



Multilink-Multirole Demo User's Guide

Multilink_Multirole_Demo_User's_Guide

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1. Overview

This document explains how to setup a Multilink-Multirole demo using SAML21 Xplained Pro, BM71-XPro, BNO055 Click board. This document briefly talks about setting up hardware, building application, programming application and running a demo.

This demo application showcases a Proof-of-Concept example of using **ble_host_sdk** to setup BM71 as a Multilink-Multirole device where it plays both GAP-Central and GAP-Peripheral roles, simultaneously. This demo application uses custom GATT service to share accelerometer and gyroscope sensor data with remote device.

The following table provides the list of supported BLE services and Characteristics in this application.

Name	UUID	Properties	Size (bytes)
Device Orientation Service (Custom)	0xF05ABAC1393611E587A60002A5D5C51B	-	-
Accelerometer Position Characteristic	0x1BC5D5A50200A687E5113639D7BA5AF0	Notify, Read	6
Gyroscope Position Characteristic	0x1BC5D5A50200A687E5113639D4BA5AF0	Notify, Read	6

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2. Configuring and flashing the service, characteristics, and descriptors to BM71 XPRO board

It is necessary to configure the BM71 XPRO board by making changes to the configuration file and flash the modified changes to BM71 XPRO board based on the peripheral application flow. The configuration changes demand the module to configure in Manual mode and add GATT service table.

By default, the BM71 XPro board is configured to operate in Auto mode. The Microchip Studio project, however, requires the module to set up in Manual mode.

The following instructions show how to setup and configure the module to add configuration changes.

1. Connect the BM71 XPro directly to the PC using the MicroUSB on the board. The BM71 XPro board should enumerate a COM port. If not, check if the necessary MCP2200 drivers have been installed.

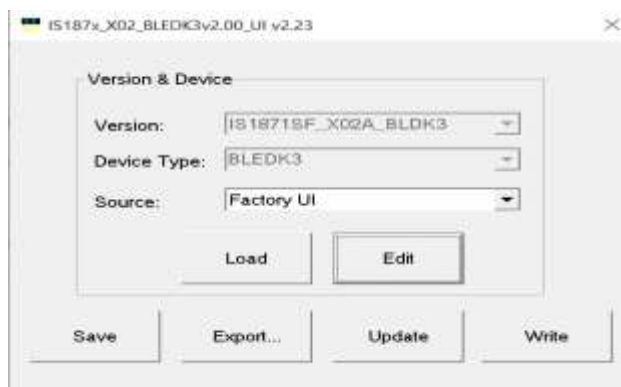
2. Set up the module to programming mode by configuring the Switch 1 in 3-pin DIP switch to ON state. The switch#1 sets the mode of operation on the module (between application mode and flash write mode). Refer to details on pin P2_0 in the BM70 datasheet for more details. The Blue LED (labeled BT_ACT, LD4) should be solid BLUE now. If not, check the following: a. Press 'Reset' button on the board.

NOTE: Make sure the jumper on J2 is set to USB.

3. Make sure that the BM71 module does have the correct BM71 firmware installed. By default they should be. However, if you have programmed the module to be RN4871, change the firmware. back to BM71. If the module has RN871 firmware, the module will not operate as expected. and the Studio project will fail.

4. Open the UI tool for the BM70/71 modules. This tool is available for download from the BM70/71 webpage under the 'Software libraries/firmware' section.

5. Open the UI tool:



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a. In the example below, the 'BM71 default table' is being used as the base file.
Click on 'Edit' to start editing the memory parameters.

b. The following changes are made in the first 'System Setup' tab:
i. Disable the low power operation.
ii. Change the operation mode to 'Manual pattern.'

The screenshot displays the 'System Setup' configuration window. It features several tabs: 'System Setup', 'System Setup2', 'LE Mode Setup', 'GATT Service Table', 'LED Setup', and 'Beacon Setup'. The 'System Setup' tab is active. The window is divided into three main sections: 'Device Information', 'Uart Setting', and 'Operation Mode Setting'. In the 'Device Information' section, the 'Name Fragment' is set to 'BM71_BLE'. The 'Uart Setting' section includes fields for 'HCI Baud Rate Index' (0x03 : 115200), 'H/W Flow Control' (Disable), 'Rx Notify Length' (0x05), 'UART RX_IND' (Disable, highlighted with a red box), 'UART Parity' (Disable), 'Parity Mode' (0x00: Odd Parity), and 'Stop Bit' (1 stop bit). The 'Operation Mode Setting' section includes 'Operation Pattern' (Manual Pattern, highlighted with a red box) and 'Configure Mode Timeout' (0x00). Navigation buttons 'Previous', 'Next', and 'Finish' are located at the bottom right.

c. In the 'GATT Service Table' tab, you will need to enter the private service/characteristics for the project.

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The following table provides the list of supported BLE services and Characteristics in this application.

Name	UUID	Properties	Size (bytes)
Device Orientation Service (Custom)	0xF05ABAC1393611E587A60002A5D5C51B	-	-
Accelerometer Position Characteristic	0x1BC5D5A50200A687E5113639D7BA5AF0	Notify, Read	6
Gyroscope Position Characteristic	0x1BC5D5A50200A687E5113639D4BA5AF0	Notify, Read	6

To create the custom GATT table using the UI Tool, select the “others” option in the ‘Service List’.



- i. The ‘Others’ is the option that allows you to create a User-defined service and characteristics. **Drag this text into the ‘Add-On Service Table’ field** above. You will get a dialog box to create the private service. Enter the Private service UUID.



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- ii. Click 'Next' and then enter the private characteristic under this service.

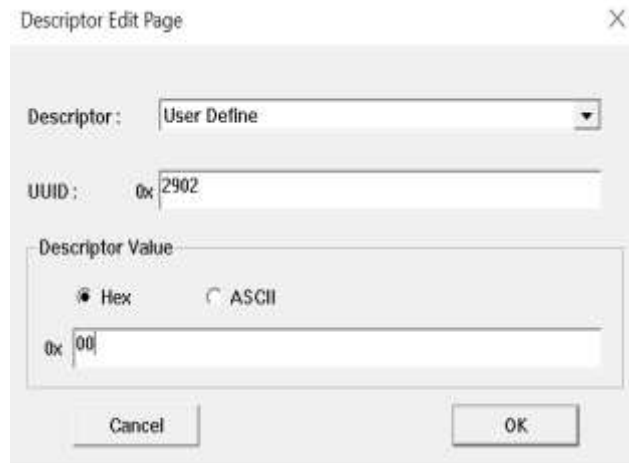
The 'Characteristic Edit Page' dialog box is shown. It has a title bar with a close button. The 'Characteristic' dropdown is set to 'User Define'. The 'UUID' field contains '0x1BC5D5A50200A6B7E5113639D7BA5AF0'. There are three checkboxes: 'Manual Read Response' (unchecked), 'Manual Write Response' (unchecked), and 'Attribute Permission' (unchecked). The 'Properties' section has two columns of checkboxes: 'Read' (checked), 'Write Without Response' (unchecked), 'Write' (unchecked), 'Notify' (checked), 'Indicate' (unchecked), and 'Extended Properties' (unchecked). The 'Characteristic Value' section has radio buttons for 'Hex' (selected) and 'ASCII' (unchecked). The value field contains '0x000000000000'. Below the field, it says '(MAX: 245 bytes, Current: 6 bytes)'. At the bottom are 'Cancel' and 'OK' buttons.

- iii. In the newly created private service in the 'Add-On service' field, right click on the private service to 'Add Characteristic' the second private characteristic. Enter the details of the second private characteristic.

This is a duplicate of the screenshot above, showing the 'Characteristic Edit Page' dialog box with the same settings: 'User Define' characteristic, specific UUID, unchecked manual response and attribute permission checkboxes, 'Read' and 'Notify' properties checked, 'Hex' value type selected, and a value of '0x000000000000'.

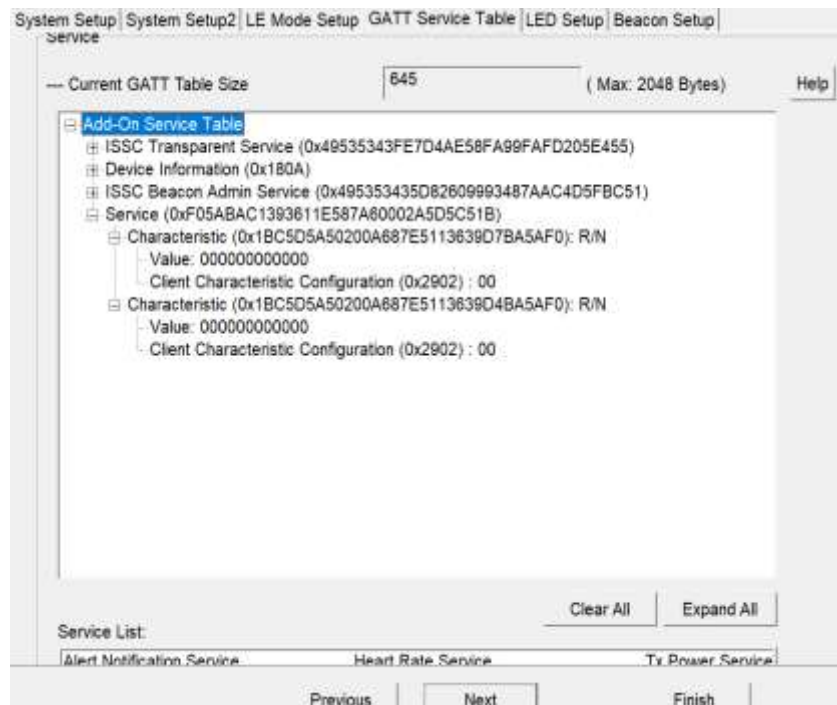
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- iv. Right click on the first Characteristic and select 'Add Descriptor' and enter the UUID as 2902



The image shows a 'Descriptor Edit Page' dialog box. It has a 'Descriptor' dropdown menu set to 'User Define'. Below it, the 'UUID' is entered as '0x2902'. The 'Descriptor Value' section has two radio buttons: 'Hex' (selected) and 'ASCII'. The 'Hex' value is entered as '0x00'. At the bottom are 'Cancel' and 'OK' buttons.

