GeoTool Seismograph Station

User Guide

Manual Version 1.0 (Demo)
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Warranty

The ‘GSP-Seis’ software includes no expressed or implied warranties of merchantability and fitness for a particular purpose, with respect to the software, or accompanying manuals. The authors, in no event, shall be liable for damages, whatsoever arising out of the use of or inability to use the ‘GSP-Seis’ software.

About this Manual

This manual has been prepared to help understand the program and the operation of radio receivers to obtain as clean a trace from telemetry signals as possible. We start by describing the operation of the program and conclude with a basic discussion of radio operation, antenna types and placement, sources of interference, and a few other topics that will make monitoring easier.

One of the most important aspects of using the program is knowing how to select audio signals, and set their levels through the Windows Audio Controls. A discussing of these is provided, but you should experiment with different audio sources and levels to become proficient with their use. Knowing which channel is selected for both recording and playback is important vital to the operation of the system. This is the source of most problems with system setup. Be sure you understand audio controls completely.

Questions

If you have questions regarding any aspect of the operation of the system, the easiest way to contact us is via email. We both check mail frequently and can answer most questions with a short turnaround time. Most of your questions should go to the first name below.

Rick Curtis: Info@geotool.com
(or)
Jim Barber: N7CXI@SiliconPixels.com

Inroduction

GSP-Seis is a new approach to monitoring earthquakes. The program is a full 32 bit Windows 95/98 ®, WindowsNT ®, WindowsME®, and WindowsXP® compatible companion to enable the user to monitor earthquake activity using the many remote telemetry monitoring stations and a scanner radio. When your scanner is coupled to the sound card in the computer, the sound card serves as a sophisticated A/D (Analog to Digital) converter, based on state of the art DSP (Digital Signal Processing) technology. The DSP engine is capable of processing clean, low distortion telemetry signals to 16-bit resolution (± 1 LSB). The monitor screen displays the seismogram in real time as data is received and processed. The program also provides controls for adjusting file-save triggers, warning tones, sound card levels, and for viewing saved files.

System Highlights

DSP VM (Virtual Machine)

- Analog signal detection provides superior performance over 'hard limited' FM detectors by permitting sub-cycle frequency recovery.

- Digital filters are individually set for each telemetry frequency and deviation.

- Each data point is the result of digital signal processing of several samples taken in a fraction of a second. The result is a clean signal output that, with a low distortion input tone, produces a very precise representation of the incoming signal.

User Interface

- The main screen displays both the incoming seismogram information on a 10, 20, 30, or 60 minute display. Also displayed are both minute and second time graticules, trigger settings, start time, number of samples per second, trace gain, center frequency, number of samples saved, maximum and minimum seismic excursion, and correction factor used to compensate for carrier drift.

- Drop down menus provide access to file viewing and printing, parameter setting, and observation of numerical data during data acquisition.

- This demonstration version is in the process of being upgraded to provide many more enhancements to allow processing of earthquake data, automatically select P and S wave arrival times, calculate approximate distance to an epicenter, and convert from velocity to acceleration displays. Other functions will be added in the near future.

System Requirements

- Pentium 90 or faster (May run on slower systems but not recommended)
- 16 MB of RAM (As with all image processing software “more RAM is better’)
- TrueColor video card (16, 24, or 32 bit display) (limited support for 256 color displays)
- 16-bit, crystal controlled sound card, with appropriate driver software
- Windows 95 ®, Windows 98®, or WindowsNT ® 4 (SP4 min.), WindowsME®, and WindowsXP®

A Word About Windows Screen Font Settings

We strongly suggest that you run Windows with your display settings set to use ‘small fonts’. If you have trouble reading ‘small fonts’ the proper solution is to set your screen to a lower resolution (i.e., instead of 1024 x 768 on a 15” monitor you might try 800 x 600). If you use ‘large fonts’ Windows will ‘scale up’ all of the screen elements including all controls and image boxes on the screen to accommodate the larger fonts.

Unfortunately, ‘fixed elements’ such as the data screen will not be scaled up as it is important to maintain the original size. The effect of this is that you will end up with large forms on your screen, which will waste precious screen area. By using ‘small fonts’, controls become more compact and more screen area is available for ‘real work’.

GSP-Seis Installation

Before installing GSP-Seis please be sure that you 'uninstall' any older version of GSP-Seis you may have on your system. Use the 'Add/Remove Programs' control panel to uninstall GSP-Seis. When prompted about controls that are no longer in use press the 'no to all' button.

