BHYxxx
Desktop Development 2.1 User Manual

BHYxxx User Manual

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1 About this user manual

This manual describes the installation and usage of the Development Desktop 2.1 User Interface (DD2.1 UI); a Windows based PC software application and related embedded firmware/software developed by Bosch Sensortec for demonstration and evaluation of sensors.

1.1 Who should read this manual

This information is intended for users who want to implement a robust BHy functionality into their applications.

1.2 Overview

- BHy and FUSER Core are connected via the sensor I2C interface (AUX I2C).
- The sensor I2C interface is accessible on the device pins of BHy, to help in further attaching the I2C sensors.
- In the BHy (BHA/BHI) shuttle board (used as reference for this document); an external magnetometer is connected to the sensor-I2C interface.
- BHy connects to the application processor with the I2C host interface, which supports data rates up to 3.4 Mbit/s.
- BHy can help in dynamic sensor configuration, which plays a major role in power consumption.

1.3 Concept of virtual sensors

In a sensor hub, the host processor does not have direct access to the physical sensors. It only accesses the so-called “Virtual Sensors”, which are actually implemented as software modules within the firmware of the hub.

BHy consists of wakeup and non-wakeup sensors. A wakeup sensor can interrupt the host, when either each sample is available or after the maximum report latency. In a non-wakeup sensor, the samples do not interrupt the host. Data for wakeup and non-wakeup sensors go in separate FIFOs.

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2 About the BHYxxx

2.1 Firmware Architecture

The Firmware architecture of BHy consists of two parts:

- **ROM mask**
  During manufacturing, ROM mask is released for integration into ASIC. This is the fixed version of the firmware.
- **RAM patches**
  RAM patches are released to enable bug-fixing, changes, and to extend functionality.

2.2 Key features of BHy

- Low power consumption
- Low cost
- I2C slave-host interface with High Speed mode (1 Mbit/s)
- Small package dimensions
- Bosch Sensor Fusion Library (BSX) integrated into ROM
- Mechanisms to apply firmware code during startup, so-called RAM patches
- Android batch support
- Android gestures (significant motion, step detector, step counter)
- Android K-data rate support and android L wake-up sensors support
- Activity recognition
- Virtual sensors can be configured independently (e.g.: rotation vector(wakeup) at 100 Hz, while gravity vector(wakeup)at 50 Hz)
- Re-configuring a virtual sensor will not interfere/interrupt the operation of other enabled virtual sensors
- Hooks to support additional virtual sensors (e.g.: altitude sensor)

3 Getting Started

The below sections highlight the procedure to set up connections between BHYxxx, DD2.1 UI, and the PC.

3.1 Setting Up the board-PC connection

The procedure to connect sensor to PC via USB is as below:

- Install DD2.1 UI.
- Insert the shuttle board and application board.

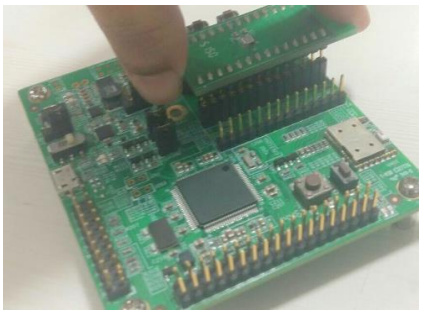

Figure 1 : Insert sensor for APP2.0

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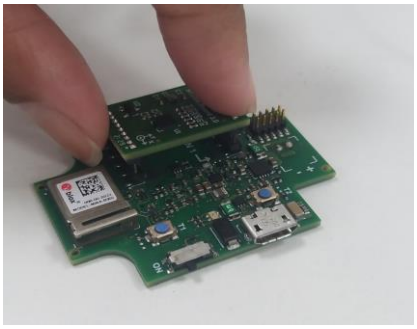

Figure 2 : Insert sensor for APP3.0

- Connect the board and PC using a USB cable/Bluetooth.

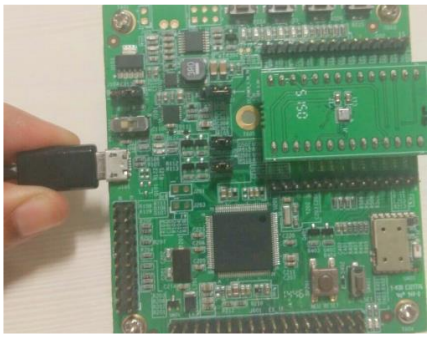

Figure 3 : Connect board and PC for APP2.0

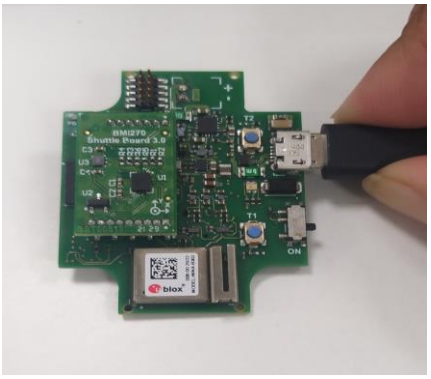

Figure 4 : Connect board and PC for APP3.0

- Turn the on/off switch **ON**. The LED glows.

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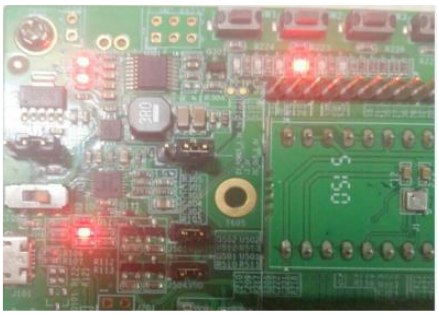

Figure 5 : Connection complete for APP2.0

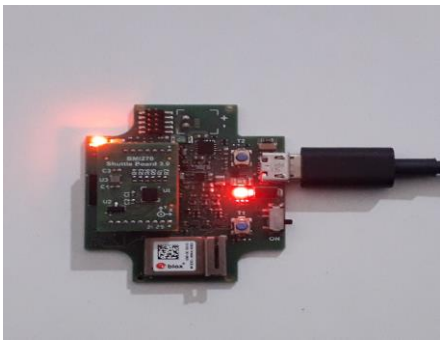

Figure 6 : Connection complete for APP3.0

3.2 Start-up view

To start the DD2.1 software:

- Click **Start > Programs > Development Desktop 2.1.**

Or

- Double click the DD2.1 software icon on the desktop.

The Graphical User Interface (GUI) of the software is as seen.

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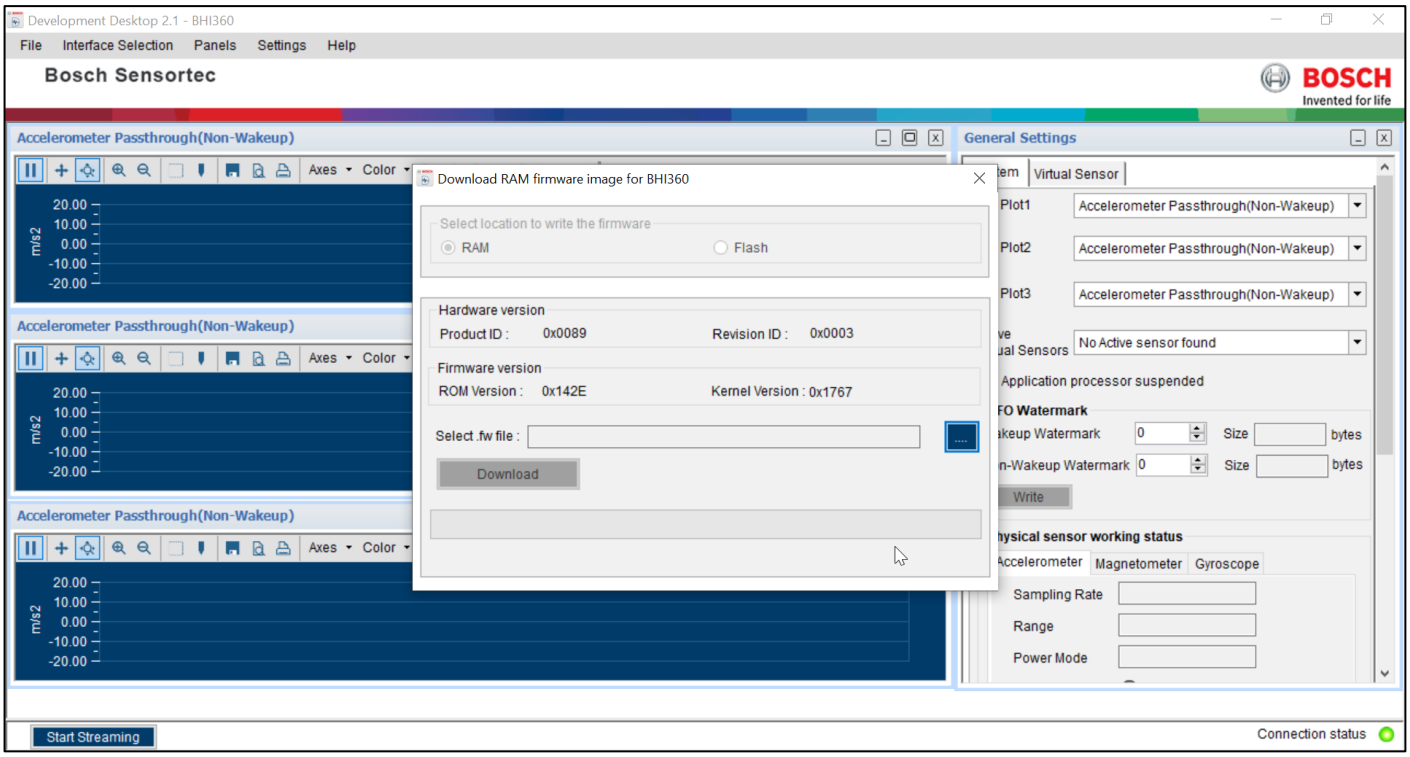

Figure 7 DD2.1 GUI

Open additional panels/views by selecting views from panel menu item.

When the PC (host) detects the BHy shuttle board, BHy patch download window will pop up and prompt for the RAM patch download. RAM Patch has to be downloaded for every power down and power up of BHy sensor. BHy patch download window will pop up only when BHy sensor is connected with the host.

All sensors are disabled by default and need to be configured before data streaming.

To receive BHy sensor data on the plotter UI, follow the below procedure:

1. Select the required virtual sensor in virtual sensor list under **Virtual sensor**.
2. Select the required Sample rate under Sample rate combo box.
3. Click **Write**.
4. Select the configured virtual sensor in plot1 /plot2 /plot3 under **System**.
5. Click **Start Streaming**. The selected virtual sensor data will be streamed in the plotter.
6. To stop data streaming, click **Stop.**

4 Working with DD2.1 – BHy

DD2.1 offers complete access to BHy sensor.

4.1 Patch file download

Patch download helps the user to download the RAM patch (the firmware) into BHy. The RAM version ID is zero by default, i.e. when no firmware has been downloaded to the device. The version of RAM will be updated once the SW patch download is finished.

To download patch file for BHy, follow steps as seen:

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1. Patch download window will pop up prompting for the RAM patch file download.

.fw file is available in Bosch Sensortec **->** DD2.1 folder.

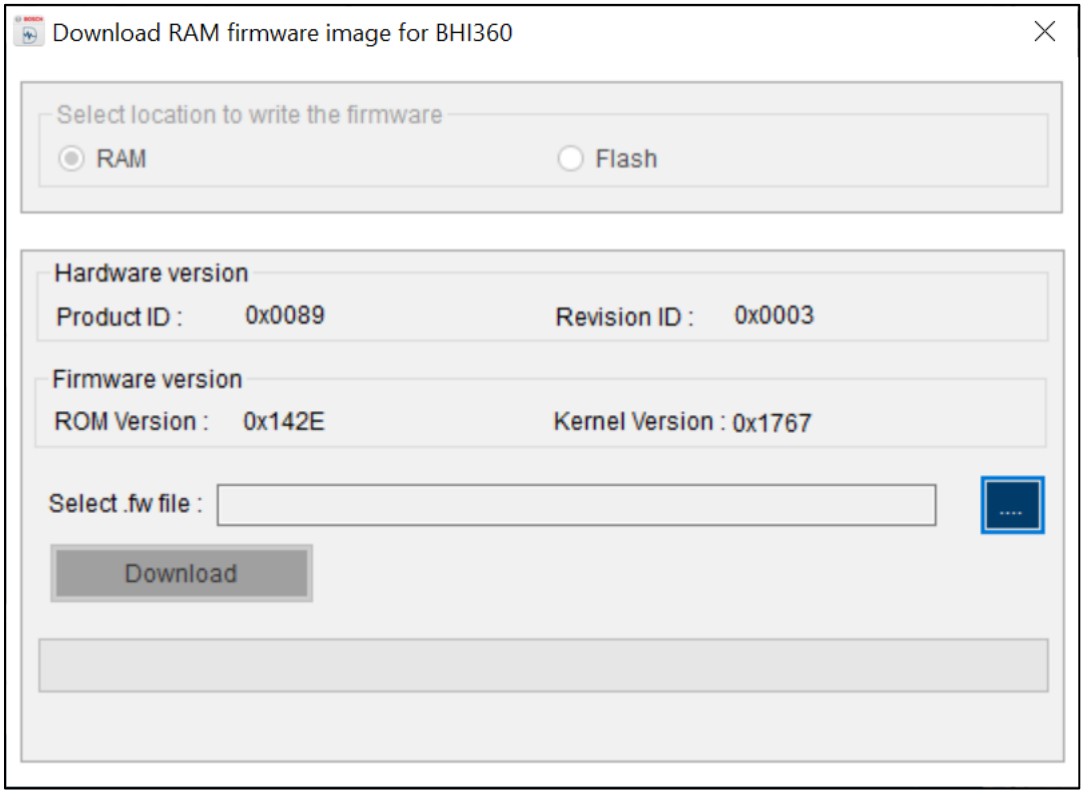

Figure 8 : BHy patch file download

2. Download *.fw* file for BHy RAM initialization. Firmware files for BHy are available at the *Firmware* subfolder of the DD2.1 installation.

