

## MODEL 6140



Model 6140 Vertical IPI String

### APPLICATIONS

The remote, continuous, and automatic monitoring of:

- Lateral deformation in dams and tailings
- The stability of natural slopes, landslides, embankments, and subsea marine sediments
- The stability of slurry walls, sheet piling and tieback walls
- Lateral movements in, around and above tunnels and underground openings

### OPERATING PRINCIPLE

The basic principle of operation is the utilization of MEMS (Micro-Electro-Mechanical Systems) tilt sensors to make accurate measurements of inclination over segments of an inclinometer casing.

The Model 6140 Vertical IPI String consists of a string of Biaxial MEMS tilt sensors, installed in rugged engineered polymer housings. One spring-loaded wheel and two fixed wheels, allow the string to positively engage the grooves of conventional inclinometer casing<sup>1</sup> maintaining

azimuth with depth. The entire string is held in tension by attaching a suspension weight from the bottom-most sensor and hanging the string from the top of the casing using a suspension cable and support bracket.

Sensors in the inclinometer string are mechanically connected with high-strength aircraft cable assemblies, which are free to pivot about the connection point. Sensors are electrically connected via a common bus cable, while the top-most sensor includes a waterproof connector

that allows for easy assembly to the chosen readout device (PC, datalogger, SCADA system, etc.) through a customer-specified readout cable.

Each sensor outputs calibrated tilt (angular degrees) and temperature (degree Celsius) readings, which can be easily imported into MS Excel, or any inclinometer visualization software, without the need to convert raw data into engineering units.

<sup>1</sup>Fits into 70 mm and 85 mm casing

### ADVANTAGES

The Model 6140 Vertical IPI String takes the benefits of MEMS technology (wide angular range, high sensitivity, excellent long-term stability) and integrates it into a robust system that requires minimal assembly and is easy to install.

With high spatial resolution (0.5 m or 2 ft.), the device is capable of measuring extreme lateral movements. Additionally, the flexible nature of the product allows for installations into deformed casings where traditional IPI systems could not be deployed.

The Vertical IPI String is light and compact, making it the ideal choice for remote and difficult to access monitoring locations. The product is fully field-serviceable and the string length can be easily extended or shortened on-site.

### DATA ACQUISITION

The Model 6140 Vertical IPI String uses industry standard Modbus<sup>®</sup> Remote Terminal Unit (RTU) protocol to communicate. It employs an RS-485 (half duplex) electrical interface, recognized for its prevalence,

simplicity, and success as a robust, industrial physical layer.

Monitoring can be accomplished using GeoNet Addressable Loggers, the Model 8020-38 Addressable Bus

Converter, Model 8600 Series Dataloggers, Campbell Scientific Dataloggers, or any other device capable of operating as a Modbus RTU client and having an RS-485 port.

TECHNICAL SPECIFICATIONS			
Range <sup>1</sup>	±90°	Maximum String Length	250 m (1,000 ft.)
Resolution <sup>2</sup>	±0.00025° (±0.004 mm/m)	Standard Sensor Length	0.5 m, 2 ft
Precision <sup>3</sup>	±0.0075° (±0.13 mm/m)	Sensor Weight	0.36 kg (0.8 lb)
Nonlinearity	±0.005° across ±30° range (±0.09 mm/m)	Materials	316 Stainless Steel, Engineered Polymer
Temperature Dependent Uncertainty	±0.001°/°C across ±5° angular range (±0.016 mm/m) ±0.0016°/°C across ±15° angular range (±0.026 mm/m) ±0.0026°/°C across ±30° angular range (±0.042 mm/m)	Electrical Cable	Four Conductor, Foil shield, Polyurethane jacket, nominal OD = 7.9 mm
Operating Temperature	-40 °C to 65 °C (-40 °F to 149 °F)	Interface	RS-485
Power Supply Voltage	12 VDC (+0%/-10%) for up to 250 sensors 15 VDC (+0%/-10%) for 251-500 sensors	Protocol	MODBUS
Peak Operating Current <sup>4</sup>	20 mA ±1 mA	Baud Rate	115,200 bps
Average Operating Current <sup>4</sup>	5 mA	Acquisition Cycle Time	350mS
Standby Current <sup>4</sup>	2 mA ±0.1 mA	Temperature Accuracy	±0.5 °C
Maximum Sensors per String <sup>5</sup>	500	Ingress Protection	IP68 to 3 MPa (300 m head water)

<sup>1</sup> Calibrated Range: ±30°  
<sup>2</sup> 99% confidence interval (i.e. 99 out of 100 individual readings fall within this tolerance).  
<sup>3</sup> Includes random walk (changes between consecutive readings that have no discernible cause) and seismic noise during testing.  
<sup>4</sup> Operating and standby current are for each individual sensor in a string.  
<sup>5</sup> Dependent on datalogger used. Consult datalogger manufacturer.

### ORDERING INFORMATION

- |  |   |  |
|--|---|--|
| <p><b>6140-1:</b> Vertical IPI String Top, with Readout Cable connector</p> <p><b>6140-0.5M:</b> Vertical IPI String Middle, 0.5 m spacing</p> <p><b>6140-2FT:</b> Vertical IPI String Middle, 2 ft spacing</p> <p><b>6140-2:</b> Vertical IPI String Bottom, with Suspension Weight connector</p> <p><b>6140-3-1:</b> Suspension Cable, &lt;5 m length</p> <p><b>6140-3-2:</b> Suspension Cable, 6 to 10 m length</p> | <p><b>6140-3-3:</b> Suspension Cable, 10 to 20 m length</p> <p><b>6180-2:</b> Suspension Bracket</p> <p><b>6140-4:</b> Suspension Weight</p> <p><b>6140-5-1:</b> Vertical IPI String Connector Bottom, 0.5 m spacing, for strings with &gt;100 sensors, 1 required for every 100 sensors</p> <p><b>6140-5-2:</b> Vertical IPI String Connector Bottom, 2 ft spacing, for strings with &gt;100 sensors, 1 required per 100 sensors</p> | <p><b>6180-3-1:</b> Readout Cable, &lt;15 m length bare leads</p> <p><b>6180-3-2:</b> Readout Cable, 16 to 30 m length, bare leads</p> <p><b>6180-3V:</b> Readout Cable, &gt;30 m length, bare leads</p> <p><b>6140-6:</b> Installation tool</p> <p><i>*Each string comprises a customer-specified number of 6140 middle sensors and one of each of the following: 6140-1, 6140-2, 6140-3, 6140-4, 6180-2, 6180-3. Strings over 100 sensors require one 6150-5 for every 100 sensors</i></p> |
|--|---|--|

### COMPATIBLE READOUTS AND DATALOGGERS

- |  |   |   |
|--|---|---|
| <p><b>8600 Series:</b> Multi-Channel Dataloggers</p> <p><b>8800 and 8900 Series:</b> GeoNet Wireless Data Acquisition System</p> | <p><b>8920, 8930, 8950 Series:</b> GeoNet Cellular, Wi-Fi, and Satellite Network Logger</p> | <p><b>8940:</b> GeoNet Dataloggers</p> <p><b>8020-38:</b> Addressable Bus converter</p> |
|--|---|---|



Model 6140 Vertical IPI String

Please note: The Model 6140 is currently Patent Pending.