
| |
|---|
| <h1>EVK-CC2541</h1> <h2>BLE LaunchPad (BT01-2)</h2> |
| <h3>Bluetooth Low Energy Development Kit</h3> |

User Manual

DOC. VERSION 1.2

DIGIMORE ELECTRONICS CO., LTD
October 2017



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| Revision History | | |
|-------------------------|--|------------|
| Version | Revision Description | Date |
| 1.0 | Preliminary Version | 2017-08-31 |
| 1.1 | 1. Update Pictures 2. Add Service List for Demonstration Application | 2017-09-15 |
| 1.2 | 1. Add / Modify the description in Chapter 4 2. Add the description in Appendix A-1 | 2017-10-25 |

Chapter 1 General Description

1.1 Description

BLE LaunchPad (BT01-2) is an entire development kit for user to design Bluetooth Low Energy (BLE) application.

BLE LaunchPad (BT01-2) contains a Bluetooth module BT01-2 using TI Bluetooth low energy controller CC2541. TI CC2541 is a world-leading chip in Bluetooth Low Energy 4.0 and offers variety of peripherals such as UART, SPI, I2C and Timer.

BLE LaunchPad (BT01-2) also embeds a famous FTDI FT232R USB-UART interface chip, a High-PSRR 300mA LDO, Buttons and LEDs. The LaunchPad can let user focus on their project development and verify the project easily and rapidly.



Chapter 2 Application

2.1 Application

- Bluetooth Low Energy Project Design and Verify
 - Rapid design End Product by importing the same module on the LaunchPad.
- Education Environment
- Concept or Prototype Demonstration Kit
- Pre Programmed Firmware of LaunchPad demonstrates BLE-UART bridge function, Button State via BLE and LED brightness by PWM.

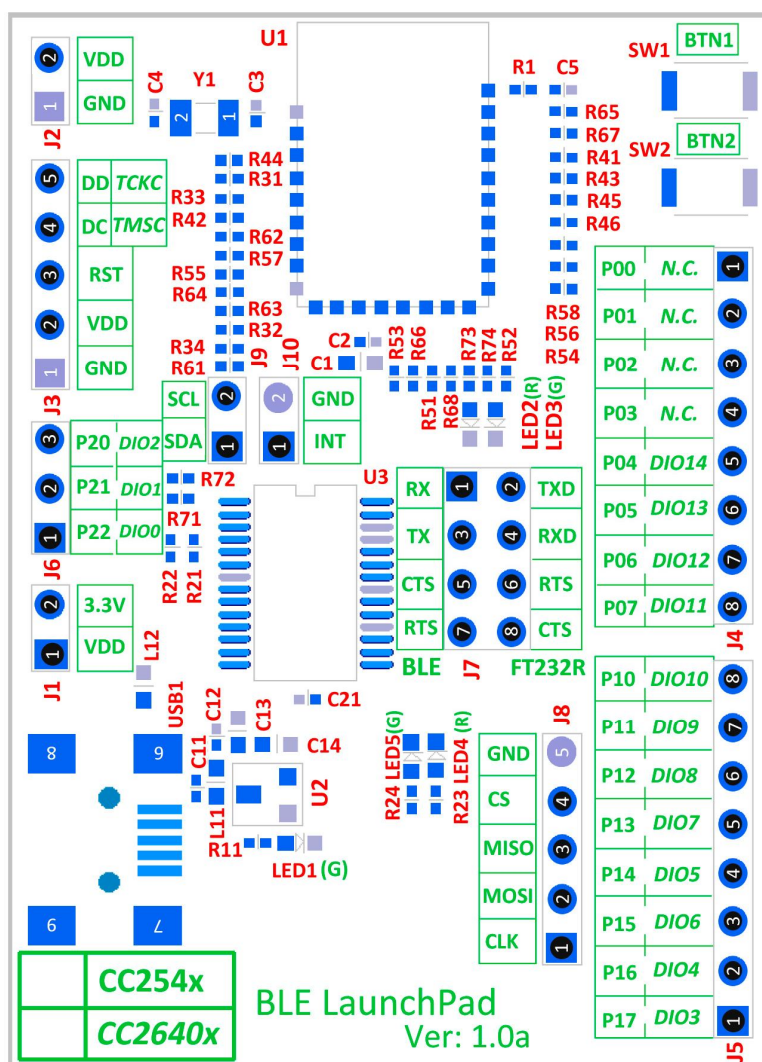
Chapter 3 Features

3.1 Features

- BT01-2 Bluetooth Module with TI CC2541
 - Bluetooth Version 4.0 low energy (LE, Single Mode) compliant.
 - High-Performance and Low-Power 8051 Microcontroller Core With Code Prefetch.
 - In-System-Programmable Flash, 256KB.
 - 12-Bit ADC With Eight Channels and Configurable Resolution.
 - 21 General Purpose I/O.
 - I2C Interface.
 - Powerful USARTs With Support for Several Serial Protocols.
 - On Board PCB Antenna and Crystal.
 - Module Dimension: 14.8mm x 10mm.
- FTDI FT232R
 - USB 2.0 Full Speed compatible.
 - Entire USB protocol handled on the chip. No USB specific firmware programming required.
 - FTDI's royalty-free Virtual Com Port (VCP) and Direct (D2XX) drivers eliminate the requirement for USB driver development in most cases.
 - Data transfer rates from 300 baud to 3M baud (RS422, RS485 and RS232) at TTL levels.
 - Transmit and receive LED drive signals.
 - UART interface support for 7 or 8 data bits, 1 or 2 stop bits and odd / even / mark / space / no parity.
 - Alternative Jumper Design to use the function of FT232R independently.
- LDO
 - Fast Ultra High-PSRR, Low-Noise 300mA CMOS LDO.
 - 3.3V Output Voltage.
- Mini USB Type B Connector
 - To PC communication.
 - Supply Main Power.
- Variety of Individual Pin Header Sections
 - Power Source Option.
 - General Purpose I/O (GPIO).
 - Peripherals.
 - Flash Programming and Debugging.
- Buttons and LEDs
 - Input / Output function control.
- LaunchPad Dimension: 55mm x 40mm.

