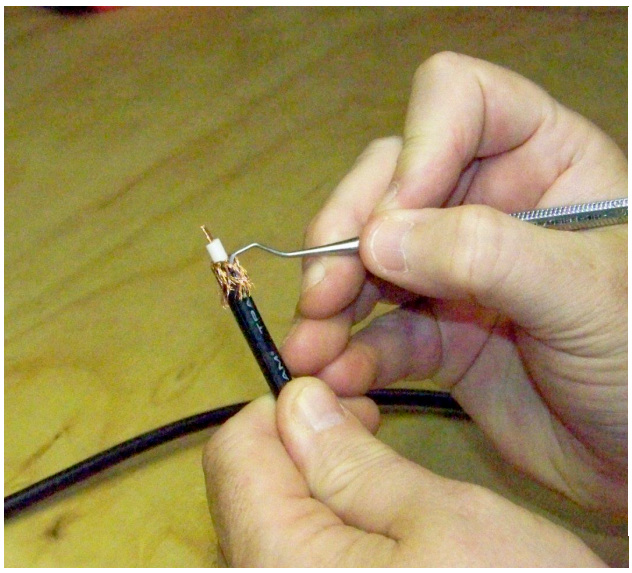
From the first cut around the cable, take the knife and cut a line to the end of the cable.



Remove the outside cover from the inner wires. You will now see the copper shielding.



Bend the copper shielding back to the black covering.



Carefully cut the white cover away from the center conductor.

Untangle the copper shielding so it will lay flat against the black covering.

Attach connector.

Appendix D - How to Install a Sound Card and Software

If you live in North or South America, the SuperSID pre-amp requires a sound card that can record (or sample) up to 96 kHz. Most computers have a sound card that only records at 48 kHz, so you may need to install a new sound card. Carefully read these instructions through completely, then follow the instructions to successfully install a new card for your SuperSID.

1. Install your Audigy/whatever software
2. Install sound card into computer
3. Make sound card settings
4. Use Quick Mix to save your settings



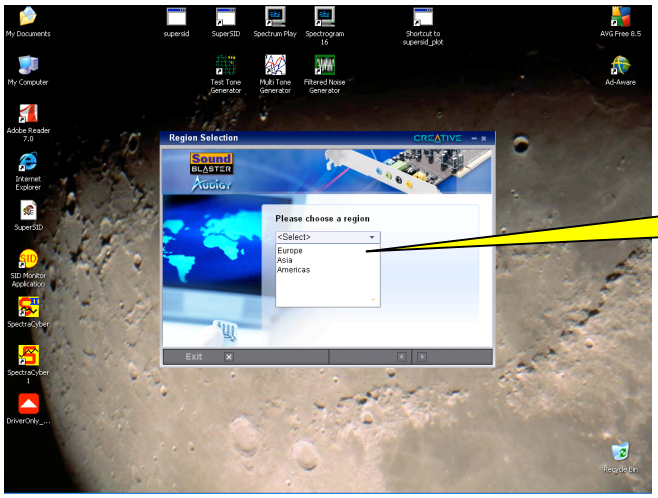
Don't forget to install the sound card driver software *BEFORE* installing your card into your computer.



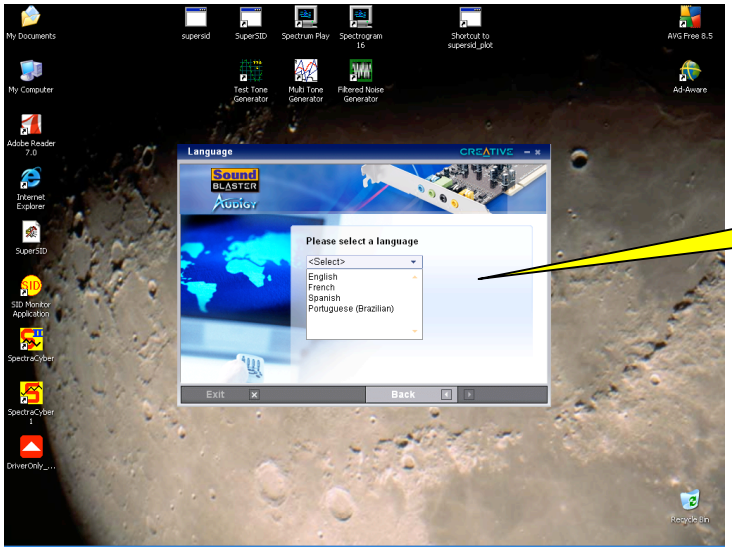
Insert disk into computer



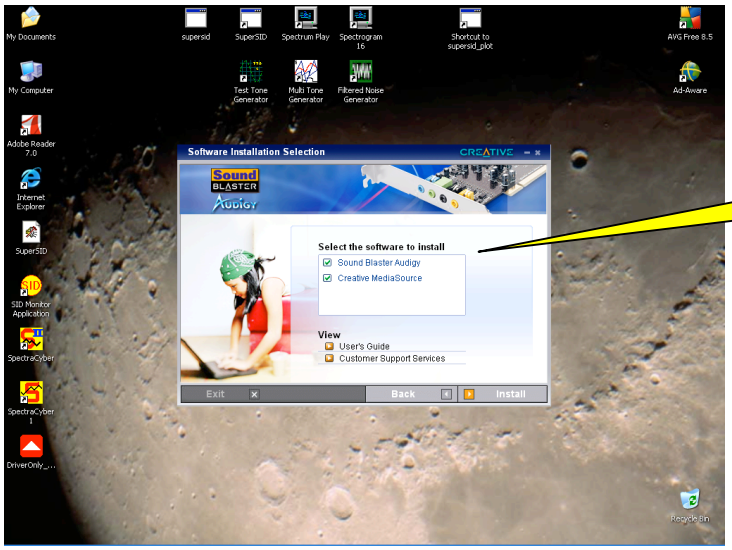
Program will start
Click NEXT



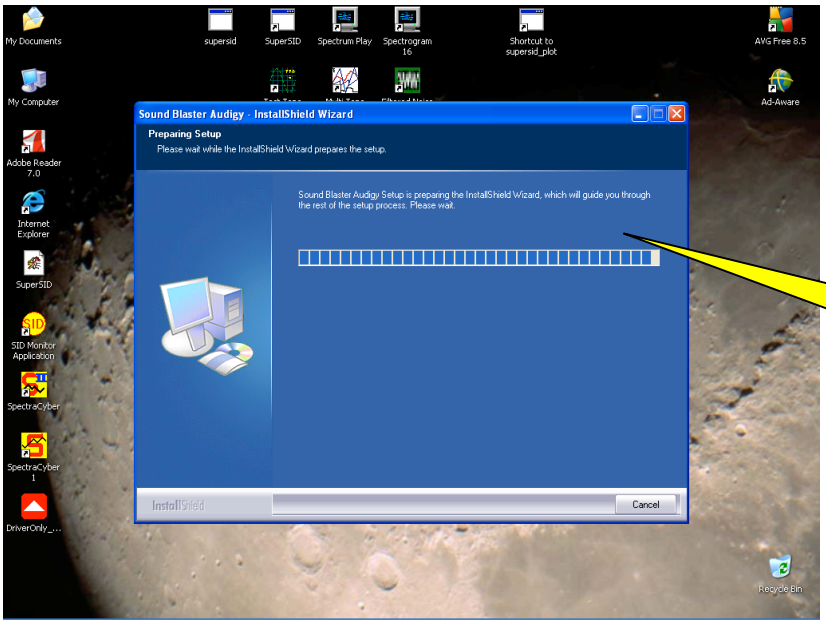
Select Area of the world



Select Language



Click on INSTALL

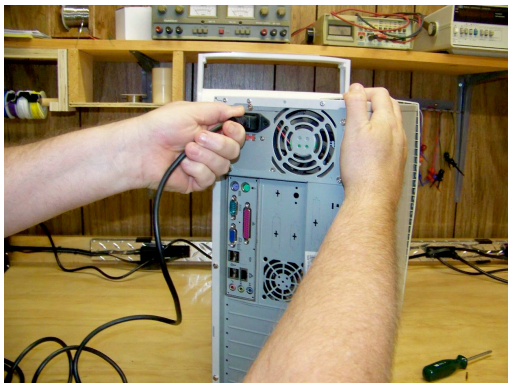


Now install the sound card into your computer. READ THIS COMPLETELY BEFORE INSTALLING CARD



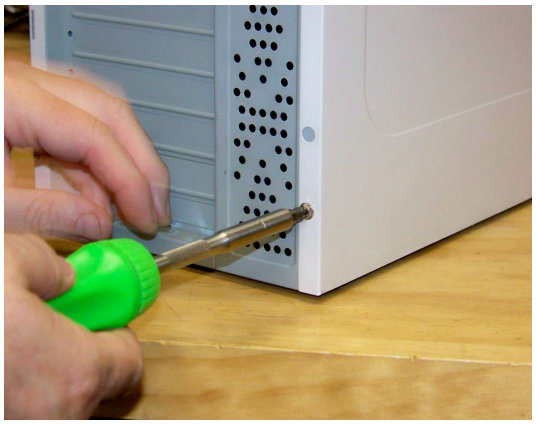
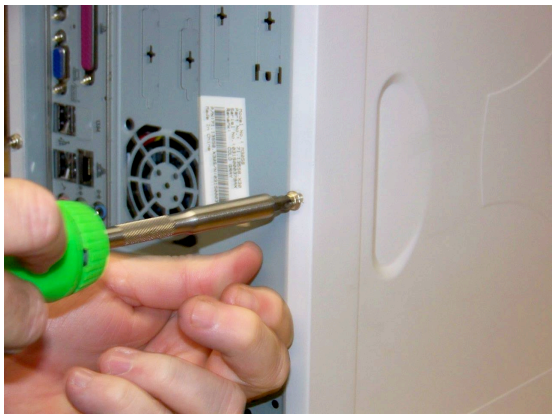
CAUTION

BE SURE POWER CORD AND ALL CABLES ARE REMOVED BEFORE OPENING COMPUTER TO AVOID ELECTRIC SHOCK.