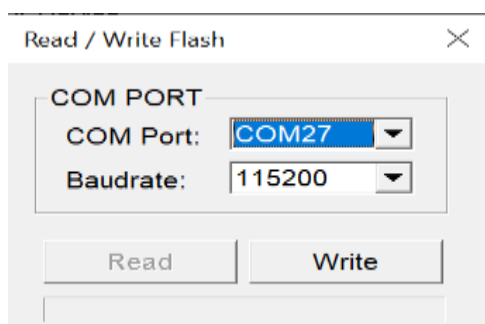
- v. Similarly add the descriptor for the second characteristic as well with the same UUID value (2902)
- vi. The final 'Add-On Service Table' should look like below.



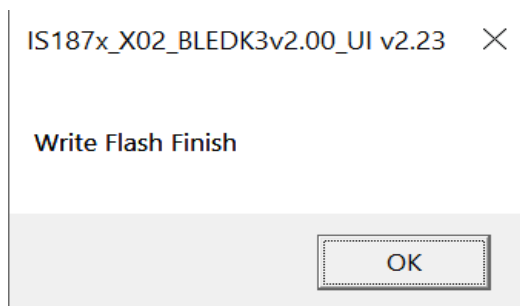
The image shows a screenshot of the 'GATT Service Table' window. The 'Current GATT Table Size' is 645 (Max: 2048 Bytes). The 'Add-On Service Table' is expanded, showing a list of services and characteristics. The 'Service List' at the bottom includes 'Alert Notification Service', 'Heart Rate Service', and 'Tx Power Service'. Navigation buttons 'Previous', 'Next', and 'Finish' are at the bottom right.

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- vii. Click on 'Finish'. All the parameter required are now set and ready to flash to device.
- viii. Click on 'Write' option in UI tool.
- ix. Select the COM port corresponding to the BM71 XPRO board. Make sure the Blue LED is still Solid ON to make sure the module is 'Write Flash' mode.



- x. Click on 'Write'. After the confirmation acceptance the configuration file will be written into the device memory.



- xi. Now, that the Flash write operation is done, the module needs to be set back to 'Application mode': Set the Switch#1 in the DIP switch to OFF and change the J2 jumper.

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3. Hardware Setup

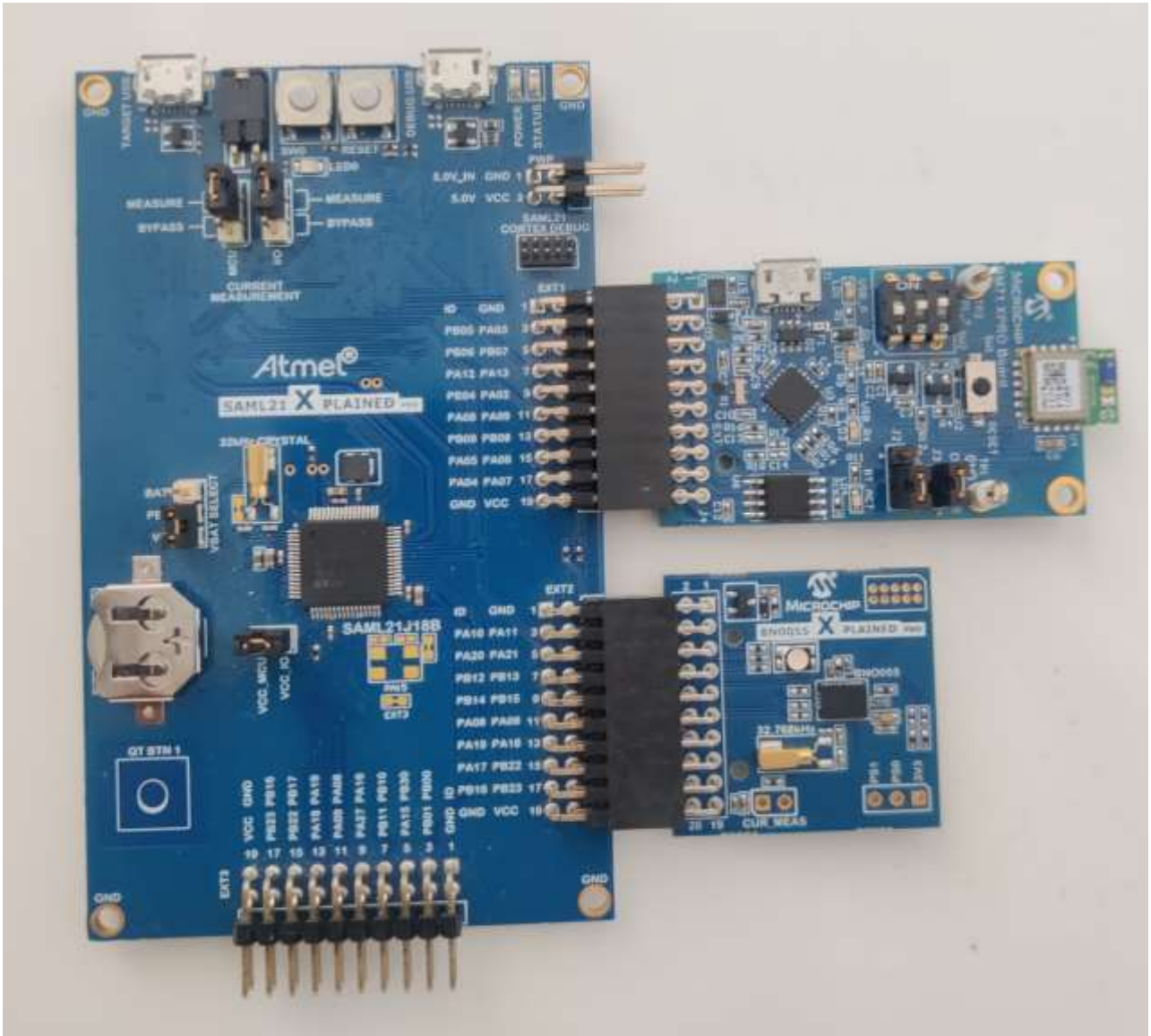


Figure 1: SAML21 Xplained Pro with BM71-XPRO and BNO055 Xplained PRO Board

1. Plug in the BM71-XPro board into EXT1 of SAML21 Xplained Pro board as shown in Figure 1.
2. BNO055 Xplained PRO Board is used in this demo. Plug-in the BNO055 board into the EXT2 of SAML21 Xplained Pro as shown in Figure 1.
3. Connect the SAML21 Xplained Pro board to the host PC using micro USB cable.

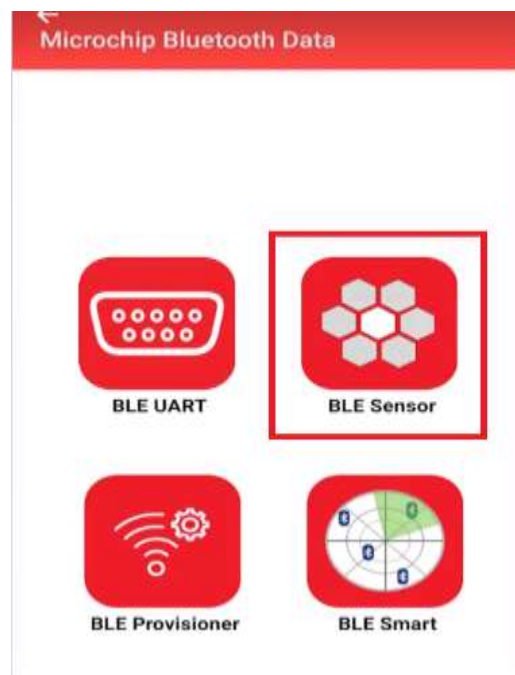
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4. Smart Phone Application

- i. Download the Microchip Bluetooth Data (MBD) mobile application from the play store.



- ii. Select the BLE Sensor tab



- iii. Select the RN4870 Sensor/BM70 Compact Demo Board option



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5. Console

The Multilink-Multirole demo application uses the Universal Asynchronous Receiver/Transmitter (UART) interface on SAML21 Xplained Pro to send the status messages like Advertising, Connected, Disconnected ... etc. Any serial application (ex: TeraTerm) can be used to interact with SAML21 Xplained Pro.

Use the following serial port configuration to interact with BM71.

