Technical Document

How to play with BHI260AB shuttle board

Bosch Sensortec

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1 Introduction

The BHI260AB is a family of ultra-low power smart sensor hubs consisting of Bosch Sensortec's new, programmable 32-bit microcontroller (Fuser2), a state-of-the-art 6-axis IMU and a powerful software framework containing pre-installed sensor fusion library BSX4 and other sensor processing software within a small 44 pad LGA package.

The Fuser2 Core is configurable to operate at 20 MHz (Long Run mode) and 50 MHz (Turbo mode). It can boot from a wide variety of hosts, ranging from a small Cortex-M0™ MCU up to multicore application processors, while it has also the ability to run standalone, when booting from an attached flash memory.

In combination with its wide connectivity and extendibility, the BHI260AB becomes a versatile and ideal solution when it comes to always-on sensor processing at ultra-low power consumption.

The BHI260AB is the second generation of smart sensor hub compared to the first generation BHI160 and BHI160B smart sensor hubs. The comparison table is as shown in Table 1.

Table 1 comparison between BHI160B and BHI260AB

Parameter	BHI160B	BHI260AB
Dimensions	3 mm x 3 mm x 1 mm	3.6 mm x 4.1 mm x 0.83 mm
Processor Clock Speed	10 MHz	20 MHz (long run) or 50 MHz (turbo)
Primary host interface type	(I2C, 3.4MHz)	(I2C, 3.4MHz)/(SPI, 50MHz)
Secondary sensor interface	One (I2C, 400Hz)	Up to four (I2C, 1MHz)/(SPI, 50MHz)
Memory	48KB RAM, 96KB ROM no flash support	256KB RAM, 144KB ROM up to 8MB external flash
Max. Output sample rate (Hz)	200Hz	800Hz
Integrated Algorithms	State of the art BSX3 Sensor Fusion	Enhanced BSX4 Sensor Fusion with : • Higher data rates • Configurability (e.g. Low Power options) • Additional Virtual Sensors
Programmability	Programmable by customer Sensor software framework support Metaware compiler support	Programmable by customer Sensor software framework and OpenRTOS support Metaware compiler and GCC support

Every time when BHI260AB is powered on, the RAM patch with the filename "*.fw" needs to be downloaded into BHI260AB. Then the host needs to enable one or multiple virtual sensors with selected output data rate (ODR). Then BHI260AB will automatically output results continuously.

This document shows instructions on how to play with the BHI260AB shuttle board to quickly evaluate BHI260AB.

2 Hardware

The hardware includes one APP2.0 base board, one BHI260AB shuttle board and one micro USB cable as shown in Figure 1.

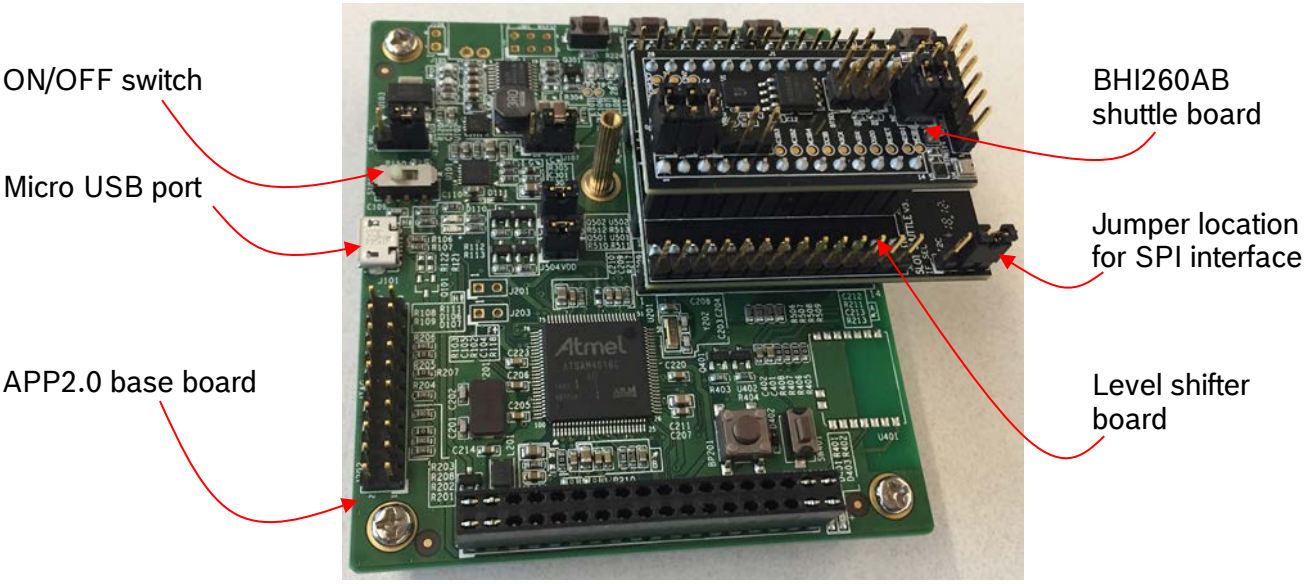


Figure 1 APP2.0 base board and BHI260AB shuttle board

Since BHI260AB operates at 1.8V only and APP2.0 base board uses 3.3V, a level shifter is required to convert 3.3V to 1.8V for BHI260AB power supply and digital interface.

On the level shifter board, please place the jumper at the location for SPI interface because the following software uses SPI interface by default.

APP2.0 base board can be purchased at https://www.mouser.com/ProductDetail/Bosch-Sensortec/Application-Board?qs=sGAEpiMZZMuqBwn8WqcFUoBr6H0DPHbmmKD1%2FZpnPHTNXN07wcSwfQ%3D%3D.

