1. Hardware

1.1. Introduction

The FSM300 is a compact IMU module based on Hillcrest's BNO080 9-axis SiP. The FSM300 incorporates the BNO080, a 32.768 kHz crystal and passive components into a compact module form factor that can be quickly and easily integrated into a design. The FSM300 provides all the motion based outputs available on the BNO080. It does not support environmental sensors.

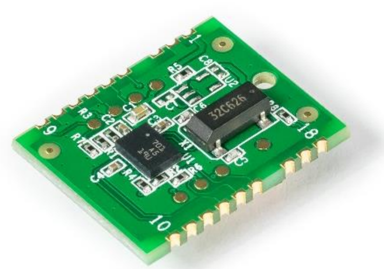

Figure 1: FSM300

1.2. Connections with Nucleo

The FSM300 uses the Sensor Hub Transport Protocol (SHTP) to communicate with a system or application processor (host that connects to the FSM300). The SHTP protocol is documented in the *BNO080 Datasheet* [1], allowing a customer to potentially develop their own host software if they choose to do so. In order to ease customer integration, Hillcrest has developed software that runs on a host platform such as the STM32F4x1RE Nucleo series. The software driver fully implements the communication protocol used by the FSM300. Hillcrest provides this software driver package as source code.

Please refer to Hillcrest *FSM30X Datasheet* [4] and *FSM300 Connection with Nucleo* [5] for more information on the pinout and connection.

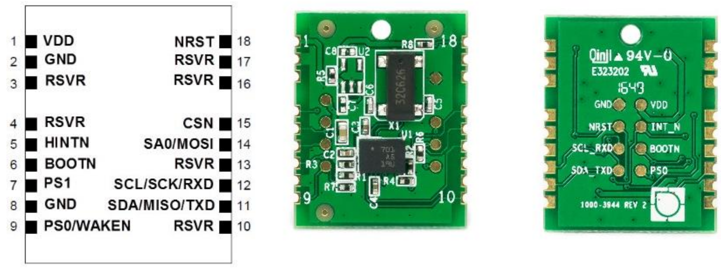

Figure 2: FSM300 Pinout

Customers who intend to use the FSM300 for their own software development should purchase STM32F4x1RE Nucleo series separately. There are two options to evaluate the FSM300 modules, which will be explained in detail in the next section.

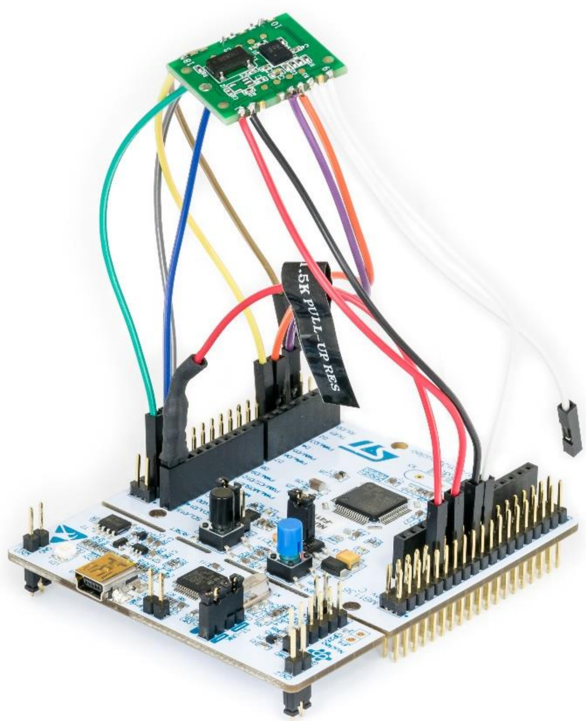

Figure 3: FSM300 connected to STM32F411RE Nucleo Board (I2C mode shown)

2. Software

2.1. FSM300 with STM32 Nucleo Board Running a PC Demo Application

Customers can download STM32 Nucleo board image with Hillcrest software that allows communication between the FSM300 and Freespace® MotionStudio 2.

Freespace® MotionStudio 2 is a Windows application to allow users to control and configure the FSM300 through a USB interface. This approach can be used for a quick evaluation of the FSM300. A generalized system diagram is shown in Figure 4.

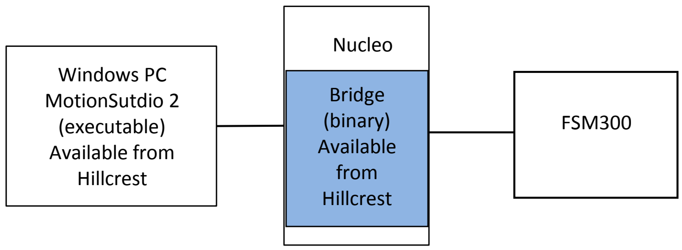

Figure 4: Simplified System Diagram with Freespace® MotionStudio 2

2.1.1. Program STM32F4 Nucleo Board with the Bridge Binary

Download Nucleo Bridge Binary from http://hillcrestlabs.com/products/fsm300/#tab-03.

Program STM32 Nucleo board you purchased with the bridge image:

- Open STM32 ST-LINK Utility.
- Target->Connect.
- Target->Program.
- In new window select “File path” to locate the file you just downloaded.
- Click “Start”.

