- Earthquake Monitoring
- Micro-seismic studies
- Structural Analysis
- Blast Monitoring
- Surveillance

Overview

Typical exploration seismographs can be triggered only by a discrete pulse from an external device such as a hammer switch, blaster, vibrator or some other form of contact closure. Because Geometrics seismographs are always sampling, a real time analysis of incoming data on all channels can be performed on a decimated data stream and the systems triggered automatically based on user-defined criteria. This can be useful for a variety of applications – earthquake monitoring, micro-seismic studies, vibration and blast monitoring – even surveillance.

Alternately, when 100% data recording is required, Geode/NZ seismographs can record continuously. Data are partitioned into user defined files and can be resized using a post-processing utility.

Operation

Geometrics seismic event detection software allows you to monitor one or more channels for a seismic anomaly. If an event meeting your criteria occurs on any (or all) of the designated channels, the seismograph will trigger and record the data.

The event detection algorithm works as follows: on each designated monitoring channel, noise samples are gathered from the data stream. Average RMS values of the noise are calculated for two contiguous time windows. If the ratio of the average energy in Window 2 divided by the average energy of Window 1 is more than a certain threshold, an "event" is detected by that particular channel. This is similar to the 'STA/LTA' algorithm widely used in earthquake monitoring.
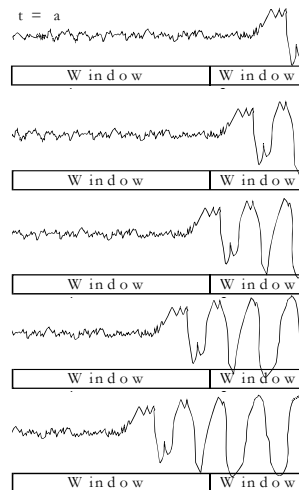
The lengths of Window 1 and Window 2 are selected by the user, as is the threshold ratio required for an event.

The system can be configured to trigger if a **single** channel receives an event, or if **all** of a set of channels receive an event simultaneously.

Combinations of channels can be used to detect specific events or eliminate false triggers.

- Events detected on designated 'OR' channels will trigger the seismograph when **any one** of the specified channels sees an anomaly.

- Events detected on designated 'AND' channels will trigger the seismograph when **all** of the specified channels see an anomaly.

Once the Geode or NZ operating software has determined a trigger has occurred, a trigger command is sent to start the seismograph recording at the user defined sample rate and record length. Some variation in the process exists between models of when the Geode selected as the trigger master receives a trigger command, the Geode generates a hardware trigger sent to all Geode/NZ boards in the system. All boards trigger simultaneously with no delay at the sample interval specified in the ACQUISITION dialog box. .

Data are then transmitted to the seismic control PC and stored in a user defined format. A time stamp is added to the data either by the PC, or by an optional external GPS if greater accuracy is required.

Once this process is complete, the seismograph returns to its armed state and continues to monitor the decimated data stream, ready to trigger again when an anomaly is detected.

Self-trigger Algorithm - Detailed Description

Geometrics StrataVisor and Geode seismographs collect data continuously at the system's maximum sample interval. Data are temporarily stored on the A/D cards in memory that is configured as a circular buffer. These data are transmitted to the seismic controller PC in two ways, either as

- a decimated continuous stream of data used for event monitoring purposes
- a seismic data file at a user defined sample rate and record length, sent in response to either a hardware or software command

The decimated continuous stream of data can be used to measure the output from the sensors attached to the system, almost in real time. Data are decimated at a rate shown in the table below. Once an event condition is detected in the decimated data stream, a command is sent to the A/D cards to send the more densely sampled data at a user defined sample rate. This is possible even though some time has passed because the data are still in the circular buffer and can be retrieved before they are overwritten by more recently sampled data. To ensure that all of the more densely sampled data representing the detected event are transmitted to the control PC, it is necessary to set a 'pretrigger' recording time. This is done by specifying a negative delay in the ACQUISITION menu of the seismograph.

Decimated noise data are partitioned into 40 sample 'blocks' to make computation easier and demand less resources from the CPU. Two adjacent windows are constructed from these noise blocks and the RMS values from each noise window are calculated and compared. If the ratio between these windows exceeds a user defined threshold, a trigger command is generated for the A/D cards to send the more

densely sample data, as specified by the required sample rate and record length.

