level developments

SOLAR-360-4/20: Single Axis Sensor ±1-180° , 4-20mA, RS232

Features

- Factory & user customisable range: ±1° to ±180°
- Single axis measurement
- RS232 Digital & 4-20mA analogue outputs
- High resolution and accuracy
- Low temperature drift, with optional temperature compensation to further improve temperature performance
- Tough sealed anodised aluminium housing (IP67)
- CE certified and RoHS compliant
- 2 Meter cable, 5 Pin M12 male connector
- Low cost relative to performance
- Small size, 75 x 37.5 x 15mm and light weight

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 both a digital RS232 interface and an analogue 4-20mA output signal. 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	16 35	mA mA	Value at -ve full scale range (4mA output) when powered with a 24V supply Value at +ve full scale range (20mA output) when powered with a 24V supply
Operating Temperature	-40 to 85	°C	Maximum operating temperature range. Units can be calibrated between -20 and 70°C on request.
RS232 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
Frequency Response	1	Hz	This is the frequency at which the output is 3dB less than the input value. This is adjustable between 16Hz and 0.125Hz via the RS232 control commands
Mechanical shock	5000	G	Shock survival limit for internal sensor 5000G for 0.5ms
Weight	45	g	Not including cable
Cable	0.25	m	5 Core cable with PUR jacket (see page 5)
Connector	M12x5 Male	-	Moulded male M12 connector, A-coded (see page 5)
Sealing	IP67	-	Seal rating applies to housing and cable gland. Gland is not designed for flexible cable installation, as this may compromise seal rating
Analogue Output	4-20	mA	Output is linear with respect to change in angle (see page 4)

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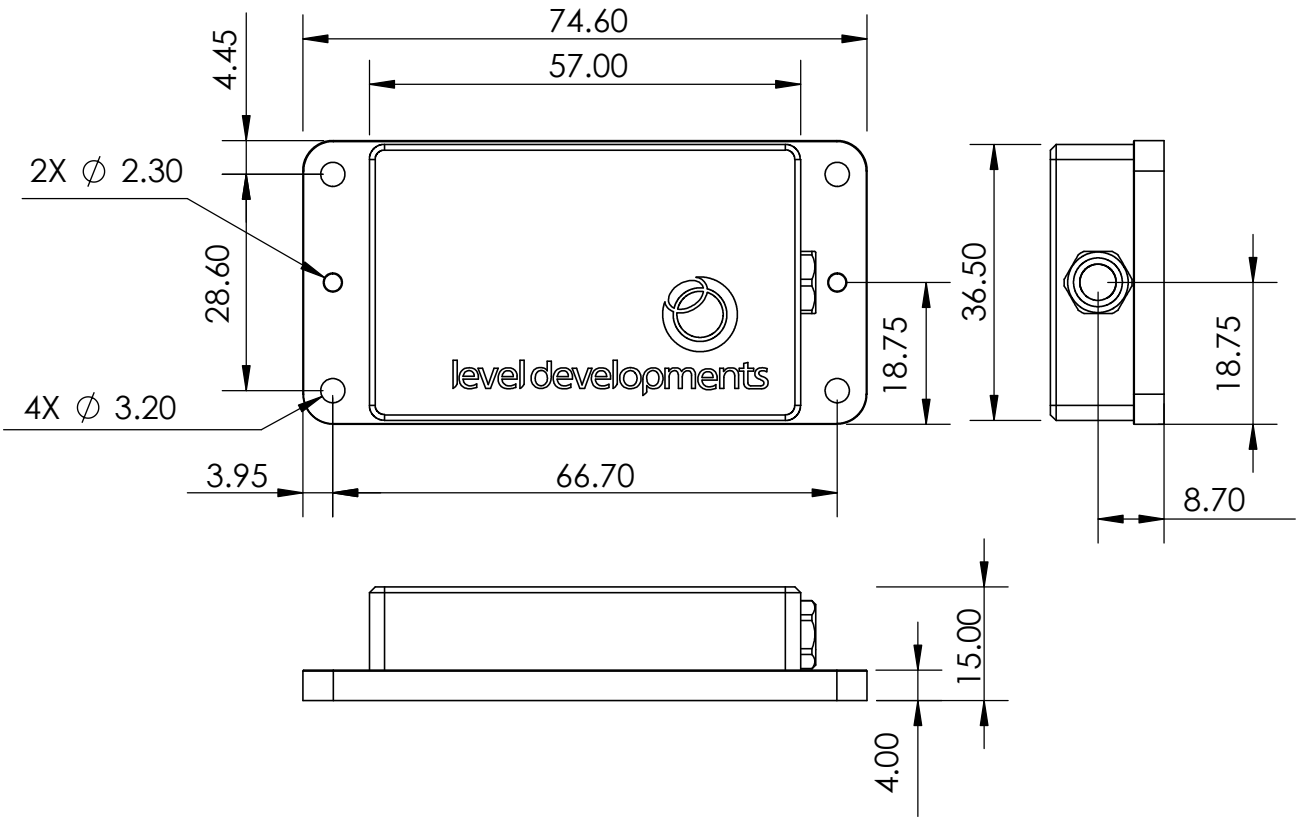
Performance Specifications