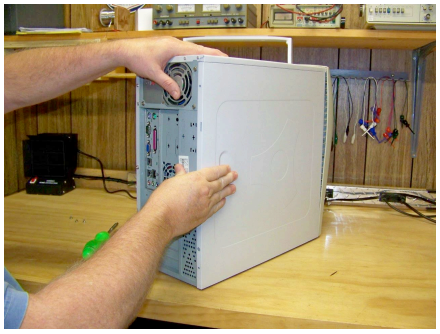




Unplug your power cord

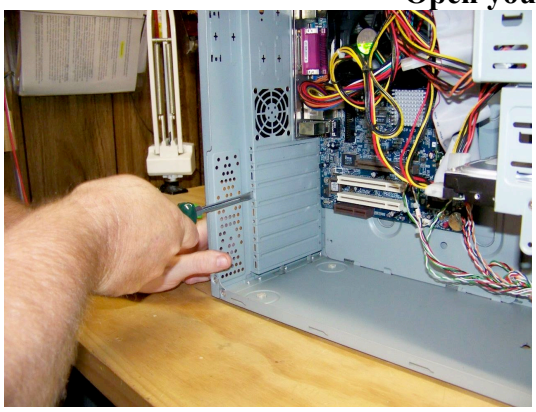
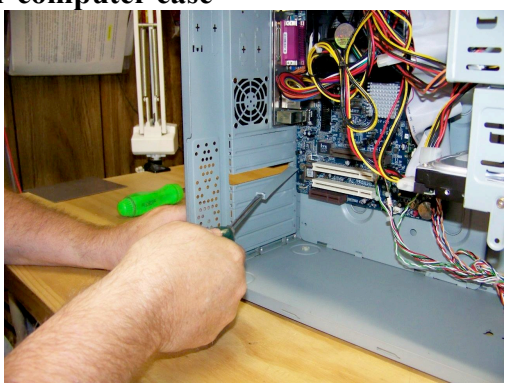



Unscrew your computer case



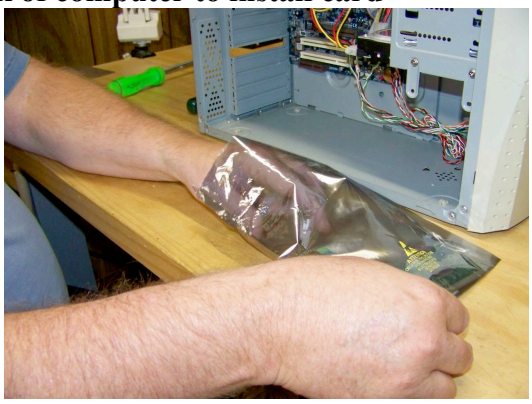


Open your computer case

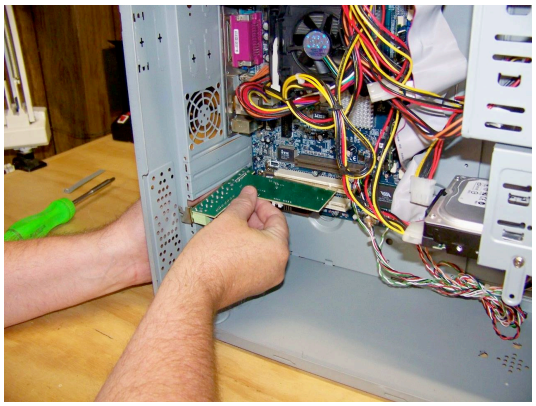
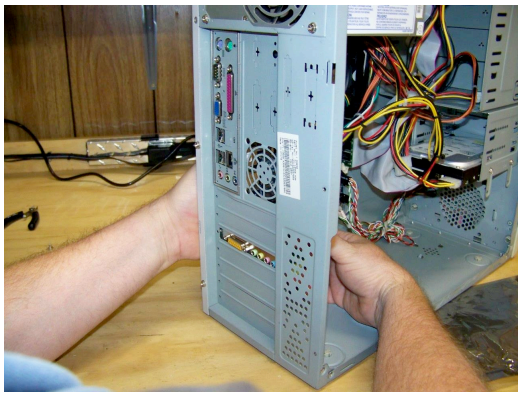



Open slot on back of computer to install card



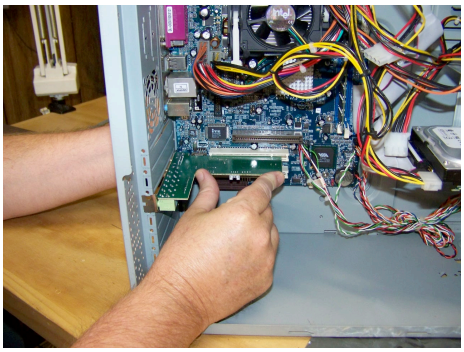


Remove sound card from plastic bag

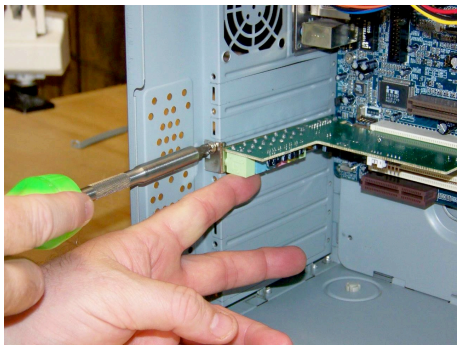



Insert card into computer mother board and open slot

Be sure to touch case while installing card to avoid damage from static discharge



Support case with hand while pushing card into place.



Use screw to hold card in place



Close computer case

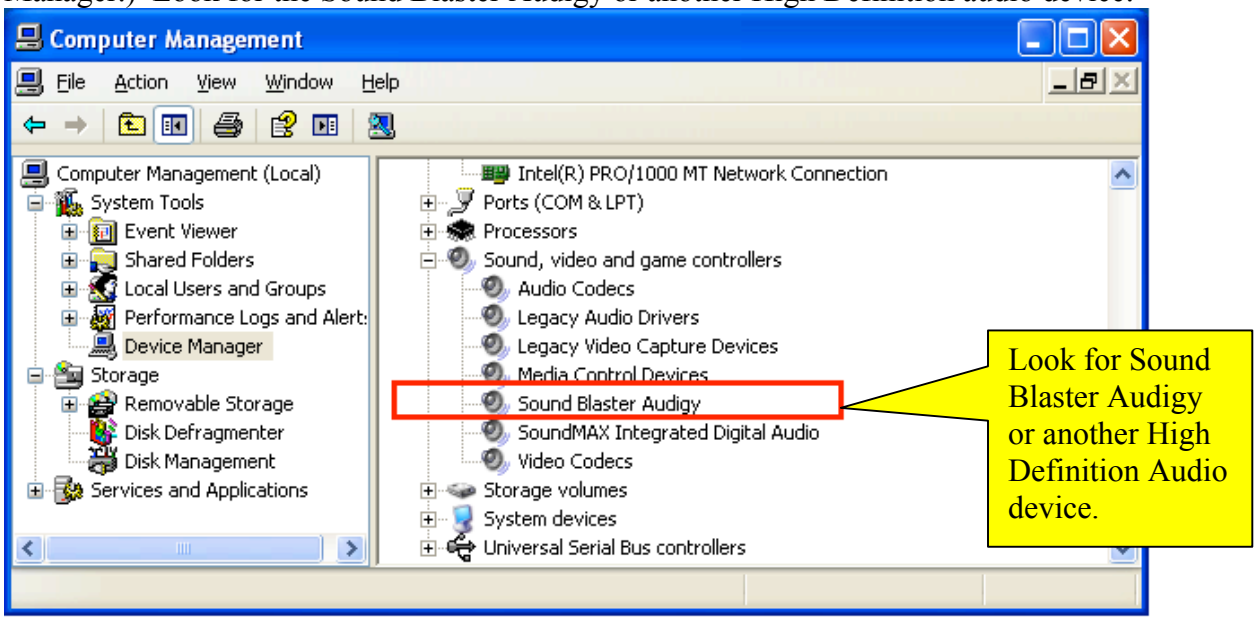


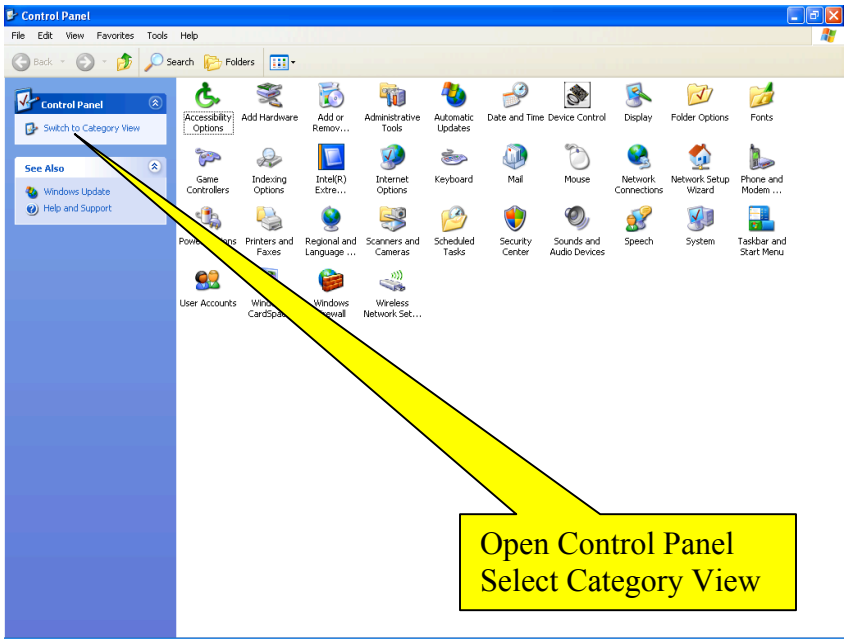
Job completed!