Chapter 4 Hardware Description

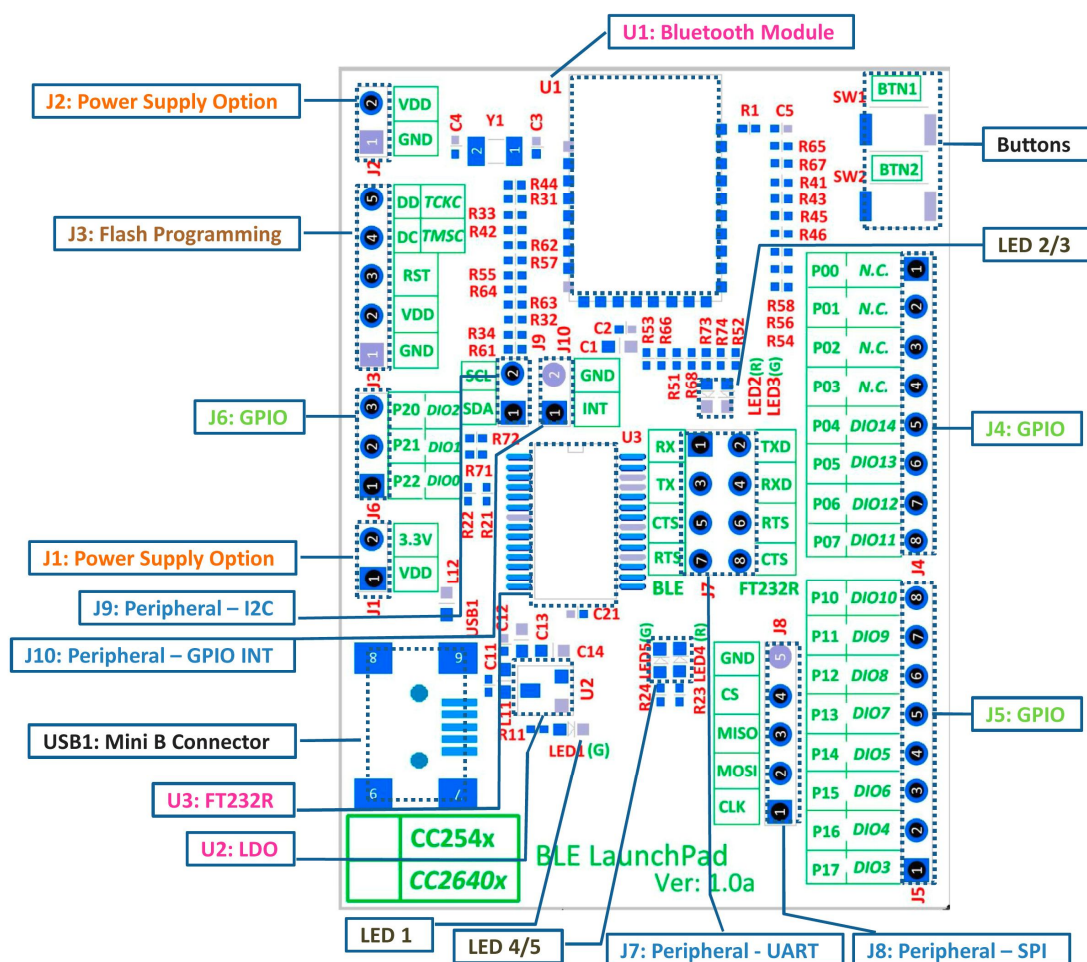
4.1 Hardware Placement



Note:

- The LaunchPad designs for variety of TI Bluetooth Low Energy chips.
e.g., BT01-2 embeds TI CC2541
BT03-1 embeds TI CC2640R2F
Please see the marked point on Left-Down corner of the LaunchPad to distinguish CC254x or CC2640x you are using.
- The Pin Name of GPIO and Flash Programming (J3 / J4 / J5 / J6):
- In Normal font: Definition for CC254x
- In *Italics* font: Definition for CC2640x
- In this document, it will introduce for the LaunchPad using CC2541.**

4.2 Hardware Definition



| Power Supply Option | | |
|---------------------|---|------------------|
| Marking Name | Description | Note |
| J1 | Select the Power Source from LDO (3.3V). Marking Pins are 3.3V and VDD. ** 3.3V: Output Voltage from LDO. ** VDD: Power Supply Pin for CC2541. | Ship With Jumper |
| J2 | Select the Power Source from external equipment, e.g., batteries. Marking Pins are VDD and GND. ** VDD: Power Supply Pin for CC2541. The voltage range is 2 – 3.6V. ** GND: Ground Pin for CC2541. ** If user chooses J2 operation, please remove the shipped jumper on J1. | — |

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| Flash Programming and Debugging | | |
|---------------------------------|--|---|
| Marking Name | Description | Note |
| J3 | <p>Contain 5 pins for Flash Programming and Debugging of CC2541. Marking Pins are DD, DC RST, VDD and GND. ** DD: Debug Data (Port 2.1) Pin of CC2541. ** DC: Debug Clock (Port 2.2) Pin of CC2541. ** RST: RESET_N pin of CC2541. ** VDD: Power Supply Pin for CC2541. ** GND: Ground Pin for CC2541.</p> | <ol style="list-style-type: none"> 1. Operate With TI CC Debugger 2. Refer to Chapter 6.3 for details |

| GPIO | | |
|--------------|---|------|
| Marking Name | Description | Note |
| J4 | Contain I/O Port 0.0 to Port 0.7 of CC2541. Marking Pins are P00 to P07. | — |
| J5 | Contain I/O Port 1.0 to Port 1.7 of CC2541. Marking Pins are P10 to P17. | — |
| J6 | <p>Contain I/O Port 2.0 to Port 2.2 of CC2541. Marking Pins are P20 to P22. ** For I/O Port 2.3 and Port 2.4, they are used for Crystal 32.768K Hz.</p> | — |

| Peripheral | | |
|--------------|---|---|
| Marking Name | Description | Note |
| J7 | <p>UART Function Pins and contains BLE side and FT232R side.</p> <p>BLE side (Left): ** Marking Pins are RX, TX, CTS and RTS. ** USART UART Mode Pins of CC2541.</p> <ul style="list-style-type: none"> - RX connects to Port 0.2 of CC2541. - TX connects to Port 0.3 of CC2541. - CTS connects to Port 0.4 of CC2541. - RTS connects to Port 0.5 of CC2541. <p>** These pins needs to configure by USART0 ALT.1</p> <p>FT232R side (Right): ** Marking Pins are TXD, RXD, RTS and CTS. ** UART function pins of FT232R.</p> | <ol style="list-style-type: none"> 1. Ship With two Jumpers on RX <-> TXD TX <-> RXD 2. Refer to Appendix A-2 for details 3. To operate FT232R independently, please remove the two shipped jumpers. |

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| | | |
|-----|--|-----------------------------------|
| J8 | USART SPI Mode Pins of CC2541. Marking Pins are GND, CS, MISO, MOSI and CLK. <ul style="list-style-type: none"> - CS connects to Port 1.4 of CC2541. - CLK connects to Port 1.5 of CC2541. - MOSI connects to Port 1.6 of CC2541. - MISO connects to Port 1.7 of CC2541. - GND: Ground Pin for CC2541. ** These pins need to configure by USART1 ALT.2 | Refer to Appendix A-2 for details |
| J9 | I2C Pins of CC2541. Marking Pins are SCL and SDA. | — |
| J10 | Marking Pins are GND and INT. ** GND: Ground Pin for CC2541. ** INT connects to Port 2.0 of CC2541. ** Users can program this pin to be an INT function by their FW development. | — |

| Buttons | | |
|--------------|---|------|
| Marking Name | Description | Note |
| BTN1 (SW1) | Button Input for User Application. ** BTN1 connects to Port 0.0 of CC2541. ** Active Low. | — |
| BTN2 (SW2) | Button Input for User Application. ** BTN2 connects to Port 0.1 of CC2541. ** Active Low. | — |

| LEDs | | |
|--------------|---|---|
| Marking Name | Description | Note |
| LED1 (G) | LED1 indicates the USB Power Supply 5V supplies. ** In color Green. | — |
| LED2 (R) | LED Operation for User Application. ** LED2 connects to Port 1.3 of CC2541. ** Active High. ** In color Red. | 1. In demonstrated FW, LED2 (R) configures for Brightness by PWM. 2. Refer to Appendix A-2 for details |
| LED3 (G) | LED Operation for User Application. ** LED3 connects to Port 1.2 of CC2541. ** Active High. ** In color Green. | In demonstrated FW, LED3 (G) configures for Advertising or Connecting. |
| LED4 (R) | LED4 indicates the UART function RX <-> TXD is working. ** LED4 actives by FT232R and default configuration is TXLED#. ** In color Red. | — |

