

SI & SA evaluation kits for high-precision inertial sensors

The SI & SA evaluation kits are inertial sensor modules including control board, sensor board and software for easy-to-use read-out and quick evaluation of the sensor data. The capacitive inclinometers and accelerometers from First Sensor are based on single crystal silicon sensor elements and utilize state-of-the-art micromechanical technology (HARMS, AIM) to achieve large signal-to-noise ratios and excellent stability over temperature.



Benefits of the AIM technology

- Ultra-low cross axis sensitivity due to HARMS technology
- Thin-film free mechanical components, single crystal silicon based
- Minimizing of parasitic capacitances due to insulation of the functional components by air gap
- Complete dry processing
- Excellent thermal performance
- Large signal-to-noise ratio
- Mechanical over-damped to reduce parasitic signals
- Customer specific measurement ranges due to flexible adjustment of mass, spring and damping

Features of the sensor system

- Dual axis measurement
- Excellent stability over temperature
- Digital SPI interface
- High resolution ADC offering more than 100 dB dynamic range
- Configurable bandwidth output filter
- Shock survival 1500 g
- Hermetically sealed package
- Customized sensor solutions for packaging and signal processing

Applications

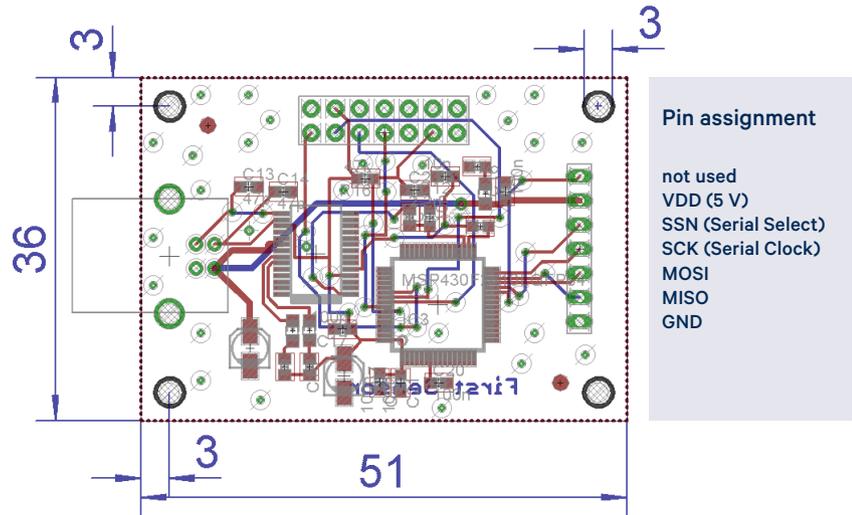
- Geoengineering
- Condition monitoring
- Navigation
- Security systems
- Platform control and stabilization
- Tilt sensing and leveling
- Industrial applications

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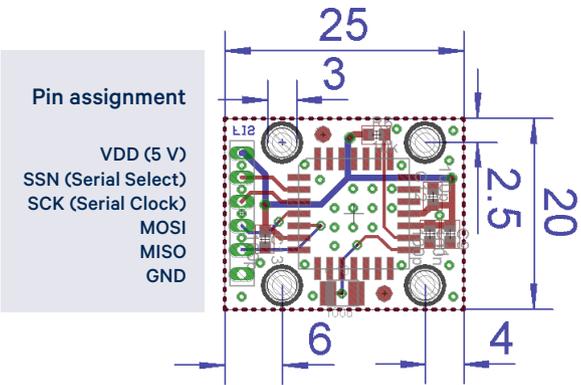
Dimensional drawing and electrical connection

Caution:
The product can be damaged by incorrect connection. Please double check the cable configuration between sensor and control board.

Control board



Sensor board



dimensions in mm

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User manual of the terminal software

The software that is used for evaluation of the sensors is a simple terminal program and runs under Windows operating systems. In case of using Linux as operating system please contact us. The evaluation kit is powered using the USB interface. Therefore, no additional reference voltage is necessary. The software is running without an installation. However, it is necessary to install the drivers of the FT232R USB serial converter. Please connect the sensor board “SensB01.SX-XX.S1.C-XX” with the control board “ConB01.SX-SPI” (for the correct connections check the pin assignment) as well as the control board with a PC. When the new hardware is detected automatically, continue the installing using manual selection of the drivers which are located in the folder “.../First Sensor/driver”. The drivers are correctly installed if you have done this procedure two times. In case that the hardware is not detected automatically, it is recommended to use the device manager for selecting the unknown hardware and installing of the required drivers.

