



Features

- Single axis measurement, range $\pm 180^\circ$
- High resolution and accuracy
- Low temperature drift, with optional temperature compensation to further improve temperature performance.
- Single-drop RS232, RS485 or multi-drop RS485 interface with ModBus protocol
- RS232/RS485 (non-ModBus) models feature an additional user-selectable NMEA0183 format
- Tough sealed anodised aluminium housing (IP67)
- CE, RoHS and EN61326-1 (EMC) compliant
- 4 core 2m PUR cable with 4 pin M12 Connector



Description

The SOLAR-360 inclinometers are range of high performance low cost single axis tilt sensors for measurement of angle throughout the full 360° range. Through a flexible configuration and calibration program we can supply this device compensated for any specific operating temperature range. The housing is a small, low profile Aluminium housing, hermetically sealed to IP67. The cable is a shielded black PUR cable and is suitable for continuous outdoor use. They utilise a very high performance MEMS sensor which exhibits

low long term drift compared with many competitive devices. Originally designed for use in concentrating Solar Trackers, they can also be used in a wide range of other applications. It has an RS232 and RS485 interface option with our standard communication protocol as well as a version with RS485 multi drop ModBus communication protocol. They are CE and RoHS certified, and are manufactured, calibrated and tested in our UK factory to guarantee performance to the stated specification.

General Specifications

Parameter	Value	Unit	Notes
Supply Voltage	9-30	V dc	Supply is filtered, suppressed and regulated internally, however we recommend the use of a low noise supply to prevent noise coupling to the sensor.
Operating Current	30mA (@ 9V) 20mA (@ 12V) 10.5mA (@ 24V)	mA	Supply current depends on supply voltage.
Operating Temperature	-40 to 85	°C	Maximum operating temperature range. Units can be calibrated between -20 and 70°C on request.
RS232/485 Output Rate	38400	bps	Bit rate is adjustable between 115.2k, 57.6k, 38.4k, 19.2k, 9.6k, 4.8k and 2.4k via the digital interface
RS232 Data Format	38.4, 8,1,N		1 start bit, 8 data bits, 1 stop bit, no parity
RS485 ModBus Format	38.4, 8,1,N		1 start bit, 8 data bits, 1 stop bit, no parity
Low Pass Filter Freq.	1	Hz	Features a low pass filter which is adjustable between 16Hz & 0.125Hz via the control commands, see pages 8 & 13 for more details. The default setting is 1Hz.
Mechanical shock	5000	G	Shock survival limit for internal sensor 5000G for 0.5ms
Weight	45	g	Not including cable
Cable & Connector	2m M12	-	2m 4-core braided screen cable with black PUR jacket and M12 male connector
Sealing	IP67	-	Seal rating applies to housing and cable gland. Gland is not designed for flexible cable installation, as this may compromise seal rating