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| | | |
|----------|---|---|
| LED5 (G) | LED5 indicates the UART function TX <-> RXD is working. ** LED5 activates by FT232R and default configuration is RXLED#. ** In color Green. | — |
|----------|---|---|

| Auxiliary Units | | |
|-----------------|---|------|
| Marking Name | Description | Note |
| U1 | Bluetooth Module BT01-2 with TI CC2541. ** Dimension: 14.8mm x 10mm. | — |
| U2 | Fast Ultra High-PSRR, Low-Noise 300mA CMOS LDO 3.3V Output Voltage. | — |
| U3 | FTDI FT232R USB-UART Interface Chip | — |
| USB1 | USB Mini-B Connector. | — |

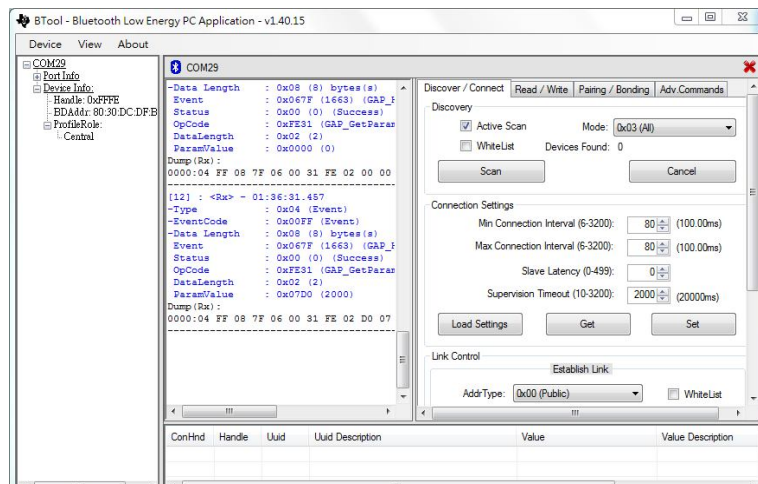
Chapter 5 Getting Started with BLE LaunchPad

5.1 Introduction

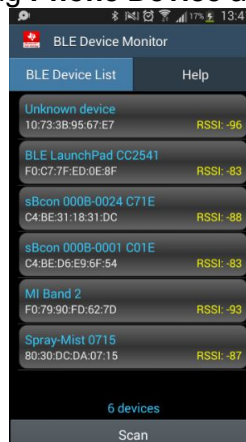
The LaunchPad ships with a BLE-UART bridge application as demonstration. Base on this demonstration, you can get started with Bluetooth Low Energy (BLE) Application.

In this chapter, it will guide you through the several steps required to get familiar with the LaunchPad. There are some of hardware devices or tools that can be used for using current demonstration application or developing your own application at later days. For the LaunchPad, you can use these ways to get started:

1. Demonstrate / Develop using **UDK-CC2540 BLE-USB Dongle (BT02-2)** and **BTTool**:



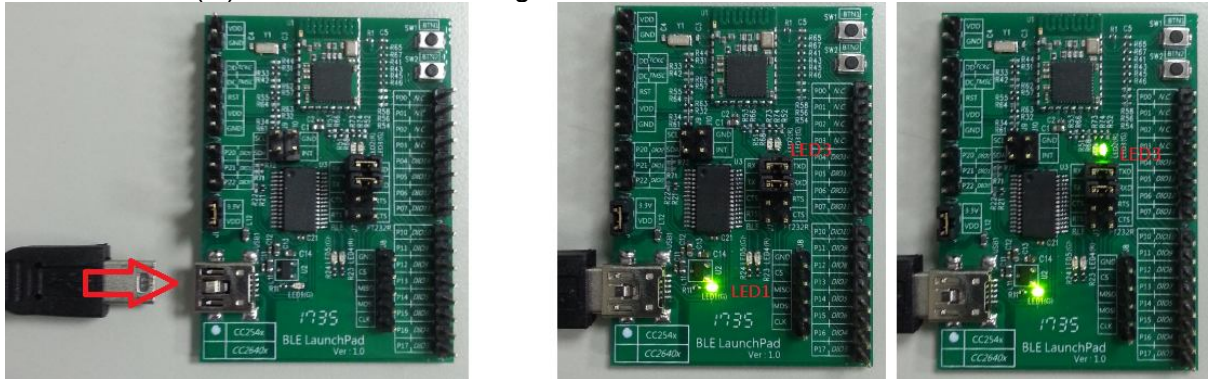
2. Demonstrate / Develop using **Phone Device** and **TI BLE App**:



3. Demonstrate / Develop using Virtual Com Port (Serial Port) Tool Application.

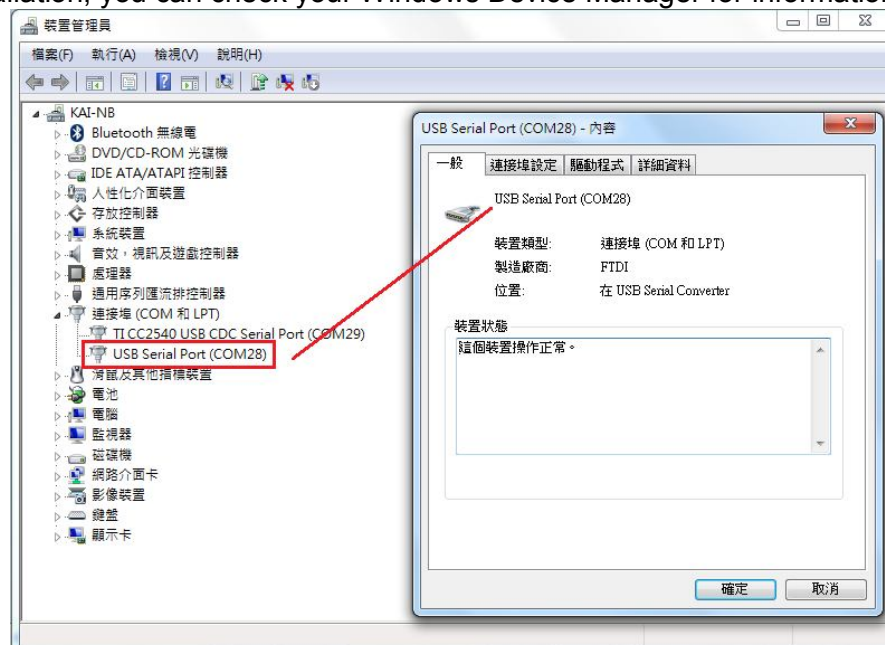
5.2 Hardware and Software Setup

1. Connect the LaunchPad to Laptop or Desktop Computer via Mini USB Cable.
 - a. The LED1 (G) will be lit Green.
 - b. The LED2 (R) and LED3 (G) will be lit Red and Green for one second.
 - c. The LED3 (G) will start to be blinking Green and the LaunchPad will auto advertise.