If you have downloaded a GSP-Seis update patch file you should not uninstall your previous version of GSP-Seis. When you run the patch file it will simply replace some of the CPIX files with those required by the newer version.

If you received GSP-Seis on a CD simply insert the disk and follow the installer instructions.

If you received GSP-Seis on a set of floppy disks insert disk 1 into your floppy drive, open the disk with Windows, and double click on the SETUP.EXE icon. Follow the installer instructions.

If you downloaded GSP-Seis as several .ZIP files then either unzip the files onto individual floppy disks (i.e., Disk 1, Disk 2 ...), or unzip the files into a temporary folder on your hard drive. Then run SETUP.EXE either on the first floppy or in the temporary folder. Follow the installer instructions.

If you downloaded GSP-Seis as one large .EXE file then just double click on that file to start the installation. Follow the installer instructions.

The 'suggested default' installation directory for GSP-Seis is:

C:\Program Files\GeoTool\GSP-Seis

Bug Reports

If you find a problem with GSP-Seis please document exactly how the problem can be reproduced and observed and email the report to either:

Rick Curtis: Info@geotool.com
(or)
Jim Barber: N7CXI@SiliconPixels.com

Please include a full description of your computer system (memory, cpu, speed etc.) and GSP-Seis version number along with the bug report. Please also check the GeoTool web page (http://www.geotool.com/geoseis.htm) for any updates to the software or problem solutions in the FAQ. Your particular problem may have already been addressed in the FAQ or by a program update.

Registration

(All prices in US dollars)

Email registration: (you DL the program from our web site)	$ 50.00
Media shipment: (you request a CD with registration)	$ 10.00
Replacement/update:	$ 15.00

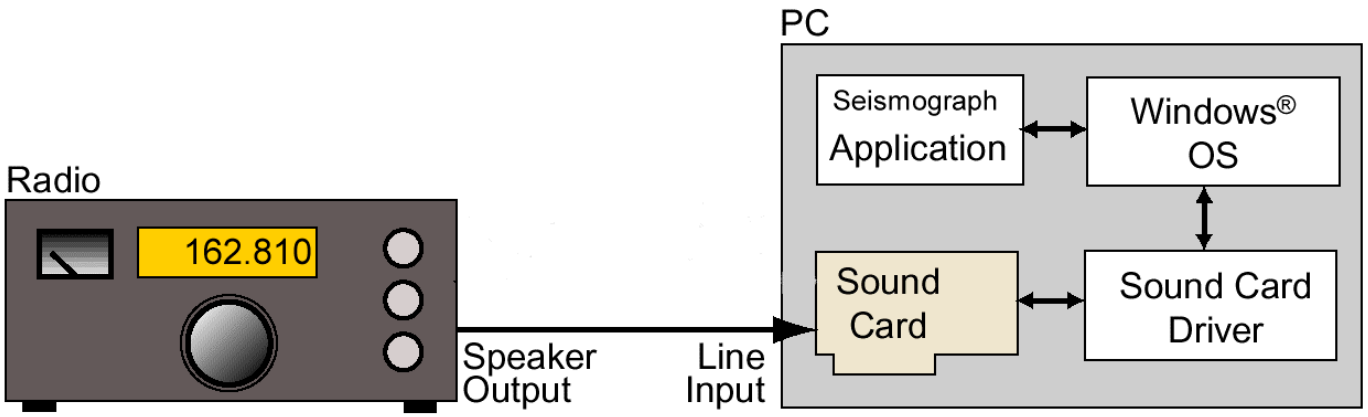
GSP-Seis. Unfortunately we cannot discount media shipments if they are requested. Unregistered copies of GSP-Seis are fully functional but will only run for 30 days.