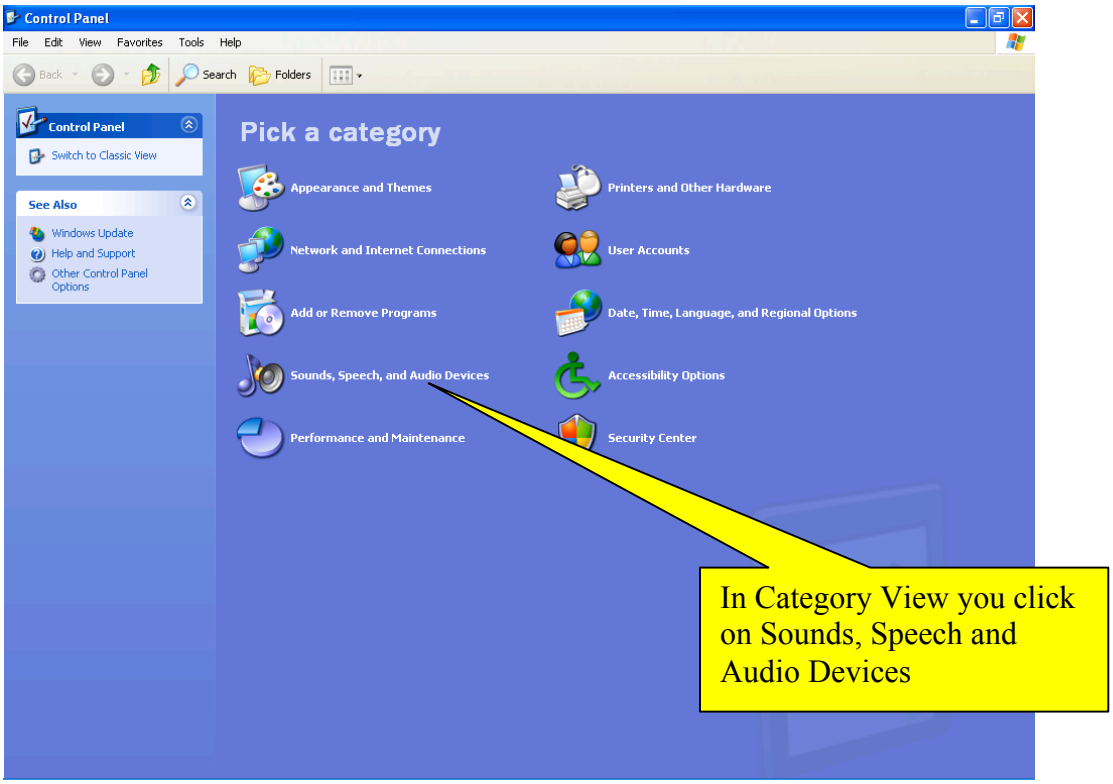
Now you are ready to set your sound card settings.

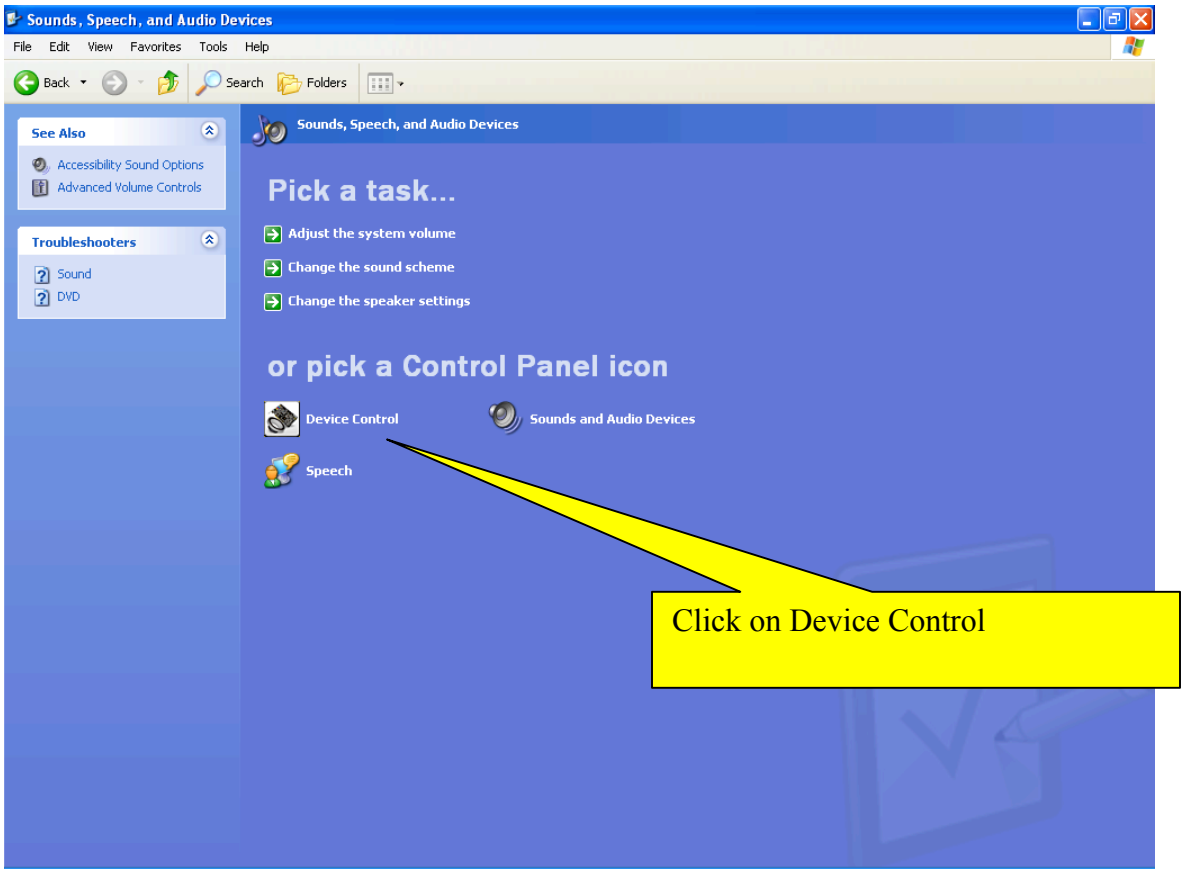
Sound Card Settings

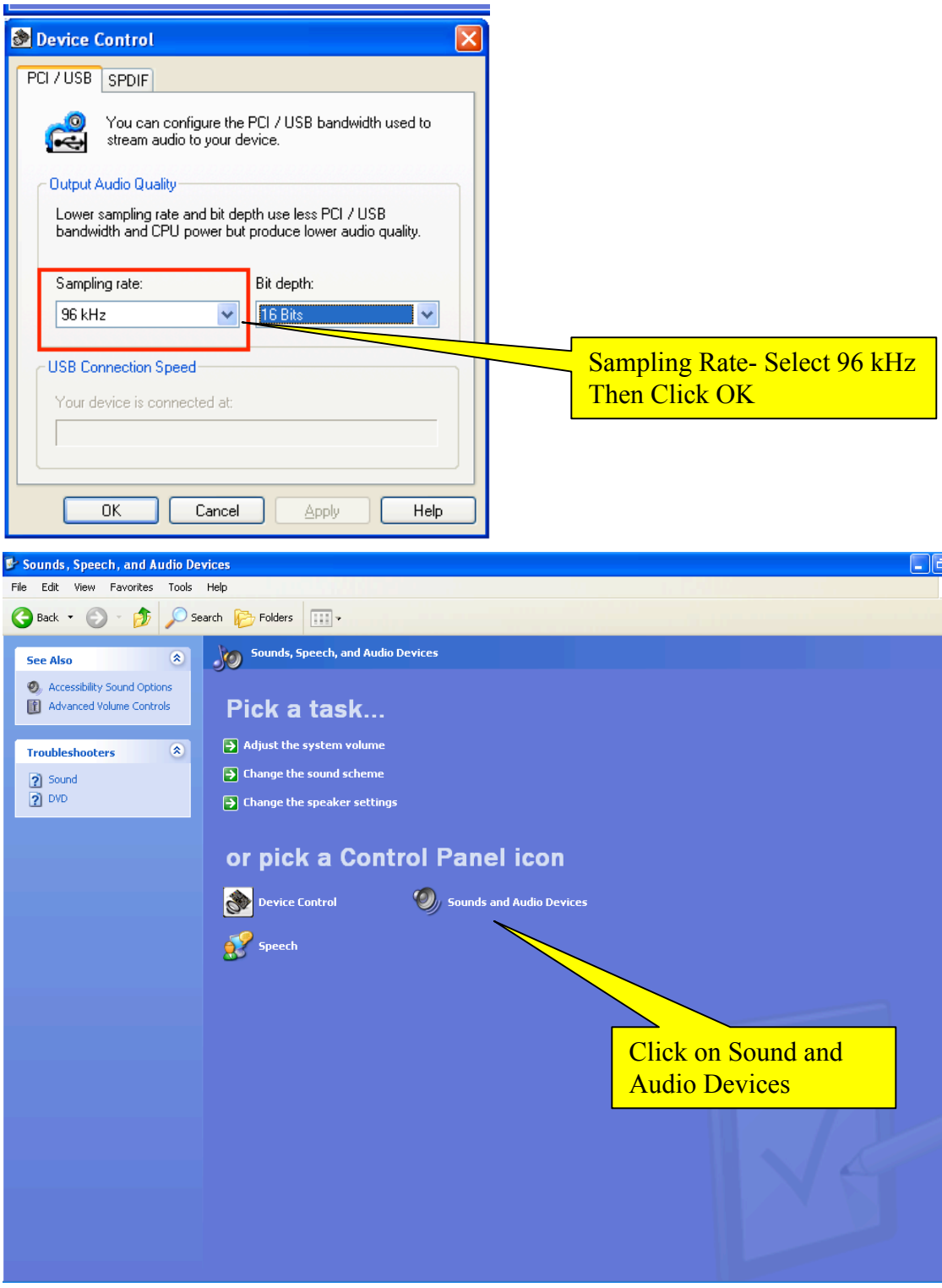
Go to your **Start** menu, point to **Settings**, then click on **Control Panel**. Double-click **Administrative Tools**, then double-click **Computer Manager**. Click on **Device Manager**. Then **Sound, video and game controllers**. (Or, click on My Computer ->Manage -> Device Manager.) Look for the Sound Blaster Audigy or another High Definition audio device:

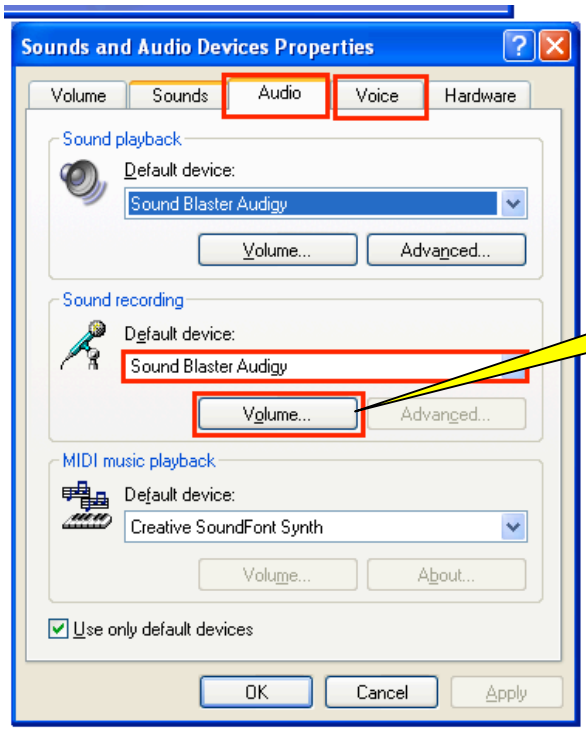




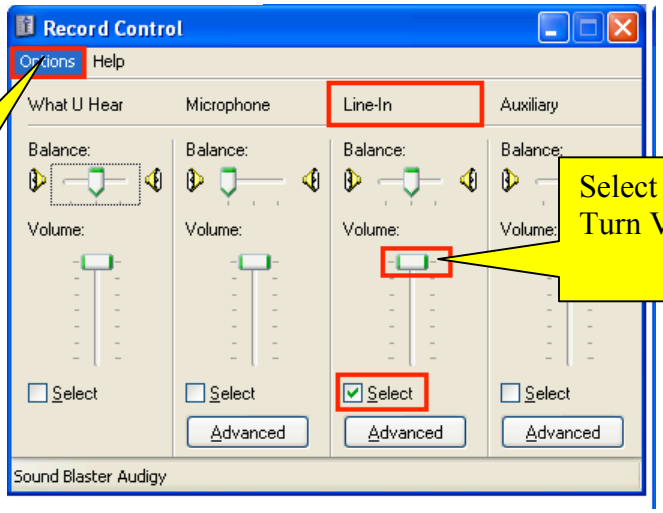

Control Panel
File Edit View Favorites Tools Help
Back Search Folders
Control Panel
Switch to Classic View
See Also
Windows Update
Help and Support
Other Control Panel Options
Pick a category
Appearance and Themes
Printers and Other Hardware
Network and Internet Connections
User Accounts
Add or Remove Programs
Date, Time, Language, and Regional Options
Sounds, Speech, and Audio Devices
Accessibility Options
Performance and Maintenance
Security Center
In Category View you click on Sounds, Speech and Audio Devices


Sounds, Speech, and Audio Devices
File Edit View Favorites Tools Help
Back Search Folders
See Also
Accessibility Sound Options
Advanced Volume Controls
Troubleshooters
Sound
DVD
Sounds, Speech, and Audio Devices
Pick a task...
Adjust the system volume
Change the sound scheme
Change the speaker settings
or pick a Control Panel icon
Device Control
Sounds and Audio Devices
Speech
Click on Device Control


Device Control
PCI / USB
SPDIF
You can configure the PCI / USB bandwidth used to stream audio to your device.
Output Audio Quality
Lower sampling rate and bit depth use less PCI / USB bandwidth and CPU power but produce lower audio quality.
Sampling rate:
96 kHz
Bit depth:
16 Bits
USB Connection Speed
Your device is connected at:
OK
Cancel
Apply
Help
Sampling Rate- Select 96 kHz
Then Click OK
Sounds, Speech, and Audio Devices
File Edit View Favorites Tools Help
Back Search Folders
See Also
Accessibility Sound Options
Advanced Volume Controls
Troubleshooters
Sound
DVD
Sounds, Speech, and Audio Devices
Pick a task...
Adjust the system volume
Change the sound scheme
Change the speaker settings
or pick a Control Panel icon
Device Control
Sounds and Audio Devices
Speech
Click on Sound and
Audio Devices

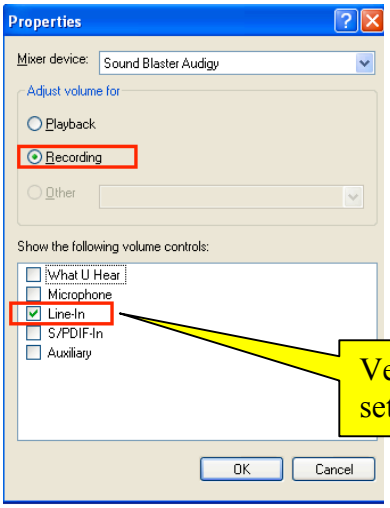


Under Audio tab, Sound Recording, Default Device is Sound Blaster Audigy Click on Volume



After selecting Line-In and sliding Volume to Max, Click on Options and select Properties

Select Line-In
Turn Volume up to Max



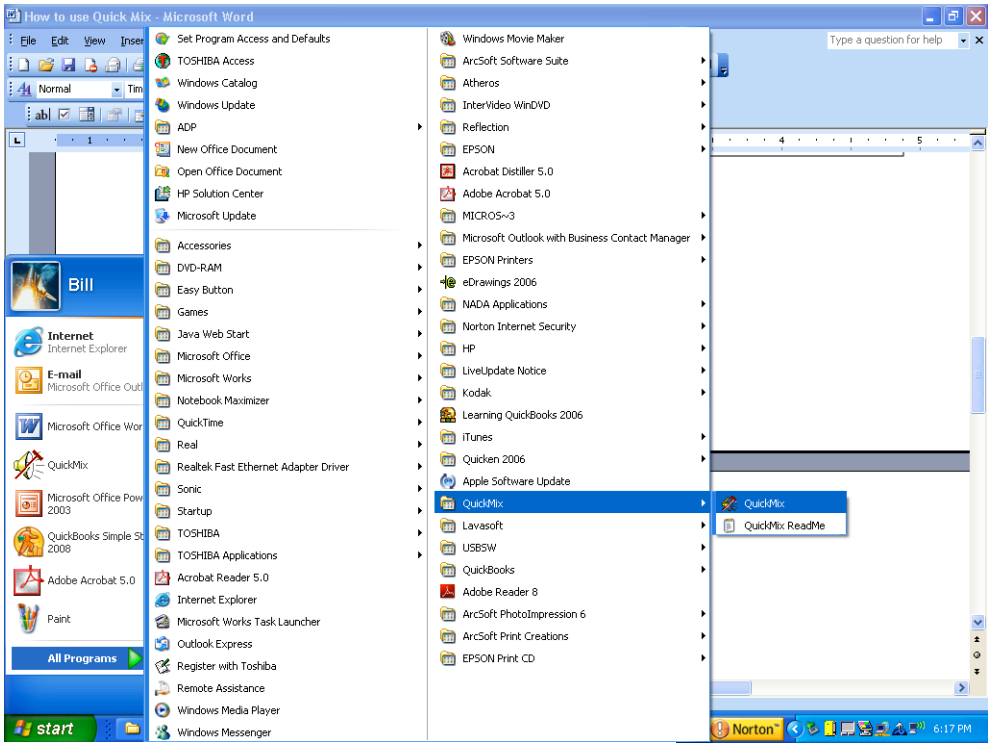
Verify Recording is set to Line-In

How and Why to Use Quick Mix

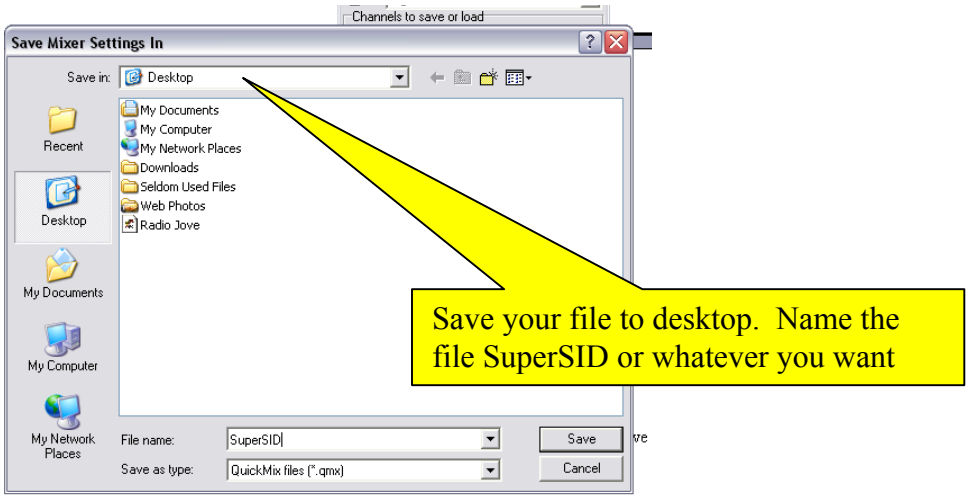
Windows will sometimes lose the settings shown above after installing updates or running other programs. You can use a program called "Quick Mix" to make it easy to restore your settings.

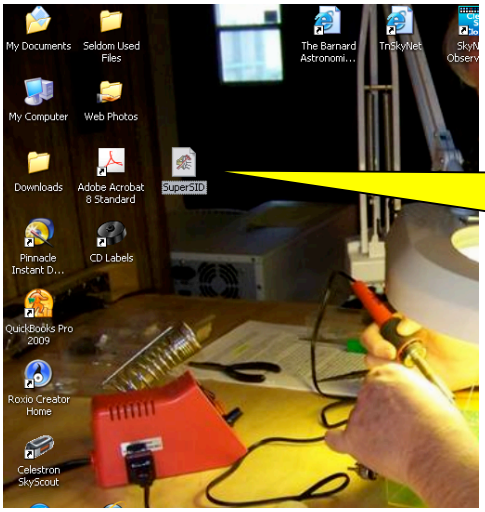
Download and install Quick Mix http://www.msaxon.com/quickmix/QuickMixIn.EXE

Now go to Programs and open QuickMix:






Channels to save or load
Save Mixer Settings In
Save in: Desktop
My Documents
My Computer
My Network Places
Downloads
Seldom Used Files
Web Photos
Radio Jove
Recent
Desktop
My Documents
My Computer
My Network Places
File name: SuperSID
Save as type: QuickMix files (*.qmx)
Save
Cancel
Save your file to desktop. Name the file SuperSID or whatever you want