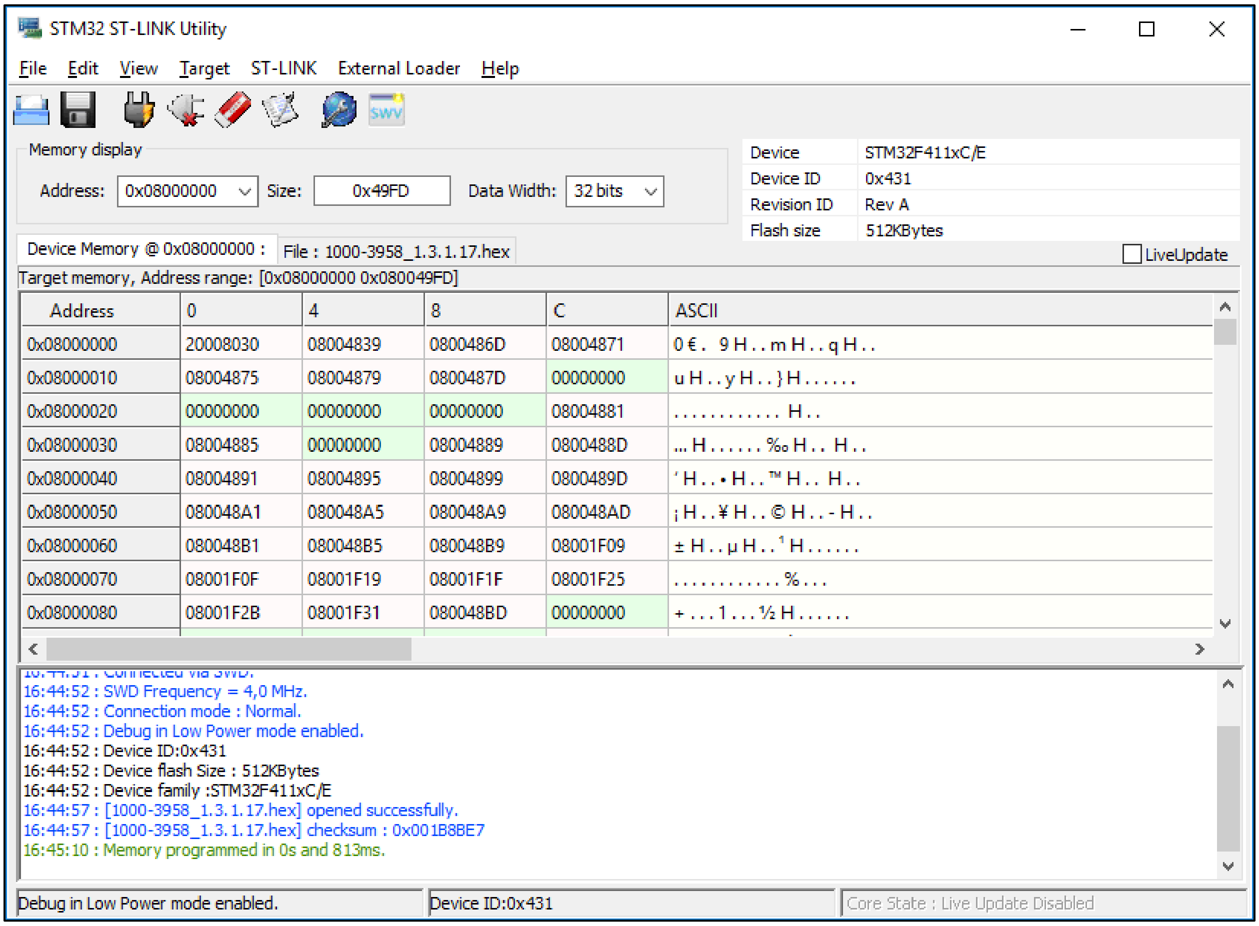

Figure 5: STM32 ST-LINK Utility Window

2.1.2. Other Requirements

Running Freespace® MotionStudio 2 with FSM300 requires the following items.

- ST-LINK/V2 USB driver available from the ST website (http://www.st.com/en/embedded-software/stsw-link009.html).
- ST32 Virtual COM Port Driver from ST website (http://www.st.com/en/development-tools/stsw-stm32102.html). The FSM300 software package is tested with STSW version 1.4.0. Once you have downloaded and extracted the driver, follow the readme.txt file for the instruction to complete the installation.
- Freespace® MotionStudio 2 application from http://hillcrestlabs.com/products/fsm300/#tab-03.

Connect USB Type A to Mini-B cable to Nucleo board and your PC. The virtual COM port should appear in your Device Manager.

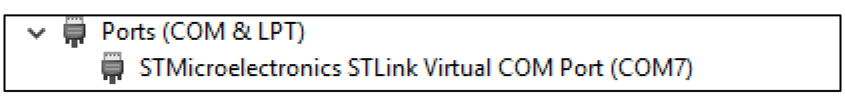

Figure 6: Device Manager to Check Installed Driver for ST Virtual COM Port

Start Freespace® MotionStudio 2 (MotionStudio2.exe) after STM32 Nucleo virtual COM port is successfully detected in your PC.

2.1.3. Running PC Application

Start Freespace® MotionStudio 2

After you unzip the PC Application package, launch MotionStudio2.exe under MotionStudio2 folder. This will open MotionStudio2 window.

