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2. GENERAL DESCRIPTION

The SENIS® SENA2Dx Eval Kit is designed for evaluation of the fast magnetic angle sensor (FAMAS) sensor to measure the rotation angle of the in-plane components of a magnetic field. Figure 2 shows the location of the field sensitive volume (FSV) which dimensions are about 100 x 100 x 10 μm³. The kit allows users to run and test the SENA2Dx sensor quickly and it includes the mounted sensor on a printed circuit board (PCB), a control box with a RaspberryPi (RasPi) to communicate and configure the sensor as well as cable and power supply (Table 1). There is green LED on the PCB to indicate if the sensor is powered.

For details please consult the data sheet of the SENA2Dx sensor chip <https://www.senis.ch/sensors>.

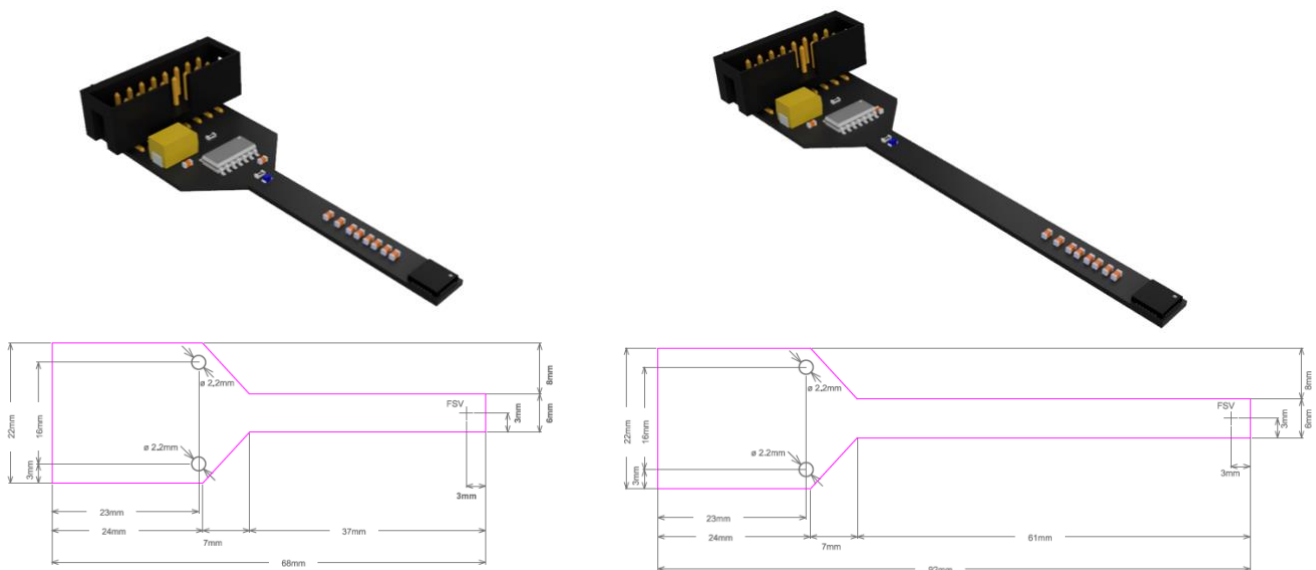


Figure 1: Two different evaluation PCB sizes are available. Left: Version 1.0a; Right: Version 1.0b; The location of the field sensitive volume (FSV) is indicated and it placed about 0.75 mm below the chip surface.

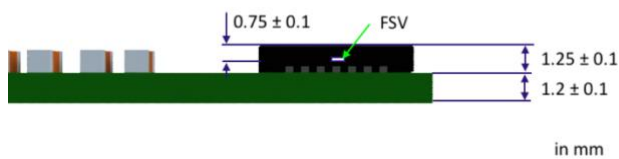


Figure 2: Vertical position of the field sensitive volume (FSV)

Important Note: It is recommended not to hot-plug the evaluation PCB to the RasPi. So, please make sure that the RasPi is switched off (i.e. disconnect device from power supply) and disconnect also the HDMI cable since some screens may deliver power through the interface.