** In the Pre Programmed Firmware of **BLE LaunchPad (BT01-2)**, it uses the Advertising Name in **BLE LaunchPad CC2541**.

2. If the LaunchPad connects to your PC (USB port) at the first time, Windows will auto detect the FT232R and install the driver for it.
After installation, you can check your Windows Device Manager for information.



** FT232R will operate as a USB Serial Port, e.g., COM28 as above.

** Take note of this port number, as it will be needed in order to use your virtual com port (serial port) application.

** If you have a driver issue, please check the FTDI's website for installation.

<http://www.ftdichip.com/Support/Documents/InstallGuides.htm>

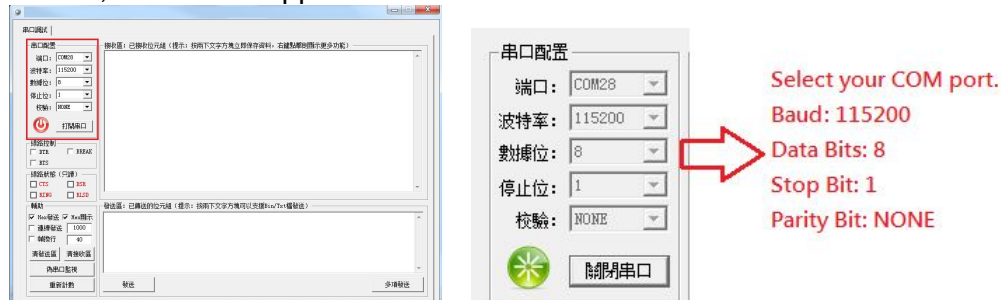
EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit

3. Virtual Com Port (Serial Port) Application

To communicate with current demonstration application, you will need a virtual com port (serial port) application on your Laptop or Desktop Computer.

This virtual com port (serial port) application communicates with FT232R and FT232RL communicates with the Bluetooth Low Energy Application by UART.

For instance, we use the application tool as below:



** The demonstration uses the baud in 115200 and the format is 8-N-1.

** If you are using the demonstration, please follow the setting value above.

4. Demonstrate / Develop using **BLE-USB Dongle (BT02-2)** and **TI BTool**:

a. For the installation of **BLE-USB Dongle (BT02-2)**, please refer to the user manual of BLE-USB Dongle (BT02-2).

b. **TI BTool** is a Windows application that allows you to control a central device using the serial interface and perform various BLE functions while connected to a peripheral device.

** In this demonstration,

Central Device: BLE-USB Dongle

Peripheral Device: BLE LaunchPad

** TI BTool can be installed automatically while you install the TI BLE-Stack.

** About TI BLE-Stack, please download it at TI website www.ti.com/ble-stack.

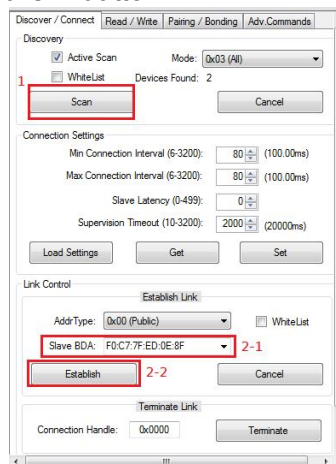
c. Connect your LaunchPad to BTool, please follow these steps:

Step 1 (Choose the Discover / Connect Tab Window):

Press "Scan" button on BTool. It will scan the nearby BLE Devices.

Step 2 (Choose the Discover / Connect Tab Window):

After the scanning is complete, choose the device to connect via "Slave BDA" area and then press "Establish" button.

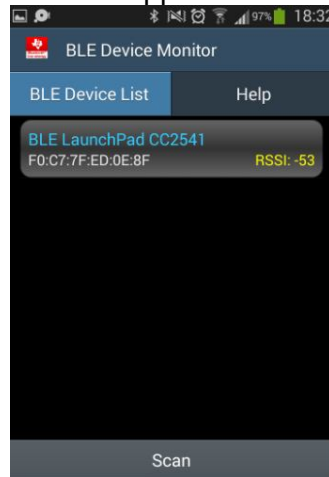


EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit

5. Demonstrate / Develop using **Phone Device** and **TI BLE App**:
- Download and Install TI BLE App or 3rd Party App from the Apple App Store or Google Play.



** In the demonstration, we will use TI App “BLE Device Monitor” on Android.



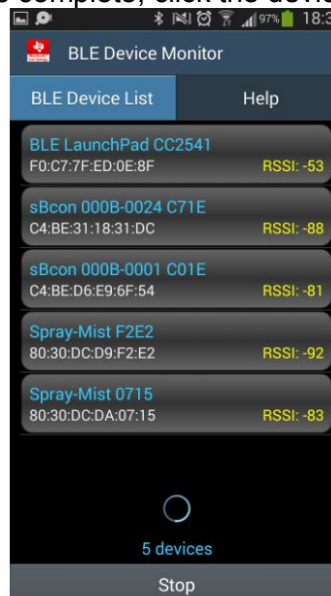
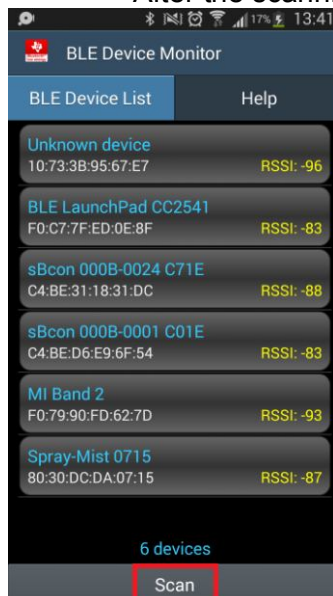
- Connect your LaunchPad to TI BLE App, please follow these steps:

Step 1:

Press "Scan" button on App. It will scan the nearby BLE Devices.

Step 2:

After the scanning is complete, click the device name you want to connect.



** In the Pre Programmed Firmware of **BLE LaunchPad (BT01-2)**, it uses the Advertising Name in **BLE LaunchPad CC2541**.

** You can find the name in **BLE LaunchPad CC2541** on your App and the minor digits is BDA (Bluetooth Device Address) of the LaunchPad, e.g., F0:C7:7F:ED:0E:8F.

5.3 Demonstration

In the Pre Programmed Firmware of LaunchPad, it offers several functions for demonstration including of Bluetooth Low Energy transmission or digital operation functions. For instance, you can observe BLE-UART bridge function, Button State via BLE and LED brightness by PWM. For the BLE service list of demonstration, please refer to Appendix A-3 for details.

