TECHNICAL INFORMATION

PREDICTIVE MAINTENANCE SYSTEMS

SENSONICS LTD

Seismic Technical Note

SEISMIC PROTECTION & MONITORING SYSTEM FOR GENERAL INSTALLATIONS

1.1 General System Description

1.1.1 Introduction

The system is intended to detect ground motion and to display alarms centrally, remotely when the detected vibration severity exceeds a predetermined value. Seismic event signals are also recorded to provide a time history for subsequent analysis.

The purpose of the system is to provide protection in the event of earth tremors which could affect the structural integrity of the buildings and/or plant.

1.1.2 General Principle of Operation

Ground motion is detected by means of a 'Seismic Switch' which comprises three orthogonally- mounted seismic pick-ups together with electronic circuits which amplify and filter the signals produced by the pick-ups and compare these with a pre- set, adjustable threshold. If any signal exceeds this threshold, then a relay changes state. The relay contacts remain in the changed state for a pre-set length of time after the ground motion signal falls below the pre-set threshold. When this time period has elapsed, the relay and its contacts will return to the original state ready for the next event.

The relay contact outputs from each of three 3-axis seismic switches distributed around the site are cabled to a central monitoring point where a voting logic system assesses the individual alarm situation. If two seismic switches have sensed the same event, then the voting system considers this to be genuine and initiates its own contact change. There is also an output from the central monitoring point via a cable to a remote location where an alarm annunciator displays an identified alarm.

The three seismic switches also provide, via a voltage to current converter card, continuous vibration signals via a cable to a recorder located at the central monitoring point (equipment cubicle). These signals are stored for a pre-event period and are continuously overwritten. Signals above a pre-determined magnitude are considered to be a 'seismic event' and are identified for the duration of the event. These events are then copied to a disc together with the pre and post event signals. The information may be removed for subsequent analysis by a separate stand-alone computer loaded with the Seismic Replay Software.

Each equipment assembly within the overall system contains detection circuits for 'equipment failure', and provides relay contact outputs for indication within and remote from the central monitoring unit. All the integrity alarm relay outputs from all the individual units are connected in series so that a failure in any one of the units will cause a relay to open, which bring up a group system fault alarm.

The system normally operates from the 48V dc power supply rack which is driven by 110V ac but will, in the event of mains failure, continue to operate for up to 3 hours on rechargeable batteries associated with an Uninterruptable Power Supply (UPS) located at the central monitoring unit (equipment cubicle).

Calibration and routine checking of the seismic monitoring system is achieved by means of a signal generated centrally and connected via switches to the input of each seismic unit in turn.

During calibration periods the system is not taken off-line. The seismic switches are calibrated individually, while the system continues to function from two switches. The 2 out of 3 voting system is duplicated with the facility to switch from one system to the other. In this way each system can be functionally tested while the other system remains on line. At the end of the calibration procedure a system test can be performed. This is the only time the system will be 'off-line' and should be limited to a maximum period of approximately 2 minutes per calibration check.

1.1.3 Plant-mounted Equipment

Each of the three 3-axis seismic switches is individually mounted on a vertical surface which is an integral part of the building structure. Each seismic unit is held rigidly to the building structure by means of three anchor studs set into the concrete walls of the cable ducts.

The housing for each seismic switch is identical and comprises a painted steel enclosure attached to a plated steel mounting plate provided with three mounting holes. The housing has a hinged lid which is held closed by a pair of wing nuts which, when tightened, pull the lid and housing together into a captive gasket which maintains the sealing of the enclosure to IP.66 rating. The lid is padlocked to prevent unauthorised access which should not be necessary during normal operation. The cable which enters the housing via the lower gland plate is terminated at klippon terminals within the enclosure.

Power for operation of the seismic switches is permanently connected via the cable from the 48V dc power supply unit located in the seismic monitoring equipment cubicle.

1.1.4 Seismic Monitoring Equipment Cubicle

The cubicle is 800mm wide by 950mm deep and 2.075m tall and is fitted with an armoured- glass-panelled front door and a sheet steel rear door. It is firmly anchored to the floor by six anchors through the base into the concrete. Both front and rear doors have key- lockable handles and provision for padlocks.

All the seismic monitoring equipment is located at the front of the cubicle such that all operational visual indicators are visible through the glass door (there are additional fault diagnostic indicators viewable via the rear door). The operator will be directed to the diagnostic indicators at the rear by the indications visible through the glass front door.

Access to the cubicle via the front door will be necessary during normal operation for the 'acceptance' and 'resetting' of any alarms. Access to the cubicle via the rear door will be necessary during installation and maintenance.