Figure 7: Startup Window of Freespace® MotionStudio 2

Establish Connection to the Nucleo Board

From the menu panel on the left, select Device Connection. This panel allows users to select device type, transport protocol and more.

- “Device Type” of the bridge is set to ST Nucleo.
- ST Link Virtual COM Port available in your PC appears in “Virtual COM Port” box.
- “Target Device” is set to SHTP over I2C by default. Follow the instruction in the Application Note - *FSM300 Connection with Nucleo* [5] Section I2C. Please note that Freespace® Motion Studio 2 currently supports SHTP over I2C and SHTP over SPI interface.
- Use “Connect” button to start.

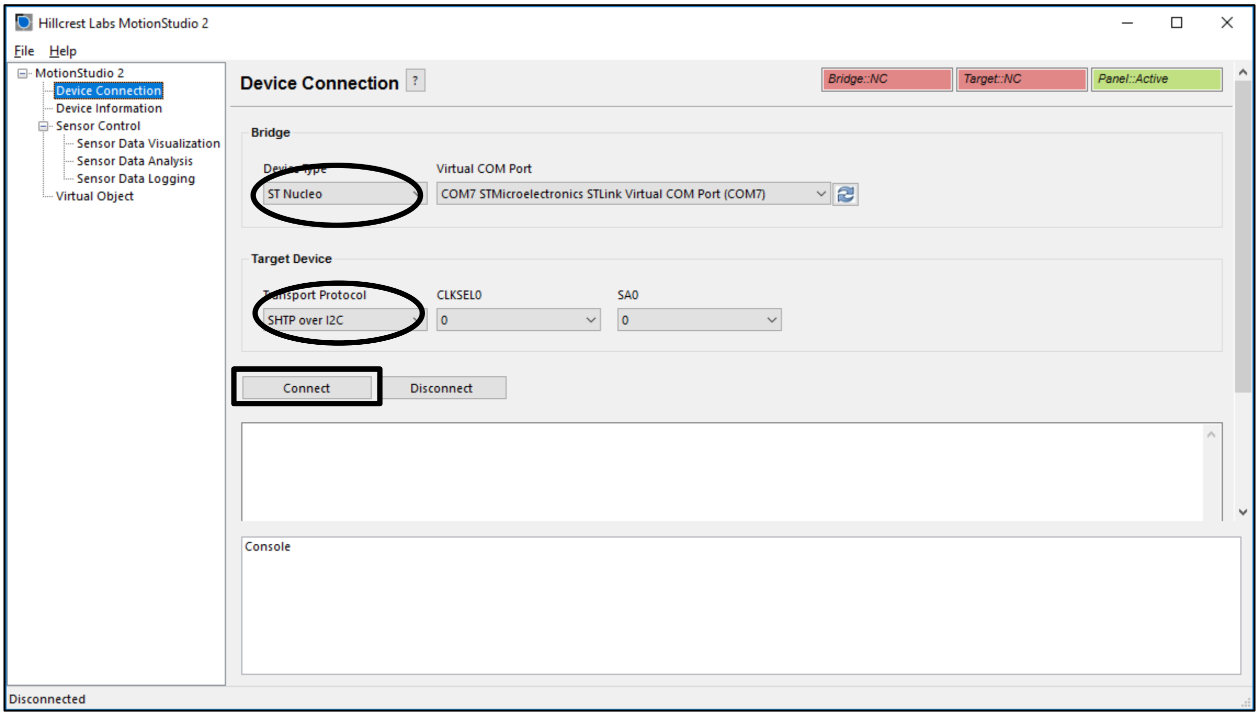

Figure 8: Device Connection Panel in Freespace® MotionStudio 2

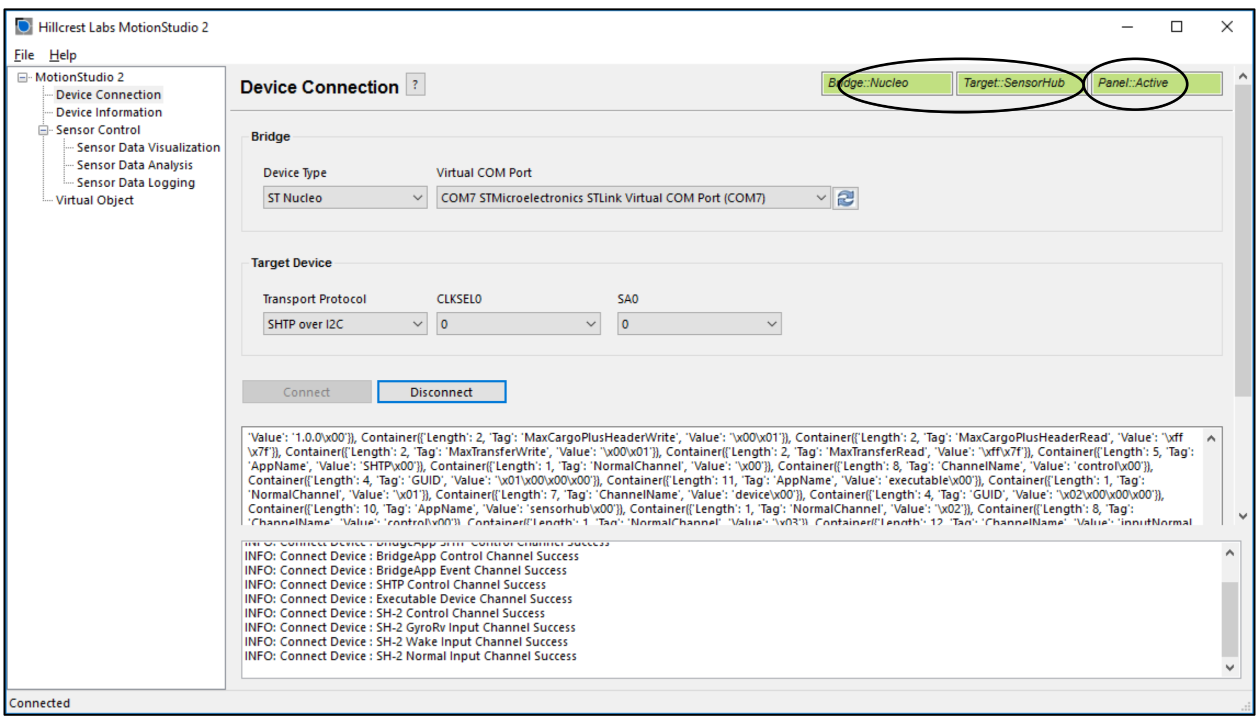

Figure 9: Device Connection Window after Successful Communication in Freespace® MotionStudio 2

When connection process is completed, the three status indicator text boxes on the upper right hand corner of the panel and the console window on the bottom would provide the result of connection process. The three status indicators show the status of the connected system and the status of the associated panel. If the specific panel supports the protocol used by the connected device, the panel becomes active and shows in green color.