APP2.0 base board schematics is available online at https://ae-bst.resource.bosch.com/media/_tech/media/application_board_2_0/BST-DHW-AN001-01_APP2_0_Hardware_Description_.pdf.

BHI260AB shuttle board can be requested through local sales representative and its schematics is available online at https://ae-bst.resource.bosch.com/media/_tech/media/shuttleboard_flyer/BST-DHW-FL026.pdf. On BHI260AB shuttle board, Bosch BMM150 and AKM AK09915 magnetometers are installed. Bosch 3-in-1 environmental sensor BME280 (temperature, air pressure and humidity) is also installed.

3 Software

In order to evaluate BHI260AB shuttle board, there are three software available,

- Development Desktop 2.0 (DD2.0)
- COINES v2.0
- ARC GNU IDE 2019.03-rc2 Eclipse

Their differences are as shown in Table 2.

Table 2 functionalities of these three SW

Functionalities	DD2.0	COINES	ARC GNU
Real-time waveforms	Yes	No	No
Log data into a CSV file	Yes	Yes	Yes
Low level programming	No	Yes	Yes
Develop and test own algorithm	No	Yes	Yes
Generate customized RAM patch	No	No	Yes

3.1 DD2.0 SW

DD2.0 SW can be downloaded online at https://ae-bst.resource.bosch.com/media/_tech/media/development_desktop_software/DevelopmentDesktop20_V3.19.exe. After installation users are able to download the RAM patch into BHI260AB, enable virtual sensors, view real-time results and log results into a CSV file. The instructions are as shown below.

- Connect micro USB cable from APP2.0 base board to PC USB port. Switch on APP2.0 base board.

- Launch DD2.0 SW and DD2.0 will automatically recognize the BHI260AB shuttle board. A dialog window will be popped up asking to download the RAM patch as shown in Figure 2.

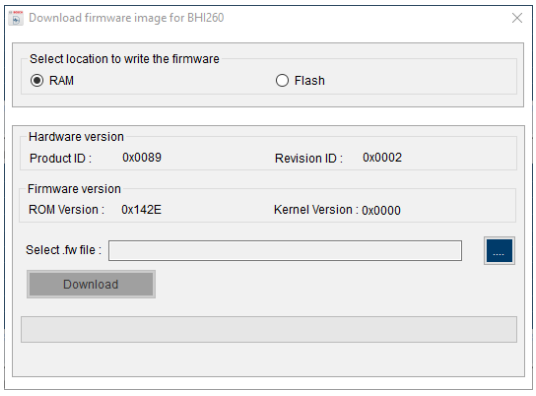


Figure 2 RAM patch download dialog

- Click the "…" button and select the "Bosch_LGA_SHUTTLE_BMI160_BMM150.fw" that is located in the "C:\Program Files\Bosch Sensortec\Development Desktop

2.0\Firmware\BHI260\RAM Images" folder. Then click the "Download" button. After a short while users should see the text "BHI260 firmware is downloaded successfully". Then close this dialog.

- Next step is to enable one or multiple virtual sensors by clicking the "Virtual Sensor" tab on the top right corner of DD2.0 SW. For example, from the "Virtual Sensor" dropdown list select "Gravity (Non-Wakeup)" and then click "Write Info" tab. Select 100Hz from the "Sample Rate" dropdown list and then click "Write" button.

- Similarly enable virtual sensor "Linear Acceleration (Non-Wakeup)" and "Orientation (Non-wakeup)" with the same 100Hz sample rate and click the "Write" button.

- Click "System" tab on the top right and select the above three virtual sensors from Plot1, Plot2 and Plot3 respectively. Then click "Refresh" button to check if each physical sensor is active or not from their "Power Mode" status respectively.

- Now click "Start Streaming" button on the bottom left to see the waveforms in real-time by rotating the APP2.0 base board with BHI260AB shuttle board plugged in. When moving on a flat surface back and forth, linear acceleration is changing in Plot2, while gravity vector in Plot1 remains the same as shown in Figure 3.

