GeoSIG
swiss made to measure

Seismic Monitoring System for Nuclear Power Plants

CONTENT

INTRODUCTION

According to regional, national and international regulations, Nuclear Power Plants (NPP) need to be able to mitigate potential effects of an earthquake.

Such mitigation can be achieved by utilising specific instrumentation for monitoring the earthquake ground motions and the response of the plant features to these motions.

This type of instrumentation is called Seismic Monitoring System (SMS).

Main functions of the SMS are:

- Detection of any (significant) earthquake at plant location
- Provide data records of acceleration at defined locations
- Perform OBE/SSE exceedance evaluation
- Provide a report to the plant operator after an event
- Periodical self test execution

GeoSIG delivers complete SMSs for the NPP applications. These systems;

- Comply fully or exceed regional, national and international nuclear regulatory requirements
- Come with comprehensive certification and documentation, which can as well be supplied from scratch for any particular requirement.
- Include powerful industrial computer for complex data processing based on different algorithms including response spectra analysis
- Perform automatic analysis and evaluation of the earthquake impact on monitored structures
- Provide comprehensive and fast notification and reporting features
- Warrant the robustness, reliability and functionality to serve it main purpose
- Include self diagnostic and testing features to assure continuous system readiness to act once in a life
- Present simplicity of operation, maintenance and upgrade

This document provides an overview of the SMS supplied by GeoSIG.

Upon request several more detailed documents are available, such as:

Sample Operator Report

Sample Design Report

Qualifications and Certificates

Regulatory Compliance

Reference Letters

Detailed Technical Notes on Example Systems

Terms and Conditions

OVERVIEW

The core of the **GeoSIG Seismic Monitoring System** (SMS; or SAS for Alarm System) is a Central Processing Unit (CPU) rack mounted in a seismically and EMC safe cabinet together with an industrial PC and relevant peripherals.

Detection / Recording Units (DRU's) consisting of accelerometers, seismometers or complete seismic station packages are placed at remote locations that are connected to the CPU through shielded copper or fibre optic cables.

The system has been designed in a way that it is not bound to a single topology. There could be only the sensors or both sensors and data acquisition out in the field.

GeoSIG, **unlike any other supplier, can offer three different and versatile solutions** for the seismic instrumentation of Nuclear Power Plants.

Decentralized Recording

Sensors and recorders are on sites

Increased reliability due to independent recording
Error free digital data transmission within the plant
Optimised cost of data cables
Preferable for new installations

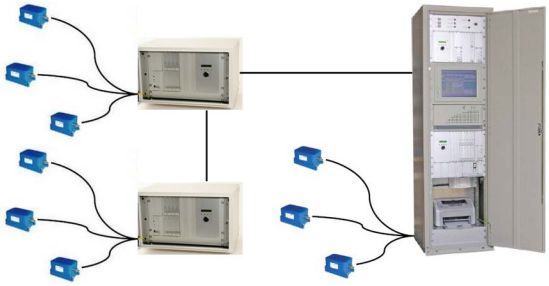
One is the **Decentralised System**, where each measuring point has a seismic sensor together with a dedicated recorder and there is a system central controlling the overall operation and providing system intervention and maintenance.

Second one is the **Centralised System** where only the seismic sensors are located at the measuring points and all other functionality are provided by the system central.

Centralized Recording

Only sensors are on sites

Simple devices in controlled area (analog sensors)
Simplified diagnostics and maintenance
In most cases, existing cables can be reused
Preferable for system upgrade projects

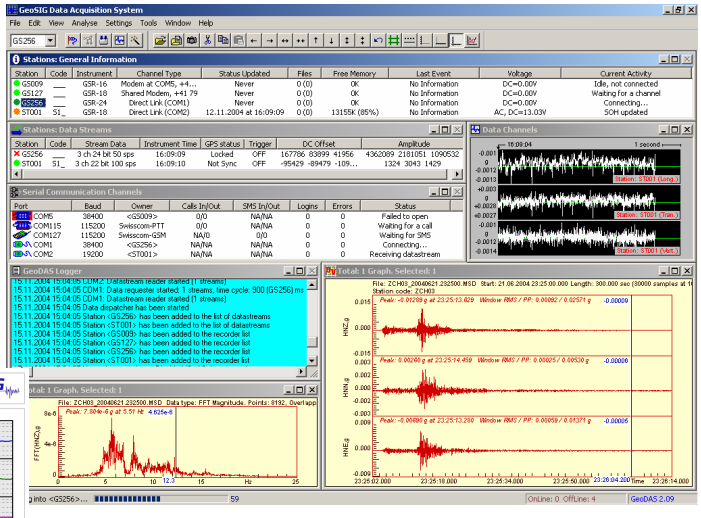


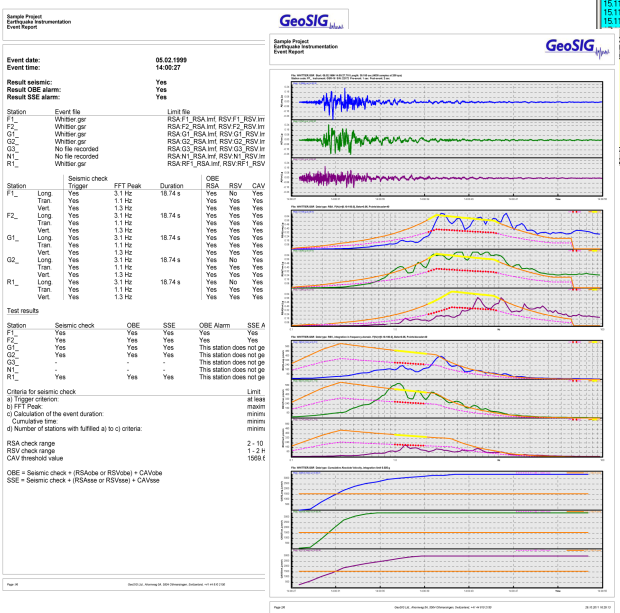
Cost optimized solution suitable for monitoring of nuclear power plants operating multiple units

And finally the **Cascaded System**, which is a combination of the decentralised and centralised systems to provide a more flexible deployment.

The system provides high modularity and flexibility so that an upgrade is simplified and that as much as possible existing elements can be reused.

State of the art **GeoDAS** software is utilized in the CPU. GeoDAS monitors all DRU's in parallel, as a result of the dedicated serial communication links that are provided by the system hardware.





For each measuring channel the recording threshold and the alarm limit values can be set individually. Detailed response spectrum limits can be fully defined along with other parameters as required by relevant regulations or customized user requirements.

Continuously monitoring the DRU's, the CPU detects seismic events, generates associated alarms and automatically processes the recorded data. It performs periodical tests on the system and monitors the system-wide state of the health as well as analyses the detailed cause of any malfunction. **A fully automated Detailed Operator Report is provided a few minutes after the occurrence of an earthquake**.

GeoSIG
swiss made to measure

SYSTEM CENTRE

SMS, Seismic Monitoring / Alarm System
GeoDAS Software

GeoSIG Ltd
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

SMS / SAS Seismic Monitoring / Alarm System

Features

Recording, advanced analysis and annunciation according to latest or custom regulations

Automatic RSA, RSV, CAV calculations and OBE, SSE exceedence evaluation

Upto 48 remote stations or sensors

18 or 24-bit event based and/or continuous recording

Common timing and triggering within the system

Completely over-voltage protected

Continuous system-wide SOH monitoring

Reporting and alerting via visual and audible tools as well as printed matter

Seismically and EMC proven design

Comprehensive configuration of the whole system via the enhanced computer interface

Outline

The core of the SMS / SAS is a Central Processing Unit (CPU) with a multi-channel digital recorder system rack mounted in a seismically and EMC safe cabinet together with an industrial PC and relevant peripherals.

Accelerometers, seismometers or complete seismic station packages, which are referred to as Detection / Recording Units (DRU's) are placed at remote locations that are connected to the CPU through shielded or fiber optic cables.

The system has been designed in a way that it is not bound to a single topology. There could be only the sensors or both sensors and data acquisition out in the field. Advantages of these topologies are briefly explained in the specifications section.

The system has a great modularity and flexibility so that an instrumentation upgrade is simplified and that as much as possible existing elements can be reused.

State of the art **GeoDAS** software is utilized in the CPU. GeoDAS monitors all DRU's in parallel, as a result of the dedicated serial communication links that are provided by the system hardware. By monitoring continuously the DRU's, the CPU detects seismic events, generates associated alarms and automatically processes the recorded data. Also it performs periodical tests on the system and monitors the system-wide state of the health as well as analyses the detailed cause of any malfunction. The result of the data processing is provided in a report a few minutes after the occurrence of an event.

For each measuring channel the recording threshold and the alarm limit values can be set individually. Detailed response spectrum limits can be fully defined along with other parameters as required by relevant regulations or customized user requirements.

Specifications SMS / SAS Seismic Monitoring / Alarm System

SMS / SAS with Centralized Recording

Advantages:
Simple devices in controlled area (analog sensors).
Simplified diagnostics and maintenance.
Higher compatibility with existing systems for upgrade.

SMS / SAS with De-centralized Recording

Advantages:
Independent recording units increase redundancy and reliability.
Link from remote to central can use Fiber Optics.
Digital transmission between remote and central locations.

Seismic Switches

Seismic switches in a centralized recording system are implemented as a separate acquisition module with its own power supply. It has independent cable connection to its own accelerometer sensor. Alarm output is generated from the cabinet.

In a de-centralized system, seismic switches are implemented as additional remote unit. Instead of a trigger information, they forward to the central system a signal defined by the alarm level. Seismic switches can be also implemented as fully independent units having directly the alarm output in the form of relay contacts.

Basic System Specifications

Sensor

AC-23 Servo Accelerometer

Frequency Response:	0.1 Hz to 100 Hz
Largest signal:	± 2 g Std. (±1, ±0.5, ±0.2 g optional)

AC-63 Force Balance Accelerometer

Frequency Response:	DC to 100 Hz
Largest signal:	± 2 g Std. (± 1, ± 0.5 g optional)

Digitizer

A/D Converter:	22 bits, 24 bits optional
Least significant bit:	0.025 % of full scale
Sampling rates:	100, 200, 250 SPS per channel
Bandwidth:	40% of sampling rate

Data Recording

Pre-event-Time:	1 to 30 seconds
Post-event-Time:	1 to 100 seconds

Level Triggering

Lower band limit:	0.1 Hz (20 dB / decade)
Upper band limit:	12 Hz (40 dB / decade)
Range:	0.1 to 100 % of full scale

On-Board Memory

Type:	2 Gbyte Flash Memory per module card
Recording time:	29 / 19 minutes per 2 Mbytes (@ 3 channels, 200 SPS)

Indicators

Green:	AC Power LED
Green:	Run/Stop LED
Yellow:	Event/Memory LED
Red:	Warning/Error LED
LCD display:	User selectable choice of display parameters

Self Test

Permanently active, self monitoring and user selectable, periodical system test including comprehensive sensor, memory, filter, real time clock, battery level and hardware tests.

Seismic Switch / Warning Unit Option

The warning option provides two independent warning / error outputs (relay contacts) based on user selectable criteria.