Performance Specifications

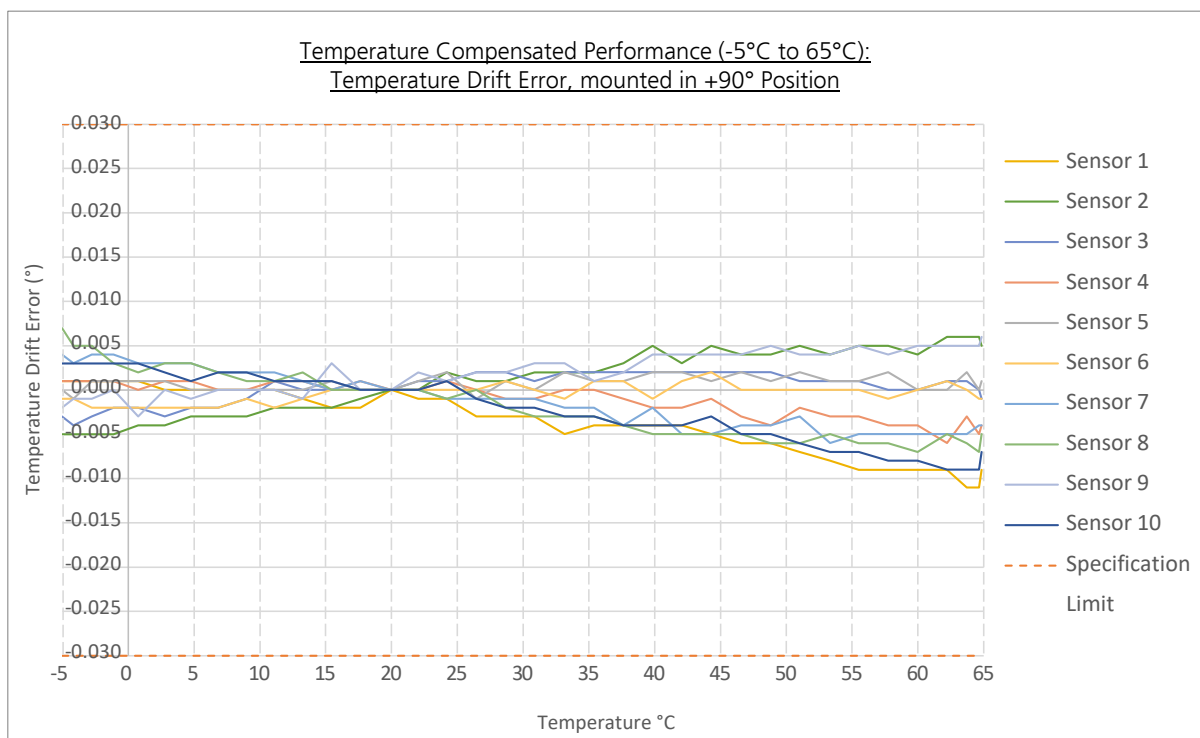
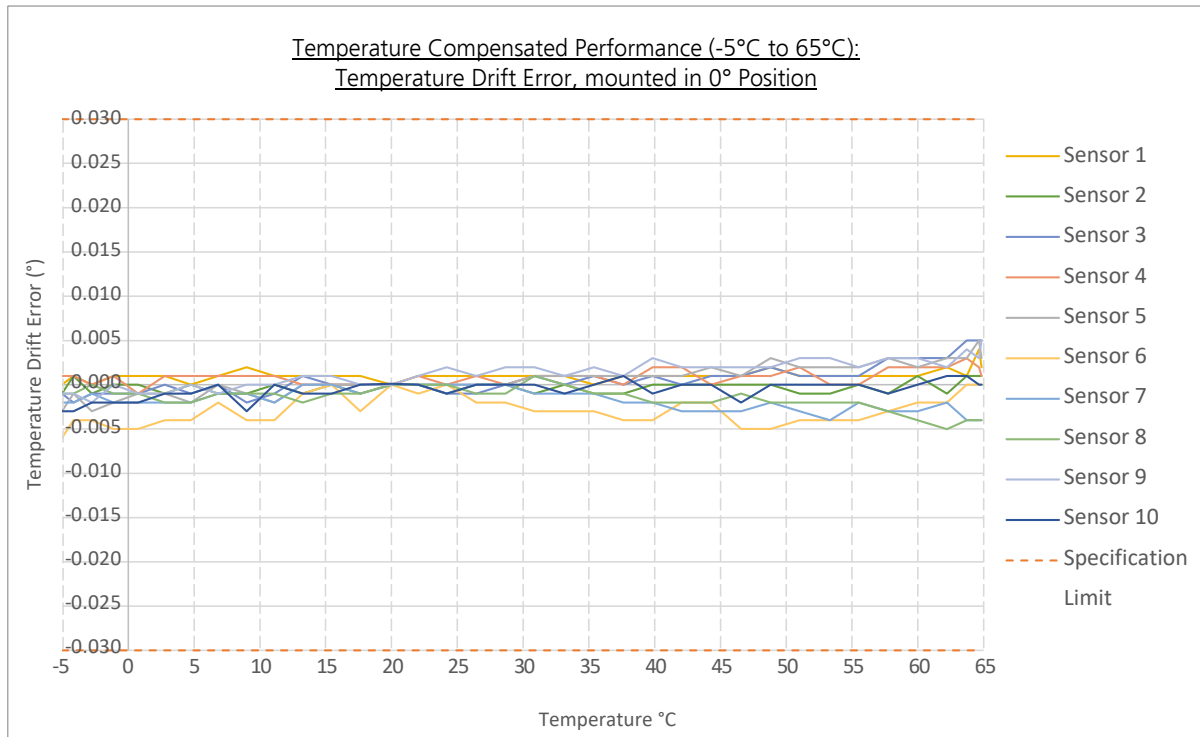
Parameter	SOLAR-360	Unit
Measuring range	±180	°
Accuracy (@20°C)	±0.015	°
Temperature Errors (without compensation)		
Zero Drift	±0.0013	°/°C
Sensitivity Drift	±0.0011	%/°C
Temperature Errors (with compensation)		
Zero Drift	±0.0003	°/°C
Sensitivity Drift	±0.0002	%/°C
Accuracy -10 to 60°C (without compensation)	±0.10	°
Accuracy -10 to 60°C (with compensation)	±0.03	°
Long Term Stability	±0.007	°
Resolution (@1Hz BW)	0.002	°

