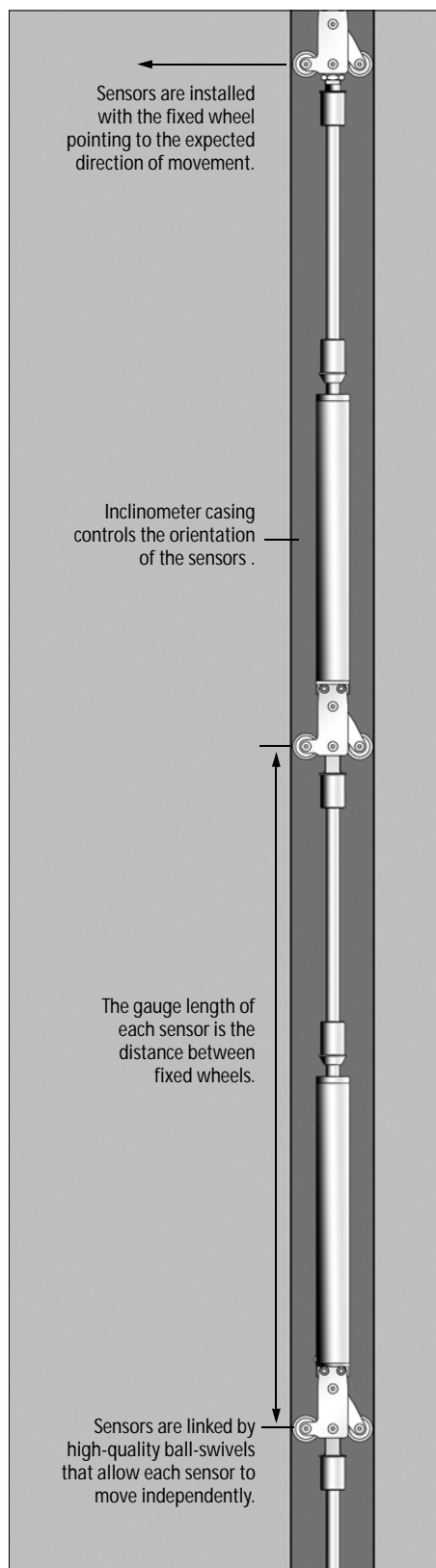


MEMS Vertical In-Place Inclinometer



Applications

The MEMS in-place inclinometer is ideal for data logging and real-time monitoring. Typical applications include:

- Monitoring deformation of the diaphragm walls that support deep excavations.
- Monitoring ground movements induced by tunnel construction.
- Monitoring deformations of embankments and retaining walls.
- Monitoring landslide areas above dams, highways, and railroads to provide early warning of slope failure.

Operation

The system consists of a number of in-place inclinometer sensors that are installed in inclinometer casing.

The casing provides access for subsurface measurements. Grooves inside the casing control the orientation of the sensors.

The casing is typically installed in a vertical borehole that passes through a suspected zone of movement into stable ground below. One set of grooves is aligned with the expected direction of movement, down hill or towards an excavation, for example.

The sensors are positioned inside the casing to span the zone of movement. When the ground moves, the casing moves with it, changing the inclination of the sensors inside.

Inclination measurements from the sensors are processed to provide the casing profile, the displacement in mm for the gauge length of each sensor, and the cumulative displacement in mm for the entire string of sensors.

In most applications, sensors are connected to a data acquisition system, and readings are transmitted to processing software that can trigger alarms based on displacements or rates of change.



Advantages

Real Time Monitoring: The in-place inclinometer is ideal for continuous, unattended monitoring and can deliver readings in near-real time.

Configurable Gauge Lengths: The use of varied gauge lengths can provide better measurements while reducing the total number of sensors needed for complete coverage. Use shorter gauge lengths to obtain detailed measurements within the zone of interest; use longer gauge lengths to monitor other zones.

Durable and Reusable: Sensors are equipped with durable wheels that make it practical to periodically remove the sensors, verify readings with a traversing probe, and then reinstall the sensors. Later, when the project is finished, the sensors can be recovered and reinstalled at another project site.

Complete Solutions: DGSI offers complete monitoring solutions that include data loggers and Atlas web-based data management software. Atlas can check for alarm conditions in near-real time and can present plotted data immediately after the readings are obtained.

SYSTEM CONFIGURATION

A complete IPI system includes inclinometer casing, IPI sensors, wheels, and gauge tubing, signal cable, a suspension kit and suspension cable, a data logger, and software to process data.

Inclinometer Casing: Choose 70 mm or 85 mm (2.75 or 3.34 in) diameter inclinometer casing.

Uniaxial or Biaxial Sensors: Uniaxial sensors measure tilt in the plane of the wheels. Biaxial sensors include a second sensor that measures tilt in the plane perpendicular to that of the wheels.

Wheels: Choose wheels to fit 70 mm casing or 85 mm. When there is only one sensor, order one bottom wheel and one top wheel. If there are n sensors in the string, order one bottom wheel, one top wheel, and $n-1$ middle wheels. For example, for a string of four sensors, order one bottom wheel, one top wheel, and three middle wheels.

Tubing for Gauge Lengths: Order gauge tubing for each sensor. Tubing is sized to make exact gauge lengths of 1, 2, or 3 m or 3, 5, or 10 feet. Custom gauge lengths can be special-ordered.

Signal Cable: Order signal cable for each sensor. The length should be sufficient to run from the location of the sensor to the location of the data logger.

Top Suspension Kit: Order one top suspension kit for each installation. The kit includes hand ring, chain, hook, cable thimbles, and clamps. Requires stainless steel cable, not included.

In-Line Suspension Kit: The in-line suspension kit is used to suspend an independent string of sensors from sensors above. This allows monitoring of two more zones of interest in the borehole. The kit includes cable thimbles and clamps. Requires stainless steel cable, not included.

Data Logger: The Slope Indicator M-Logger is specifically designed to read MEMS sensors. It can operate an AM16/32 multiplexer to read up to 16 biaxial IPI sensors. See separate datasheet.

The Campbell Scientific CR1000 data logger allows direct connection of two biaxial sensors or three uniaxial sensors. Adding a 16/32 multiplexer increases the capacity to 16 uniaxial or biaxial sensors. Up to five multiplexers can be added to the CR1000 data logger. LoggerNet software is required to retrieve data from the logger.

Data Reduction Software: Readings retrieved from the logger can be processed manually by spreadsheet or automatically by the Atlas web-based data management system.

VERTICAL IPI SENSORS

Uniaxial IPI Sensor 57804121

Biaxial IPI Sensor 57804122

Top Wheels for 70 mm Casing . . . 57805024

Middle Wheels for 70 mm Casing 57805022

Bottom Wheels for 70 mm Casing 57805026

Top Wheels for 85 mm Casing . . . 57805034

Middle Wheels for 85 mm Casing 57805032

Bottom Wheels for 85 mm Casing 57805036

Tubing for 1 m Gauge Length . . . 17804221

Tubing for 2 m Gauge Length . . . 17804222

Tubing for 3 m Gauge Length . . . 17804223

Tubing for 3 ft Gauge Length . . . 17804231

Tubing for 5 ft Gauge Length . . . 17804232

Tubing for 10 ft Gauge Length . . . 17804233

Signal Cable 50613527

SUSPENSION KITS

Top Suspension Kit 57804310

In-Line Suspension Kit 57804320

3.2mm Stainless Steel Cable 50402310

MANUAL READOUT

EL / MEMS Data Recorder 56813500

Terminal Box 57711600

Jumper Cable 56813557

The EL / MEMS Data Recorder is a manual readout that can be used to check sensors at installation time. It can also be used with a terminal box if the IPI sensors will be read manually. See separate data sheet for details.

IPI SENSOR SPECIFICATIONS

Sensor Type: Micro Electro-Mechanical Systems (MEMS) tilt sensor for tilt readings. Thermistor for temperature readings.

Requirements: Accepts power input between 7.5 to 15 Vdc. Outputs ± 2.5 volt differential signal. Biaxial version contains two tilt sensors.

Calibrated Range: ± 10 degrees.

Resolution: 9 arc seconds or 0.04 mm/m using the CR1000 data logger.

Repeatability: ± 22 arc seconds or ± 0.1 mm/m.

Calibration: 11-point calibration obtained at three temperatures from 4 to 20 °C.

Max Gauge Length: 3 meters.

Required Casing: Fits 70 or 85mm (2.75 or 3.34") diameter casing.

Housing: Stainless steel, 38 mm (1.25") diameter, waterproof to 2760 kPa (400 psi).

Signal Cable: Signal cable has seven, 22-gauge tinned-copper conductors, shield, and polyurethane jacket.

