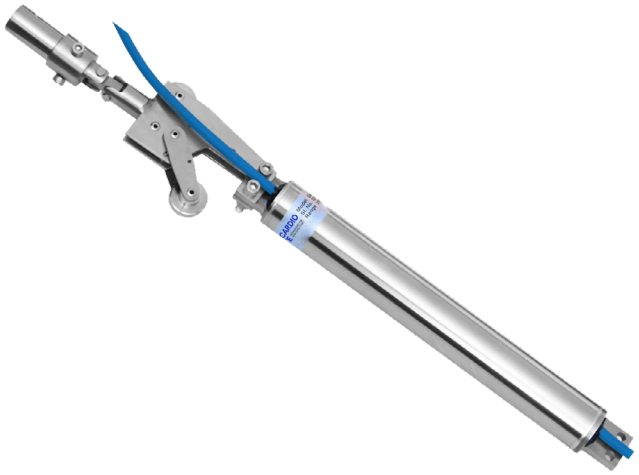
ENCARDIO RITE
METASENSING FOR MEGA STRUCTURES

DIGITAL IN-PLACE INCLINOMETER

MODEL EAN-56

DATASHEET



OVERVIEW

The EAN-56 digital in-place inclinometer system is designed to monitor lateral movement and settlement in geotechnical applications such as retaining walls, embankments or slope, dams, and tunnels. It provides precise and reliable data on ground deformation, enabling the identification of potential hazards and structural movement patterns over time.

The EAN-56 IPI system consists of a series of inclinometer access tubes installed in a borehole or embedded in earth/rock fill or concrete structures and an IPI chain positioned inside it to span the movement zone. The IPI chain consists of digital biaxial tilt sensors (SDI-12 and Modbus output) fitted with a pair of pivoted sprung wheels and connected to rigid bars (gage tube) of desired length. A single 3-conductor bus cable connects each sensor in a daisy chain to the datalogger at the top of the borehole.

When sub-soil ground displacement occurs, the inclinometer casing changes shape with ground movement, and the IPI chain (of tilt sensors) measures the deviation of the casing as a series of connected straight lines (gage length). The tilt sensor measurements i.e. the angle of inclination from the vertical is converted to lateral deviation using "L sin θ" where L is gage length, and θ is the angle of tilt from vertical. By summing readings of successive sensors, a complete profile of the access tubing is obtained. By comparing these profiles, the horizontal displacement of the gage well at different depths over a period of time may be determined.

Applications include monitoring lateral movement in embankment fills, earthworks, landslide areas, deflection in retaining and diaphragm walls, piles, and the stability of dams and tailings. The data can be transmitted in real-time to data management platforms via IoT dataloggers, providing instant alarms and early warnings to facilitate timely decisions and actions.

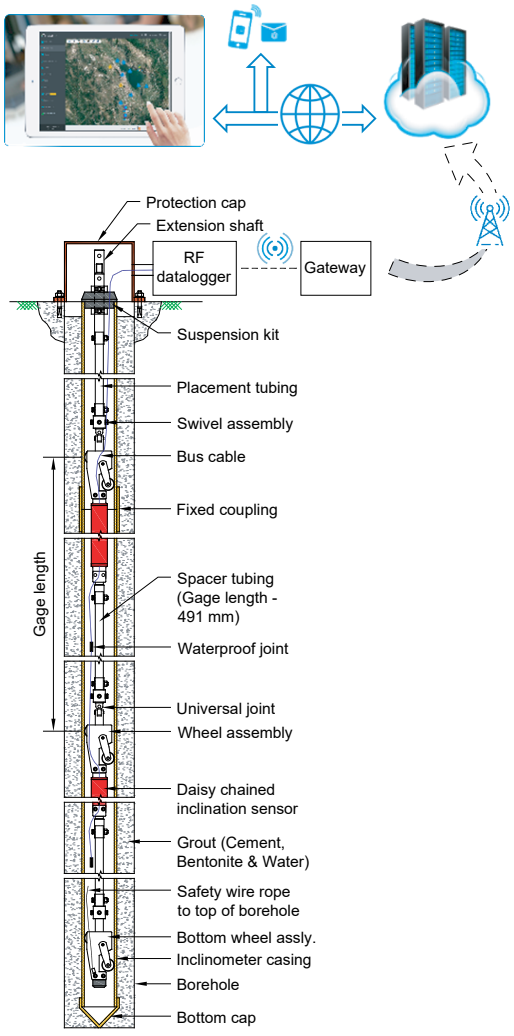
FEATURES

- **Accurate measurement:** Precisely measures lateral movement and inclination of structures based on established and reliable measurement principles.
- **Digital output:** The tilt sensors offer SDI-12 and Modbus digital outputs, ensuring compatibility with modern data acquisition systems.
- **Customizable gage length:** Gage lengths of sensors can be customized from 1 m to 3 m or 3 to 5 feet. providing flexibility for different monitoring depths.
- **Suspension wire rope option:** For monitoring specific portions of a borehole, a suspension stainless steel wire rope allows for targeted sensor placement, avoiding the need for a full borehole profile.
- **Temperature stability:** Excellent stability across a wide temperature range.
- **Ip 68 rating:** Durable and reliable design suitable for harsh environments; water-protection upto 100 mwc.
- **Modular sensor configuration:** The system consists of a series of inclinometer access tubes with connected tilt sensors, forming a flexible chain of sensors for a complete profile of ground movement.
- **Daisy-chain connectivity:** Sensors are connected in a daisy-chain configuration, enabling easy setup and efficient data transmission with a single bus cable linking all sensors to the datalogger.
- **Long-term stability:** Delivers reliable performance over extended periods, crucial for long-term structural health monitoring.

