

HallinSight® **Magnetic Measurement System**

MANUAL INTERFACE

Documentation of Interface and Protocol
for Manual Operation

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Version 2.0

Version	Date	Changes
1.0	2020-03-20	Initial Version
1.1	2020-04-21	Revised Version
2.0	2021-08-01	More Sensor Modules Added

Version History

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1

Basic Information

This document contains all information on operating a HallinSight® Magnetic Measurement System via its serial interface and lists available commands of the communication protocol.

Even if it was composed to the best of one's knowledge it cannot be guaranteed that all specifications are correct. Therefore, all information is specified as subject to change as well as errors and omissions are excepted.

For possibilities of user specific adaptations of the HallinSight® Technology and further information please visit www.iis.fraunhofer.de/hallinsight

1.1

Operating Conditions

The HallinSight® Magnetic Measurement System was designed for indoor use in laboratories and under moderate conditions. It is not designed for outdoor use or rough conditions. The magnetic sensors are calibrated for use within an ambient temperature range from 10 °C to 30 °C. As the sensors heat up during measurement, the sensor temperature should not exceed 55 °C. If the sensors are operated outside this range a temperature warning is transmitted because the best metering precision cannot be guaranteed.

Please note that 3D-printed parts of the camera housing of some systems are only approved for temperatures up to 60 °C.

1.2

Customer Support

For questions and troubleshooting please contact the customer support at the Fraunhofer Institute for Integrated Circuits IIS: hallinsight@iis.fraunhofer.de

2 Hardware Interface

For communication with the HallinSight® System it has to be connected to an USB port on a PC or on another compatible device that supports USB. The USB connection is realized via a serial interface (CDC device class over virtual COM port) and uses an ASCII-based protocol for communication.

2.1 USB Driver Installation

When connecting the HallinSight® System to the USB interface (e.g. on a PC) for the first time the driver for the USB interface has to be installed. Since it is a common serial port driver many systems are providing a suitable driver (COM port). If the installation was successful, a new entry in the list of serial ports should exist. (On Windows PC: Device Manager: *WIN+R: devmgmt.msc* -> "Ports (COM & LPT)". You should find a new entry called "USB Serial Device".) Note the assigned COM port for opening the port and communication with the measurement system.

2.2 Interface Configuration

Once the driver is installed you can communicate with the HallinSight® System via the virtual COM port. You can use any terminal program e.g. Putty or Hterm for communication as well as measurement environments like LabVIEW or Matlab. Recommended port settings are: Baudrate 115200, 1 stop bit, no parity, 8 data bits.

Once the port is open you can send the ASCII characters and will get ASCII coded answers from the interface. The only strong requirement is to terminate every transmission to the port with a line feed character (String: `\n`, decimal: `d10` or hexadecimal: `h0A`). All enclosed answers are also terminated with line feed so they can be easily detected. Some answers are multiline formatted so you will have to read more than just one line to get the full answer. Please see section 8 for detailed description of the answers.

2.3 Hardware State

The state of the measurement system is indicated with multiple signal LEDs. These are mounted inside the camera housing and can be seen from the outside. Green LEDs indicate the state of the power supply. Blue signal LEDs indicate the state of the controller operating system to reset the system. One LED is toggled every second to indicate that the operating system is running. If this LED is not blinking you should reconnect the power supply. A second static blue LEDs show that the measurement system is in ready state. The third blue LED is glowing as long as a measurement is active. A red LED is the indicator for hardware errors. If the red LED is active the sensor module is defective or an error during communication with the connected sensors has occurred.