1.2 Voting Alarm System

1.2.1 System Description

The alarm voting logic system is duplicated. A two way switch directs all alarm signals from the three seismic switches to either system. The duplicated voting systems will normally operate in parallel with each other. Either voting unit may be disconnected from the system for test purposes whilst the second voting system remains in circuit.

The system as a whole consists 19in x 1u units, 2off master annunciator racks, RA.8119 for diagnostic 2 out 3 voting with front panel indicator windows with legends as shown on drawings SK.5254B and SK.5255B. There is also a slave annunciator rack with front panel indicator windows with legends as shown in drawing SK.5256B. Similar units (repeaters) with blank front panels provide the relay outputs for the control room annunciators and system control..

The system is powered from the 48Vdc PSU rack. This is a dual, diode- interconnected PSU system with each half capable of taking the full system load and with its input power supplied from the uninterruptable power supply (UPS).

1.2.2 Principles of Operation

Fault Interlock If a seismic switch develops a defect which trips the integrity alarm within the switch, then the relevant 'seismic switch fault' alarm and 'system fault' (group) alarm will be indicated locally (i.e. at the cubicle) and the 'seismic event' alarm from the defective seismic switch will be disabled. The 'seismic system fault' alarm will be relayed via the repeater racks to the control room and scanner systems. The alarm voting system will then vote on the remaining two operational seismic switches.

Alarm Voting Under normal operating conditions (i.e. the calibration check has not been selected), and two seismic switches trip nearly-simultaneously (i.e. within the delay period pre-set within the seismic switch) will cause the voting system to decide that a seismic event has occurred and this will initiate a 'Seismic Event' Alarm together with the appropriate 'Seismic Switch Activated ' alarm(s). The Event Alarm will remain activated until manually reset by the operator.

However, if only one seismic switch gives an active output then the voting system will not allow a seismic event output and this in turn will inhibit the 'Seismic Switch Active' input from initiating a 'Seismic Switch Activated' alarm output. Hence spurious alarms on one seismic switch are suppressed.

Seismic System Fault Alarm This alarm is a group alarm and may be initiated by any of the alarms indicated on the slave annunciator rack. These in turn may be initiated by a group of faults which are indicated by diagnostic LED's located on the racks from which the faults originate. Thus providing a diagnostic chain of failure indicators from overall system fault down to specific failure.

Each main board within the local alarm voting and diagnostic system (including relay repeater racks) has a PSU integrity alarm indicator (a green PSU OK LED) which is visible from the rear of the racks. If such a failure should occur within the alarm voting and diagnostic system then an additional fault relay will initiate a seismic system fault alarm output to the control room annunciator.

1.3 Seismic Recording System

The Seismic Recorder is a PC based digital data acquisition system capable of digitising and processing nine analogue signal inputs from plant mounted Seismic units. Each channel consists of a DC biased analogue signal representative of vibration acceleration in the range 0g to 2g peak to peak and frequencies of 0.1Hz to 30Hz.

The Seismic Recorder unit receives all nine of the dynamic analogue signals (time waveform) from the three voltage to current cards in each of the three seismic switches, continuously digitises and records them on to a buffer memory, with a time period of at least 1 hour. The recorder also monitors each channel for peak acceleration levels. The monitored acceleration levels are compared against a corresponding user configurable alarm threshold and if this threshold is exceeded an event condition is triggered.

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An event condition results in the Seismic Recorder generating a local display and relay output alarm indication and a recording of the seismic event input signal to a local Silicon Disc Drive. Once the event has finished the recorded event data file will also be backed up to a local floppy disk drive. This floppy disc may then be removed and taken to an alternative PC where the data may be analysed with the Seismic Replay software (see HB.1150). The floppy disc drives are located behind a locked door so that only the keyholder can remove or replace a disc.

A recorded event will consist of three parts. Pre-event data is the recorded signal prior to the event occurring. This is a user configurable time between 0 and 60 seconds. Active event data is the recorded signal during the event and may be up to 5 minutes in length. The Post-event data is the recorded signal for a period of time after the event has finished. This is configurable by the user between 0 and 60 seconds. All of this information is appended into a single event file for viewing and analysis. This event file is time and date stamped by the system as it is acquired.

In addition to the acceleration signal measurement the Seismic Recorder also monitors system status. This includes individual transducer integrity, disc drive integrity and watchdog system failure indication.

This recorded data is also accessible via a parallel data port and RS232 link to a replay software programme loaded onto a portable PC.