Parameter	Notes
Measuring range	Defines the calibrated measurement range. Direction of measurement can be reversed and zero position can be reset anywhere in range. Settings are stored in non volatile memory so are remembered after power down.
Accuracy (@20°C)	This is the maximum error between the measured and displayed value at any point in the measurement range when the device is at room temperature (20°C). This value includes cross axis errors and zero bias error.
Temperature Errors	Temperature errors come in two forms, zero drift and sensitivity drift. These values show the maximum errors for standard and compensated devices.
Zero Drift	If the device is mounted to a level surface in the zero position, this value is the maximum drift of the output angle per °C change in temperature.
Sensitivity Drift	When the temperature changes there is a change in sensitivity of the sensor's output. The error this causes in the measurement is calculated from the formula: $E_{sd} = SD \times \Delta T \times \theta$ Where: E_{sd} is the change in output (in degrees) due to sensitivity temperature change SD is the sensitivity drift specification from the above table (0.003%) ΔT is the change in temperature in °C θ is the current angle of the inclinometer axis in question in degrees.
Accuracy -10 to 60°C (without compensation)	This is the maximum error between the measured and displayed value at any point in the measurement range at any temperature over the specified temperature range without individual temperature compensation.
Accuracy -10 to 60°C (with compensation)	This is the maximum error between the measured and displayed value at any point in the measurement range at any temperature over the calibrated temperature range with individual temperature compensation.
Long Term Stability	Stability depends on environment (temperature, shock, vibration and power supply). This figure is based on being powered continuously in an ideal environment.
Resolution (@1Hz bandwidth)	Resolution is the smallest measurable change in output.



Temperature Stability Performance (with Temperature Compensation)

