# VERTICAL IPI STRING

GEOKON®

**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

Model 6140-HOIST: Assists in the installation and removal of IPI strings.

## 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[1] 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. For longer, heavier IPI strings, the Model 6140-HOIST, with sturdy frame, pulley system, support cable, and cable reel, is available to help facilitate their installation and removal. (The hoist is strongly recommended for strings exceeding 100 sensors.)

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.

*[1]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® 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 Digital 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[1] | ±90° | Maximum String Length | 250 m (1,000 ft) |
| Resolution[2] | 0.00025° (0.004 mm/m) | Standard Sensor Length | 0.5 m, 2 ft |
| Precision[3] | ±0.0075° (±0.13 mm/m) | Weight, Sensor | 0.36 kg (0.8 lb) |
| Nonlinearity | ±0.005° across ±30° range (±0.09 mm/m) | Weight, Suspension Weight | 1.6 kg (3.6 lb) |
| Temperature Dependent Uncertainty | ±0.001°/°C across ±5° angular range (±0.016 mm/m)<br>±0.0016°/°C across ±15° angular range (±0.026 mm/m)<br>±0.0026°/°C across ±30° angular range (±0.042 mm/m) | Materials | 316 Stainless Steel, Engineered Polymer |
| 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<br>15 VDC (+0%/–10%) for 251-500 sensors | Protocol | MODBUS |
| Peak Operating Current[4] | 20 mA ±1 mA | Baud Rate | 115,200 bps |
| Average Operating Current[4] | 5 mA | Acquisition Cycle Time | 350mS |
| Standby Current[4] | 2 mA ±0.1 mA | Temperature Accuracy | ±0.5 °C |
| Maximum Sensors per String[5] | 500 | Ingress Protection | IP68 to 3 MPa (300 m head water) |
| Datalogger Sensor Limits | GeoNet ADR: 64<br>GeoNet DHP: 500<br>Model 8600: 500 | Electrical Cable | Four Conductor, Foil shield, Polyurethane jacket, nominal OD = 7.9 mm |

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

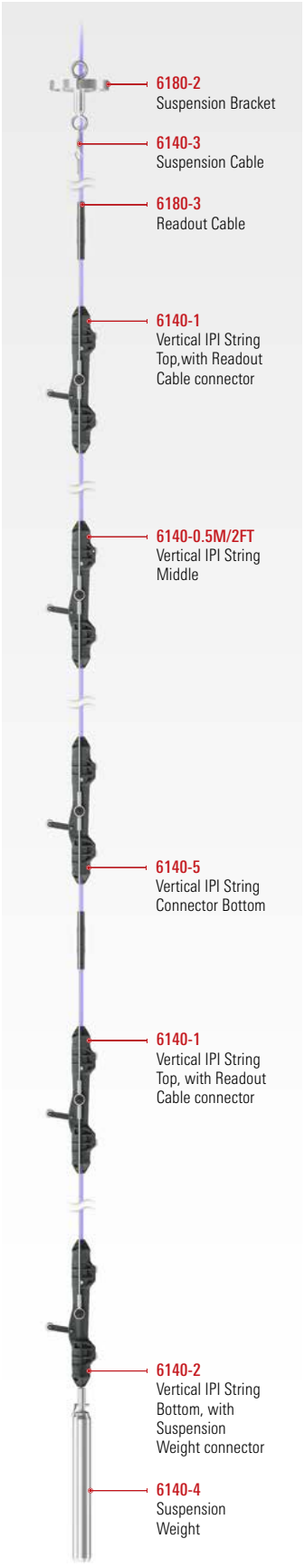
## ORDERING INFORMATION

**6140-1:** Vertical IPI String Top, with Readout Cable connector
**6140-0.5M:** Vertical IPI String Middle, 0.5 m spacing
**6140-2FT:** Vertical IPI String Middle, 2 ft spacing
**6140-2:** Vertical IPI String Bottom, with Suspension Weight connector
**6140-3-1:** Suspension Cable, <5 m length
**6140-3-2:** Suspension Cable, 5 m to 10 m length
**6140-3-3:** Suspension Cable, 10 m to 20 m length
**6140-4:** Suspension Weight
**6140-5-1:** Vertical IPI String Connector Bottom, 0.5 m spacing, for strings with >100 sensors, 1 required per 100 sensors
**6140-5-2:** Vertical IPI String Connector Bottom, 2 ft spacing, for strings with >100 sensors, 1 required per 100 sensors
**6140-6:** Sensor Hold
**6140-HOIST:** Installation/Removal Hoist
**6180-2:** Suspension Bracket
**6180-3-1:** Readout Cable, bare leads, <15 m length
**6180-3-2:** Readout Cable, bare leads, 15 m to 30 m length
**6180-3V:** Readout Cable, bare leads, >30 m length

**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 6140-5 for every 100 sensors*

## COMPATIBLE READOUTS AND DATALOGGERS

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

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***Please note:*** *The Model 6140 is currently Patent Pending.*


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**GEOKON**
48 Spencer Street
Lebanon, NH 03766 • USA

www.geokon.com
e: info@geokon.com
p: +1 · 603 · 448 · 1562

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*Not all models are CE approved. Contact GEOKON for details.*