Sensor Control

The Sensor Control panel allows the users to enable and disable the various sensors individually. There are two ways to control sensors:

- To enable an individual sensor at a default operation rate, use the check box on the right end of the row for each sensor.
- To enable sensors at specific rates, input the requested operation period, in microseconds, in the 'Requested Period (us)" fields. Then click the "Set Sensor Periods" button on the top of the panel. All sensors will be updated with specified operating period. The "Requested Period (us)" fields which are left blanked or obtained invalid value are assumed to be "zero".

In many cases, the sensors do not operate at the exact rate as requested. The actual operating period is shown in the "Reported Period (us)" field. Users can also use the "Get Sensor Periods" button on top of the panel to refresh the actual operating period for all sensors.

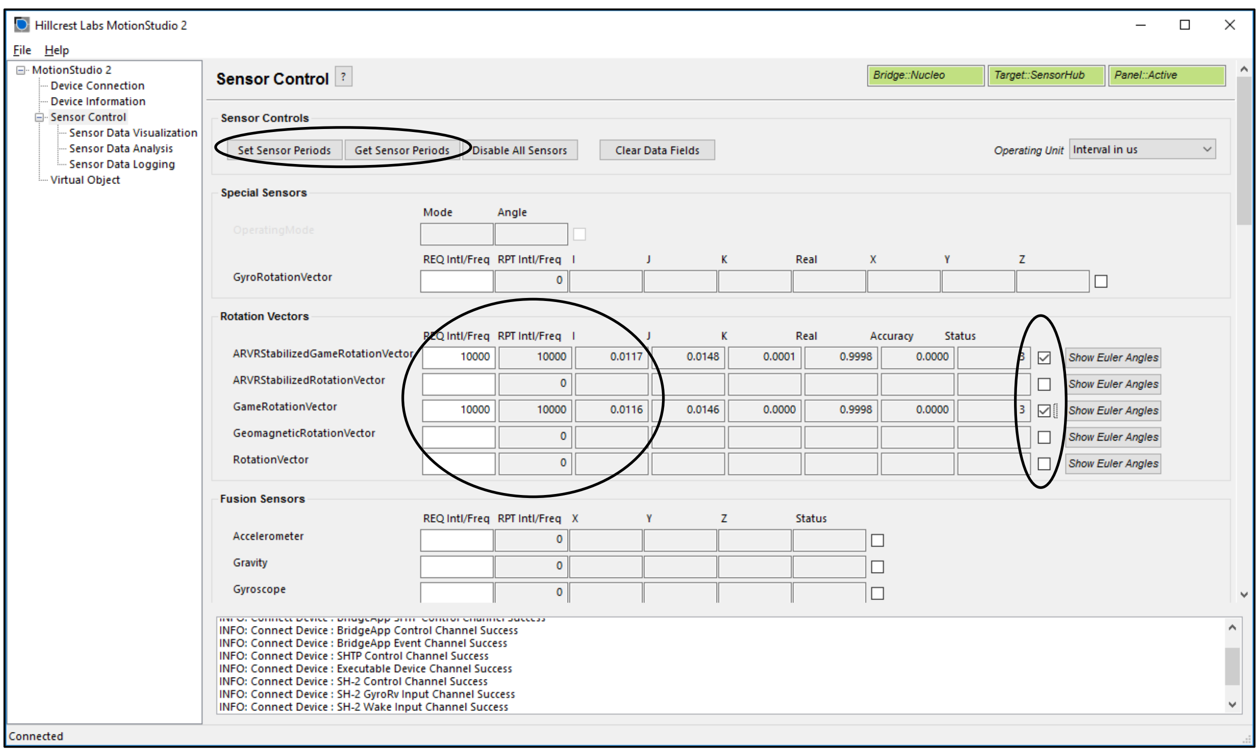

Figure 10: Sensor Control Panel in Freespace® MotionStudio 2

Virtual Object

Virtual Object panel shows the orientation of the device. Please note that you need to enable sensors in **Sensor Control** panel, select the sensor from the drop-down menu in **Virtual Object** panel. The sword in the Virtual Object will move to the device orientation.