3 Software Protocol

3.1 Commands

Communication with the HallinSight device is done with ASCII characters and is based on view simple commands. All sent commands have to be terminated with line feed (\n or h0A or d10). All enclosed answers are also terminated with line feed. If any error occurs, the answer starts with "ERROR:" followed by a short error description. Table 1 gives an overview of the available commands:

Command	Description	Answer	2 nd Input
'H' or 'h'	Show help	Full help as text	none
'I' or 'i'	Print device info	Hardware info, serial numbers, sensor positions	none
'A' or 'a'	Set averaging	"Set averaging value (max. 65535):"	1 – 65535 (uint 16bit)
'C' or 'c'	Set configuration	"Set measurement config:"	0 – 4
'G' or 'g'	Perform single-shot measurement	Timestamp and full set of measurements in binary single precision float format	none
'M' or 'm'	Perform timer based measurement	Timestamp and full set of measurements in binary single precision float format	none
'R' or 'r'	Reset sensors	"Reset sensors..."	none
'S' or 's'	Stop measurement	"Stop measurement..."	none
undefined	Undefined input	"ERROR: Invalid command. Type 'h' for help!"	none

Table 1: Available commands for communication with measurement system

3.1.1 Undefined Input

Any unknown input will result in getting back following error message:
"ERROR: Invalid command. Type 'h' for help!"

3.1.2 Show help

This command shows a greeting message and all available commands as menu.

3.1.3 Print device info

This command prints details of the connected hardware. It is transferred in two blocks and every line is terminated with line feed. The first block shows information about software version, serial number of the hardware, connected microcontroller, used sensor type, available configurations of the system and number of 3-D sensors (pixels). The second block contains all serial numbers and geometric positions of the pixels. The serial numbers of the sensors are transferred in hexadecimal format followed by the geometric positions of the sensor pixels:

Pixel Nr. \t Sensor Serial \t Pixel 0 X (mm) \t Pixel 0 Y (mm) \t Pixel 0 Z (mm) \n

3.1.4 Set averaging

With this command averaging of measurement results can be set. Sending this command will result in the answer *"Set averaging value (max. 65535):"*. The user is now prompted to send a second input that has to be a number between 1 and 65535. Any other input will result in getting an error message and keeping the old averaging value. The sent number is echoed and terminated with line feed. The measurement results are transmitted as arithmetical mean value.

3.1.5 Set configuration

This command sets the measurement mode of the HallinSight® System. Table 5 shows available modi. It depends on the purchased measurement hardware, if multiple measurement modi are available and which range and configuration they provide. The set index is echoed and terminated with line feed. Selecting an invalid mode will result in getting an error message and keeping the old configuration. Afterwards all measurements are performed with the chosen mode.

Mode	Measurement Range	Active Pixels	Integration Time	Measurement Frequency
0	Fixed range	Dual pixel	2 ms	25 Hz
1	+/- 100 mT	Dual pixel	2 ms	25 Hz
2	+/- 400 mT	Dual pixel	2 ms	25 Hz
3	+/- 800 mT	Dual pixel	2 ms	25 Hz
4	+/- 2000 mT	Dual pixel	2 ms	25 Hz

Table 2: Standard Measurement modi

3.1.6 Perform single-shot/timer based measurement

This command starts a single/continuous timer based measurement with the set averaging and the chosen configuration. Every data block starts with a timestamp formatted in binary unsigned 32 bit integer and is followed by all sensor measurement results formatted in binary single precision float values (32 bit). The block is terminated with stop byte h85 (d133) and contains occasionally stuff bytes h79 (d121). To avoid stop bytes within the data block, every occurring stop byte is marked with a leading stuff byte h79 (d121). Every stuff byte has to be removed from the data block and the following byte has to be decremented by 1 to get the original value. After decoding the data block the measurement result can be interpreted to single precision float format (one single timestamp and 8 entries for every FH5401c sensor):

Timestamp - Error Code - Sensor Temperature (°C) - Bx of Pixel 0 (μT) - By of Pixel 0 (μT) - Bz of Pixel 0 (μT) - Bx of Pixel 1 (μT) - By of Pixel 1 (μT) - Bz of Pixel 1 (μT)

For a detailed description of the error code see the section 3.2.

3.1.7 Reset sensors

With this command all connected sensors are reset to an initial state. The command is confirmed with the message *"Reset sensors..."*. After a successful reset an additional initialization message will be send. A reset might be necessary if one of the critical errors occur (see section Error Treatment).

3.1.8 Stop measurement

The stop command stops a continuous measurement. The command is confirmed with the message *"Stop measurement..."*.