2.1 Eval Kit Content

Figure 3 shows the content of the evaluation kit. The item number labels correspond to the description in Table 1

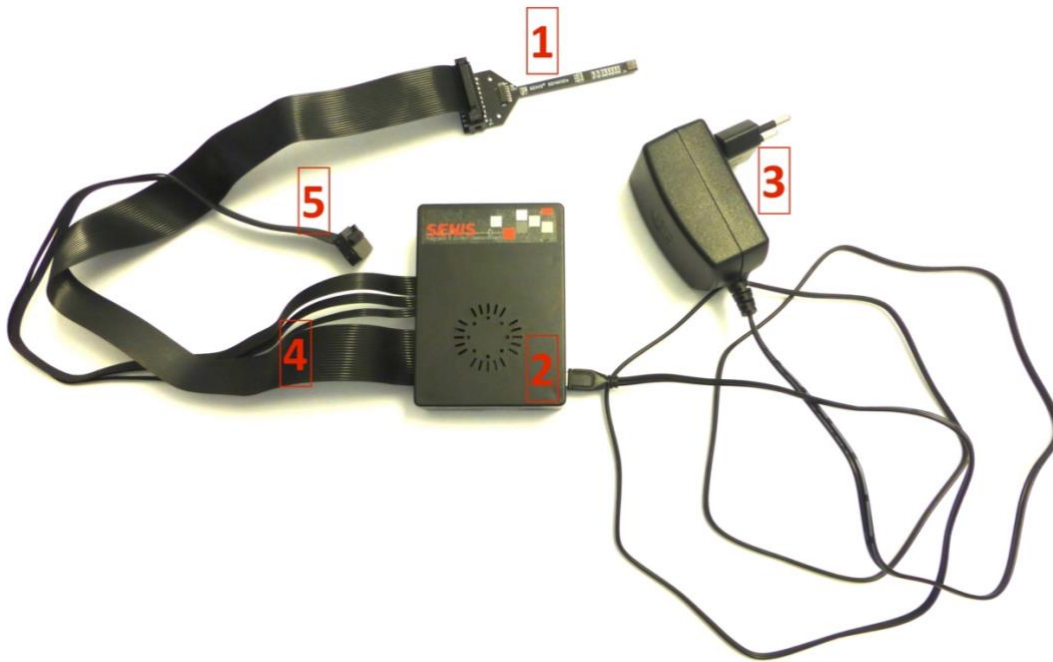


Figure 3: Evaluation kit content.

Item No.	Item	Description
1	Evaluation PCB v1.0a or b	1.2 mm thick FR4 PCB with SENA2Dx sensor mounted
2	Control Box	Provides SPI Interface, API and GUI
3	Power Supply¹	5V original Power Supply with microUSB connector
4	Connection Cable 01	16-way ribbon cable to connect the Control Box (2) to the Evaluation PCB v1.0 (1); IDC connector CON01
5	Connection Cable 02	14-way ribbon cable to give access to voltages and digital outputs of the SENA2Dx; IDC connector CON02

Table 1: Evaluation Kit Content

¹ The original power supply should be used to operate the eval kit. Otherwise, min. 5.1V output voltage and 2.5 A rated power supply needs to be connected.

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3. INTRODUCTION

The small adapter PCB is fully equipped with the SENA2Dx sensor and its necessary components for stable and reliable operation. All relevant signals are available on a 14 pin (2 x 7) IDC connector (Table 3; Figure 5). There is no need to install software to operate the sensor since the RasPI 3B provides the serial peripheral interface (SPI), advanced programming interface (API) and everything is pre-installed on the microSD card including the operating system. The RasPI is the SPI master and controls the sensor chip.

Since SENA2Dx is equipped with an one time programmable (OTP) memory, the user may write once the most favorable settings to the memory and operate the sensor without RasPI connected (external power supply needed in this case).

The voltages (VCM, VDD, etc.) are accessible for users to monitor the power domains of the sensor.