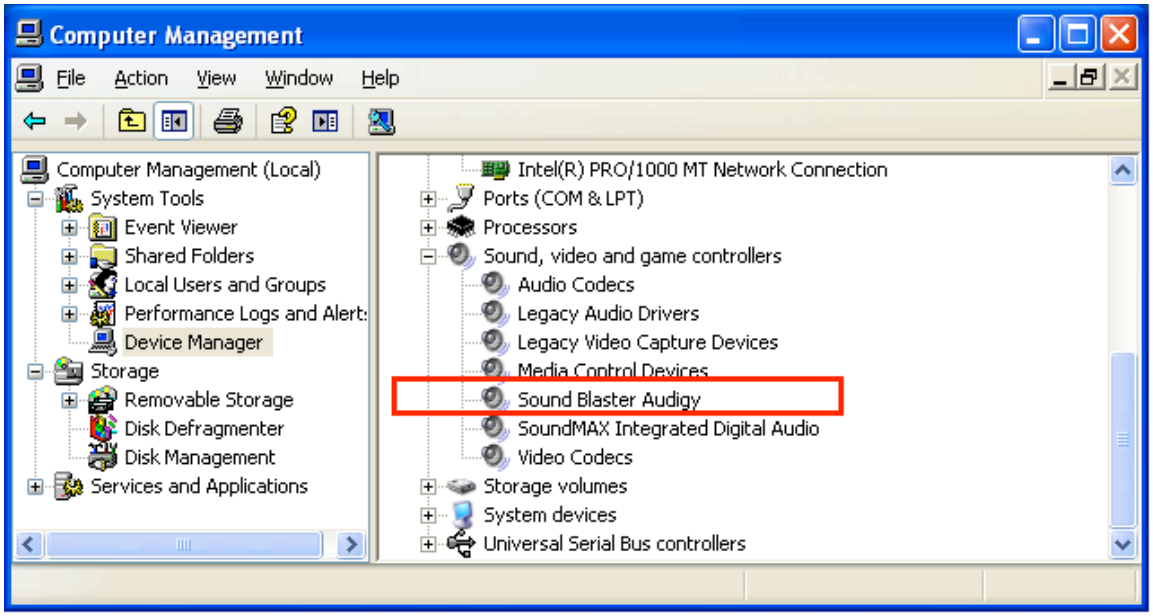

My Documents
Seldom Used Files
My Computer
Web Photos
Downloads
Adobe Acrobat 8 Standard
SuperSID
Pinnacle Instant D...
CD Labels
QuickBooks Pro 2009
Roxio Creator Home
Celestron SkyScout
The Barnard Astronomi...
TnSkyNet
When/if you lose your sound settings, double click on the QuickMix file icon and your sound card settings are restored for SuperSID.

Appendix E – Sound Input Troubleshooting Tips

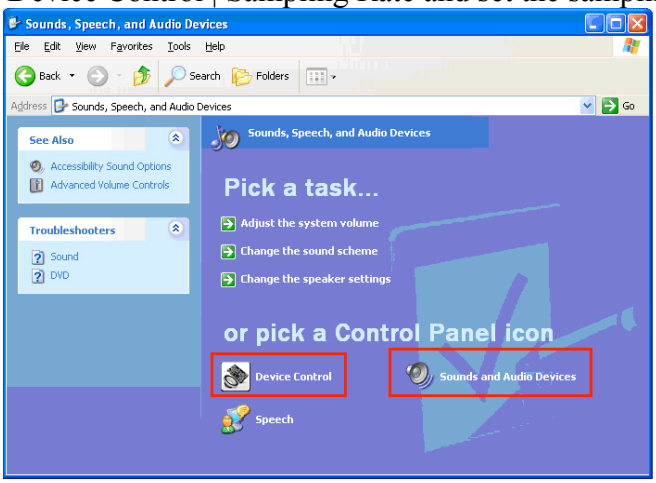
There are a few Windows annoyances that we ran into while testing SuperSID. We would like to document these here.

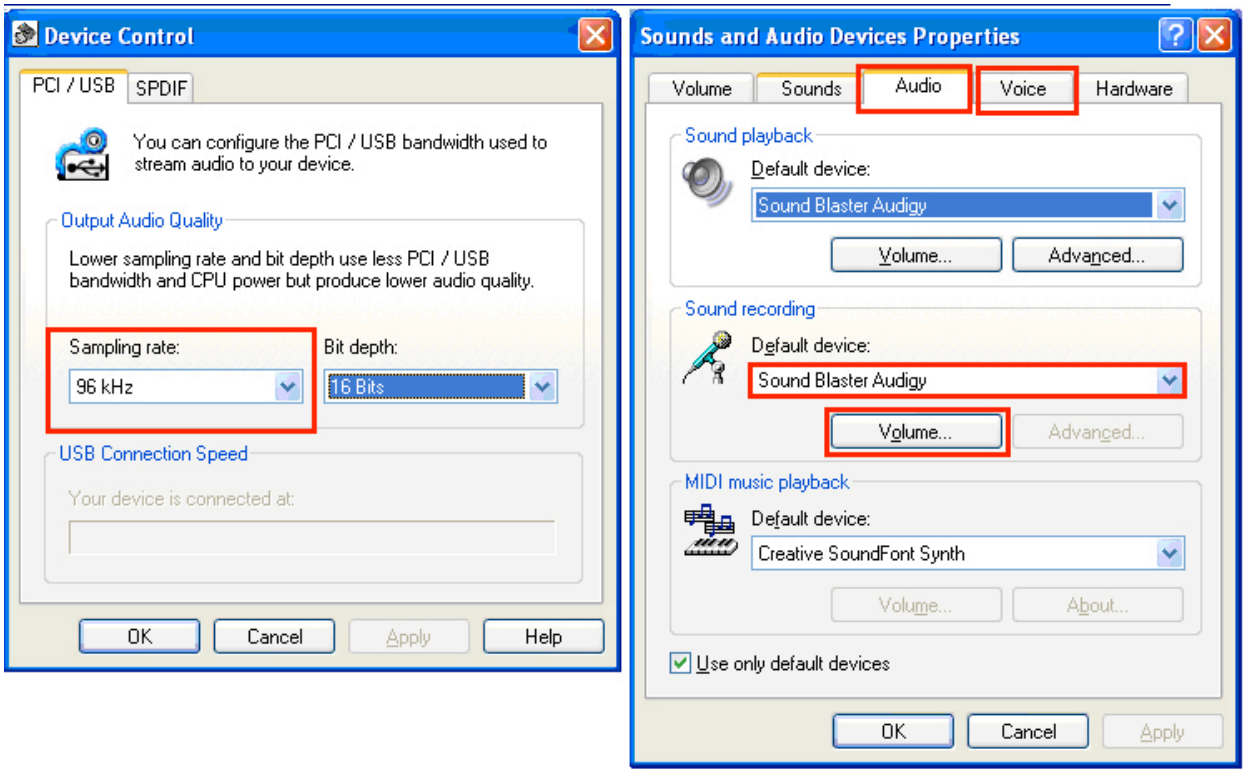
1. **Install SoundBlaster Audigy SE driver and check** (see Appendix D)**.**
Make sure you install the driver software first before adding the sound card to your PCI bus.

Right Click on "My Computer" | Manage| Device Manager
It should show the "Sound Blaster Audigy" device without the yellow question mark. If you do get a yellow question mark, try a reboot after installing the driver. This sometimes helps.



2. **Check default Sound Card, default audio Recording Device and Sampling Rate.**
Go to Control Panel | Device Control | Sampling Rate and set the sampling rate to 96KHz

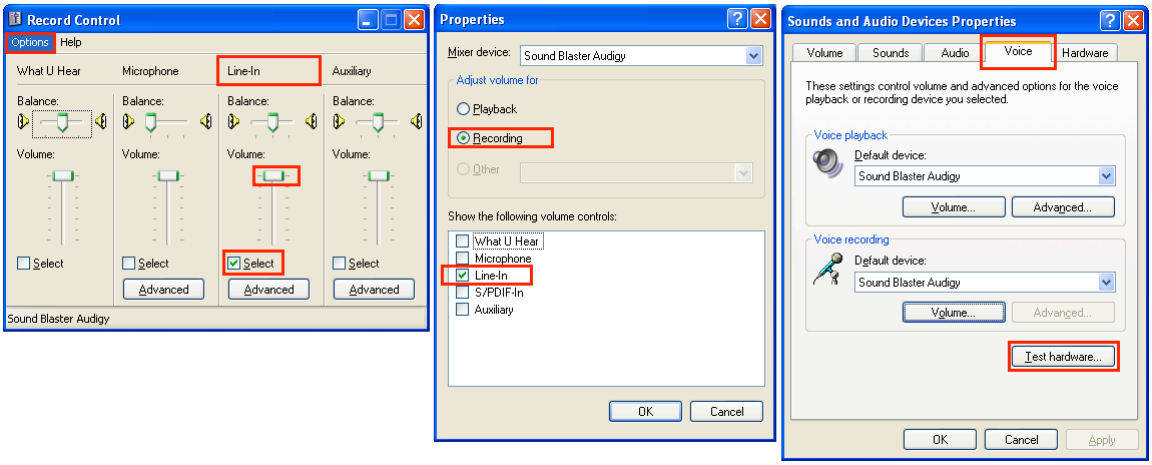




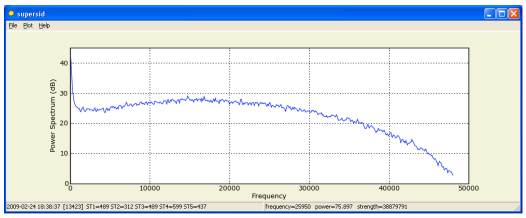
Next, go to Control Panel | Sound and Audio Devices | Voice Tab
Select "Line-in" as the recording channel

There are several recording channels available under "Recording Control | Menu Options"

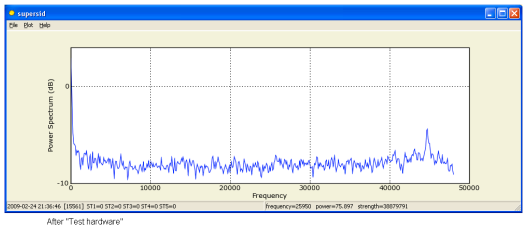
NOTE ***:
From beta testing feedback, we found that Windows automatically switches Recording Channel to something else and disables "Line-in" when we ran Windows Updates, Test Hardware and sometimes just by rebooting the machine. If you suddenly find your signal missing or an error in reading, double check this and re-select "Line-in" as the recording input.



3. “Test hardware…”
We observed something when running “Test hardware”. Windows asks us to read into the microphone: ”This is a test…..” We are not sure what else the Wizard does or optimizes, but the effect is that the frequency response looks flatter. We believe the Wizard adjusts the coefficient of a built-in software band-pass filter. We used a function generator to sweep a test tone from 3KHz to 48KHz the output look fine. So, the Test hardware feature does help.