GSP-Seis registration is available from the following agents:

USA and Worldwide

Rick Curtis – GeoTool
P.O. Box 10288
Newport Beach, CA 92668, USA
Email: info@geotool.com
http://www.geotool.com/geoseis.htm

Jim Barber, Silicon Pixels
P.O. Box 579
Selah, WA 98942 USA
Email: N7CXI@SiliconPixels.com
http://www.SiliconPixels.com

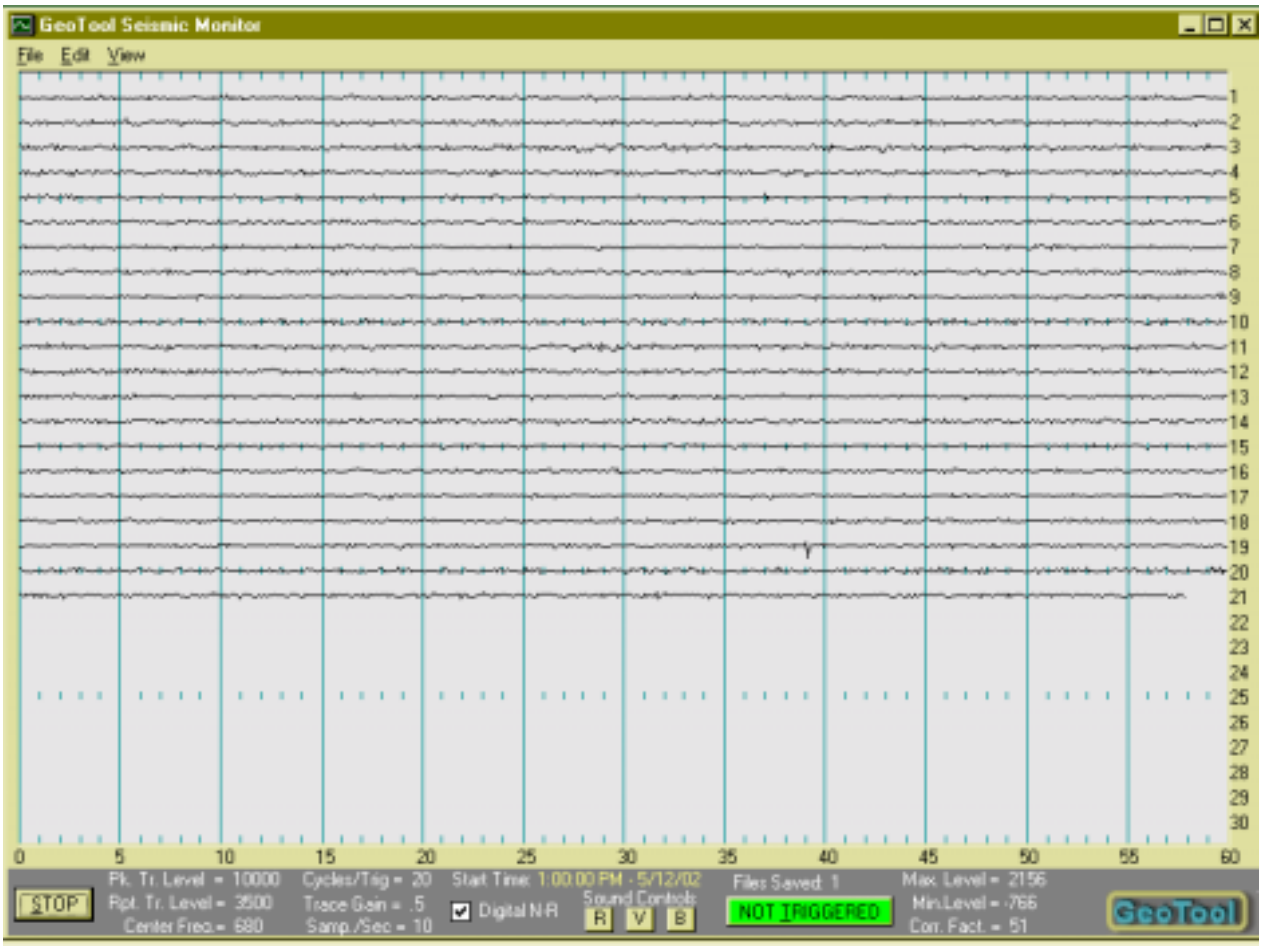


GSP-Seis System Block Diagram

System Overview

GSP-Seis a 32-bit seismograph program that runs on Intel® based PCs under Windows® 95, 98, ME, XP or NT4. For telemetry reception, audio is fed from a suitable output (speaker or aux out) of a radio receiver (tuned to a seismic telemetry signal) to the 'Line Input' jack of a 16-bit Windows® sound card. GSP-Seis then processes the audio telemetry signal by accessing the audio card through standard Windows® API (Application Programmers Interface) calls. Windows® then communicates with the sound card hardware using the sound card driver software supplied either on the Windows® installation CD or obtained from the sound card manufacturer. It is strongly recommended that you check to be sure you are running the latest version of the driver software for your sound card. Typically sound card driver updates can be obtained directly from the card manufacture's web sit on the Internet.