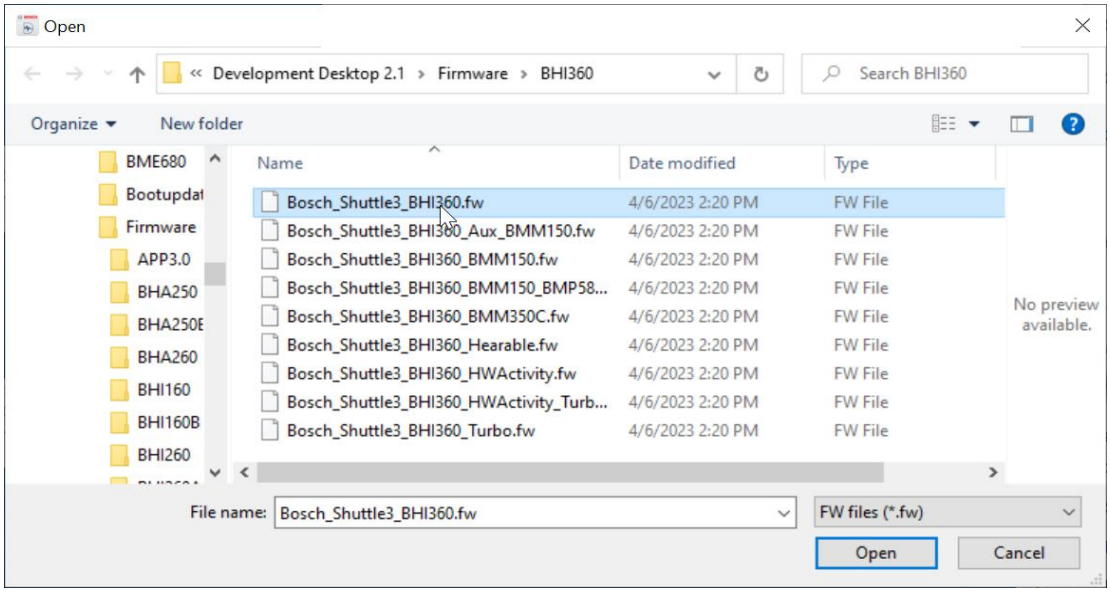

Figure 9 *: fw software patch file*

1. Click **Download** for BHy RAM patch initialization

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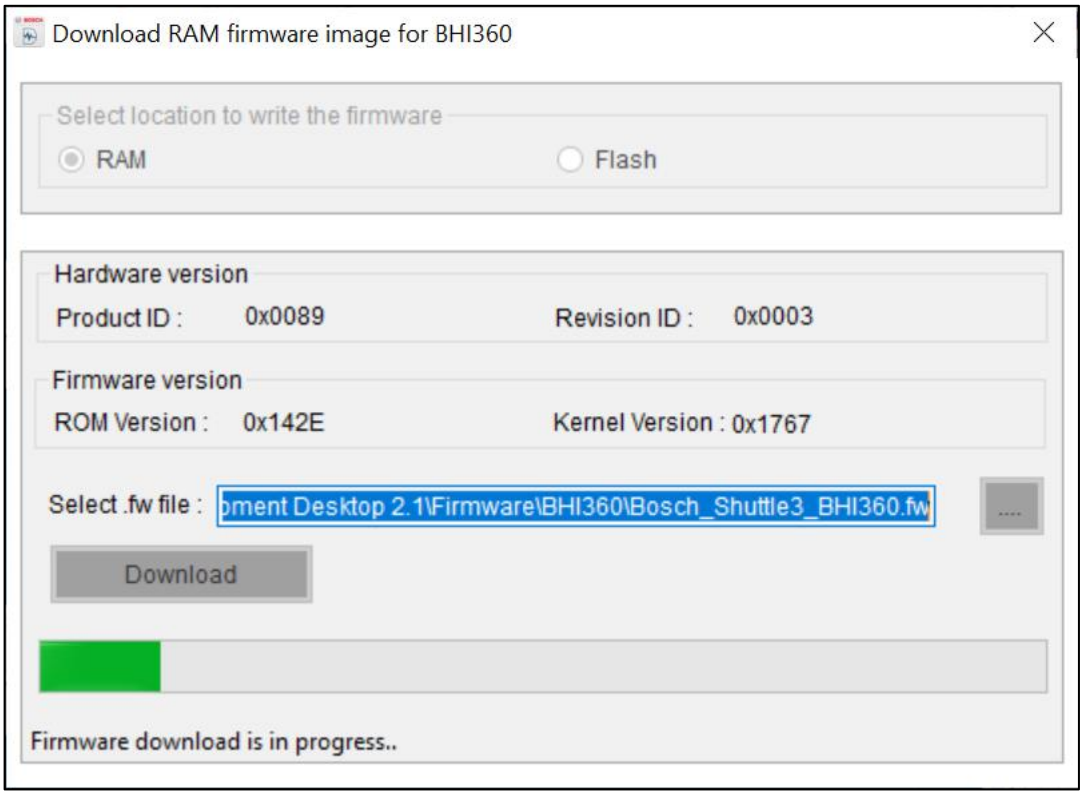

Figure 10 BHy patch download

2. Once the download is complete, the status message *"BHy firmware updated successfully"* is displayed on the BHy patch download window.

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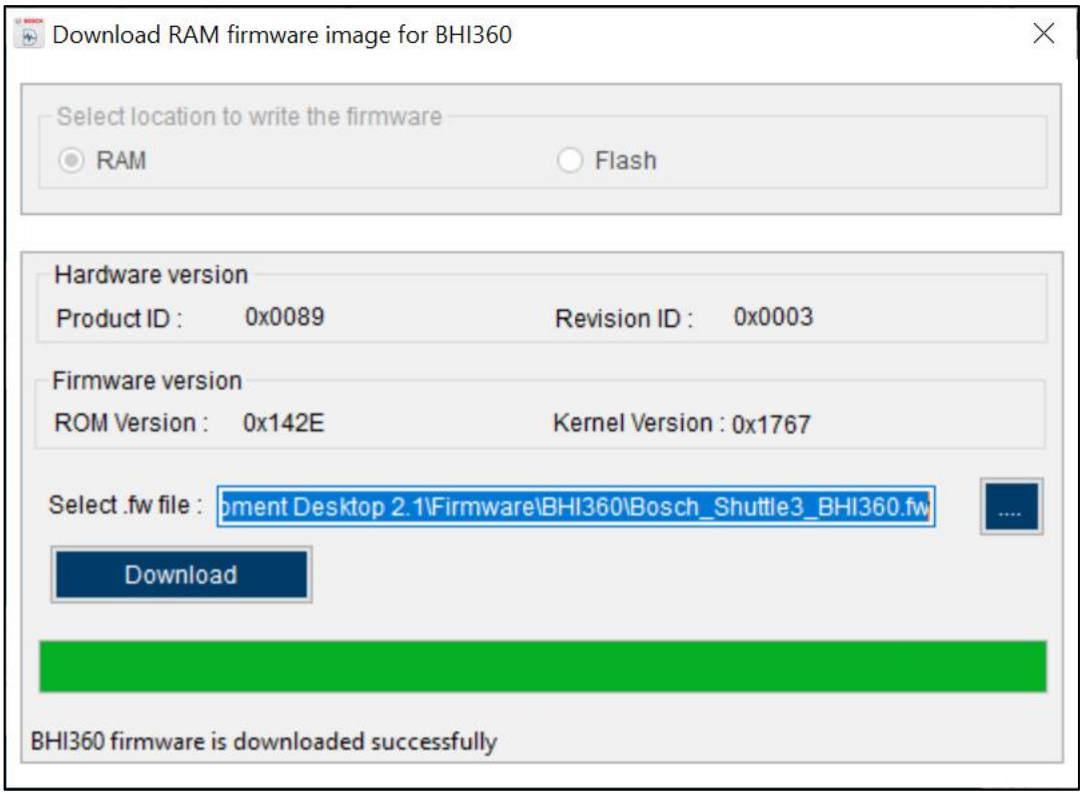

Figure 11 : BHy patch download completion

3. Product ID, Revision ID, ROM version, and updated RAM version is updated on the BHy patch download window.

4.2 General settings

The general settings of DD2.1 are available at the right side of the DD2.1 window. These settings are discussed below:

4.2.1 Virtual Sensor Configuration

Virtual sensors have to be configured by the user. The sampling rate, range, and maximum latency of any specific virtual sensor is configured under **Virtual Sensor**.

The easiest way to enable a sensor is to select a sample rate different from 0 Hz (Sample rate of 0 Hz disables the sensor). All other parameters are optional.

i. Write Info

The sampling rate, range, and maximum latency is configured for the selected virtual sensor under **Write Info**. Once this data is selected, click **Write** to transfer data into the device.

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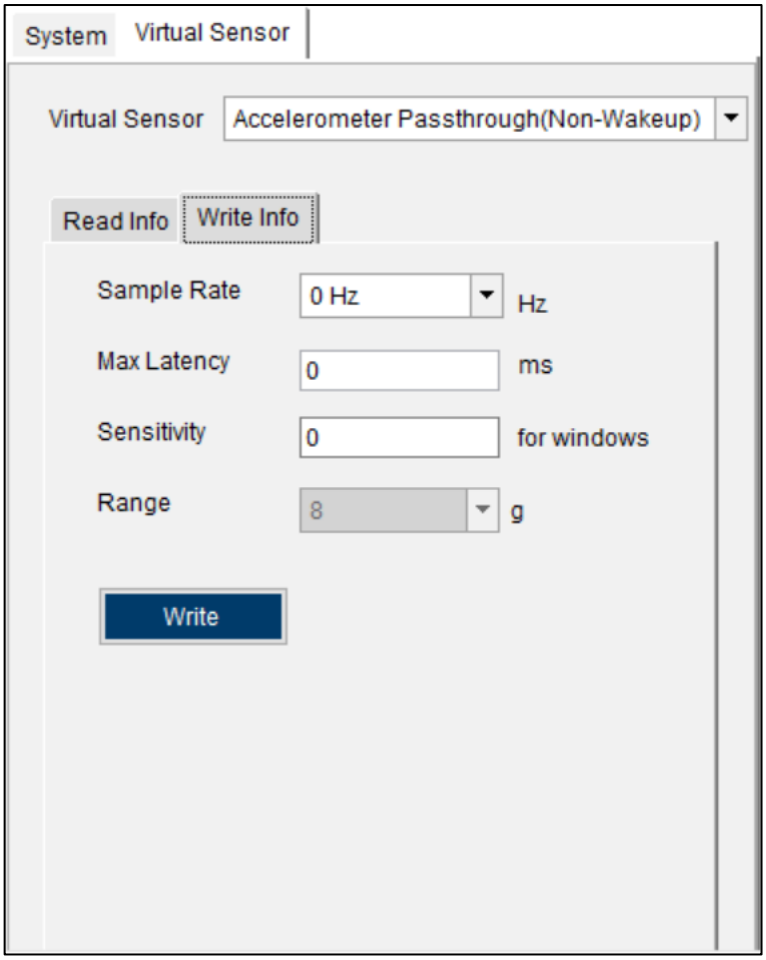

Figure 12 : Writing information into the device

To select sample rate, select it in the **Sample Rate** drop down box. Maximum latency is the time interval after which the interrupt is generated. Maximum latency value is set to zero for non-batch mode and non-zero for batch mode. If the maximum latency value is set in write info, batching is enabled for the selected virtual sensor. Sample rate and maximum latency can be written individually for each sensor.

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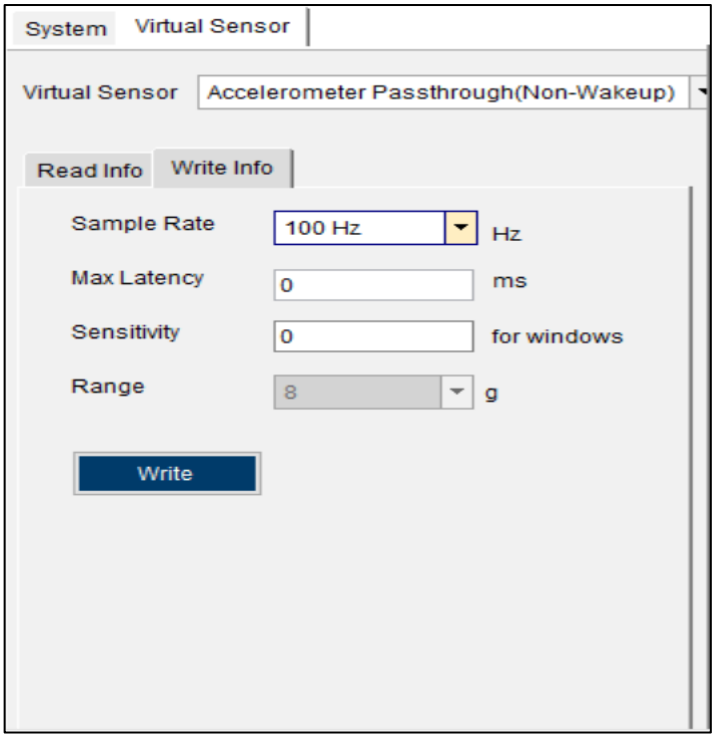

Figure 13 : Selecting sample rate

ii. Read Info

To read all virtual sensor information, click **Read Info** -> **Read**. This section provides the following information for the selected sensor.