To adjust the camera position, move the cursor to the Virtual Object Panel, then press the LEFT mouse button. Hold the button down and move the mouse to change the view position. To reset the camera position, use the "Reset Camera Position" button.

To display the game rotation vectors, select the game rotation vectors from the drop-down menu, the data fields should start updating with the received sensor data. The virtual object will move to the orientation of the hardware. Use the Sensor Control Panel to enable or disable the specific sensor. This panel does not control the sensor but displays the output data.

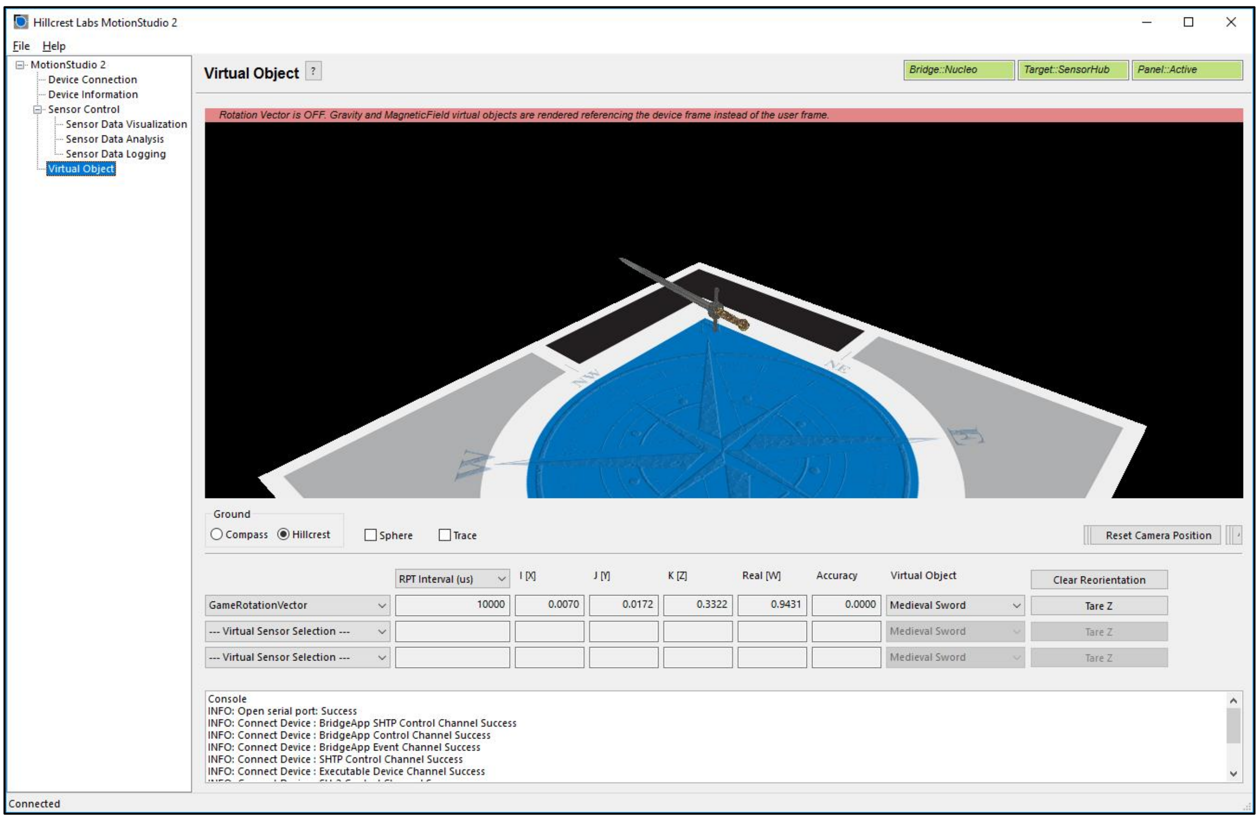

Figure 11: Virtual Object Panel in Freespace® MotionStudio 2

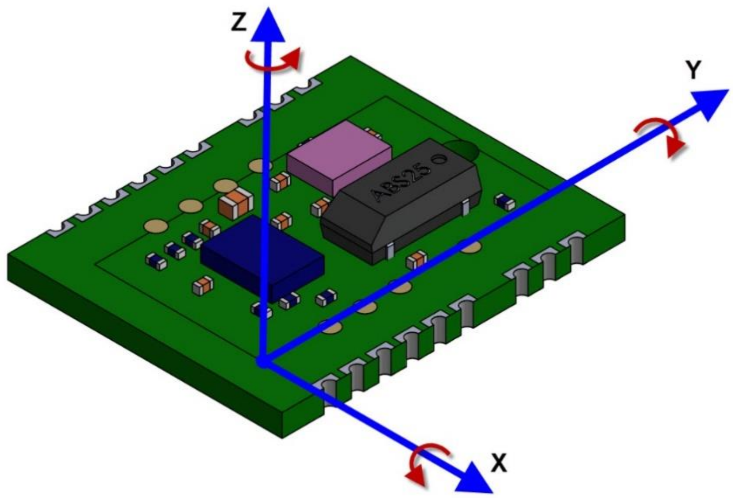

Figure 12: FSM300 Orientation

Please follow the instruction below to align your device.