The GSP-Seis application software is comprised of a DSP (Digital Signal Processor) based telemetry demodulation engine (Virtual Machine), which communicates with the graphical user interface displays (GUIs). The VM (Virtual Machine) is responsible for providing seismic telemetry signal recovery. The use of DSP technology enables superior signal recovery (and clarity) especially under poor signal conditions. The VM also provides a real time display of the incoming seismic trace.



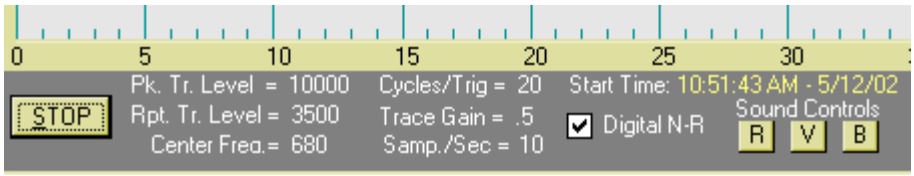
GUI Layout

The graphical user interface (GUI) comprises an on-screen real time seismogram and data display, with standard Windows drop down menus to access other functions. A few definitions are necessary to understand the various on screen displays,

Definitions

Trigger – When ground shaking exceeds the trigger level, the program will play the seismic telemetry signal through your speaker system, serving as an alarm that the predetermined trigger levels have been exceeded and will save the current data in a file following completion of the screen.

Trigger Level - The trigger level is set to the absolute value of the value of the incoming data. This value ranges from 0 to 35,565, or half of a 16 bit binary number. You need only enter a positive number for trigger levels.



Left Side of On-Screen Data Display

Start Button – Starts the program running. Changes to:

Stop Button – With the program running, this button is used to stop data acquisition. Also toggles with Control-'S'.

Pk. Tr. Level – *Peak Trigger Level* – Displays current setting for the level at which the program will trigger a file save and warning tone. Maximum value of this level is ±35,565.

Rpt. Tr. Level – *Repeat Trigger Level* – Displays current setting for level which when exceeded several times, will trigger a file save and warning tone. Maximum value of this level is ±35,565.

Cycles/Trig. – *Cycles Per Trigger* – Displays current setting for number of excursions beyond Repeat Trigger Level required for a low level trigger to occur. Typically this is set to somewhere near one to two times the number of samples per second.

Trace Gain – *Trace Gain* – Gain of screen trace. At a gain of 1.0 a full scale reading would just cover the entire screen. The trace gain can be any value from 0.1 to a maximum recommended value of 80.

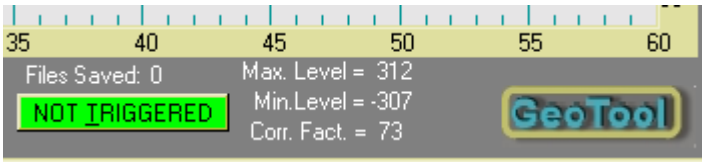
Center Freq. – *Center Frequency* – Carrier Frequency for telemetry input.

Samp./Sec. – *Samples Per Second* – Number of digital samples taken each second. This number ranges from 10 to 50 in steps of 10. As the number of samples taken (or the number of minutes monitored) increase, so does the saved file size.

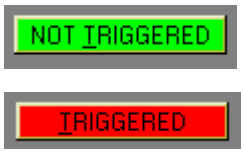
Start Time – *Time Program Started* - The time, based on the computer clock, at which the program started collecting data.

Digital N/R – *Digital Noise Reduction* – Digital noise reduction. Useful for some types of radio interference noise.

Sound Control Panel Access – Press 'R' for the recording sound mixer, 'V' for the playback volume mixer, and 'B' to view both panels. The mixers will come up on top of each other if you press 'B'. While in either mixer control, pressing Control-'S' will change the complexity of the control.



Left Side of On-Screen Data Display



Trigger Indicator – Shows trigger status. Green button with "NOT TRIGGERED" indicates no trigger received or trigger canceled by user. Red button with 'TRIGGERED' indicates trigger has been received or user manually set trigger.