Alarms:	2 relay for 2 alarm levels
Alarm levels:	0.1 to 100 % of full scale (User programmable per axis)
Relay Hold-On:	1 to 60 seconds (User Programmable)

GeoSIG Ltd
Ahornweg 5a
5504
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

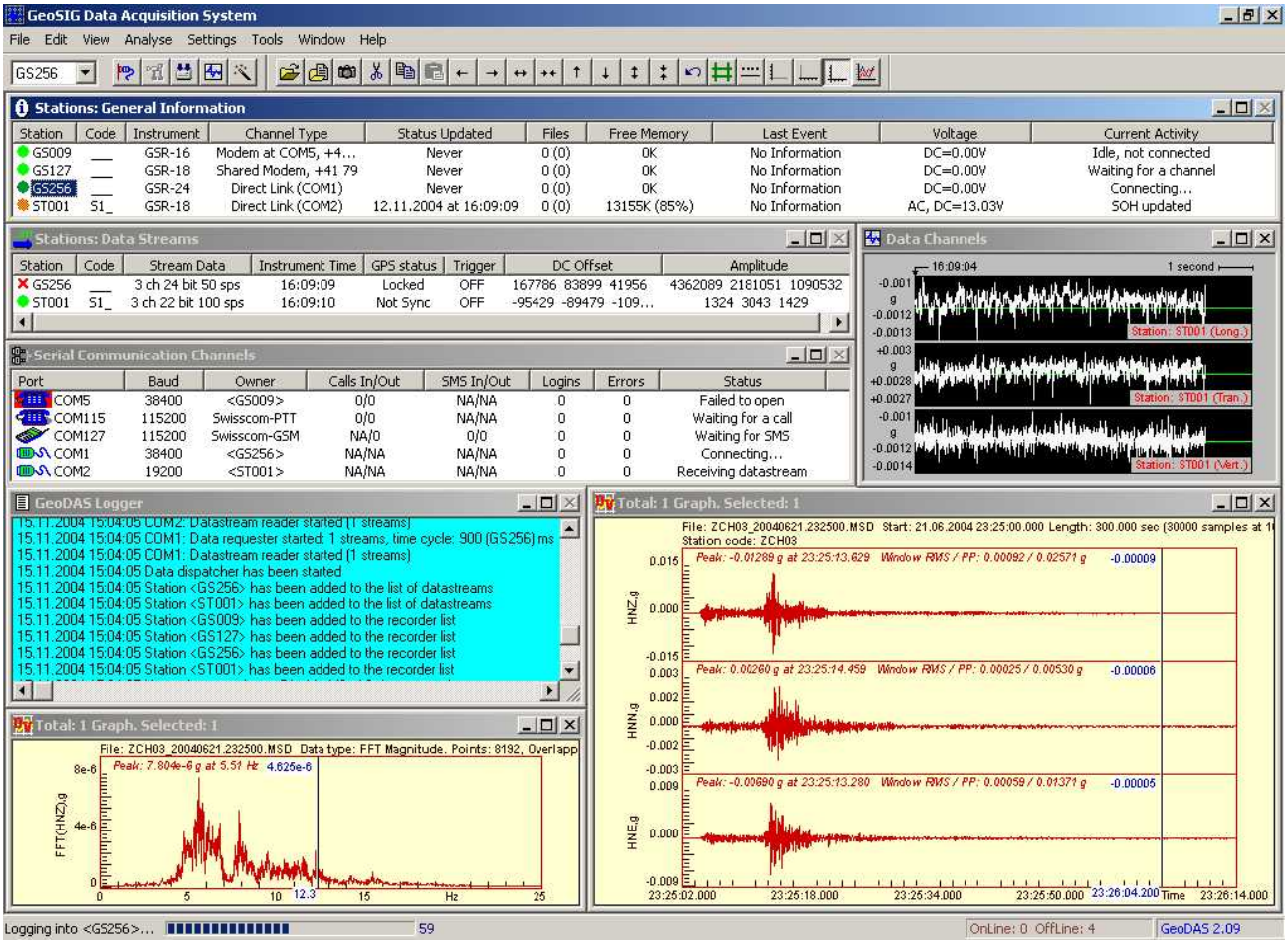
GeoDAS NPP Features

Introduction

This document summarizes the features and functionalities of the GeoDAS used in the NPP seismic Instrumentation Projects.

This document is intended be studied together with other GeoSIG technical documents relating to NPP instrumentation to grasp the full context and the concepts mentioned.

If supplied within the context of an NPP Seismic Monitoring System, a special version of GeoDAS software is delivered to be used to perform data analysis of the recorded time history, perform alarm and announcing if the analysis determines that the seismic event has exceeded software thresholds established by the structural engineers and operators of an NPP.



Summary of Operation

Site-specific parameters are set into the recorders in order to prepare the DRUs to detect and record any events. The event files are kept in the recorder memory, which is a flash memory card. As soon as new event occurs the relevant recorder settings like time, date, serial number, type of sensor and trigger level are attached to the data file are saved to the recorder's memory. This event file will be automatically downloaded to the CPU computer. Further the event files are processed and analysed for Seismic, OBE and SSE checks. Further analysis is possible with the ODV feature under manual mode.

In normal operation mode of the system, the CPU downloads event files from each DRU automatically. At any time, a user can download any event recording manually by means of the Event Manager.

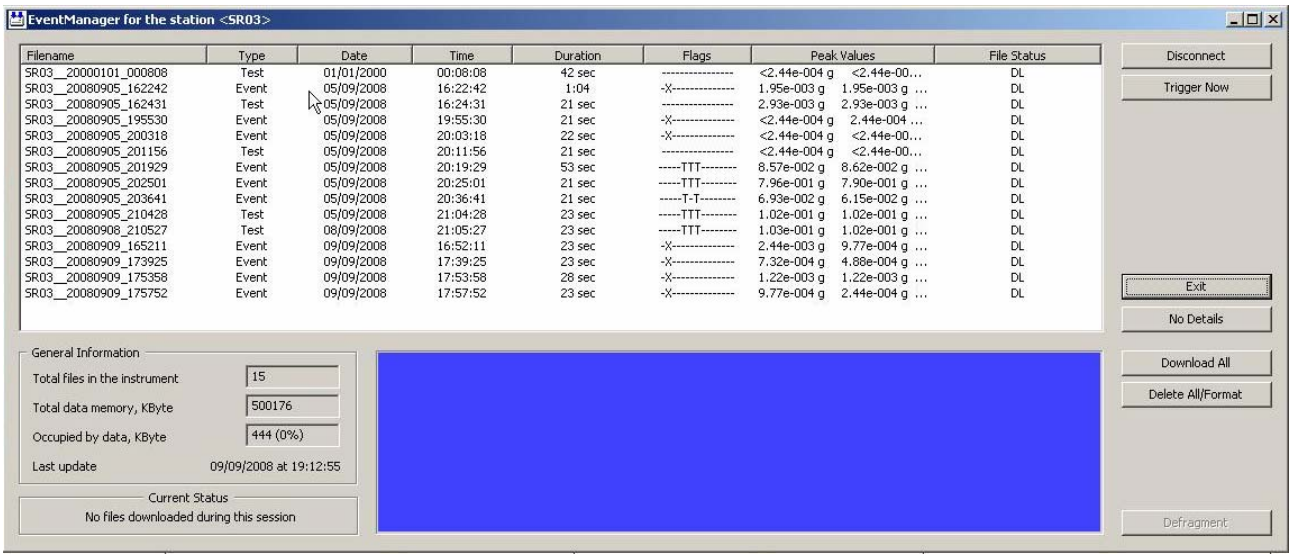


Figure 1. Event Listing

The recorders operate according to the specified settings, even without being connected to the CPU computer, since the data is saved in the recorders memory.

The system computer performs a Response Spectra Analysis (RSA) of the time domain record to determine the acceleration at the various frequencies. The structural SSE and OBE levels for the location of the accelerometer may be entered into the system and the RSA compared against the SSE and OBE levels established for each site.

When the RSA analysis exceeded the SSE and OBE levels the computer will generate a software alarm to the GNC, which will in turn activate the Alarms that a SSE and/or OBE level has been exceeded. The system may also be set up to automatically print out the time history, RSA with OBE & SSE levels, Fast Fourier Transform (FFT) and Cumulative Absolute Velocity (CAV) on the HP laser printer.

The OBE alarm (OBE exceedance) is a combination the calculated elements done by GeoDAS it can be one of the following combination:

- CAV Only: Cumulated Absolute Velocity
- CAV and OBE PSA: Cumulated Absolute Velocity and Pseudo Spectral Acceleration
- OBE PSA Only: Pseudo Spectral Acceleration
- OBE PSA and OBE SV: Pseudo Spectral Acceleration and Spectral Velocity.
- CAV and OBE PSA and OBE SV: Cumulated Absolute Velocity and Pseudo Spectral Acceleration and Spectral Velocity

Once the event data has been recorded in the individual Recording module it remains in the non-volatile flash memory until removed by an authorized operator. Once an event has occurred the event record will be automatically downloaded to the central system computer located in the central control panel where the GeoDAS software will automatically perform an analysis of the time history record. Within a few minutes the computer will have performed the preliminary analysis of the seismic event and if structural levels have been exceeded provide an appropriate alarm making the system fully compliant to the new NPP guideline and requirements.

The alarm threshold levels may be individually set on each channel. The recording alarm threshold will cause the time domain recording of all acceleration signals exceeding the alarm threshold.

Authorized structural engineers and managers have found it useful to access the computer via the LAN and download a particular event record for further analysis on their a computer at their desk. GeoSIG provides a site license for the use of the GeoDAS software package allowing the use of the analysis package on as many computers as the customer requires. GeoDAS allows limited and controlled access at various levels to maintain security and allow for the effective maintenance and operator control to the system.

GeoDAS NPP Features

GeoSIG recommends that the customer establishes internal operating procedures for system test and maintenance including a procedure for copying and archiving event records. A Read/Write CD is provided for that purpose. The system performance, hard drive disc file space, computer memory and recording module non-volatile memory has been sized to satisfy the system requirements and provide reliable long-term operation.

The software has two modes of operation:

- Standard, where the software is in the so-called “autodownload-mode”, downloading and analysing automatically any events
- Extended, where the user can stop the autodownload-mode and login to the DRUs manually

Seismic Check

After an event is recorded the CPU computer will retrieve the recorded data from the DRUs for further analysis. Any reserve units will not be used for seismic check. Automatic analysis after retrieval of data in the computer will decide if the event is seismic or non-seismic. The decision whether an event is seismic or non-seismic is based on several tests listed below.

Table 1. Seismic / non seismic event detection

Number	Tests for ‘seismic event detection’	Non-seismic Event if…	Seismic Event if…
1	Number of DRU locations with recordings	Only 1 recorder triggered	2 of 6 recorders triggered
2	Duration	Duration is below 2 s	Duration is above 2 s
3	FFT	FFT shows frequency peak above 33 Hz	FFT shows frequency peak below 33 Hz

The operator can repeat any of the tests referred to in the above table in deciding whether the event is classed as seismic or not. In case of several DRUs triggered, the exact trigger times are compared. If the differences are below three seconds, the recordings are classified as one event. The limits for the seismic check parameters are as follows:

Table 2. Seismic check parameter settings and ranges

Parameter	Minimum	Maximum	Standard Setting
Number of DRU locations triggered	1	6	2
Duration [s]	1	10	2
FFT Peak [Hz]	5	50	33

The event is declared seismic if all criteria are fulfilled; otherwise it is treated as non-seismic.

Non-Seismic Event

After a non-seismic event the operator presses first the “ACK” button on alarm-panel to acknowledge the alarm and then presses the “RESET” button to clear the alarm so that:

Table 3. Non-seismic event actions

Alarm	Action
Alarm-panel:	“EVENT” indicator lamp goes out
Alarm Relays:	“EVENT” relay goes back to normal state
Monitor:	Displays the results of the performed seismic check

The parameters defining the criteria for qualifying the recorded event as “non-seismic” will need to be reviewed after a training period to verify that the filtering applies is correct. RSA, RSV and CAV calculations are performed, but no OBE/SSE exceedance result is shown and no alarm is generated.

Seismic Event

In case of the event is classified as seismic by the system, RSA, RSV and CAV calculations are performed and the results are compared with allowed levels for the following criteria to establish its degree of severity and activate further alarms / relays. Results of the tests are displayed on the CPU computer monitor and are also printed.