- Sensor Type
- Driver ID
- Driver Version
- Power
- Max Range
- Resolution
- Max Rate
- FIFO Reserved
- FIFO Max
- Event Size

- Reserved

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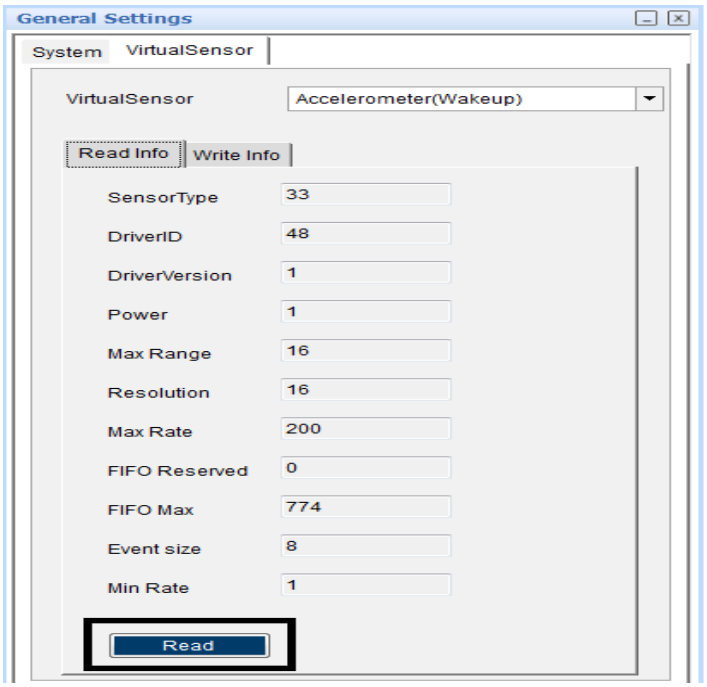

Figure 14 : Read Info Section

iii. Plotter selection section

Plot1, Plot2 and Plot3 are the three plotter selections available for virtual sensor selection.

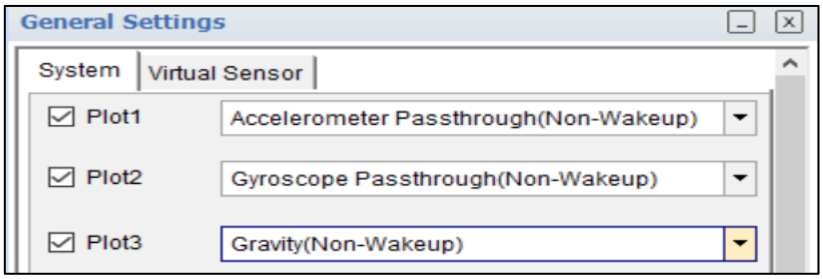

Figure 15 : Virtual Sensor Selection

Sensor data is plotted as a graph based on the virtual sensors selected under plot1, plot2 and plot3.

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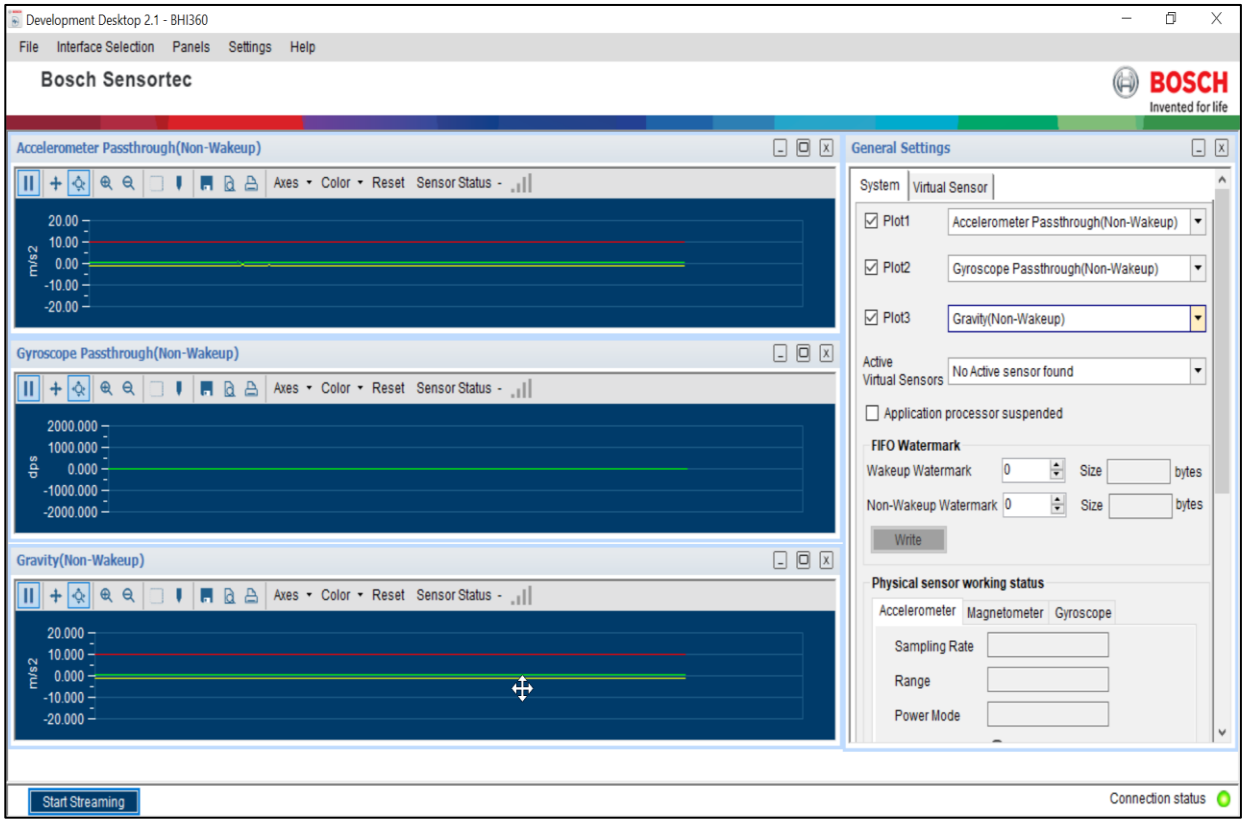

Figure 16 : Plotter Selection Section

4.2.2 FIFO Watermark

FIFO watermark level denotes the number of bytes in the FIFO buffer before the interrupt is initiated.

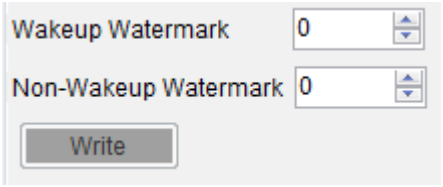

Figure 17 : FIFO Watermark

To generate a FIFO watermark, enable the FIFO watermark Meta event in Panels -> Sensor events and Meta events. The interrupt is generated once the FIFO reaches the specified watermark level. FIFO watermark levels are indicated individually for wakeup and non-wakeup sensors.

4.2.3 FIFO size

FIFO size represents the total size of the FIFO buffer. The size of the FIFO is displayed as seen below:

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Figure 18 : FIFO size

4.2.4 Physical sensor working status

Physical sensor working status indicates the sampling rate, range, power mode, and interrupt enable status for physical sensors.

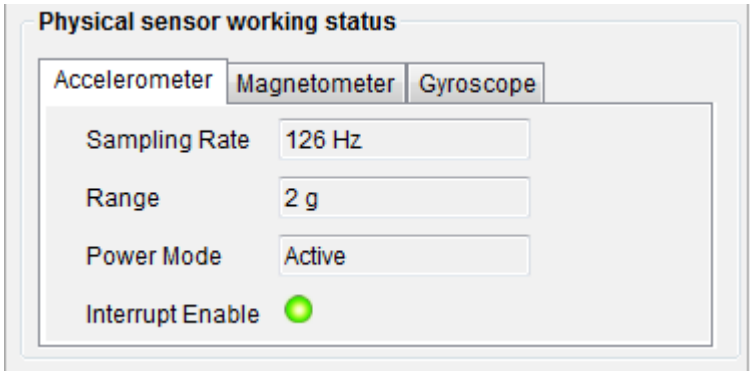

Figure 19 : Physical sensor working status

Power mode of the physical sensor is any one of the below mentioned modes depends on the sensor configuration.

- Sensor Not Present
- Power Down
- Suspend
- Self-Test
- Interrupt Motion
- One Shot
- Low Power Active
- Active

Interrupt enable status is indicated by means of status LED. When the interrupt is enabled, the LED glows green.

4.2.5 Application processor Suspended

When the checkbox *Application Processor Suspended* is selected for a non-wakeup sensor, no data is plotted. Once wakeup sensor is configured, then both non-wakeup and wakeup sensor data will be plotted in the plotter.

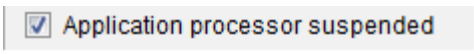

Figure 20 : Application processor suspended checkbox

4.2.6 Orientation

The orientation feature informs the status of orientation change of the sensor with respect to the gravitational field vector *g*. The orientation values are given to the user as roll, pitch, and heading angles.

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Figure 21 : Orientation

4.2.7 System Reset

This is hard reset functionality. The VDD and VDDIO are turned off and then on. This triggers the power-on-reset circuitry of the sensor. BHy RAM is cleared during system reset.

Hence, the user needs to download the RAM again after resetting the system. BHy patch download window will pop up once the system is reset. This helps the user to upgrade RAM patch.

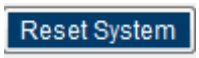

Figure 22 : Reset System

4.2.8 Refresh

After clicking

, following fields are updated in the UI:

- FIFO Size
- Working status
- ODR under BSX library
- Physical sensor working status
- Calibration status

4.2.9 Disable/Enable interrupts

Enable/Disable interrupt feature is used to enable and disable the interrupts generated by host.

Interrupts are enabled by default. User can click on **Disable Interrupt** to disable the interrupt generation.

4.3 Panels

Panels are available at **Menu** -> **Panels**, the functionalities of which are discussed below:

4.3.1 Data Export

Data Export is used to log the plotted sensor signals into a file. The two methods to launch data export are:

- Go to **Menu** -> **Panels** -> **Data Export**.
- Click **Ctrl + D**

The procedure to implement data export is as follows:

1. Click **Panels** -> **Data Export** -> **Select Destination**.

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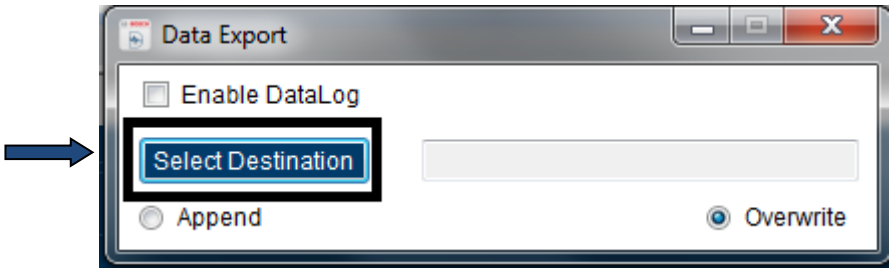

Figure 23 : Select data log destination

2. Select the destination path.
3. The configured sensors are automatically selected in the data export panel.
4. If the sensors are not selected, click on **General Settings** -> **Refresh**.
5. Check the Enable Data Log check box