3.2 Error Handling

There are two kinds of errors that can occur. The first kind is a configuration or hardware error. Those always result in receiving an error message that starts with "ERROR:" and is terminated with line feed. If you receive an error message, your input could not be interpreted or the connected hardware is not working properly. In any case you should interpret the message and either correct your input or reset the connected sensor to bring them in a proper state again. Hardware errors can be caused by poor supply over USB, EMV pulses during operation or mechanical damages to the sensor hardware. Following error messages are implemented:

During every communication:

ERROR: Invalid command. Type 'h' for help!

During configuration:

ERROR: Configuration not available! Please select a configuration between x and y!

ERROR: Averaging value invalid. Please select number between 1 and 65535!

During initialization and/or measurement:

ERROR: Wrong sensor ID determined. Please connect suitable sensor module!

ERROR: Sensor addresses corrupted. Please reset sensor module!

ERROR: Error during sensor initialization. Please reset sensor module!

The second type of error can occur during a measurement. Therefore with every measurement of a sensor an error code is transmitted. If the code is equal to 0, the measurement was performed without errors. Every deviation indicates an error that can be treated for the individual sensor that delivered the error. The error code is composed of several error bits and has to be interpreted bitwise. See Table 3 for possible error flags and how to handle the related measurement result.

Error Code (binary)	Error Name	Description	Recommended Action
0	No error	Measurement ok	-
1	Ready error	Sensor decimation faulty: Measurement not finished yet	Discard measurement result
10	Calculation error	Sensor calculation faulty: Error during sensor post processing	Discard measurement result
100	Temperature warning	Sensor temperature out of limits (15°C – 55°C)	Keep temperature within limits
1000	Range warning	Sensor ADC overflow: Sensor signal out of range	Discard result and change <i>Module Range</i>
10000	Overflow warning	Sensor sensitivity overflow: Sensitivity correction out of range	Discard measurement result
100000	Histogram warning	Sensor ADC histogram failure: ADC value not plausible	Discard measurement result
1000000	Normalizing warning	Sensor normalizing overflow: Error during sensor post processing	Discard measurement result
10000000	Correction warning	Sensor correction overflow: Internal angle calculation error	Ignore (not affecting magnetic measurement result)

Table 3: Error codes during measurement

The error code has to be interpreted bitwise. Examples:

Code (b00000000): No Error

Code (b00000001): Ready Error

Code (b00000100): Temperature Warning

Code (b10100010): Combined Calculation, Histogram and Correction Error

The temperature flag should be monitored if maximum metering precision is needed.

4 HallinSight® Sensor Modules

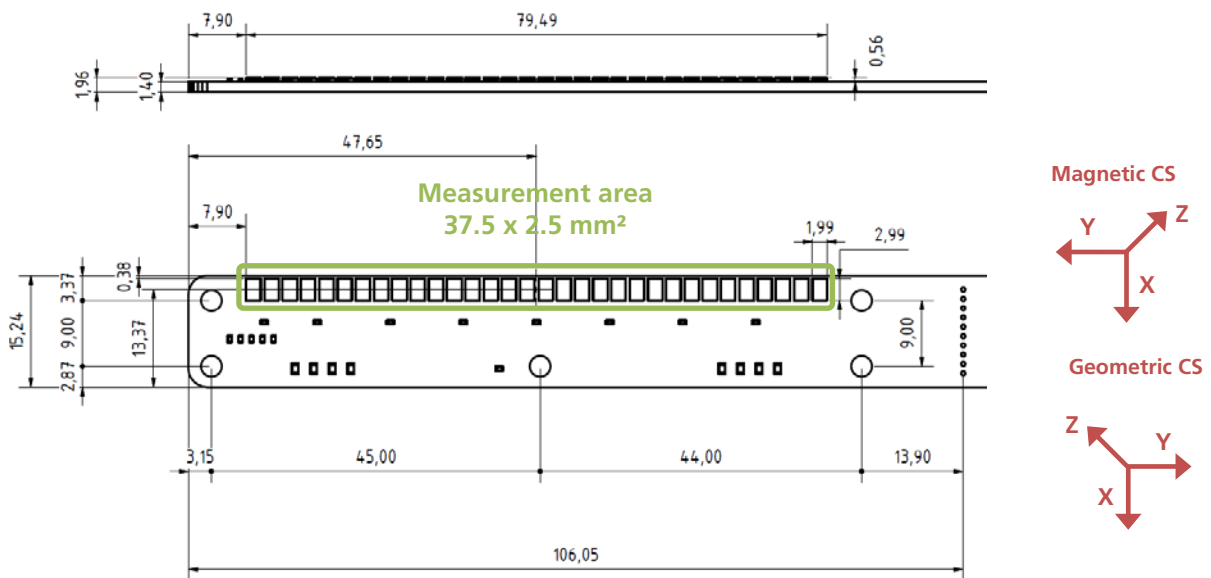
Different HallinSight® Sensor Modules are available. Hardware geometrics, coordinate systems and technical features are specified below. All geometric measures are in *mm*; coordinate systems (CS) are right-handed (order: x-y-z).