- Enable Game Rotation Vector and ARVR Stabilized Game Rotation Vector in "Sensor Control" panel.
- Switch to Virtual Object panel and move the background so the black corner of the Hillcrest logo on the ground plane points to your forward direction (heading).
- Hold the FSM300 module Y+ axis points to your forward direction as well.
- Select "Game Rotation Vector" in drop down menu and click "Tare Z". Now, sword will point to the edge of the Hillcrest logo and is aligned with your device Y+.

- Switch to "ARVR Stabilized Game Rotation Vector" in drop down menu to evaluated ARVR Stabilized Game Rotation Vector.

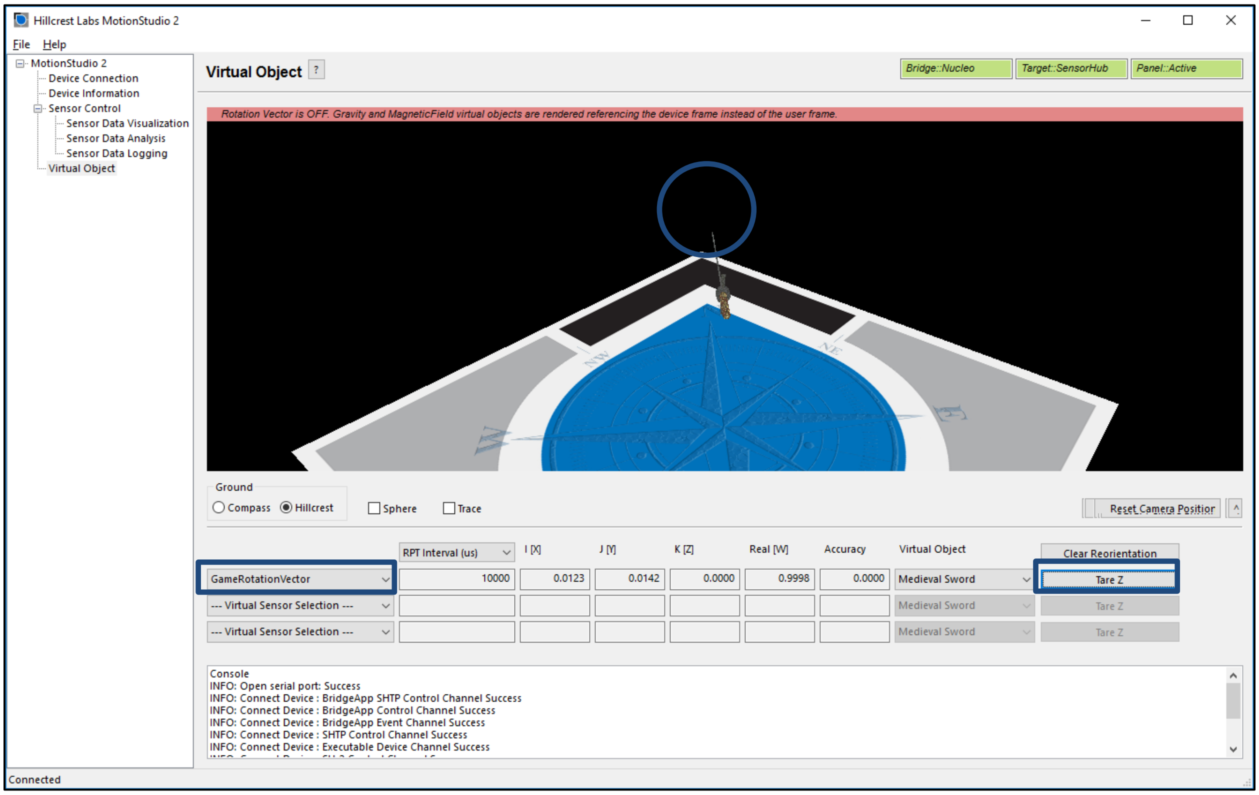

Figure 13: Sensor Orientation in Virtual Object Panel in Freespace® MotionStudio 2

2.2. FSM300 with STM32 Nucleo Board in Development Environment

The example software requires the following items to execute.

- IAR Embedded Workbench® for ARM (EWARM) by IAR Systems.
- ST-LINK/V2 USB driver. This driver is available from the ST website and is supported by the IAR Embedded Workbench for ARM (EWARM). After installing EWARM, check IAR_INSTALL_DIRECTORY\arm\drivers\ST-Link\ directory. Please skip this step if you have installed already from Section 2.1.2.
- ST32 Virtual COM Port Driver from the ST website. Please skip this if you have installed already from Section 2.1.2.

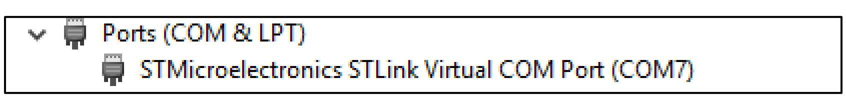

Figure 14: Installed driver for ST Virtual COM port

- Terminal emulator software like Tera Term or PuTTy. Set up the terminal emulator at 115200 – 8bit – no parity – 1bit stop bit – no flow control.