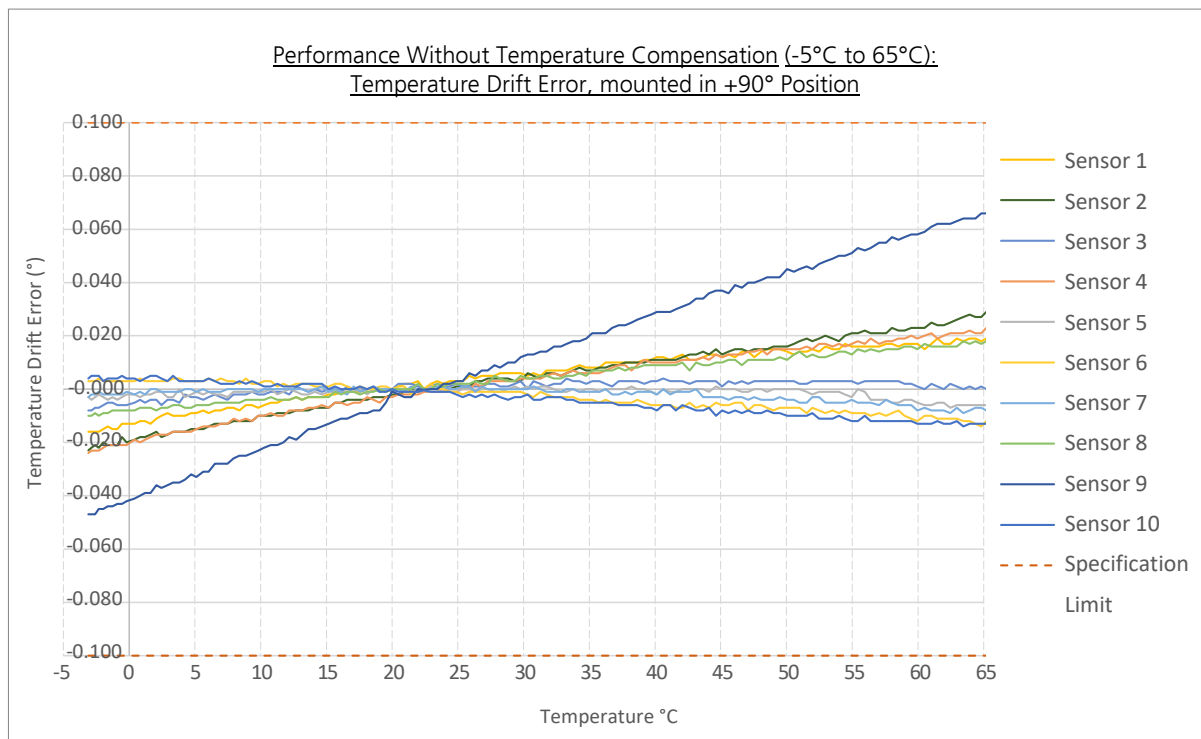
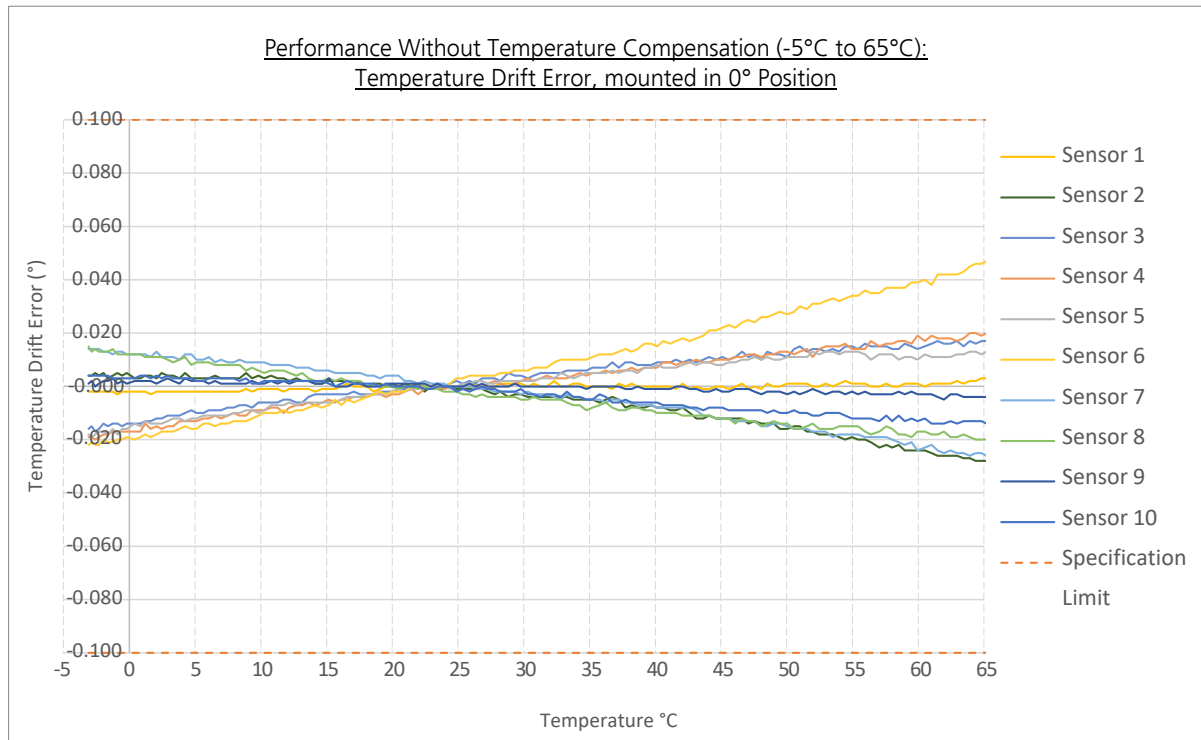
One of the largest effects on accuracy for any inclinometer sensor is the effect of temperature. A change in temperature can cause a shift in the zero position as well as affecting the overall sensitivity of the device. The SOLAR-360 sensor is available with (and without) additional temperature compensation. The graphs below demonstrate typical performance of these devices with additional temperature compensation (SOLAR-360-2). The top graph shows data from sensors mounted in the 0° position (see page 5), the bottom graph shows them at 90°.





