

Vibration Monitoring System



CHANG - IN INC.

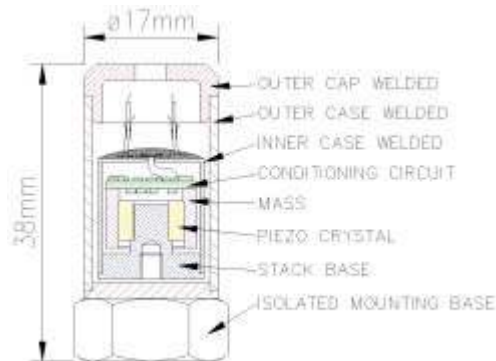
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1. Vibration Transducers(Accelerometer)

The accelerometer is based on the electrical properties of piezoelectric crystal. In operation, the crystal is stressed by the inertia of a mass. The variable force exerted by the mass on the crystal produces an electrical output proportional to acceleration. Two common methods of constructing the device to generate a residual force are compression mode and shear mode respectively. A residual force is of course required to enable the crystal to generate the appropriate response, moving in either direction on a single axis. A shear mode construction is illustrated below.



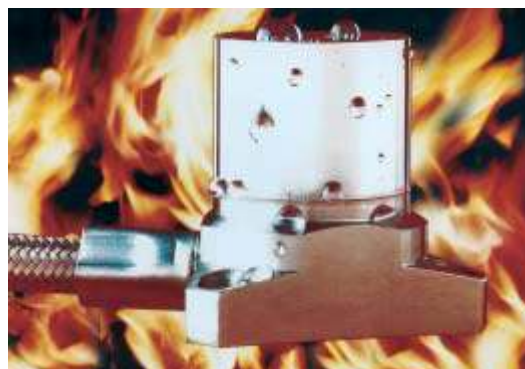
Shear mode construction

Shear mode devices which apply a shear force to the inner and outer surfaces of a ring of crystal (as opposed to a perpendicular force to a disk of crystal), offer a distinct advantage over standard compression techniques.

When mounting the device to the plant, normally through a stud & screw arrangement, the mechanical stresses within the transducer assembly change. Compression mode devices are particularly affected by these stresses, which produce low frequency effects, compounded if further integration is carried out. Sensonics shear mode range of transducers are unaffected by base strain and offer a true low frequency performance down to 0.4Hz.

Although the piezoelectric accelerometer is a self-generating device, its output is at a very high impedance and is therefore unsuited for direct use with most display, analysis, or monitoring equipment. Thus, electronics must be utilised to convert the high impedance crystal output to a low impedance capable of driving such devices. The impedance conversion electronics may be located within the accelerometer, outside of but near the accelerometer, or in the monitoring or analysis device itself.

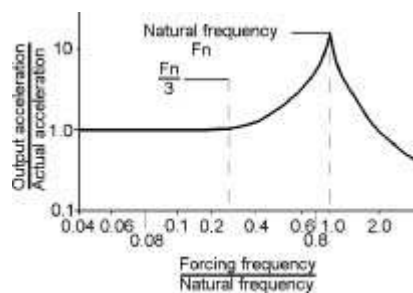
Accelerometers with internal electronics are convenient and can use inexpensive conventional plugs and cable but they are limited to temperatures of typically 120°C. Locating the electronics in a cool location away from the accelerometer allows the transducer to tolerate higher temperatures.



An accelerometer operates below its first natural frequency. The rapid rise in sensitivity approaching resonance is characteristic of an accelerometer, which is an un-damped single-degree-of-freedom spring mass system. Generally speaking, the sensitivity of an accelerometer and the ratio between its electrical output and the input acceleration is acceptably constant to approximately 1/5 to 1/3 of its natural frequency. For this reason, natural frequencies above 30KHz tend to be used.

The frequency response curve can be influenced by a number of factors, mainly the mass, the stiffness and the degree of system damping. The resonant peak of the accelerometer can be eliminated by increasing the damping. However, increasing the damping introduces a phase shift in the linear range whereas un-damped accelerometers have very little phase shift until near the natural frequency. It is therefore usual to have un-damped accelerometers with very high natural frequencies so that the linear range is extended as far as possible. Typical damping ratios are 0.01 to 0.05.

This resonant frequency in combination with the appropriate damping can be utilised to monitor bearing impact. Several manufacturers, including Sensonics have developed transducers that utilise the 'ringing' of the transducer to mechanical impulses to measure the health of roller bearings. This technique analyses the high frequency response of the transducer (at resonance) to determine an 'impact factor' normally in dB, which is directly proportional to the quantity and force of metal on metal impacts. This factor is normalised to an overall health measurement by consideration of bearing dimensions and rotational speed.



Typical accelerometer frequency response

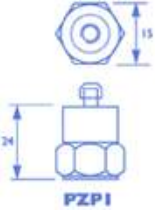
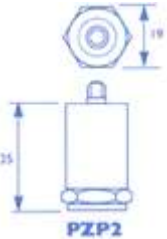
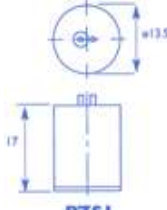


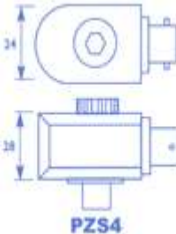
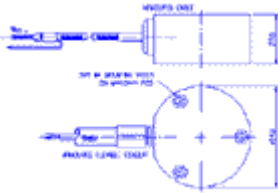
Accelerometers are available in various output configurations. The industry standard drive utilises a 2wire current source interface operating at a nominal bias voltage of +12Vdc typ., with an output sensitivity of 100mV/g. This configuration limits the dynamic range to around $\pm 70g$, which is suitable for most applications.

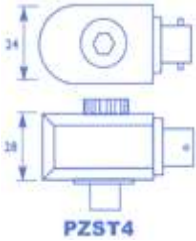
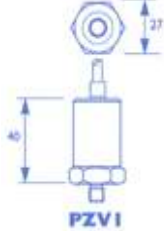

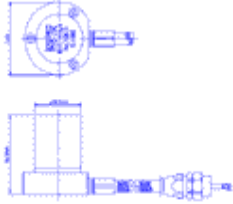
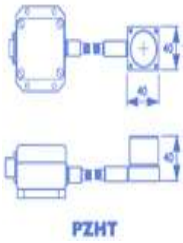
Larger dynamic ranges can be achieved through lowering the sensitivity at the expense of signal to noise ratio, 10mV/g as an example, or utilising current output devices, which can provide $\pm 1000g$ depending on sensitivity requirements (10pC/g is typical).

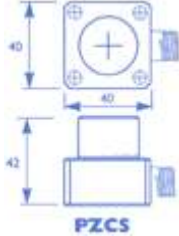

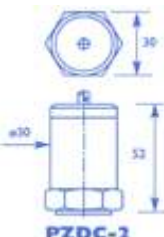
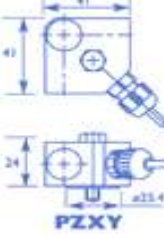
Standard accelerometers are also available with velocity outputs in either metric or imperial format, although for these configurations the required measurement range must be understood if the correct sensitivity is to be selected (0–20mm/s, 0–50mm/s etc.). Since the integration function to convert the acceleration to velocity is carried out within the accelerometer, the low frequency performance is typically limited to around a few hertz.

The limited complexity of the conditioning circuitry that can be included within the accelerometer combined with the integrated noise tend to be the limiting factors.