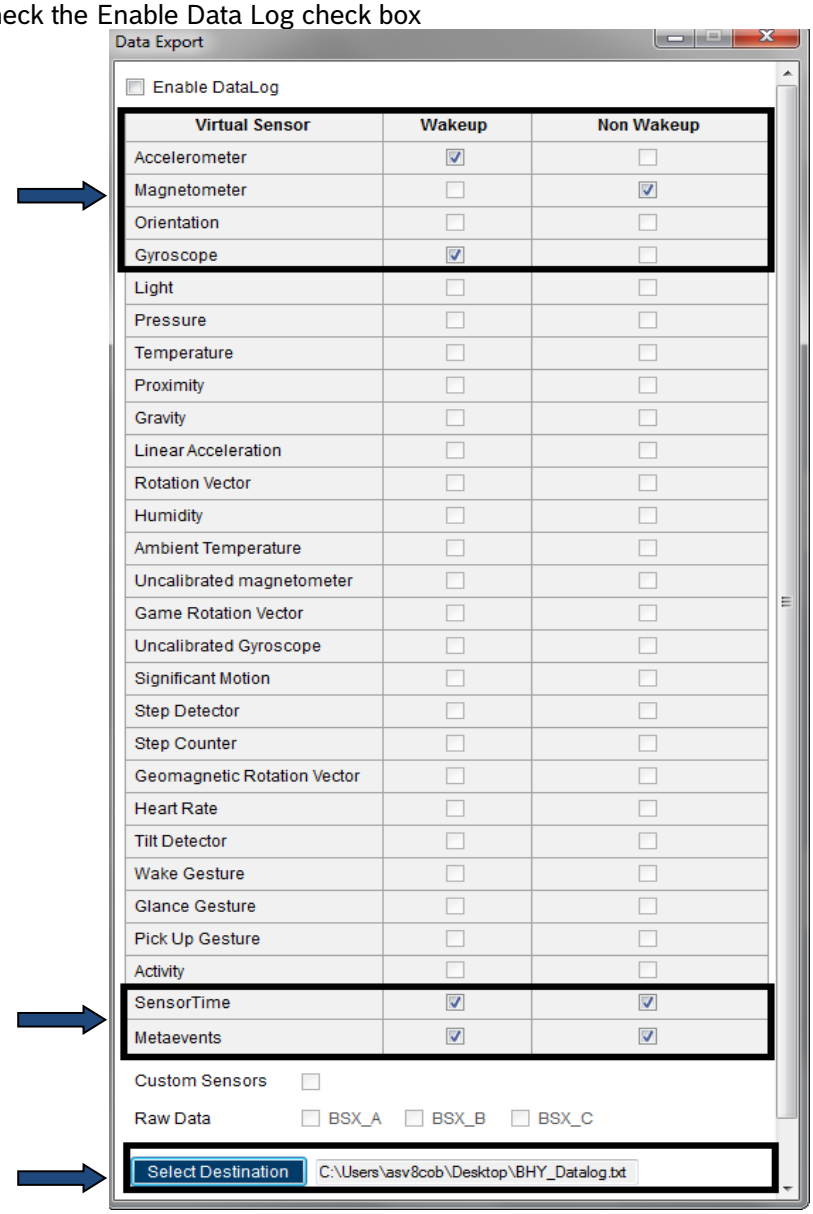

Figure 24 : Data logging

6. To plot sensor signals on the plotter, click **Start Streaming.**
7. To end plotting, click **Stop Streaming**. The output of the sensor is saved in the desired destination path.
8. Two data log files will be generated :
    a. One with the user given filename

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b. One with user given filename ending with _raw for raw data reference.

1. Formatted Data log

Data log will contain the below listed sensor information:

(i) Name and date
(ii) Sensor time for non-wakeup and wakeup sensors
(iii) X,Y, and Z axes for non-wakeup and wakeup sensors (W –quaternion if applicable)
(iv) BSXA, BSXB, BSXC, if raw data output is enabled
(v) Meta event name, Byte1, and Byte2 for non-wakeup and wakeup sensors

2. Raw data log

Raw data dump is logged as a separate file along with the formatted data output log. Following information is seen in the raw data log.

(i) Timestamp MSW LSB
(ii) Timestamp MSW MSB
(iii) Timestamp LSW LSB
(iv) Timestamp LSW MSB
(v) Data

4.3.2 Binary View

To launch binary view, click **Menu** -> **Panels** -> **Binary view.**
In the binary view, the sensor registers are identified by their addresses. Binary view for BHy is represented by I2C register map and parameter map and is the actual representation of the sensor memory map.

Register map

To launch register map, click on **Panels** -> **Binary view** -> **Register map**.
I2C register map displays the register address and corresponding values (In decimal, hexadecimal, and binary formats). To read all values at the same time, click **Read**.

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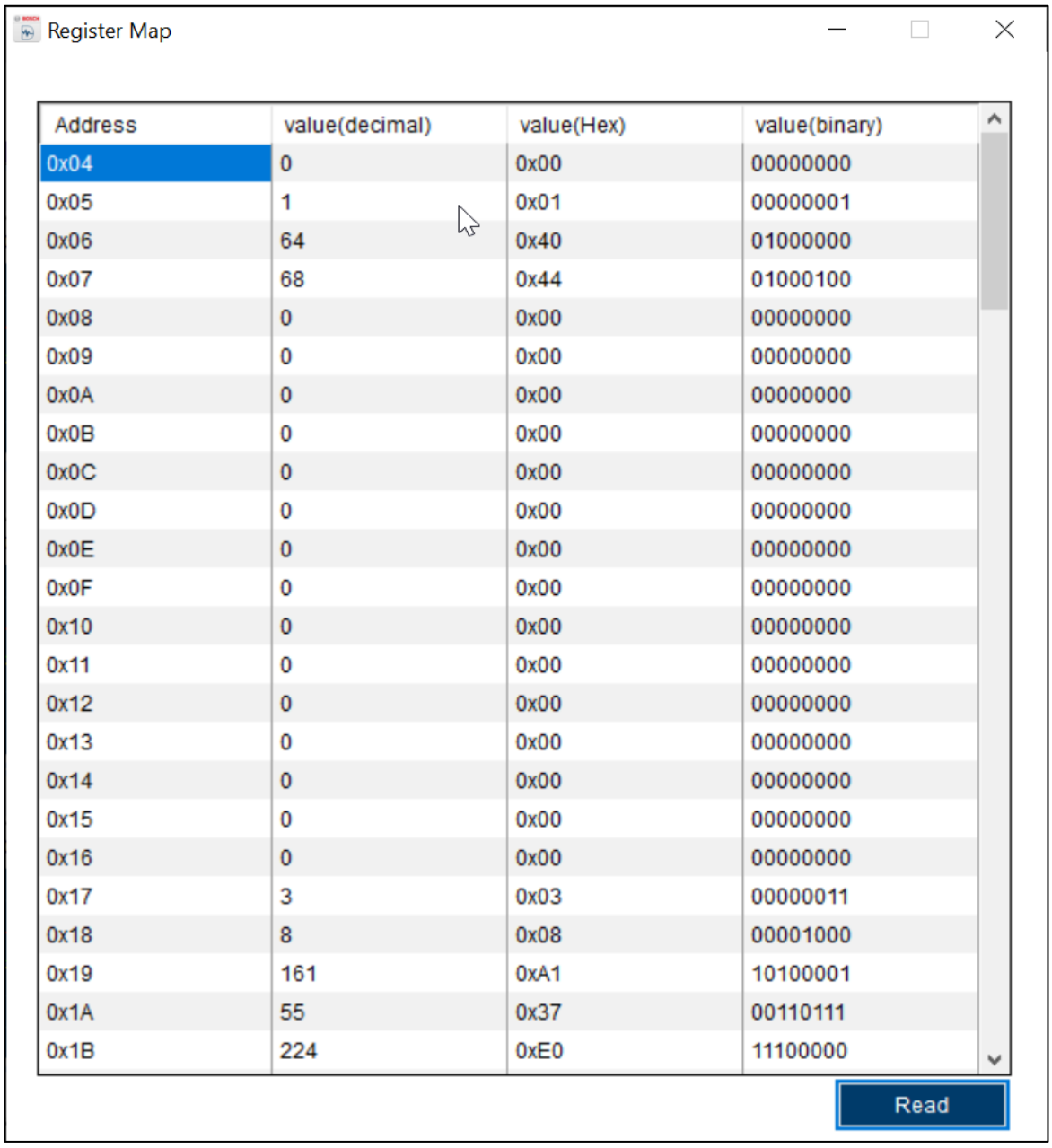

Figure 25 : I2C register map

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System parameter map

To launch system parameter map, click **Panels** -> **Binary view** -> **System Parameter Map.**
System parameters are used to control general features. There are totally 96 parameters in the system parameter map. The user can view the selected parameters by providing the starting and ending parameter number.
To load selected parameters, click **Update.** Parameters 1 to 3 will be loaded as default view.

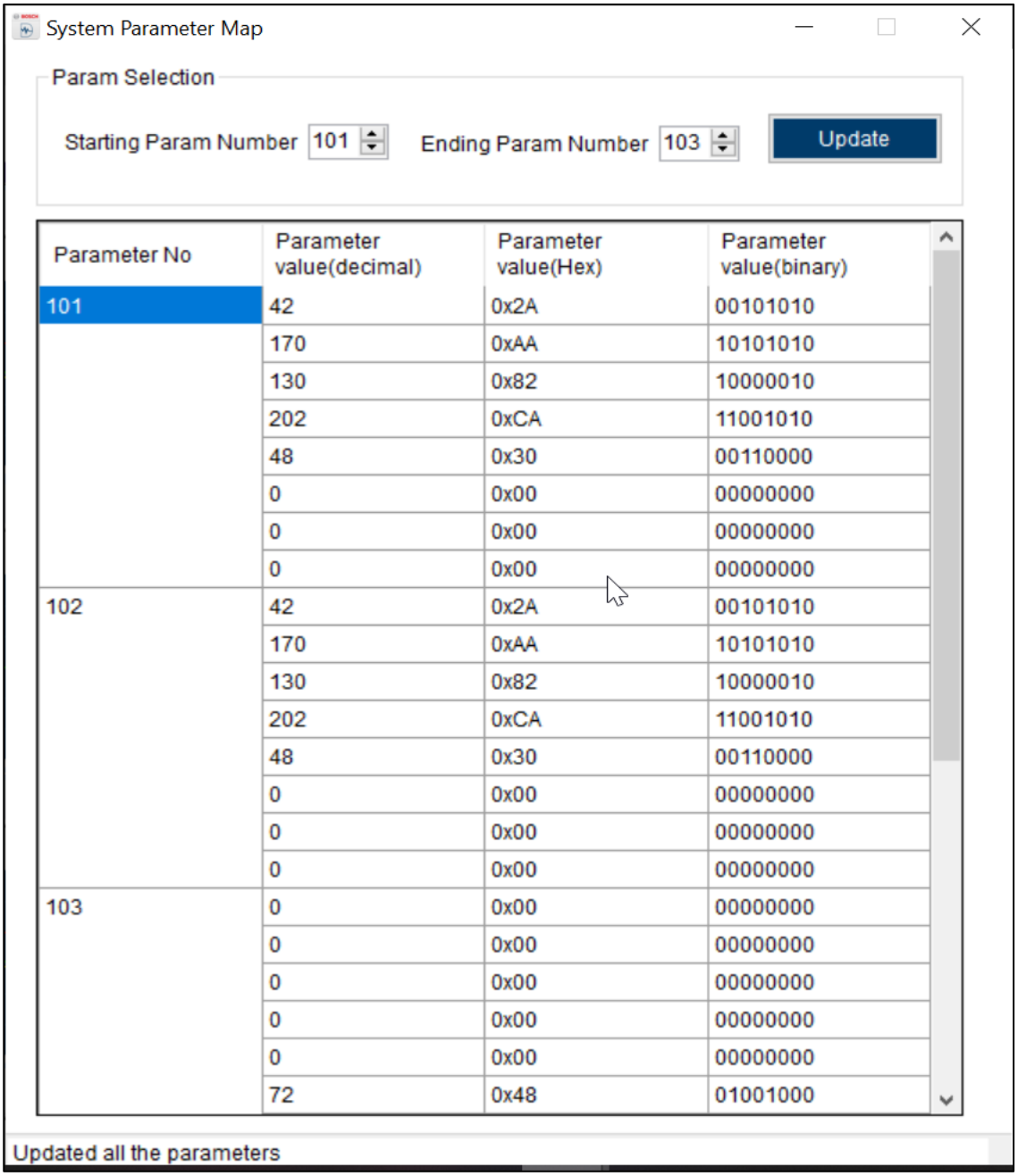

Figure 26 : System parameter map

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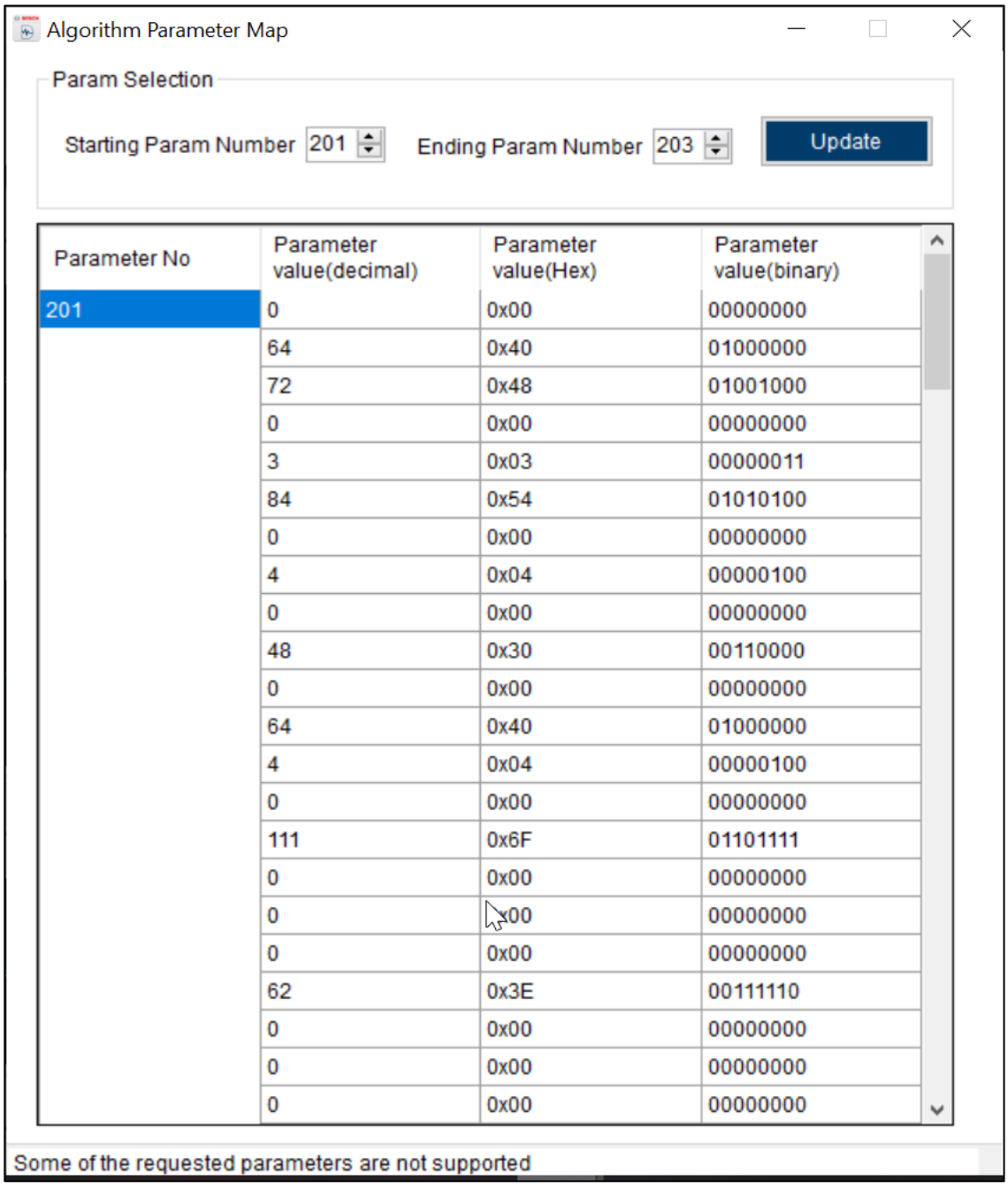
Algorithm parameter map