4. HARDWARE SET-UP

4.1 Connector CON01 – Sensor Adapter PCB and Control Box

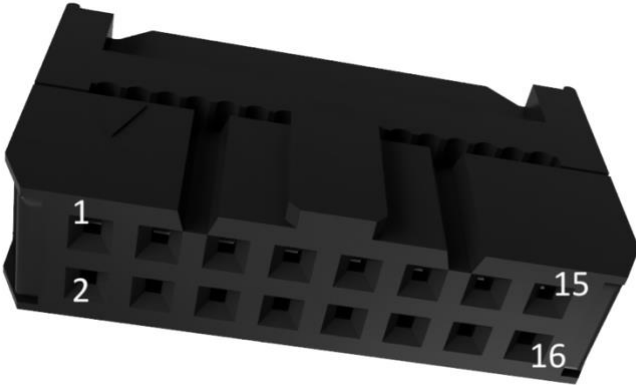


Figure 4: IDC connector CON01 head female, pitch 2.54 mm, 16 poles

CON01 pin	Signal	Description
1	VREF	Reference Voltage (+1.25 V); power
2	VCM	Virtual Ground (+2.25 V); output
3	GND	Ground (analog & digital)
4	VCCA	Internal regulated analog supply voltage (4.5V); power
5	VCC	Main Supply Voltage of the adapter PCB incl. SENA2Dx sensor(+5V); power
6	TEST_EN	For internal use only; do not connect
7	TEST_DMUX	For internal use only; do not connect
8	MCLK	SPI Interface Clock Signal
9	SSB	Chip (Slave) Select (active-low)
10	MOSI	SPI Interface Master Out Slave In Signal
11	MISO	SPI Interface Master In Slave Out Signal
12	VDD	Internal Core Supply Voltage (+3.3 V); power
13	GND	GND; power
14	Z_W	Digital Output
15	B/V	Digital Output
16	A/U	Digital Output

Table 2: IDC connector CON01 pin assignment



4.2 Connector CON02 – Voltages and Digital Output Signals

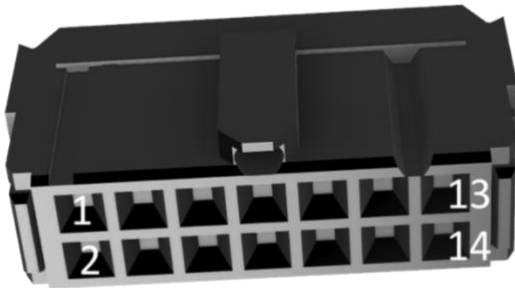


Figure 5: IDC connector CON02 head female, pitch 2.54 mm, 14 poles

CON02 pin	Signal	Description
1	VREF	Reference Voltage (+1.25 V); power
2	VCM	Virtual Ground (+2.25 V); output
3	-	NC
4	VCCA	Internal regulated analog supply voltage (4.5V); power
5	-	NC
6	TEST_EN	For internal use only; do not connect
7	TEST_DMUX	For internal use only; do not connect
8	-	NC
9	-	NC
10	VDD	Internal Core Supply Voltage (+3.3 V); power
11	GND	Ground (analog & digital); power
12	Z_W	Digital Output
13	B/V	Digital Output
14	A/U	Digital Output

Table 3: IDC connector CON02 pin assignment



4.3 Schematics of the test board

Figure 6 shows the schematics of the printed circuit board which is connected to the control box.