User manually sets trigger by clicking on the button, or by pressing Control-'T'.

Files Saved

Files Saved – Number of files saved since startup. Pressing 'Stop' button resets this value.

Max. Level

Min. Level

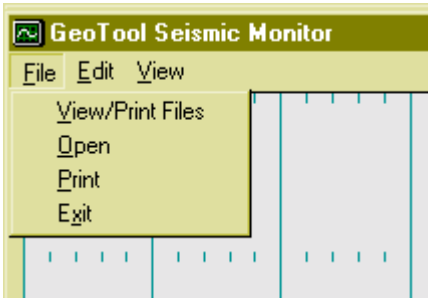
Maximum and Minimum Data Level – Displays highest and lowest telemetry reading displayed on the current seismogram screen. Resets when new screen is started. Maximum value of this reading is ±35,565.

Corr. Factor

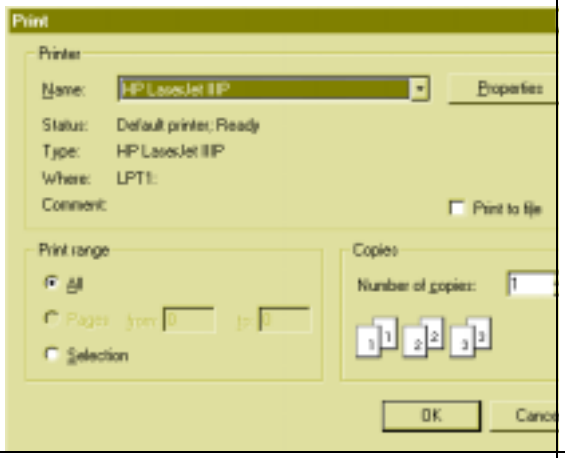
Correction Factor – Displays current setting for level which when exceeded several times, will trigger a file save and warning tone. Maximum value of this level is ±35,565.

Windows Drop Down Menus

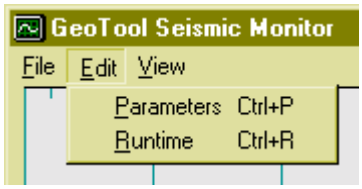
‘File’ Drop Down Menu



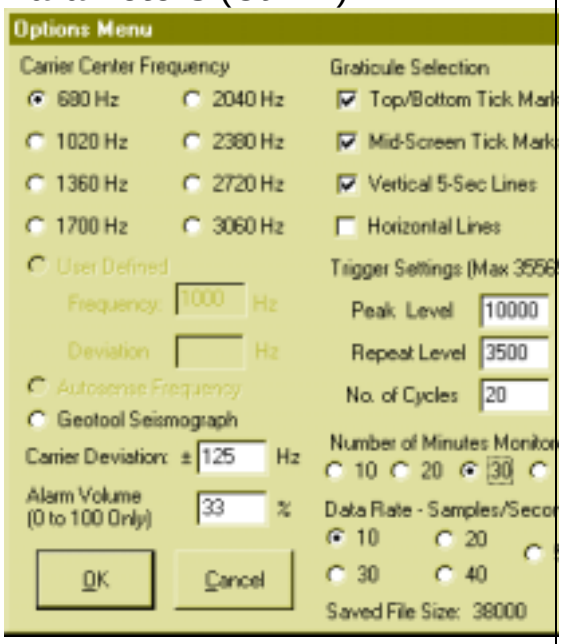
View/Print Files 	This command opens a SECOND Instance of the GSP-Seis program for viewing and printing files. It will not run the program. Several functions are inactivated since this program is used only for viewing, deleting, and printing screens.
Open 	This command opens the standard windows file open dialogue box. You may click on a file to open it, or highlight it and delete it. You also have several other standard windows dialogue box functions available including making new folders and viewing different displays.

Print 	The *Print* command opens the standard Windows print dialogue box, with all the standard print functions available. The print function will print the entire screen to the selected printer.
Exit	The *Exit* command is used to exit the print program and return to the GSP-Seis main window.