GeoDAS NPP Features

OBE/SSE Check

The OBE and SSE alarms are generated solely by the CPU computer utilizing GeoDAS and the alarm-logic. It simply converts the received string to the appropriate electrical signals to drive the relay and alarm lamps.

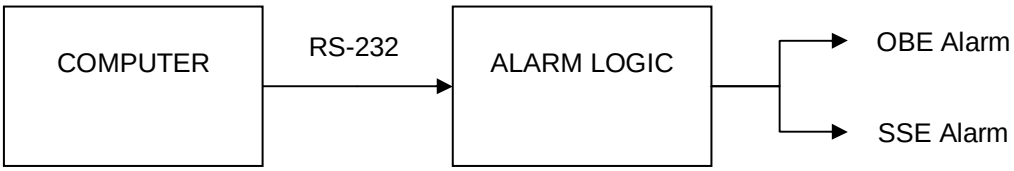


Figure 2. OBE/SSE Alarm topology

In case of the event is classified as seismic by the system, RSA, RSV and CAV calculations are performed f and the result is compared with allowed levels for the following criteria:

Table 4 Exceedance of individual OBE criteria

OBE/SSE Calculation	**Criteria exceeded if…**
RSA	• At least one component site level is exceeded
RSV	• At least one component site level is exceeded
CAV	• At least one component greater than 0.16 g-s[1]

For example, if Reference sensor is not available, although the event has been classified as seismic, the printed report will show an error message and data has to be retrieved locally from the DRUs by means of laptop in case the unavailability of reference sensor data is due to some communication problem.

The parameter setting for seismic and OBE/SSE can be entered through windows. The figure below shows the layout of the OBE settings window. The SSE settings can be entered in a window with the same layout, named “SSE Exceedance”.

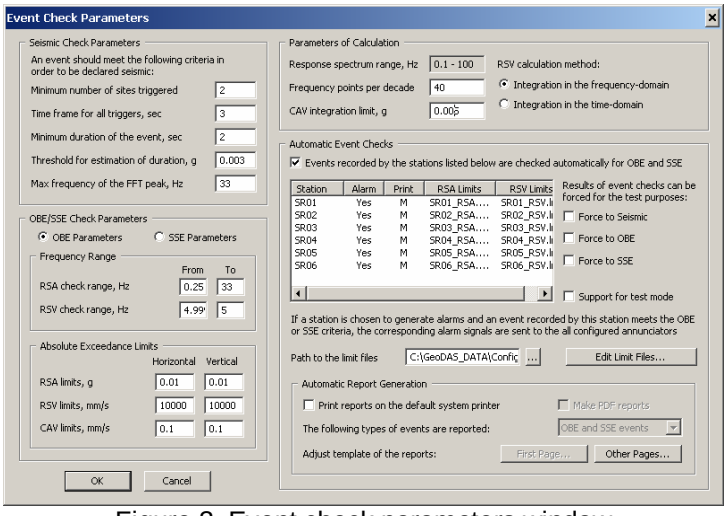


Figure 3. Event check parameters window

If the event calculation shows exceedance of OBE or SSE site levels, the computer sets the OBE or SSE alarm and the following alarm will occur. OBE or/and SSE alarm will be reset manually by the operator.

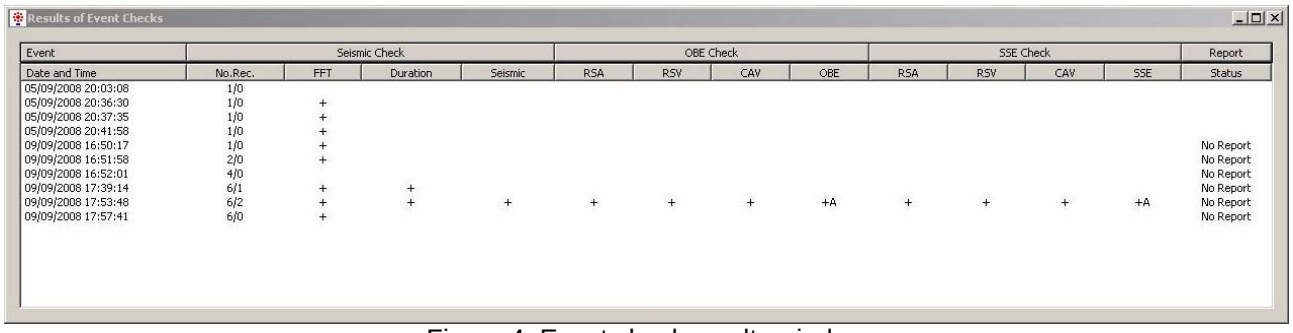
Table 5. OBE, OBE max. acceleration, CAV event actions

Alarm	**Action**
Alarm-panel:	• “OBE” or/and “SSE” indicator lamp flashes
Alarm Relays:	• “EVENT”, “OBE” or/and “SSE” relay active
Monitor:	• Displays the results of the performed OBE/SSE check

[1] The unit [g-s] is used in the NRC Regulatory Guide 1.166 and refers to integrated acceleration in [g] over time in [s]. Within the Seismic Instrumentation project all CAV values are treated in [mm/s]. 0.16 g-s corresponds to 1’570 mm/s.

Display of Processing Results

For each event recording, results of seismic, as well as OBE/SSE checks are displayed in a table. The below figure shows an example of the “event check results” window.



Event	Seismic Check				OBE Check				SSE Check				Report
Date and Time	No.Rec.	FFT	Duration	Seismic	RSA	RSV	CAV	OBE	RSA	RSV	CAV	SSE	Status
05/09/2008 20:03:08	1/0												
05/09/2008 20:36:30	1/0	+											
05/09/2008 20:37:35	1/0	+											
05/09/2008 20:41:58	1/0	+											
09/09/2008 16:50:17	1/0	+											No Report
09/09/2008 16:51:58	2/0	+											No Report
09/09/2008 16:52:01	4/0												No Report
09/09/2008 17:39:14	6/1	+	+										No Report
09/09/2008 17:53:48	6/2	+	+	+	+	+	+	+A	+	+	+	+A	No Report
09/09/2008 17:57:41	6/0	+											No Report

Figure 4. Event check results window

For each event, a context menu can be accessed (right-click) with the following functions:

- The printing of any report can be repeated or forced manually at any time after an event.
- Each event can be manually re-checked for Seismic, OBE or SSE.

After each event recording retrieved from the system that is classified as 'seismic', a report will be printed automatically by the system, giving a summary of the check results (first page) and detailed waveforms for each DRU (one page per unit).

An example report is illustrated in a separate document.

The software can be programmed such that the report will be printed also if an event is not classified as ‘seismic’. The waveforms included in the detailed waveform plots are:

1. Time-history (3 components)
2. RSA plot showing limits (3 components)
3. RSV plot showing limits (3 components)
4. CAV plot showing limits (3 components)

A report can be regenerated and reprinted at any time manually again. The connected printer is always switched on. Further more, the printing of a report for a specific event can be repeated or forced manually by the user. There will be a provision for the user to enter event-specific comment, such as earthquake magnitude.

GeoDAS NPP Features

Processing Time Estimation

The timeline of system triggering / analysis is indicating in the next table. It is based on typical record length of some 50 seconds (30 seconds shake + 10 seconds pre-event and 10 seconds post-events) acquired at 100 sps. The recorded file has a size of 45 kByte and has a download time of 12 seconds at 38400 bps.

Table 6. Step by step estimated elapsed time

Pos	Activity	Duration	Start	End
1	Earthquake waves hit the plant	0	00:00:00	00:00:00
2	From the continuous measurement stream, the trigger system, after applying band-pass filtering detects an acceleration exceedance.	Few ms	00:00:00	00:00:00
3	Seismic recorders report trigger to alarm module. Alarm module applies Boolean logic to define if recording must occur or not.	Few ms	00:00:00	00:00:00
4	Alarm module applies Boolean logic to define if an alarm has to be generated.	Few ms	00:00:00	00:00:00
5	Common alarm received in control room.	Few ms	00:00:00	00:00:00
6	The computer is continuously monitoring the recorders for new recorded event.	50 seconds	00:00:00	00:00:50
7	The computer detects recorded events. An event condition is declared and it will downloads files as soon they are ready.	6 x 15 = 90 seconds	00:00:50	00:02:20
8	Analyse process start by verifying if event is seismic (number of triggered stations, duration and main frequency).	10 seconds	00:02:20	00:02:30
9	OBE and SSE exceedance is checked.	30 seconds	00:02:30	00:03:00
10	OBE / SSE exceedance alarm generated is event is of seismic origin.	Few ms	00:03:00	00:03:00
11	The event report is printed.	30 seconds	00:03:00	00:03:30

The main control is alarmed that an event occurred immediately when the earthquake hit the plant [5].

OBE/SSE alarm is (in case of exceedance) generated after about 3 minutes [10].

The event report is typically available after 3.5 minutes [11].

Logging

Within the CPU computer the events and results listed below will be logged. This allows the user to have complete information about the alarms and the time they were performed.

Table 7. Logged information

Type	Logged information
System trigger	Source, date and time
OBE, OBE max. acceleration, CAV Alarm	Source, date and time
Power Loss	Source, date and time
System Error	Source, date and time
Test Results	Values, date and time

GeoSIG
swiss made to measure

RECORDERS

GSR-18AH, Independent Recorders
GNC, Central Recording System

GeoSIG Ltd
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

GSR-18AHDC / GSR-18AH Strong Motion Recorder

Features

- **Standard 128 Mbytes Onboard Memory (Optional up to 2 Gbytes**
- **Dynamic Range: 111 dB @ 100 SPS**
  108 dB @ 200 SPS
- **RMS Noise: 5 µV @ 100 SPS**
  7 µV @ 200 SPS
- **On-line Diagnostics and**
- **Self-Checking System**
- **LED and LCD Status Indication**
- **Detailed Analysis Tool with dedicated GeoDAS Data Analysis Package**
- **Also available only as Digitiser for Seismic Network**
- **Sets New Standards in Price / Performance for 18 Bit Technology**

(Picture shows IP66 version without MIL type connectors)

Outline

The **GSR-18AH Strong Motion Recorder** has a dynamic range of 111 dB @ 100 SPS and 108 dB @ 200 SPS. The standard 3 channel system has selectable sampling rates from 100 to 250 SPS.

A variety of sensors can be connected to the GSR-18AH offering solutions for applications in miscellaneous fields.

Various network solutions such as independent or interconnected recording networks and local or central recording networks can be configured easily with highly advanced functions such as on-line surveillance, common trigger and time synchronisation. The standard parameter settings and the user-defined configurations can be transferred easily from the PC to the **GSR-18AH**.

Transferring data to PC while recording is possible and can be done also via modem. Optionally available is the dial-up system, which allows the **GSR-18AH** to call automatically a predefined telephone number after an event has been recorded.

A comprehensive package of advanced, menu-driven analysis software is available. **GeoDAS** is included with the **GSR-18AH** and can be used on-site for a first impression of the recorded data. **GeoDAS Data Analysis Package** is a dedicated evaluation program especially designed by **GeoSIG** for earthquake and civil engineering data analysis. It contains all necessary functions and performances for detailed evaluation in the frequency domain functions (FFT, Power Spectrum, Response Spectrum). Additional include integration (acceleration-velocity and velocity-displacement), CAV (Cumulated Absolute Velocity), Space (Rotation, Display) and various data filters.

The **GSR-18AH** is also available as **GSD-18AH** Digitiser only integrated into **GeoSIG Seismic Network Systems.**

The **GSR-18AH** is the ideal, compact and most cost effective **18-Bit** approach.

Specifications GSR-18AH Strong Motion Recorder

Set-up and Configuration
All the necessary parameter and configuration settings are selectable with the easy-to-use GeoDAS Windows program. The configuration of the GSR-18AH is stored in an internal EEPROM, which secures the configuration set-up independent of any backup battery requirements.