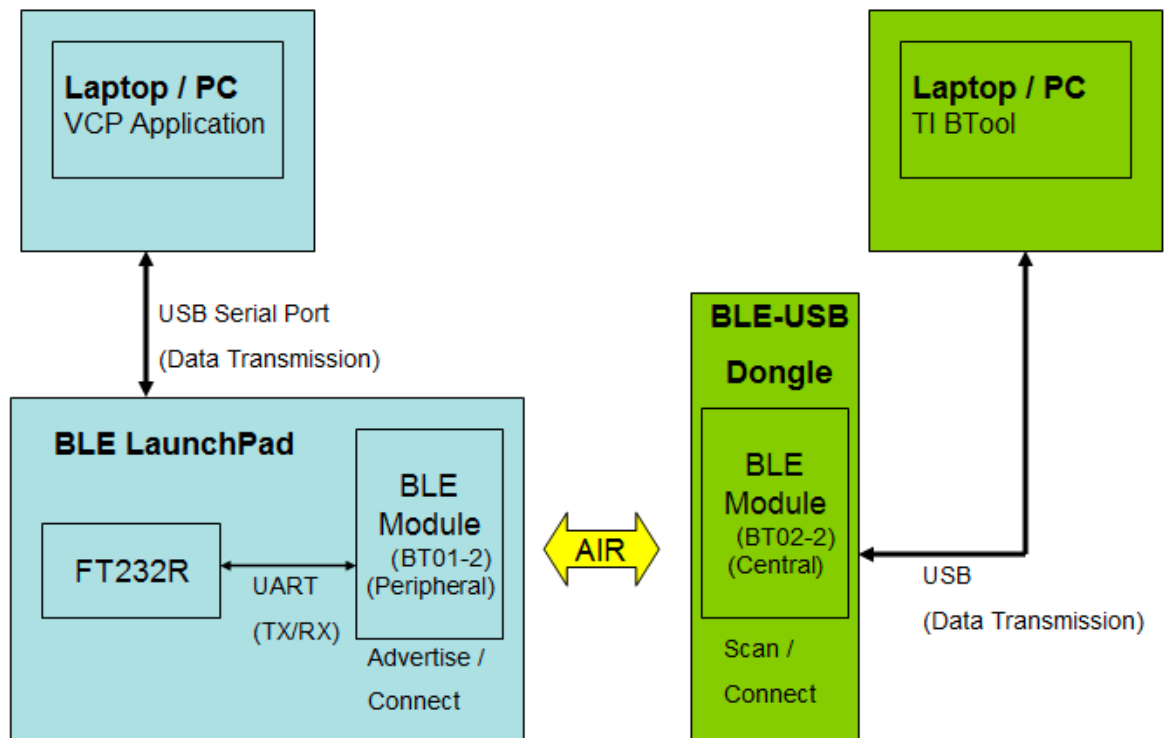
1. BLE-UART bridge function

In Bluetooth classic (BR/EDR) systems, a Serial Port Profile (SPP) is an adopted profile defined by the Bluetooth Special Interest Group (SIG) used to emulate a serial port connection over a Bluetooth wireless connection. For Bluetooth low energy systems, an adopted profile for implementing SPP over BLE is undefined, thus emulation of a serial port must be implemented as a vendor-specific custom profile.

The BLE-UART bridge function herein demonstrates for SPP over BLE implementation by using two environments (tools). Before these two descriptions below, please setup your hardware and software in chapter 5.2.

a. Using **BLE-USB Dongle (BT02-2)** and **TI BTool**:

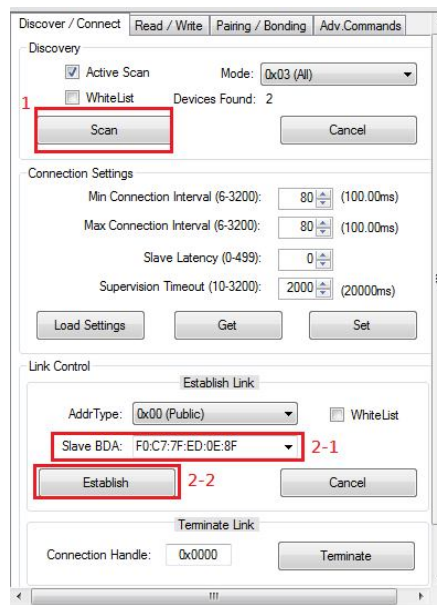
The block diagram of this demonstration is shown below.



Step 1:

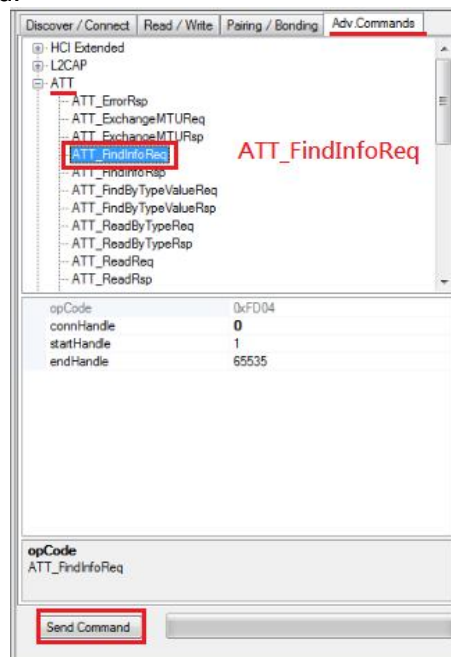
Connect the LaunchPad by BTool. (Refer to chapter 5.2, Discover / Connect Tab Window and Scan / Establish Slave BDA).

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Step 2:

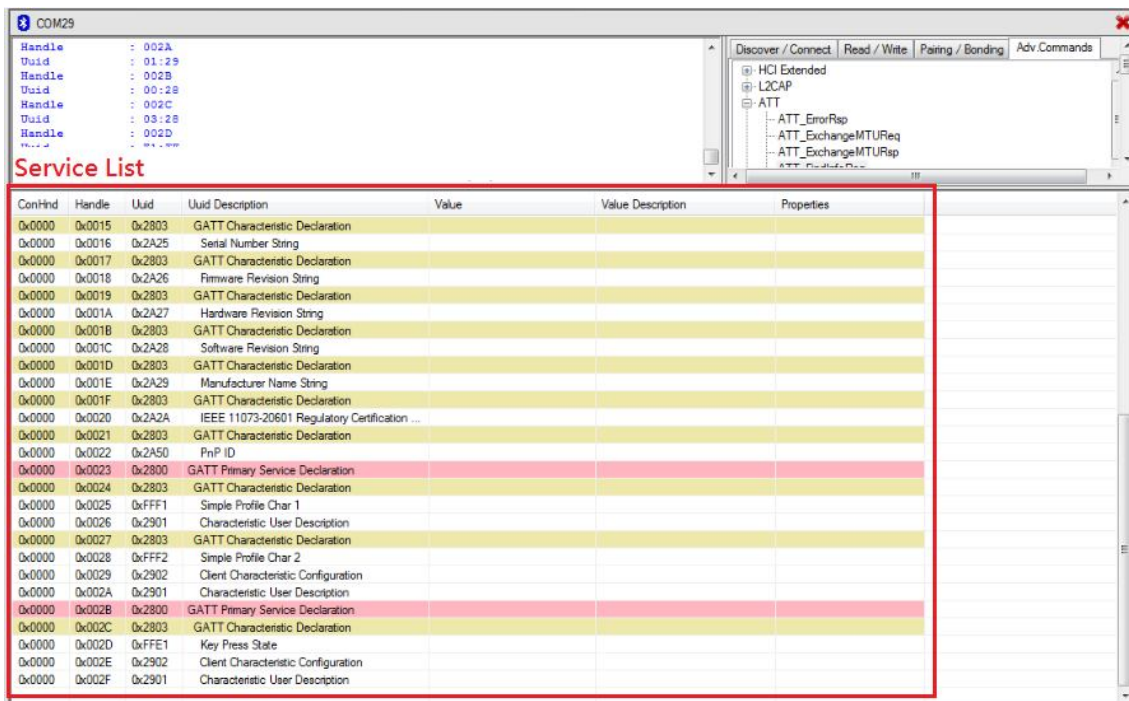
- Choose the “Adv. Commands” Tab Window.
- Select the “ATT_FindInfoReq” command inner the “ATT” block.
- You can double click the command area or press “Send Command” button to send the command.