Before “Test hardware”

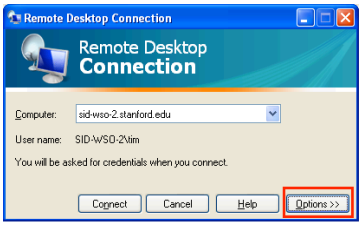


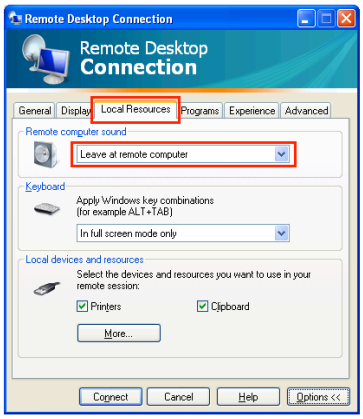
After “Test hardware”

NOTE***:
You may want to plug in a microphone or the actual PreAmp output to “Line-in” before running the “Test hardware” otherwise it fails, because without a connector, the signal (at the tip) is shorted to ground (ring) at the Line-in (Blue) connector.

Windows automatically de-selects Line-in after the “Test hardware”, so you need to double check and select Line-in as our recording input, again.

4. Remote Desktop:
When using Remote Desktop to look at supersid running on a remote PC, you need to go to “Options | Local Resources”. Then choose “Remote computer sound” as “Leave at remote computer”. Otherwise, Windows will intercept the remote sound input and route it to the local PC, and hence no audio stream flows into supersid.





Appendix F - Common Sources of Interference

The most common sources of electrical noise (interference) are usually located in close proximity to the antenna. Here is a list of the most common sources that should be eliminated:

- **Computer Monitors**: When not using your computer monitor it is best to turn it off for data collection
- **Microwave ovens:** Can be devastating to a SID monitor
- **Television Set**: The antenna should be shielded or kept at least 10-15 feet away from a television that is on.
- **Florescent Lights**: The noise from these is usually small but can be a problem with some antennas
- **Motors and Pumps**: Not always a problem but they have the potential to cause noise
- **Light Dimming Switch**: New models are not usually a problem but some older switches have the capability of being noise sources.
- **Outdoor sulfur lights**

To make sure your antenna is shielded from these noise sources, be sure to place the antenna as far from these culprits as possible. A minimum distance of 10 feet is recommended. If you need to place a computer monitor near the antenna, turn it off when data collection is taking place.

Appendix G - Obtaining and Formatting your Longitude and Latitude

Find your site's latitude and longitude. There are several ways to this:

1. Look on a map
2. Google your city name
3. Explore the various websites that help you identify your latitude & longitude
4. Ask a city official

To convert your latitude from degrees, minutes, seconds to ddd.ff

North is Positive
South is Negative
Latitude = Degrees + (Minutes / 60) [round seconds to nearest minute]

Example:

N 37 39'
= + 37 + (39 / 60)
= + 37 + (0.65)
= 37.65 *(it is ok to round to nearest degree)*

To convert your longitude from degrees, minutes, seconds to ddd.ff

East is Positive
West is Negative
Longitude = Degrees + (Minutes / 60)

Example:

W 122 7'
= - 122 + (7 / 60)
= - 122 + (0.1167)
= -122.12 (*ok to round*)

Appendix H - SuperSID Configuration File

C:\supersid_v1_1\Config\supersid.cfg contains the settings for your SuperSID. These include:

Keyword	*Example Values*	*Comments*
site_name	WSO *or* SARA *or* ITALY-2	A short name that you chose, or were assigned, to identify your site (20 characters, **no spaces**)
longitude	-122.17	Your site's longitude in decimal format
latitude	37.41	Your site's latitude in decimal format
utc_offset	-07:00	The number of hours you are different from Universal Time (See http://www.worldtimezone.com/).
time_zone	PST	Your time zone. See http://www.worldtimezone.com/wtz-names/timezonenames.html
monitor_id	174	The serial number labeled on your SuperSID instrument.
audio_sampling_rate	96000	Set this to either 48000 or 96000, depending upon the sampling rate of your sound card.
***** This is an important parameter, which MUST match with the installed sound card!** AC97 sound cards, an older standard, are able to see VLF stations up to 22 kHz. HD sound cards, a newer standard, allow audio_sampling_rate = 96000 and are able to see VLF stations up to 48 kHz. Sites in North and South America are required to have HD sound cards, set audio_sampling_rate = 96000 Sites in Europe, Asia, Africa can set audio_sampling_rate = 48000. An AC97 sound card can NOT monitor a frequency higher than 23900 Hz. And setting the frequency higher will NOT change the monitor rate and will result in errors.		
log_interval	5	Sets the sampling rate to once every 5 seconds (i.e. signal strengths are measured and logged into a data file once every 5 seconds)
log_format	sid_format *or* supersid_format	Determines whether data from the various transmitters you are picking up is stored in one single file (supersid_format) or multiple files (sid_format). Set this to sid_format to share data in the easiest way and to be consistent with previous SID monitors.

log_type	filtered *or* raw	Use "filtered" to remove transient noise & produce cleaner data files.
plot_offset	1	Not used yet. But, if available later, will display the daily plot with local time.
scaling_factor	1.0	using raw data from A/D without scaling
automatic_upload	yes *or* no	Indicates whether to send (via ftp) data files to Stanford. This requires internet access. Default is no, until data looks good and the user chooses to forward them to Stanford. Everyday, at 24:00 UTC, supersid checks these options and does or doesn't upload files.
ftp_server	sid-ftp.stanford.edu	The name of the Stanford machine to which to ftp files. Do NOT change this unless told to by Stanford.
ftp_directory	/incoming/SuperSID	Designated location for the SuperSID data files. Do NOT change this unless told to by Stanford.

After the above parameters comes a set of information identifying the VLF transmitting stations which your SID can receive. These are dependent upon your location and your sound card. We have set the defaults to those most likely to be picked up in North and South America with an HD soundcard.

If you are not in these areas, see the VLF station list in Appendix A for a complete list of stations. Choose a few frequencies to monitor, those which seem to stay high above the noise level for your instrument. Then adjust the config file accordingly.

The color indicators stand for red, blue, green, cyan, yellow, black (only available with 96kHz sampling rate):

```
number_of_stations = 6

[STATION_1]
call_sign = NAA
color = r
frequency = 24000

[STATION_2]
call_sign = NLK
color = b
```

```
frequency = 24800


[STATION_3]
call_sign = NML
color = g
frequency = 25200

[STATION_4]
call_sign = NPM
color = c
frequency = 21400

[STATION_5]
call_sign = NWC
color = y
frequency = 19800

[STATION_6]
call_sign = JJI
color = k
frequency = 22200
```

Appendix I – Other Options for Viewing Your Data

To collect and view your data with SIDPlot

If you have an original SID distribution, your SID distribution disk contained a little graphing tool that will take a file's worth of SID data and immediately plot it for you. Once you copy the files off the distribution disk, to obtain a SID graph from your data, use your mouse to drag a properly formatted SID output text file icon onto the "plot.bat" file icon, and a graph will pop up in a new window.

If you have an older SID, these files should have been installed on your system into:
C:\SOLARSID\SIDPlot
If they have not, then copy them from your old SID distribution disk to this location.

Contents of the SIDPlot folder:

plot.bat	a Microsoft Windows script that will invoke the wgnuplot.exe program to plot your SID data.
SampleData-1.txt SampleData-2.txt	Sample SID data files
plot3.7.2	Plot settings file
wgnuplot.exe	The three wgnuplot files are to execute graphing and to help understand the program called GNUplot.
wgnuplot.GID	
wgnuplot.hlp	

To test the program, drag the icon/name of one of the two sample SID files we provide (above) onto plot.bat. You should see a graph pop up right away. Plot.bat calls up the GNUplot software to do the graphing, using the settings dictated in the file plot3.7.2. There is no installation procedure other than copying the files to your system.

GNUplot is a flexible graphing program based on open source software. We chose it for its simplicity, its flexibility, and because you, the user, could modify and improve the settings if desired. We hope that as you become familiar with GNUplot, you will find it easy to work with, and strong enough to grow with your research.

If you drag a file onto the plot icon and no graph is generated, there is most likely a problem with the data file format. In order for GNUplot to plot your SID data successfully, it is important that you give it a file it will understand. Look at the examples provided with your distribution disk for comparison. Your SID software should produce properly formatted SID output text files. Look for them in C:\SOLARSID\Data.

The settings and information for how the plot will appear on your screen (color, length, tick marks, et cetera) can be found in the file named "plot3.7.2". We encourage you to change that

file to your own preferences if you wish. (Save a copy of the original as a backup, in case you decide you need the original later.) For information on each setting in the plot3.7.2 file, view the plot3.7.2 file and then consult the help file for GNUplot: wgnuplot.hlp.

There is no need to open or edit plot.bat unless you wish to learn about it or modify it. Some settings that you might change in plot.bat are :

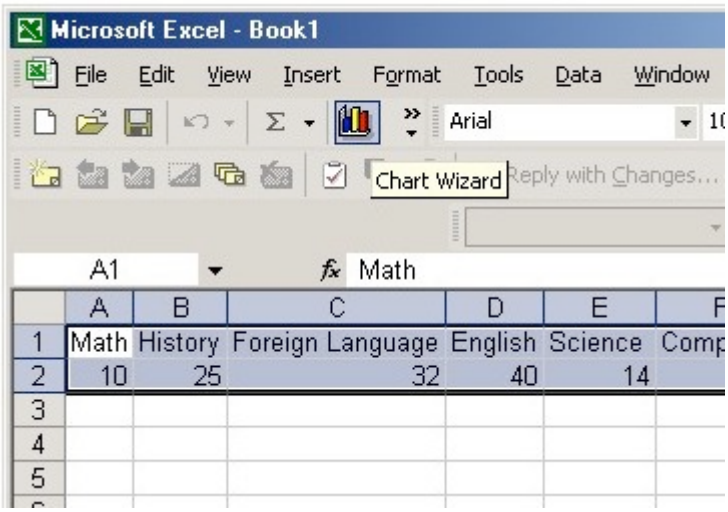
1. The plot window settings. These are referenced in line 3. In the default case the window size is 1:3, and has no title (hence the "" after the word title).
2. The name of the settings file "plot3.7.2". You may wish to use your own settings and even set up a few different "plot.bat" files with name variations. For example, you may have plot_a.bat that references "plot.abc" as the settings file, and plot_b.bat that references "plot.xyz" as the settings file, depending on what you wanted to see from your SID plots.