Data Analysis
The GeoDAS program provides basic time history data evaluation in the field. The GSR-18AH supplies data available in binary format or as ASCII files. The GeoDAS Data Analysis Package covers the requirements of detailed laboratory analysis for most earthquake and civil engineering applications. Any customary in trade evaluation software package can of course be used as well.

Sensor
Various sensors suitable to your application are available. All sensors are housed in a compact case with a single bolt mount, easy to install and to level with three levelling screws. The sensors can also be built into the GSR-18AH unit (internal sensors). Also available as a standard option is a current loop interface (0 to 20 mA) for signal transfer over long distances as well as a gain selection to expand the signal range.

AC-63 Force Balance Accelerometer

Frequency Response:	DC to 50 Hz
Largest signal:	± 2 g Std. (± 1, ± 4 g optional)

AC-23 Geophone-based Accelerometer

Frequency Response:	0.1 Hz to 100 Hz
Largest signal:	± 2 g Std. (±1, ±0.5, ±0.2 g optional)

CMG-5T Güralp™ Accelerometer

Frequency response:	DC to 100 Hz
Largest signal:	± 2 g

CMG-40T1 Güralp™ Seismometer

Frequency response:	1 Hz to 80 Hz
Largest signal:	± 10 mm/s

Anti Aliasing Filter

Filter response type:	FIR (finite impulse response)
Attenuation:	> 110 dB above Nyquist
Filter equation:	contact GeoSIG

Digitiser

Type:	4-Channel 22-Bit Sigma-Delta ADC
Dynamic Range:	111 dB RMS @ 100 SPS 108 dB RMS @ 200 SPS
RMS Noise:	5 µV @ 100 SPS 7 µV @ 200 SPS
Sampling rates:	50, 100, 200, 250 SPS per channel
Bandwidth:	40% of sampling rate

Data Recording

Pre-event-Time:	1 to 30 seconds
Post-event-Time:	1 to 100 seconds

Triggering

Level Triggering

Lower band limit:	0.1 Hz (20 dB / decade)
Upper band limit (Can be turned ON or OFF):	12 Hz (40 dB / decade)
Range:	0.01 to 100 % of full scale

STA/LTA Triggering

STA-Base:	0.1 to 10 seconds
LTA-Base:	1 to 100 seconds
STA/LTA-Ratio:	1 to 60 dB

On-Board Memory

Memory:	128 Mbytes Flash Memory
Recording time:	19 minutes per 2 Mbytes (@ 3 channels, 200 SPS)

Removable ATA memory card (Optional)

Type:	PC Card ATA Memory Compact Fl. (PC compatible without additional software)
Size:	128, 256, 512 Mbyte, 1, 2 GByte

Power Supply

Type:	Switched power supply (GSR-18AHDC)
Internal battery:	Rechargeable, 12 VDC, 12 Ah Sealed Lead acid battery
Power consumption:	160 mA @ 12 VDC
Autonomy:	> 3 days
AC voltage:	230 VAC (115 VAC optional)
Internal charger:	230 VAC (115 VAC optional, GSR-18AH)

Time Base

Standard clock accuracy:	20 ppm (10 min/year @ - 10 °C to + 50 °C)
External time interfaces:	GPS (optional)

Indicators

Green:	AC Power LED
Green:	Run/Stop LED
Yellow:	Event/Memory LED
Red:	Warning/Error LED
LCD display:	User selectable choice of displayed parameters

Communication

Serial ports:	3 (1 for communication, 1 for GPS, 1 for un-interrupted data-stream)
Baud rates:	2400, 9600, 38400, 115200
Communication protocol:	TG protocol
Protocol securities:	Checksum and software handshaking
Communication:	PC/RS-232 port or modem
Modem operations:	Auto Dial

Environment / Housing

Operational temperature:	- 20 °C to + 70 °C
Storage temperature:	- 40 °C to + 85 °C
Humidity:	0 to 100 % RH (non condensing)
Type:	Aluminium housing
Size:	330 x 230 x 180 mm
Weight:	~15 kg (incl. 12 Ah battery)
Protection:	IP66 (optionally IP68, NEMA6P, with MIL type connectors)

Self Test
Permanently active, self monitoring and user selectable, periodical system test including comprehensive sensor, memory, filter, real time clock, battery level and hardware tests.

Seismic Switch / Warning Unit Option
The GSR-18AH warning option provides four independent warning / error outputs (relay contacts) based on user selectable criteria. This option allows configuring the GSR-18 as a seismic switch.

Alarms:	2 relay for 2 alarm levels
Alarm levels:	0.1 to 100 % of full scale (User programmable per axis)
Relay Hold-On:	1 to 60 seconds (User programmable)
Capacity:	The contacts are suitable for a low voltage control. In case large load must be switched then external relays should be implemented.
Max voltage:	125VAC / 125 VDC
Max current:	250 mA

Interconnection Capabilities
GeoSIG offers various interconnection options to achieve Common Time, Common Trigger and Communication networks. Please refer to relevant documentation under "Strong Motion Instrument Networks"

GeoSIG Ltd
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

GNC-CR24 / CR18 / CR16 / CR12 Central Recording System

Features

- **Unlimited Extension of Channels**
- **Common Trigger, Common Time Synchronisation**
- **Available for 12 Bit, 16 Bit, 18 or 24 Bit**
- **Full Integration in GeoSIG's Network Concept**
- **LED and LCD Status Indication**
- **On-Line Surveillance, Diagnostics and Self Checking System**
- **Detailed Analysis Tool with dedicated GeoDAS Data Analysis Package Module**
- **Broad Application Field**
- **Compact and User-Friendly**
- **Minimal Maintenance**

Outline

The **GNC-CR** Central Recording System is a Multichannel Recorder containing several Recorder Module Cards. It can be extended to an almost unlimited amount of channels by adding further **12 Bit, 16 Bit, 18 or 24 Bit** Recorder Module Cards. These unique features are based on a very compact and user friendly design.

The sensors are interconnected in a star topology and every sensor has its own connection to the **GNC-CR** Central Recording System. The Network Center provides on-line surveillance, common trigger and time synchronisation. The LCD indication informs continuously about the current status of the Network Center.

Individual trigger setting based on module channel information is possible. Data are stored on solid state CMOS SRAM or Flash memory.

With the **GNC-CR** Central Recording System and a connected Personal Computer the parameters of each Recorder Module Card can be set easily and specifically to desired requirements. The actual status can be monitored on-line on the screen. If an error or a warning occurs on one of the Recorder Module Cards, it will be indicated immediately on the PC screen and a LED lamp on the front panel will be activated.

A listing of the recorded data with the corresponding peak values of the acceleration can be shown on-line on the PC screen. Data evaluation can start immediately after retrieving measured events to the PC.

The **GNC-CR** Central Recording System is housed in a rack system.

Specifications GNC-CR24 / CR18 / CR16 / CR12 Central Recording System

Set-up and Configuration
All the necessary parameter and configuration settings are selectable with the easy-to-use GeoDAS Windows program. The configuration of the GNC-CR are stored on internal EEPROM which secure the configuration set-up independent of any back-up battery requirements.

Data Analysis
The GeoDAS program provides basic time history data evaluation in the field. The GNC-CR supplies data available in binary format or as ASCII files. The GeoDAS Data Analysis Package covers the requirements of detailed laboratory analysis for most earthquake and civil engineering applications. Any customary in trade evaluation software package can of course be used as well.

Sensor
The sensors are housed in a compact case with a single bolt mount, easy to install and to level with three levelling screws. Also available as a standard option is a current loop interface (0 to 20 mA) for signal transfer over long distances as well as a gain selection to expand the signal range.

AC-23 Geophone-based Accelerometer

Frequency Response:	0.1 Hz to 100 Hz (200 optional)
Largest signal:	± 2 g Std. (±1, ±0.5, ±0.2 g optional)

AC-63 Force Balance Accelerometer

Frequency Response:	DC to 100 Hz
Largest signal:	± 2 g Std. (± 1, ± 0.5 g optional)

CMG-5T Güralp™ Accelerometer

Frequency response:	DC to 100 Hz
Largest signal:	± 2 g

VE-13 Velocity sensor

Frequency response:	1 Hz to 315 Hz
Largest signal:	± 100 mm/s

VE-23 Velocity Sensor

Frequency response:	4.5 Hz to 315 Hz
Largest signal:	± 100 mm/s

Digitizer

A/D Converter:	12 Bit, 16 Bit, 18 Bit, 24 Bit
Dynamic:	72, 96, 111, 130 dB
Sampling rates:	50[1], 100, 200, 250[2] SPS per channel
Bandwidth:	40% of sampling rate

Data Recording

Pre-event-Time:	1 to 30 seconds (120 for 24 Bit)
Post-event-Time:	1 to 100 seconds

Triggering

Level Triggering

Lower band limit:	0.1 Hz (20 dB / decade)
Upper band limit:	12 Hz (40 dB / decade)
Range:	0.1 to 100 % of full scale

STA/LTA Triggering

STA-Base:	0.1 to 10 seconds
LTA-Base:	1 to 100 seconds
STA/LTA-Ratio:	1 to 60 dB

On-Board Memory on Recording Module RMC-12 / 16 / 18 / 24:

Type:	2 GByte Flash Memory per module card
Recording time:	29 minutes per 2 Mbytes (12 / 18 Bit) 19 minutes per 2 Mbytes (18 / 24 Bit) (@ 3 channels, 200 SPS)

Power Supply

Type:	Switched power supply
Internal battery:	Rechargeable, 12 VDC, 7.2 Ah Lead battery
Autonomy:	2 days divided by No. of RMC Cards
AC voltage:	80 - 264 VAC
DC voltage:	12 VDC
Power consumption:	1 W per RMC @ 12 VDC typically

Time Base

Standard clock accuracy:	20 ppm (10 min/year @ -10 °C to +50 °C)
External time interfaces:	GPS

Indicators

Green:	AC Power LED
Green:	Run/Stop LED
Yellow:	Event/Memory LED
Red:	Warning/Error LED
LCD display:	User selectable choice of display parameters

Communication

Serial ports:	2 (1 for communication, 1 for GPS)
Baud rates:	1200, 2400, 4800, 9600, 38400, 57600, 115200
Communication protocol:	TG protocol
Protocol securities:	Checksum and software handshaking
Communication:	PC/RS-232 port or optional modem
Modem operations:	Auto Dial

TCP/IP Communication Option
Using a RS-232-TCP/IP device server, GNC can be seamlessly integrated in a TCP/IP computer network for instrument setup and data acquisition. Doing so each GNC-CR can be assigned a unique IP Address.

Environment / Housing

Operational temperature:	-20 °C to +70 °C
Storage temperature:	-40 °C to +85 °C
Humidity:	0 % to 100 % (non condensing)
Type:	Painted steel housing
Size up to 24 channels (4 x 3 axis or 12 x 1 axis):	600 x 575 x 370 mm
Size up to 48 channels 10 x 3 axis or 30 x 1 axis):	600 x 575 x 630 mm
Weight:	30 to 50 kg (incl. 7.2 Ah battery) depending on amount of channels
Protection:	IP54

Self Test
Permanently active, self monitoring and user selectable, periodical system test including comprehensive sensor, memory, filter, real time clock, battery level and hardware tests.

Software
Complete GeoDAS software package to perform setup, testing, data retrieval and data analysis.

Seismic Switch / Warning Unit Option
The GNC-CR warning option provides two independent warning / error outputs (relay contacts) based on user selectable criteria. This option allows to configure the GNC-CR as a seismic switch.