Baud rate	115200
Data	8 bits
Parity	none
Stop	1 bit
Flow control	none

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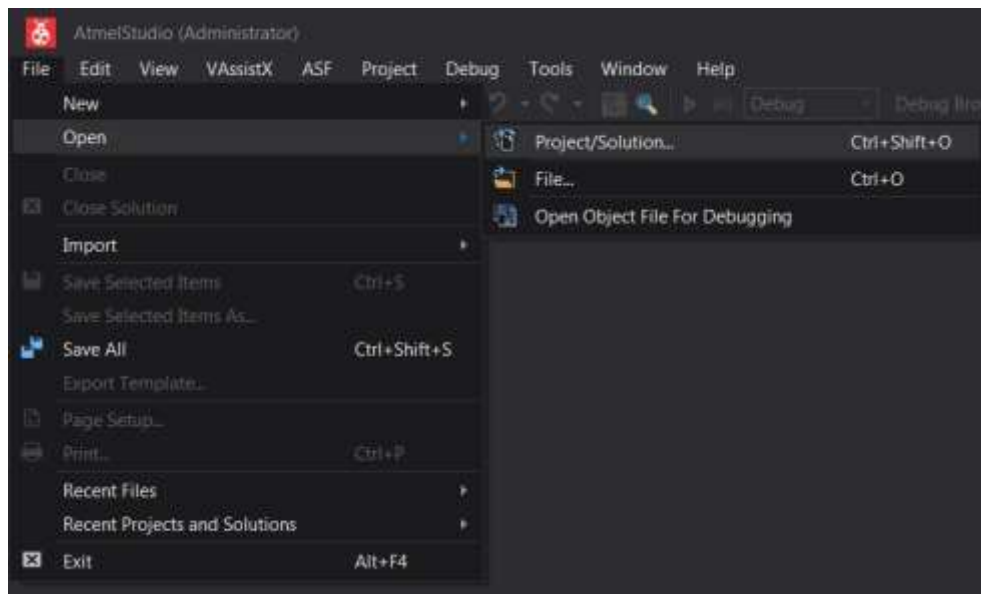
6. Build Procedure

This section describes the build procedure of Multilink-Multirole demo application on Atmel Studio 7.

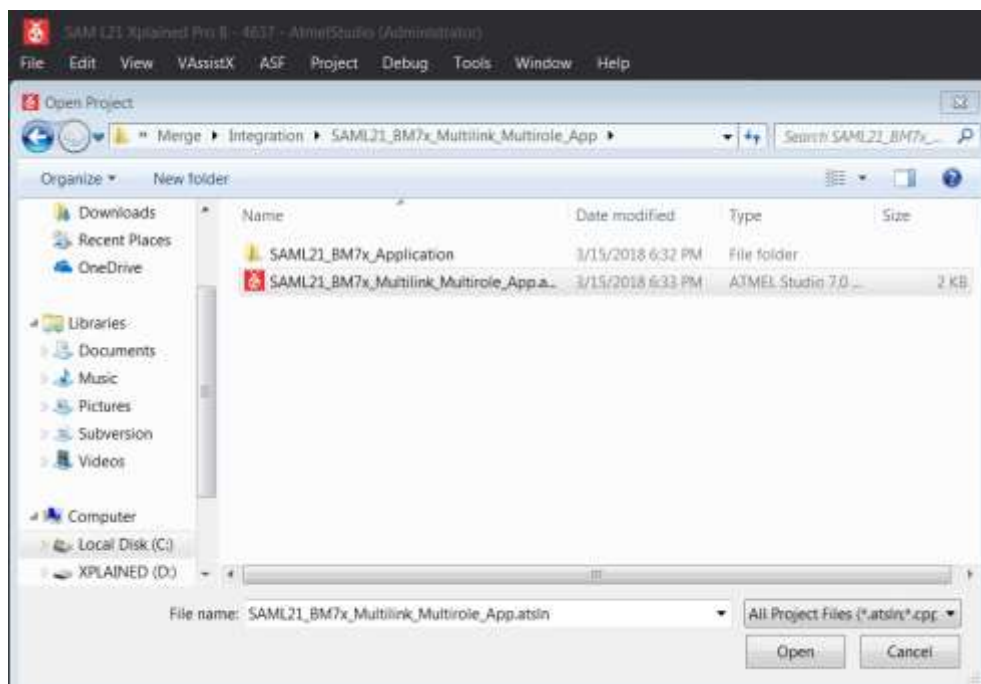
6.1 Open Atmel Studio 7

6.2 Open Multilink-Multirole Demo Application

Go to menu **File → Open → Project/Solution**



2. Select “SAML21_BM7x_Multilink_Multirole_App.atsln” and press **Open**.

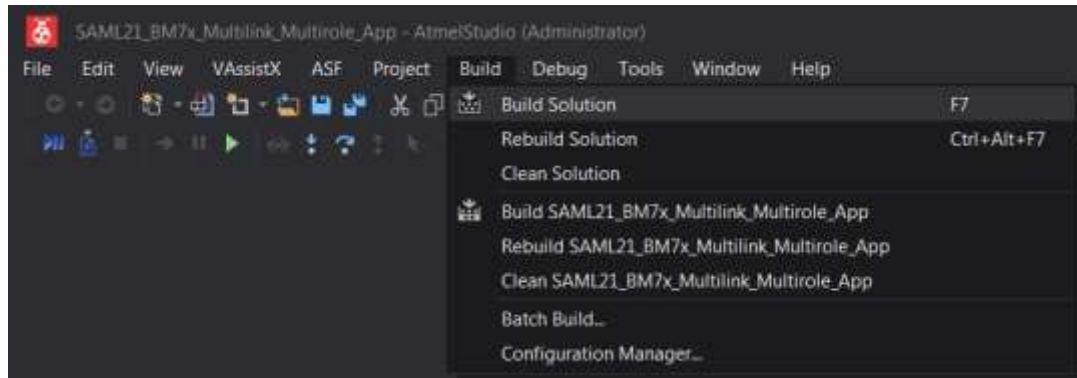


3. Once the project is opened, you can see the files attached to this project in Solution Explorer Window

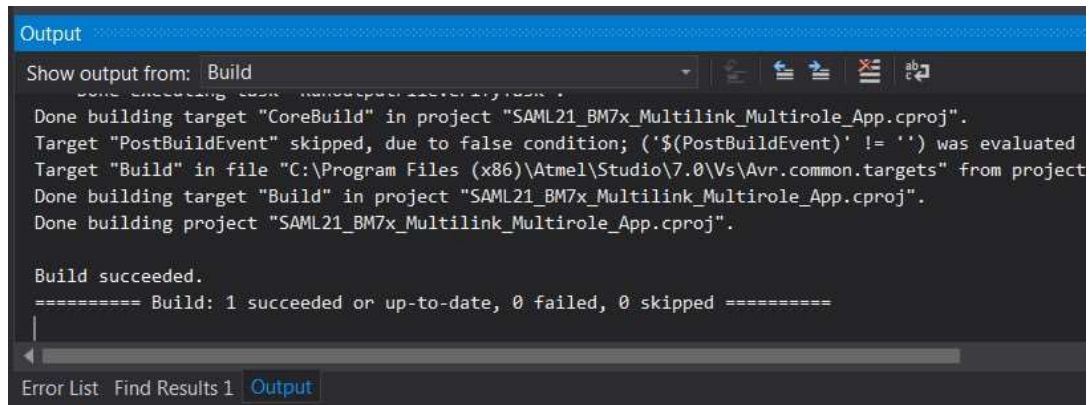
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6.3 Build Multilink-Multirole Demo Application

Go to menu **Build → Build Solution** or Press **F7**



2. Build status can be checked in **Output** window



3. You can find the Hex images in `..\SAML21_BM7x_Application\Debug`.

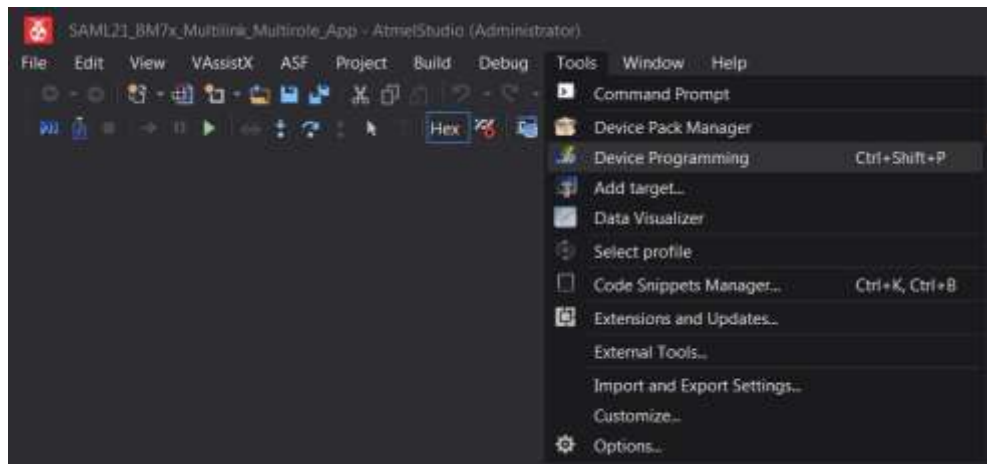
6.4 Programming Multilink-Multirole Firmware

This section describes the procedure to program Multilink-Multirole demo firmware on SAML21 Xplained Pro board.

