



## Features

- Dual axis measurement, range from  $\pm 5$  to  $\pm 45^\circ$
- 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-2 inclinometers are range of high performance low cost dual axis tilt sensors for measurement of angle in both the pitch and roll axes. Through a flexible configuration and calibration program we can supply this device with any measurement range from  $\pm 5^\circ$  to  $\pm 45^\circ$ . It can also be supplied compensated for a 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. 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
<b>Supply Voltage</b>	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.
<b>Operating Current</b>	30mA (@ 9V) 20mA (@ 12V) 10.5mA (@ 24V)	mA	Supply current depends on supply voltage.
<b>Operating Temperature</b>	-40 to 85	°C	Maximum operating temperature range. Units can be calibrated between -20 and 70°C on request.
<b>RS232/485 Output Rate</b>	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
<b>RS232 Data Format</b>	38.4, 8,1,N		1 start bit, 8 data bits, 1 stop bit, no parity
<b>RS485 &amp; ModBus Format</b>	38.4, 8,1,N		1 start bit, 8 data bits, 1 stop bit, no parity
<b>Low Pass Filter Freq.</b>	1	Hz	Features a low pass filter which is adjustable between 16Hz & 0.125Hz via the control commands, see pages 7 & 12 for more details. The default setting is 1Hz.
<b>Mechanical shock</b>	5000	G	Shock survival limit for internal sensor 5000G for 0.5ms
<b>Weight</b>	45	g	Not including cable
<b>Cable &amp; Connector</b>	2m M12	-	2m 4 Core braided screen cable with black PUR jacket and M12 male connector
<b>Sealing</b>	IP67	-	Seal rating applies to housing and cable gland. Gland is not designed for flexible cable installation, as this may compromise seal rating