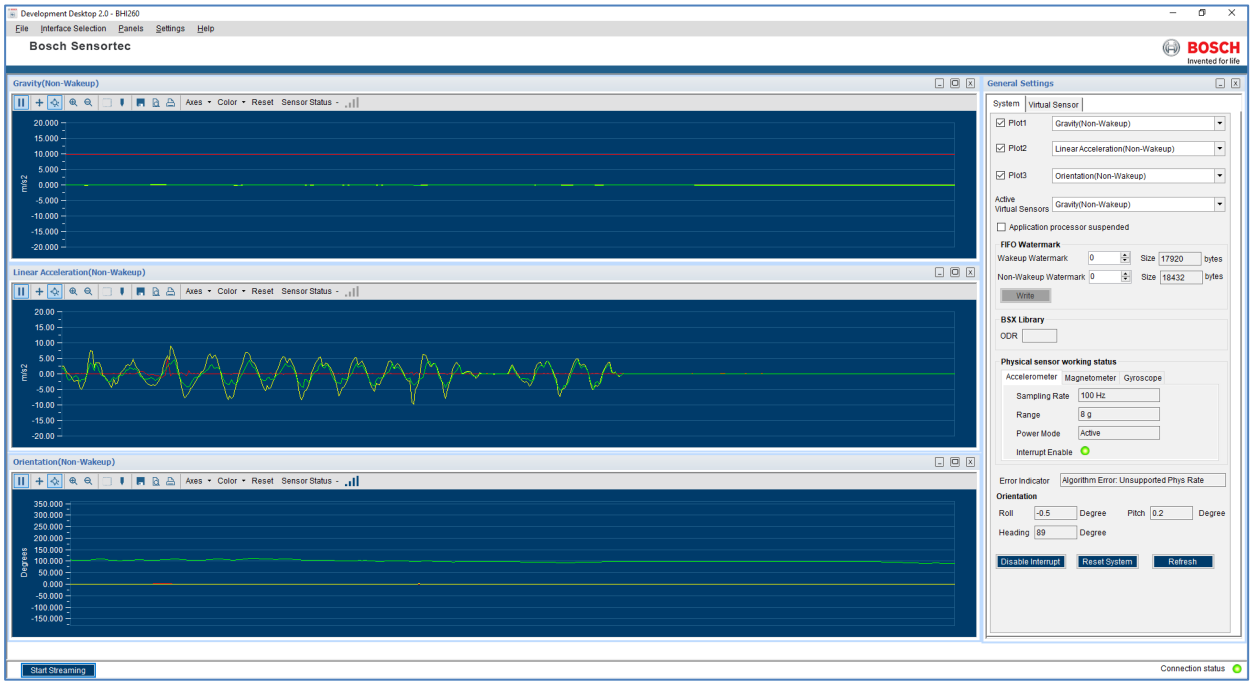
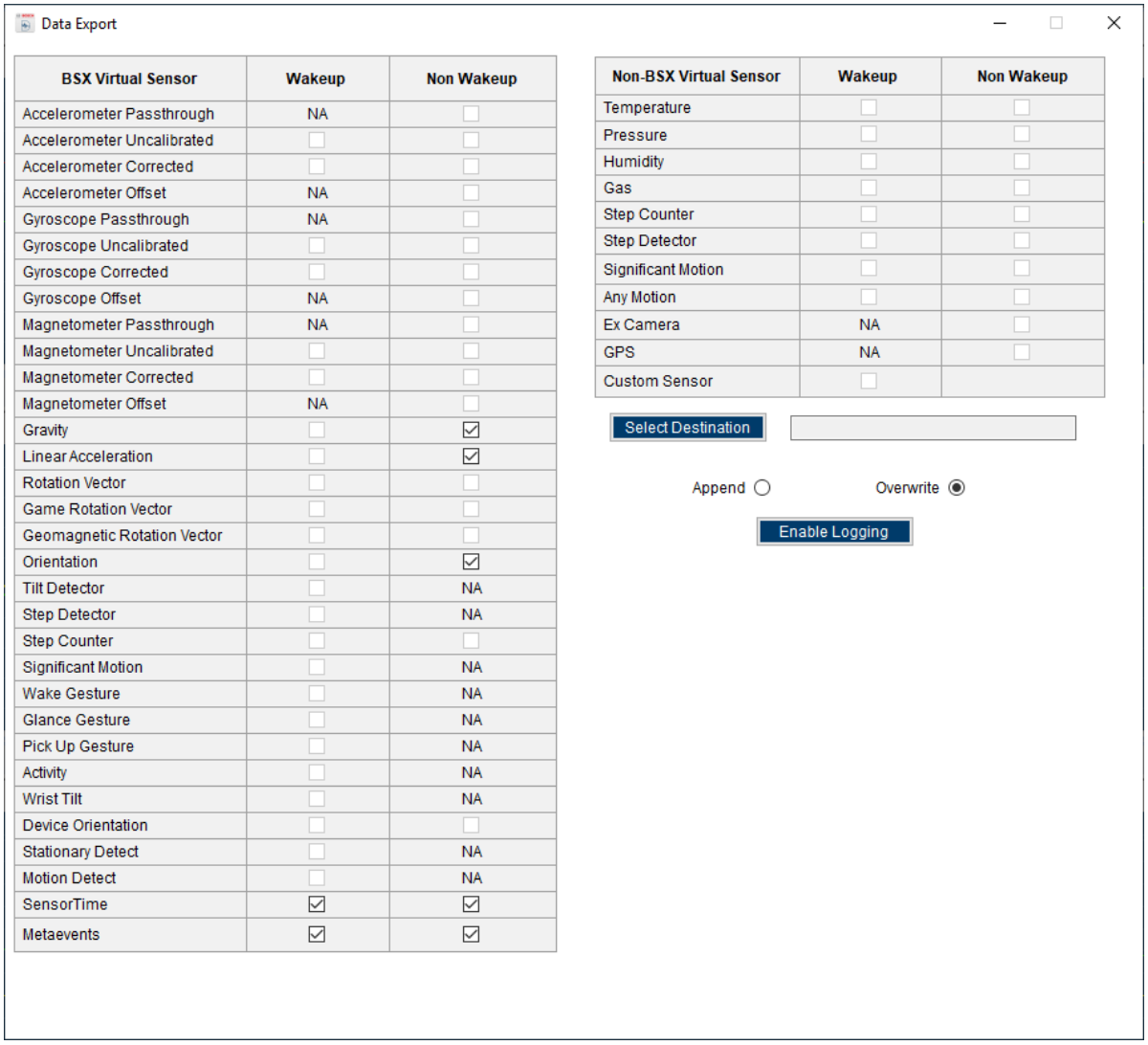


Figure 3 BHI260AB virtual sensors' waveforms

- Click "Panels -> Data Export" a dialog window will pop up as shown in Figure 4. The enabled virtual sensors' results can be saved into a CSV file.