Parameter	Value	Unit
Measuring range	±1 to ±180	°
Zero Bias Error	±0.02	°
Accuracy (@20°C)	±0.07	°
Temperature Errors (without compensation) Zero Drift Sensitivity Drift	 ±0.002 ±0.003	 °/°C %/°C
Temperature Errors (with compensation) Zero Drift Sensitivity Drift	 ±0.001 ±0.001	 °/°C %/°C
Accuracy -10 to 60°C (without compensation)	±0.3	°
Accuracy -10 to 60°C (with compensation)	±0.1	°
Long Term Stability	±0.02	°
Resolution (@1Hz BW)	0.001	°

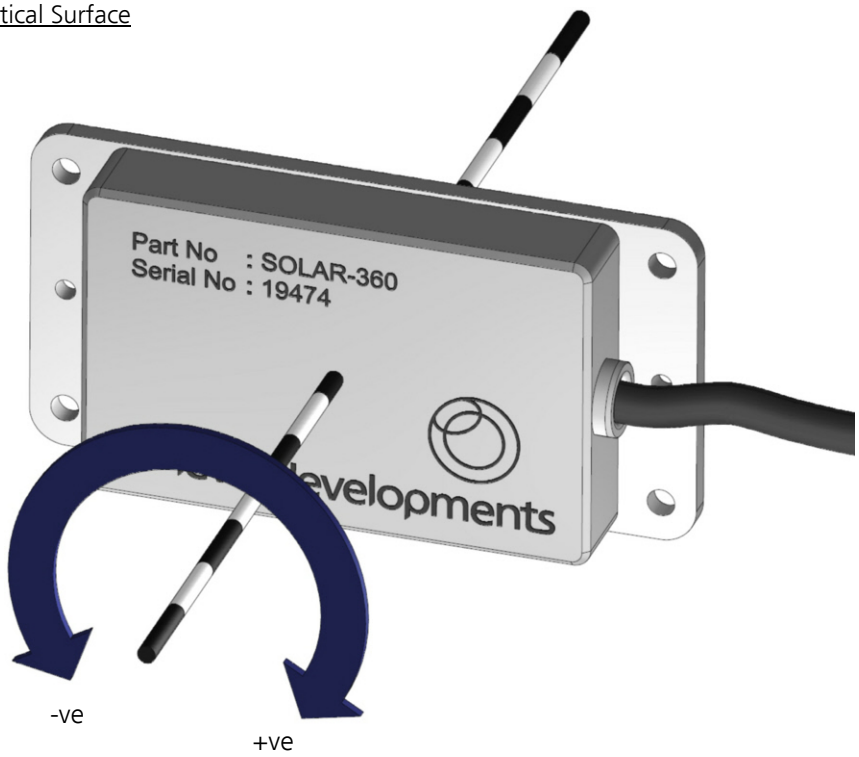
Parameter	Notes
Measuring range	Defines the calibrated measurement range. Direction of measurement can be reversed and zero position can be reset anywhere in range. Settings are stored in non volatile memory so are remembered after power down.
Zero Bias Error	This is the **maximum** angle from the device when it is placed on a perfectly level surface. The zero bias error can be removed from measurement errors either by mechanical adjustment, or as a fixed offset value after installation, or by using the 'setzcur' command to zero the device (see page 8)
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.
Temperature Errors Zero Drift Sensitivity Drift	Temperature errors come in two forms, zero drift and sensitivity drift. These values show the maximum errors for standard and compensated devices. 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. 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: $\mathbf{E_{sd} = SD \times \Delta T \times \theta}$ Where: $\mathbf{E_{sd}}$ is the change in output (in degrees) due to sensitivity temperature change **SD** is the sensitivity drift specification from the above table (0.014%) **ΔT** is the change is 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.

