level developments

ISM-2 : Inclinometer Sensor Module, 2-Axis, UART Interface

Features

- Dual axis measurement, range from ±5 to ±45°
- High resolution and accuracy
- Low temperature drift, with optional temperature compensation to further improve temperature performance
- Three user selectable power modes: Normal Power mode, Low Power mode, and Sleep mode
- UART communications interface, with adjustable user-settings, (e.g. Filtering)
- Very small and lightweight (42x19x6mm)
- Flat-flex ribbon cable (FFC) for simple installation
- Low cost relative to performance

Description

The ISM-2 (Inclinometer Sensor Module) is a range of high performance, low cost and low power, dual axis tilt sensors for measurement of angle in both the pitch and roll axes. Through a flexible calibration program we can supply this device with any measurement range from ±5° to ±45°, and they are available with/without additional temperature compensation. The overall size of the package is extremely small and lightweight, which makes it ideal for integration into systems which require a small form factor. They utilise a very high performance MEMS sensor which exhibits low long term drift compared with many competitive devices. They have a UART interface, and use our standard communication protocol which is easy to use. Each device is supplied with a flat-flex (FFC) type cable and mounting bracket for simple installation. Power can be supplied using either a 2.25V-3.6V, 5V-30V, or 6-30V DC supply, see page 4 for connection details. They are RoHS certified, and are manufactured, calibrated, and tested in the UK.

General Specifications

Parameter	Value	Unit	Notes
Supply Voltage When powered using pin 1	2.25V - 3.6V	V dc	A clean and stable supply should be used. Powering from pin 1 bypasses all protection, care must be taken to avoid damage.
Supply Voltage When powered using pin 2	5V - 30V	V dc	This input is filtered, suppressed & regulated but a low noise supply is recommended to prevent noise coupling to the sensor & there is no reverse polarity protection.
Supply Voltage When powered using pin 6	6V - 30V	V dc	This input has reverse polarity protection, is filtered, suppressed & regulated. However, a low noise supply is recommended to prevent noise coupling to the sensor.
Operating Current Normal run mode Low power mode Sleep mode	 5.2 750 160	 mA uA uA	This is the maximum current draw when powered via any of the pins. The default mode at the time of shipping is Normal Run Mode
Operating Temperature	-40 to 85	°C	Maximum operating temperature range.
UART Data Format	38.4k,8,1,N	bps	User adjustable settings. The default is 38400bps, 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 UART commands, see pages 5 & 6 for more details. The default setting is 1Hz.
Mechanical shock	5000	G	Un-powered shock survival limit for internal sensor 5000G, for 0.5ms.
Weight	9	g	Weight of the full assembly including cable.
Cable & Connector	FFC, 6pin	-	6-Pin flat-flex cable with same side contacts, 85.5mm long, (see page 4).

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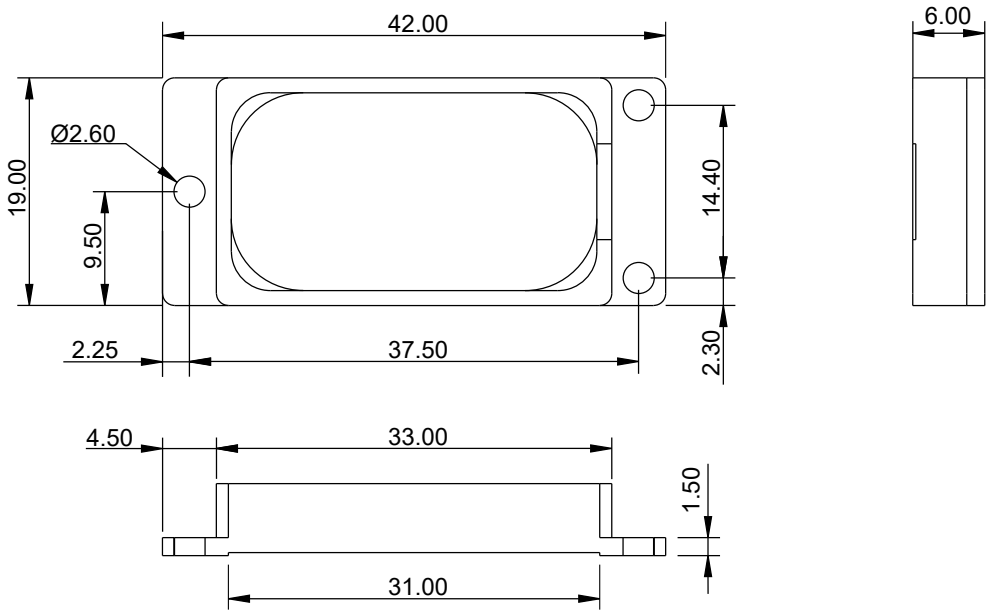
Performance Specifications

