**GEOSTRING - In Place MEMS Inclinometer**

**Description**

The GEOSTRING inclinometer system is an array of closely spaced MEMS sensors used with a data-logger. It is ideal for real time continuous and unattended monitoring of lateral displacement of soil, rock, and structures.

The GEOSTRING array consists of a number of sensor nodes installed vertically in either 70mm (2.75 inch) diameter inclinometer casing or in 38mm (1.5-inch) diameter Schedule 40 PVC pipe.

The casing or pipe provides access for subsurface measurements. The joints between nodes are strong and stable, allowing the array to maintain consistent orientation of all the nodes, regardless of installation type.

The pipe or casing is typically installed in a vertical borehole that passes through a suspected zone of movement. The nodes are spaced at 0.61 m (2 ft) intervals and provide a reading resolution similar to a traversing probe. The array spans the zone of movement. If movement occurs, the casing/pipe moves, changing the inclination of the nodes inside.

Inclination measurements from the nodes are processed to provide graphs of the casing profile and changes in the profile. Changes indicate displacement (movement).

The GEOSTRING system is an array connected to a SENSLOG data acquisition system. Readings are transmitted to processing software that can trigger alarms based on displacements or rates of change.

Nodes, cables, connectors and gauge rods are exceptionally robust, allowing easy removal of an array at the end of the project and deployment on other projects.

GEOSTRING segments have joints capable of bending to 90°, allowing for compact shipping.

**Key Features**

- Easy installation
- Real-time monitoring
- Single cable installation
- Interconnected nodes
- Pre-loaded calibration factor in each node
- Sensorless (dummy) nodes available
- Ultra-robust components
- Long-term reliability
- Cost effective
- Retrievable, reusable

**Applications**

- Slope stability, early warning of slope failure.
- Performance of dams and embankments
- Ground movements due to tunneling
- Deflection of laterally loaded piles
- Deformations of retaining walls.
- Monitoring landslide areas

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A typical system requires casings, GEOSTRING segments, a suspension kit, a bottom plug, a jumper cable, and a datalogger.

**Casing**

Select either the 70 mm (2.75 in) diameter inclinometer casing or the 38 mm (1.5 in) diameter Schedule 40 PVC pipe. When ordering your GEOSTRING System, it is very important to indicate the type of installation in order that proper centralizers will be included on the array.

**GEOSTRING Standard Segment 3.048 m (10 ft), 5 nodes**

A Standard GEOSTRING array consists of 3.048 m (10 ft) segments. Segments can be installed in any sequence, since the calibration of each node is embedded in the sensor and read by the data logger.

Each segment has a male connector at the upper end and a female connector at the lower end. The lower end can be recognized by the presence of a centralizer and a universal joint, as seen in the picture on the right.

**GEOSTRING Custom Segments, 1 to 4 nodes**

GEOSTRING custom segments can be manufactured in shorter lengths of 0.608 m (2 ft), 1.219 m (4 ft), 1.828 m (6 ft) and 2.438 m (8 ft) length (with 1, 2, 3 or 4 nodes, respectively). Custom segments allow the flexibility to adjust the array to the depth of your boreholes.

**GEOSTRING Sensorless Dummy Segments**

GEOSTRING sensorless (dummy) segments are available in 0.609 m (2 ft) and 1.524 m (5 ft) for installation at any place within the array, allowing designers to optimize their system by only monitoring the zone of interest. A custom patchcord is required if the dummy portion occurs between monitored sections of the array. Separate jumper cables are another option for the monitored sections.

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**GEOSTRING - In Place MEMS Inclinometer**

**GEOSTRING Signal Cable**
To install the signal cable, attach the bottom plug to the female connector on the first segment of the array to be placed in the casing. Insert the bottom end of the first segment, plug first, into the casing.

**GEOSTRING Bottom Plug**
One bottom plug is required for the end of each array. The bottom plug has a male connector on one end and is used to protect the last node from water ingress via the connector.

**GEOSTRING Jumper Cable**
A jumper cable connects the top of each array to the data logger. The jumper cable has a female connector on one end and exposed, inner-conductor wires on the other for connection to the data logger.

**GEOSTRING Suspension Kit**
One suspension kit is required for each array. The kit includes the suspension gate and hardware for securing the array to the casing or pipe.

**Data Logger**
The GEOSTRING system is connected to a Senslog data acquisition system and readings are transmitted to a processing software that can trigger alarms based on displacement or rate of change.

A variety of Campbell Scientific data loggers can be integrated in a Roctest Senslog for GEOSTRING systems. Two GEOSTRING arrays can be connected to each CR6 or CR1000X. Incorporating an MD485 per GEOSTRING array, the CR1000 can read five arrays, the CR800 three arrays and the CR300 one array.


**Data Retriever**
The GEOSTRING array outputs the displacement as engineering units, requiring less computing power and a lighter load on your data acquisition system. The nodes are preloaded with the calibration information, allowing the segments to be installed in any order.

Readings retrieved from the logger can be processed manually by spreadsheet or automatically by third-party, web-based monitoring programs.

**Nominal Jumper Cable Limits for an Array of Nodes**

<table>
<thead>
<tr>
<th>Number of Nodes</th>
<th>Max Jumper Length (m) 12V Supply</th>
<th>Max Jumper Length (m) 24V Supply</th>
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<tr>
<td>200</td>
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**Easy Shipping**
GEOSTRING segments have joints capable of bending to 90°, allowing for compact packaging.

Five segments, each 3.048 m (10 ft) long can be shipped in a box measuring approximately 64 x 64 x 64 cm (26 x 26 x 26 in) which weighs less than 22 kilograms (50 pounds).

The arrays can be shipped via standard overnight service due to their compact size.

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Specifications

Sensor type: MEMS (Micro Electro-Mechanical Systems) tilt sensors for inclination readings
Thermistor for temperature readings

Calibrated Range: ±30 degrees from vertical over a temperature range of -10°C to +40°C

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

Repeatability: ±±2 arc seconds or ±0.4 mm/m

Power requirements: Minimum supply voltage of 10 Vdc. Maximum supply voltage of 30 Vdc. Digital RS485 signal requires Campbell Scientific data logger

Housing: Stainless steel, 32 mm diameter, waterproof to 2 MPa

Weight: 0.54 kg per 0.6m (1.2 lb per 2 feet) gauge length

Waterproof: Waterproof to 2 MPa (300 psi)

Signal Cable: Jumper Cable for connecting the system to the datalogger. Connectors are rated to 70 MPa (10,000 psi)

Casing: 70 mm (2.75 in) diameter casing
38 mm (1.5 in) Schedule 40 PVC Pipe

Data Logger: Compatible with CR6, CR300, CR800, CR1000 & CR1000X Data Loggers
MD485 RS-485 Interface required for CR300, CR800 & CR1000 Data Loggers

Ordering Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Length (m)</th>
<th>Length (ft)</th>
<th>Inclinometer Casing System</th>
<th>Schedule 40 PVC Pipe System</th>
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<td><strong>GEOSTRING Standard Segment</strong></td>
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Smartec SA reserves the right to make any changes in the specifications without prior notice