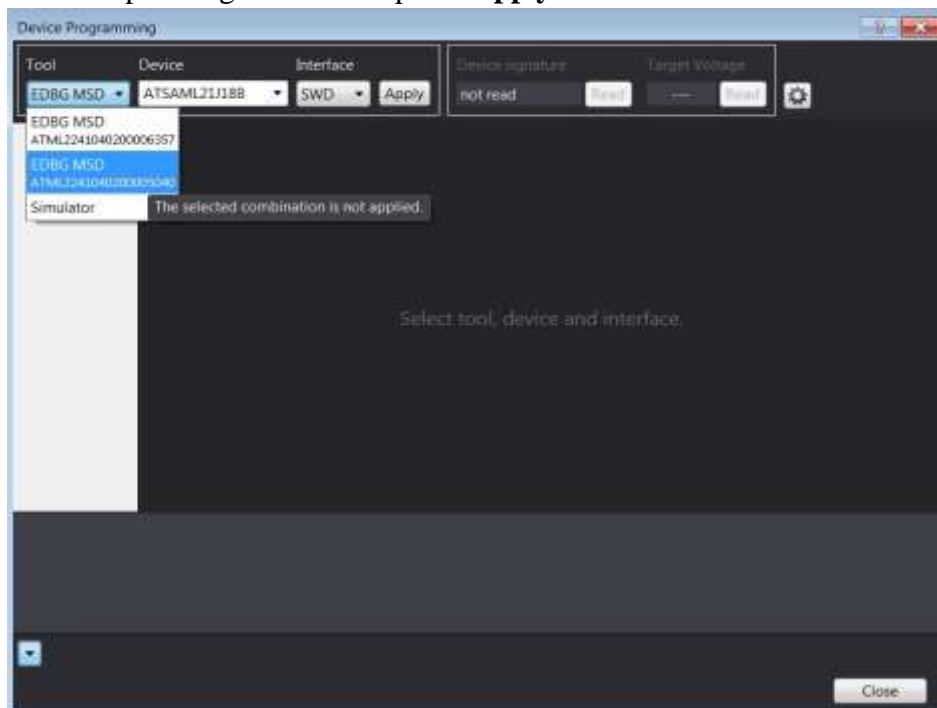
1. Connect the SAML21 Xplained Pro board to the host PC using micro USB cable. Perform the following steps:
 - a. Verify that the virtual COM port is enumerated on the host PC.
 - b. Make sure that POWER LED (green) is solid ON.

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2. To program the HEX files into the SAML21, go to menu **Tools** → **Device Programming** or Press **Ctrl + Shift + P**.

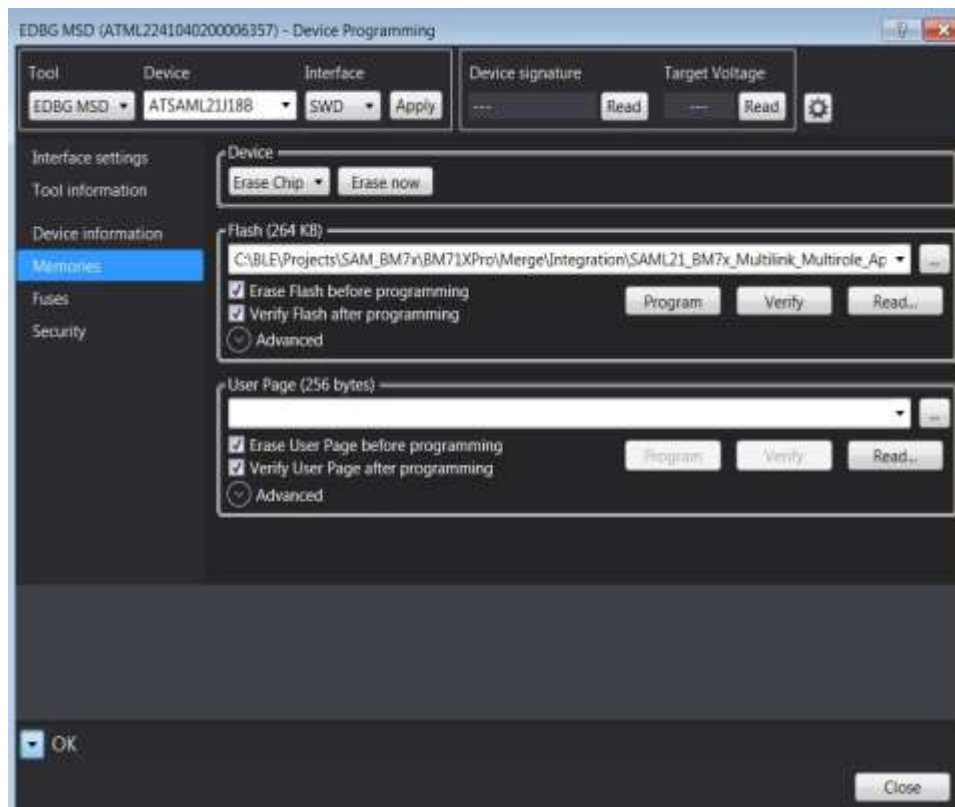


3. Select the corresponding **EDBG** and press **Apply**.

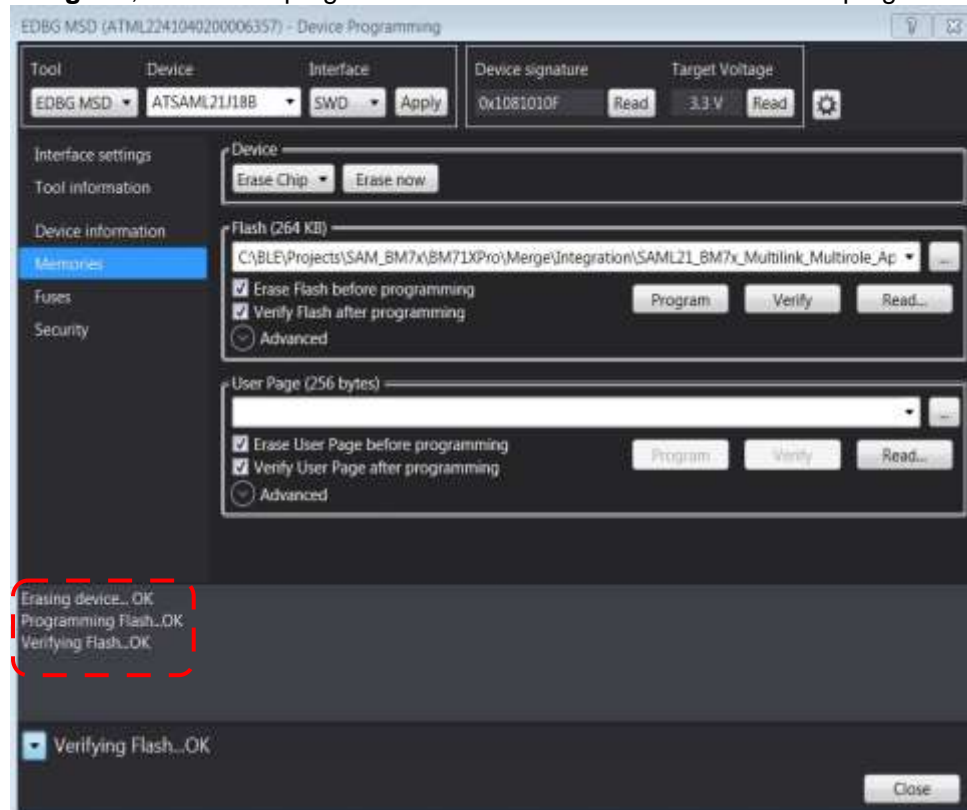


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4. Go to **Memories** Tab and select Hex file.



5. Press **Program**, the tool will program SAML21. You can check the status of programming.



6. Once programming is done, close the Device Programming window.

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7 Running Multilink-Multirole Demo

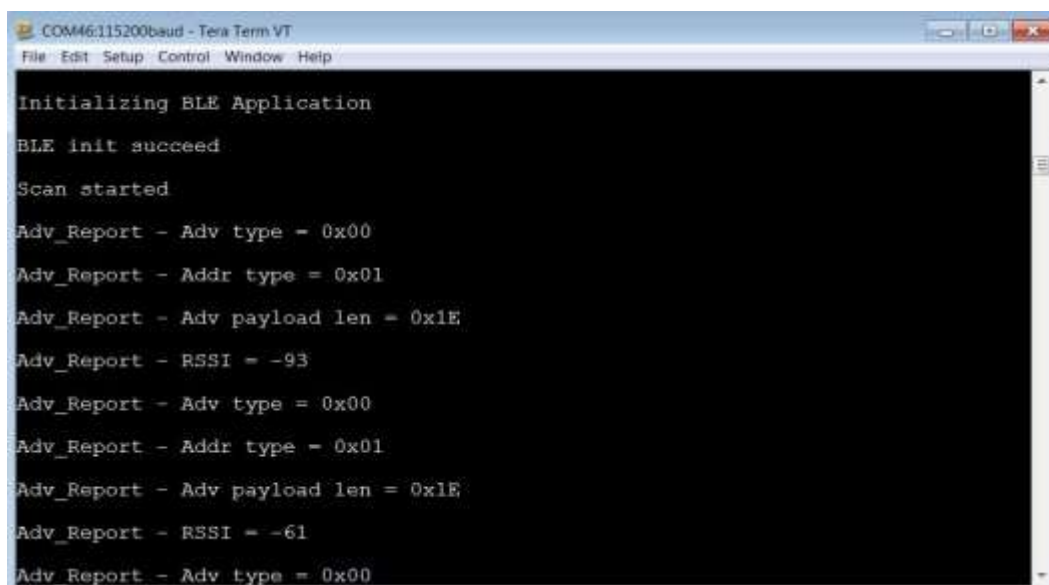
In this demo the Multilink-Multirole device plays both GAP-Central and GAP-Peripheral roles. First the device will play a GAP-Central role and it scans and connects with remote GAP-Peripheral device. Once connected Multilink-Multirole device will play a GAP-Peripheral role and it starts advertising and further accept connection from remote GAP-Central device.