To launch algorithm parameter map, click **Panels** -> **Binary view** -> **Algorithm parameter map.**

Algorithm parameter map is used to read, write, and demonstrate algorithm related data (e.g, calibration data). There are 127 parameters available in algorithm parameter map. Parameters 1 to 3 will be loaded as default view.



Parameter No	Parameter value(decimal)	Parameter value(Hex)	Parameter value(binary)
201	0	0x00	00000000
	64	0x40	01000000
	72	0x48	01001000
	0	0x00	00000000
	3	0x03	00000011
	84	0x54	01010100
	0	0x00	00000000
	4	0x04	00000100
	0	0x00	00000000
	48	0x30	00110000
	0	0x00	00000000
	64	0x40	01000000
	4	0x04	00000100
	0	0x00	00000000
	111	0x6F	01101111
	0	0x00	00000000
	0	0x00	00000000
	0	0x00	00000000
	62	0x3E	00111110
	0	0x00	00000000
	0	0x00	00000000
	0	0x00	00000000

Figure 27 : Algorithm Parameter Map

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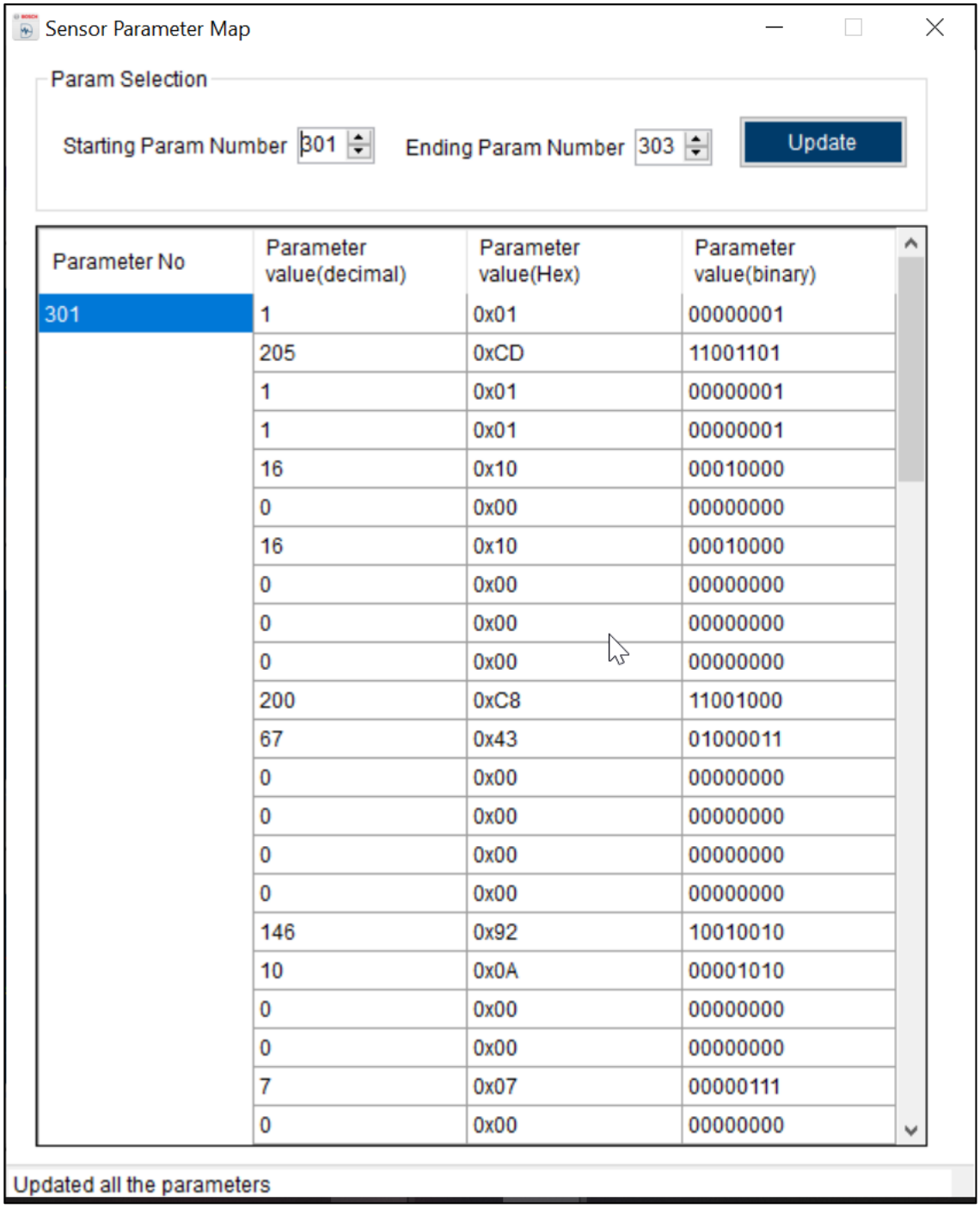
Sensor parameter map

To launch sensor parameter map, click **Panels** -> **Binary view** -> **Sensor parameter map.**
There are totally 127 parameters in the system parameter map. The user can view the selected parameters by providing the starting and ending parameter number.

To load selected parameters, click **Update.** Parameters 1 to 3 will be loaded as default view.



Parameter No	Parameter value(decimal)	Parameter value(Hex)	Parameter value(binary)
301	1	0x01	00000001
	205	0xCD	11001101
	1	0x01	00000001
	1	0x01	00000001
	16	0x10	00010000
	0	0x00	00000000
	16	0x10	00010000
	0	0x00	00000000
	0	0x00	00000000
	0	0x00	00000000
	200	0xC8	11001000
	67	0x43	01000011
	0	0x00	00000000
	0	0x00	00000000
	0	0x00	00000000
	0	0x00	00000000
	146	0x92	10010010
	10	0x0A	00001010
	0	0x00	00000000
	0	0x00	00000000
	7	0x07	00000111
	0	0x00	00000000

Figure 28 : Sensor parameter map

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Soft Pass-through parameter map

To launch sensor parameter map, click **Panels** -> **Binary view** -> **Soft Pass-through parameter map.**

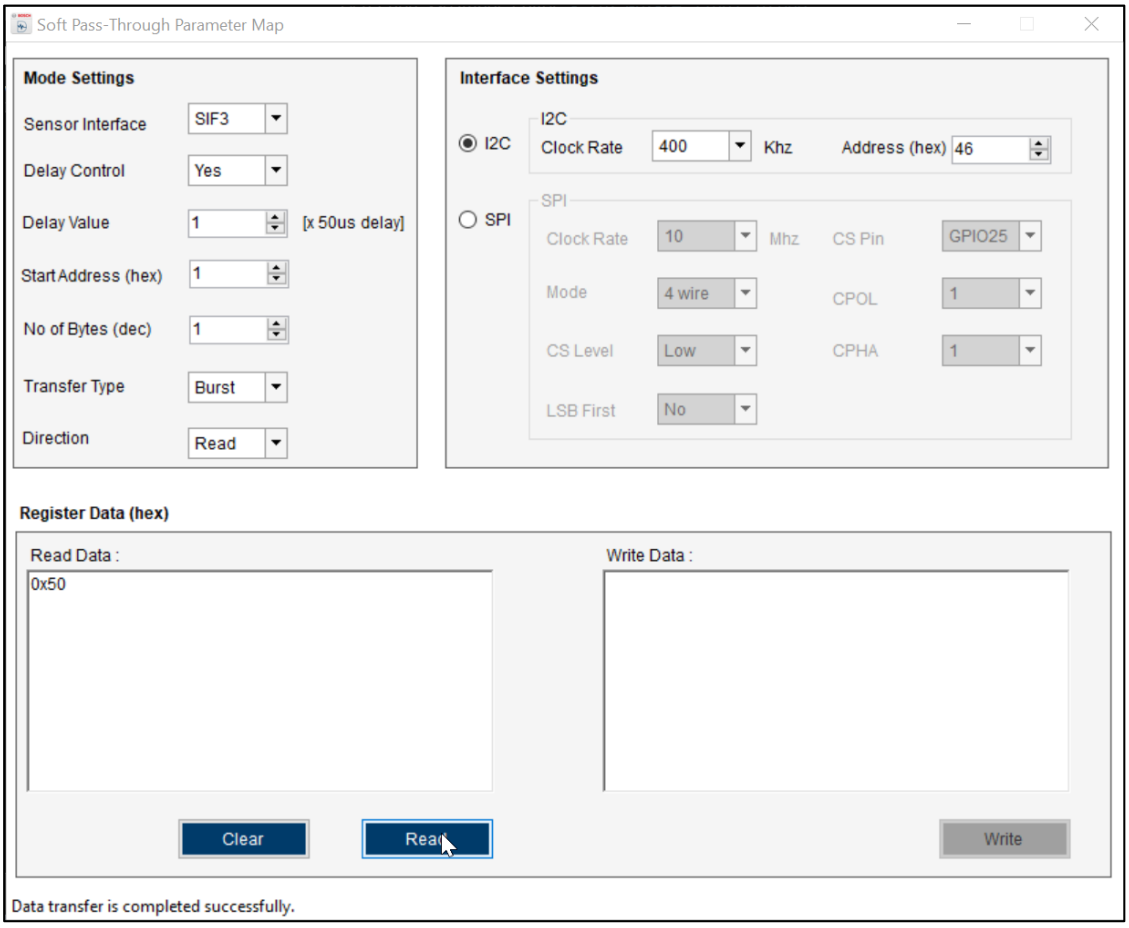

Figure 29 Soft Pass-through

4.3.3 I2C register Access

To launchI2C register access, click **Panels** -> **Select I2C Register Access**
This view provides direct access to the I2C registers. The values can be written into, or read from I2C register.

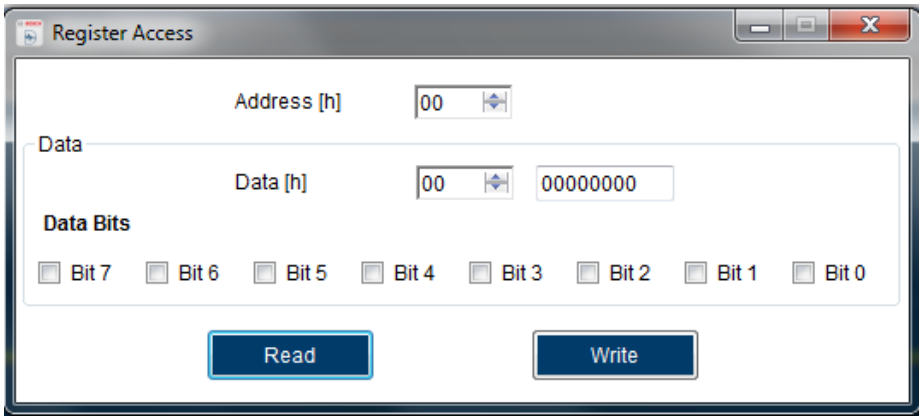

Figure 30 : Register access

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4.3.4 Sensor Events and Meta Events

The two methods to launch sensor events and meta events are:

- Click **Panels** -> **Sensor events and Meta events**
- Click **Ctrl + M**

To enable/ disable the meta events, go to **System Parameter** -> **Meta Event Control Parameter.**
Sensor events and Meta events panels consist of wakeup and non–wakeup tab pages. Interrupt Status LEDs, activity list, event, interrupt enable column are specific for both wakeup and non-wakeup. The generated meta events are displayed in the right side of the panel.