Alarms:	2 relay for 2 alarm levels
Alarm levels:	0.1 to 100 % of full scale (User programmable per axis)
Relay Hold-On	1 to 60 seconds (User Programmable)

[1] 24 Bit version only

[2] 12, 16 and 18 Bit version only

GeoSIG
swiss made to measure

SENSORS

AC-23 Servo-Accelerometer

AC-63 MEMS Based Force Balance Accelerometer

GeoSIG Ltd
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

AC-23 / AC-22 / AC-21 Accelerometer

Features

- **Full Scale ± 0.1, 0.2, 0.5, 1, 2 and 4g jumper selectable**
- **Bandwidth 0.1 Hz to 100 Hz (optional 200 Hz)**
- **Dynamic range > 125 dB**
- **Excellent temperature stability**
- **Strong-Motion, Free field and Industrial applications**
- **Downhole version (AC-23-DH) is also available**
- **Different housing and mounting options are available**
- **Single Bolt Mounted Enclosure provides up to ± 10° of Levelling Adjustment**

Outline

The AC-23 package is a triaxial accelerometer sensor designed for Strong Motion and industrial applications where a high sensitivity is required.

The AC-2x series are state-of-the-art servo-accelerometers based on standard exploration geophone mass-spring system with electronic feedback. Having remarkable temperature and aging stability because of the very simple principle, the AC-2x rarely requires maintenance.

The outstanding dynamic range performance and linearity of the AC-2x which is more than 125 dB at ± 2 g full scale within the 0.1 to 50 Hz range, makes this accelerometer a perfect sensor for many applications.

Triaxial, biaxial and uniaxial configurations are all available in surface and downhole models, complementing the versatile useability of the AC-2x.

The AC-2x is housed in a sealed cast aluminium housing with the dimensions of 195 x 112 x 96 mm. The housing also offers a single bolt mounting system with three levelling screws. Stainless steel housings as well as internal mounting inside GSR-xxAH housing options are available.

With the help of the TEST LINE the sensor can be easily and completely tested. Full scale is user selectable on site by setting the internal jumpers.

The AC-2x accelerometer is directly compatible with the GeoSIG recorders.

Specifications AC-23 / AC-22 / AC-21 Accelerometer

General Characteristics

Application: Strong Motion earthquake survey
Industrial applications requiring high sensitivity

Configurations:

	Triaxial	Biaxial	Uniaxial	Axes	Alignment**
AC-23 or AC-23i*:	■			X – Y – Z	H – H – V
AC-22-H or AC-22-Hi*:		■		X – Y	H – H
AC-22-V or AC-22-Vi*:		■		X (or Y) – Z	H – V
AC-21-H or AC-21-Hi*:			■	X (or Y)	H
AC-21-V or AC-21-Vi*:			■	Z	V

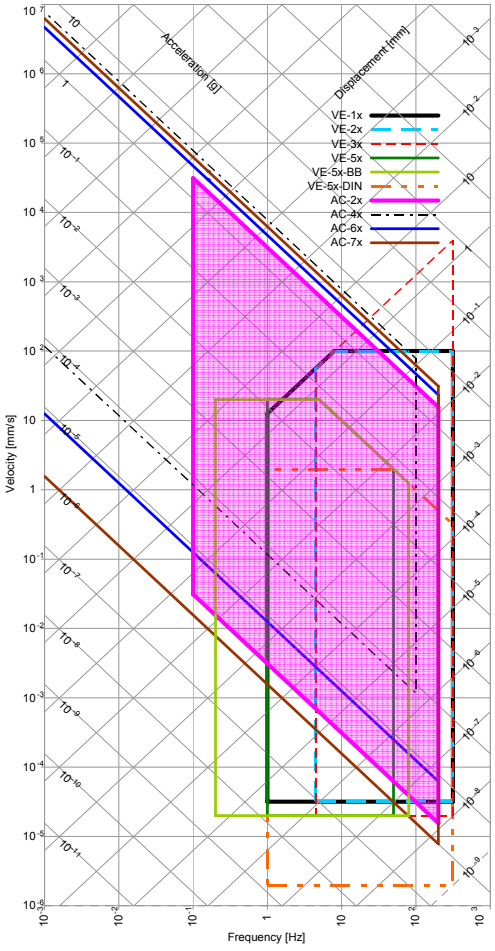
* i : Internal sensor ** H: Horizontal, V: Vertical

Full Scale Range: Jumper selected in range
± 0.1, ± 0.2, ± 0.5, ± 1, ± 2 and 4g
for ± 10 V diff at output

Sensor Element

Type: Servo-accelerometer based on geophones with feedback
Dynamic Range: >125 dB effective at ± 2 g full scale
Linearity: 0.1 %
Accuracy: ± 0.4 dB max over the bandwidth
Cross Axis Sensitivity: 1 %
Bandwidth: 0.1 Hz (1 pole) to 100 Hz (1 pole)
optional 200 Hz
Damping: 0.7 critical
Offset Drift: < 1 mV/^{0}C
Span drift: < 200 ppm/^{0}C
Full Scale output: 0 ± 10 V differential (20 Vpp)
optional 2.5 ± 2.5 V single-ended (5 Vpp)
0 to 20 mA current loop

Measuring Range: See Plot



Power

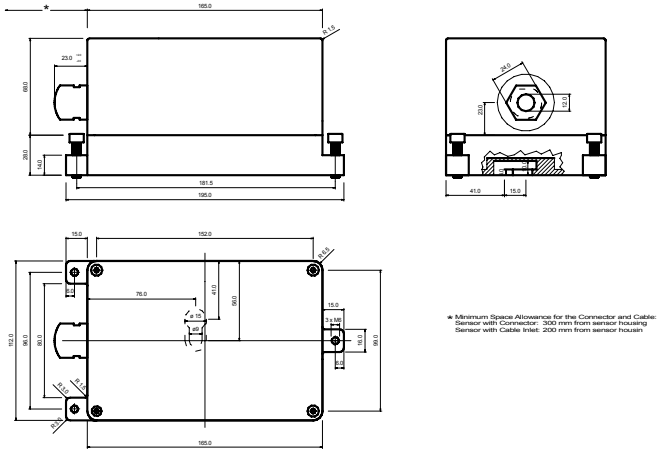
Supply Voltage: 12 VDC regulated (10 to 15 V)
Consumption: 40 mA @ 12 V
Mating: Binder / Coninvers type RC
Overvoltage Protection: All pins are protected

Connector Pin Configuration

Pin 1-2, 3-4, 5-6 Signal output for axis X, Y, Z
Pin 7-8 Test input, Digital test-pulse (0 – 12 V)
Pin 9-10 +12 VDC Power Supply
Pin 11-12 Auxiliary input
Case Shielded Ground

Environment/Housing

Housing Type: Cast aluminium
Sealed access cover
Housing Size: 195 x 112 x 96 mm
Weight: 2.5 kg
Index of Protection: IP 65
optional IP 68
Temperature Range: - 20 to 70 °C (operating)
- 40 to 90 °C (non-operating)
Humidity: 0 to 100 % (non-condensing)
Orientation: Floor or wall mounting (to be specified in order)
Mounting: Single bolt, surface mount, adjustable within ± 10°



Standard AC-23 Floor mounted, Full scale ± 2 g,
2 m cable with cable inlet and recorder mating connector, concrete anchor bolt and user manual on CD

Options

Cable & connector: Cable connector
Metallic, Shielded, IP67, 12 pins, male
optional MIL, Bendix PT07A 14-19P
Cable with shielded twisted pairs for any length (including mating sensor connector) with open end
Cables for connection to GeoSIG recorder
Connector on user specification mounted at cable end
Housing: Watertight IP 68 housing
Downhole housing (AC-2x-DH)
Stainless steel protective housing
As internal sensor
Mounting: Wall mounted

Ordering Information

Specify: Type of AC-2x, full scale range, and other applicable options

GeoSIG Ltd
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

AC-23 / AC-22 / AC-21-DH Downhole Accelerometer

Features

- **Full Scale ± 0.1, 0.2, 0.5, 1, 2 and 4g jumper selectable**
- **Bandwidth 0.1 Hz to 100 Hz (optional 200 Hz)**
- **Dynamic range > 125 dB**
- **Excellent temperature stability**
- **Strong-Motion, Free field and Industrial applications**
- **No field adjustment required**
- **Strong mechanical design**
- **Fits in 3 inch casing**

Outline

The AC-23-DH sensor package is a triaxial accelerometer designed for borehole applications regarding Strong Motion earthquake survey and monitoring.

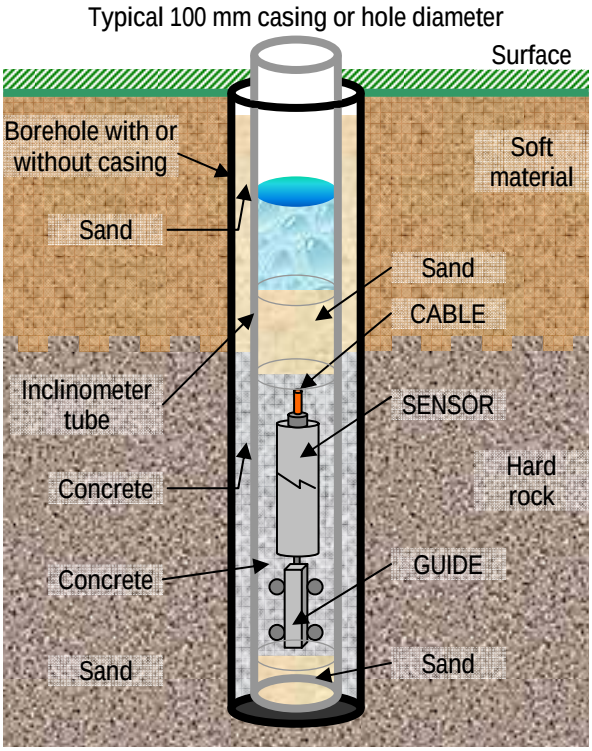
The AC-2x-DH sensors are servo-accelerometers based on a standard exploration geophone mass-spring system with electronic feedback. This type of sensor gives a very good stability versus temperature or aging because of the very simple principle.

The sensor does not require maintenance and has very low aging drift. With the help of the TEST LINE the sensor can be easily, completely tested.

The family of AC-2x-DH accelerometer is directly compatible with the GeoSIG recorders.

The downhole casing contains the entire sensor system. The sensor is connected through Overvoltage Protection stage to the recorder at the surface with a cable.

Using inclinometer tubes and the provided guiding wheels, the sensor can be oriented before insertion in the tube.



Specifications AC-23 / AC-22 / AC-21-DH Downhole Accelerometer

General Characteristics

Application: Strong Motion earthquake survey, Industrial applications requiring high sensitivity.