BSX Virtual Sensor	Wakeup	Non Wakeup
Accelerometer Passthrough	NA	☐
Accelerometer Uncalibrated	☐	☐
Accelerometer Corrected	☐	☐
Accelerometer Offset	NA	☐
Gyroscope Passthrough	NA	☐
Gyroscope Uncalibrated	☐	☐
Gyroscope Corrected	☐	☐
Gyroscope Offset	NA	☐
Magnetometer Passthrough	NA	☐
Magnetometer Uncalibrated	☐	☐
Magnetometer Corrected	☐	☐
Magnetometer Offset	NA	☐
Gravity	☐	☑
Linear Acceleration	☐	☑
Rotation Vector	☐	☐
Game Rotation Vector	☐	☐
Geomagnetic Rotation Vector	☐	☐
Orientation	☐	☑
Tilt Detector	☐	NA
Step Detector	☐	NA
Step Counter	☐	☐
Significant Motion	☐	NA
Wake Gesture	☐	NA
Glance Gesture	☐	NA
Pick Up Gesture	☐	NA
Activity	☐	NA
Wrist Tilt	☐	NA
Device Orientation	☐	☐
Stationary Detect	☐	NA
Motion Detect	☐	NA
SensorTime	☑	☑
Metaevents	☑	☑

Non-BSX Virtual Sensor	Wakeup	Non Wakeup
Temperature	☐	☐
Pressure	☐	☐
Humidity	☐	☐
Gas	☐	☐
Step Counter	☐	☐
Step Detector	☐	☐
Significant Motion	☐	☐
Any Motion	☐	☐
Ex Camera	NA	☐
GPS	NA	☐
Custom Sensor	☐	

Figure 4 Log data into a CSV file

3.2 COINES SW

COINES v2.0 SW can be downloaded online at https://ae-bst.resource.bosch.com/media/_tech/media/coines/COINES_v2.0_Windows.exe. After installation users are able to find the folder C:/Windows/COINES/v2.0 as shown in Figure 5.

COINES ("COmmunication with INertial and Environmental Sensors") provides a low-level interface to APP2.0 base board and each sensor shuttle board. Users can access MEMS sensors through a C interface. COINES can be used with the SensorAPI of the sensor. The SensorAPI is available at https://github.com/BoschSensortec. Source code of sample applications and SensorAPI are provided with the COINES library as a package. Users can modify, compile and run the sample applications. However, users cannot create their own virtual sensors with their own algorithms and then generate customized BHI260AB RAM patches.

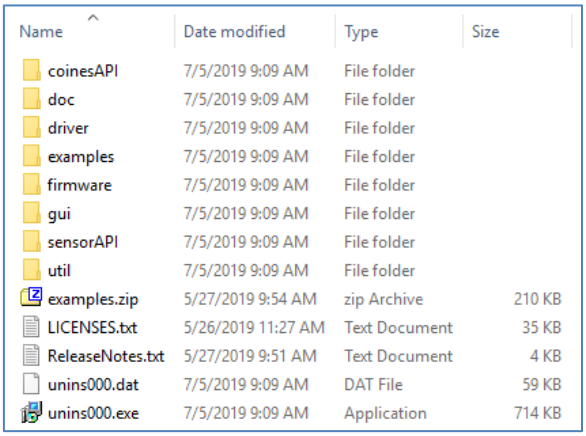


Figure 5 COINES folder

One example of using COINES together with the APP2.0 base board and BHI260AB shuttle board is as shown below.

- Go to folder C:\COINES\v2.0\examples\c\bhy2\rotation_vector in Windows File Explorer. Then press and hold “Shift” key on the keyboard and then right click the mouse. Select “Open PowerShell window here” as shown in Figure 6.

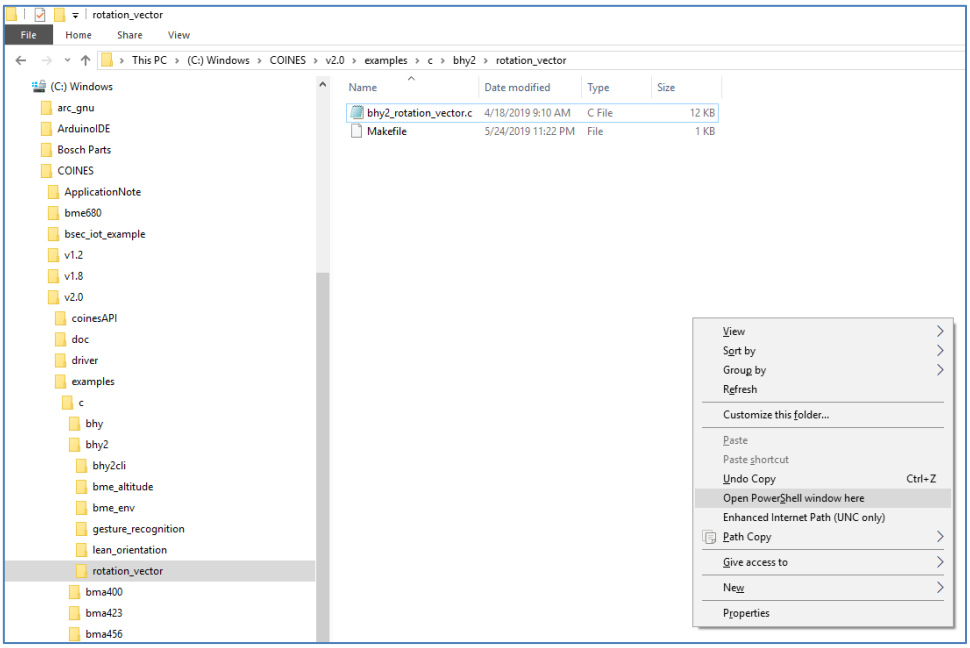


Figure 6 COINES example folder

- Type mingw32-make and press Enter key. The exe file is generated as shown in Figure 7.