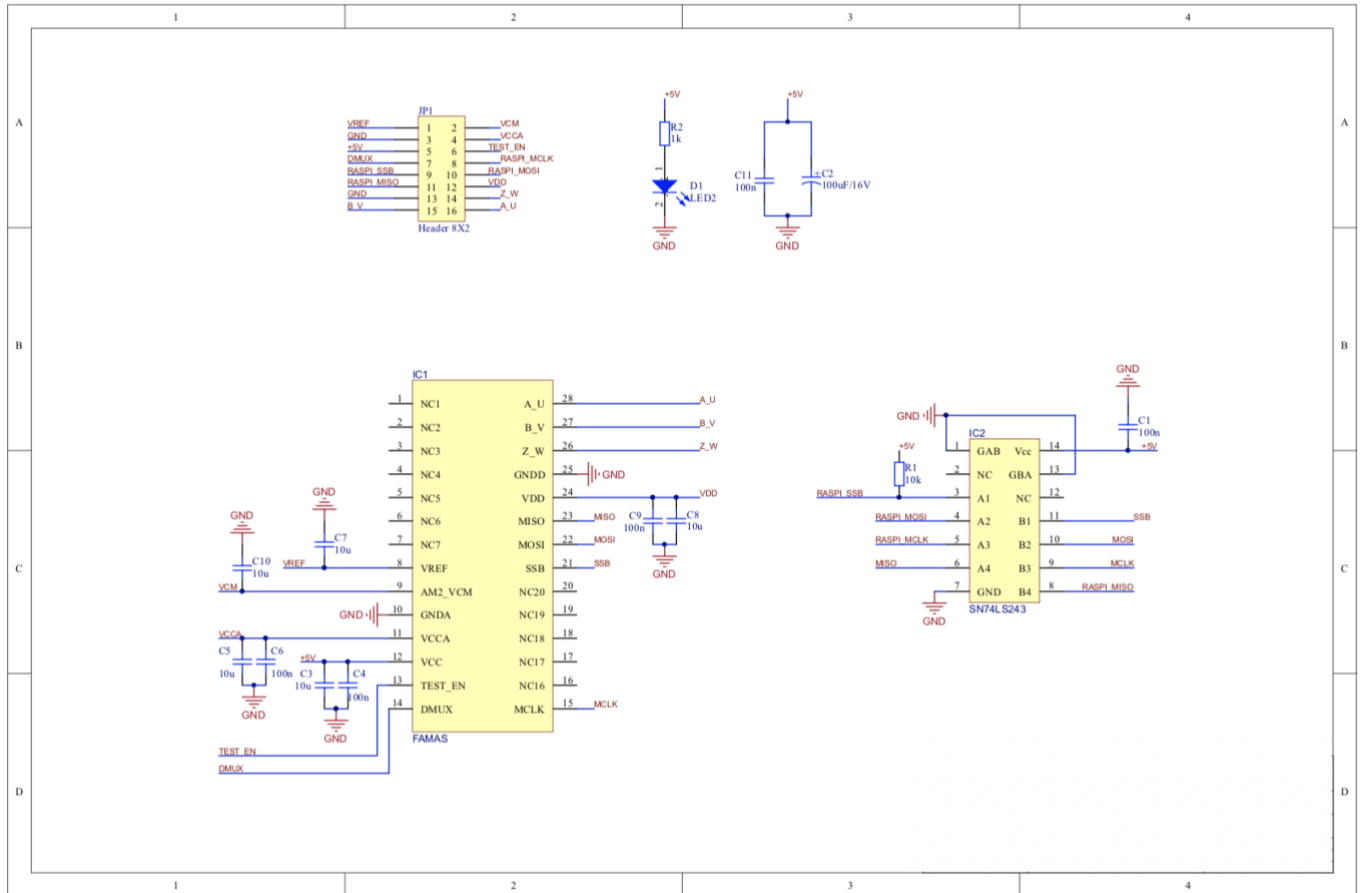


Figure 6: Schematics of the evaluation kit sensor board.

5. SOFTWARE

The RasPi is equipped with a 16 GB microSD card with all necessary software pre-installed and tested for Raspbian GNU/Linux version 10 (buster)² and python version 3.7.3³. Note that updates or upgrades of the system may cause compatibility issues and affect the functionality and/or performance of the software and libraries provided by SENIS.

All relevant files which are needed for the communication with SENA2Dx are located at /home/pi/software/famas_sw and subfolders.