NOTE: There are differences in the response packet send by the BM71 firmware for the Read_Local_Specific_Primary_Service(0x3C) command in regards to different firmware version. Until the firmware Version 1.11 it follows same pattern and in V2.03 the response data packet structure changes. To make the application compactable with all the firmware version, the read back function is modified with a macro.

`#define Older_Firmware_Versions`

By default, this macro is commented in the code to make is work with the latest released firmware (2.03 at time of creation of this document). If the user is using an earlier firmware version, then it is recommended to uncomment this macro in the code.

1. After programming the demo, press a reset button on Multilink-Multirole device (Reset button on SAML21 Xplained Pro board).
 - a. Make sure that POWER LED (green) on SAML21 Xplained Pro board is solid ON and the LD4 (blue) on BM71-XPro is blinking at a regular interval.
2. Ensure that the Multilink-Multirole device is scanning by checking the TeraTerm window for a message “Scan started”.



```
COM46:115200baud - Tera Term.VT
File Edit Setup Control Window Help

Initializing BLE Application
BLE init succeed
Scan started
Adv_Report - Adv type = 0x00
Adv_Report - Addr type = 0x01
Adv_Report - Adv payload len = 0x1E
Adv_Report - RSSI = -93
Adv_Report - Adv type = 0x00
Adv_Report - Addr type = 0x01
Adv_Report - Adv payload len = 0x1E
Adv_Report - RSSI = -61
Adv_Report - Adv type = 0x00
```

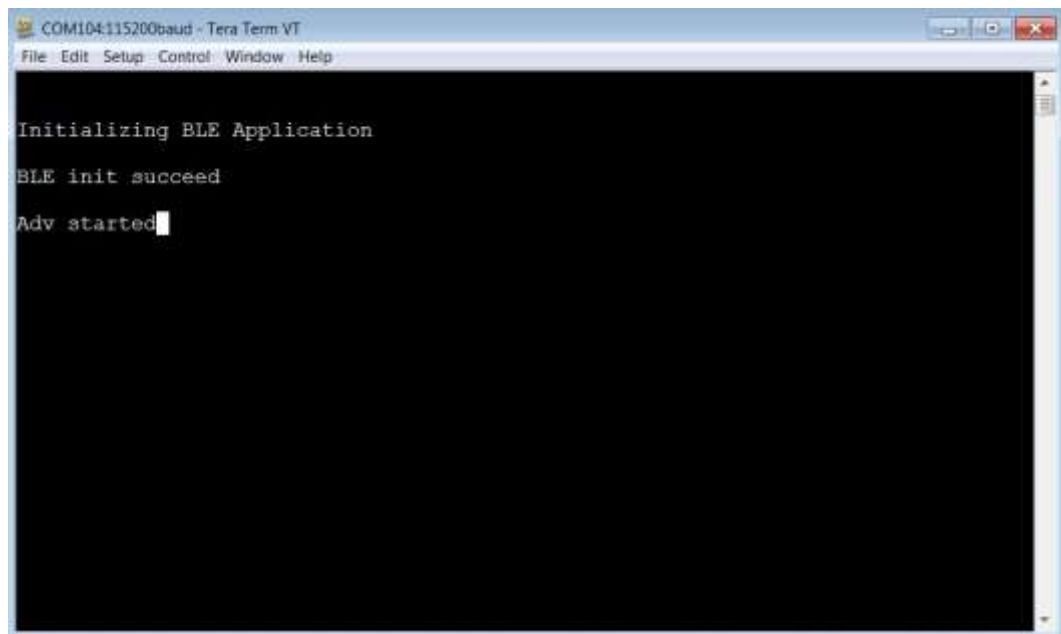
3. Prepare a GAP-Peripheral device (Refer: GAP_Peripheral_Demo_Getting_Started_Guide.doc)

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4. Connect the GAP-Peripheral device to the host PC using micro USB cable. Perform the following steps:
 - a. Verify that the virtual COM port is enumerated on the host PC.
 - b. Open the enumerated COM port on a serial terminal application like TeraTerm with the following settings:

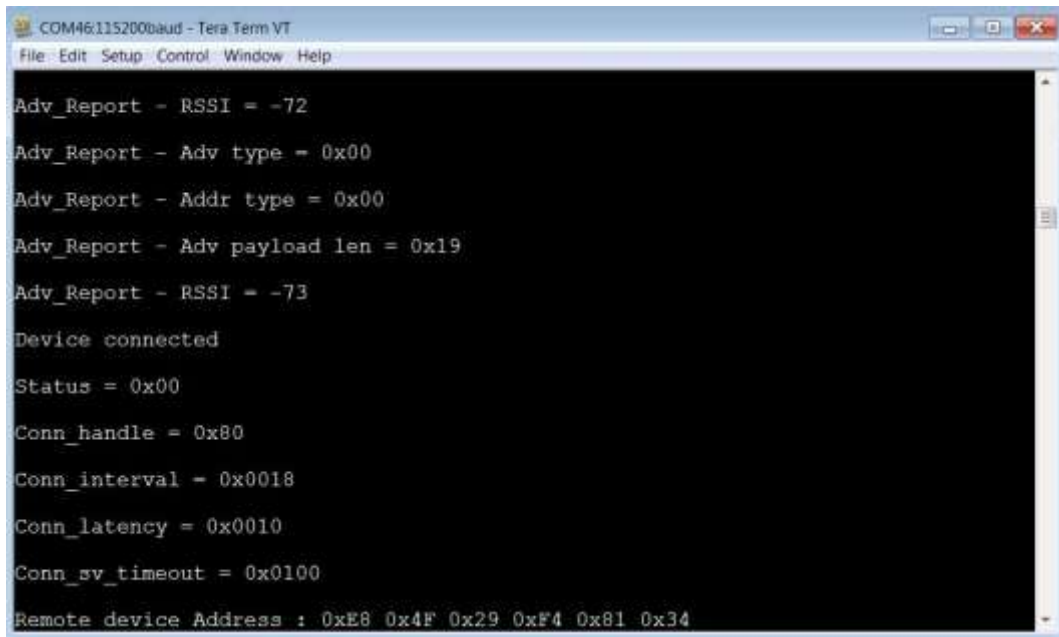
Baudrate	115200
Data	8 bits
Parity	none
Stop	1 bit
Flow control	none

- c. Make sure that POWER LED (green) on SAML21 Xplained Pro board is solid ON.
 - d. Press Reset button on SAML21 Xplained Pro board and verify that LD4 (blue) on BM71-XPro is blinking at a regular interval.
5. Ensure that the GAP-Peripheral device is advertising by checking the TeraTerm window for a message “Adv started”.



6. Multilink-Multirole device which is currently scanning will initiate a connection with GAP-Peripheral device if it discovers GAP-Peripheral device and the advertising parameter matches its requirement.

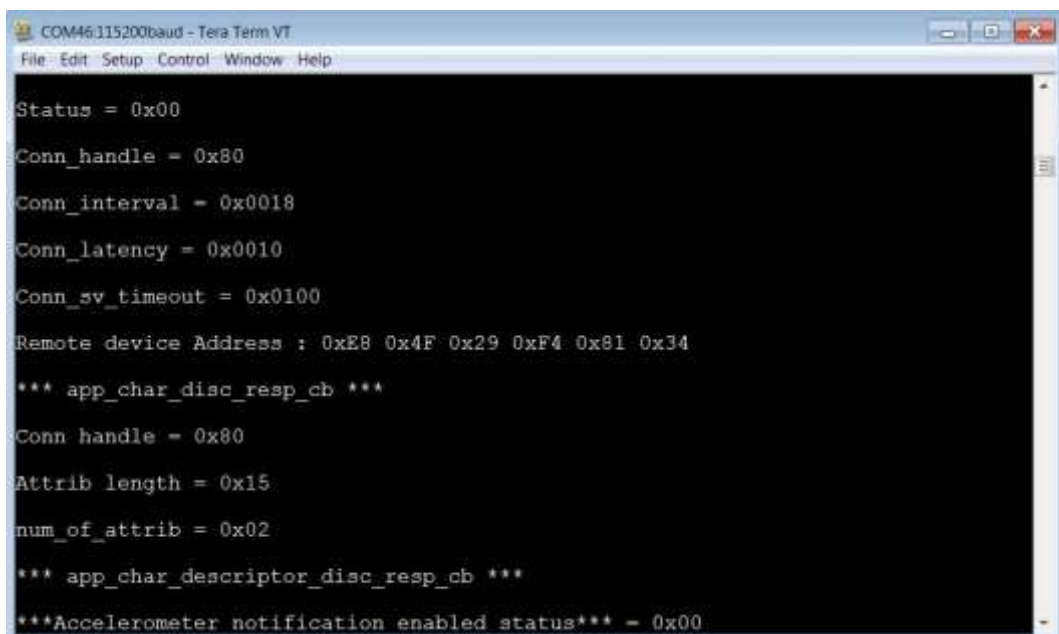
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A screenshot of a Tera Term VT window titled 'COM46:115200baud - Tera Term VT'. The window displays the following text:

```
Adv_Report - RSSI = -72
Adv_Report - Adv type = 0x00
Adv_Report - Addr type = 0x00
Adv_Report - Adv payload len = 0x19
Adv_Report - RSSI = -73
Device connected
Status = 0x00
Conn_handle = 0x80
Conn_interval = 0x0018
Conn_latency = 0x0010
Conn_sv_timeout = 0x0100
Remote device Address : 0xE8 0x4F 0x29 0xF4 0x81 0x34
```