Configurations:

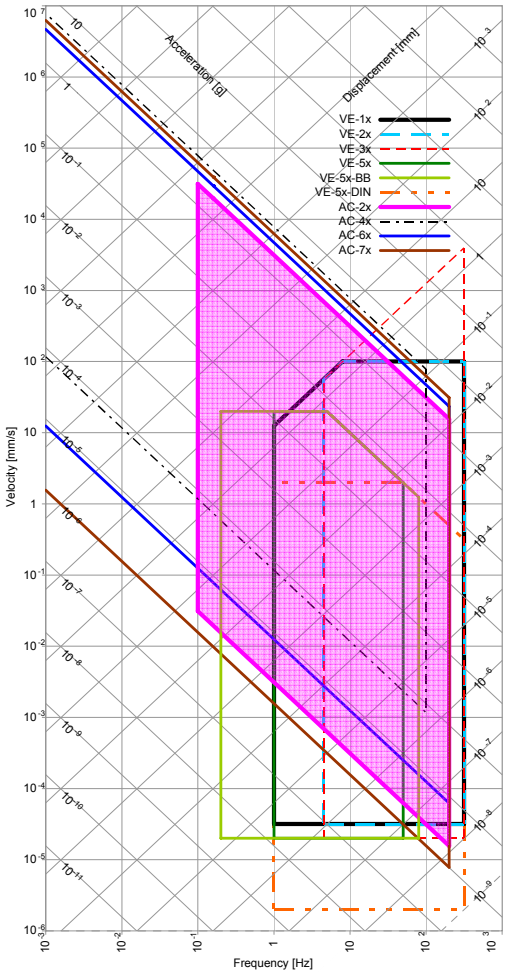
	Triaxial	Biaxial	Uniaxia	Axes	Alignment**
AC-23:	■			X – Y – Z	H – H – V
AC-22-H:		■		X – Y	H – H
AC-22-V:		■		X (or Y) – Z	H – V
AC-21-H:			■	X (or Y)	H
AC-21-V:			■	Z	V

** H: Horizontal, V: Vertical

Full Scale Range: Factory configurable to:
± 0.1, ± 0.2, ± 0.5, ± 1, ± 2 and ± 4g
for ± 10 V diff at output

Sensor Element

Type: Servo-accelerometer based on geophones with feedback
Dynamic Range: >125 dB effective at ±2 g full scale
Linearity: 0.1 %
Accuracy: ± 0.4 dB max over the bandwidth
Cross Axis Sensitivity: 1 %
Bandwidth: 0.1 Hz (1 pole) to 100 Hz (1 pole) optional 200 Hz
Damping: 0.7 critical
Offset Drift: < 1 mV/^{0}C
Span drift: < 200 ppm/^{0}C
Full Scale output: 0 ± 10 V differential (20 Vpp)
Measuring Range: See Plot



Interface

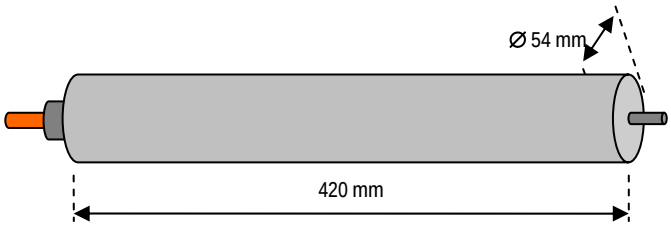
Power supply voltage: 12 VDC regulated (10 to 15 V)
Consumption: 40 mA @ 12 V
Connector: Metallic, Shielded, IP67, 12 pins, male mounted at end of cable.
Other connectors on request.
Mating: Binder / Coninvers type RC
Overvoltage Protection: All pins are protected

Connector Pin Configuration

Pin 1-2, 3-4, 5-6 Signal output for axis X, Y, Z
Pin 7-8 Test input, Digital test-pulse (0 / 12 V)
Pin 9-10 +12 VDC Power Supply
Pin 11-12 Auxiliary input (unused)
Case Shielded Ground

Environment/Housing

Housing Type: Aluminium cylinder, fully sealed
Housing Size: Diameter 54 mm, length 420 mm
Weight: 3.5 kg



Index of Protection: IP 68, up to 5 bars water pressure
Temperature Range: - 20 to 70 °C (operating)
- 40 to 90 °C (non-operating)
Humidity: 0 to 100 %
Orientation: Using 3” inclinometer casing (Figure 1) with included guidewheels (Figure 2).

Standard AC-23-DH Full scale ± 2 g, recorder mating connector and user manual on CD. Borehole cable length to be defined.

Optional Accessories

DH-TUBE 3” inclinometer casing as in figure 1 in sections of 3 meters with coupling elements.
Installation kit: All required tools and fixation consumables for up to 100 meters of casing.
DH-BALL Glass Balls for settlement of downhole sensor (25 kg bag)

Ordering Information

Specify: Type of AC-2x-DH, acceleration full scale, depth of borehole and total cable length.

Figure 1

Figure 2

GeoSIG Ltd
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

AC-63 / AC-62 / AC-61 Force Balance Accelerometer

Features

- **Full Scale ± 2 g (0.5, 1, 3 or 4 g optional)**
- **Bandwidth DC to 50 or up to 250 Hz**
- **Dynamic Range > 120 dB**
- **Offset stability**
- **Temperature and drift compensation**
- **No installation adjustments required due to Digital Sensor Control (DSC)**
- **Downhole version (AC-63-DH) is also available**
- **Robust suspension system**
- **Single Bolt Mounted Enclosure provides up to ± 10° of Levelling Adjustment**

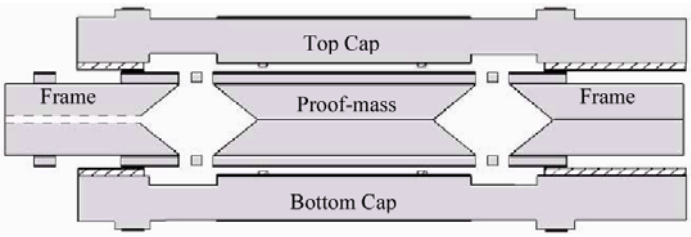
Outline

The AC-63 is a reliable Force Balance Accelerometer based on the latest MEMS (Micro Electro-Mechanical Systems) technology.

The sensor package is designed for applications regarding earthquake and structural monitoring and measuring. All these applications require a high dynamic, rugged sensor with minimum maintenance.

The MEMS accelerometer has a variable capacitor design that is operated in a closed-loop configuration with a custom mixed-signal application-specific integrated circuit (ASIC).

The MEMS accelerometer is a wafer stack composed of four individual wafers bonded together. Within the inner two wafers of the stack, and suspended by silicon springs, is a moving structure called the proof-mass. This forms a differential variable capacitance between the surfaces of the moving proof-mass and the fixed caps. As the accelerometer is subjected to vibration, the proof-mass moves between the fixed plates which, in turn, causes a change in the differential capacitance.



Cross-section of the MEMS accelerometer 4 wafer stack

A Digital Sensor Control (DSC) is used to provide the AC-63 with exceptional user-friendly features. At turn on the DSC nulls all outputs including the vertical channel. This powerful feature allows the users to install the AC-63 and turn it on. Time consuming offset adjustment and instrument levelling are not necessary.

The DC response allows the sensor to be easily repaired, tilt tested or recalibrated in the field. With the help of the TEST LINE the AC-63 accelerometer can be completely tested assuring proper operation and accurate acceleration measurement.

Specifications AC-63 / AC-62 / AC-61 Force Balance Accelerometer

General Characteristics

Application: Earthquake and structural monitoring and measuring

Configurations:

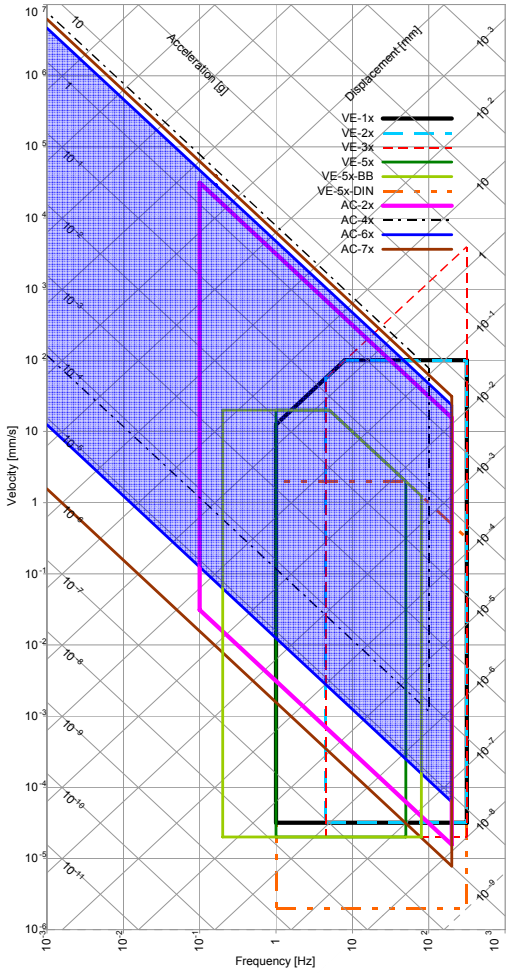
	Triaxial	Biaxial	Uniaxial	Axes	Alignment**
AC-63 or AC-63i*:	■			X – Y – Z	H – H – V
AC-62-H or AC-62-Hi*:		■		X – Y	H – H
AC-62-V or AC-62-Vi*:		■		X (or Y) – Z	H – V
AC-61-H or AC-61-Hi*:			■	X (or Y)	H
AC-61-V or AC-61-Vi*:			■	Z	V

* i : Internal sensor ** H: Horizontal, V: Vertical

Full Scale Range: ± 2 g
optional ± 0.5, ± 1, ± 3 or ± 4 g

Sensor Element

Type: Force Balance Accelerometer
Dynamic Range: >120 dB effective at ± 3 g full scale
Nonlinearity: < 0.1 %
Hysteresis: < 0.01 %
Cross Axis Sensitivity: < 0.2 %
Bandwidth: DC to 100 Hz
optional upto 250 Hz
Damping: 0.7 critical
Offset Drift: 100 ug / °C
Span Drift: 75 ppm / °C
Full Scale Output: ± 10 V differential
optional 0 ± 5 V single ended
Measuring Range: See plot



Power

Supply Voltage: 9.2 to 15 VDC, single supply
Consumption: 70 mA @12 V

Connector and Cable

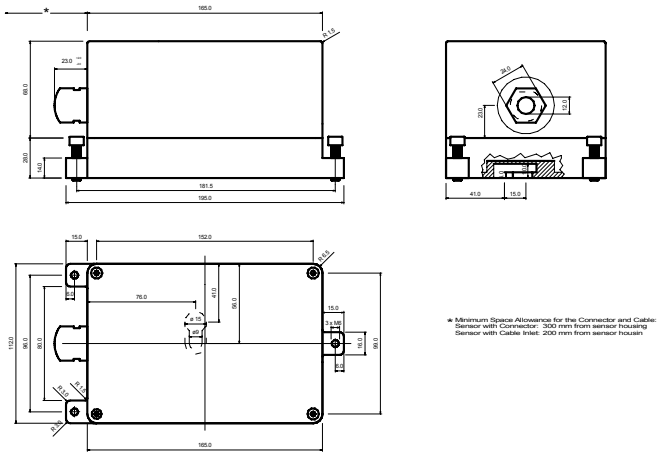
Several options exist. See separate sheet.
Surge Protection: All pins are protected

Connector Pin Configuration

Pin 1-2, 3-4, 5-6 Signal output for axis X, Y, Z
Pin 7-8 Test input, Digital test-pulse (0 – 12 V)
Pin 9-10 +12 VDC Power Supply
Pin 11-12 Auxiliary input (reserved)
Case Shielded ground

Environment/Housing

Housing Type: Cast aluminium
Sealed access cover
Housing Size: 195 x 112 x 96 mm
Weight: 3.0 kg
Index of Protection: IP 65
optional IP 68
Temperature Range: - 20 to 70 °C (operating)
- 40 to 85 °C (non-operating)
Humidity: 0 to 100 % (non-condensing)
Orientation: Can be configured for mounting in any position. See separate sheet.
Mounting: Single bolt, surface mount, adjustable within ± 10°



Standard AC-6x Floor mounted, Full scale ± 2 g,
2 m cable with cable inlet and recorder mating connector, concrete anchor bolt and user manual on CD

Options

Cable & connector: Cable connector
Metallic, Shielded, IP67, 12 pins, male
optional MIL, Bendix PT07A 14-19P
Cable with shielded twisted pairs for any length (including mating sensor connector) with open end
Cables for connection to GeoSIG recorder
Connector on user specification mounted at cable end
Housing: Watertight IP 68 housing
Downhole housing (AC-6x-DH)
Stainless steel protective housing
As internal sensor (no housing)
Mounting: Wall mounted

GeoSIG Ltd
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

AC-63 / AC-62 / AC-61-DH Downhole Accelerometer

Features

- **Full Scale ± 2 g (0.5, 1, 3 or 4 g optional)**
- **Bandwidth DC to 50 or upto 250 Hz**
- **Dynamic range >120 dB**
- **Digital Sensor Control (DSC)**
- **No field adjustment required**
- **Temperature and drift compensation**
- **Robust suspension system**
- **Fits in 4" (100 mm) borehole**
- **Same basic specifications as AC-63**

Outline

The AC-63-DH is a reliable Force Balance Accelerometer tailored for borehole applications, based on the latest MEMS (Micro Electro-Mechanical Systems) technology.