When the system is recording a seismic event a command signal is given to the annunciator racks which causes the 'Seismic Recorder Operating' indicators to flash. These indicators will continue to flash until 'accepted' and 'reset' manually via the push buttons on the master rack. If the 'Accept' and 'Reset' buttons are operated during a 'Seismic Recorder Operating' event, then the 'Accept' will cause the annunciator window to stop flashing and remain lit steady, but the 'Reset' will not extinguish the window or stop the recording. The annunciator window will automatically extinguish when the event recording has ceased.

Should another 'Seismic Events' occur before the previous one has been Accepted and Reset, then these will also be recorded as before, without any loss of data.

1.4 Functional Check System

1.4.1 General Description

There are two calibration racks, (RA.8124) located in the cubicle and used for generating and switching a signal for a functional check of the triaxial seismic switches. One rack does not inhibit the alarms during a functional check and the other is used to check the system without affecting its functionality.

1.4.2 Calibration Rack with Voted Alarm

The front panel consists of a key operated switch and three rotary selector switches. The key operated switch enables an authorised person only (keyholder) to operate the calibration unit. The key can only be removed when the system is in the 'OFF' position. This eliminates the possibility of a seismic alarm signal being generated accidentally by an unauthorised person.

In the 'OFF' position the seismic monitoring system remains in normal operation and the calibration signal does not interfere with the seismic detectors.

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The rotary switches select the calibration signals to the detectors. Each switch has seven positions: off, X Lo, X Hi, Y Lo, Y Hi, Z Lo, and Z Hi. The individual rotary switches are allocated to individual seismic triaxial detectors.

With this arrangement of the rotary switches, the user may either select one triaxial system, or activate two or more alarms at the same time. In the latter case the master rack voting alarm rack system can also be checked,

The sine wave generated in the calibration unit is conducted to the detectors via individual buffer amplifiers. The signal level is constant and the actual calibration level is set-up in the triaxial seismic switches in accordance with the requirements. In this case the user may set up different alarm levels at the different detector locations without disturbing the adjustment at the central calibration unit.

The X, Y, Z and Hi, Lo selection is achieved by BCD-coded digital signals conducted to the three different locations.

The front panel keyswitch also operates a relay which provides a signal to the other systems, indicating that the seismic switches are not in normal operation. The 'seismic calibration check' indicator on the master rack front panel will illuminate.

Due to the long time-constant of the seismic amplifiers, the operator should ensure that sufficient time is allowed before readings are taken.

1.4.3 Calibration Rack with Inhibited Voted Alarm

This unit allows each Master Annunciator Voting rack to be checked in turn off-line, whilst the other rack remains on-line. The voting system under test having its alarm outputs defeated.

1.5 48V dc Power Supply Unit

This unit is located within the Seismic Monitoring Equipment Cubicle and are powered by 110V, 50Hz from the Uninterruptable Power Supply. The output from this unit is used to power the seismic switches and the racks in the cubicle.

1.6 Uninterruptable Power Supply (UPS)

This unit is intended to supply uninterrupted AC power to the Seismic Monitoring System for a period following the loss of the primary power source (110V 50 Hz mains). In principle the mains input is used to charge a battery bank which powers a static inverter. The latter generates 110V 50 Hz which continuously supplies the full system load under normal conditions and will continue to do so for a specified period following loss of mains power.

1.7 Equipment List (per System)

Item	Reference No.	Description	Qty
ASM-35A	IS.2939	Seismic Switch	3
RA.8119	IS.2947	Master Annunciator Rack with Voting	1
RA.8119	IS.2949	Master Annunciator Rack with Voting (Without Controls)	1

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Item	Reference No.	Description	Qty
RA.8120	IS.2940	Slave Annunciator Rack	1
RA.8122	IS.2683	Repeater Rack	1
RA.8124	IS.2937	Calibration Rack (Alarms not Inhibited)	1
RA.8124	IS.2938	Calibration Rack (Alarms Inhibited)	1
Recorder System	IS.2941	7U rack mounted, 15in colour Monitor type RAK 15	1
		1U lockable drawer mounted keyboard	1
		4U rack mounted PC, MITAC type MCH-203, Pentium 2, P333 processor, Sensonics software no: S0073	1
Replay Software		Sensonics software no: S0074	1
RA.8118-1	IS.2685	48Vdc PSU Rack to power system	1
UPS	600VA Miniverter	Uninterruptable Power Supply (Manufactured by Power Systems International Ltd)	1
Batteries	3VA13	Powersafe, 6V Type F (Manufactured by Chloride Industrial Batteries Ltd)	9
Cubicle	EA.3121D	Cubicle to house all the above apart from the seismic switches	1

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