5.1 Graphical User Interface

The graphical user interface (GUI) is part of the pre-installed SENIS software and provides basic functionality to read data from the SENA2Dx sensor as well as to control it. To start the GUI, the user has to double click the link at the desktop called "Run FAMAS GUI". If a pop-up window appears, choose Execute to run the GUI⁴.

The GUI is organised in four tabs: Sensor Control, Gauges, Angle versus Time and Save.

² <https://www.raspberrypi.org/documentation/raspbian/>

³ <https://www.python.org/downloads/release/python-373/>

⁴ To avoid this pop-up window open the file manager (pcmanfm): Edit->Settings->General: check the "Don't ask options on launch executable file"

The **Sensor Control** tab (Figure 7) allows to control the most important functions of the sensor chip, such as the front-end gain (Set Gain) to choose the magnetic sensitivity, the operation mode (hi-precision, balanced, hi-speed, user-def) and to verify the SPI interface. At any time, the current angle resolution and selected sensor operation mode is displayed. To achieve best performance, it is advised to set the gain to the highest value (10).



Figure 7: Image of the FAMAS Control tab.

The **Gauges** tab (Figure 8) represents live the current angle reading and rotational speed measured by the sensor.

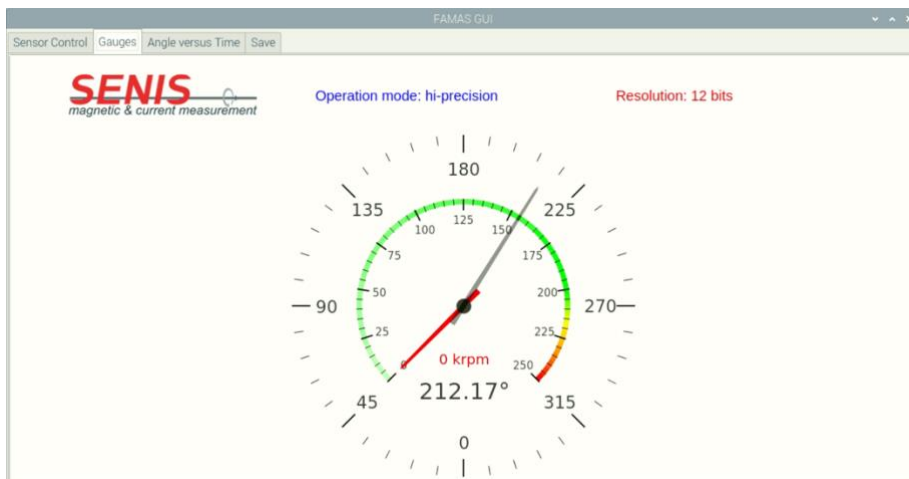


Figure 8: Image of Gauges tab.

In the **Angle versus Time** tab (Figure 9) the user can observe the angle reading against time. At higher rotational speed, the of the sensor data may be read and represented too slowly, so that there appears aliasing. Also, the time stamps are not strictly equidistant, thus the angle representation may appear not as a linear function of time at constant rotation speed.