For direct integration with SCADA and PLC based systems, most manufacturers offer direct 4–20mA outputs covering a factory set range of either acceleration or velocity vibration. This can be an extremely cost effective solution (provided the required measurement range is again well understood) since no signal conditioning unit is required to drive the transducer or process the resulting measurement. The resulting current loop output is typically either a peak or an RMS representation of the vibration signal and therefore signal frequency analysis is not possible.

Model Type	Description	Applications
 <p>PZP1</p>	<p>PZP1 Accelerometer Lightweight, high response without internal charge amplifier. - Frequency response: 0.5Hz - 20kHz - Dynamic range: 600g</p>	<p>Suitable for gearbox, high frequency or high temperature monitoring. A separate in-line charger is available</p>
 <p>PZP2</p>	<p>PZP2 Accelerometer Medium sized unit without internal charge amplifier, a radiation resistant version is available. - Frequency response: 0.5Hz - 9kHz - Dynamic range: 300g</p>	<p>Nuclear Installations and other general machine monitoring applications</p>
 <p>PZS1</p>	<p>PZS1 Accelerometer Our smallest unit with integral electronics. Extended low end frequency response. - Frequency response: 0.4Hz - 11kHz - Dynamic range: 70g</p>	<p>OEM's and embedded applications</p>
 <p>PZS2</p>	<p>PZS2 Accelerometer Low cost industrial 2 wire unit small footprint - Frequency response: 0.4Hz - 11kHz - Dynamic Range 70g</p>	<p>Suitable for most types of rotating machinery, pumps, motors, fans, etc. Ideal for use with portable data collectors.</p>
 <p>PZS3</p>	<p>PZS3 Accelerometer The standard 2-wire unit for harsh industrial applications. Extended low end frequency response. - Frequency response: 0.4Hz- 11kHz - Dynamic range: 70g</p>	<p>Electric Motors, generators, paper machines, steel mills, etc.</p>
 <p>PZS4</p>	<p>PZS4 Accelerometer Low profile shear mode industrial accelerometers with low base strain, single point mount and side exit connections. - Frequency response: 0.4Hz - 11kHz - Dynamic Range: 70g</p>	<p>Electric Motors, Generators, Paper Machines, steel mills, etc. where height is limited</p>
 <p>PZS5</p>	<p>PZS5 Accelerometer The extremely robust unit for heavy industry. Armoured conduit option gives excellent protection. - Frequency response: 0.4Hz - 11kHz - Dynamic range: 70g</p>	<p>Steam and gas turbines, gas circulators etc., where monitoring is critical.</p>

Model Type	Description	Applications
 <p>PZST4</p>	<p>PZST4 Accelerometer 3/4 wire dual sensor for harsh industrial applications where temperature monitoring is required as well as vibration.</p> <p>- Frequency response: 3.5Hz - 11kHz - Dynamic range: 70g & 30 to 125oC</p>	<p>Suitable for most types of rotating machinery, pumps, motors, fans, etc. Ideal for use with portable data collectors / analysers</p>
 <p>PZV1</p>	<p>PZV1 Accelerometer Low cost industrial accelerometer with output proportional to vibration velocity.</p> <p>- Frequency response: 2.5Hz - 6kHz - Dynamic range: 200g or 500mm/s</p>	<p>Suitable for pumps, fans and motors and most types of rotating machines.</p>
 <p>PZV2</p>	<p>PZV2 Accelerometer The standard 2 wire unit for harsh industrial applications with direct velocity output.</p> <p>- Frequency response: 2.5Hz - 6kHz - Dynamic range: 75g</p>	<p>Electric motors, generators, paper machines, steel mills, etc.</p>
	<p>PZV3 Accelerometer</p>	
 <p>PZHT</p>	<p>PZHT Accelerometer The extremely robust unit for high temperatures in heavy industry. Armoured conduit gives excellent protection.</p> <p>- Frequency response: 8Hz - 10kHz - Dynamic range: 70g</p>	
	<p>PZHT2 Accelerometer</p>	
	<p>PZHT3 Accelerometer</p>	

Model Type	Description	Applications
 <p>PZCS</p>	<p>PZCS (QZ/73) Accelerometer</p> <p>The extremely robust unit for heavy industry with current output.</p> <p>- Frequency response: 2.5Hz - 10kHz - Dynamic range: 75g</p>	<p>Military applications amongst others.</p>
 <p>PZDC</p>	<p>PZDC Vibration Transmitter</p> <p>Loop powered vibration transmitter with 4-20mA output for overall vibration level in velocity terms.</p> <p>- Frequency response: 10Hz - 1kHz - Dynamic range: See data sheet</p>	<p>Suitable for most types of machine and provides direct input to SCADA or DCS systems.</p>
 <p>PZDC-2</p>	<p>PZDC-2 Vibration Transmitter</p> <p>Dual output unit Loop powered vibration sensor with 4-20mA output for overall vibration level in velocity terms with raw a/c. output voltage.</p> <p>- Frequency response: 10Hz - 1kHz (Vel)(ISO2372) 2.5Hz - 11kHz (Accel) - Dynamic range: See data sheet</p>	<p>A PZDC accelerometer with an extra raw a.c. output to be collected and/or analysed locally by a data collector/analyser once SCADA/DCS has alarmed.</p>
 <p>PZXY</p>	<p>PZXY Triaxial Accelerometer</p> <p>Industrial triaxial sensor for measuring vibration in 3-axis in one place. X, Y & Z eliminates the requirement for expensive mounting blocks.</p> <p>- Frequency response: 0.4Hz - 7KHz - Dynamic range: 70g in each axis</p>	<p>Space saving unit will save on fitting three individual sensors and replaces three cable runs with just the one</p>

2. Eddy Current Proximity Probes

The principle of operation, as the name implies, depends upon the eddy currents set up in the surface of the target material – shaft, collar, etc. adjacent to the probe tip.

The Eddy probe tip is made of a dielectric material and the probe coil is encapsulated within the tip. The coil is supplied with a constant RF current from a separate Eddy Probe Driver connected via a cable, which sets up an electromagnetic field between the tip and the observed surface.

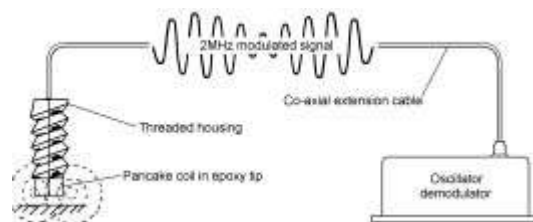
Any electrically conductive material within this electromagnetic field, i.e. the target material, will have eddy currents induced in its surface. The energy absorbed from the electromagnetic field to produce these eddy currents will vary the strength of the field and hence the energising current, in proportion to the probe–target distance. Such changes are sensed in the driver where they are converted to a varying voltage signal.

The whole probe, extension cable and driver system relies for its operation on being a tuned circuit and as such is dependent on the system's natural frequency.

Thus each system is set up for a fixed electrical/cable length. Eddy probe systems are usually supplied with 2, 5, 9 or 14 metre total cable lengths.