If you make changes to the settings file, or make improvements to plot.bat that you feel might be helpful to the SID community, we would love to hear about it. Perhaps we could build an online library at the SID website to facilitate graphing in our community. You are part of that community, so please contribute any helpful programs via email to **sid@sun.stanford.edu.**

To Collect and View Your Data with Microsoft Excel

1. **Retrieve and save in a temporary location one of your data files from C:\supersid_v1_1\Data. NEVER edit a SID datafile with Excel directly. Excel changes the formats of these and will mess up your timestamps.**

2. **Open your file with the Microsoft Office Excel program**
   Open the file you've selected (File -> Open -> copy_of_your_datafile
   If you see a row of ####### in Column A, widen that column until you see your data
   Select columns A and B
   Open the chart wizard icon



   Select chart type: Line

Select chart sub-type: Line [the 1st one]
Click <Next>
Click <Series>
Place your cursor in Category (X) axis labels, click it, then select column A
Click <Next>
Click <Next>
Click <Finish>
Right-click on Y axis
Click <Format Axis>
Click <Scale>
Set Minimum: -6 [Set Maximum: 6
Set Category (X) axis Crosses at: -6
[The 6s are good for the original SID.
For SuperSID, pick something reasonable for your data]
Click <Ok>

3. **To save the graph in Excel format, select "File→ Save as"**
   Never save a SID file back to the original data file, since Excel will gratuitously change the file format for you and information about your timestamps will be lost.

Appendix J – Solar Flare Classifications

http://spaceweather.com/glossary/flareclasses.html

The ranking of a solar flare is based on its X-ray output. Flares are classified according to the order of magnitude of the peak burst intensity (I) measured at the Earth in the 0.1 to 0.8 nm wavelength band as follows:

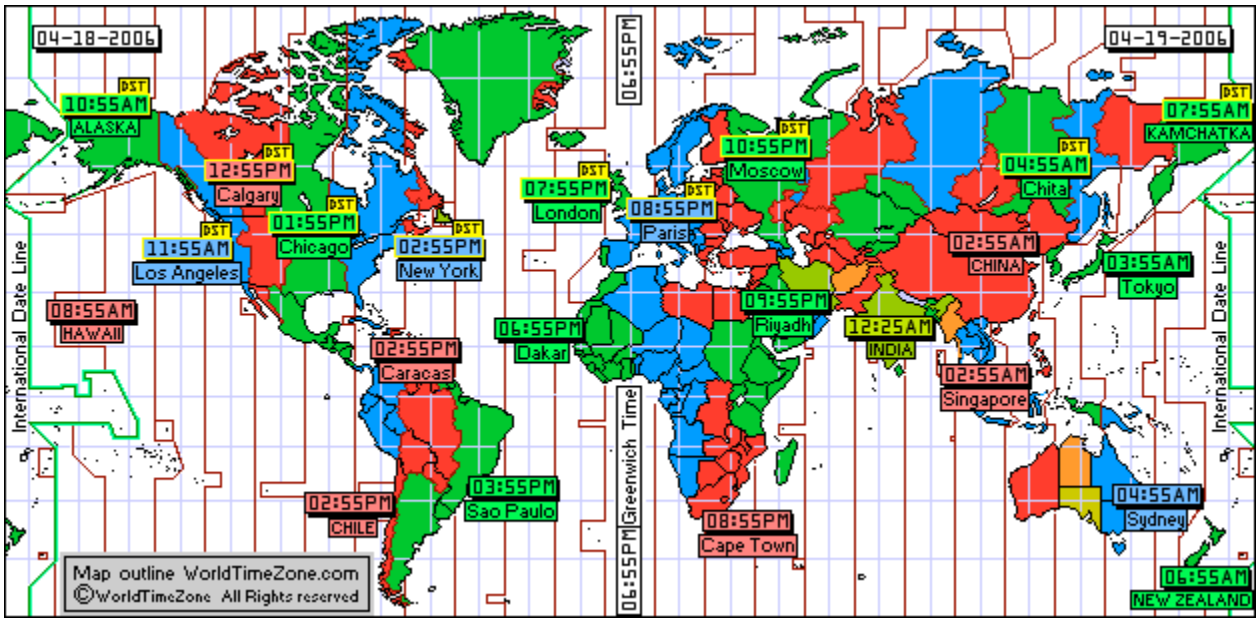
Measured as the Peak, 1-8 Angstrom (0.1-0.8 nm band)	
Solar Flare Class	**Intensity: Watts / square meter**
B	$I < 10^{-6}$
C	$10^{-6} <= I < 10^{-5}$
M	$10^{-5} <= I < 10^{-4}$
X	$I >= 10^{-4}$

Note: the GOES satellite cannot read past 10^{-2} watts/meter^2 -- that translates to an X-20 flare.

Each category has nine subdivisions ranging from 1-9, e.g. C1 to C9, M1 to M9, X1 to X9. A multiplier is used to indicate the level within each class. For example: M6 = 6 X 10^{-5} watts/square meter.

Appendix K - World Time Zones

To compare our data, we need to understand the Earth's various timezones. SID data files are kept with UTC (Coordinated Universal Time) time stamps. UTC is derived from International Atomic Time, which is a coordinate time scale tracking notional proper time on the rotating surface of the Earth, and sets current time or official time around the globe. It is similar to GMT (Greenwich Mean Time.) Most times are measured in hours and minutes from UTC. All our SID data is given in UTC so that we can easily compare data. You will need to determine your time zone to compute how much different your local time is from UTC.



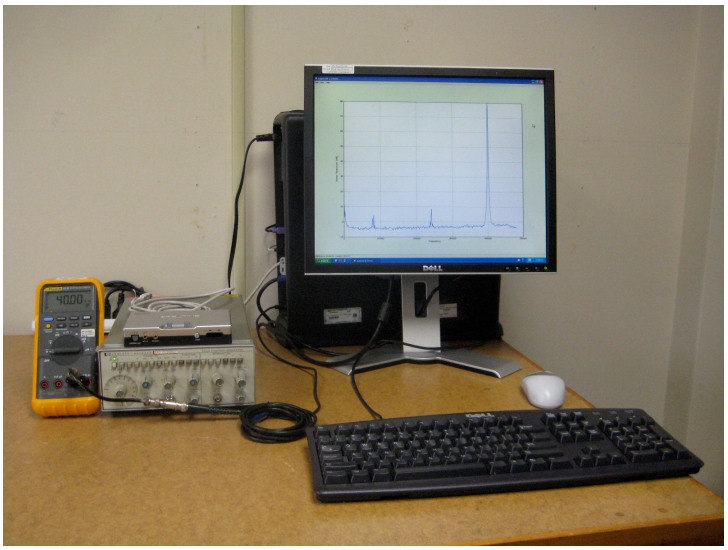
Map from http://www.worldtimezone.com/.

To find your timezone and its offset from UTC, go to:
http://www.greenwichmeantime.com/gmt-converter2.htm

Appendix L - SuperSID System Tests

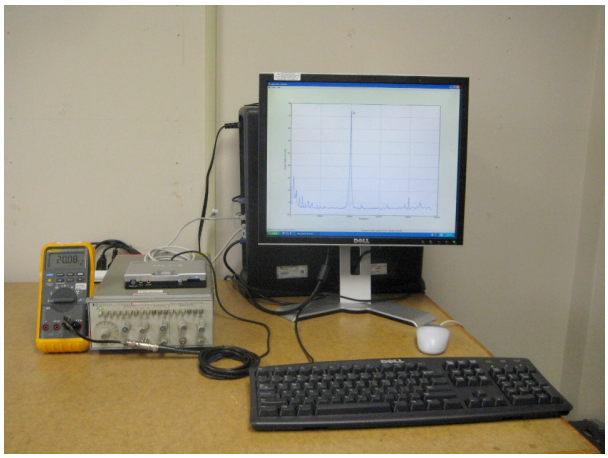
1. Internal Sound Card Noise/Performance Check.

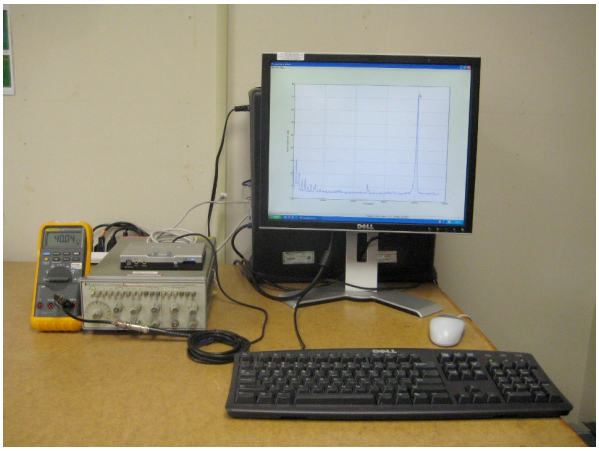
To check the system noises and over all performance, we use:
- A function generator (HP 3312A) to generate a small sine wave (~5mV).
- A multi-meter (Fluke-87-5) to display the frequency of the signal.
- Output of the function generator is connected directly to line-in of the sound card.



- We sweep the frequency across the working range (DC-48KHz) and study the responses.
- The display always shows one clean peak at expected frequency (ex: 40.00KHz in the above picture)
- The noise floor is very low and the frequency response is flat.
- The power spectrum plot typically uses log scale, which enables us to see tiny energy components embedded in the signal. (Signal strength in dB = 20 log10 (P2/P1)).
- For example here, the signal level is ~80dB higher than noise level (equivalent to 10,000 times!)
- That means the instrument noises (introduced by the PC, hard drive, CPU fan, sound card, cables, monitor) thus far, are quite small. If the antenna and preamp could produce the signal level at ~5mV, this instrument should be able to track the signal strength over time with very little error.
- It is interesting to mention that, at WSO (a low noise site), when we connected the antenna wire directly to the sound card we could see the VLF stations (without a preamp). The signals although are very small, but visible on this display.