‘Edit’ Drop-Down Menu



Parameters (Ctrl+P)



The *Options Menu* allows setting of:

Carrier Frequency

Geotool Seismograph Station Option

Alarm Volume (0 to 100% of Master Output Volume – Set maximum level with ‘Wav’ output slider)

Visibility of tick marks and lines on display screen

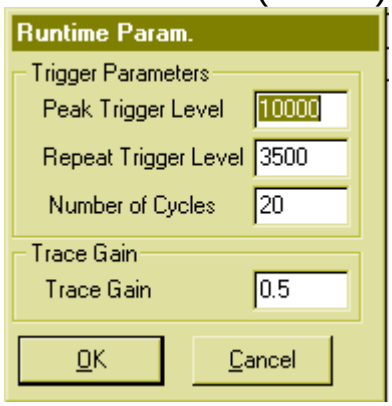
Trigger sensitivities

Number of Minutes displayed on screen

Data Rate

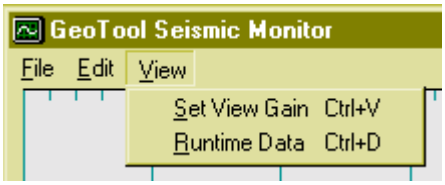
Note: Program stops running when this menu is opened because changing most of the parameters requires restarting.

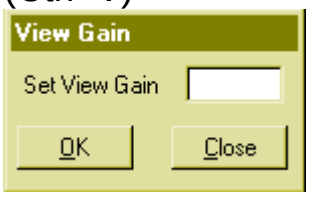
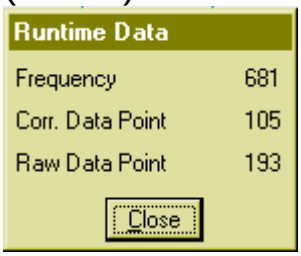
Runtime Data (Ctrl+R)



Allows setting of Trigger parameters while program is running.

'Runtime' Drop-Down Menu



View Gain (Ctrl+V) 	*View Gain* – Set view gain to any value between 0.1 and about 80 for clearest viewing, depending on size of trace.
Runtime Data (Ctrl+D) 	*Runtime Data* – Displays monitored frequency, corrected data point, and raw data point as they are received.

Telemetry Stations

Seismic telemetry stations are located throughout the country. Many are digitally connected to monitoring facilities at universities, the United States Geological Survey, and other government agencies. Others use analog telemetry tones to relay information from remote sites to radio receivers and digital converters. The latter are the telemetry systems that GSP-Seis is designed to monitor.

The telemetry tones use eight different audio carrier frequencies between 680 Hz to 3060 Hz. A full-scale reading of the seismograph causes the tone to vary (deviate) ±125 Hz above and below the carrier frequency. This full deviation causes a full screen deflection of the trace on the GSP-Seis screen, at a gain setting of 1. GSP-Seis converts the 250 Hz total deviation into 16-bit data, or approximately 65,535 points.

Most telemetry stations are set with relatively high gains. This allows them to pick up distant earthquakes, but makes even small local events go off scale easily. For that reason, telemetry station monitoring is not well suited to providing a warning for earthquakes. It is, however, a very good source of data for watching earthquakes from

relatively great distances. For example, large earthquakes in South America can commonly be seen on telemetry monitors in California.

Telemetry Transmitter Frequencies

Transmitter frequencies used by the U.S. Government for telemetry usually fall in the following frequency bands:

162.000 -174.000 Mhz • 216.000 - 220.000 Mhz • 406.100.- 420.000 Mhz

Other California frequencies that may be used for telemetry are as follows:

San Francisco Bay Area - Northern California

163.0500	163.0500	165.8100	171.0000	406.1900	412.2500
163.4400	163.4400	166.4000	172.8600	407.3520	413.5100
163.6050	163.6050	166.8250	217.6000	408.5120	414.6650
163.9100	163.9100	167.8050	217.6900	409.6000	415.2000
164.8450	164.8450	170.3100	218.2500	410.5500	415.2250

Southern California

162.5940	163.3970	163.9375	165.8065	166.6595	171.2190
162.5970	163.6060	164.0060	165.8095	167.1940	171.2220
162.8060	163.6090	164.0095	166.4190	167.1970	171.4065
162.8090	163.7935	164.8440	166.4220	167.8065	173.1940
163.3500	163.7970	164.8470	166.6565	167.9085	175.2550