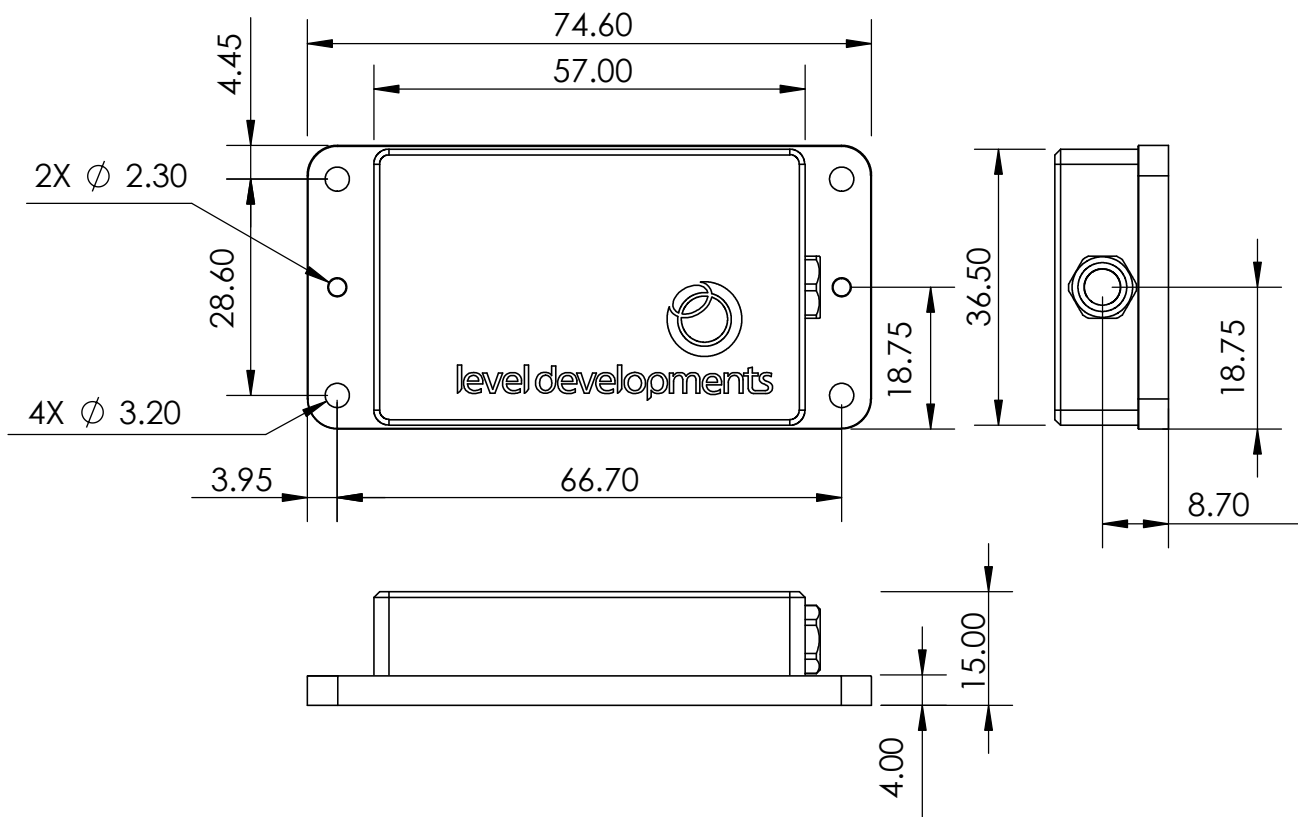
Temperature Stability Performance (without Temperature Compensation)

The graphs below demonstrate typical performance of these devices without additional temperature compensation (SOLAR-360-1). The top graph shows data from sensors mounted in the 0° position (see page 5), the bottom graph shows them at 90°.