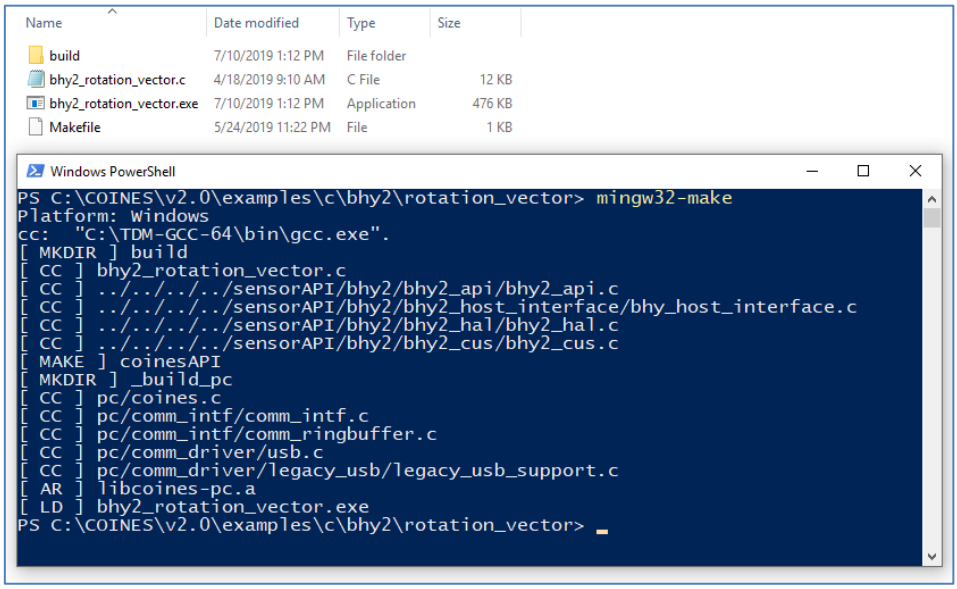


Figure 7 COINES compiling to EXE file

- Type .\bhy2_rotation_vector.exe and press Enter key. The RAM patch will be downloaded to BHI260AB shuttle board and COINES lists all the virtual sensors. Then COINES displays rotation vector quaternions x, y, z, w continuously as shown in Figure 8.

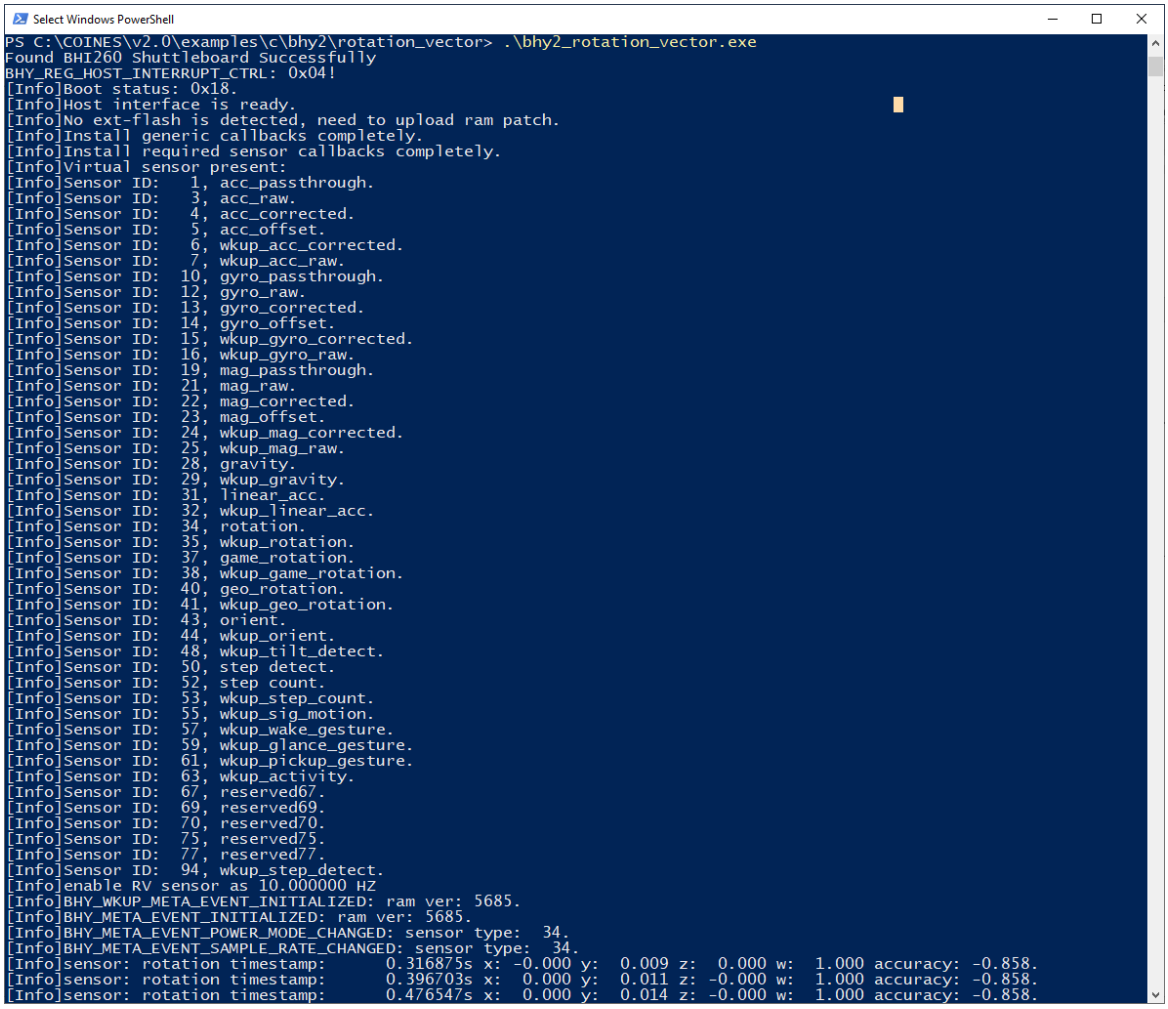


Figure 8 COINES example results

- Users can modify “bhy2_rotation_vector.c” file and compile it again for further evaluation. COINES has its own editor IDE on the desktop of the PC after installation.