Housing Drawing



Axis Direction and Mounting Orientation

Mounted on Vertical Surface



Analogue Output Change With Angle

All inclinometers measure a change in the effect of gravitational field on a mass to derive angle. As the inclinometer sensor is rotated, the sensing element is subject to gravitational forces which move the proof mass. The signal generated by this movement is measured and through a digital signal processor the response is linearised and then sent to the output interface. In addition to the digital (RS232) interface, each device outputs an electrical current signal, varying between 4mA and 20mA as the angle changes. This can be converted to angle using the formula:

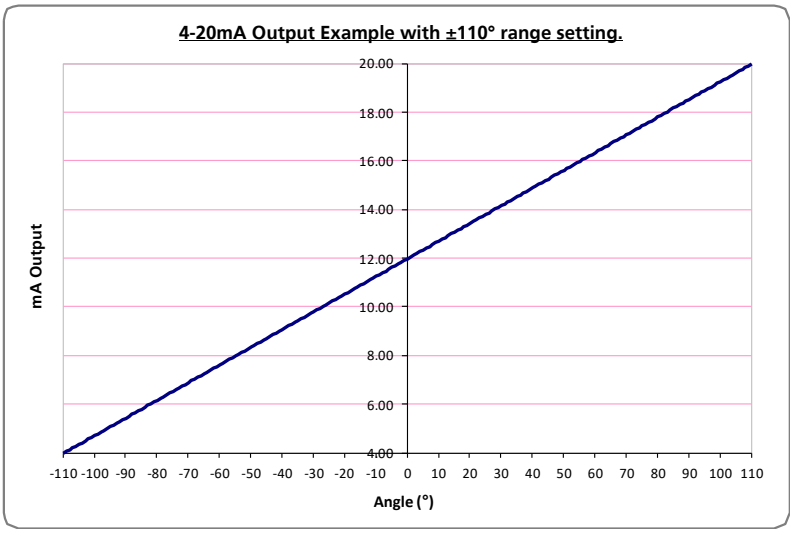
$$\text{Angle} = (\text{Iout} - 12) \times \left(\frac{\text{Range}}{8}\right)$$

Where :

Angle = The angle of the device in degrees

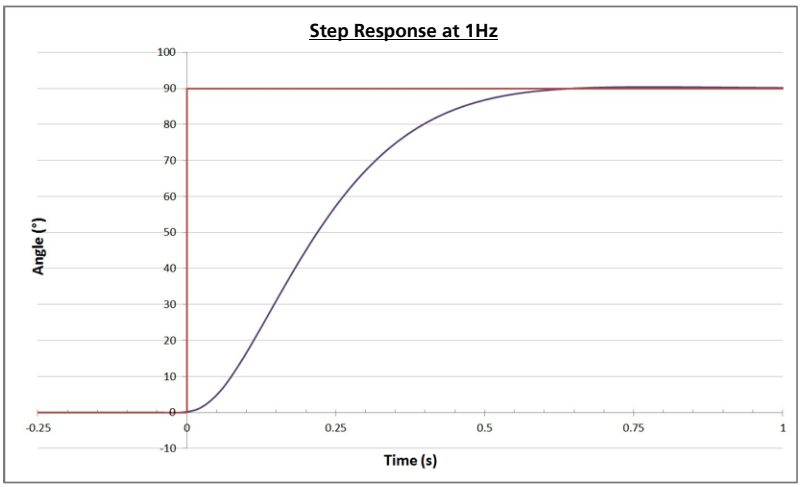
$\mathbf{I_{out}}$ = Measured output from the sensor in mA

Range = Measuring range of the device: Depending on the part number, the default setting is either: 30, 90, or 180 (e.g. ±180°) this can be adjusted to any value between 1 & 180 using RS232 commands as shown on page 6.



Frequency Response Filter Indexes

The frequency response of the sensor can be changed to any of the response times shown in the table. The filter is a 2nd order Besel low pass filter implemented in a IIR algorithm. The factory default setting is 1Hz & is adjustable from 0.125Hz to 16Hz as shown below and on page 6.