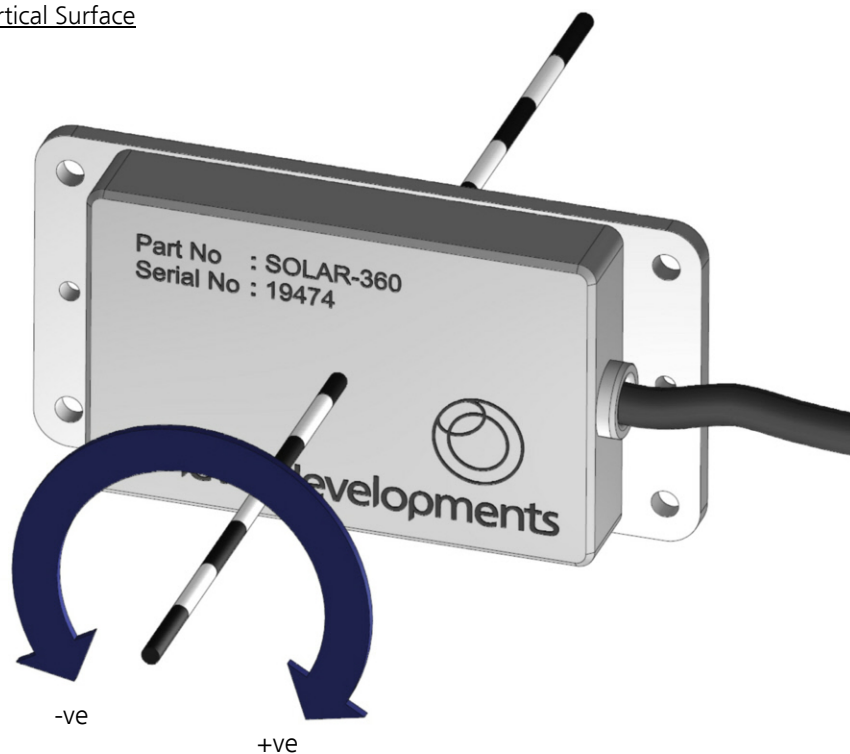


Housing Drawing



Axis Direction and Mounting Orientation and Wiring Details

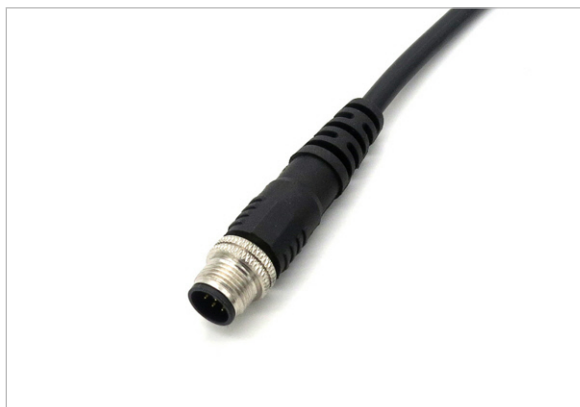
Mounted on Vertical Surface





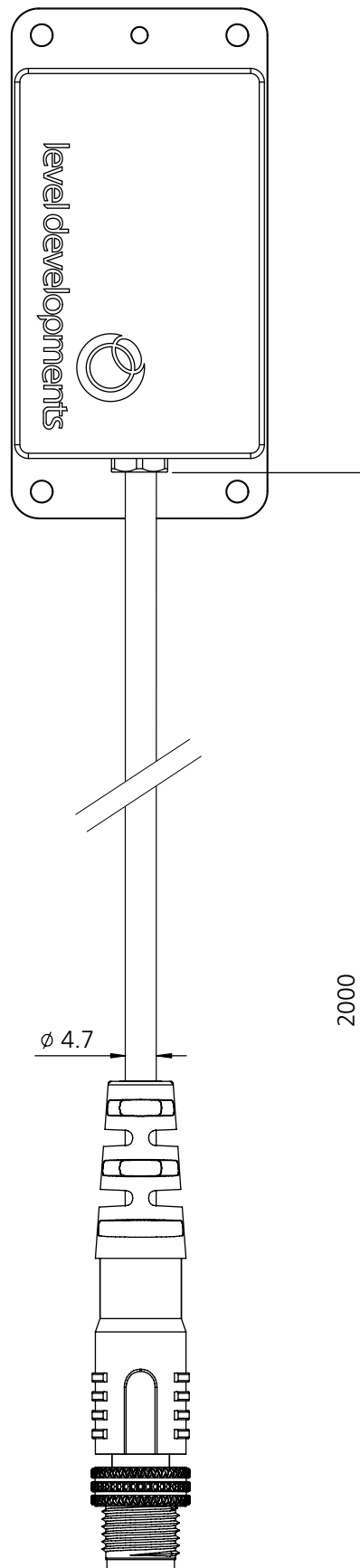
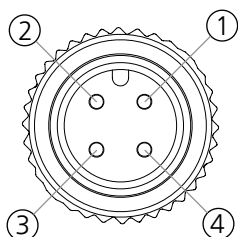
Cable and Connector Details

Parameter	Value
Connector description	M12 4-pin male
Connector make-up	Over-moulded
Coding	A-coded
Overall length	2 meters
Connector seal rating	IP67
Braided	Yes
Braid type	Tin plated Copper
Jacket material	PUR
Jacket diameter	4.7mm (max)
Wire Gauge	24 AWG
Conductor strands	41x0.08mm



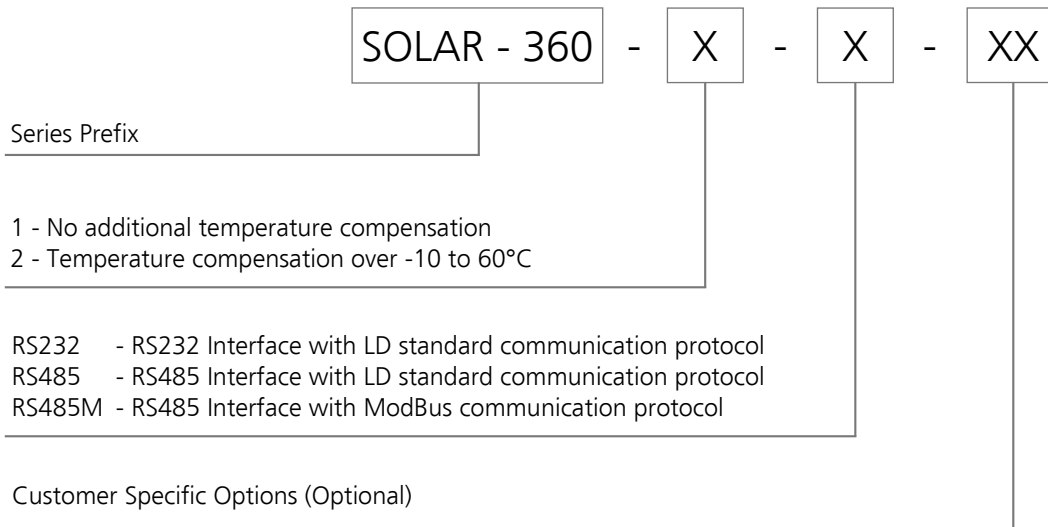
Pin Number	Internal Wire Colour	Function
1	Brown	+ve Supply
2	White	Gnd (0v)
3	Blue	RS485 A or RS232 Rxd
4	Black	RS485 B or RS232 Txd