Step 3

Extend the bottom window on BTool, you can find all of Service List in this demonstration.

EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit



- ** To read the content in service list: Single Click the row.
- ** To write the content in service list: Double Click the row.

Step 4

Ensure your Virtual Com Port (Serial Port) Application is ready to work. (Refer to chapter 5.2, Virtual Com Port (Serial Port) Application)



Select your COM port.
Baud: 115200
Data Bits: 8
Stop Bit: 1
Parity Bit: NONE

- ** The demonstration uses the baud in 115200 and the format is 8-N-1.

Step 5

For the service of BLE-UART bridge function, you can refer to UUID 0xFFFF1 and 0xFFFF2 shown in the picture below.

| | | | | | |
|--------|--------|---------|-------------------------------------|---|-------------|
| 0x0000 | 0x0023 | 0x2800 | GATT Primary Service Declaration | F0 FF | |
| 0x0000 | 0x0024 | 0x2803 | GATT Characteristic Declaration | 0A 25 00 F1 FF | |
| 0x0000 | 0x0025 | 0xFFFF1 | Simple Profile Char 1 | 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 | Rd Wr: 0x0A |
| 0x0000 | 0x0026 | 0x2901 | Characteristic User Description | APP_to_BLE_UART_Tx | |
| 0x0000 | 0x0027 | 0x2803 | GATT Characteristic Declaration | 10 28 00 F2 FF | |
| 0x0000 | 0x0028 | 0xFFFF2 | Simple Profile Char 2 | | Nfy: 0x10 |
| 0x0000 | 0x0029 | 0x2902 | Client Characteristic Configuration | 00 00 | |
| 0x0000 | 0x002A | 0x2901 | Characteristic User Description | BLE_UART_Rx_to_APP | |

** UUID 0xFFFF1:

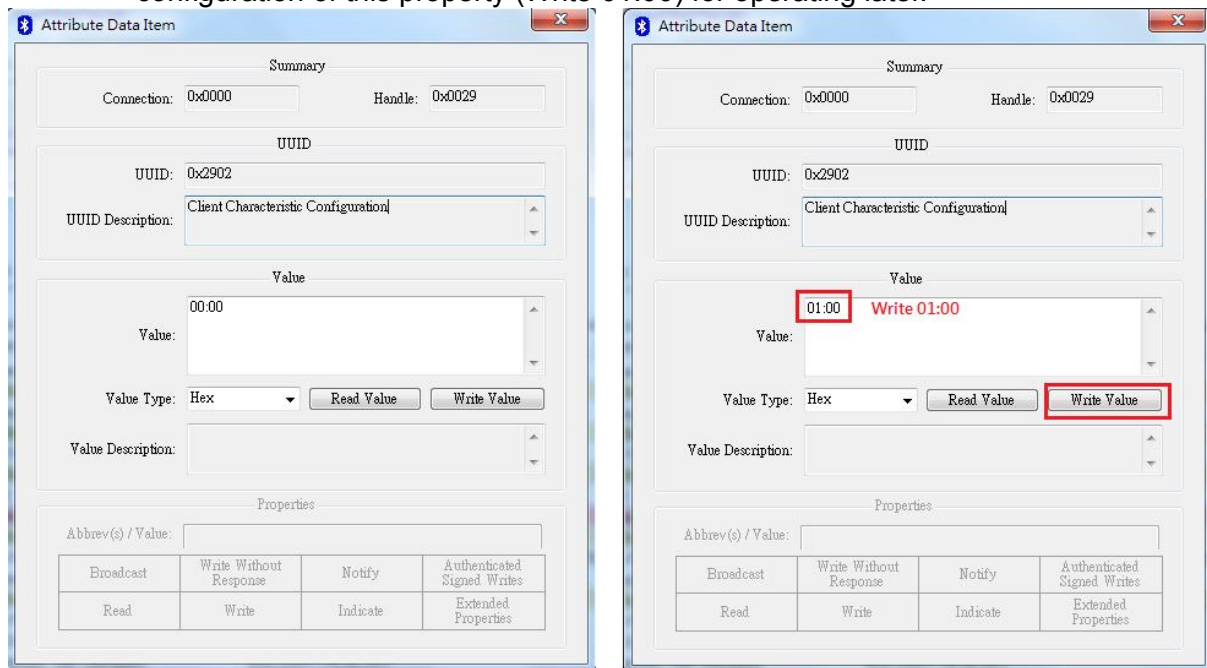
- Description is APP_to_BLE_UART_Tx.
- This operation transmission way is:
BTool → BLE-USB Dongle → AIR Transmission →
LaunchPad → Virtual Com Port Application

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- The maximum payload is 20 Bytes.
- ** UUID 0xFFFF2:
 - Description is BLE_UART_Rx_to_App.
 - This operation transmission way is:
Virtual Com Port Application → LaunchPad → AIR Transmission →
BLE-USB Dongle → BTool
 - The maximum payload is 20 Bytes.

Step 6

UUID 0xFFFF2 uses the property in Notification. Please enable the configuration of this property (Write 01:00) for operating later.



| | | | | | | |
|--------|--------|---------|-------------------------------------|---|-----------------------------|------------|
| 0x0000 | 0x0023 | 0x2800 | GATT Primary Service Declaration | F0 FF | | |
| 0x0000 | 0x0024 | 0x2803 | GATT Characteristic Declaration | 0A 25 00 F1 FF | | |
| 0x0000 | 0x0025 | 0xFFFF1 | Simple Profile Char 1 | 00 | | Rd Wr 0x0A |
| 0x0000 | 0x0026 | 0x2901 | Characteristic User Description | APP_to_BLE_UART_Tx | | |
| 0x0000 | 0x0027 | 0x2803 | GATT Characteristic Declaration | 10 28 00 F2 FF | | |
| 0x0000 | 0x0028 | 0xFFFF2 | Simple Profile Char 2 | | | Nfy 0x10 |
| 0x0000 | 0x0029 | 0x2902 | Client Characteristic Configuration | 01 00 | Ensure the content is 01:00 | |
| 0x0000 | 0x002A | 0x2901 | Characteristic User Description | BLE_UART_Rx_to_APP | | |

Step 7

UUID 0xFFFF1 Operation

(BTool → BLE-USB Dongle → AIR Transmission →
LaunchPad → Virtual Com Port Application)