Other software, for instance specialized measurement programs, can also be used if they are capable of sending and receiving correct command strings. Each command string send from the controlling computer has to be terminated by a CR-LF sequence (Carriage Return, Line Feed, Ox0D0A). Commands that are not terminated with his sequence are not recognized as valid by the microcontroller. The microcontroller responds to valid commands by executing the requested commands and sending a response string, also terminated with CR-LF sequence. For communication with the control board “ConB01.SX-SPI” it is necessary to setup correct parameters for the additional COM-port. After starting the program using “HTerm.exe” please verify that the preconfigured parameters are selected as shown in Figure 1. The correct COM port that is used for the evaluation kit is obtained by using the device manager of the PC.

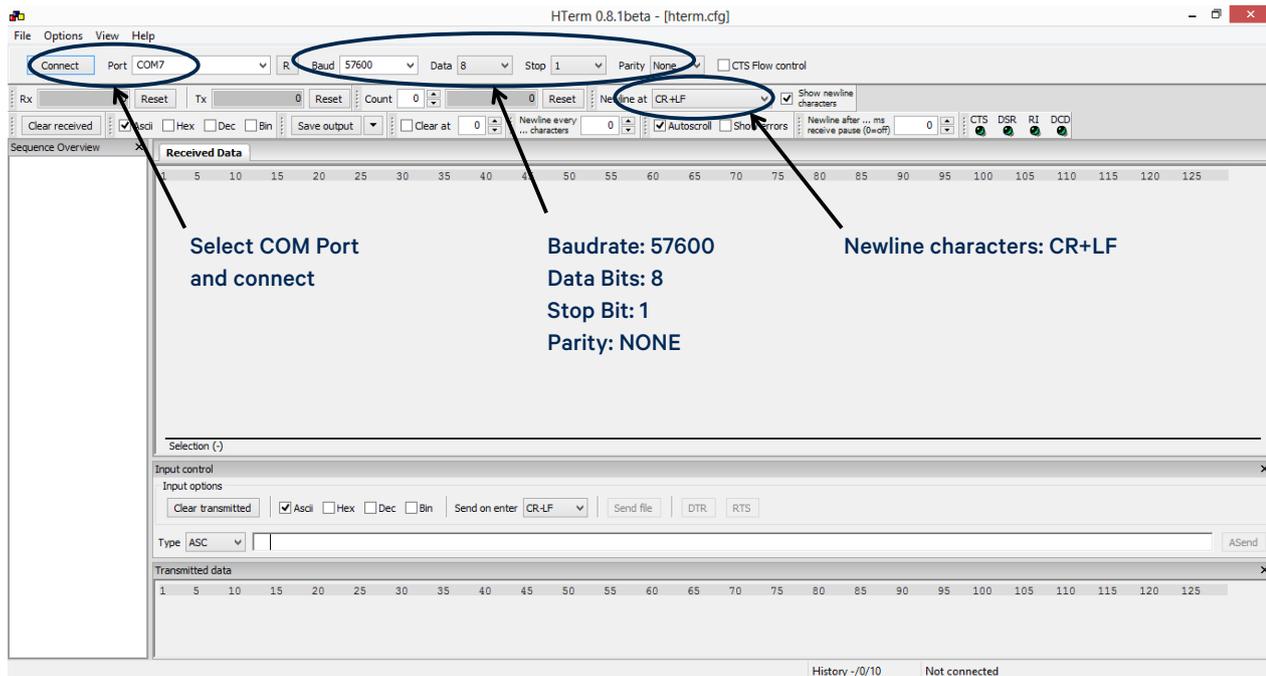


Fig. 1: Control panel of the terminal software and selection of the COM-port parameters