Parameter	ISM-2-05	ISM-2-15	ISM-2-30	ISM-2-45	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 Sensitivity Drift	 ±0.0015 ±0.0030	 ±0.0015 ±0.0030	 ±0.0015 ±0.0030	 ±0.0015 ±0.0030	 °/°C %/°C
Temperature Errors (with compensation) Zero Drift Sensitivity Drift	 ±0.0003 ±0.0006	 ±0.0003 ±0.0006	 ±0.0003 ±0.0006	 ±0.0003 ±0.0006	 °/°C %/°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 (with 1Hz damping filter)	0.001	0.001	0.001	0.001	°

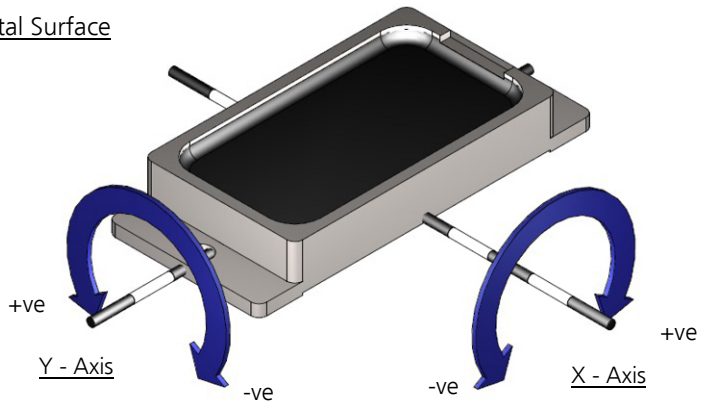
Parameter	Notes
Measuring range	Defines the calibrated measurement range. Direction of measurement can be reversed and zero position can be reset anywhere in range. Settings are stored in non volatile memory so are remembered after power down.
Zero Bias Error	This is the **maximum** angle from the device 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	These figures are for devices without additional temperature compensation. See part numbering options on page 7 for further details. 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 (0.003%) **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 (with 1Hz damping filter)	Resolution is the smallest measurable change in output.

Housing Drawing



Axis Direction and Mounting Orientation

Mounted on a Horizontal Surface



Part Numbering

ISM - 2	-	XX	-	X	-	X

Series Prefix

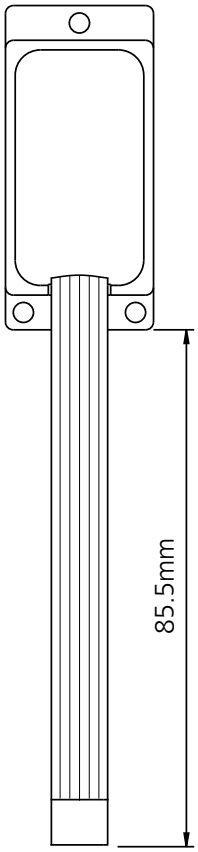
05 - ±5° Full Scale Measurement Range
15 - ±15° Full Scale Measurement Range
30 - ±30° Full Scale Measurement Range
45 - ±45° Full Scale Measurement Range

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

Customer Specific Options (Optional)

Cable Details

Parameter	Value
Type	Flat-Flex (FFC) Cable
MPN	MP-FFCA10061003A
Contact arrangement	Same side (underside)
Overall length (not including inside)	100mm
Number of pins total	6
Pitch	1mm
Insulator	PET (White)
Support	PET (Blue)
Contact	Brass, tin plated



Function	Pin Number
+ve Supply [2.25V to 3.6V DC]	1
+ve Supply [5V to 30V DC]	2
UART Tx [0 / 3.3V]	3
UART Rx [0 / 3.3V]	4
Gnd [0V]	5
+ve Supply [6V to 30V DC]	6

Note: Use only 1 power pin at a time.

Pins: 6,5,4,3,2,1

Power Modes

There are 3 user-selectable power modes which are accessed via the control commands.

Mode Name	Mode Number	Mode Description	Power
Normal	1	The processor runs continuously and processes the sensor data and angle calculations at full speed and is always ready for communication	5.2mA
Low Power	2	The processor processes the sensor data at full speed, but sleeps between readings. It requires an additional <NULL> character in the communication sequence to wake up.	750uA
Sleep	3	The processor and sensor are in full sleep mode. Requires an additional <NULL> character in the communication sequence to wake up. After wake, the filter needs to stabilise for the current filter time constant to get an accurate reading from the sensor.	160uA

This setting is not automatically stored in the non-volatile memory when changing between power modes to prevent reaching the maximum number of writes if the modes are frequently changed. To save the current power mode to non-volatile memory use the command "set-pmm" (see control commands section for more details)

Control Command Set - Normal Power Mode

Data is transmitted and received over UART 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 and will be remembered after removing power (except where stated otherwise).