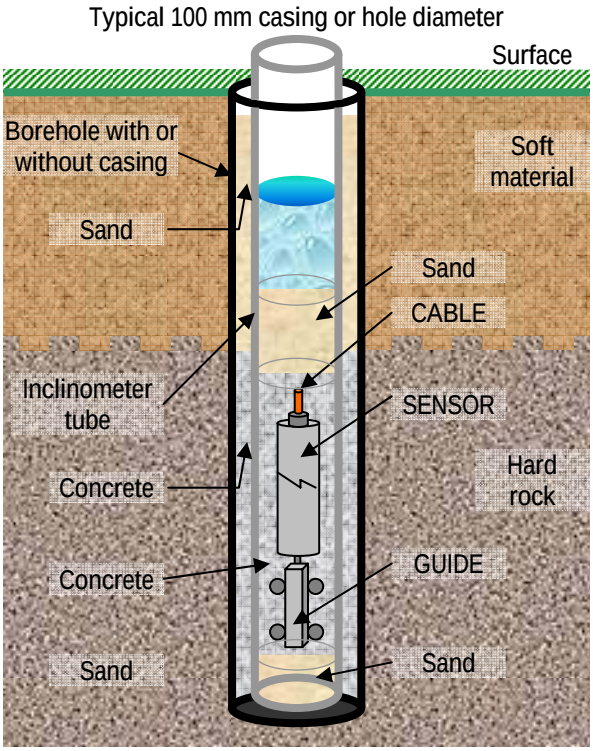
A Digital Sensor Control (DSC) is used to provide the AC-63-DH with exceptional user-friendly features. At turn on the DSC nulls all outputs including the vertical channel. This powerful feature allows the users to install the AC-63 and turn it on. Time consuming offset adjustment and instrument levelling are not necessary.

The DC response allows the sensor to be easily repaired, tilt tested or recalibrated in the field. With the help of the TEST LINE the AC-63 accelerometer can be completely tested assuring proper operation and accurate acceleration measurement.

The downhole housing contains the entire sensor system. The sensor is connected through Overvoltage Protection to the recorder at the surface with a cable.

Using inclinometer tubes and the provided guiding wheels, the sensor can be inserted in the borehole with a defined orientation.

The AC-63-DH accelerometer is directly compatible with the GeoSIG recorders.



Specifications AC-63 / AC-62 / AC-61-DH Downhole Accelerometer

General Characteristics

Application: Earthquake and structural monitoring and measuring

Configurations:

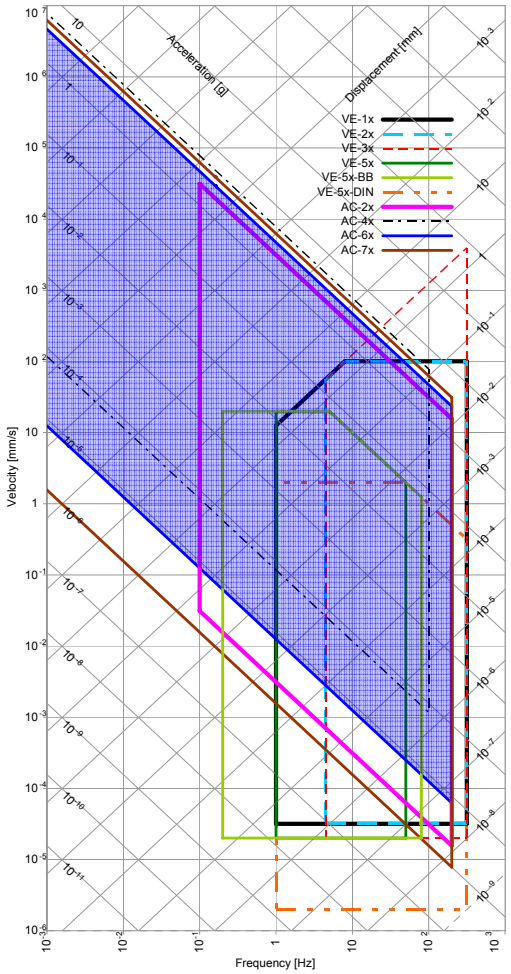
	Triaxial	Biaxial	Uniaxial	Axes	Alignment**
AC-63:	■			X – Y – Z	H – H – V
AC-62-H**:		■		X – Y	H – H
AC-62-V**:		■		X (or Y) – Z	H – V
AC-61-H**:			■	X (or Y)	H
AC-61-V**:			■	Z	V

** H: Horizontal, V: Vertical

Full Scale Range: ± 2 g
optional ± 0.5, ± 1, ± 3, ± 4 g

Sensor Element

Type: Force Balance Accelerometer
Dynamic Range: >120 dB effective at ± 3 g full scale
Nonlinearity: < 0.1 %
Hysteresis: < 0.01 %
Cross Axis < 0.2 %
Bandwidth: From DC to 100 Hz
optional upto 250 Hz
Damping: 0.7 critical
Offset Drift: 100 ug / °C
Span Drift: 75 ppm / °C
Full Scale Output: ± 10 V differential
optional 0 ± 5 V single ended
Measurement Range: See Plot



Power

Supply Voltage: 9.2 to 15 VDC, single supply
Consumption: 70 mA @12 VDC (average)

Connector

Several options exist. See separate sheet.
Surge Protection: All pins are protected

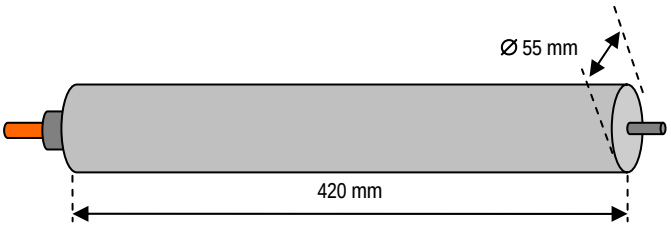
Connector Pin Configuration

Pin 1-2, 3-4, 5-6 Signal output for axis X, Y, Z
Pin 7-8 Test input, Digital test-pulse (0 – 12 V)
Pin 9-10 +12 VDC Power Supply
Pin 11-12 Auxiliary input (reserved)
Case Shielded ground

Environment/Housing

Housing Type: Aluminium cylinder
Fully sealed and resin filled
Housing Size: Diameter 55 mm, length 420 mm
Weight: 3.5 kg

Index of Protection: IP 68, up to 10 bar water pressure
Temperature Range: - 40 to 85 °C (operating)
- 40 to 85 °C (non-operating)
Humidity: 0 to 100 %
Orientation: Using 3” inclinometer casing (Figure 1) with included guidewheels (Figure 2).



Standard AC-6x-DH Full scale 2 g, sensor mating connector and user manual on CD.
Borehole cable length to be defined.

Accessories

DH-TUBE 3” inclinometer casing as in figure 1 in sections of 3 meters with coupling elements.
Installation kit: All required tools and fixation consumables for up to 100 meters of casing.

Ordering Information

Specify: Type of AC-6x-DH, acceleration full scale, depth of borehole and total cable length.

Figure 1

Figure 2

GeoSIG
swiss made to measure

EXAMPLE SYSTEM

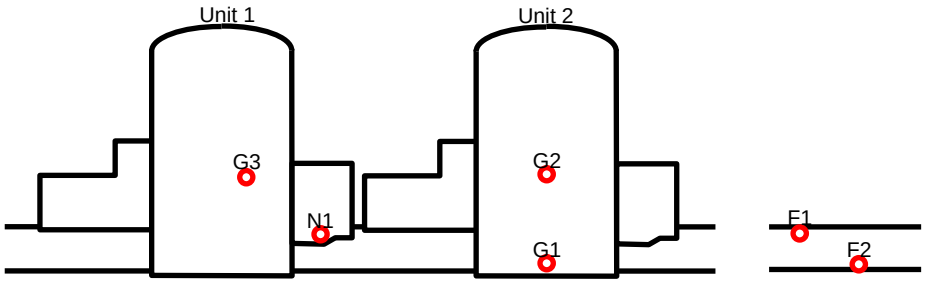
Beznau NPP in Switzerland

Beznau Nuclear Power Plant
Seismic Instrumentation Network
Switzerland

GeoSIG

Project Overview

Axes	Sensors	Digitisers/ Recorders	Communication	System Center	Duration (weeks)
18	6	6	Cable/modem	1 Data Center	40



F1: Freefield at surface
F2: Freefield on bedrock
N1: State of Emergency building, mat foundation
G1: Security building, mat foundation
G2: Security building, operation floor level 340
G3: Security building, operation floor level 340

Scope:
Nuclear Power Plant (NPP) safety monitoring against seismic motions, and other ambient dynamic loads to:
(i) Evaluate and observe structural safety and integrity as well as safe operation,
(ii) Assess and compare the behaviour against the seismic design criteria,
(iii) Develop and improve emergency and safety measures as well as awareness,
(iv) Contribute to regional seismic database.

System:
AC-23 force balance accelerometers, GSR-18 digitiser/recorders and one Central Processing Unit (CPU).
All stations store the motion signals detected by the sensors in local recorders, for redundancy.
GeoDAS software is utilized to: i) monitor the stations, ii) download event recordings automatically, iii) check system state of health, which can be used to analyze the detailed cause of any malfunction, iv) Analyze downloaded data by means of seismic and OBE/SSE checks, v) issue alarms.
Recording threshold and the alarm limit values can be set individually for each measuring channel.
Alarm transmission and communication between stations and the CPU via fiber-optic cable.
Self-monitoring and testing facilities for periodic testing of the entire measurement chain.

Outputs:
Three alarm levels: trigger, calculated, system failure.
Laser printed seismic event records including 3 component time-history and RSA, RSV and CAV plots with limits.
Data is stored on event basis in case a dynamic event is detected.

Client:
Nordostschweizerische Kraftwerke (NOK)

GeoSIG Ltd.
Ahornweg 5A, 5504 Othmarsingen, Switzerland
Tel: +41 44 810 2150, Fax: +41 44 810 2350
Web: www.geosig.com, e-mail: info@geosig.com

GeoSIG
swiss made to measure

REFERENCE LIST

World Wide Nuclear Power Plants with GeoSIG Instrumentation

GeoSIG Ltd.
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

22nd March 2011

Selected NPPs Instrumented with GeoSIG Instruments*

In the past decades, GeoSIG Instruments have been delivered to more than 60 NPP's in more than 15 countries worldwide. Some of the NPP's around the world, which are instrumented with GeoSIG Instruments, are listed below.