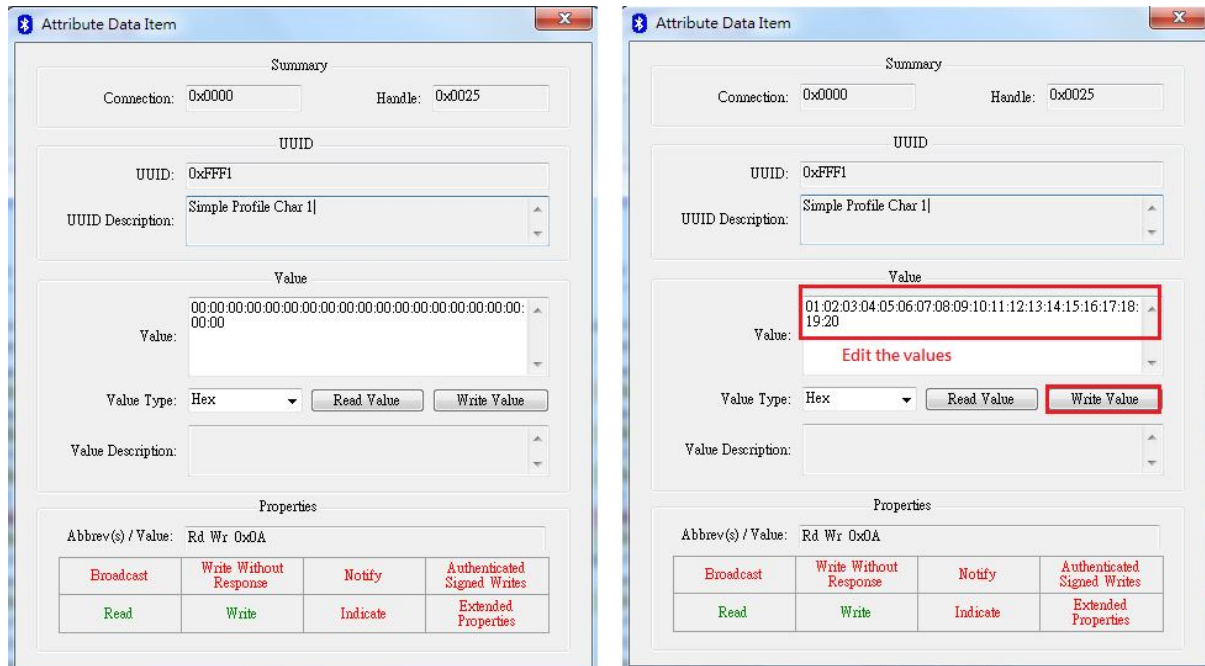
- Double click the row of UUID 0xFFFF1.

| | | | | | | |
|--------|--------|---------|-------------------------------------|---|--|------------|
| 0x0000 | 0x0023 | 0x2800 | GATT Primary Service Declaration | F0 FF | | |
| 0x0000 | 0x0024 | 0x2803 | GATT Characteristic Declaration | 0A 25 00 F1 FF | | |
| 0x0000 | 0x0025 | 0xFFFF1 | Simple Profile Char 1 | 00 | | Rd Wr 0x0A |
| 0x0000 | 0x0026 | 0x2901 | Characteristic User Description | APP_to_BLE_UART_Tx | | |
| 0x0000 | 0x0027 | 0x2803 | GATT Characteristic Declaration | 10 28 00 F2 FF | | |
| 0x0000 | 0x0028 | 0xFFFF2 | Simple Profile Char 2 | | | Nfy 0x10 |
| 0x0000 | 0x0029 | 0x2902 | Client Characteristic Configuration | 00 00 | | |
| 0x0000 | 0x002A | 0x2901 | Characteristic User Description | BLE_UART_Rx_to_APP | | |

- Edit the value you want to transmit on the BTool and then press "Write Value"

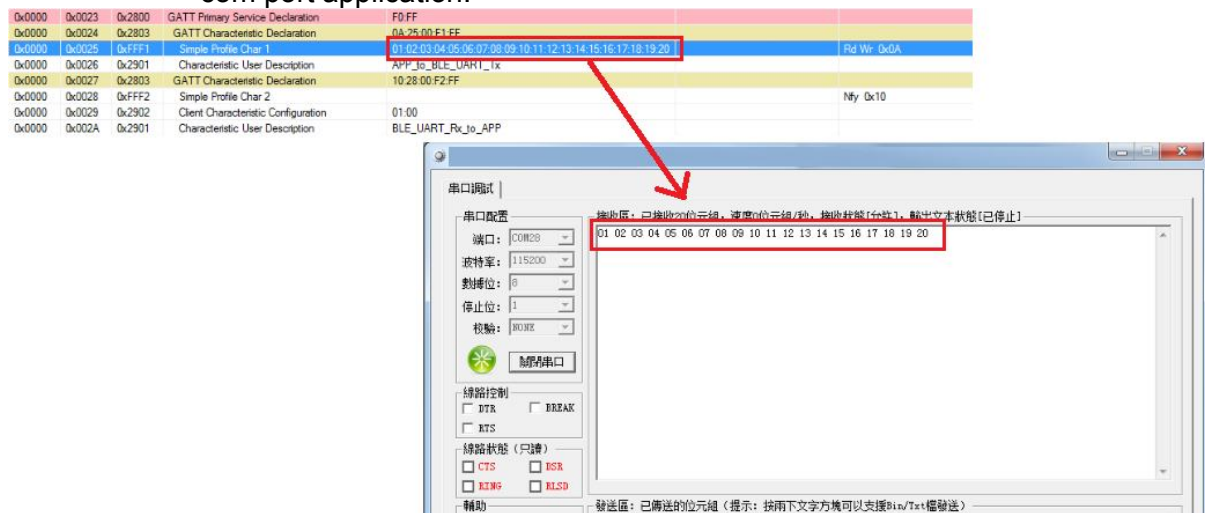
EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit

button.



** In this instance, we use 20 bytes data and the data structure is in 01:02:03:04:05:06:07:08:09:10:11:12:13:14:15:16:17:18:19:20.

- After the operation, you can observe the data is transmitted to your virtual com port application.