2. USB Sound Card Noise/Performance Check

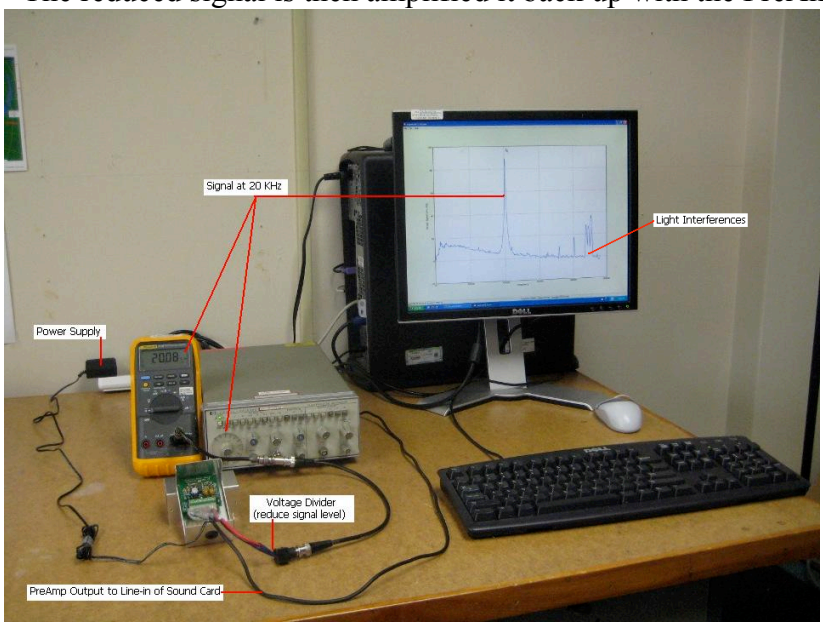




- We perform similar checks on a Sound Blaster External sound card.
- As in above pictures, we see the test signal at 20.08 KHz and 40.04 KHz.
- Again, the noise floor is very low and the frequency response is very flat.
- There are some artifacts at ~0-10KHz.
- They are small and not moving around, therefore not effecting SID data (at ~19.8-40.75 KHz.)
- Similarly, we can use this way to test other sound cards to see if they could be used.

3. PreAmp Noise/Performance Check

- Here, we add a PreAmp to the test.
- Since, this function generator can not generate very small signal (~0.1mV).
- We add a voltage divider to reduce the signal ~1000 times.
- The simple voltage divider is made of 3 resistors in series: 100K+200+100K.
- The signal is picked up at two ends of the middle resistor (200).
- The reduced signal is then amplified it back up with the PreAmp, and fed to the sound card.



- The PreAmp (as expected) amplifies both signal and noise at its inputs.
- Which raises the signal, the noise floor and other interferences in the surrounding (ex: Lab lights).
- The instrument still performs very well.
- Sweeping the frequency across the working range (DC-48KHz).
- Supersid always displays a clean peak at the expected frequency.
- The noise floor is higher, but the signal level is still good, >60dB above the noise floor (or 1000 times).

- The instrument shows that it is still capable of producing very clean SID data.
- In the field, the signal-to-noise that the user will see depends on the quality of the antenna and the noise level at the site.

*** Signal visibility was one of our main goals in designing SuperSID. We hope the display will help users to trouble shoot and to refine their setup in the field. Any change made, from antenna dimension, to antenna alignment, from reducing cable length, to having better regulated power supplies, can have a positive impact. If a modification successfully raises the signal level, relatively to the noise floor, it is an improvement! The data would be cleaner. Users could try other ideas and the result could be seen immediately on the display.

3. A Low Cost Function Generator

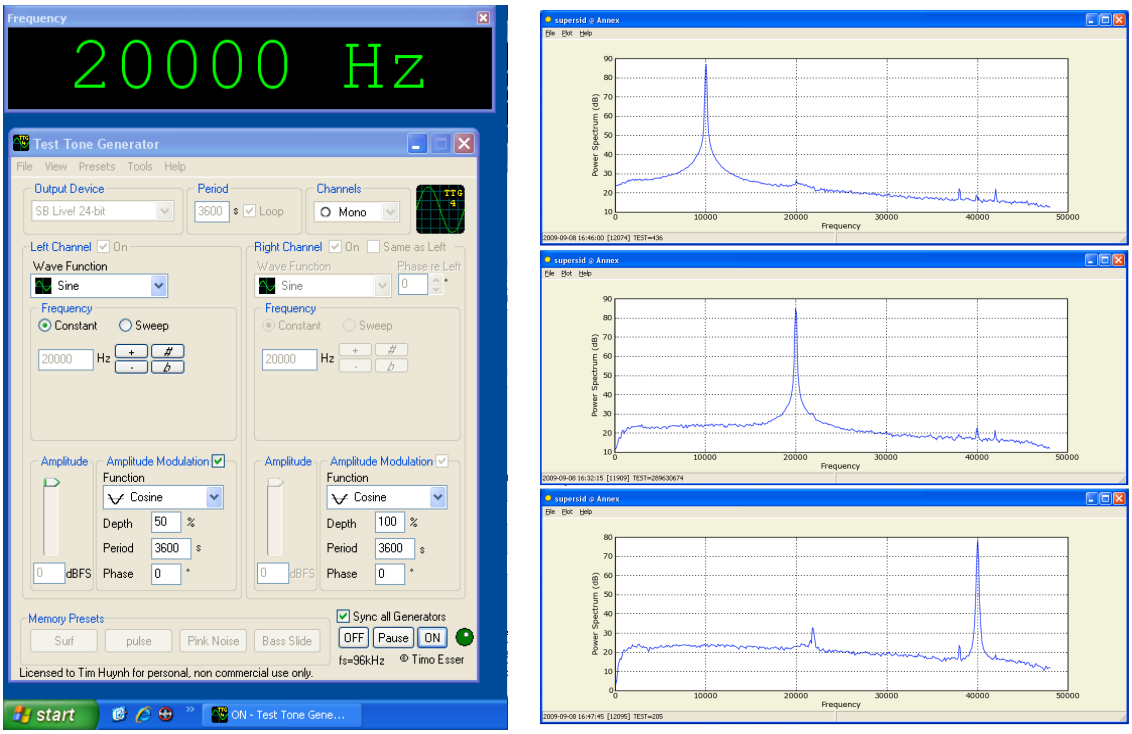
- Many small schools (site) might not have budget for a function generator and multi-meter.
- It could be very intriguing for students to hear the sound (pitch), see the signal, and play with knobs.

Test Tone Generation

There is a shareware program (Test Tone Generator) that we found useful to check the operation of the sound card before collecting real data. See

http://www.esseraudio.com/ttg.htm

It can generate a clean sin wave and allows you to sweep the frequency, change the amplitude and amplitude-modulate the signal.

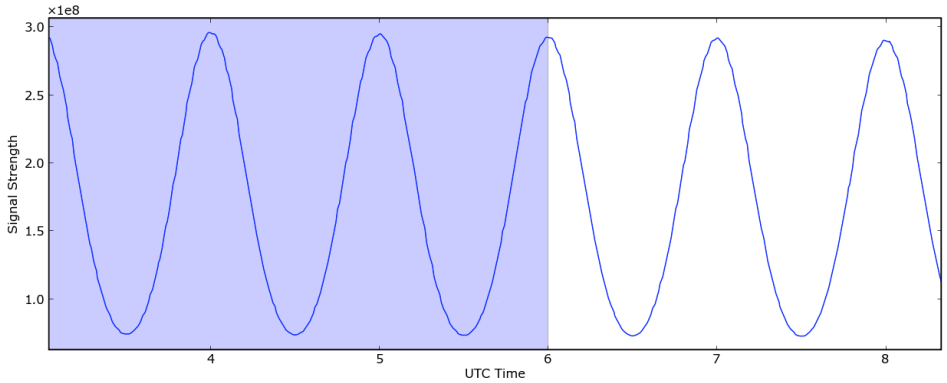


- The teacher could use 2 PCs: one to generate the test tone, one to display the power spectrum of the test signal. (Simply, we could use as small audio cable to directly connect line-out of the first PC to line-in of the second PC)
- But here, for this document, we actually would like to keep everything the same to compare the plots.
- As before, we use a small voltage divider to reduce voltage level, then amplify it with the preamp, before connecting to line-in of the second sound card.
- Above, on the right are the frequency responses when the test signal is at 10 KHz, 20 KHz and 40 KHz.
- We found that Test Tone Generator could generate test signal, clean enough for our purpose.
- We ran this test continuously for five days and the software seem to be robust enough.

4. Burn-in Test

- In Test Tone Generator, we could turn on Amplitude Modulation which modulates or slowly changes the amplitude of the signal. For example, we could set the frequency to 20000 Hz, modulate the signal 50% over 3600 seconds (as in above picture) and use supersid to track the signal strength at 20 KHz over 24 hours.

- The data file would look like this.



- In order words, we use Test Tone Generator to generate a know test pattern, one “simulated” sun-rise and sun-set every hour, and use it to check the spectrum estimation the linearity of the system.
- This could be used as one of the tests to check PreAmp circuitry after assembly.
- We first collect the data of couple good boards to get the typical profile, or where the highs and lows should be.
- We should see a nice sine if a PreAmp is working properly.
- After being burned-in for 24 hours, if a component fails, or a component is not within specs, we probably will see different pattern. Hopefully, that would help us catch the board before shipping.

Appendix M - SID Monitor Quick Reference Sheet

My site name	
My monitor ID	
My Timezone & its offset from GMT	
My latitude & longitude	
Transmitters I pick up	
Help email	SuperSID@radio-astronomy.org
SuperSID configuration file	C:\supersid_v1_1\Config\supersid.cfg
SuperSID main application	C:\supersid_v1_1\Program\supersid.exe
SuperSID data	C:\supersid_v1_1\Data
SuperSID manual, data guide, research guide	C:\supersid_v1_1\Doc
SID data site	http://sid.stanford.edu/database-browser/
SID ftp site	sid-ftp.stanford.edu
SID web site	http://sid.stanford.edu
Current solar flare charts (GOES)	http://www.sec.noaa.gov/rt_plots/xray_5m.html
Previous solar flare catalogs (GOES)	http://www.sec.noaa.gov/ftpmenu/indices/events.html
Solar images, current (SOHO)	http://sohowww.nascom.nasa.gov Hit "Sun Now" button
Farside solar images (Stanford)	http://soi.stanford.edu/data/full_farside/
Space Weather current info	http://spaceweather.com (general) http://www.sec.noaa.gov/SWN (detailed)
Current Sunspots / Active Regions (SOHO)	http://sohowww.nascom.nasa.gov Hit "Sunspots" button
Time zone information	http://www.greenwichmeantime.com/gmt-converter2.htm