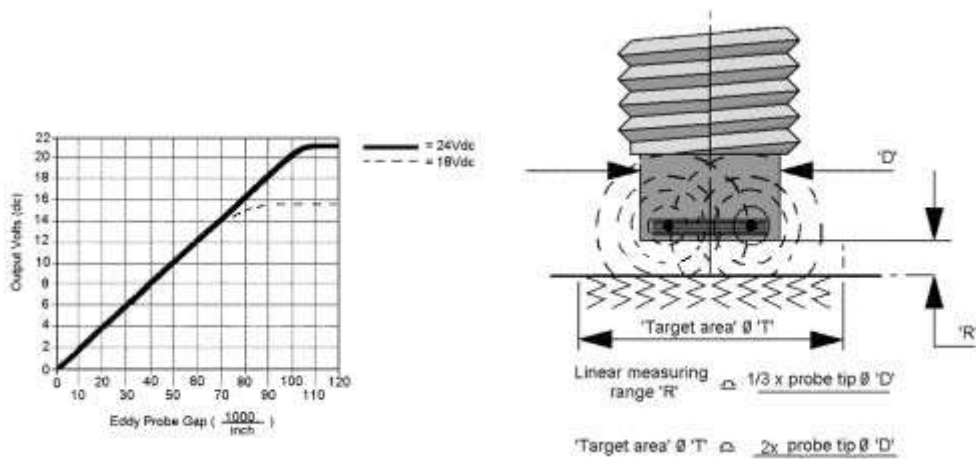
The probe types available are generally according to the API670 standard (see later discussion). Three main variants, straight mount, reverse mount and disc type probes make up the Sonsonics range. The main difference between the straight and reverse mount is the location of the thread on the probe body and the fixing nut. Reverse mount tend to be used exclusively with probe holders, while straight mount are the more common and are used on simple bracketry or mounting threads where adjustment to the target is achieved through use of the thread on the probe body in conjunction with a moveable lock nut. The maximum measurement range available on this type of probe is typically 8mm.

The disc probe mounts the encapsulated coil on a metal plate with fixed mounting holes, making a very low profile assembly with a side exit cable. Larger coils can be mounted on this plate; for example, the 50mm diameter tip probe can provide a measurement range of beyond 25mm. However, care must be taken to ensure the target area is sufficient to obtain the required linear response. Note the relationship opposite . between linear range, probe tip and target area.



System overview



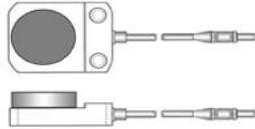

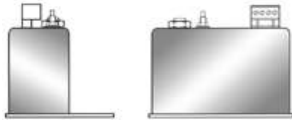
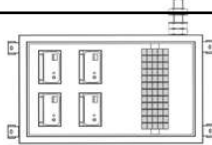
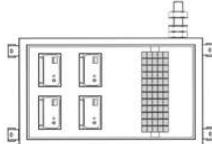
In rotating plant, the variations in shaft/bearing distance created by vibration, eccentricity, ovality etc. can thus be measured by probes mounted radially to the shaft. When the target is stationary the measured voltage can be used to set the probe/target static distance. Shaft speed can also be measured by placing the probe viewing a machined slot or a toothed wheel.



Eddy current probe empirical relationships



System overview T typical straight probe with driver

STRAIGHT MOUNT PROBES			
Probe Type	Range	Tip Diameter	Data Sheet
PRS 02	2.5 mm	5 mm	L156
PRS 04	4 mm	8 mm	L157
PRS 08	8 mm	20 mm	L158
AECP 02	2.5mm	-	DS1150
AECP 04	2.5 or 4mm	-	DS1151
REVERSE MOUNT PROBES			
Probe Type	Range	Tip Diameter	Data Sheet
PRR 04	4 mm	8 mm	L159
AECPR 04	2.5 or 4mm	-	DS1152
DISC PROBES			
Probe Type	Range	Tip Diameter	Data Sheet
PRD 04	4 mm	8 mm	L161
PRD 08	8 mm	20 mm	L162
PRD 12	12 mm	25 mm	L163
PRD 18	18 mm	40 mm	L164
PRD 25	25 mm	50 mm	L165
SYSTEM PRODUCTS			
<p>EXTENSION CABLES</p> <p>Available in various 'tuned' lengths up to 18m. With or without stainless steel over braid armouring. Various connectors, oversheaths and sealing glands supplied fitted.</p>			
<p>DRIVER UNITS</p> <p>Compact design either baseplate or DIN rail mounted. Four connections per box required - 24V, 0V and Signal</p>			
<p>PROBE HOLDER</p> <p>Replace probes without calibration. In aluminium alloy or stainless steel, internal adjustment of probe depth. Fully Sealed.</p>			
<p>DRIVER HOUSING</p> <p>Steel enclosure with removable gland plates and lockable door. Sealed to IP65. Capacity for 1, 2, 4 or 6 drivers. Fully wired with terminals fitted.</p> <p>DATA SHEETS DH1/10 DH2/20 DH4/34 DH6/60</p>			

3. Velocity Transducers (Speed Sensor)

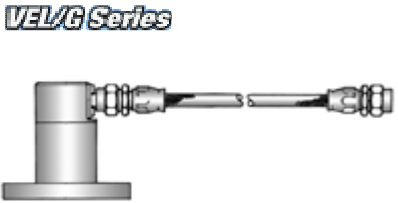
The velocity transducer is inherently different to the accelerometer with a conditioned velocity output. This device operates on the spring-mass-damper principle, is usually of low natural frequency and actually operates above its natural frequency. The transducing element is either a moving coil with a stationary magnet, or a stationary coil with a moving magnet. A voltage is produced in a conductor when the conductor cuts a magnetic field and the voltage is proportional to the rate at which the magnetic lines are cut. Thus, a voltage is developed across the coil, which is proportional to velocity.

This type of transducer can provide sensitivities of up to 20mV/mm/s and is convenient because it generates a signal without an external power supply and the signal usually does not require further amplification.

The sensitivity vs. frequency response curve of a velocity pickup is limited at low frequencies by the optimum damping of the first natural frequency; at high frequencies its response is limited by the amount of motion necessary to overcome the inertia of the system, as well as by the presence of higher order natural frequencies.

For practical purposes, a typical velocity pick-up is limited to frequencies between approximately 10 and 1500 Hz. This has an advantage in certain applications where high frequency vibration (generated from steam noise for example) can saturate standard accelerometers with a built-in integration function.

It is possible to obtain moving coil type transducers which operate in any axis. The high specification units tend to be only available for operation in either the vertical or horizontal plane due to the arrangement of the sprung mechanism and orientation during factory calibration.

Model Type	Description
 <p><i>VEL/G Series</i></p>	<ul style="list-style-type: none"> ◦ Heavy industrial ◦ Self generating ◦ 500mV/In/Sec/ or 100mV/In/Sec output ◦ Magnetically shielded ◦ Frequency range 4.5 Hz to 3 KHz

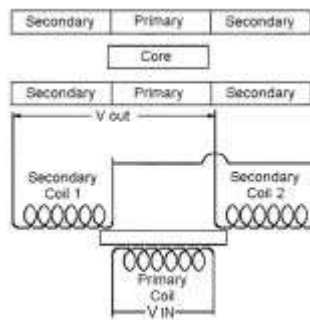
Specification

Output	.....	500mV/in/sec PK +/-3% or 100mmV/in/sec PK +/-3%
Frequency range	.....	4.5Hz to 3 KHz dependant on orientation/sensitivity
Linearity	.....	+/-2% at 100 Hz
Max Displacement	.....	100 mils PK to PK
Max Acceleration	.....	2000g in sensitive axis, 50g in non-sensitive axis
Temperature Range	.....	-29 to 121oC
Dimensions	.....	Please consult Data Sheet
Connector Orientation	.....	Top or side exit

4. LVDT Displacement Transducers

The LVDT is an electromechanical device that produces an electrical signal whose amplitude is proportional to the displacement of the transducer core.

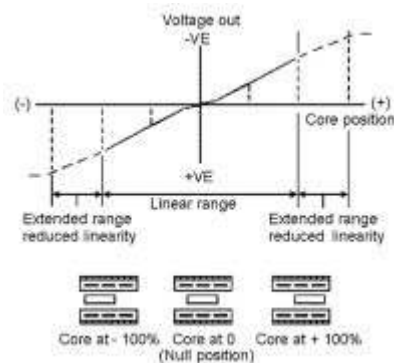
The LVDT consists of a primary coil and two secondary coils symmetrically spaced on a cylindrical former.



Schematic of an LVDT

A magnetic core inside the coil assembly provides a path for the magnetic flux linking the coils. The electrical circuit is configured as above with the secondary coils in series opposition.

When an alternating voltage is introduced into the primary coil and the core is centrally located, then an alternating voltage is mutually induced in both secondary coils. The resultant output is zero, as the voltages are equal in amplitude and in 180° opposition to each other. When the core is moved away from the null position the voltage in the coil, toward which the core is moved, increases due to the greater flux linkage and the voltage in the other primary coil decreases due to the lesser flux linkage. The net result is that a differential voltage is produced across the secondary windings, which varies linearly with change in core position. An equal effect is produced when the core is moved from a null in the other direction but the voltage is 180° different in phase.



Core displacement characteristics

The LVDT can be operated where there is no contact between the core and extension rod assembly with the main body of the LVDT housing the transformer coils. This makes it ideal for measurements where friction loading cannot be tolerated but the addition of a low mass core can. Examples of this are fluid level detection with the core mounted on a float and creep tests on elastic materials. This frictionless movement also benefits the mechanical life of the transducer, making the LVDT particularly valuable in applications such as fatigue life testing of materials or structures. This is a distinct advantage over potentiometers which are prone to wear and vibration.

The principle of operation of the LVDT, based on mutual inductance between primary and secondary coils, provides the characteristic of infinite resolution. The limitations lie within the signal processing circuitry in combination with the background noise.

The principles of operation of the LVDT enables the transducer to be configured in a variety of housings depending on the degree of mechanical protection required. The use of rod end bearings, linear rolling element bearings and flexible conduit, helps the LVDT to survive even the most severe environments.

The LVDT principle can also be applied to the measurement of angular position; an RVDT (Rotary Variable Differential Transformer) converts the rotation of a shaft into a proportional electrical output signal.

Although the transducer is capable of continuous rotation, a plot of angular rotation against magnitude and phase of the output signal over 360° would result in a complete sinusoidal wavelength response and therefore two null positions. To avoid ambiguity, just one of the null positions is chosen during calibration, providing a typical measurement range of ± 60°. Some key characteristics of the Sensonics LVDT range are as follows.

- Range : 2.5mm to 600mm
- Core type : Sprung, guided or free
- Signal connection : End or side exit connector or cable with option of conduit.
- Mechanical conn : Rolling, ball or rod end
- Operating temp : -40°C to +220°C
- Specials : Submersible (.100m depth), Short body to stroke ratio



A range of Sensonics LVDT devices

Model Type

SL Series LVDT	SR-W/DR-W Series LVDT
DM Series LVDT	SB Series LVDT
DM-W Series Waterproof LVDT	TD Series LVDT
E Series AC LVDT	HI Series LVDT
DE Series DC-DC LVDT	SHI Series LVDT
SR Series LVDT	DC 8042 Series
DR Series LVDT	LVDT Bracketry

5. Accessories

To help gain the most benefit from your accelerometers, Sensorics manufacture a wide range of ancillary products which include...



Fixings and Mounting Studs

With all types and sizes of threads, which can be isolated and are suitable for welding or cementing to machine castings.



Connection and Switching Boxes

For easy data collection from installed transducers.



In-line Charge Amplifiers

For charge sensitivity accelerometers



Accelerometer Simulation Units

For calibration of all monitoring systems

Other accessories include : Cable, Connector and Conduit Harnesses

Bracketry - To enable effective mounting of Accelerometers in difficult positions.

Magnetic Bases - For temporary mounting of all transducers

The preferred method is using fixing screws or studs, this is the most dependable method and gives the best frequency response.

For Transducers that are likely to be removed often, quick release fastenings can be provided.

When machine cases cannot be prepared, transducer fixings can be cemented in place.

Magnetic bases can be provided when transducers are to be mounted temporarily, although some degradation of Frequency response is likely. Contact spikes can be used for "hand held" vibration measurement.

6. Multichannel Monitoring Systems

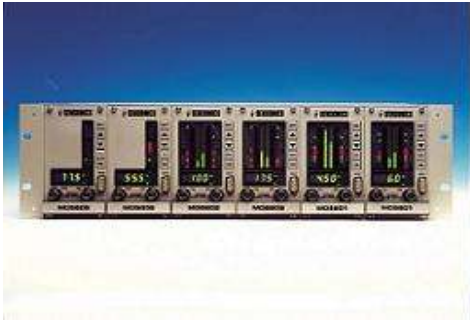
1) SENTRY Machine Protection System (Microprocessor Based)

- Effective and Unobtrusive machinery protection

The Sentry Monitoring and Protection System has been designed using the latest technology to give maximum warning of impending machine failure without producing costly spurious alarms. It is intended to be permanently installed and requires little or no intervention from operators until a real event occurs.

- Designed to Have the Flexibility to Suit any monitoring requirement

Because each Sentry Monitor Module has its own microprocessor controller it is almost entirely user configurable, offering the most flexibility available whilst retaining the levels of reliability that Sensorics is renowned for.



>> Racking System

- Available in 19" or 10.5" versions to hold 6 or 3 modules.
- Panel mount facility
- High integrity design
- Detachable connector blocks for ease of maintenance
- Standard module mating connectors with polarity keys

>> System Set-Up

- Standard PC compatibility
- Logical, user friendly, multiple choice question/answer format
- Library facility to record standard set-up configurations
- Protected configuration
- High speed downloading of information via RS232 link to module front panel

>> Sentry monitoring Series Standard Features

- High visibility LED display with wide viewing angle
- Modular self contained conditioning units
- Completely configurable via front panel or PC based software
- Independent power supplies for increased system integrity
- Individual Intel microprocessor in each module
- Bargraph and digital display on applicable modules
- Conforms to API 670 and GDCD 96
- Compact 3U racking system
- Up to 6 independent current or voltage outputs per module
- Individual dual level alarms
- System integrity alarm
- Transducer/PSU integrity alarm
- Up to 6 alarm relays per module
- Transducer power supply
- Raw transducer signal via front panel
- BNC connectors
- Networkable serial outputs

>> Product Details

- [M08601 Dual Channel Absolute Vibration Module](#)
- [M08602 Dual Channel Relative Vibration Module](#)
- [M08603 Dual Channel Thrust/Axial Position Module](#)
- [M08604 Dual Channel Rod-Drop Module \(Recips\)](#)
- [M08605 Four Channel Temperature Module](#)
- [M08606 Reverse Rotation Module](#)
- [M08607 Dual Mode Eccentricity Module](#)
- [M08608 Dual Channel Speed Module](#)
- [Sentry Overspeed - Voted System - IEC61508 SIL3](#)
- [M08609 LVDT Monitor Module](#)
- [M08610 Dual Channel Phase Marker Module](#)
- [M08611 Process Monitor Module](#)
- [M08612 Mark Space Ratio, Differential Expansion Module](#)

2) AEGIS Machine Protection Systems(Analogue Based)

- LOWCOST, HIGH INTEGRITY SIGNAL CONDITIONING

The Aegis monitoring system provides continuous monitoring without the need for operator intervention, it's 'Fit and Forget' design is ideal for machinery protection without costly false alarms.



>> Reduce Maintenance Costs and Increase Plant Productivity

MO9600 Series Monitoring System is a modular lost signal conditioning system which is primarily intended for plant Condition Monitoring functions. It is ideally suited to applications where continuous monitoring of machinery is required to prevent deteriorating condition causing expensive collateral damage and eventually complete breakdown.

Where periodic Condition Monitoring is performed by the use of off line portable data collectors MO9600 Series can provide economical, continuous protection for plant from rapidly developing faults that can occur between surveys.

>> Modular Construction

Each Monitor fits either a 19" or 10.5" standard rack with a common display module that can show the current measured level of any channel and its alarm settings.

- Monitors vibration, temperature, shaft speed, axial displacement, thrust and element bearing condition.
- Suitable for use on all types of rotating machines - motors, pumps, fans, turbines, compressors, mills etc.

>> Each Monitor Module Features

- Dual level, adjustable alarms, suitable for warning or trip functions.
- Analogue outputs for trending or recording purposes (typically 4-20mA) Isolation optional.
- System integrity alarm.
- Individual power supply 110/240v AC or 24 Vdc
- Buffered raw transducer signal presented on front panel BNC for analysis purposes

The Aegis system has been designed and extensively tested to provide effective reliable monitoring without the generation of false alarms or the need for ongoing operator intervention.

>> System Features

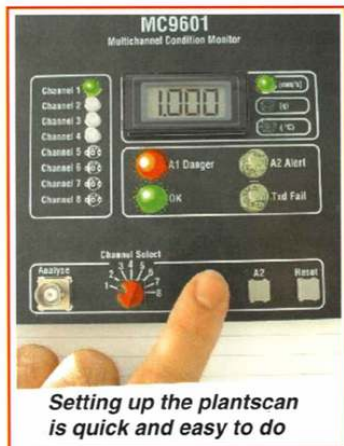
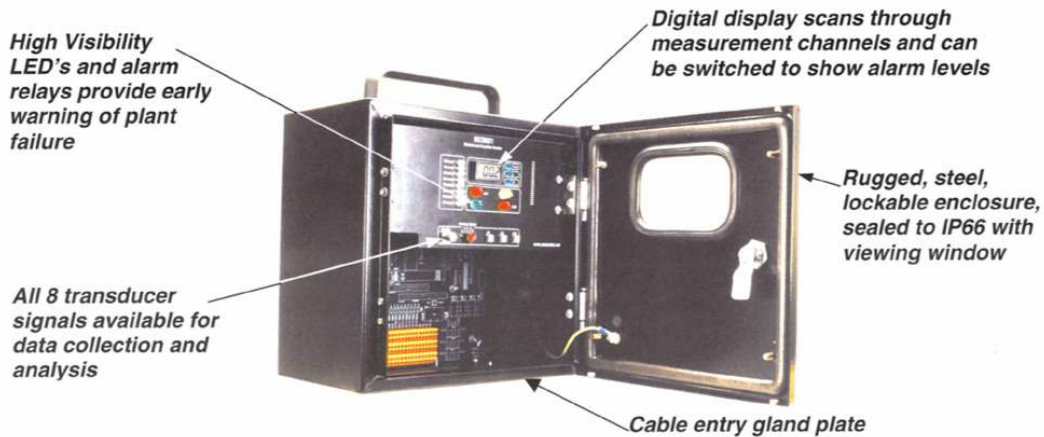
- LED high visibility numeric display
- Front panel LED annunciation of alarms
- Calibration check facility
- Alarm attenuation facility (for run-up purposes)
- Remote alarm reset facility
- Alarms can be normally open or closed, latching or non-latching with normally energised or de-energised relays.

>>Product Details

- [M09601 Vibration Monitor Module](#)
- [M09601E Eccentricity Monitor Module](#)
- [M09602 Rolling Element Bearing Monitor Module](#)
- [M09603 Thrust \(Axial Position\) Monitor Module](#)
- [M09605 Temperature Monitor Module](#)
- [M09607 Aegis Reverse Rotation Module](#)
- [M09608 Speed Monitor Module](#)
- [M09609 LVDT Monitor Module](#)
- [M09611 Process Module \(4-20mA Input\)](#)

3) Plantscan & Fan/Mill Condition Monitor

Protect rotating machinery from mechanical breakdown and reduce maintenance costs with this easy to use, effective condition monitor



- ◆ Low cost, highly effective monitoring system.
- ◆ Up to 8 channels of Vibration or Temperature monitoring.
- ◆ Provides effective round the clock protection for rotating machines from mechanical breakdown.
- ◆ Transducer signals available on BNC for data collection/analysis, manually switched through each channel.
- ◆ Backlit LCD digital display.
- ◆ Adjustable scaling for vibration & temperature ranges.
- ◆ Continuous individual analogue outputs for each channel, (current or voltage).
- ◆ Selectable vibration monitoring mode, acceleration or velocity.
- ◆ Factory set band pass filter frequencies, (12 dB/octave).
- ◆ True RMS conversion for effective monitoring.
- ◆ Two individually adjustable level alarms for each channel, with manually switched display of set level.
- ◆ Transducer integrity fail alarm and channel defeat facility.
- ◆ Local or remote reset facility.

Each monitored channel is scanned for approximately 5 seconds. A green channel identification LED illuminates to indicate which reading is currently displayed, when an alarm situation occurs this LED will become amber or red in colour depending on the level of alarm reached. The larger alarm LED situated directly beneath the display will illuminate continuously whenever an alarm condition is present on any channel. The transducer integrity alarms are shown by a green LED. Dynamic signals can be collected for analysis/trending purposes via the BNC connector on the display panel and selection the desired channel on the rotary switch.

>>Product Details

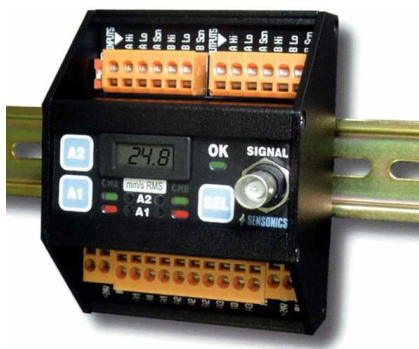
- [Plantscan 4/8 Channel Condition Monitor](#)
- [FCM/MCM-4 Channel Fan/Mill Condition Monitor](#)

4) DN2600 Series

The DN2601 is a low cost, high performance two channel vibration (or vibration and temperature) alarm monitor in a modular format ideally suited for protection of all of your rotating machinery against costly breakdown, including turbines, motors, pumps, fans, etc.

With its compact size and convenient DIN rail mounting, it can be fitted locally to the machine or remotely in equipment panels.

Machine protection is provided with the DN2601's dual adjustable alarms to automatically trip plant, or via its analogue outputs applied to SCADA, DCS or other monitoring / control systems.