- If user’s PC is Windows 10 OS x64, then please download TDM64-GCC-5.1.0-2 online at https://sourceforge.net/projects/tdm-gcc/files/TDM-GCC%20Installer/tdm64-gcc-5.1.0-2.exe/download. And then install it because it will be used to compile the code in COINES.

3.3 ARC GNU IDE 2019.03-rc2 Eclipse

The ARC GNU IDE 2019.03-rc2 for Windows can be downloaded online at https://github.com/foss-for-synopsys-dwc-arc-processors/toolchain/releases/download/arc-2019.03-rc2/arc_gnu_2019.03-rc2_ide_win_install.exe. It is all-in-one IDE for BHI260AB that allows users to develop their own algorithms, generate their own RAM patch together with the BHI260AB SDK and test the code together with COINES SW as a terminal.

The BHI260AB SDK "BHI260_SDK_Installer_V1.0.0.exe" is available under NDA. Please contact local sales representative for the NDA before BST FAE (field application engineer) sends the BHI260AB SDK to the user.

The following instructions show how to use ARC GNU IDE to develop customized BHI260AB RAM patch.

The example here is to create a new virtual sensor so called "Lean Device Orientation (LDO)" which uses BHI260AB accelerometer data to display which axis is pointing to sky. For example, Z+ means Z axis is pointing to sky and Z- means Z axis is pointing to ground.

- Assume the ARC GNU IDE, BHI260 SDK and COINES v2.0 have been installed on a Windows x64 PC.

- Launch ARC GNU IDE and click menu "File -> Import…". Then select "Existing Code as Makefile Project" and click "Next" button. Then click "Browse" button to locate the BHI260 SDK folder on your PC and click "Finish" button.

- Repeat the above step to import C:\COINES\v2.0\examples\c\bhy2\bhy2cli folder. Bhy2cli is a command line interface tool between PC and BHI260AB shuttle board. Users can open a Terminal in ARC GNU IDE and type commands there to see the results.

- In ARC GNU IDE click "BHI260_SDK" on top left and then click menu "Project -> Properties". Click "C/C++ Build" on the left of the popup window and type "build.bat" on the Build command Edit box as shown in Figure 9.

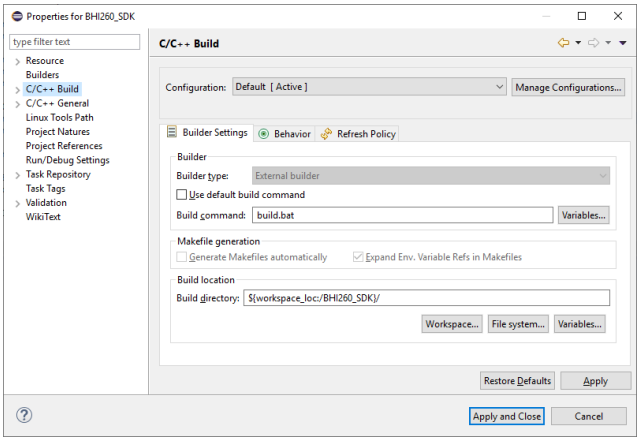


Figure 9 Project Properties Builder Settings

- Then click “Behavior” tab and make the configurations as shown in Figure 10.

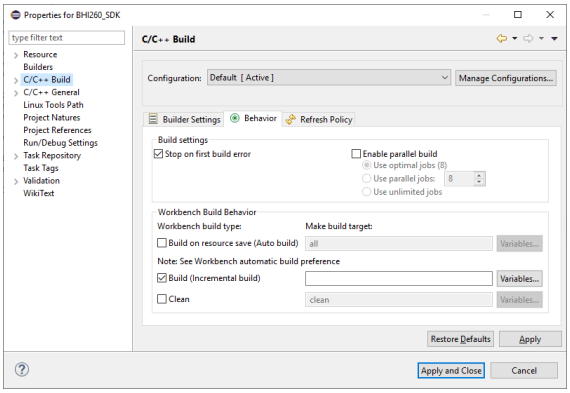


Figure 10 Project Properties Behavior

- Click menu “Windows -> Show View -> Terminal”. A new “Terminal” tab will show up. Then click the “Open a Terminal” icon on the right side and click “OK” button as shown in Figure 11.

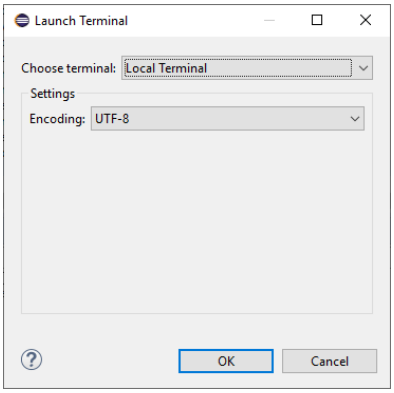


Figure 11 Terminal configuration

- Now ARC GNU IDE is ready to use.

The following three steps show how to create own virtual sensor and generate own RAM patch *.fw file.