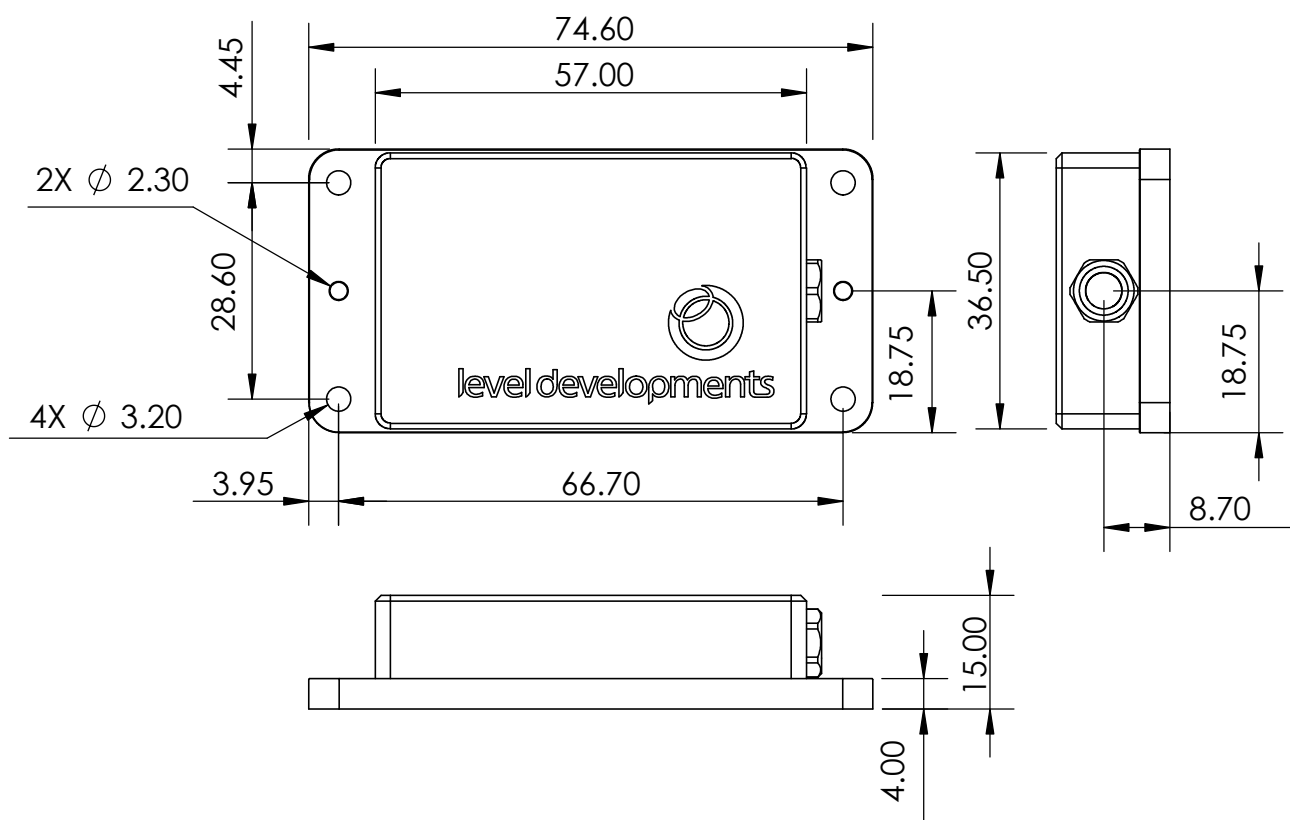
## Performance Specifications

Parameter	SOLAR-05	SOLAR-15	SOLAR-30	SOLAR-45	Unit
Measuring range	±5	±15	±30	±45	°
Zero Bias Error	±0.005	±0.010	±0.015	±0.020	°
Accuracy (@20°C)	±0.010	±0.020	±0.030	±0.040	°
Temperature Errors (without compensation)					
Zero Drift	±0.0015	±0.0015	±0.0015	±0.0015	°/°C
Sensitivity Drift	±0.0030	±0.0030	±0.0030	±0.0030	%/°C
Temperature Errors (with compensation)					
Zero Drift	±0.0003	±0.0003	±0.0003	±0.0003	°/°C
Sensitivity Drift	±0.0006	±0.0006	±0.0006	±0.0006	%/°C
Accuracy -10 to 60°C (without compensation)	±0.070	±0.090	±0.120	±0.150	°
Accuracy -10 to 60°C (with compensation)	±0.025	±0.030	±0.050	±0.065	°
Long Term Stability	±0.007	±0.007	±0.007	±0.007	°
Resolution (@1Hz BW)	0.001	0.001	0.001	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 <b>maximum</b> 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 'setzcure' command to zero the device (see page 8)
Accuracy (@20°C)	This is the <b>maximum</b> 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	These figures are for devices without additional temperature compensation. See part numbering options on page 7 for further details.
Zero Drift	If the device is mounted to a level surface in the zero position, this value is the <b>maximum</b> 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%) $\Delta T$ is the change in temperature in °C $\theta$ is the current angle of the inclinometer axis in question in degrees.
Accuracy -10 to 60°C (without compensation)	This is the <b>maximum</b> 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 <b>maximum</b> 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.