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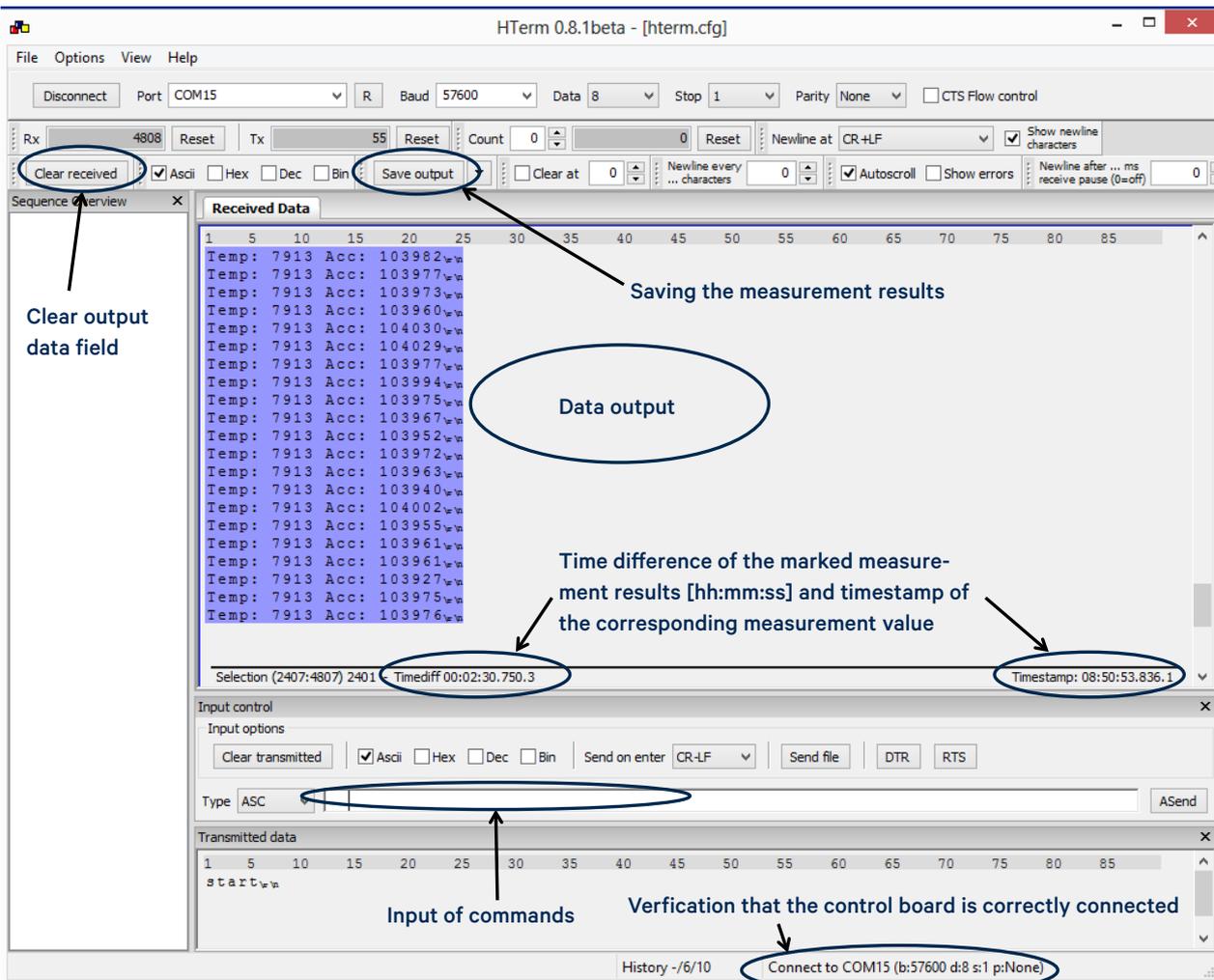


Fig. 2: General overview of the control panel

As shown in Figure 2 the control panel consists of two general buttons (clearing the received data and saving the measurement results), a data output section, a read out of the timing information as well as a command line interface.

To store the measurements results the button “Save output” is used. The default kind of the result file is similar to a text file format. Please note, that the complete data of the output section is stored in the result file. Therefore, clearing the output data field is recommended before starting the measurement. This is done by pressing the “Clear received” button.