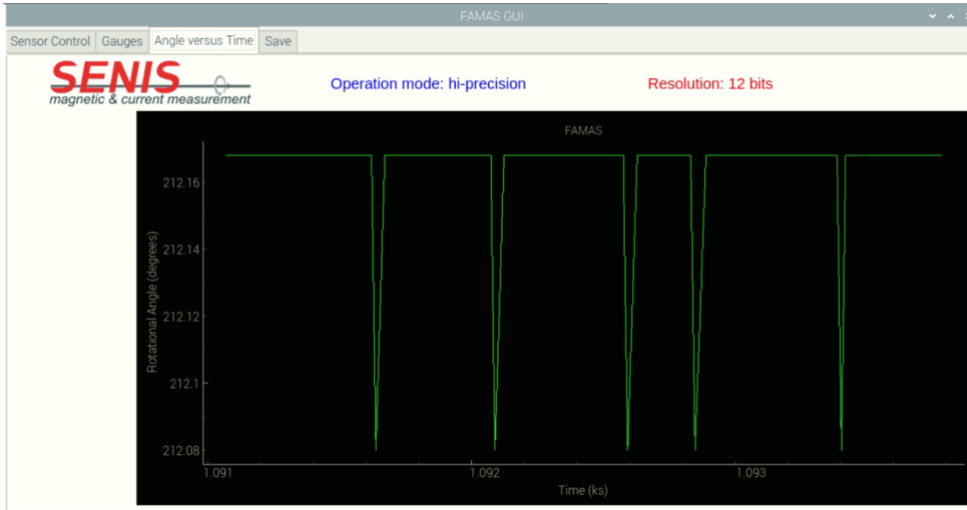


Figure 9: Image of Angle versus Time tab.

The **Save** data tab (Figure 10) allows the user to save the actuals rotation angle data against time in a csv file. The tab consists of:

- A text field to define the file path and name, which is also possible by clicking on the symbol next to it.
- Save and Stop buttons which allow to start and stop data saving on-the-fly.
- The save n number of samples button with a text field, which allows to save a certain number of data points.
- A plot area to show the sampled data, which is saved to the csv file.

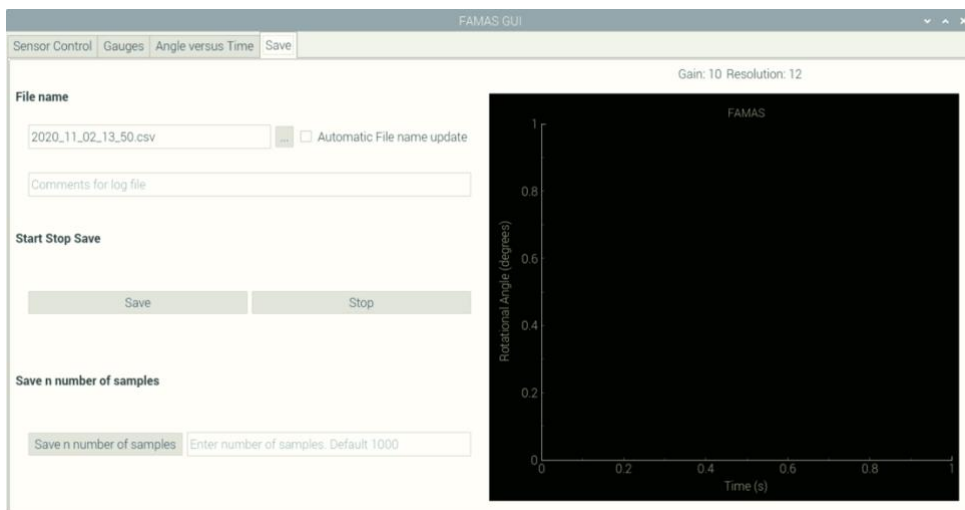


Figure 10: User Interface Save data tab.



Finally, Figure 11 shows an example of a saved data file in csv format which can be used for further analysis.

```
2020_11_02_14_52.csv x
1 Comment:
2 Time in seconds; angle
3 180.83274066448212, 212.16796875
4 180.84905185364187, 212.16796875
5 180.8630895242095, 212.16796875
6 180.87648553494364, 212.16796875
7 180.93368219863623, 212.16796875
8 180.96197691280395, 212.16796875
9 180.9984902953729, 212.16796875
10 181.05116596259177, 212.16796875
11 181.08895292505622, 212.16796875
12 181.1152144316584, 212.16796875
13 181.1340968972072, 212.16796875
14 181.16205317806453, 212.16796875
15 181.17854926083237, 212.16796875
16 181.1925485469401, 212.16796875
17 181.21494056098163, 212.16796875
18 181.22943453025073, 212.16796875
19 181.2544953711331, 212.16796875
20 181.26710868161172, 212.16796875
21 181.2809812501073, 212.16796875
22 181.2954342290759, 212.16796875
23 181.30775092821568, 212.16796875
24 181.3286696234718, 212.16796875
25 181.34061382617801, 212.16796875
26 181.35540721938014, 212.16796875
27 181.37132664117962, 212.16796875
28 181.38692497462034, 212.080078125
29 181.40325923636556, 212.16796875
30 181.41665529925376, 212.16796875
31 181.4305218262598, 212.16796875
32 181.44502996094525, 212.16796875
33 181.46767530590296, 212.16796875
34 181.48760244902223, 212.16796875
35 181.5064593423158, 212.16796875
36 181.51910223532468, 212.16796875
37 181.54413202502152, 212.16796875
```

Figure 11: Image of a saved csv file.