2.3. FSM300 with STM32 Nucleo Board Running Example Application

Hillcrest provides a complete software package for the STM32F4x1RE Nucleo boards.

The example application for the FSM300 source code is available in public github.

https://github.com/hcrest/bno080-nucleo-demo

Clone this repository using the --recursive flag with git. Alternatively, you can download a ZIP file from the link.

git clone --recursive https://github.com/hcrest/bno080-nucleo-demo.git

Everything required to obtain outputs from the FSM300 is included in this package. The software package incorporates the FSM300 sensor hub driver, enabling SH2 functionality for the development system.

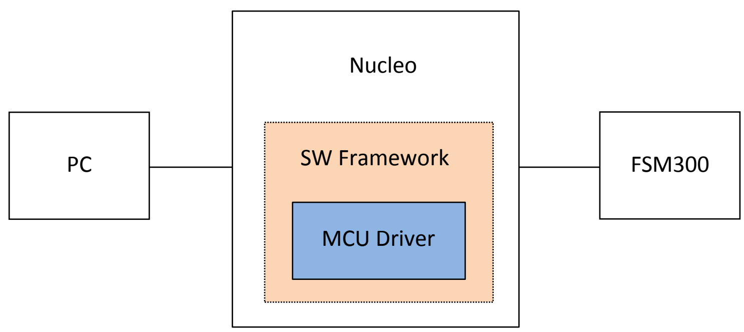

Figure 15: Simplified System Diagram (blue indicates driver developed by Hillcrest)

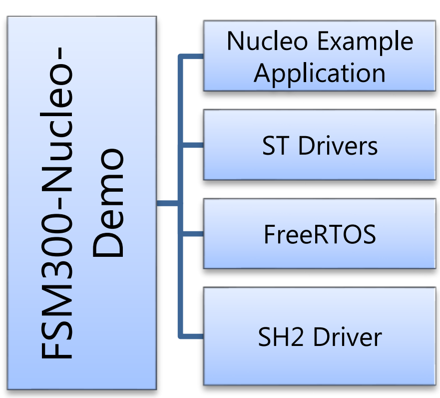

Figure 16: Source Code Structure

The software is organized as an IAR EWARM project that can be dropped into the IAR IDE on a Windows PC. Follow this procedure to compile the project and download the software to the Nucleo board.

- Open IAR Embedded Workbench for ARM (EWARM).
- In the File menu, select Open and choose Workspace. Browse to where the example package is extracted and select “sh2-example-nucleo/EWARM/Project.eww”. This should open an IAR workspace with all the files within the project.
- Select one of sh2-demo-i2c, sh2-demo-spi, sh2-demo-uart or demo-rvc in the project configuration based on the board connection. Refer the information in the Application Note - *FSM300 Connection with Nucleo* [5]. Please note that all 4 protocols are supported in MCU workspace.
- In the “Project” menu, select “Rebuild All” to compile the project.
- After the project is successfully compiled, go to the Project menu and select Download and Debug.

The “sh2” directory contains a full implementation of the Hillcrest communications protocol for the BNO080 and User’s Guide for Hillcrest’s SH-2™ driver.

The reader is encouraged to review the *BNO080 datasheet* [1] and the *SH-2 Reference Manual* [2] for details on how to construct messages.

The output from the FSM300 is printed through the serial port. The first few lines indicate that the host has established proper communication (“Product ID Request”) with the BNO080 and the BNO080 has responded with version information (“Product ID Response”).

Rotation vector is enabled at 100Hz by default and reports are printed through the serial port.