Furthermore, after the measurement has been finished it is possible to read out the duration of the measurement. Using “Ctrl+a”, all data of the output section is marked and the time difference is shown in the timing information line. Otherwise the timestamp of the operating system could be used to calculate the duration of the measurement. In this case it is necessary to read out the timestamp of the first and the last measurement result.

To adjust the measurement and the sensor parameters some simple commands are necessary. A list of available commands is depicted in Table 16 and shown in the data output section when the command HELP is written in the command line and finished using the enter button.

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Overview of available commands using the terminal software

Command	Usage/value	Description
Using the following commands it is possible to configure the measurement parameters and to receive status information of the register values.		
START		Starts output of measurement results over serial interface. Output values will be the current chip temperature and the current acceleration of the selected axis. Please note that results are raw data, expressed in [LSB] and without any compensation. To convert the raw data into a corresponding temperature in [°C] or acceleration in [g] please see chapter "5.3 First Measurements".
STOP		Stops output of measurement results over serial interface.
HELP		A list of all available commands and their usage is shown.
RSYS	ADD	Read the 32 bit data from the corresponding address of the system register. The kind of input is RSYS ADD value.
RSYS	ALL	List of all system register values. The kind of input is RSYS ALL.
SET	A or B	SETA or SETB is used to select the sensitive direction of the sensor. Up to now, simultaneous read out of both sensor channels is not possible. However, you can switch between the two channels using the command SETvalue (value A or B is written without space).
PARAM	LIST	List of the configured sensor settings and the corresponding values of the registers. The kind of input is PARAM LIST.
PARAM	AVG	The command PARAM AVG is used to control the averaging factor as well the output data rate of the evaluation kit. Allowed values are 1..255. Default value is 1 leading to an output data rate of about 100 Hz in case of using default values of OBW and DSE. Due to the USB interface 200 Hz is the maximum output data rate. To calculate the output data rate equation (4) is used (see chapter "4.3 Filter and Output Data Rate Registers"). If you exceed the maximum output data rate of 200 Hz by configuring OBW and DSE, please use PARAM AVG to decrease the output data rate of the evaluation kit. Usually the noise of the sensor is proportional to the square root of the output data rate. The kind of input is PARAM AVG value.
PARAM	NR	Sets the number of measurement points. Allowed values are 0..50000. If 0 (default value) is set, the sensor does continuous measurements. The kind of input is PARAM NR value.
LVM		Enables the low voltage mode. Allowed values are 0 (normal operation) or 1 (low voltage mode using 1.2V measurement voltage (default: 1 (SI) and 0 (SA)))
To configure the sensor settings the command WSYS is used. The usage of the command refers to the adjusted register name and possible values are also described in chapter "4. Description of System Registers". The kind of input is WSYS usage value.		
WSYS	DOS	Configures the Filter Decimation Output selection. Allowed values are 0 = normal output, 1 = DCF is bypassed and 2 = DCF and HBF are bypassed. (default: 0)
WSYS	OBW	Configures the Filter Decimation Factor. Usually changing the Filter Decimation Factor during operation requires a resetting. However, this is done automatically. Allowed values are 0..7 (default: 3).
WSYS	DSE	Configures the Down Sampling Factor and determines the ration between the output bandwidth and the output data rate. Allowed values are 0 and 1 (default: 0)
WSYS	CLK	Configures the Sampling Frequency of the excitation voltage. Allowed values are 1..127 (default: 100)
WSYS	VREF	Configures the Voltage Reference required for driving the sensors excitation. The voltage can output 2.1V and up to 4.4V that is adjusted using allowed values between 0..15 (default: 0)
WSYS	GAIN1	Configures the Sense Gain Control 1 of both sensor channels. Allowed values are 2..15 (default: 11 (SI) and 12 (SA), should be adjusted to application specific value)
WSYS	GAIN2	Configures the Sense Gain Control 2 of both sensor channels. Allowed values are 0..7 (default: 5 (SI) and 2 (SA), should be adjusted to application specific value)
WSYS	ADCA	ADC digital Gain of Channel SetA. Allowed values are 0..524288 (default: 500)
WSYS	ADCB	ADC digital Gain of Channel SetB. Allowed values are 0..524288 (default: 500)
WSYS	OFTA	Offset Trimming of Channel SetA by adjusting the positive terminal, the negative terminal is configured automatically. Allowed values are 3141..8191 (default: 5667)
WSYS	OFTB	Offset Trimming of Channel SetB by adjusting the positive terminal, the negative terminal is configured automatically. Allowed values are 3141..8191 (default: 5667)
WSYS	SF0, SF1, SF2, B0, B1, B2, T0	Coefficients of Scale Factor, Bias and nominal temperature in quadratic equation. Nominal temperature is 64 times higher than the raw data of the temperature sensor in normal operation mode. (see Table 15 for allowed values)
WSYS	CSEL	Sensor output selection (1 = normal output, 0 = calibrated output using the temperature coefficients).