5.2 API

Since the GUI supports only a limited set of the SENA2Dx programming possibilities, the user gets access to the full functionality through the advanced programming interface (API). The API is implemented as interface class in the file `FamasInterface.py`. Furthermore, evaluation kit includes the entire source code of the firmware for the sensor.

Either use the link “Start FAMAS Interface” on the desktop to run iPython3 and invoke the interface, or do it manually, i.e. open a shell and type: `cd /home/pi/software/famas_sw && ipython3 -i init_interface.py`. If a pop-up window appears, choose “Execute in Terminal” to run the script. This will create an object “`famas_dev`” of the interface class, and the user is ready to access all methods and class variables. The most important methods are listed alphabetically and explained in the following section. Looking at the `init_interface.py` file should give an idea how the user can just create her or his own Python file and insert code to perform certain tasks.

5.2.1 Measurement and Log File Location

Measurement files are saved per default to the file location `/home/pi/data/measurement_data/` and log files are saved to `/home/pi/data/logs/` in time stamped folders.

5.2.2 Most Important API Methods

Initialise⁵ the interface class to get access to the API: `famas_dev = famas.FamasInterface()`

The following methods are then accessible with the “dot” operator e.g.: `famas_dev.closeSPI()`

Note that the utility methods, such as `write_bits_to_byte`, are not explained here. Often functions are shown with their default values for arguments e.g. `configureSPI(SPIMaxSpeedHz="7.8MHz")`.

`calc_angle()`

Reads the actual angle and returns angle value as float number.

`calc_rot_speed()`

Reads and returns the current rotational speed in rpm as float number.

`perform_B_field_measurement()`

⁵ Assuming that the interface is imported as `import FamasInterface as famas`

Triggers measurement of the magnetic field strength. The result stored in status register.

read_B_field_strength_reg_val()

After perform_B_field_measurement(), this bit is updated and returns 0 if magnetic field magnitude is > 15 mT and 1 for < 15 mT.

read_data_resolution()

Returns the current encoder resolution in bits. Possible values: 8, 9, 10, 12 (the resolution is set by the operation mode and/or filter)

read_fe_gain()

Returns current (front-end) gain setting as float number: Possible values 2.5, 5, 10

read_speed_meas_pre_scaler()

Returns the current pre-scaler setting.

reset_encoder_zero_pos()

Set the 0 deg position back to the original one (if it was zeroed - set_encoder_zero_pos())

set_encoder_to_AqB()

Choose ABI as digital output interface.

set_encoder_to_UvW()

Set UVW as output interface.

set_encoder_zero_pos()

Set current magnet angle position as 0 deg.

set_fe_gain(fe_gain_val=2.5)

Sets current front-end gain. Allowed values: 2.5, 5, 10

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set_operation_mode(data="hi-precision")

Choose the operation mode of the sensor. Valid parameters: "hi-precision", "balanced", "hi-speed", "user-def"

set_register_to_default()

This function resets the registers to their default (power-up) value.

set_speed_meas_pre_scaler(pre_scaler_sel=1)

Since at low rotational speeds the counter that keeps track of the rotational speed would overflow, the user may choose a pre-scaler. Valid values are: 1, 8, 84, 512

verify_spi_interface(iterations=100)

Performs read and write operations to verify SPI connectivity. The default is 100 read and write operations.

write_reg(reg_address=[0x10], data_to_write=[0x00])

The write register command is implemented as secure-write and returns True or False.