7. Once connected, the Multilink-Multirole device initiates service discovery and look for device orientation service.

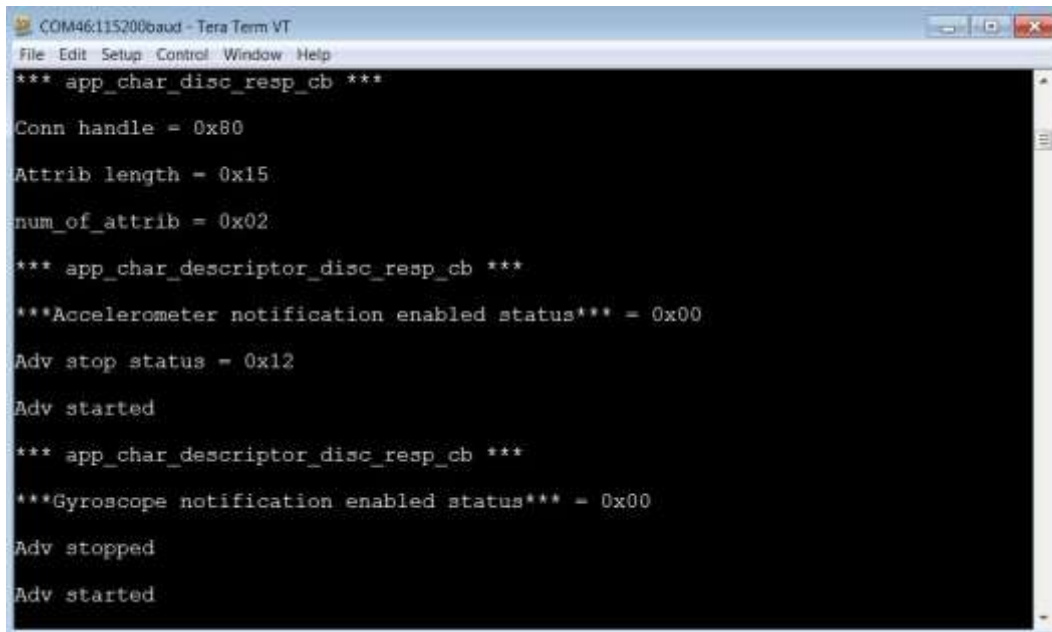


A screenshot of a Tera Term VT window titled 'COM46:115200baud - Tera Term VT'. The window displays the following text:

```
Status = 0x00
Conn_handle = 0x80
Conn_interval = 0x0018
Conn_latency = 0x0010
Conn_sv_timeout = 0x0100
Remote device Address : 0xE8 0x4F 0x29 0xF4 0x81 0x34
*** app_char_disc_resp_cb ***
Conn handle = 0x80
Attrib length = 0x15
num_of_attrib = 0x02
*** app_char_descriptor_disc_resp_cb ***
***Accelerometer notification enabled status*** = 0x00
```

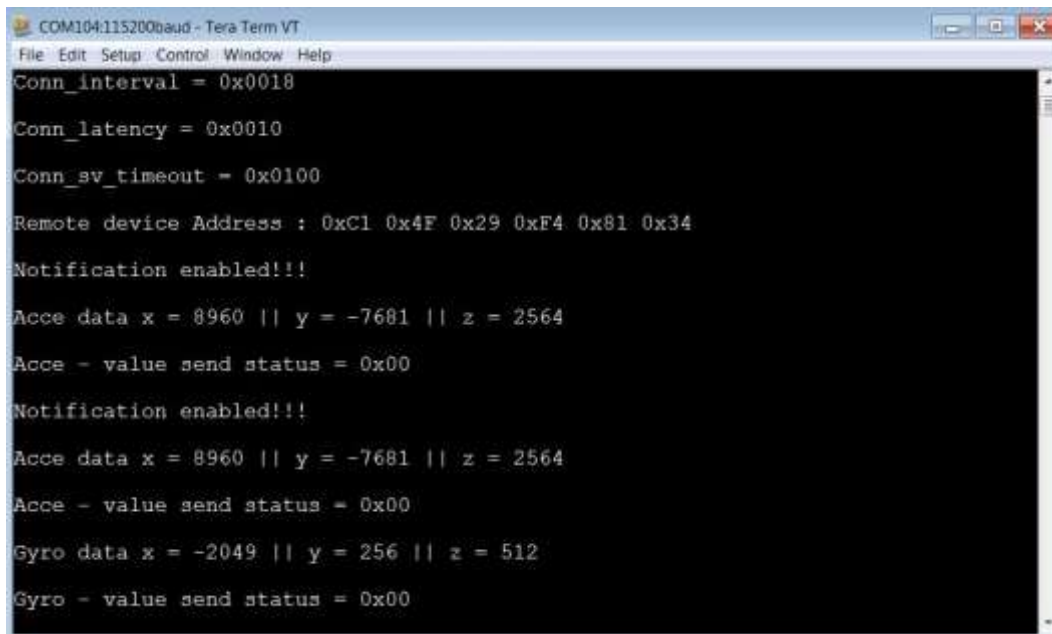
8. When the Multilink-Multirole device discovers the device orientation service and its characteristics, it enables notifications on the accelerometer and gyroscope sensor characteristics.

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```
COM46:115200baud - Tera Term VT
File Edit Setup Control Window Help
*** app_char_disc_resp_cb ***
Conn handle = 0x80
Attrib length = 0x15
num_of_attrib = 0x02
*** app_char_descriptor_disc_resp_cb ***
***Accelerometer notification enabled status*** = 0x00
Adv stop status = 0x12
Adv started
*** app_char_descriptor_disc_resp_cb ***
***Gyroscope notification enabled status*** = 0x00
Adv stopped
Adv started
```

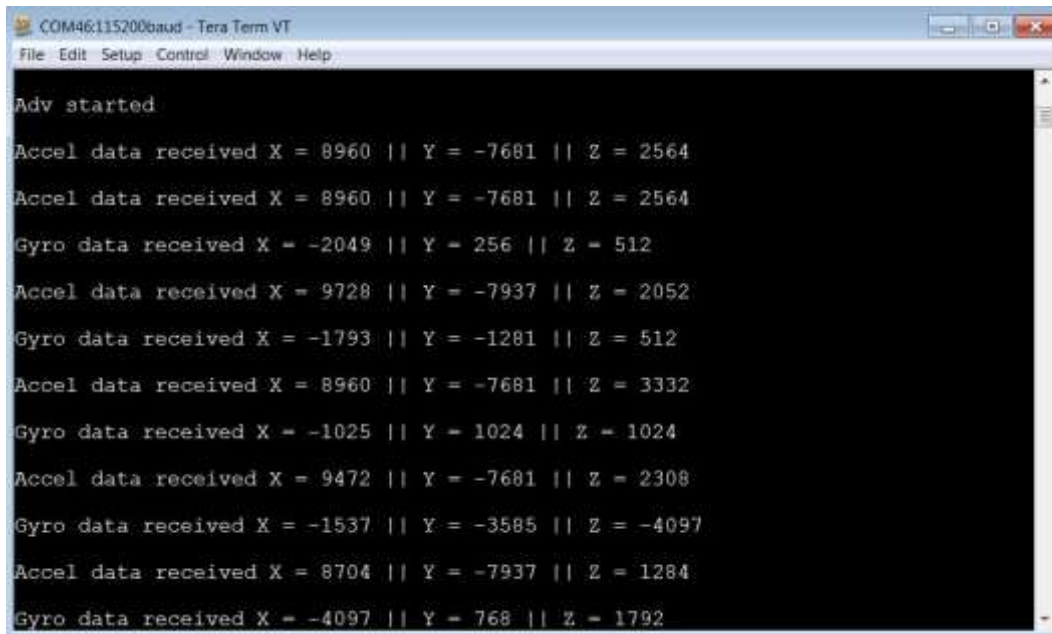
9. At this stage, Multilink-Multirole device will start advertising. So that the remote GAP-Central device can connect with Multilink-Multirole device.
10. Once the accelerometer and gyroscope sensor characteristics notifications enabled, the GAP-Peripheral device start sending accelerometer and gyroscope sensor data.