No.	Country	Project	Delivered
67	South Korea	Shin-Kori Unit 3 & 4	2011
66	South Korea	Waste Storage Facility (LILW)	2009
65	South Korea	Shin-Wolsong Unit 1 & 2	2009
64	Switzerland	Mühleberg	2009
63	Switzerland	Leibstadt Phase 2	2009
62	South Korea	Shin-Kori Unit 1 & 2	2008
61	Switzerland	Beznau Phase 2	2008
60	USA	Susquehanna – Upgrade	2008
59	Lithuania	Ignalina – Modernization	2007
58	Switzerland	Gösgen Phase 2	2007
57	Switzerland	Gösgen Phase 1	2006
56	South Korea	Wolsong 1/2 - Upgrade	2005
55	Switzerland	Leibstadt Phase 1	2005
54	China	Tianwan	2004
53	Switzerland	Beznau Phase 1	2003
52	South Korea	Ulchin Unit 5 & 6	2002
51	Spain	José Cabrera (Zorita) - Upgrade	2002
50	Bulgaria	Kozloduy	2001
49	Argentina	Embalse	2000
48	France	Marcoule	2000
47	Lithuania	Ignalina	2000
46	Slovakia	Bohunice	1999
45	Czech Republic	Temelín	1998
44	Slovakia	Mochovce	1998
43	Armenia	Metsamor	before 1998
42	Belgium	Doel	before 1998
41	Belgium	Tihange	before 1998
40	Canada	Gentilly	before 1998
39	Canada	Pickering	before 1998
38	Germany	KMK Mülheim-Kärlich	before 1998
37	Hungary	Paks	before 1998
36	South Korea	Kori	before 1998
35	South Korea	Wolsong Unit 1 & 2	before 1998
34	Spain	Trillo	before 1998
33	Spain	Vandellos	before 1998
32	Spain	José Cabrera (Zorita)	before 1998
31	Taiwan	Maanshan	before 1998
30	USA	Arkansas Nuclear One	before 1998
29	USA	Beaver Valley Unit 2	before 1998
28	USA	Braidwood	before 1998

GeoSIG Ltd.
Ahornweg 5A
5504 Othmarsingen
Switzerland

Tel : +41 44 810 2150
Fax : +41 44 810 2350
Email : info@geosig.com
www.geosig.com

22nd March 2011

Selected NPPs Instrumented with GeoSIG Instruments*

No.	Country	Project	Delivered
27	USA	Byron	before 1998
26	USA	Callaway	before 1998
25	USA	Clinton	before 1998
24	USA	Connecticut Yankee	before 1998
23	USA	Crystal River	before 1998
22	USA	Davis-Besse	before 1998
21	USA	Diablo Canyon	before 1998
20	USA	Enrico Fermi	before 1998
19	USA	Hanford N-Reactor	before 1998
18	USA	Hatch	before 1998
17	USA	Humboldt Bay	before 1998
16	USA	Kewaunee	before 1998
15	USA	LaSalle County	before 1998
14	USA	Marble Hill	before 1998
13	USA	Millstone Unit 3	before 1998
12	USA	Monticello	before 1998
11	USA	Palo Verde	before 1998
10	USA	Peach Bottom	before 1998
9	USA	Point Beach	before 1998
8	USA	Prairie Island	before 1998
7	USA	Rancho Seco	before 1998
6	USA	Salem	before 1998
5	USA	South Texas Project	before 1998
4	USA	Susquehanna	before 1998
3	USA	Trojan	before 1998
2	USA	Wolf Creek	before 1998
1	USA	Zion	before 1998

*: Majority of the instruments supplied before 1998 belong to the period of time when a strategic alliance was in place with TERRA Technology Corporation while we jointly designed, developed, manufactured and marketed a number of products on a global scale with considerable success.

GeoSIG
swiss made to measure

COMPANY PRESENTATION

Company Brochure

GeoSIG, the Swiss manufacturer of systems and solutions for earthquake, seismic, structural, dynamic and static monitoring and measuring

GeoSIG Ltd provides superior instruments, state-of-the-art systems and solutions for earthquake, seismic, structural, dynamic and static monitoring and measuring.

Since 1992, having established a permanent and strong position at the top tier of the industry and with significant experience in the development of systems for scientific, engineering and industrial applications, GeoSIG has supplied thousands of systems in successful operation around the world.

Composed of highly dedicated and talented individuals with many years of experience in their fields, GeoSIG has developed a large variety of Strong Motion and Seismic Recorders, Sensors and Civil Engineering Monitoring Systems and provides high quality instruments and network systems.

The principle objective of GeoSIG is providing measuring solutions that meet customers' requirements. This tenet is fulfilled by highly versatile products in terms of features, functions, quality and reliability at an optimum price performance ratio.

The design and development of all GeoSIG systems are centred on obtaining the highest possible levels of performance, durability and reliability; qualities which are inherently associated with the words 'Swiss Quality'.

To assure continuing leadership, GeoSIG places a strong emphasis on incorporating the most advanced technologies.

GeoSIG has succeeded in bringing out excellent products and is recognised and well known in the seismic and civil engineering market place. GeoSIG Instruments have been designed from the outset with the future in mind. The open architecture, leading edge digital electronics, and the use of advanced engineering facilities have resulted in a system design with the power and flexibility to perform not only today's but tomorrow's instrumentation and monitoring requirements.

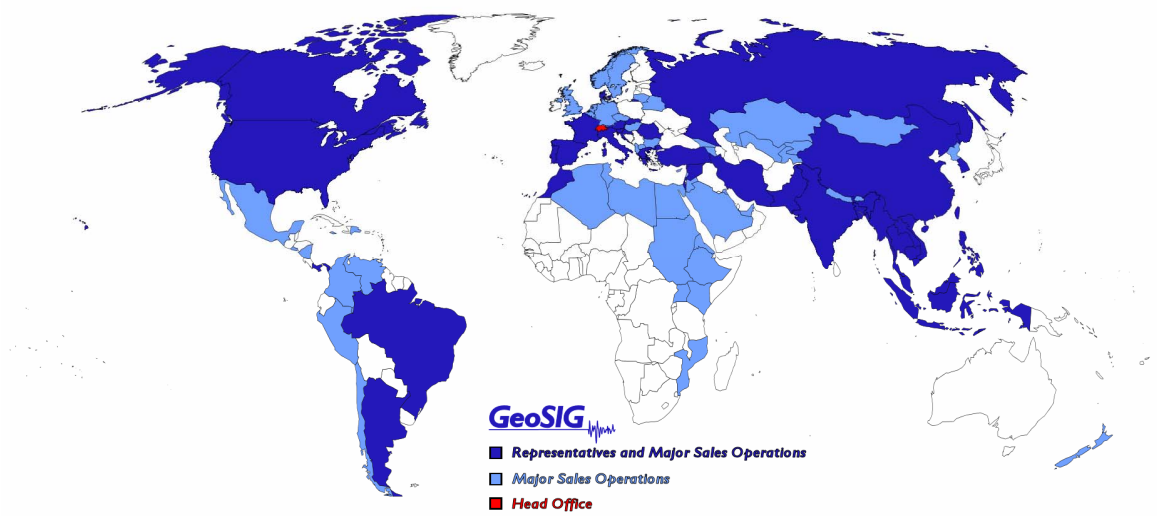
Numerous projects have been successfully completed ranging from single instruments to massive networks in more than 80 countries around the world.

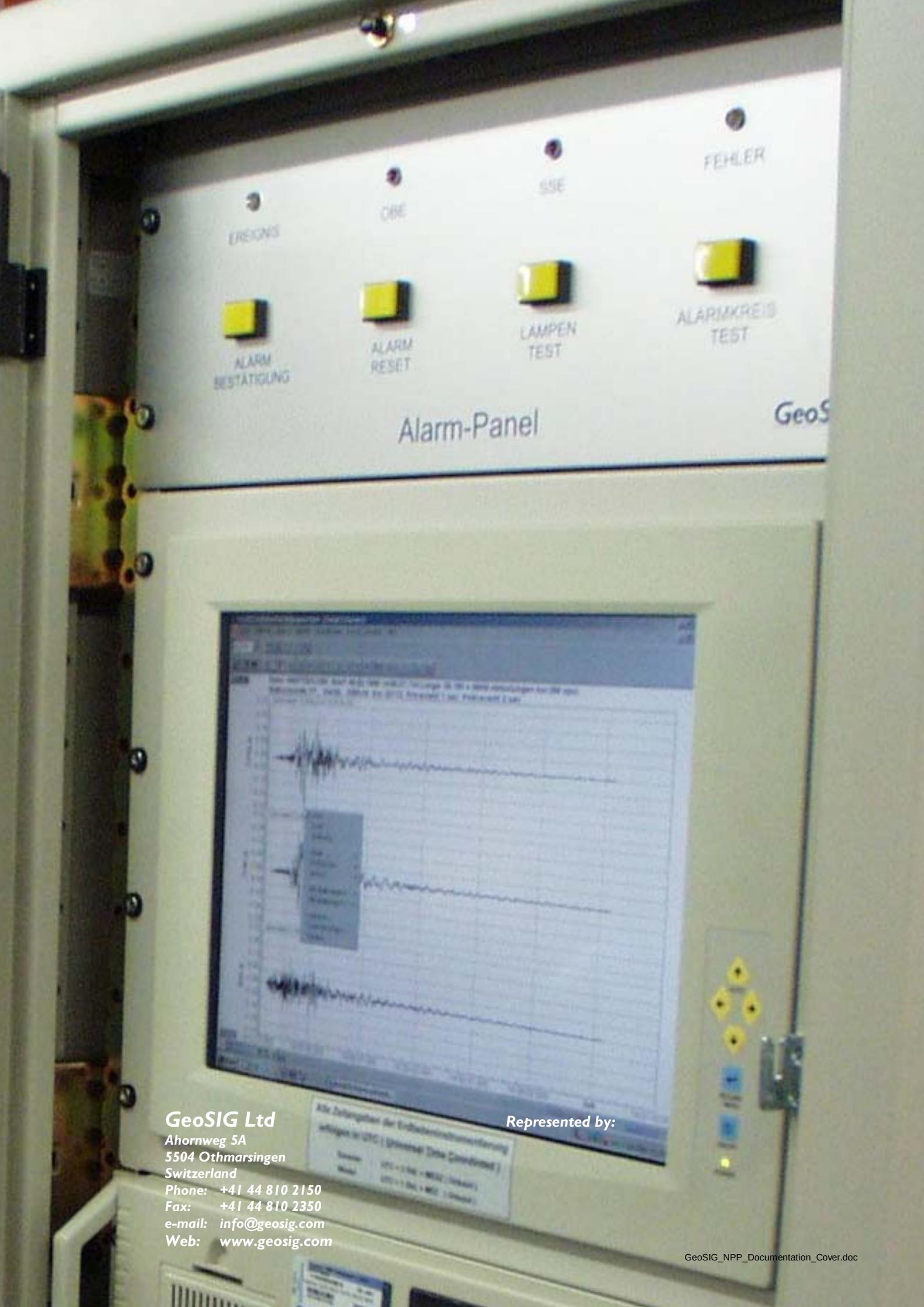
More than 38 determined representatives have been assigned in more than 55 countries around the globe. This experienced and widespread representative network enables GeoSIG to be present round the clock in the service of their customers.

To complement its technical capabilities and to attain high levels of quality assurance, GeoSIG has invested extensively in support and infrastructure which has collimated in achieving ISO 9001 accreditation. In mid 1997 GeoSIG has been assessed and approved to the quality administration systems, standards and guidelines of BS EN ISO 9001: 1994. Following re-assessments in 2004 and in 2010 yielded approvals for BS EN ISO 9001: 2000 and BS EN ISO 9001: 2008, respectively, applying to the design, development, manufacture, supply and servicing of geophysical measuring solutions (QMS Quality Management Systems Limited, Certificate Number: GB2117).

GeoSIG Head Office is located in Othmarsingen, Switzerland, only 20 minutes away from the Zurich International Airport. This large facility incorporates the administration; commercial and project management; research, development and design; manufacturing, testing and repair as well as training amenities. This well organised constellation provides a focused and fully integrated activity.

GeoSIG recognises that the most valuable asset is the combined expertise, experience and talents of its team, affiliates and customers. Dedication, talent, knowledge and experience enable GeoSIG to continue being one of the principal suppliers of measuring solutions.





GeoSIG Ltd
Ahornweg 5A
5504 Othmarsingen
Switzerland
Phone: +41 44 810 2150
Fax: +41 44 810 2350
e-mail: info@geosig.com
Web: www.geosig.com

Represented by: