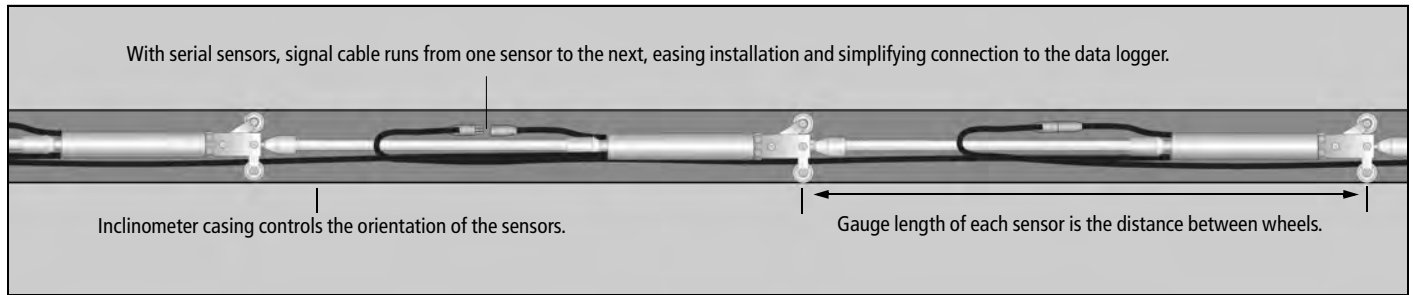


# Horizontal In-Place Inclinometer Sensors



## Applications

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

- Monitoring ground movements induced by tunnel construction and excavation.
- Monitoring stabilization measures such as compensation grouting and underpinning.
- Monitoring settlement under tanks and landfills and in embankments and dams.



## 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.

Casing is typically installed in a trench that crosses the area to be monitored. One set of grooves must be aligned to vertical, since the instrument is expected to monitor vertical movements (settlement or heave).

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.

**Single Cable Installation:** Serial sensors are supplied with cable to connect to the sensor above and the sensor below, effectively reducing the number of signal cables to one. This eases installation and simplifies connections to the data logger.

**Configurable Gauge Lengths:** The use of varied gauge lengths can provide better measurements while reducing the total number of sensors needed for complete coverage.

**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 monitoring software. Atlas can check for alarm conditions in near-real time and can present plotted data immediately after the readings are obtained.

**SERIAL SYSTEM CONFIGURATION**

A serial IPI system includes inclinometer casing, serial sensors with wheels and gauge tubes, placement accessories, and jumper cable. A data logger is normally used to collect the data and software such as Atlas is used to process the data.

**Inclinometer Casing:** Choose 70 or 85 mm (2.75 or 3.34") inclinometer casing. The 85 mm size is preferred.

**Serial Sensor:** Horizontal IPI sensors have a uniaxial sensor that is oriented to measure tilt in the plane of the wheels.

**Wheels:** Choose wheels to fit 70 or 85 mm inclinometer casing. Order sensor wheels for each sensor. Order one horizontal top wheel for each chain of sensors. Top wheel can be omitted if gauge tube of top sensor is held directly by a tubing clamp at the top of the casing.

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

**Signal Cable:** Serial sensors include signal cable sufficient for gauge lengths up to 3m. Cables have connectors that allow them to be joined into a bus. A bottom plug is required for the bottom of the bus. A jumper cable connects the top of the bus to a data logger.

**Placement Accessories:** Order one tubing clamp for each installation. Tubing clamp replaced top wheel if it holds gauge tube of top sensor directly. If top sensor is deeper into the casing, then order a placement tube and a top wheel. Placement tube is supplied in 3m lengths. Order a coupling to create longer lengths.

**Data Logger:** The Slope Indicator M-Logger is specifically designed to read MEMS sensors. It can operate a single chain of up to 16 serial sensors. The M-Logger can also be used to verify proper operation of the sensors before they are installed.

The Campbell Scientific CR1000 data logger allows connection of up to 6 chains of serial sensors, and the Campbell Scientific CR800 data logger allows direct connection of up to 3 chains of serial sensors. LoggerNet software will be 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.

**SERIAL IPI SENSORS**

Horizontal Serial IPI Sensor . . . . 57804623L

Sensor Wheels for 70 mm Casing. 57805122  
Horizontal Top Wheel, 70 mm . . . 57805021

Sensor Wheels for 85 mm Casing. 57805132  
Horizontal Top Wheel, 85 mm . . . 57805031

Tubing for 1 m Gauge Length. . . . 57805221  
Tubing for 2 m Gauge Length. . . . 57805222  
Tubing for 3 m Gauge Length. . . . 57805223  
Tubing for Custom Length . . . . . 57805240

Bottom Plug. . . . . 57804510  
Jumper Cable, 25m. . . . . 56804525  
Splice Kit . . . . . 50612515

**STANDARD IPI SENSORS**

Horizontal IPI Sensor . . . . . 57804123  
Signal Cable . . . . . 50613527

A standard IPI system requires inclinometer casing, standard sensors with wheels, gauge tubes, and signal cable for each sensor, and placement accessories.

Specify the cable length for each sensor: the distance between intended location of the sensor and the data logger.

Wheels, tubing, and placement accessories are the same as those used with serial sensors.

**PLACEMENT ACCESSORIES**

Tubing Clamp, 85 mm Casing . . . . 57805255  
Tubing Clamp, 70 mm Casing . . . . 57805252  
Placement Tube, 3 m Length . . . . 57804240  
Coupling for Placement Tube . . . . 57804245

**IPI SENSOR SPECIFICATIONS**

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

**Requirements:** Accepts power input between 8 to 15 Vdc. Outputs ±2.5 volt differential signal.

**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.

**Signal Cable:** Signal cable has seven 22-gauge shielded conductors encased within a polyurethane jacket. Signal cable supplied with serial sensors include waterproof connectors rated to 70 MPa (10,000 psi). Signal cable for standard sensors is ordered to specific lengths and does not use connectors.

**NOMINAL LIMITS FOR IPI CHAINS**

Jumper Cable Length (meters)	Number of Sensors	M-Logger	CR800	CR1000
40	50		✓	✓
75	43		✓	✓
115	37		✓	✓
150	32		✓	✓
190	27		✓	✓
225	23		✓	✓
265	19		✓	✓
300	16	✓	✓	✓
340	13	✓	✓	✓
375	10	✓	✓	✓