- Open the “boards” folder under BHI260_SDK project in ARC GNU IDE. Copy and paste “Bosch_SHUTTLE_BHI260_BMM150.cfg” file and then rename it as “Bosch_SHUTTLE_BHI260_BMM150_LDO.cfg”. At the end of this file, add below two lines as shown in Figure 12.

```
131, -1.000000 # custom LDO data source
132, -1.000000 # custom LDO algo
```

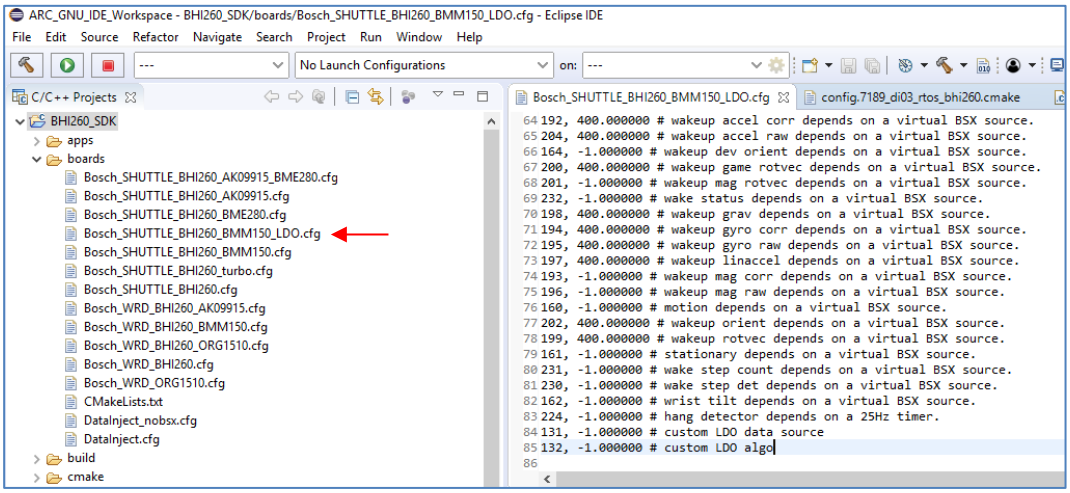


Figure 12 Create a new *.cfg file

- Double click the file “config.7189_di03_rtos.cmake” under the “common” folder. Add the line Bosch_SHUTTLE_BHI260_BMM150_LDO as shown in Figure 13.

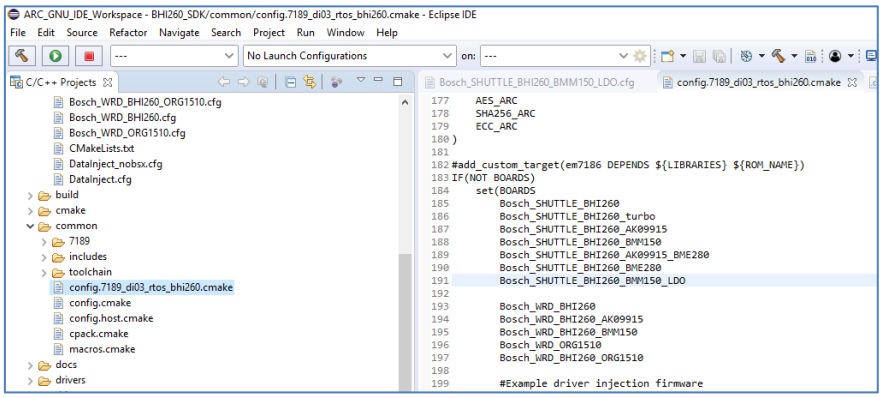


Figure 13 Add the new cfg board name

- In the “drivers” folder two driver source codes have been implemented as an example: VirtBSXCustomAccelDataSource and VirtBSXLeanDeviceOrientation. They need to be added under the ENABLED_DRIVERS in the file “config.7189_di03_rtos.cmake” as shown in Figure 14.

  The VirtBSXCustomAccelDataSource driver defines the accelerometer data is from the Fuser Core2 BSX4 sensor fusion library.

  The VirtBSXLeanDeviceOrientation driver is how the new own customized algorithm is implemented.