When the virtual sensors are enabled, the user can see the status of interrupts like significant motion, step detector, tilt detector, wake gesture, glance gesture, and pickup gesture. To enable, go to **General Settings** -> **Virtual Sensor** -> **Sampling Rate**, and set a required sampling rate.

If an interrupt occurs for significant motion, step detector, tilt detector, wake gesture, glance gesture, and pickup gesture, the LED glows green. **Count** will give the number of step counts detected.

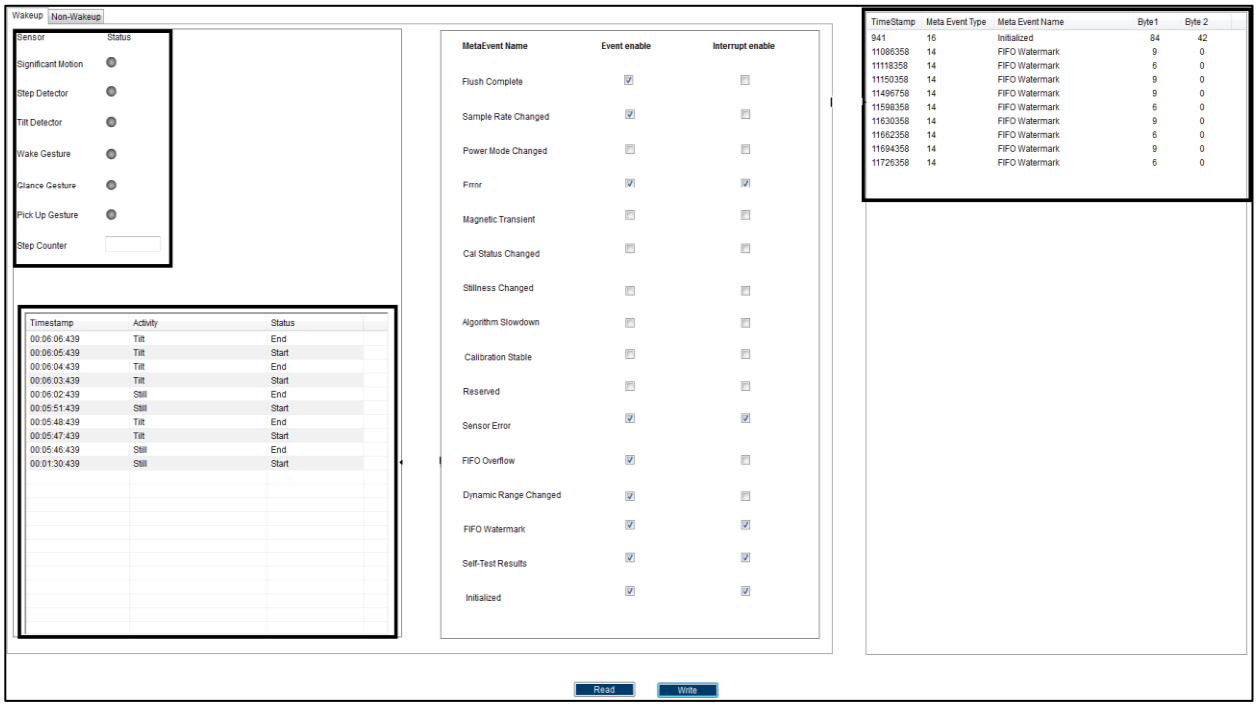

Figure 31 : Sensor events and meta events panel

If the activity sensor is enabled, the activity status list updates the status of the wakeup/ non-wakeup activity with its name & the corresponding timestamp.

To enable the Meta events and interrupts, select **Event Enable** and **Interrupts Enable** checkboxes, and click **Write.**
To disable, uncheck the same checkboxes.
Read will read the configuration status of interrupts and Meta events.

The enabled meta events are generated in the right side of the interrupts and meta events window.

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4.3.5 Batching panel

Virtual sensors can be individually configured using the batching panel. The main use of batching panel is to set the latency time in which the sensor data can be plotted instead of plotting the data for each occurrence of the sample. Batching can be set for both wakeup and non-wakeup sensors but one at a time.

The two methods to launch batching panel are:

- Click **Panels** -> **Batching panel**
- Click **Ctrl + B**

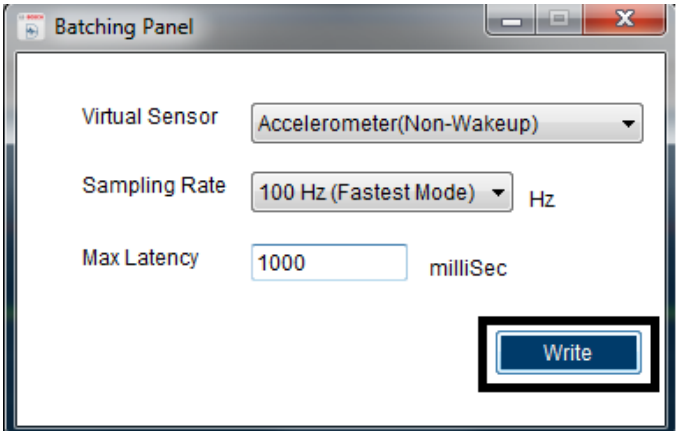

Figure 32 : Batching panel

To implement batching, go to **Virtual Sensor** -> **Maximum Latency** and provide input.

The main difference between Batching panel and batching in virtual sensor tab is that all the other virtual sensors are disabled once the batching is set for an individual sensor. But, batching can be set for more than one sensor in **Virtual Sensor** tab.

5 Demonstration

Below steps, describe the procedure to use BHy taking accelerometer as an example.

1. Open DD2.1. In the BHy Patch Download window, download the RAM patch file.

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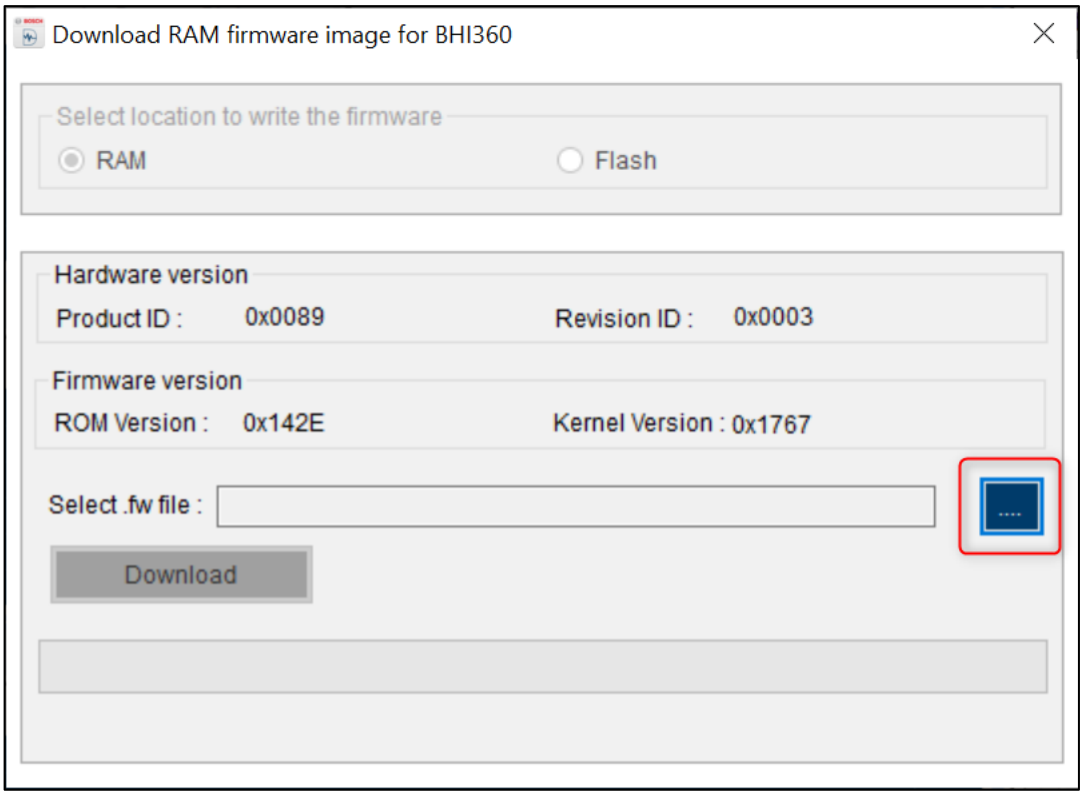

Figure 33 : BHy patch download

2. Select the RAM patch files to be downloaded using the browser.

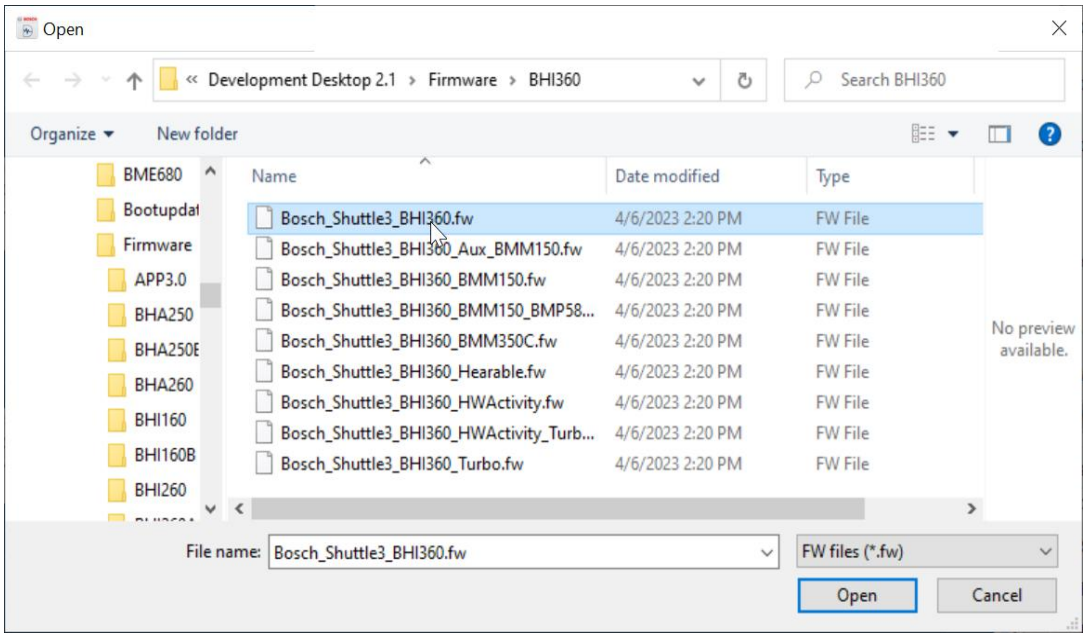

Figure 34 : RAM patch file selection

3. To download the RAM patch. Click **Flash**.

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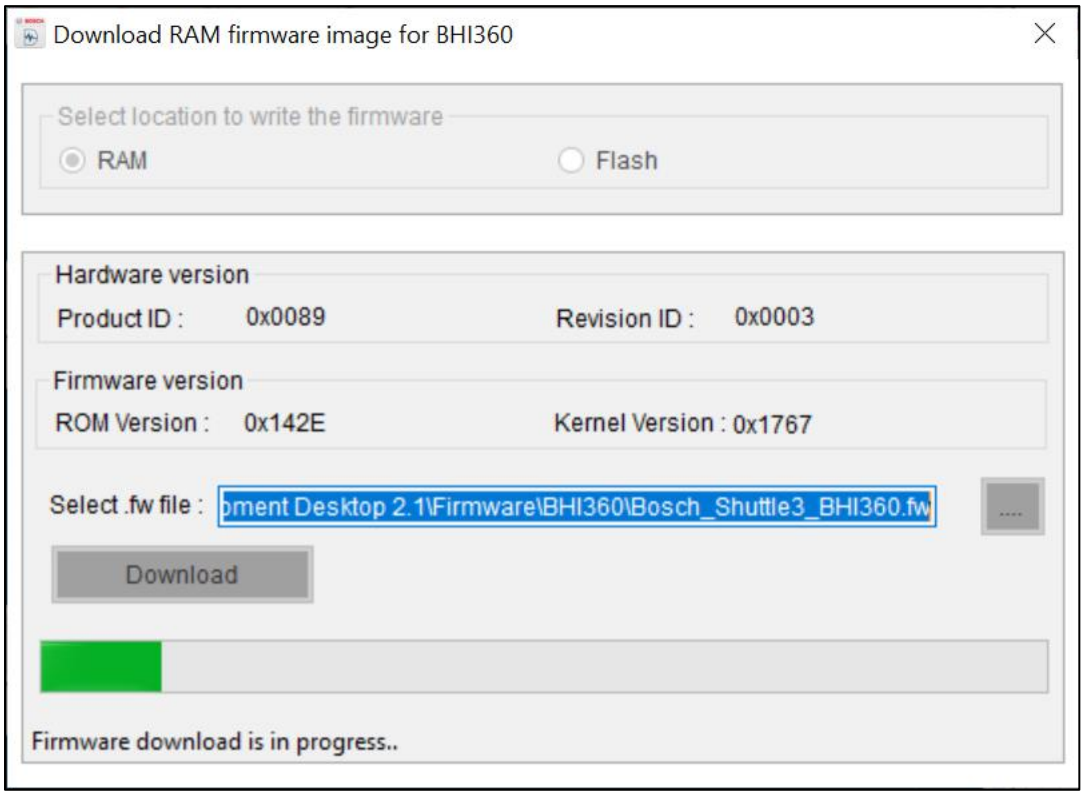