```
COM104:115200baud - Tera Term VT
File Edit Setup Control Window Help
Conn_interval = 0x0018
Conn_latency = 0x0010
Conn_sv_timeout = 0x0100
Remote device Address : 0xC1 0x4F 0x29 0xF4 0x81 0x34
Notification enabled!!!
Acce data x = 8960 || y = -7681 || z = 2564
Acce - value send status = 0x00
Notification enabled!!!
Acce data x = 8960 || y = -7681 || z = 2564
Acce - value send status = 0x00
Gyro data x = -2049 || y = 256 || z = 512
Gyro - value send status = 0x00
```

11. Upon receiving sensor data notifications, the Multilink-Multirole device print them on serial console.

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A screenshot of a TeraTerm VT window titled 'COM46:115200baud - Tera Term VT'. The window displays a series of sensor data readings in a monospaced font. The data is organized into pairs of 'Accel data received' and 'Gyro data received' lines, each showing X, Y, and Z axis values separated by vertical bars. The readings are as follows:
Adv started
Accel data received X = 8960 || Y = -7681 || Z = 2564
Accel data received X = 8960 || Y = -7681 || Z = 2564
Gyro data received X = -2049 || Y = 256 || Z = 512
Accel data received X = 9728 || Y = -7937 || Z = 2052
Gyro data received X = -1793 || Y = -1281 || Z = 512
Accel data received X = 8960 || Y = -7681 || Z = 3332
Gyro data received X = -1025 || Y = 1024 || Z = 1024
Accel data received X = 9472 || Y = -7681 || Z = 2308
Gyro data received X = -1537 || Y = -3585 || Z = -4097
Accel data received X = 8704 || Y = -7937 || Z = 1284
Gyro data received X = -4097 || Y = 768 || Z = 1792

12. Prepare a GAP-Central device (Refer: GAP_Central_Demo_Getting_Started_Guide.doc)

13. Connect the GAP-Central device to the host PC using micro USB cable. Perform the following steps:

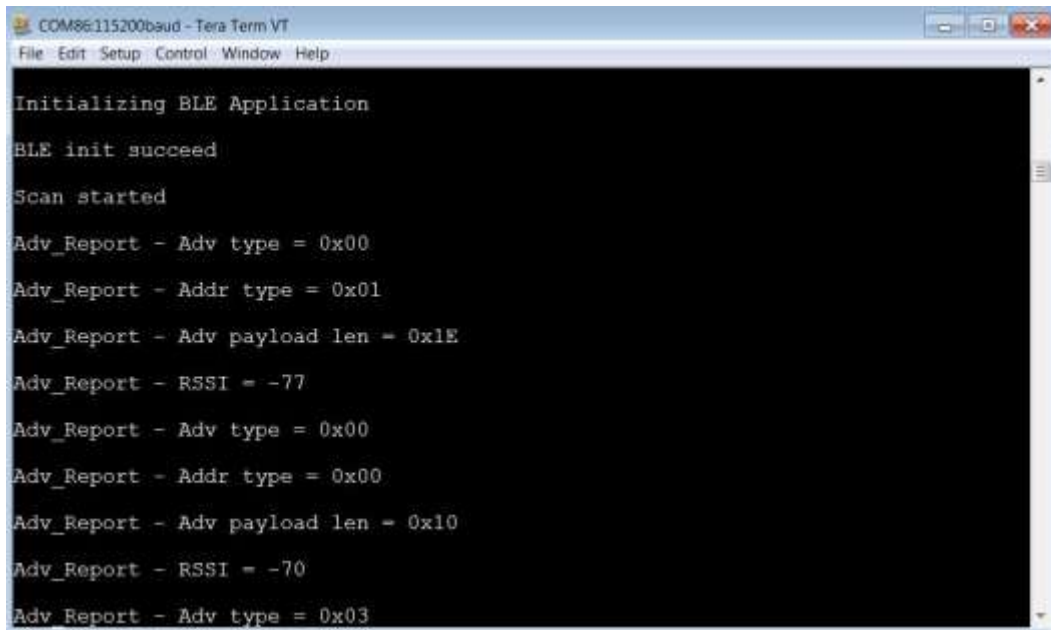
- a. Verify that the virtual COM port is enumerated on the host PC.
- b. Open the enumerated COM port on a serial terminal application like TeraTerm with the following settings:

Baudrate	115200
Data	8 bits
Parity	none
Stop	1 bit
Flow control	none

- c. Make sure that POWER LED (green) on SAML21 Xplained Pro board is solid ON.
- d. Press Reset button on SAML21 Xplained Pro board and verify that LD4 (blue) on BM71-XPro is blinking at a regular interval.

14. Ensure that the GAP-Central device is scanning by checking the TeraTerm window for a message “Scan started”.

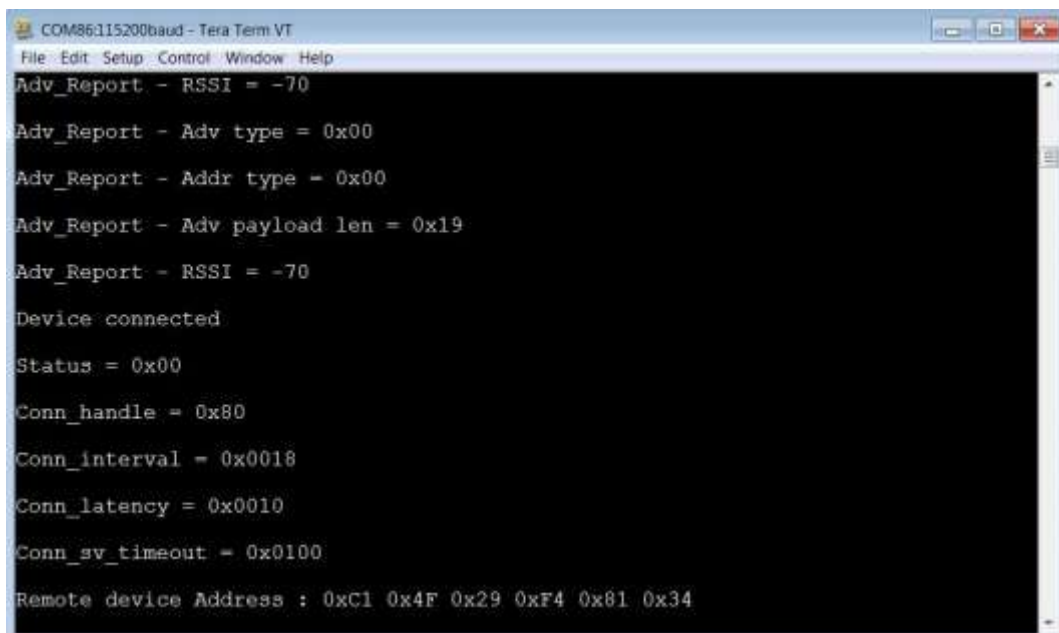
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```
COM86:115200baud - Tera Term VT
File Edit Setup Control Window Help

Initializing BLE Application
BLE init succeed
Scan started
Adv_Report - Adv type = 0x00
Adv_Report - Addr type = 0x01
Adv_Report - Adv payload len = 0x1E
Adv_Report - RSSI = -77
Adv_Report - Adv type = 0x00
Adv_Report - Addr type = 0x00
Adv_Report - Adv payload len = 0x10
Adv_Report - RSSI = -70
Adv_Report - Adv type = 0x03
```

15. GAP-Central device which is currently scanning will initiate a connection with Multilink-Multirole device if it discovers Multilink-Multirole device and the advertising parameter matches its requirement.

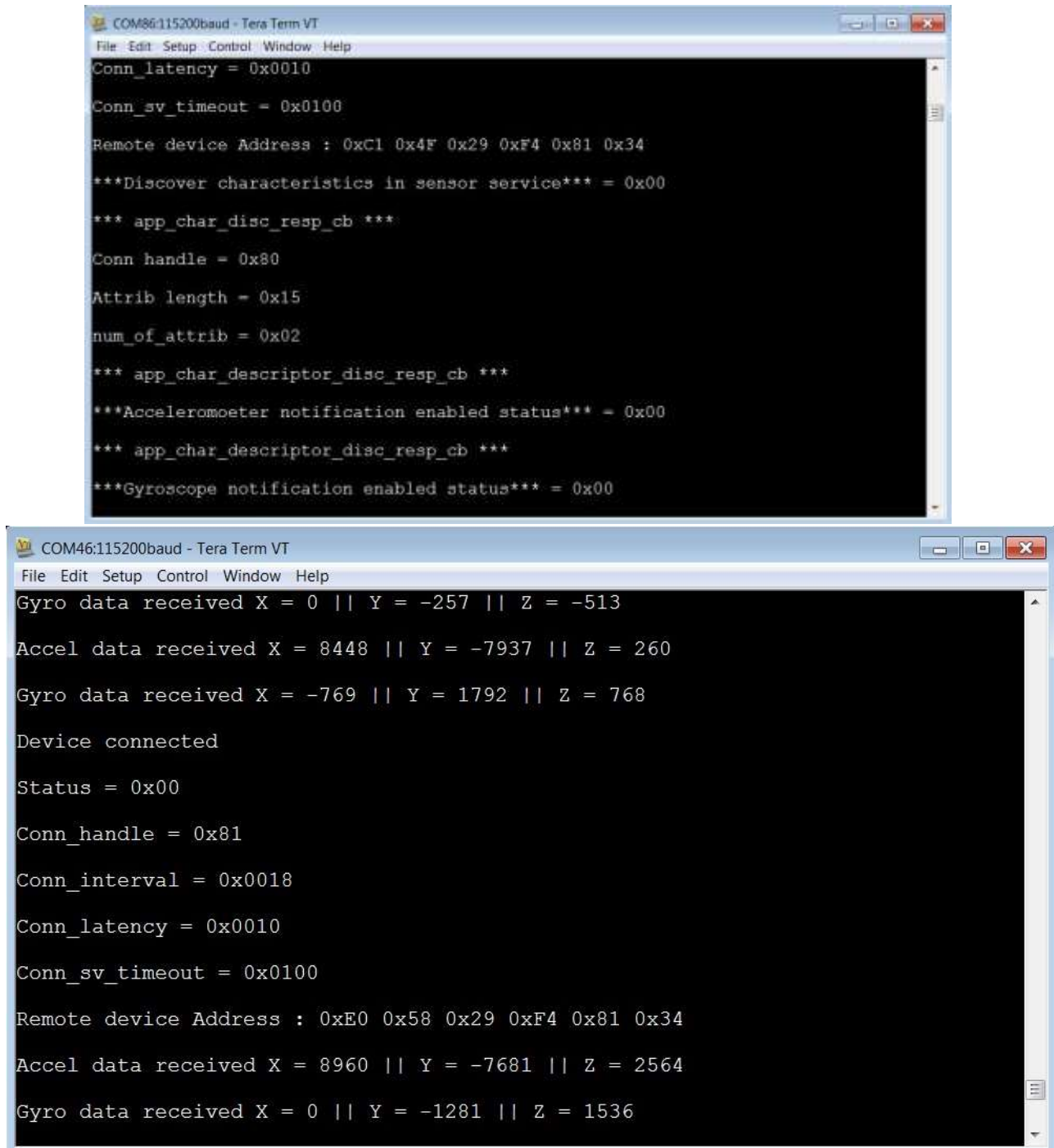


```
COM86:115200baud - Tera Term VT
File Edit Setup Control Window Help

Adv_Report - RSSI = -70
Adv_Report - Adv type = 0x00
Adv_Report - Addr type = 0x00
Adv_Report - Adv payload len = 0x19
Adv_Report - RSSI = -70
Device connected
Status = 0x00
Conn_handle = 0x80
Conn_interval = 0x0018
Conn_latency = 0x0010
Conn_sv_timeout = 0x0100
Remote device Address : 0xC1 0x4F 0x29 0xF4 0x81 0x34
```