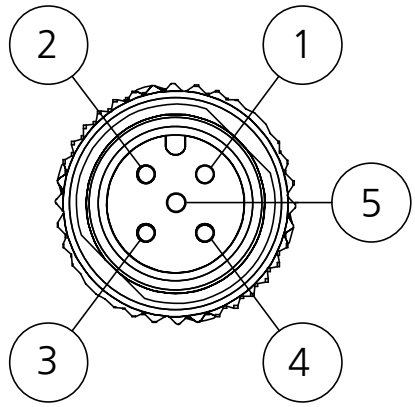


Freq. Response (Hz)	Command (See Page 6)	Damping Time (ms)
0.125	setflt1	8000
0.25	setflt2	4000
0.5	setflt3	2000
1	setflt4	1000
2	setflt5	500
4	setflt6	250
8	setflt7	125
16	setflt8	62

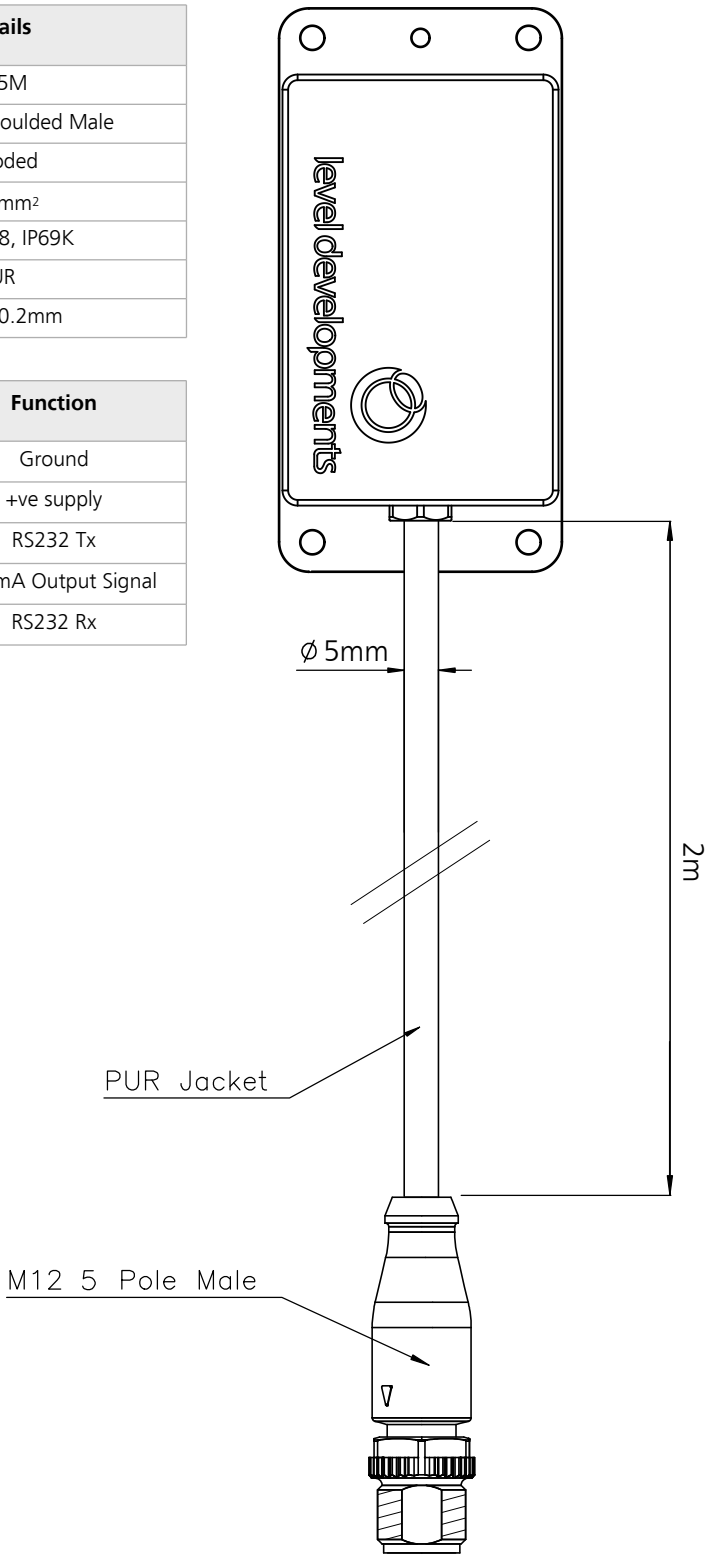
Cable Details

Parameter	Details
Length	0.25M
Connector type	5 pin M12 Moulded Male
Coding	A-Coded
Conductor cross section	0.34mm²
Seal rating	IP67, IP68, IP69K
Jacket material	PUR
Jacket Diameter	5mm ±0.2mm