Figure 35 : Flash/ Download

4. Once download is complete and successful, the message *BHy firmware is updated successfully* is displayed.

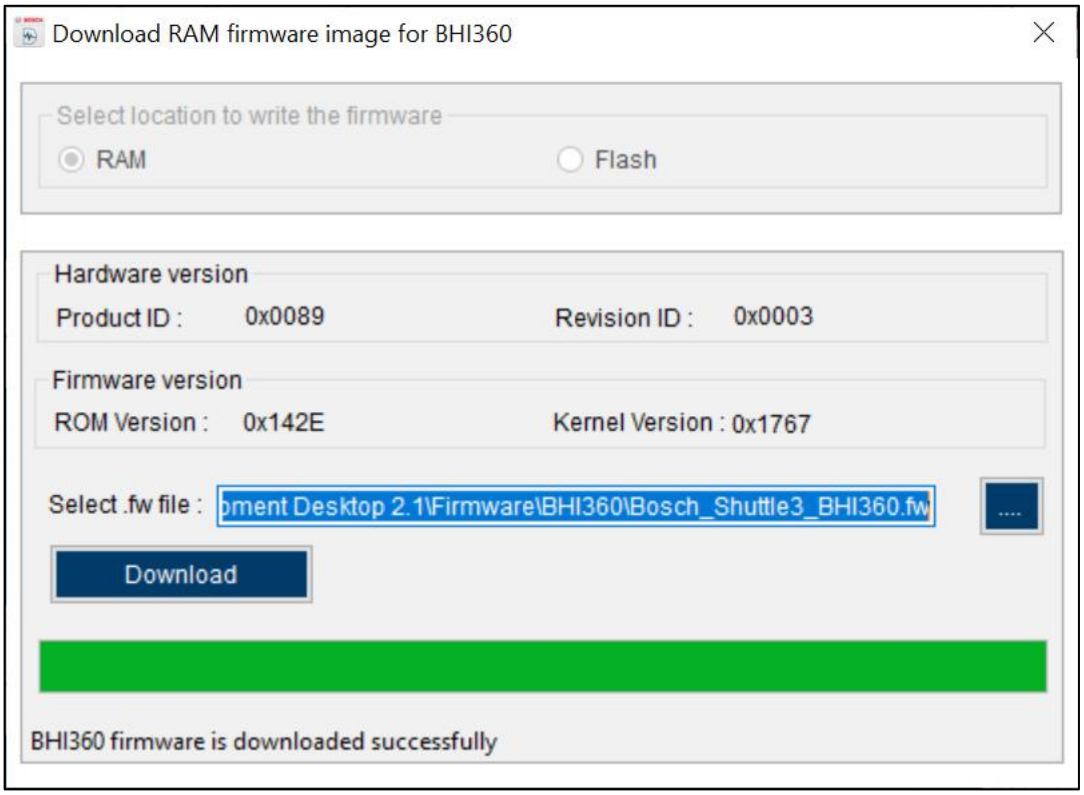

Figure 36 : BHy patch download completion

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5. When no sensor is enabled, no data **is** plotted. In order to update the current setting status**, go to General Settings -> Refresh.**

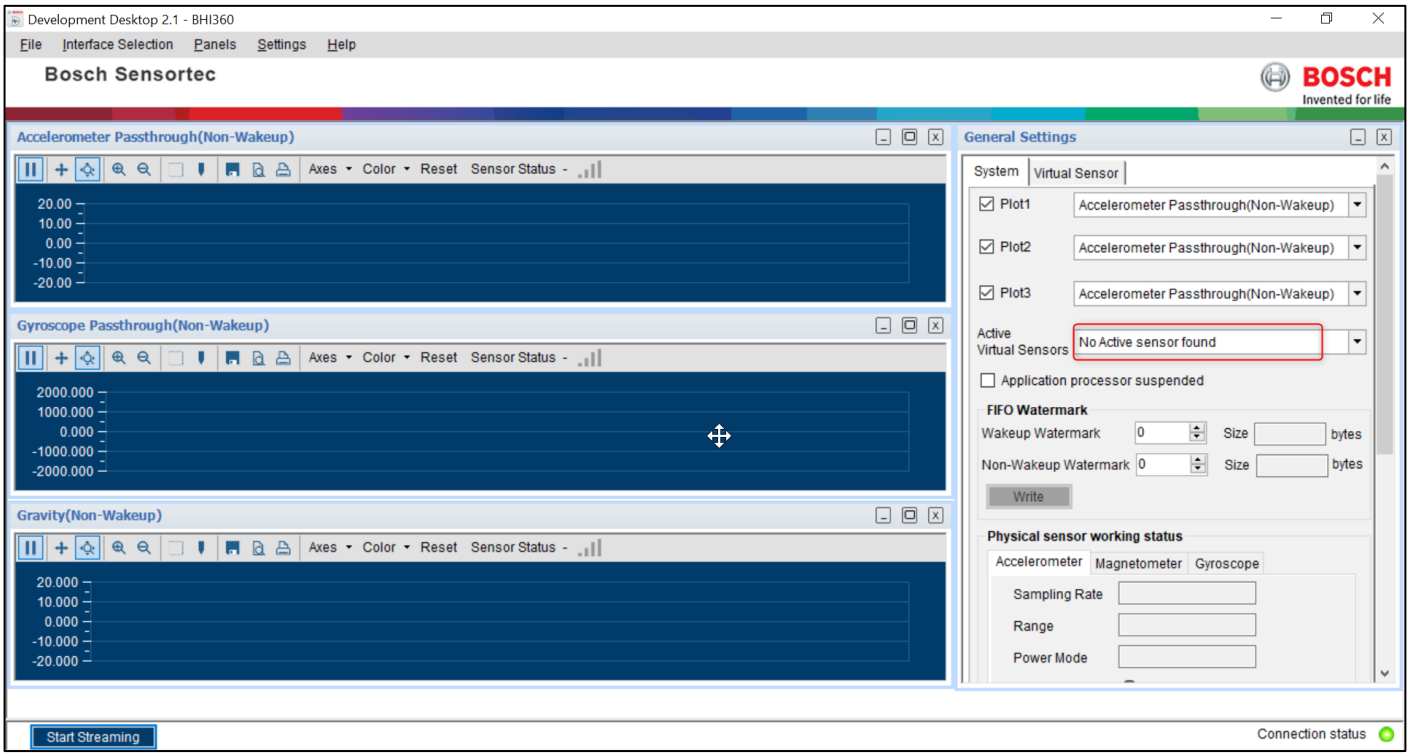

Figure 37 : Streaming data in DD2.1

6. Go to **Virtual Sensor** -> **Virtual Sensor List** -> **Accelerometer Passthrough(Non-Wakeup)**

7. Go to **Sampling Rate -> Sampling Rate Combo Box -> Write.**

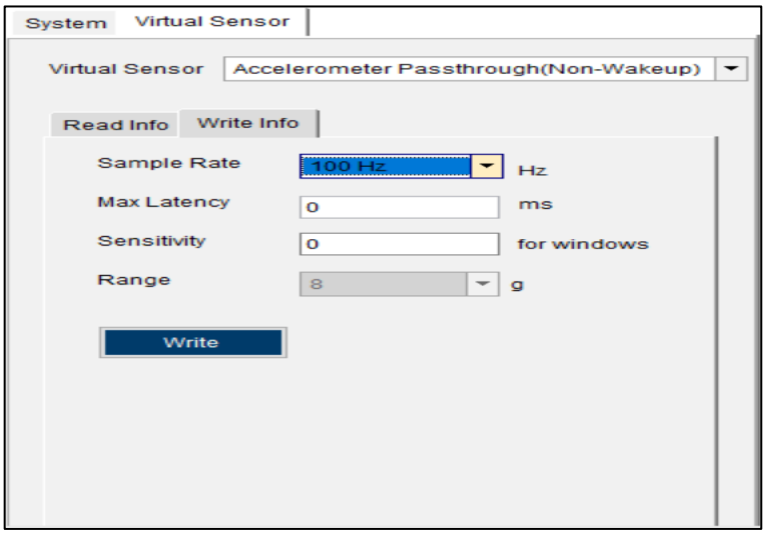

Figure 38 Selecting sample rate

1. Go to **System** -> **Plotter Selection** -> **Accelerometer Passthrough(non wakeup)** -> **Start**.

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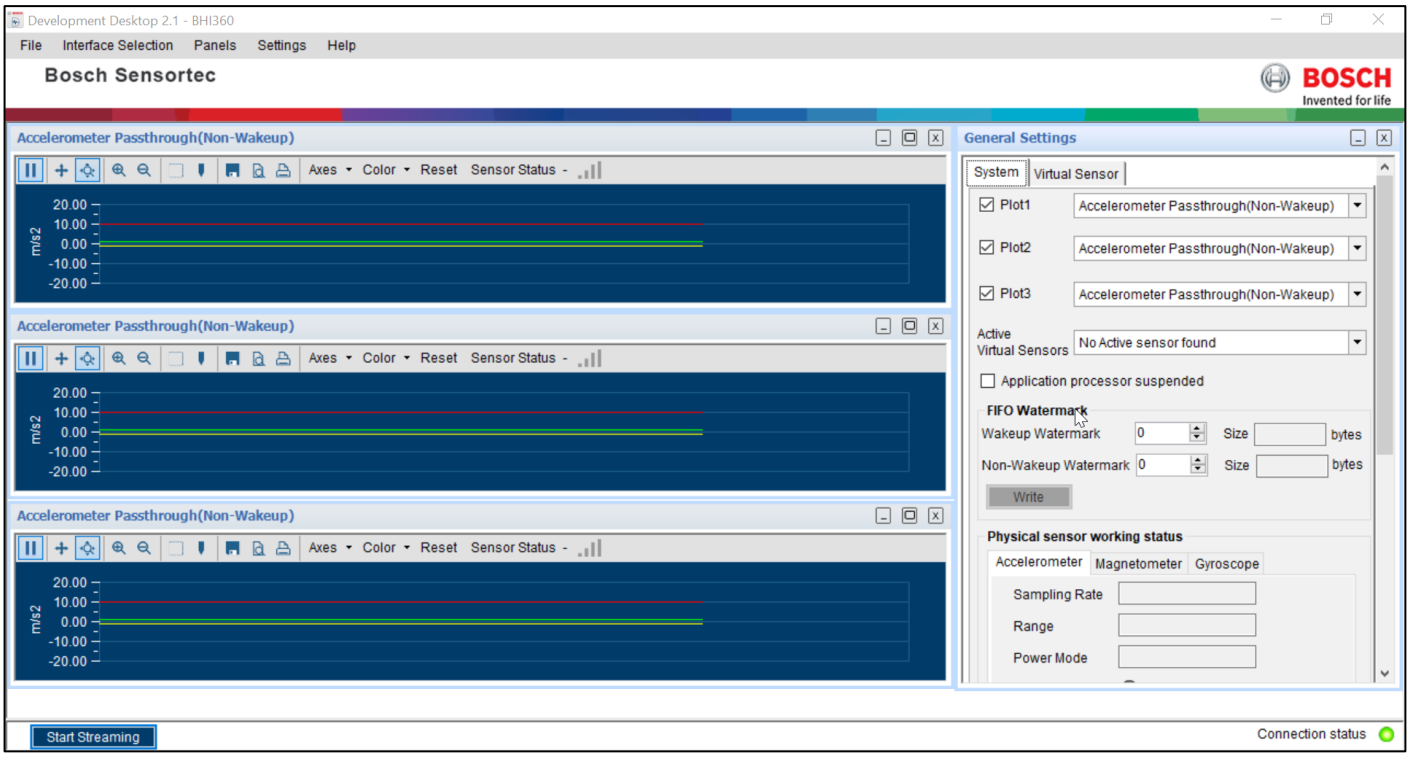