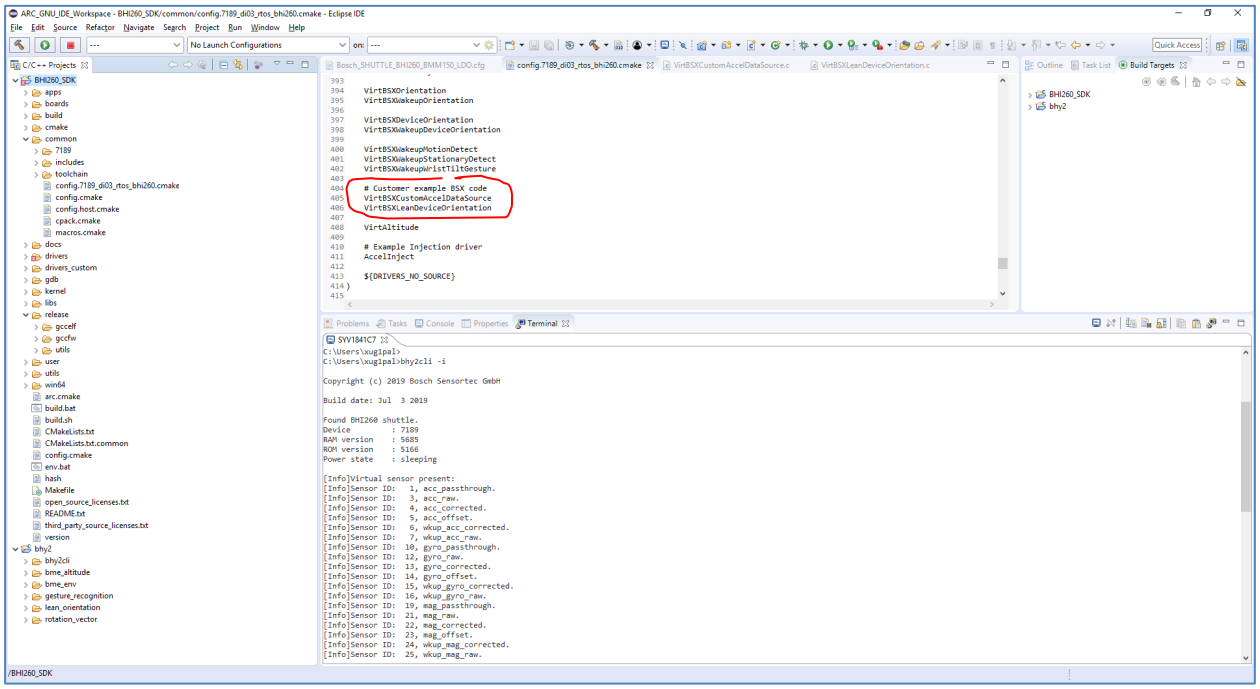


Figure 14 Add the two new custom drivers' names

- Click menu "Project -> Build All". It should show 0 errors. Then click the "release -> gccfw" folder and the "Bosch_SHUTTLE_BHI260_BMM150_LDO.fw" has been generated there.

The following steps show how to test the new virtual sensor performance.

- In Terminal type the following,
  bhy2cli -b <path_to_release_gccfw_folder>/Bosch_SHUTTLE_BHI260_BMM150_LDO.fw
  The new RAM patch will be downloaded into BHI260AB shuttle board as shown in Figure 15.

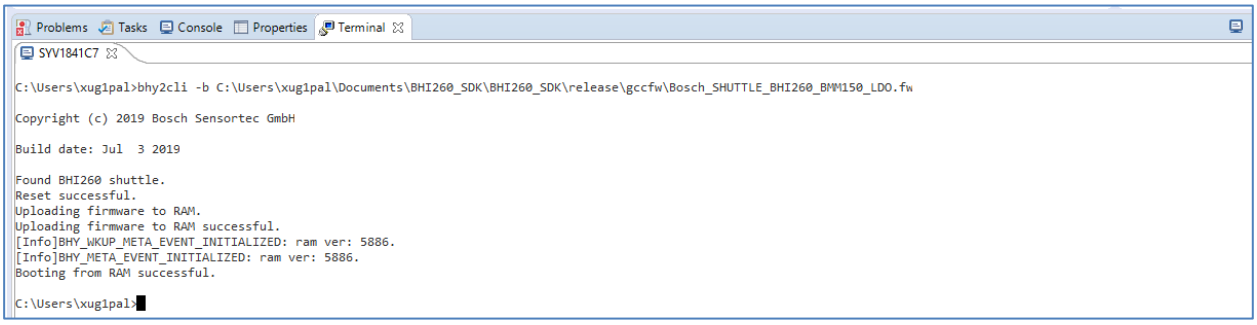


Figure 15 bhy2cli –b command to download RAM patch to BHI260AB shuttle board

- In Terminal type bhy2cli –i command and press Enter key. It will list all the Sensor IDs as shown in Figure 16. Sensor ID 160 is the new virtual sensor that is just implemented.

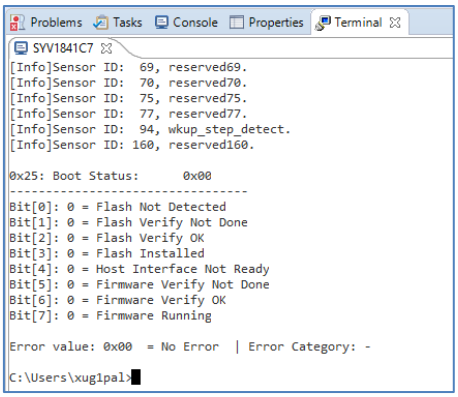


Figure 16 bhy2cli –i command to list all sensor IDs

- In Terminal type bhy2cli -a 160:LDO:nw:2:c:c -c 160:10 command and press Enter key. It will display the results at 10Hz when the BHI260AB shuttle board is facing different orientations as shown in Figure 17.

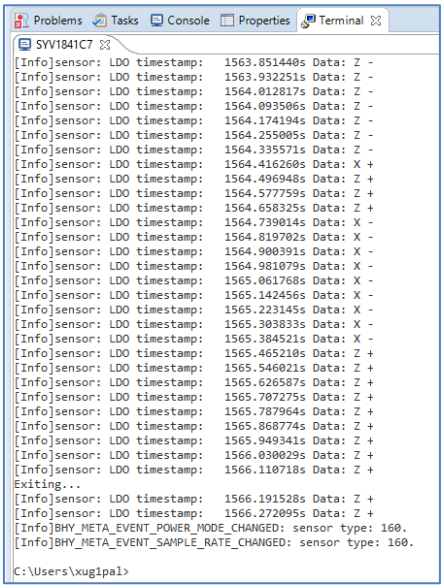


Figure 17 bhy2cli –a command to show results

4 Legal disclaimer

4.1 Engineering samples

Engineering Samples are marked with an asterisk (*) or (e) 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.

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5 Document history and modification

Rev. No	Chapter	Description of modification/changes	Date
1.0		Document creation	July 18th, 2019

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