BHYxxx User Manual

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Notes
Data and descriptions in this document are subject to change without notice. Product photos and pictures are for illustration purposes only and may differ from the real product appearance.
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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 BH, to help in further attaching the I2C sensors.
- In the BH (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.
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](image-url)
Connect the board and PC using a USB cable/Bluetooth.

- Turn the on/off switch **ON**. The LED glows.
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.
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:
1. Patch download window will pop up prompting for the RAM patch file download.

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

![Download RAM firmware image for BHI360](image)

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.

![fw software patch file](image)

Figure 9: `fw` software patch file

1. Click **Download** for BHy RAM patch initialization
2. Once the download is complete, the status message “BHy firmware updated successfully” is displayed on the BHy patch download window.
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.
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.
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
iii. Plotter selection section

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

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

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

![FIFO Watermark](image)

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:
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.

![Physical sensor working status](image)

Figure 19: Physical sensor working status

- 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.

![Application processor suspended checkbox](image)

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.
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.

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.
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.

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
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-wake up and wake up sensors
   (iii) X, Y, and Z axes for non-wake up and wake up sensors (W – quaternion if applicable)
   (iv) BSXA, BSXB, BSXC, if raw data output is enabled
   (v) Meta event name, Byte1, and Byte2 for non-wake up and wake up 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.
### Figure 25: I2C register map

<table>
<thead>
<tr>
<th>Address</th>
<th>value (decimal)</th>
<th>value (Hex)</th>
<th>value (binary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x04</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x05</td>
<td>1</td>
<td>0x01</td>
<td>00000001</td>
</tr>
<tr>
<td>0x06</td>
<td>64</td>
<td>0x40</td>
<td>01000000</td>
</tr>
<tr>
<td>0x07</td>
<td>68</td>
<td>0x44</td>
<td>01000100</td>
</tr>
<tr>
<td>0x08</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x09</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x0A</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x0B</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x0C</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x0D</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x0E</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x0F</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x10</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x11</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x12</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x13</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x14</td>
<td>0</td>
<td>0x00</td>
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<tr>
<td>0x15</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x16</td>
<td>0</td>
<td>0x00</td>
<td>00000000</td>
</tr>
<tr>
<td>0x17</td>
<td>3</td>
<td>0x03</td>
<td>00000011</td>
</tr>
<tr>
<td>0x18</td>
<td>8</td>
<td>0x08</td>
<td>00001000</td>
</tr>
<tr>
<td>0x19</td>
<td>161</td>
<td>0xA1</td>
<td>1010001</td>
</tr>
<tr>
<td>0x1A</td>
<td>55</td>
<td>0x37</td>
<td>00110111</td>
</tr>
<tr>
<td>0x1B</td>
<td>224</td>
<td>0xE0</td>
<td>11100000</td>
</tr>
</tbody>
</table>
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.

![System parameter map](image)

**Figure 26 : System parameter map**
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.

![Algorithm Parameter Map](image)

**Figure 27: Algorithm Parameter Map**
Sensor parameter map

To launch the 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.

![Sensor parameter map](image)

Figure 28: Sensor parameter map
Soft Pass-through parameter map

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

![Soft Pass-through parameter map](image)

**Figure 29 Soft Pass-through**

### 4.3.3 I2C register Access

To launch I2C 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.

![Register Access](image)

**Figure 30 : Register access**
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.

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.
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

![Batching panel](image)

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

3. To download the RAM patch. Click **Flash**.
4. Once download is complete and successful, the message **BHy firmware is updated successfully** is displayed.
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](image)


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

![Figure 38 Selecting sample rate](image)

1. Go to System -> Plotter Selection -> Accelerometer Passthrough(non wakeup) -> Start.
9. Enable orientation and rotation vector virtual sensors same as above
8. Go to Panels -> 3D compass. 3D compass along with orientation data is displayed in the UI.

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

![Computer Management](image)

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

**Table 1 Trouble Shooting**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Possible cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>If <strong>Connection Status</strong> remains grey red after checking the <strong>Start</strong> Button.</td>
<td>Application Board is turned off.</td>
<td><strong>Power on</strong> the application Board and restart the DD2.1 application. If the board is powered by rechargeable battery, ensure that the battery is charged.</td>
</tr>
<tr>
<td>Unable to locate the data logged file.</td>
<td>Destination path not properly defined.</td>
<td>Locate the file in the setup path of Development Desktop.</td>
</tr>
<tr>
<td>Error message “Please connect application Board” is displayed.</td>
<td>Application Board is not connected properly.</td>
<td>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.</td>
</tr>
<tr>
<td>Error message “Please connect Shuttle Board” is displayed.</td>
<td>Shuttle Board is not fixed properly.</td>
<td>Ensure that the Shuttle Board is correctly fixed in the Development Board.</td>
</tr>
<tr>
<td>Error message “Please select a path or file for logging” is displayed.</td>
<td>Destination path for saving the logged data is not defined.</td>
<td>Select the <strong>Data Export</strong> option in the file menu and specify the destination path.</td>
</tr>
<tr>
<td>Error message “Please select File from File Menu → Data Export option to proceed” is displayed.</td>
<td>Destination path not selected.</td>
<td>In the file menu, select the Data Export option and select the destination path.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Error message “Please Connect Valid Sensor” is displayed.</td>
<td>Wrong sensor fixed on the application Board.</td>
<td>Ensure that correct sensor is fixed on the application Board.</td>
</tr>
<tr>
<td>Graph for x, y, z channel not plotted.</td>
<td>Channel x, y, z not checked.</td>
<td>Ensure that x, y, z channels are checked.</td>
</tr>
</tbody>
</table>
7 Legal disclaimer

i. Engineering samples

Engineering Samples are marked with an asterisk (*) or (e). Samples may vary from the valid technical specifications of the product series contained in this data sheet. They are therefore not intended or fit for resale to third parties or for use in end products. Their sole purpose is internal client testing. The testing of an engineering sample may in no way replace the testing of a product series. Bosch Sensortec assumes no liability for the use of engineering samples. The Purchaser shall indemnify Bosch Sensortec from all claims arising from the use of engineering samples.

ii. Product use

Bosch Sensortec products are developed for the consumer goods industry. They may only be used within the parameters of this product data sheet. They are not fit for use in life-sustaining or safety-critical systems. Safety-critical systems are those for which a malfunction is expected to lead to bodily harm, death or severe property damage. In addition, they shall not be used directly or indirectly for military purposes (including but not limited to nuclear, chemical or biological proliferation of weapons or development of missile technology), nuclear power, deep sea or space applications (including but not limited to satellite technology).

The resale and/or use of Bosch Sensortec products are at the purchaser’s own risk and his own responsibility. The examination of fitness for the intended use is the sole responsibility of the purchaser.

The purchaser shall indemnify Bosch Sensortec from all third party claims arising from any product use not covered by the parameters of this product data sheet or not approved by Bosch Sensortec and reimburse Bosch Sensortec for all costs in connection with such claims.

The purchaser accepts the responsibility to monitor the market for the purchased products, particularly with regard to product safety, and to inform Bosch Sensortec without delay of all safety-critical incidents.

iii. Application examples and hints

With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Bosch Sensortec hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights or copyrights of any third party. The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics. They are provided for illustrative purposes only and no evaluation regarding infringement of intellectual property rights or copyrights or regarding functionality, performance or error has been made.
8 Document history and modification

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<td>1.0</td>
<td>BHYxxx User Manual</td>
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