Sample Interval (usec)	Decimation Factor	Block Length (ms)
20.83	240	200
31.25	160	200
62.5	80	200
125	40	200
250	20	200
500	10	200
1000	5	200
2000	2	160
4000	1	160
8000	1	320
16,000	1	240

The threshold calculation is undertaken on all channels, and these channels may be compared using AND or OR Boolean logic, as dictated by the requirements of the survey. This threshold calculation is repeated on all channels each time a noise block is received from each channel.
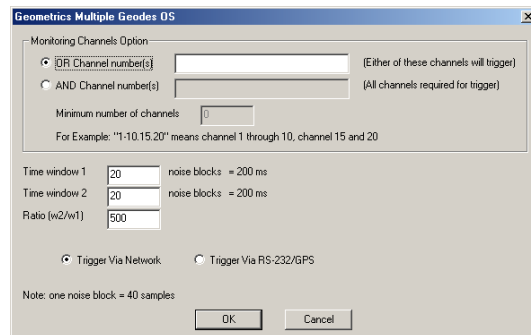
When using AND channels to trigger, the length of the W1 and W2 windows should be sufficient so that the event being measured exceeds the threshold value for a long enough time period for the event to be registered as detected in other monitoring channels as well. If this condition is not met, a trigger will not be generated even though all channels may have detected the event individually at different times. This is particularly true for events that do not excite the sensors simultaneously. Detection of non-simultaneous events can be partly improved using the "Minimum Number of Channels" box setting. If this is set to be less than the total number of channels, then the system will trigger without all AND'd channels detecting an event.

Note that an appropriate sample rate should be chosen since it effects both the decimated noise sample rate and the final record sample rate. With an incorrect sample rate, it is conceivable that higher frequency events may be aliased and not be detected. Consult the decimation chart above to minimize this effect. In addition, some short time periods may occur between noise blocks where no data are transmitted.

GPS Time Stamp for Self-Triggered Data

If an accurate time of trigger is required, Geometrics provides a GPS and trigger synchronization circuit to time stamp each record, accurate to a few microseconds. The system is composed of the following parts:

- GPS clock
- Trigger synchronization box
- Seismic recorder (Geode, NZ or NX)
- Control computer

The system functions as follows:

1 - The GPS provides a continuous 1 pulse per second pulse train to the in put of the trigger synchronization box.

2 – when an event is detected from the decimated data stream by the PC control software, an enable command is sent out the RS-232 port to the trigger synch box. This allows the next GPS pulse to be transmitted from the synch box to the hardware trigger input of the seismograph, which triggers the seismograph at a precisely known time. This known time, generated by the GPS, is simultaneously sent via the RS-232 port to the seismograph control software, where it is included in the data header.

To enable the external GPS trigger via the trigger synchronization box, select the 'Trigger Via RS-232/GPS' option on the self-trigger dialog box.

$t = 0$
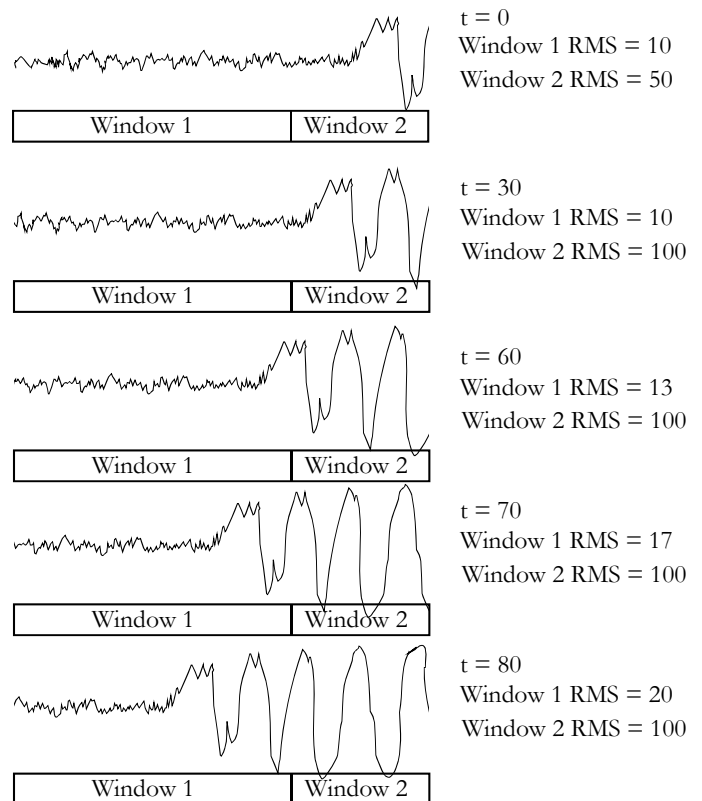Window 1 RMS = 10
Window 2 RMS = 50

Window 1	Window 2

$t = 30$
Window 1 RMS = 10
Window 2 RMS = 100

Window 1	Window 2

$t = 60$
Window 1 RMS = 13
Window 2 RMS = 100

Window 1	Window 2

$t = 70$
Window 1 RMS = 17
Window 2 RMS = 100

Window 1	Window 2

$t = 80$
Window 1 RMS = 20
Window 2 RMS = 100

Window 1	Window 2

The above diagram shows the progression of an event through the detection algorithm. If the threshold is set at 5, then this channel will detect the event at t=0. The event will remain detected at t=30, t=60, t=70, and t=80. After that, the ratio will drop below the threshold, and the event will no longer be detected.