M12 male connector
View from front:





Part Numbering

Example:**SOLAR-360-2-RS485M**

SOLAR-360 Series dual axis inclinometer

±180° Full Scale Measurement Range

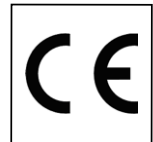
Temperature compensated over the range -10 to 60°C

RS485 Interface with ModBus communication protocol

Certification

The products are type approved to in accordance with the following directive(s):

EMC Directive 2004/108/EC



And it has been designed, manufactured and tested to the following specifications:

BS EN61326-1:2021

Electrical equipment for measurement, control and laboratory use

Tested For	Standard Tested To
Conducted RF Emissions	EN 55011: 2016 + A2: 2021 Class A Table 2 Rated Input power ≤ 20 kVA
Radiated Emissions	EN 55011: 2016 A2: 2021 Class A Table 4 Rated Input power ≤ 20 kVA
Electrostatic Discharge	EN 61326-1: 2021 Table 2 Performance criteria B
Radiated RF Immunity	EN 61326-1: 2021 Table 2 Performance criteria A 10 V/m, 80 % AM 1 kHz, 80 MHz to 1 GHz 3 V/m, 80 % AM 1 kHz, 1.4 GHz to 6 GHz
Fast Transient and Burst Immunity	EN 61326-1: 2021 Table 2 Performance criteria B
Surge Immunity	EN 61326-1: 2021 Table 2 Performance criteria B
Conducted RF Immunity	EN 61326-1: 2021 Table 2 Performance criteria A 3 V, 80 % AM 1 kHz
Power Frequency Magnetic Field Immunity	EN 61326-1: 2021 Table 2 Performance Criteria A

EMC certification is available on request.



Communication Protocol Options

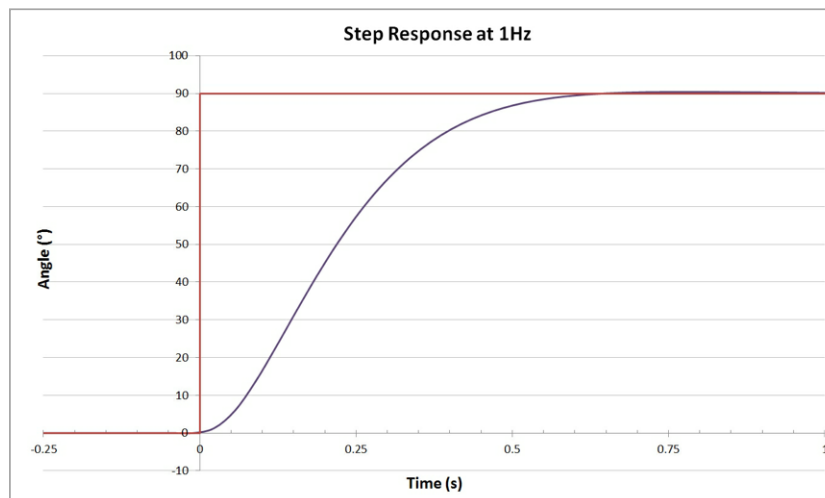
The following table describes all available communication options on our standard SOLAR-360 Range. Most of these options need to be selected before purchase as the device is configured before shipping.

Part Numbers	Physical Hardware Interface	Default Communications Protocol	User-Selectable Alternative Communication Protocol
SOLAR-360-X-RS232	RS232	Level Developments Serial Communication Protocol	NMEA0183
SOLAR-360-X-RS485	RS485	Level Developments Serial Communication Protocol	NMEA0183
SOLAR-360-X-RS485M	RS485	ModBus RTU	N/A

If you require support choosing the most applicable communication protocol for your application please email Sales@leveldevelopments.com.