SYSTEM COMPONENTS

The Encardio Rite in-place inclinometer system includes the following sub-assemblies:

EAN-56/1	Biaxial IPI sensor with SDI-12 and Modbus (RS-485) output, with pair of wheels.
EAN-52M/2-X	Gage tube for 1 m, 1.5 m, 2 m and 3 m gage length. 'X' suffix represents gage length required.
EAN-52M/3	Wheel assembly.
EAN-52M/4	Suspension kit with protective cap.
EAN-52M/5	Placement tubing (specify length) for placing string of sensors.
EAN-52M/6	Protective rope to prevent loss of sensor down hole.
EAN-52M/7	Suspension stainless steel wire rope for positioning single or group of sensors in specific portion of borehole
CS-0703	Bus cable
Casings	For casing refer to datasheet 1918-17 on "Inclinometer casing"



EAN-56 In-place inclinometer system

SPECIFICATIONS

IPI tilt sensor	
Sensor	Digital biaxial IPI sensor
Measuring range	± 15°
Accuracy[1]	± 0.1% fs
Resolution	± 0.05 mm/m (8 arc seconds)
Output	Modbus (RS-485)
Temperature range	-20°C to 80°C

[1] *As tested under lab conditions*

Datalogger (NexaWave Digilog)	
Input	Sensor with digital output
Scan/upload interval	5 seconds to 168 hours
Memory capacity	Flash Memory (64-Mbit); 2 Million data points
Communication port	RS-232 (Standard) 115 kbps
Temperature limit	-30 to 70°C
Power supply	2 x D size 3.6 V/19 Ah Lithium cells, or 2 x D size 1.5 V Alkaline high power cells, or 2 x D size 1.5 V Alkaline high power cells, or 12V SMF battery chargeable from AC mains or solar panel
Antenna	Built-in or separately mounted antenna
Housing	Corrosion resistant weather proof enclosure

Modbus Output

When used with Modbus output, a maximum of 32 sensors can be used in an IPI chain and maximum distance of datalogger from the IPI location can be 1.2 km. Any suitable Modbus datalogger can be used.

NexaWave Digilog can also be used with an additional Modbus card, if specifically ordered. However, maximum limit of Modbus IPI tilt sensors that can be connected to this NexaWave Digilog version is seven.

ESSENTIAL CONSIDERATIONS

Manual readings:

Before installing the IPI chain, take initial x-y profile of inclinometer casing with Encardio-rite model EAN-26M manual inclinometer system. The inclinometer probe gives true x-y profile of borewell with a gage length of 0.5 m. In case any abnormal movement is observed later on from the installed IPI chain, the borehole profile can be verified by removing the IPI chain and taking a fresh set of readings manually (and comparing it with the reference readings to check any abnormality).

As-built coordinates:

Determine initial Northing (X), Easting (Y) and Elevation (Z) by surveying of top of inclinometer casing after the casing is set in the borehole. Encardio Rite provides Prism target with adaptor and Settlement point on request, to facilitate this process. The data observed should be stored securely for future reference.

Gage tubes in tension state:

Ensure the IPI chain is hanging so all gage tubes are in tension. Never let the IPI chain rest on the bottom wheel assembly.

Select gage lengths judiciously:
Optimal profiling

Ensure that the entire gage length (distance between the wheel assemblies of adjacent sensors) at each sensor position remains perfectly straight. Significant deformation of the borewell (casing) over any gage length can introduce curvature, causing the sensor gage tubing to touch the inclinometer casing, and introduce a curvature in the gage tubing. This introduces errors in the sub-soil displacement profile, as the plotting assumes that each gage tubing is a perfect straight-line segment.

The diagram and table on next page shows at what deformation limit the gage tubing touches the casing and why

Deformation limits

If casing deformation exceeds the allowable range, errors will increase while plotting the displacement profile. Below are the allowable deformations for accurate results:

Gage Length L (m)	Maximum measurable angular deviation ΔA (deg)	Maximum allowed displacement over 1 m borehole length ΔA_m (deg/m)	Maximum allowed lateral movement d_{max} (mm per m)
1.0	9.6	9.6	167
1.5	6.4	4.8	111
2.0	4.8	2.4	84
3.0	3.2	1	56

These values are based on EAN-56 IPI chains in 70 mm OD, 58 mm ID inclinometer casing, assuming sub-soil movement causes a circular bend. For 85 mm OD casings, contact the factory for recommendations.

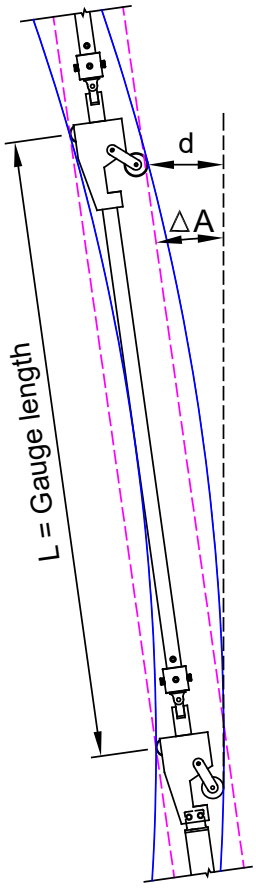
The IPI chain measures displacement at the adjacent sensor points, considering that the gage tube is in a straight line. Any localized displacement between the sensor points will therefore not be measured by the IPI chain.

Considerations

Local displacement: The IPI chain measures displacement at sensor points along a straight gage tube. Localized displacement between sensors is not captured.

Gage length optimization: Shorter gage lengths provide more reliable and accurate data. Optimize gage lengths based on site conditions and critical zones for a cost-effective system. For example, use 3 m gage lengths in stable zones and 1 m in expected slip zones of landslide areas.

Datalogger (NexaWave DigiLog)



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