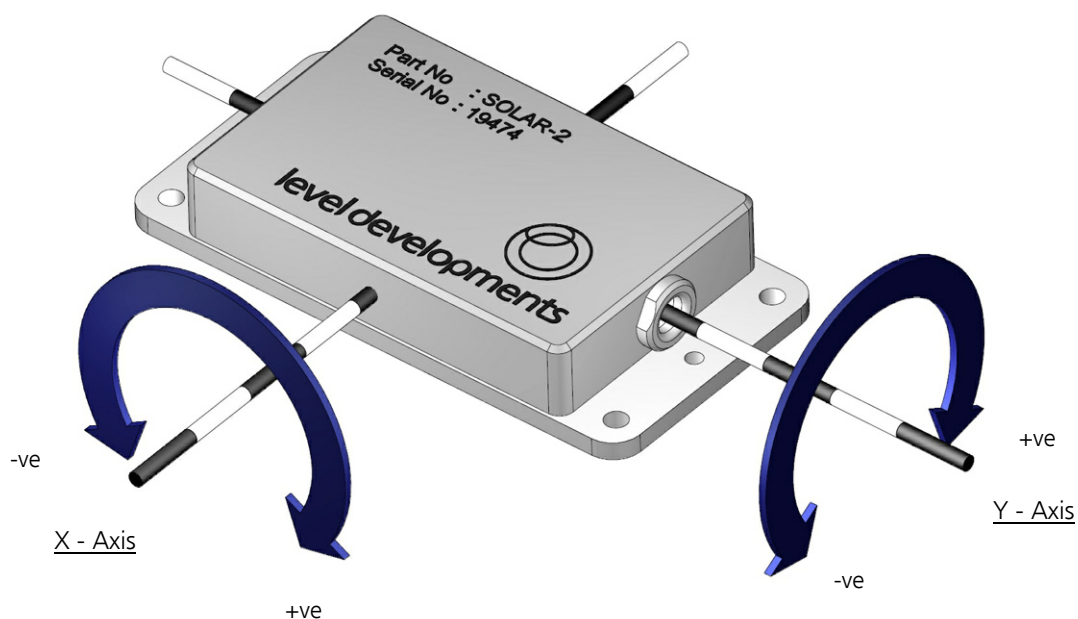


## Housing Drawing



## Axis Direction and Mounting Orientation and Wiring Details

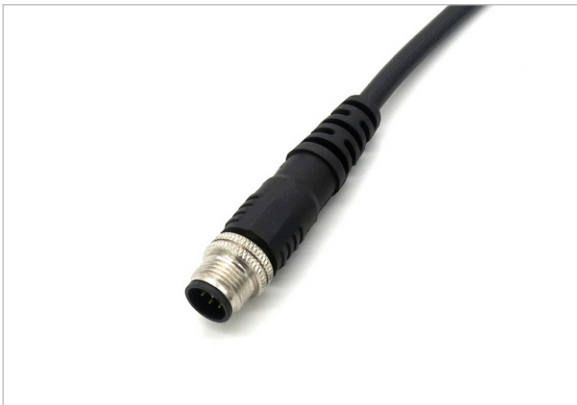
### Mounted on a Horizontal Surface





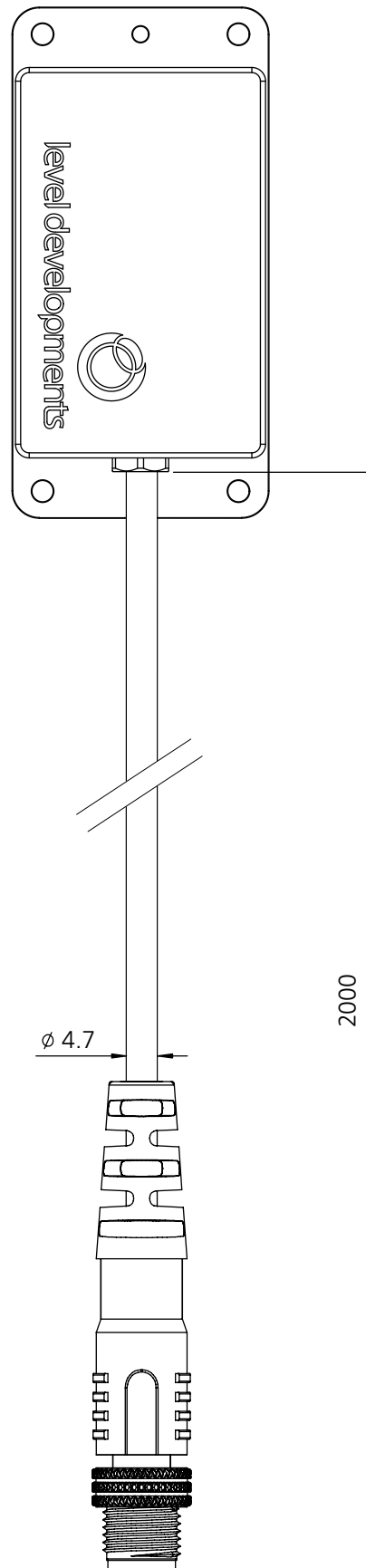
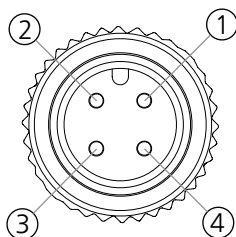
## Cable and Connector Details

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

SOLAR - 2 - XX - X - X - XX

Series Prefix

05 -  $\pm 5^\circ$  Full Scale Measurement Range  
 15 -  $\pm 15^\circ$  Full Scale Measurement Range  
 30 -  $\pm 30^\circ$  Full Scale Measurement Range  
 45 -  $\pm 45^\circ$  Full Scale Measurement Range

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

RS232 - RS232 Interface with LD standard communication protocol  
 RS485 - RS485 Interface with LD standard communication protocol  
 RS485M - RS485 Interface with ModBus communication protocol

Customer Specific Options (Optional)

Example:

**SOLAR-2-15-2-RS485M** - A SOLAR-2 series dual axis inclinometer with a  $\pm 15^\circ$  Full Scale Measurement Range, Temperature compensated over the range -10 to 60°C and RS485 Interface with ModBus communication protocol

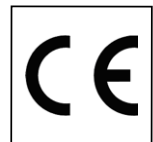
## Certification

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 $\leq 20$ kVA
Radiated Emissions	EN 55011: 2016 A2: 2021 Class A Table 4 Rated Input power $\leq 20$ 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

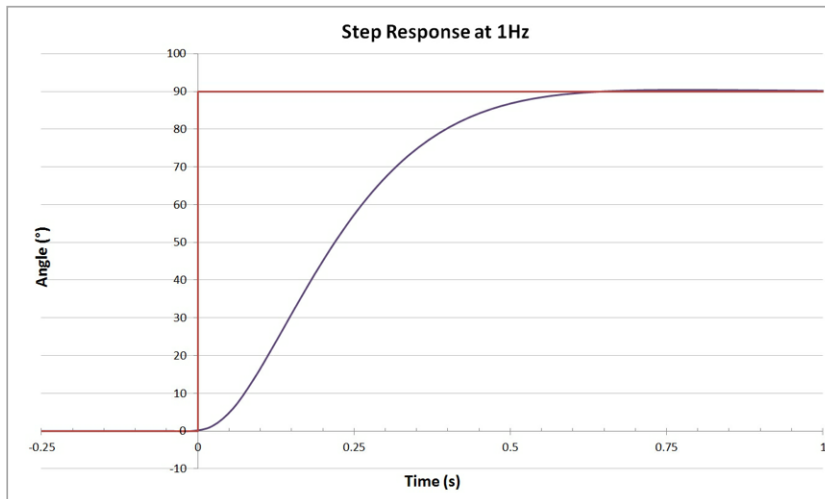
The following table describes all available communication options on our standard SOLAR-2 Range. Most of these options need to be selected before purchase as the device is configured before shipping.