16. Once connected, the GAP-Central device initiates service discovery and look for device orientation service.

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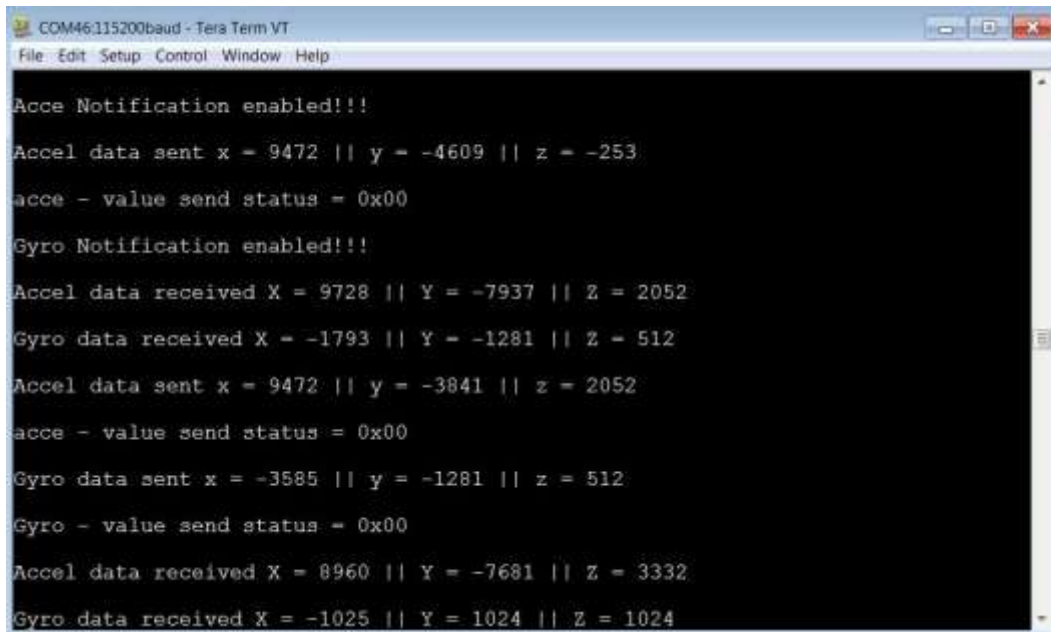


```
COM86:115200baud - Tera Term VT
File Edit Setup Control Window Help
Conn_latency = 0x0010
Conn_sv_timeout = 0x0100
Remote device Address : 0xC1 0x4F 0x29 0xF4 0x81 0x34
***Discover characteristics in sensor service*** = 0x00
*** app_char_disc_resp_cb ***
Conn handle = 0x80
Attrib length = 0x15
num_of_attrib = 0x02
*** app_char_descriptor_disc_resp_cb ***
***Accelerometer notification enabled status*** = 0x00
*** app_char_descriptor_disc_resp_cb ***
***Gyroscope notification enabled status*** = 0x00

COM46:115200baud - Tera Term VT
File Edit Setup Control Window Help
Gyro data received X = 0 || Y = -257 || Z = -513
Accel data received X = 8448 || Y = -7937 || Z = 260
Gyro data received X = -769 || Y = 1792 || Z = 768
Device connected
Status = 0x00
Conn_handle = 0x81
Conn_interval = 0x0018
Conn_latency = 0x0010
Conn_sv_timeout = 0x0100
Remote device Address : 0xE0 0x58 0x29 0xF4 0x81 0x34
Accel data received X = 8960 || Y = -7681 || Z = 2564
Gyro data received X = 0 || Y = -1281 || Z = 1536
```

17. When the GAP-Central device discovers the device orientation service and its characteristics in Multilink-Multirole device, it enables notifications on the accelerometer and gyroscope sensor characteristics.
18. Once the accelerometer and gyroscope notifications enabled, the Multilink-Multirole device start sending accelerometer and gyroscope sensor data.

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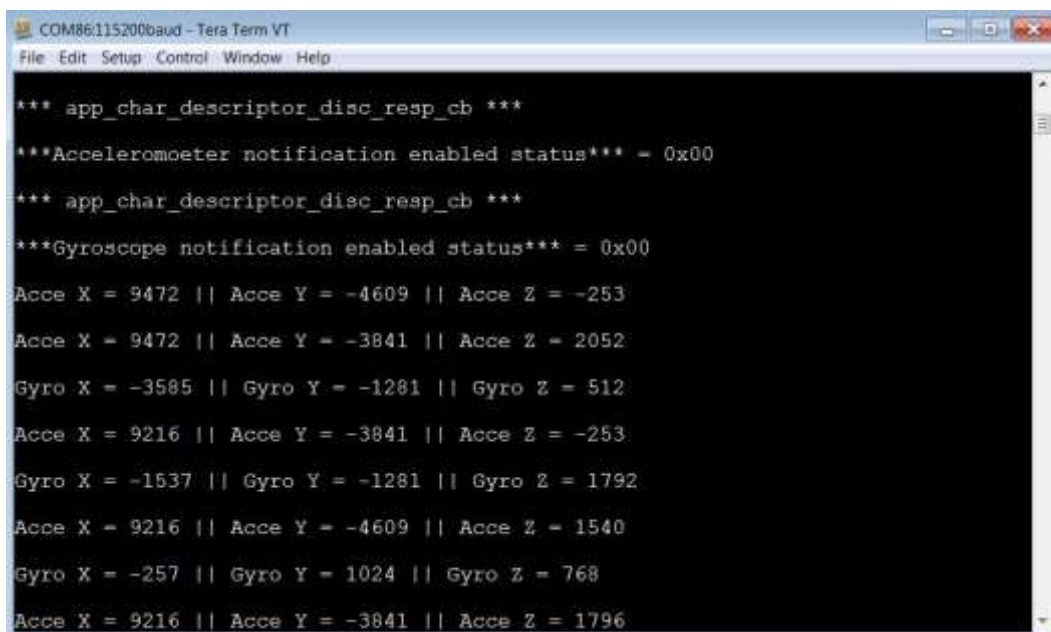


A screenshot of a Tera Term VT window titled 'COM46:115200baud - Tera Term VT'. The window displays a series of text messages on a black background with white text. The messages indicate that acceleration and gyroscope notifications are enabled, followed by several data transmissions. The data is formatted as 'x = value || y = value || z = value'.

```
COM46:115200baud - Tera Term VT
File Edit Setup Control Window Help

Acce Notification enabled!!!
Accel data sent x = 9472 || y = -4609 || z = -253
acce - value send status = 0x00
Gyro Notification enabled!!!
Accel data received X = 9728 || Y = -7937 || Z = 2052
Gyro data received X = -1793 || Y = -1281 || Z = 512
Accel data sent x = 9472 || y = -3841 || z = 2052
acce - value send status = 0x00
Gyro data sent x = -3585 || y = -1281 || z = 512
Gyro - value send status = 0x00
Accel data received X = 8960 || Y = -7681 || Z = 3332
Gyro data received X = -1025 || Y = 1024 || Z = 1024
```

19. Upon receiving sensor data notifications, the GAP-Central device prints them on serial console.



A screenshot of a Tera Term VT window titled 'COM86:115200baud - Tera Term VT'. The window displays a series of text messages on a black background with white text. The messages include status notifications for accelerometer and gyroscope, followed by several data transmissions. The data is formatted as 'X = value || Y = value || Z = value'.

```
COM86:115200baud - Tera Term VT
File Edit Setup Control Window Help

*** app_char_descriptor_disc_resp_cb ***
***Accelerometer notification enabled status*** = 0x00
*** app_char_descriptor_disc_resp_cb ***
***Gyroscope notification enabled status*** = 0x00
Acce X = 9472 || Acce Y = -4609 || Acce Z = -253
Acce X = 9472 || Acce Y = -3841 || Acce Z = 2052
Gyro X = -3585 || Gyro Y = -1281 || Gyro Z = 512
Acce X = 9216 || Acce Y = -3841 || Acce Z = -253
Gyro X = -1537 || Gyro Y = -1281 || Gyro Z = 1792
Acce X = 9216 || Acce Y = -4609 || Acce Z = 1540
Gyro X = -257 || Gyro Y = 1024 || Gyro Z = 768
Acce X = 9216 || Acce Y = -3841 || Acce Z = 1796
```

20. In this demo, the GAP-Central device can be replaced by Microchip Bluetooth Data app

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