Figure 39 : Plotting accelerometer data

9. Enable orientation and rotation vector virtual sensors same as above

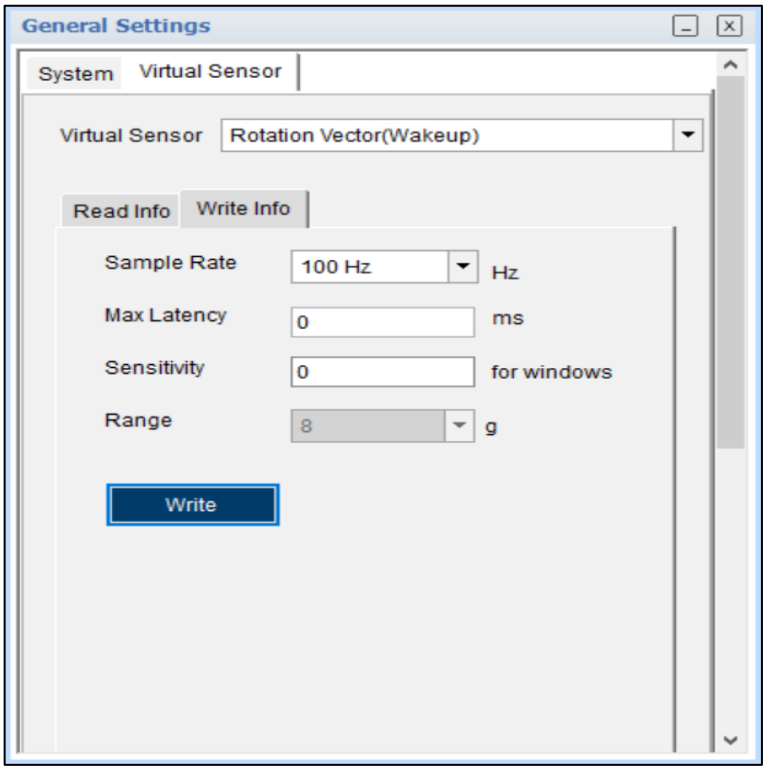

Figure 40 : Enabling rotation vector

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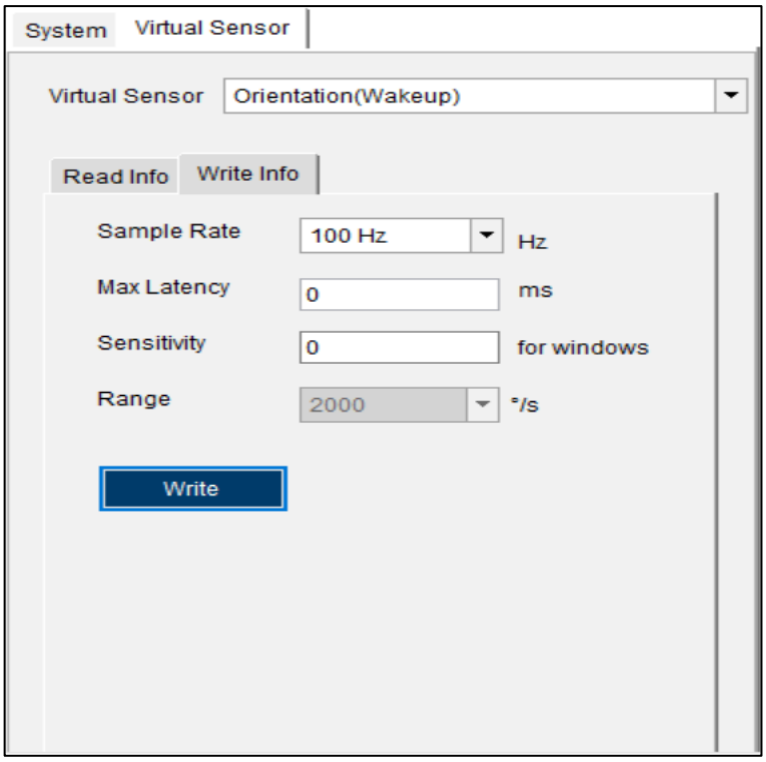

Figure 41 : Enabling orientation

8. Go to **Panels -> 3D compass**. 3D compass along with orientation data is displayed in the UI.

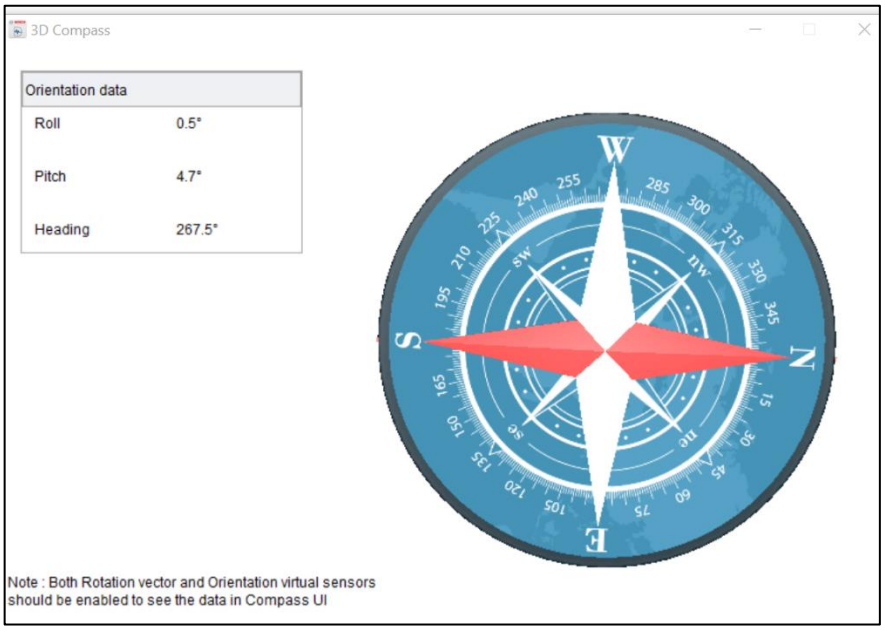

Figure 42 : 3D Compass

9. All other virtual sensors can be configured using above mentioned procedure.

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6 General troubleshooting

Follow below guidelines while working with DD2.1:

- Ensure that the shuttle board (with a valid sensor) is seated properly in the application board.
- Ensure that the PC-board connection is properly established.
- When switching on/ off DD2.1, close and restart DD2.1.
- Ensure that at least one channel is selected.

Follow these steps to check the USB connection:

1. Click **My Computer -> Manage** -> **Computer Management.**
2. Go to **System Tools** -> **Device Manager**.
3. Click on BST board and check for the USB connection.

Sometimes, data transfer between PC and application board does not work despite the USB device being properly enumerated in the Device Manager.
This could be because the application board is older or that the USB PID and VID have been used with that computer before. In this case, Windows is unable to install the required drivers automatically.
Follow these steps to check the USB connection:

1. Right-click on the USB-device corresponding to your application board (if you are not sure which device corresponds to your application Board, unplug all other USB devices like keyboard and mouse temporarily).

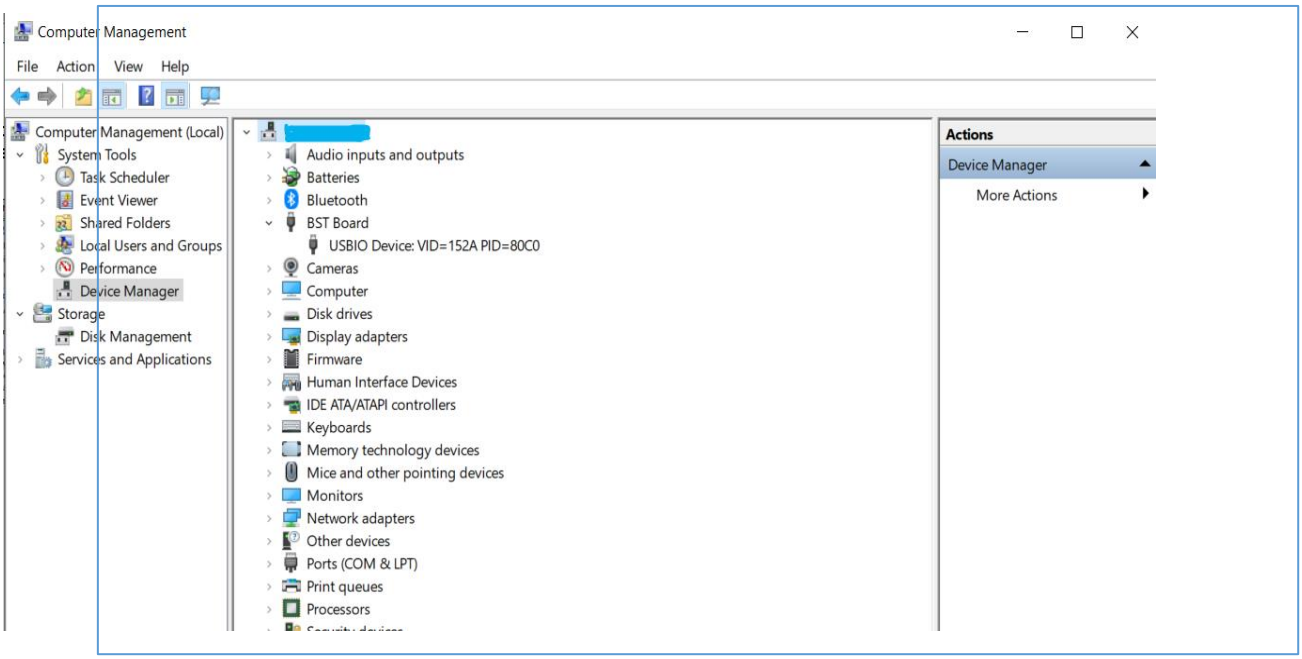

Figure 43 : Selecting USB device corresponding to application board

2. Click **Action** -> **Scan for hardware changes**. The new USB driver is installed automatically. Thereafter, the device communication will function properly.

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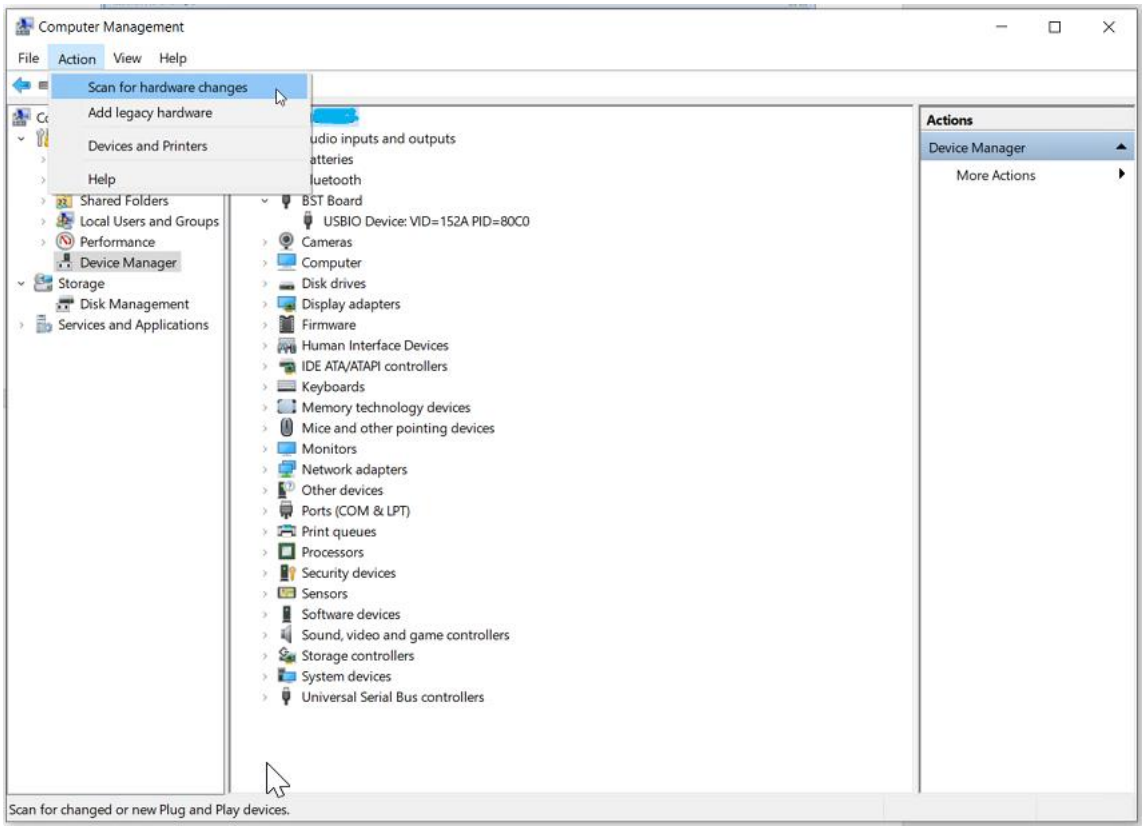

Figure 44 : USB driver installation

The following table lists some of the possible faults that you might encounter and the troubleshooting method.

Table 1 Trouble Shooting

Condition	Possible cause	Solution
If **Connection Status** remains grey red after checking the **Start** Button.	Application Board is turned off.	**Power on** the application Board and restart the DD2.1 application. If the board is powered by rechargeable battery, ensure that the battery is charged.
Unable to locate the data logged file.	Destination path not properly defined.	Locate the file in the setup path of Development Desktop**.**
Error message “**Please connect application Board**” is displayed.	Application Board is not connected properly.	Ensure that the PC is connected with the application Board properly. If the board is powered by rechargeable battery, ensure that the battery is charged.
Error message “**Please connect Shuttle Board**” is displayed.	Shuttle Board is not fixed properly.	Ensure that the Shuttle Board is correctly fixed in the Development Board.
Error message “**Please select a path or file for logging**” is displayed.	Destination path for saving the logged data is not defined.	Select the **Data Export** option in the file menu and specify the destination path.

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Error message “**Please select File from File Menu → Data Export option to proceed**” is displayed.	Destination path not selected.	In the file menu, select the **Data Export** option and select the destination path.
Error message “**Please Connect Valid Sensor**” is displayed.	Wrong sensor fixed on the application Board.	Ensure that correct sensor is fixed on the application Board.
Graph for x, y, z channel not plotted.	Channel x, y, z not checked.	Ensure that x, y, z channels are checked.

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7 Legal disclaimer

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8 Document history and modification

Rev. No	Chapter	Description of modification/changes	Date
1.0	BHYxxx User Manual	Initial release	October 2018
1.1	BHyxxx User Manual	Adopt New Format	August 2020
1.2	BHyxxx User Manual	Updated DD application version	April 2023

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