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First measurements

First Sensor's accelerometers feature a digital output signal Out_{raw} expressed in [LSB]. The output signal is described as linear characteristic in dependency of the occurring force or acceleration Acc respectively. According to equation (1) the slope of the characteristic is given as scale factor K_1 and the intercept of the characteristic is given as the bias K_0 .

$$Out_{raw}(Acc) = K_1 \cdot Acc + K_0 \quad (1)$$

Inclination sensing uses the gravity vector and its projection on the axes of the low-g accelerometer to determine the tilt angle. Referring to basic trigonometry, the projection of the gravity vector on the corresponding axis leads to an output acceleration equal to the sine of the angle between the accelerometer axis and the horizon. The horizon is typically taken to be the plane orthogonal to the gravity vector. For an ideal value of 1 g for gravity, the output inclination is calculated using equation (2).

$$Tilt = \arcsin\left(\frac{Acc}{1g}\right) \quad (2)$$

According to IEEE Std 528-2001 the scale factor K_1 of the accelerometers is defined as the ratio of a change in output to a change in the input intended to be measured. The scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data. The scale factor of the digital accelerometer is expressed in [LSB/g]. Furthermore, the bias K_0 is the average over a specified time of accelerometer output measured at specified operating conditions that has no correlation with input acceleration or rotation. The bias is expressed in [LSB].

Because there is no factory calibration of the sensor output signal it is necessary to determine both coefficients. Usually special tools for determination of the coefficients are not required. To calculate the scale factor and the bias according to equation (3) and (4) please turn your device to a vertical position and perform a measurement. Afterwards repeat the measurement using the opposite direction of rotation.

$$K_1 = \left(\frac{Out_{raw,+90^\circ} - Out_{raw,-90^\circ}}{Acc_{+90^\circ} - Acc_{-90^\circ}} \right) \quad (3)$$

$$K_0 = \left(\frac{Out_{raw,+90^\circ} + Out_{raw,-90^\circ}}{2} \right) \quad (4)$$

After calculating of both coefficients equation (1) is used to obtain the acceleration Acc utilizing the raw data of the measurement as well as the scale factor and the bias. It is also possible to use different tilt positions (for example $\pm 15^\circ$ or $\pm 30^\circ$) to obtain the coefficients K_1 and K_0 .

The integrated temperature sensor also features a digital output signal. Similar to the calculation of the acceleration the output signal of the temperature sensor is given in the following equation (5).

$$Out_{raw}(Temp) = K_1 \cdot Temp + K_0 \quad (5)$$

The scale factor of the temperature sensor is 80 LSB/K and the intercept of the characteristic is about 5950 LSB. Also the temperature sensor is not factory calibrated. For instance the 7950 corresponds to 25 °C.

Ordering information

Order #	Series	Sensor element	Signal conditioning	Housing	Measurement range
53001503	EvaK04.SI- [Inclinometer]	11. [$\pm 30^\circ$ measurment range]	S1. [24 bit ASSP]	C [Ceramic LCC28]	-30 [$\pm 30^\circ$]
Order #	Series	Sensor element	Signal conditioning	Housing	Measurement range
53001606	EvaK06.SA- [Accelerometer]	12. ± 3 g measurment range			-3 ± 3 g
53001601	EvaK01.SA- [Accelerometer]	13. ± 8 g measurment range	S1. [24 bit ASSP]	C [Ceramic LCC28]	-8 ± 8 g
53001604	EvaK05.SA- [Accelerometer]	14. ± 15 g measurment range			-15 ± 15 g