Part Numbers	Physical Hardware Interface	Default Communications Protocol	User-Selectable Alternative Communication Protocol
SOLAR-2-XX-X-RS232	RS232	<a href="#">Level Developments Serial Communication Protocol</a>	<a href="#">NMEA0183</a>
SOLAR-2-XX-X-RS485	RS485	<a href="#">Level Developments Serial Communication Protocol</a>	<a href="#">NMEA0183</a>
SOLAR-2-XX-X-RS485M	RS485	<a href="#">ModBus RTU</a>	N/A

If you require support choosing the most applicable communication protocol for your application please email [Sales@leveldevelopments.com](mailto:Sales@leveldevelopments.com).

### Low Pass Filter Frequency Indexes

The SOLAR-2 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 (ODR).



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

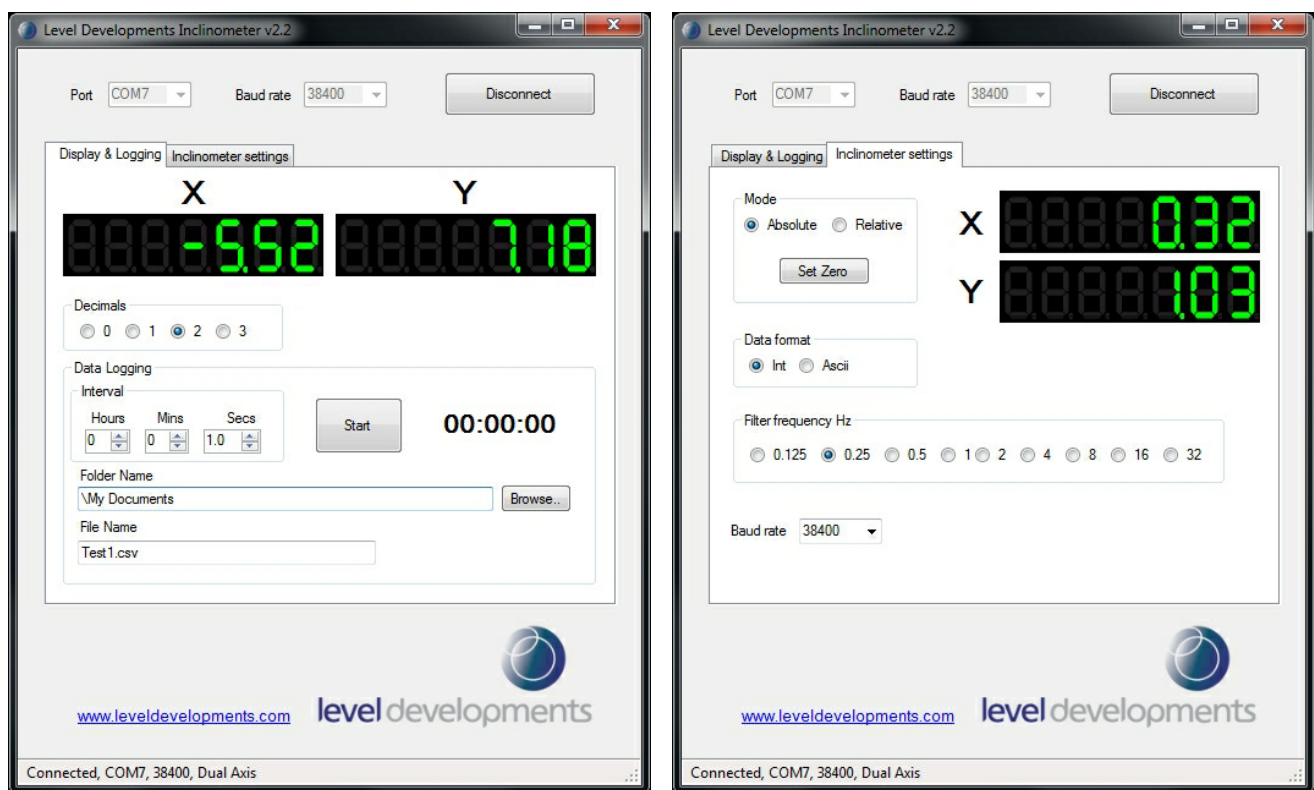


## Software

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](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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