4.1 32x2 Pixel Line Array (Line Array 64 Pixels)

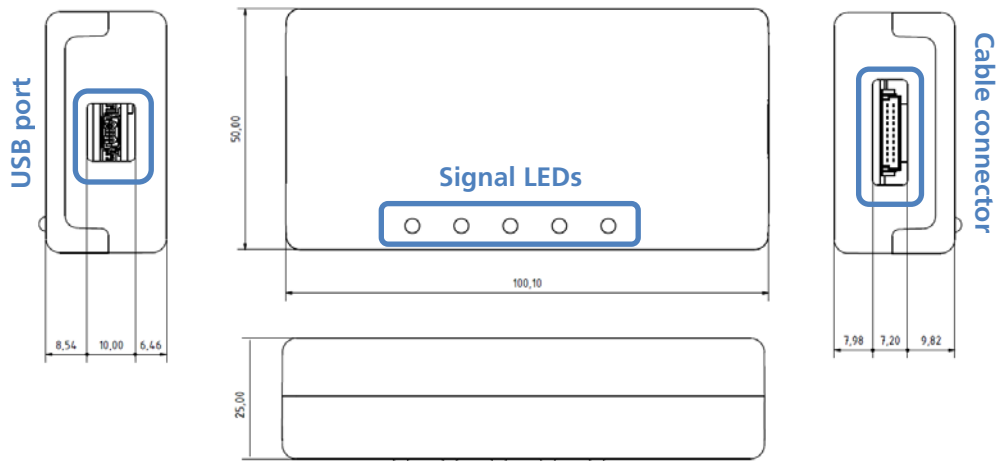
The sensor spacing in X- and Y-direction is 2.5 *mm*. The measuring distance in Z-direction is given by the sensor package and amounts about 360 μm (see chapter 5).

The 32x2 HallinSight Pixel Line Array is delivered without a case for flexible integration in systems. The PCB provides mounting holes for fixation in customer applications. For dimensions of PCB and mounting see following drawings (all dimensions in *mm*).

This HallinSight system is split in two parts: The PCB containing sensors, and the interface box that is connected to the sensor PCB with a ribbon cable and provides the USB connector for power supply and communication.



Interface box:



4.2

16x16 Pixel Plane Array (Plane Array 512 Pixels)