M12 Pin Number	Internal Wire Colour	Function
1	Brown	Ground
2	White	+ve supply
3	Blue	RS232 Tx
4	Black	4-20mA Output Signal
5	Grey	RS232 Rx



M12 male connector viewed from pin end



Level Developments Simplified Control Command Set

Data is transmitted and received over RS232 in full duplex mode. The default configuration is with the baud rate set to 38.4kbps, with 8 data bits, 1 stop bit and no parity. All commands are lower case and 7 bytes long. The time between each character of the command must be less than 100ms otherwise the device will discard the command. The settings are all stored in non volatile memory.

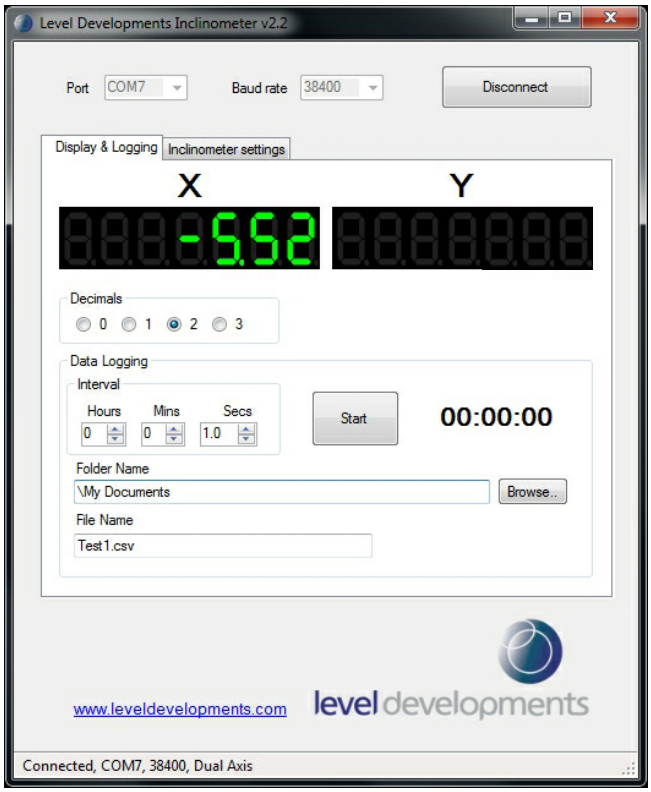
Command	Description	Response Length	Response
get-360	Returns the angle as either: - An INT32 value equal to the angle x 1000 - A fixed length ASCII string terminated with a carriage return depending on the setting of commands 'setoasc' or 'setoint' Shipping default is INT32.	4 bytes 9 bytes	0x XX XX XX XX +025.430<CR>
gettemp	Returns the temperature of the sensor as either: - An INT16 value equal to the temperature x 100 - A fixed length ASCII string terminated with a carriage return depending on the setting of commands 'setoasc' or 'setoint' Shipping default is INT32.	2 bytes 6 bytes	0x XX XX ±tt.t<CR>
str9999	Set continuous output transmission rate in milliseconds (50-9999ms) - str0100 - 100ms (0.1s) between transmissions - str8500 - 8500ms (8.5s) between transmissions	2 bytes	OK
setcasc	Sets the output to transmit the angle continuously in ASCII format at the rate defined by strXXXX.	9 bytes	+025.430<CR>
stpcasc	Stops the continuous transmission of ASCII data	2 bytes	OK
get-flt	Returns the value of the current filter time constant in ms as an INT16	2 bytes	0x XX XX
setdir5 setdir6	Sets the measurement direction to positive clockwise Sets measurement direction to negative clockwise	2 bytes	OK
setzcur	Tare function to set the current position to zero	2 bytes	OK
setzfac	Cancels tare function and resets zero to factory setting	2 bytes	OK
setoasc	Sets the output to ASCII format	2 bytes	OK
setoint	Sets the output to Integer format	2 bytes	OK
setflt1 setflt2 setflt3 setflt4 setflt5 setflt6 setflt7 setflt8	Sets the digital filter frequency response to 0.125Hz Sets the digital filter frequency response to 0.25Hz Sets the digital filter frequency response to 0.5Hz Sets the digital filter frequency response to 1Hz Sets the digital filter frequency response to 2Hz Sets the digital filter frequency response to 4Hz Sets the digital filter frequency response to 8Hz Sets the digital filter frequency response to 16Hz	2 bytes	OK
set-br1 set-br2 set-br3 set-br4 set-br5 set-br6 set-br7	Sets the BAUD rate to 2400bps Sets the BAUD rate to 4800bps Sets the BAUD rate to 9600bps Sets the BAUD rate to 19200bps Sets the BAUD rate to 38400bps (default setting) Sets the BAUD rate to 57600bps Sets the BAUD rate to 115200bps	2 bytes	OK
sfs-###	Sets the 4-20mA output to the specified full scale range where ### is equal to the range in degrees. The configurable range is 1 to 180: - sfs-001 - Sets the 4-20 output range to ±1° - sfs-090 - Sets the 4-20 output range to ±90° - sfs-180 - Sets the 4-20 output range to ±180° Shipping default is ±30° ±90° or ±180° depending on PN, see page 8	2 bytes	OK