Command	Description	Response Length	Response
get---x	Returns the X axis 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>
get---y	Returns the Y axis 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 YY YY YY YY +025.430<CR>
get-x&y	Returns the X and Y axis angle (X is transmitted first) as either: - A pair of INT32 value equal to the angle x 1000 - A fixed length comma separated ASCII string terminated with <CR> depending on the setting of commands 'setoasc' or 'setoint' Shipping default is INT32.	8 bytes 18 bytes	0x XX XX XX XX YY YY YY YY ±xxx.xxx,±yyy.yyy<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 (25-9999ms) - str0100 - 100ms (0.1s) between transmissions	2 bytes	OK
setcasc	Sets the output to transmit the X and Y angle continuously in ASCII format at the rate defined by strXXXX.	18 bytes	±xxx.xxx,±yyy.yyy<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
setdir1 setdir2 setdir3 setdir4	Sets the X axis measurement direction to positive clockwise Sets the X axis measurement direction to negative clockwise Sets the Y axis measurement direction to positive clockwise Sets the Y axis 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 low pass filter (damping) frequency to 0.125Hz Sets the low pass filter (damping) frequency to 0.25Hz Sets the low pass filter (damping) frequency to 0.5Hz Sets the low pass filter (damping) frequency to 1Hz Sets the low pass filter (damping) frequency to 2Hz Sets the low pass filter (damping) frequency to 4Hz Sets the low pass filter (damping) frequency to 8Hz Sets the low pass filter (damping) frequency 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 Sets the BAUD rate to 57600bps Sets the BAUD rate to 115200bps	2 bytes	OK
set-pm0	Sets the device to normal power mode. Note: This command is not saved to EEPROM (see set-pmm below)	2 bytes	OK
set-pm1	Sets the device to Low power mode. Note: This command is not saved to EEPROM (see set-pmm below)	2 bytes	OK
set-pm2	Sets the device to sleep mode. Note: This command is not saved to EEPROM (see set-pmm below)	2 bytes	OK
set-pmm	Saves the current power mode to EEPROM. Note: Warning, typical EEPROM life is 100,000 saves, do not exceed this value	2 bytes	OK

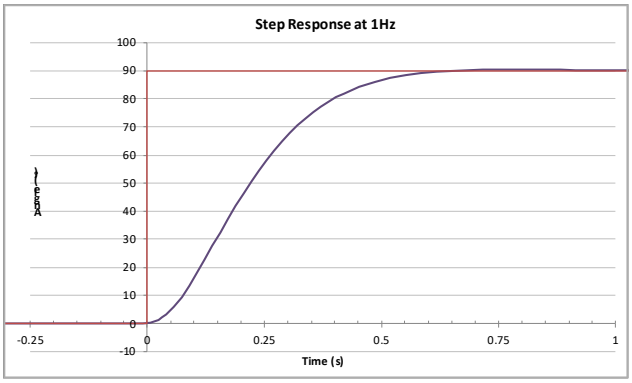
Control Command Set - Low Power & Sleep Mode

In low power & sleep mode, data is transmitted & received almost identically to normal mode (see previous section). However, the request command must start with a "wake-up" character, which is an ASCII null byte. The null byte is a control character with the value zero (0x00). After waking from sleep mode, it is necessary to wait for the filter damping time in order to take an accurate reading. Some example commands are shown below, but all commands from the command table can be used with a <NUL> prefix when communicating from low power or sleep mode.

Command	Description	Response Length	Response
<NUL>get---x	Returns the X axis 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>
<NUL>get---y	Returns the Y axis 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 YY YY YY YY +025.430<CR>
<NUL>get-x&y	Returns the X and Y axis angle (X is transmitted first) as either: - A pair of INT32 value equal to the angle x 1000 - A fixed length comma separated ASCII string terminated with <CR> depending on the setting of commands 'setoasc' or 'setoint' Shipping default is INT32.	8 bytes 18 bytes	0x XX XX XX XX YY YY YY YY ±xxx.xxx,±yyy.yyy <CR>
<NUL>set-pm0	Sets the device to normal power mode. Note: This command is not saved to EEPROM (see set-pmm below)	2 bytes	OK
<NUL>set-pm1	Sets the device to Low power mode. Note: This command is not saved to EEPROM (see set-pmm below)	2 bytes	OK
<NUL>set-pm2	Sets the device to sleep mode. Note: This command is not saved to EEPROM (see set-pmm below)	2 bytes	OK
<NUL>set-pmm	Saves the current power mode to EEPROM. Typical EEPROM life is 100,000 writes, do not exceed this value	2 bytes	OK

Low Pass Filter Frequency Indexes

The ISM-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