- Small compact size - DIN rail mounted
- Field set, dual level alarms and relays
- Transducer/cable health check
- Monitor in acceleration or velocity
- Digital display
- 4-20mA outputs
- Accelerometer, velocity transducer or eddy current probe input
- Buffered raw signal portable data collector compatible

Specification

- Input:** 2 x accelerometer, 100mV/g sensitivity as standard (or 1 x accelerometer and 1 x temperature sensor) (Option for velocity transducer input available)
Other DIN rail monitors in the range can monitor shaft vibration, temperature, thrust, position (LVDT), speed, reverse rotation
- Power:** 24V dc (22-28V dc)
- Mode:** Factory set to monitor acceleration or velocity
- Display:** 3 digit LCD display switchable between channels and alarm setpoints. Display in engineering units (mm/s or Inch/s)
- Outputs:** 2 x 4-20mA proportional to vibration level (1 per channel)
- Scaling:** Full scale of current outputs are selectable on site, from a standard list by the positioning of onboard switches
- Signal:** Buffered raw transducer signal available on BNC connector for analysis purposes
- Alarms:** 2 x individually adjustable level alarms (2 per channel)
Relays: 2 relays common to both channels, 1 for Alert (A1) and 1 for Danger (A2)
- Filters:** High and low pass filters are selectable on site, from a standard list, by the positioning of onboard switches

>>Product Details

- [DN2601 Dual Channel Vibration Monitor](#)
- [DN2602 Dual Channel Vibration Monitor](#)
- [DN2603 Single Channel Thrust Monitor](#)
- [DN2604 Dual Channel Vibration & Temperature](#)
- [DN2605 Dual Channel Temperature](#)
- [DN2608 Speed Monitor](#)

7. ME9601 Vibration Monitoring Enclosure

The ME9601 Vibration Monitor has been designed to provide high integrity, cost effective protection for rotating machinery of all types including turbines, motors, fans and compressors etc.

It is ideally suited to applications where constant surveillance is required to protect machinery against sudden deterioration in condition and avoid costly breakdowns.

The monitor uses only the highest quality components and has been extensively type tested to ensure monitoring and prevent spurious alarms.

The monitor is housed in an IP66 wall mounted enclosure. The level of the channel is brought up on the internal display in engineering units, by depressing the 'level' button after initial system power-up. Alarm levels are displayed by pressing and holding the A1 or A2 buttons.

The monitor has its own PSU for increased system integrity, an internal BNC presenting the transducer buffered raw signal and a calibration check facility.



ME9601

Three off volt free change over relays are provided, A1 and A2 level alarms, and A3 transducer/PSU integrity.

The status of A1 and A2 are indicated on the display panel by red LED's illuminating when the alarms are initiated. The A3 alarm is annunciated by a normally lit green LED in the display panel, the transducer/PSU integrity alarm is able to inhibit A1 and A2 relays when in the Alarm State. A time delay of up to 5 seconds can be applied to alarms and is strongly recommended when the unit is used for trip purposes.

The monitoring mode, (A,V or D and peak or RMS) scaling and filters can be field set by the positioning of on board switches.

One current and one voltage output are available for recording/analysis purposes at the terminal blocks on the display panel.

Other parameters can be measured with monitors from the same series:-

ME9601 - Vibration Monitor

ME9602 - Rolling Element Monitor

ME9603 - Thrust/Axial Position Monitor

ME9608 - Rotational Speed Monitor

ME9609 - LVDT Displacement Monitor

8. Portable Vibration Meter

New portable meter makes vibration monitoring easy



Sensonics has introduced Vib-check, a new pocket-size, battery operated vibration meter complete with a hand-held accelerometer probe for the monitoring of virtually all rotating machinery such as fans, centrifuges, motors, pumps and conveyors.

With a competitive price for the complete kit, Vib-Check is easy use and is ideal as an entry level instrument. With its simple three button controls, it requires no complicated training in its use, and can be effectively used by any maintenance facilities personnel.

It meets vibration management routines in accordance with ISO2372, and its portability encourages regular monitoring of vibration levels on machinery around the factory. This increases the likelihood of a successful condition monitoring programme being maintained.

Vib-Check measures vibration as acceleration from 0 to 20g, or velocity from 0 to 50 mm/S (True RMS) by selection of the tactile switches, with level gauges displayed on the 3 1/2 digital LCD readout. Its frequency range covers 10 Hz to 1 kHz and accuracy is 0.1 mm/S.

The unit also has a built-in accelerometer checking facility and is powered by a standard PP3 9V battery with a typical life of 30 to 50 hours.

The complete kit includes the meter, a hand-held probe with spike, interconnecting cable, carrying case and a guide to vibration monitoring.

Options include: Cable - Coiled, armoured and different lengths.

Spike - different lengths of 25, 100 and 200mm.

Adaptors/Studs - threaded or bondable, Quicklok or magnetic mounts.

9. Seismic Monitoring Systems

Sensonics manufactures a range of devices for the measurement and monitoring of seismic activity in the vicinity of industrial or civil installations.



Seismic Switches

SA-3 Safety Seismic Switch

SP4 Seismic Accelerometer

Digital Seismometers

Recording and Relay Systems

Alarm Voting Systems

Sensonics is an approved supplier to the UK power industry with systems in use at all of its nuclear power plants

Seismic Brochure

Seismic General Application Note

Seismic Nuclear Application Note

Seismic Reference Sites

Seismic Shortform

10. Spyder-Remote Monitoring



Spydervision From Sensorics

The complete DN36 family is line stackable to ensure rapid system integration/installation and minimal wiring requirements and can be connected to any Ethernet network to provide remote monitoring via standard internet tools.

DIN rail mounting to either 35mm or G type DIN rails, ensures that monitors can be mounted in panels with other equipment or positioned locally in a junction box to the machine to be monitored.

Suitable for monitoring many types of rotating machinery, including turbines, motors, pumps and fans etc., the complete DN36 Series offers dual channel monitoring, providing 'mix and match' measurement options such as vibration, displacement, temperature, speed, eccentricity etc. across both channels.

Measurement function on all units is factory set by fitting personality cards, whilst operators can set measurement range, unit, alarm trip points and filter selection by means of the front panel software interface. Two alarm levels per channel are available to drive common relays for the safe tripping of plant; a system integrity alarm is also routed to a separate relay. Units can also be fitted with an optional webserver for which no additional software is required.

Capable of monitoring 8 standard ICP type or current mode accelerometers as well as 4-20mA process inputs, the new plug-in and play SpyerNet provides a cost-effective solution to remote monitoring of vibration or process channels.

The compact (123mm x 107mm x 51mm) unit is fitted with an integral webserver for network monitoring and easily interfaces with the rest of the Sensorics DN36 and existing DN2600 monitors.