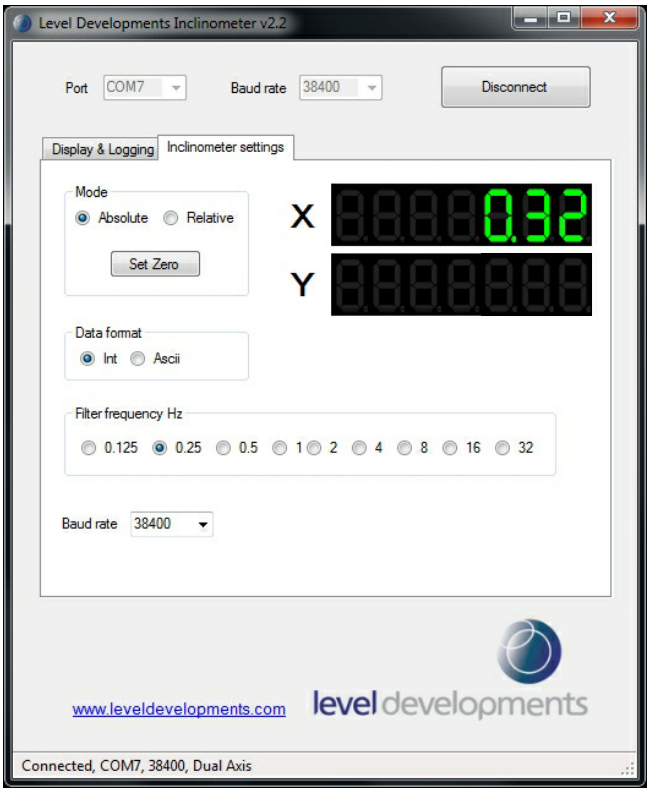
Software

A free Windows based application for reading angle, logging and device configuration is available from our website. It requires Windows XP SP3, Windows 7, 8 or 10 and works with 32 and 64 bit systems. It also requires the .net framework V3.5 or higher, and will prompt you to download and install this from Microsoft if it is not already installed on your system. A COM port is also required, and can either be a built in COM port, or a USB to Serial COM port.

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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Part Numbering

SOLAR - 360 - XX - XX - 4/20 - XX

Series Prefix - Single axis, 360° range

30 - Default full scale output range: ±30° (user adjustable)
90 - Default full scale output range: ±90° (user adjustable)
180 - Default full scale output range: ±180° (user adjustable)

1 - No additional temperature compensation
2 - Temperature compensation over -10 to 60°C

4/20 - (RS232 &) 4-20mA output with user adjustable output range: ±1° to ±180°

Customer Specific Options (Optional)

Example:	**SOLAR-360-30-2-4/20**
SOLAR-360	Single axis SOLAR series inclinometer with 360° measurement range
30	±30° default scaling of the 4-20mA analogue output (user adjustable from ±1° to ±180°)
2	Temperature compensated over the range -10 to 60°C
4/20	(RS232 &) 4-20mA output with adjustable full scale range setting (±1° to ±180°)

All models feature an RS232 interface as standard, the RS232 measurement range is ±180°

Certification

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

CE

EMC Directive 2004/108/EC

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

BS EN61326-1:2006	Electrical equipment for measurement, control and laboratory use – EMC Requirements
BS EN55011:2007, Group 1 Class B	

Certification is available on request.

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