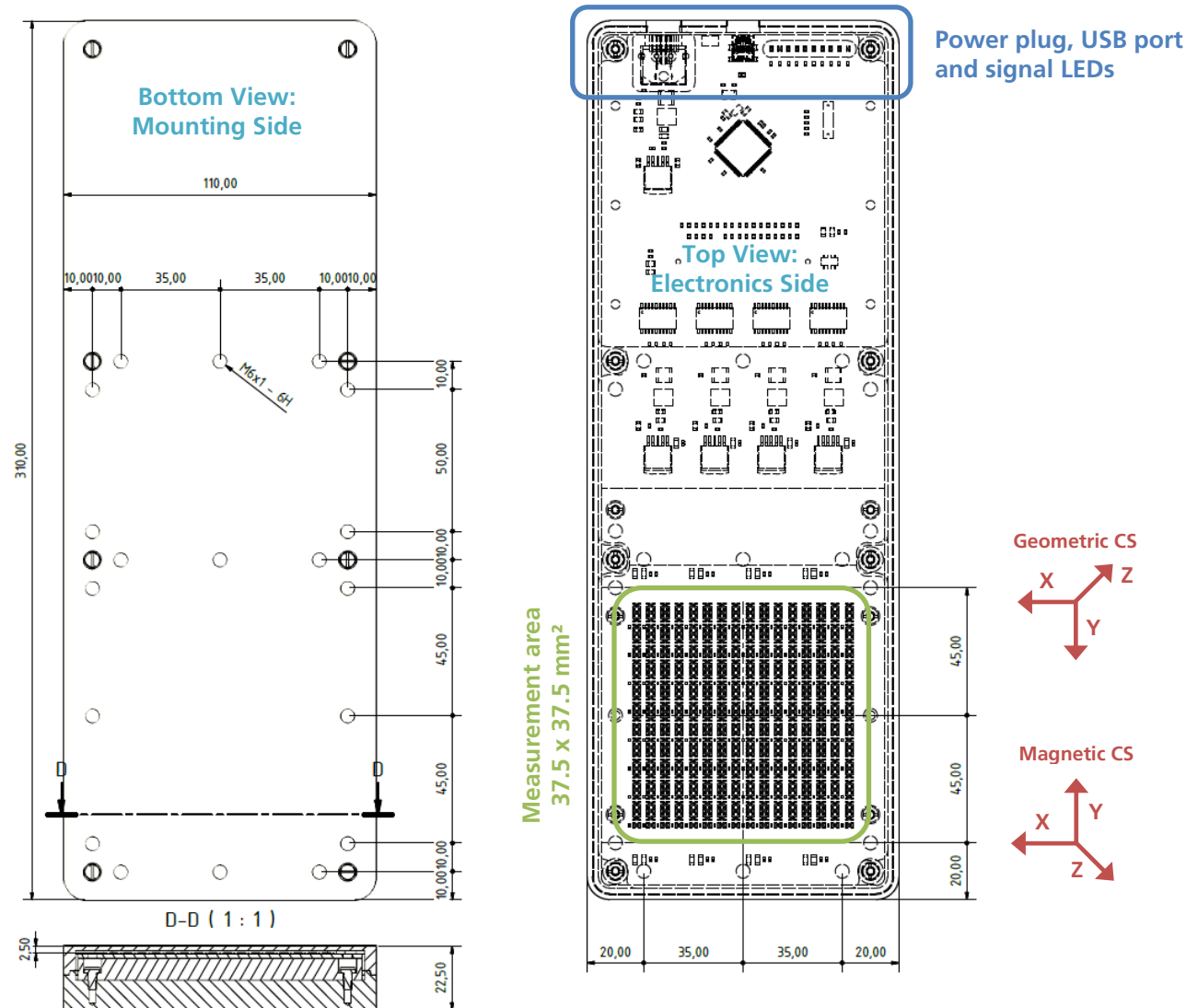
tbd

4.3

32x32 Pixel Plane Array (Plane Array 1024 Pixels)

The sensor spacing in X- and Y-direction is 2.5 mm. Measuring distance in Z-direction (distance between active sensor and case) is also 2.5 mm.

The 32x32 HallinSight Pixel Array is delivered with an aluminum case. The case provides mounting holes for integration in customer applications. For dimensions of case and mounting see following drawings (all dimensions in mm).



5 Technical Characteristics

5.1 Operating Conditions

Parameter	Value	Unit	Note
Operating Temperature	10 - 30	°C	ambient
Global Power Supply	5	V	max. 6
USB Power Supply (USB 2.0)	5	V	max. 5.25
Supply Voltage of Sensors	3.3	V	max. 3.6
Current Consumption per Sensor	10	mA	max. 15
Trigger In/Out Level	3.3	V	max. 3.6

5.2 Magnetic Specifications

All HallinSight® Magnetic Measurement Systems are fully calibrated in a magnetic reference field. The following characteristics are valid for the standard configuration of the sensors for a *Dual Pixel* measurement with a metering range of *100 mT*. Magnetic resolution and noise are directly related to metering range and scale with lower or greater ranges. All specifications are valid for operation in ambient temperature range.