11. Beran (Condition Monitoring System)

ROTATING PLANT MONITOR

Condition Monitoring Systems

BERAN
INSTRUMENTS

Reference

❖ SENSONICS customer reference list with details-TSE/VME

No.	Project	End-User	Country	Scope	Year of Supply
1	Al Mussaib Power Station	Al Mussaib Power Plant	Iraq	Turbine Instruments and Monitoring. Eccentricity, Differential Expansion, Thrust, Rotational Speed Acceleration, Displacement	2005
2	Mosul Gas Turbines	General Company of Electricity Production North Region, Mosul	Iraq	Turbine Vibration Monitoring	2004
3	FWEC for Suez Gulf FD+GR+NC Fans	EDF Suez Gulf Power	Egypt	Vibration Instruments & Monitoring on FD+GR+NC Fans (Boilers 1&2)	2001
4	FWEC for Suez Gulf FD+GR+NC Fans	EDF Port Said East Power	Egypt	Vibration Instruments & Monitoring on FD+GR+NC Fans (Boilers 1&2)	2001
5	3Sets-TSE for Moni Power Station-Cyprus	Electricity Authority of Cyprus-Moni Power Station	Cyprus	Turbine Instruments & Monitoring-3 Units-Vibration, Eccentricity, Speed, Differential Expansion, Casing Expansion	1999/2000
6	TSE Replacement Units 1,2,3 & 4	EDF Energy-West Burton Power Station	UK	Turbine Instruments & Monitoring-4 Turbines-Vibration, Eccentricity, Thrust & Speed	2002, 03, 04, 05
7	Replacement of TSE on Unit 8	ENE Malta-Marsa Power Station	Malta	Turbine Instrumentation & Monitoring-Vibration, Eccentricity, Thrust, Speed & Differential Expansion.	2004
8	VMS	Shanxi Lujin Wanqu Power Generation Co. Ltd - Shanxi Wanqu Thermal Power Plant	China	Turbine Instruments & Monitoring-Vibration Differential Expansion, Eccentricity & Thrust on 3x600MW Units	2005
9	TSE Upgrade	RWE Npower PLC - Tilbury Power Station	UK	Turbine Instruments & Monitoring-Vibration, Differential Expansion, Thrust, Speed, Eccentricity, Expansion-Displacement	2004, 05, 06
10	Production Line VME	Khash Cement Company	Iran	16 Channels of Vibration Instruments & Monitoring Cement Mill Bearings & Various Fans	2003
11	Vibration Monitoring-Centrifugal & Batch-In Cane Sugar Factory	Sugar Cane & By-Products Development Co.	Iran	50 Channels of Vibration instruments & Monitoring-Centrifugal & Batch-In Cane Sugar Factory	2003
12	Condition Monitoring at Fuel Pumping Stations-Vibration & Temperature Monitoring	BPA (British Pipeline Authority) - Various Fuel Pumping Stations Across the UK	UK	In Excess of 100 Channels of Vibration & Temperature Monitoring on Fuel Pumping Stations Across a Countrywide Pipeline Network.	1997, 2001, 02, 03, 04
13	Condition Monitoring at Fuel Pumping Stations-Vibration & Temperature Monitoring	OPA (Oil Pipelines Agency) -Various Fuel Pumping Stations Supplying the Airports & Power Stations Across the UK	UK	In Excess of 100 Channels of Vibration & Temperature Monitoring on Fuel Pumping Stations Across a Countrywide Pipeline Network.	2001, 02, 03, 04, 05

❖ Equipment site references

❖ Sentry Equipment Site References

In the home (U.K) market SENSONICS has supplied Sentry systems to around 40% of the available market. The project scope is typically turnkey with SENSONICS providing design expertise for custom measurements, equipment supply, installation and commissioning- all supported by a full documentation package. A selection of reference sites are detailed below, the majority of which are continually supported through maintenance and calibrations during outage periods.

❖ British Energy - Torness Nuclear Power Station, Scotland 1999-2000

Supply of Turbine Supervisory equipment installed on two 660MW turbine sets.

- Pedestal bearing vibration32 channels
- Thrust8 channels
- Differential Expansion12 channels
- Speed4 channels
- Reverse Rotation4 channels

Overspeed protection system for Main Boiler Feed Pumps incorporated 2 of 4 voting.

- Speed16 channels
- Voting Racks4 systems

❖ BNFL Magnox Electric - Wylfa Nuclear Power Station, Wales 2000-2005

Supply, Installation and Commissioning of Turbine Supervisory equipment (2 x 500MW) and Gas Circulator monitoring and protection equipment.

- Valve position monitoring 4 systems (utilising SENSONICS LVDTs)
- Pedestal bearing vibration 56 channels
- Speed 4 channels
- Eccentricity 8 channels

Supply, Installation and Commissioning of Blade Loss Monitoring system comprising of :

- Bearing Vibration Monitoring 24 channels
- Shaft eccentricity 24 channels
- Seismically Qualified Cubicle 8 units

❖ RWE Npower - Littlebrook power station, England, 2002-2006

Overspeed protection system for Main Boiler Feed Pumps incorporated 2 of 4 voting.

- Speed 8 channels
- Voting Racks 2 systems

Supply, Installation and Commissioning of Turbine & MBFP Supervisory equipment(2 x 660MW) for Unit 1&2 Comprising the following.

- Eccentricity 6 channels (Dual Mode Technique)
- LP Differential Expansion 2 channels (Tapered Collar)
- HP, IP Differential Expansion 2 channels (Thrust utilising 25mm range proximity)
- Casing Expansion 4 channels (Utilising SENSONICS LVDTs)
- Speed 3 channels
- Reverse Rotation 1 channel
- Process outputs Various for Load & Frequency parameters

❖ **Drax Power - Drax Power Station, England - 2002**

Overspeed protection system for Main Boiler Feed Pumps incorporated 2 of 3 voting.
Supply, Installation and Commissioning on 6 units (6 x 660MW)

- Speed 18 channels
- Voting Racks 6 systems
- Protected PSU 6 systems
- Calibration Racks 6 systems (with overspeed test capability)

❖ **Eon – Ratcliffe-on-Soar Power Station, England, 2002-2004**

Supply, Installation and Commissioning of Turbine Supervisory equipment for 4 Units, comprising the following.

- Shaft Eccentricity 8 channels (Dual Mode Technique)
- Differential Expansion 24 channels (Mark – Space Technique)
- Casing Expansion 16 channels (Utilising SENSONICS LVDTs)
- Speed 4 channel with repeaters

❖ **Corus – Redcar Steel Works Power Station, England, 2002**

Supply, Installation and Commissioning of Turbine Supervisory equipment for 4 Units, comprising the following.

- Bearing Case Vibration 28 channels
- Shaft Eccentricity 4 channels
- Bearing Temperature 32 channels

❖ **EDF Energy – West Burton Power Station, England, 2002-2005**

Supply, Installation and Commissioning of Turbine Supervisory equipment for 4 x 500MW Units, comprising the following.

- Pedestal Bearing Vibration 64 channels (Utilising SENSONICS Velometers)
- Eccentricity 8 channels (Dual Mode Technique)
- Thrust Wear 8 channels
- Speed 4 channels
- Custom Built Cubicle 4 units

❖ **Enemalta Corporation – Marsa Power Station, Malta, 2004**

Supply, Installation and Commissioning of Turbine Supervisory equipment for Unit 8, comprising the following.

- Pedestal Bearing Vibration 7 channels
- HP Eccentricity 1 channels (Dual Mode Tehnique)
- HP/LP Differential Expansion 2 channels (Mark-Space Technique)
- HP Shaft Position 2 channels
- Speed 2 channels
- Dual redundant PSU 1 unit

❖ **Eon – Kingsnorth Power Station, England, 2004-2005**

Supply, Installation and Commissioning of Turbine Supervisory equipment and High Vibration Protection System rated to SIL-2(on 3 of 4 units, final unit 2006) consisting of

- Pedestal bearing vibration 51 channels
- TMR Customised Voting rack 3 systems
- Dual redundant power supply 3 systems

❖ Mitsui Babcock – Wangqu power plant, China, 2005

Supply of Vibration Monitoring and Protection Equipment ID, PA & FD Fans and Coal Mills.

- Pedestal Bearing Vibration 24 channels
- Shaft Vibration 60 channels
- Driver / LJB Housing 24 units (wired and glanded)
- Custom Built Cubicle 4 units (with heaters, dual isolators, relay expansion)

❖ NTPC – Korba & Vindhyachal, India, 2005-2007

Supply of Vibration Monitoring and Protection systems for Main Turbine, PA & FD Fans.

- Pedestal Bearing Vibration 28 units

❖ RWE Npower – Tilbury Power Station, England, 2003-2007

Supply, Installation and Commissioning of Turbine Supervisory equipment for Units 8, 9 and 10, comprising the following.