Nationwide Federal Frequencies Shared With USGS

164.1000	166.8000	168.5000	407.4250	412.1750	417.4000
164.5250	166.8750	168.5500	407.5250	412.3750	417.5750
164.6750	166.9500	169.5750	407.5750	412.7000	417.6250
164.8000	166.9750	169.6250	408.0750	412.8250	419.8750
165.4875	167.0750	169.8250	408.5500	412.8750	419.9000
166.2750	167.1250	172.4250	410.5750	412.9500	419.9250
166.3500	167.9500	172.6750	411.6250	412.9750	419.9500
166.3750	168.2750	172.7250	411.6750	414.8250	419.9500

Monitor Radios

Most scanner radios that will receive the frequency bands outlined above will work adequately with GSP-Seis. The best-suited radios have continuously variable frequency selection by means of a tuning dial. However, most scanners with digitally programmed frequency entry will allow monitoring of telemetry signals, even if they are a little off the actual frequency. Some distortion may result, but it is worth trying a less expensive scanner before purchasing one for several hundred dollars. Many of the newer Amateur radios have variable frequency dials, wide frequency coverage, and can be used to explore for telemetry sites.

Radio Operation

Radio operation seems like it would be simple. Just turn on the radio, tune to the telemetry frequency, turn the squelch control off (typically fully counter clockwise), and start monitoring. In rare instances, if you are within ¼ mile of the telemetry site, you may get really lucky and it will work. However, you are still likely to encounter one of the two very common problems associated with computer connections to radios.

Computer Noise in the Receiver

This is by far the most common problem encountered when trying to connect radios to computers for date collection. Computers emit a great deal of radio interference. This is because there are several oscillators operating with square wave outputs that generate many harmonics. Elimination of the problem depends on a lot of factors, and no two computers will need the same noise reduction methods. In all cases the goal is to stop the RF energy from leaving the computer box, keep it out of the leads of the audio cable from the radio receiver, and keep it from getting into the receiver antenna. There are several possible solutions, and one or a combination will minimize or eliminate the problem.

Radio Receiving Antenna.

1. Orient the receiver antenna as far as possible from the computer. This alone may solve the majority of problems.
2. Use a directional antenna aimed at the telemetry station.

Computer RF Attenuation

1. Attach ferrite chokes to all leads leaving the computer, particularly the power line and monitor cords. Also attach chokes to the power cord to the radio. Chokes for this purpose are available from Radio shack and GeoTool.
2. A high quality line filter for the monitor and computer can reduce the amount of RF energy getting into the power line system. A simple surge protector does not function as a line filter. The proper unit should have both a line filter and surge protector.
3. RF signals from the computer can be coupled directly through the audio cable used to get the telemetry signal into the computer. If you have this problem, it can be minimized or eliminated by installing an inline Audio System Ground Loop Isolator (Radio Shack part number 270-054). Not only are ground loops removed, but RF interference is also greatly reduced or eliminated. The Radio Shack version of this device has two stereo lines with RCA plugs on each end. Appropriate adaptors should be attached to each end of the cable to provide a monaural plug on the side that goes into the radio, and a stereo plug for the sound card line input.

Radio Signal Quality

Most telemetry stations use frequency modulation, which like commercial FM stations provides a very low noise signal with excellent audio reproduction. One of the challenges of monitoring telemetry stations is that their transmitters are typically very weak, about 1/10 of a watt. Nonetheless, stations can be monitored at distances of 50 miles or more if there is a line of sight between the transmitter and receiver.

GSP-Seis will provide usable data with signals that do not even move an S-Meter. However, signals with a strength of S-3 to S-5 are preferred. With signals this strong, very little background noise is heard along with the tone. As with broadcast FM radio, a strong FM telemetry signal with no audio makes all the background rushing noise disappear. Such a signal is referred to a full-quieting signal. Weaker signals will have increasing amounts of background noise. No signal at all results in only noise being sent to the speaker.

If a signal has no noise and very little harmonic distortion of the telemetry tone, a gain of 20 to 60 or more can be used, and will produce a relatively clean trace on the screen. As noise increases, the trace becomes degraded and deviation from the center point of the trace increases (it appears to jump all over the screen). Even with a noisy signal, however, it is possible to use the seismograph by reducing the gain. Gains as low as 0.2 can still display earthquakes reasonably well.

Antennas

The radio antenna type and location can make a great deal of difference in the quality of signal reception. The antenna provided with most scanners is very marginal for receiving telemetry signals. A better antenna would be a dipole antenna, and even better a beam antenna comprised of several elements. Beam antennas are similar to standard television antennas, except that they are designed for use on a small band of signals.