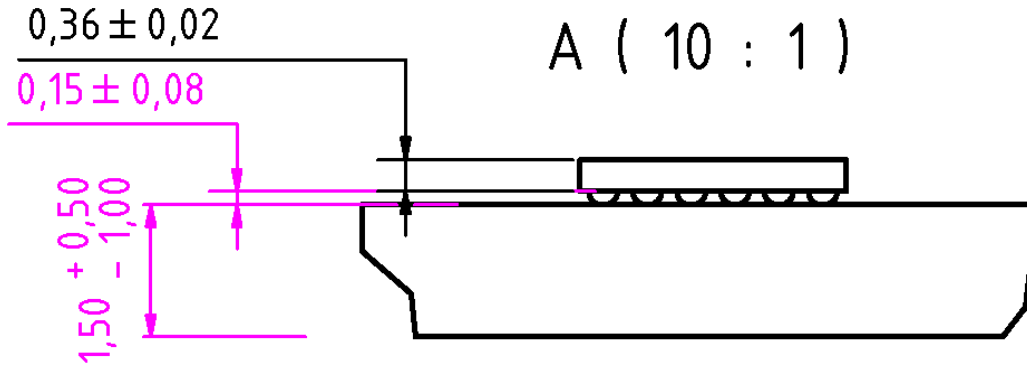
Parameter	Value	Unit	Note
Magnetic Resolution	4	μT	no avg.
Magnetic Accuracy	0.1	%	typ.
Magnetic Offset	25	μT	typ.
Magnetic Remanence	<1	μT	typ.
Magnetic Noise	25	μT	RMS
Measurement Integration Time	2	ms	no avg.
Sensor Lateral Position Error on PCB	<50	μm	typ.
Sensor Vertical Position Error on PCB	<10	μm	typ.
Sensor Rotational Position Error on PCB	<0.1	°	corrected

**Technical
Specifications**

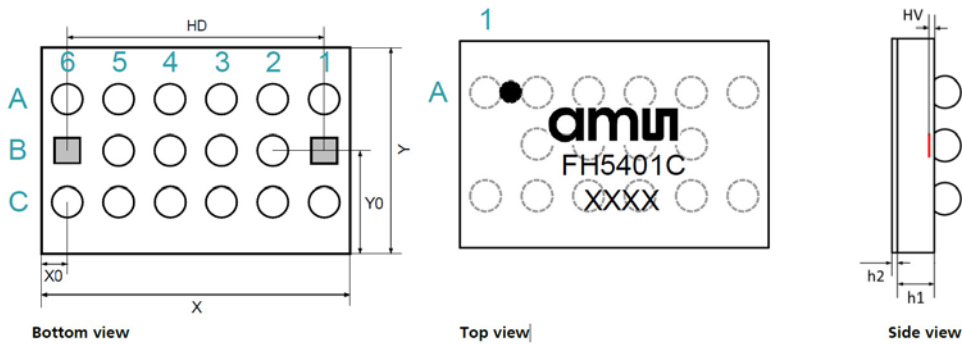
5.3

Geometric Sensor Details

The actual sensitive area is located on the bottom side of the soldered IC. The circuit board thickness is highly variable depending on the system. In contrast, the chip thickness has very low tolerance.



Every FH5401c sensor contains two 3-D Hall sensors (pixels) for vectorial measurement of magnetic fields. Geometrical dimensions of the sensor and the position of the actual sensitive sensor area can be extracted from following figure and table.



Parameter	Symbol	Typ	Unit
Chip Length	X	3035	μm
Chip Width	Y	2035	μm
Hall Sensor Distance	HD	2500	μm
x-Distance Edge-Sensor	X0	285	μm
y-Distance Edge-Sensor	Y0	1035	μm
Hall Sensor Vertical	HV	30	μm
Total Chip Thickness	h1 + h2	360	μm

Geometric Specifications