Low Pass Filter Frequency Indexes

The SOLAR-360 features a user-selectable low pass filter which can be used (for example) to reduce the effect of vibrations if they are present in the sensor's environment. The filter setting can be changed to any of the response times shown in the table below. The strongest filter (0.125Hz) will provide the greatest damping and stability, however it will also take the longest time to respond to changes in angle (and vice versa). The filter configuration is a 2nd order Bessel low pass filter implemented in a IIR algorithm. It should be noted that this setting does not relate to output data rate



Filter Index	Filter Freq. (Hz)	Damping Time (ms)
1	0.125	8000
2	0.25	4000
3	0.5	2000
4	1	1000
5	2	500
6	4	250
7	8	125
8	16	62.5

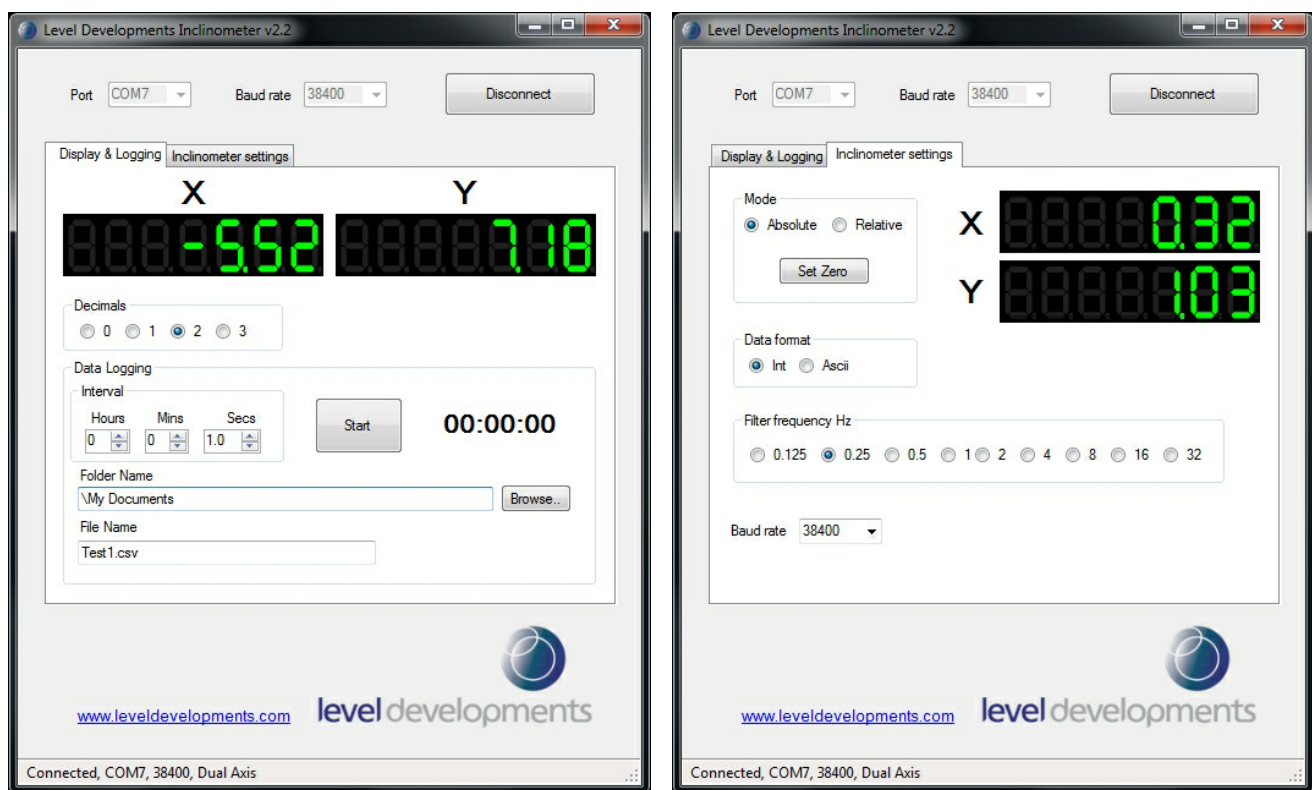


Software

A free Windows based application for reading angle, logging and device configuration is available from our website. It is compatible with Windows 10 and works with 32 or 64 bit systems. A COM port is required, and can either be a built in COM port, or a USB to Serial COM port. The application is available to download free of charge at the following link: https://www.leveldevelopments.com/wp/wp-content/uploads/software/Inclinometer_App.zip

The basic features are shown below:

- Automatic or manual configuration of COM port parameters
- Compatible with single or dual axis sensors
- Adjustable number of decimal places on displays
- Logging of data at specified intervals into CSV file
- Setting device to absolute or relative measurement mode
- Switching the data transfer protocol between Integer and ASCII
- Changing the frequency response of the sensor
- Changing the Baud rate of the sensor



We can also offer custom software development services, please contact us for further information.

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