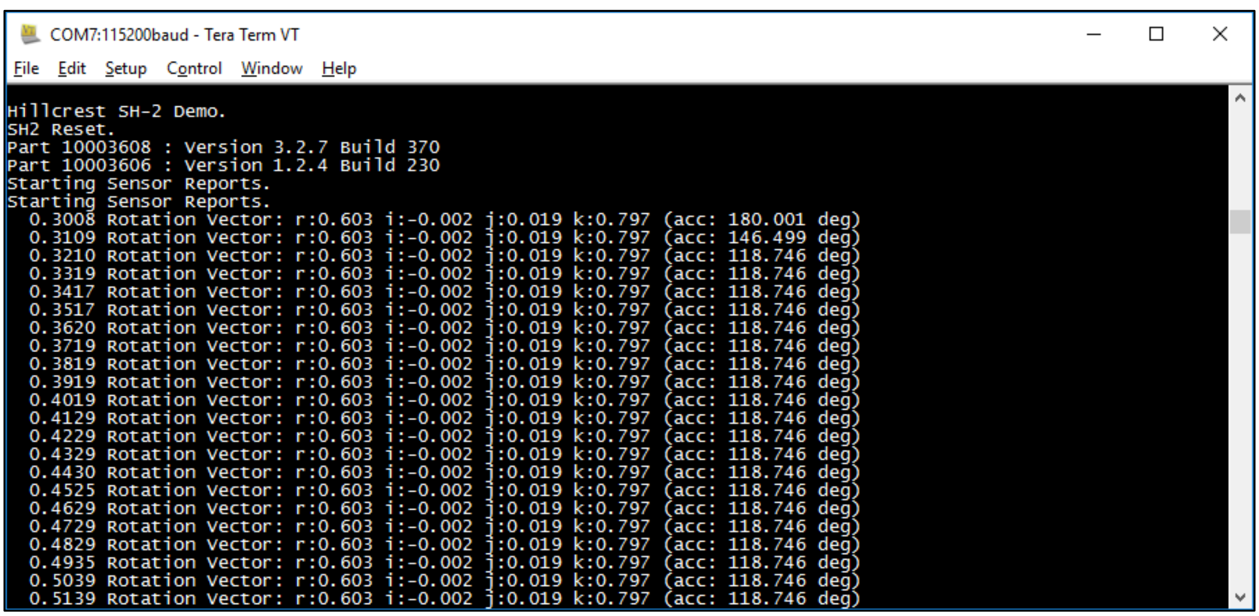

Figure 17: Terminal Emulator Screenshot

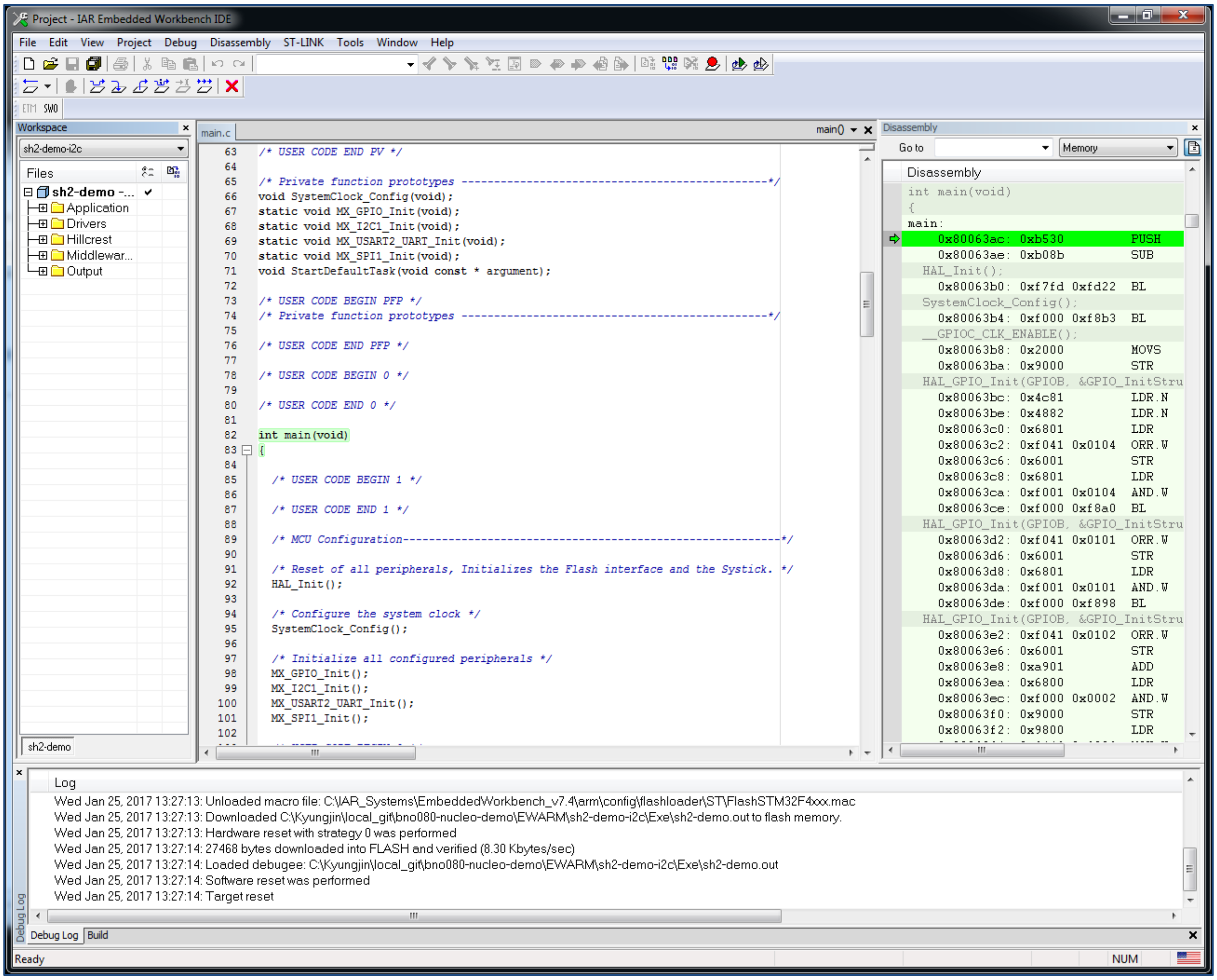

Figure 18: IAR EWARM Screenshot

References

1. 1000-3927 BNO080 Datasheet, Hillcrest Labs
2. 1000-3625 SH-2 Reference Manual, Hillcrest Labs
3. 1000-3600 SH-2 SHTP Reference Manual, Hillcrest Labs
4. 1000-4086 FSM30X Datasheet, Hillcrest Labs
5. 1000-4094 FSM300 Connection with Nucleo, Hillcrest Labs

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