- Pedestal Bearing Vibration 52 channels
- Eccentricity 12 channels (Dual Mode Technique)
- Differential Expansion 12 channels (Mark-Space Technique)
- Casing Expansion 28 channels (Utilising SENSONICS LVDTs)
- Speed 4 channels

Overspeed protection system for Main Boiler Feed Pumps incorporated 2 of 3 voting.

- Speed 12 channels
- Voting Racks 4 systems

❖ GT References – Rolls-Royce / Siemens 2005-2007

Supply of Sentry Vibration and Speed Monitoring Equipment and Transducers with customised measurement Options (i.e. Rolls-Royce averaging).

- Siemens Industrial Gas Turbines 20 channels Vibration
- Mosul Gas Turbines (Iraq) 12 channels Vibration
- Various Power Station GT sets 12 channels Vibration
- Cowes Power Station (RR Olympus) 4 overspeed systems 2 of 3 voted

❖ RWE Npower – Fawley Power Station, England, 2005-2008

Supply, Installation and Commissioning of Overspeed protection system for Main Boiler Feed Pumps incorporated 2 of 3 voting on 2 units.

- Speed 6 channels
- Voting Racks 2 systems
- Wall Mounted Cubicles 2 systems (with dual PSU, isolators, etc)

Supply, Installation and Commissioning of TSE and VME equipment for 2 x 500 MW units.

- Shaft Vibration / Eccentricity 10 channels
- Differential Expansion 10 channels (Mark-Space Technique)
- Casing Expansion 2 channels (Utilising SENSONICS LVDTs)
- Speed 2 channels

❖ **Hidroelectrica – Various Hydroelectric Power Stations, Romania, 2006-2008**

Supply of Vibration Monitoring and Protection Equipment for 24 machines across 10 different power generation sites.

- Bearing and Shaft Vibration 192 channels
- Speed and phase 24 channels
- Air Gap 4 channels

❖ **EON UK – Grain power station, England, 2009-2010**

Supply, Installation and Commissioning of 2 x 16 channel vibration monitoring systems (1 for each of 2 x oil fired 675MW steam turbines & boiler feed pumps. Equipment for both units supplied in 2009, first unit installed & commissioned in 2009, second unit to be installed in 2010. Sensonics accelerometers used.

- Pedestal Bearing Vibration32 channels

❖ **RWE Npower – Didcot A Power Station, England, 2005-2009**

Supply and Commissioning of 3 channels of mark-space type differential expansion monitors and 1 x speed/overspeed monitor for each for 4 x coal fired 500MW steam turbines (HP/IP/LP). Sensonics Senturion eddy current probes used.

- Differential Expansion12 channels (Mark – Space Technique)
- Speed/Overspeed4 channels

❖ **CESC-Titagarh Generating Station, India, 2008-2009**

Supply and Commissioning of 2 channels of mark-space type differential expansion monitors for HP & LP on each of 2 x 60MW steam turbines. Unit 4 installed & commissioned in 2009 by Sensonics, the equipment for Unit 1 was installed a few months later by the station. Sensonics Senturion eddy current probes used.

- Differential Expansion4 channels (Mark – Space Technique)

❖ **RWE Npower – Engineering Department, Electron Building, Swindon, England 2007-09**

Supply of 3 x 6 channel portable LVDT displacement monitoring systems for temporary installation as an engineering service to monitor turbine casing expansion/pedestal movement. Supplied with Sensonics SB type LVDT's.

- Casing Expansion/Pedestal Movement 18 channels

❖ **Euphrate Contract – Power Plant, Iraq, 2007**

Supply of 4 x 3 channel vibration monitoring systems, each system to monitor 3 x boiler water feed pumps (12 in total).

- Casing Vibration12 channels

❖ Jersey Electricity Co. Ltd – La Collette Power Station, Jersey, 2005-2006

Supply & commissioning of additional monitoring system for Parsons 45MW oil fired steam turbine, consisting of 2 channels of relative shaft vibration, 2 channels of mark-space type differential expansion monitoring and a voted 2 out of 3 speed monitoring and overspeed protection system. Supplied through system packager Turbine Controls Ltd.

- Differential Expansion..... 2 channels (Mark – Space Technique)
- Relative Shaft Vibration..... 2 channels
- Overspeed Protection 3 channels with 2 out of 3 voting

❖ Cengiz Enerji – Samsun Combined Cycle Power Plant, Turkey, 2009

Supply of 2 channel rod drop monitoring system through compressor packager Flotech Group of New Zealand. Used to track rider band wear on a GE Energy FS602 two throw rated 2400BHP, two-stage horizontal balanced opposed crosshead type compressor. Supplied with Sensonics Senturion eddy current probes with holders.

- Rod Drop Monitoring 2 channels with phase marker

❖ Uskmouth Power – Uskmouth Power Station, Wales, 2006-2009

Supply, Installation and Commissioning of Turbine Supervisory equipment, Crabbing Monitoring equipment and High Vibration Protection System for 3 x coal fired 120MW steam turbines. Supplied with Sensonics velocity transducers, eddy current probes & LVDT's.

- (HP/IP/LP). Differential Expansion 12 channels
- (HP/IP) Eccentricity 6 channels
- HP Case Expansion + Crabbing 6 channels
- Speed 3 channels
- Absolute Vibration..... 33 channels



Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2008

This is to certify that:

Sensonics Limited
Northbridge Road
Berkhamsted
HP4 1EF
United Kingdom

Hold's Certificate No: **FM 26920**

and operates a Quality Management System which complies with the requirements of ISO 9001:2008 for the following scope:

The design, manufacture, maintenance, management of installation and commissioning of electronic systems for machine monitoring and protection, including the supply of acceleration, velocity and displacement transducers.

For and on behalf of BSI:

Managing Director, BSI Management Systems (UK)

Originally registered: **12/01/1994**

Latest Issue: **14/04/2009**

Expiry Date: **14/06/2012**

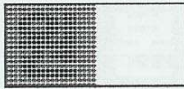


Page: 1 of 1

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BSI
Management
Systems



유자격공급자 등록증

등록번호 : 200900391

상 호 : Sensonics, Ltd

공장주소 : Northbridge Road, Berkhamsted, Hertfordshire
UK Zip Code: HP4 1EF

대 표 자 : Nick Thomp

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NO	품목 코드	품 명	품질 등급	운영 분야	유효기간
1	J206	Vibration Monitoring System	T	원자력	2009.11.19~2012.11.18

2009.11.24

한국수력원자력(주)



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2009. 11. 19

No. : QA 09-587
To : Sensonics Ltd
Reference : Mr. Russell King / Managing Director
Subject : Informing of Vendor Evaluation Result

Dear Mr. Russell King

By reviewing the application of Sensonics Ltd for vendor evaluation and approval, we are pleased to inform you that Sensonics Ltd has been approved as follows :

1. Scope : Design, Manufacturing & Supplying of Vibration Sensors and Transducers (T Class)
2. Approval Duration : ~ November 19, 2012
3. Location : Northbridge Road, Berkhamsted, Hertfordshire UK HP4 1EF
4. Approved QA Manual : Rev.13, 2009.02.04

To be on the Vendor List continuously, Please submit vendor information report to the related procurement team at least 30 days before the expiration date(Nov. 19, 2012).

If there is any subsequent changes to Company name, QA Manual, Certificate, location, scope etc. those shall be informed prior to implementation on Doosan works.

If you have any questions concerned above, please do not hesitate to contact us.

Very truly yours

QA General Manager
Doosan Heavy Industries and
Construction Co., Ltd.