Telemetry stations generally transmit with a horizontally polarized signal. Radio waves are similar to light waves in that they can be polarized. Just as horizontally polarized sunglasses cut out most of the glare coming off polished surfaces (glare is often vertically polarized), a vertically polarized antenna will not receive horizontally polarized signals well. Standard television antennas are horizontally polarized to best receive television signals. In addition, high frequency horizontally polarized signals travel over long distances more easily.

A dipole antenna can be made relatively easily. In fact, a television rabbit ear antenna can be modified by attaching 50 ohm coaxial cable (common designation RG-58) by stripping the end and attaching the center conductor to one side of the antenna, and the braided shield to the other. The total length of the antenna (in feet) can be determined by dividing 468 by the frequency of the station to be received (in Mhz). Accordingly, a signal at 162.81 Mhz would require an antenna with a length of 468 / 162.81, or about 2.8746 feet. Multiplying 12 by 0.8746 gives the number of inches, or 2 feet 4.952”, or about 2 feet 5

inches. Fine-tuning the antenna is accomplished by varying its length, and listening to the strength of the station. Remember, both sides of the antenna should be the same length.

A beam antenna can be built to achieve increased gain over that of a dipole. This is accomplished by adding elements at specific spacing and varying lengths in front of and behind the dipole. A discussion of this type antenna is beyond the scope of this manual, but information is available by searching the web for beam antennas.

Antenna orientation is important. Move the dipole antenna (or even the antenna on the radio) to a position broadside to the station you are trying to listen to. Orient the antenna horizontally. Sometimes signals are deflected from buildings, wires, or even mountains and can be skewed from horizontal. Try varying the angle of the antenna to increase the signal. You will likely discover that the higher an antenna is placed, the better the signal. An antenna on a mast above the roof will work better than one on the desk or in the window next to the computer. Also, the farther the antenna is from the computer, the less noise will be picked from the computer itself.

Audio Control Panels

The functions of the Windows audio control panels are described above. The importance of knowing what signals are being sent to the sound card cannot be overstated. You need to know what the sound card is hearing. Look at the help menu on both mixers and understand the functions. Also, experiment with the controls. Some controls allow adjustment of the balance. The record controls and some of the output controls do not allow adjustment of the balance.

Recording Mixer

The most important control is the RECORDING (Signal Input) mixer. Fortunately, most programs allow the use of only one input to the recording mixer to be sent to the sound card.

On the record mixer, you generally need only select the source. The level control does not always control the volume going in to the sound card. On my system, this is true. The volume control on my radio is the only control for the input volume. On my system the line input slider does not control the volume going into the sound card. Other systems may work differently.

Playback Mixer

The playback mixer controls the volume of the warning tone. The program adjusts the Master Volume to play the audio tone through your speakers whenever a trigger is received. The Line Input volume slider adjusts the volume of the warning tone, as does the warning volume setting in the Options – Parameters menu. Experiment to get a good level for your particular needs.

On many programs the playback mixer in the enhanced mode (hit Ctrl-S when viewing the playback mixer) contains a level control. This may be of use when setting the receive volume on some systems. Some systems will not work like mine. On my system, I set the volume by advancing the receiver volume until just before the level meter shows yellow. I do not have distortion problems if I set the control this way.

About the authors

Jim Barber is the owner of Silicon Pixels, a computer programming company in Selah, Washington. He is an extremely intelligent and crafty computer engineer specializing in automation systems and audio digital signal processing. Jim is one of the sharpest individuals I have ever met, and by far the best computer programmer I could imagine. He makes the impossible seem easy. If you have a Sound Blaster card, you probably have some of his programming already. Amateur radio operators know of his ChromaPix slow scan television program for sending pictures around the world on the ham bands, and his audio digital signal processing software ChromaSound, for filtering signals out of background noise. Check out his web site at http://www.SiliconPixels.com.

I'm Rick Curtis, owner of GeoTool, and an engineering geologist working in Southern California. I am involved in the construction industry making recommendations for new construction that render buildings safe for occupancy. Seismology is a major part of engineering geology, and I have been interested in it for many years. I built and marketed a 3-channel seismograph for several years, and now we are using Windows programming with a new concept in seismic telemetry monitoring. In the near future, a single channel seismograph will be ready for sale, which will monitor a seismic sensor at the users location. A 3-channel seismograph is in the works for late 2002 or early 2003.

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