Step 8

UUID 0xFFFF2 Operation

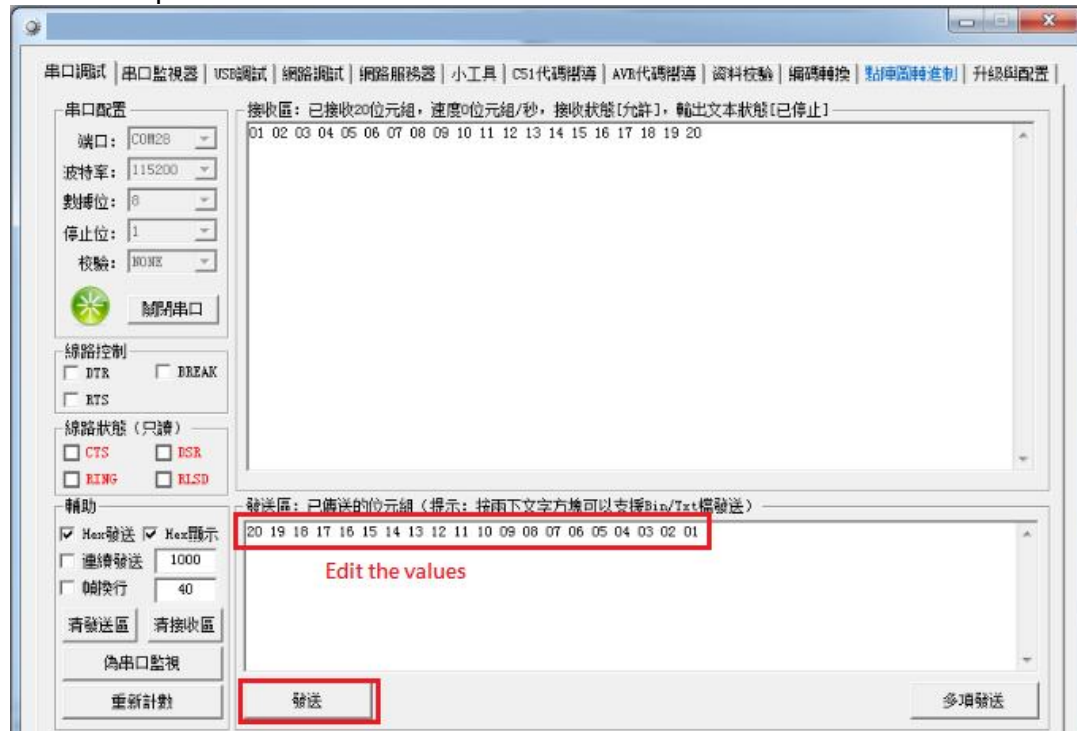
(Virtual Com Port Application → LaunchPad → AIR Transmission → BLE-USB Dongle → BTool)

** Note: You have to enable the configuration of Notification in Step 6.

EVK-CC2541 BLE LaunchPad (BT01-2)

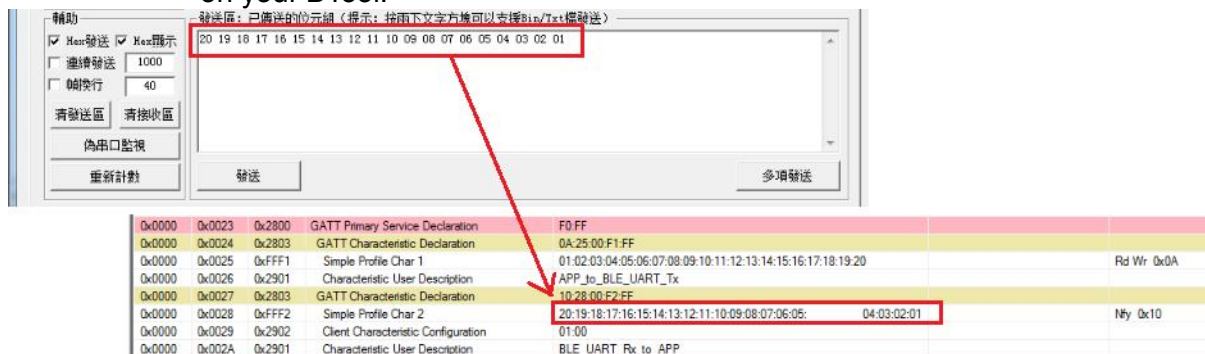
Bluetooth Low Energy Development Kit

- Edit the value you want to transmit on the virtual com port application and then press “Send” button.



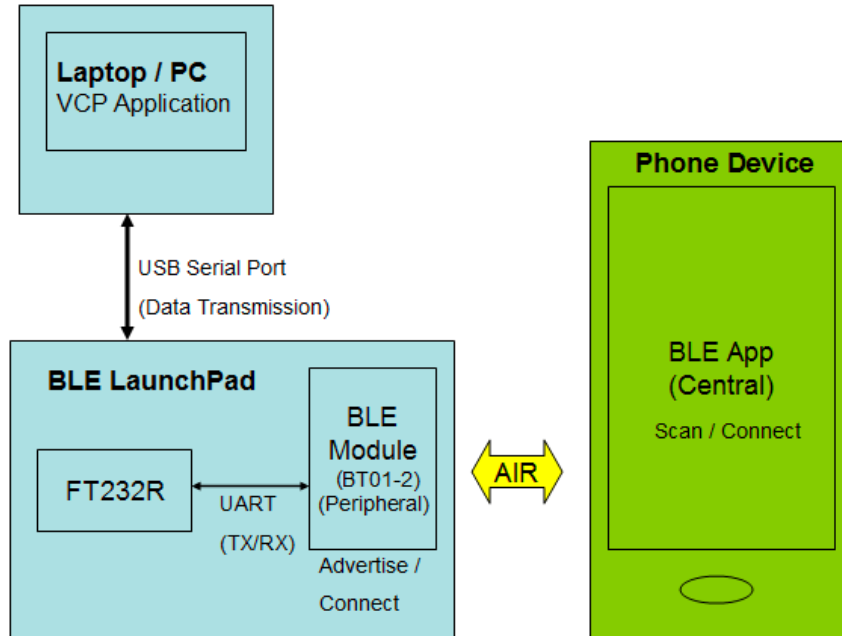
** In this instance, we use 20 bytes data and the data structure is in 20 19 18 17 16 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01.

- After the operation, you can observe the data is transmitted to UUID 0xFF2 on your BTool.



EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit

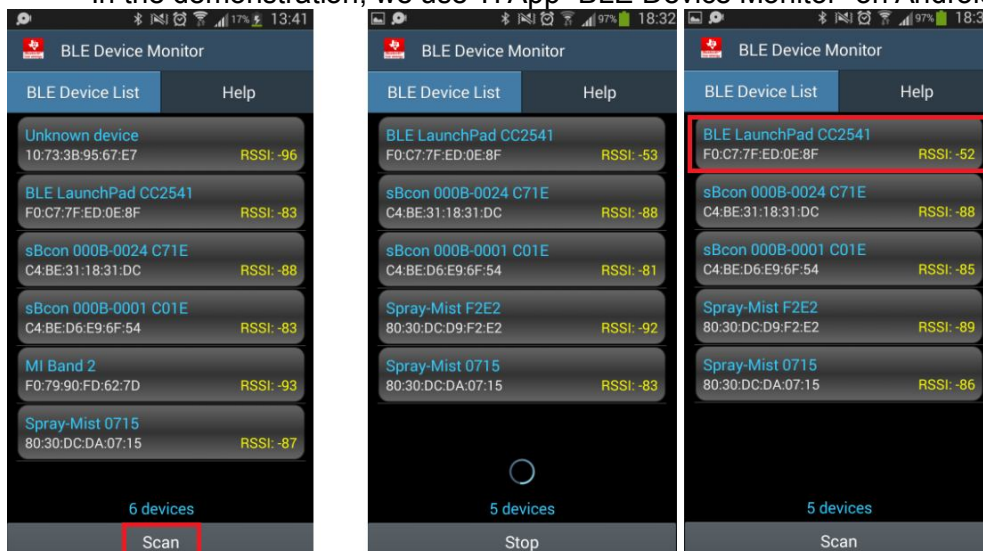
- b. Using **Phone Device** and **TI BLE App**:
The block diagram of this demonstration is shown below.



Step 1

Connect the LaunchPad to Phone Device by using TI BLE APP (Refer to Chapter 5.2, Connect your LaunchPad to TI BLE App)

In the demonstration, we use TI App “BLE Device Monitor” on Android.



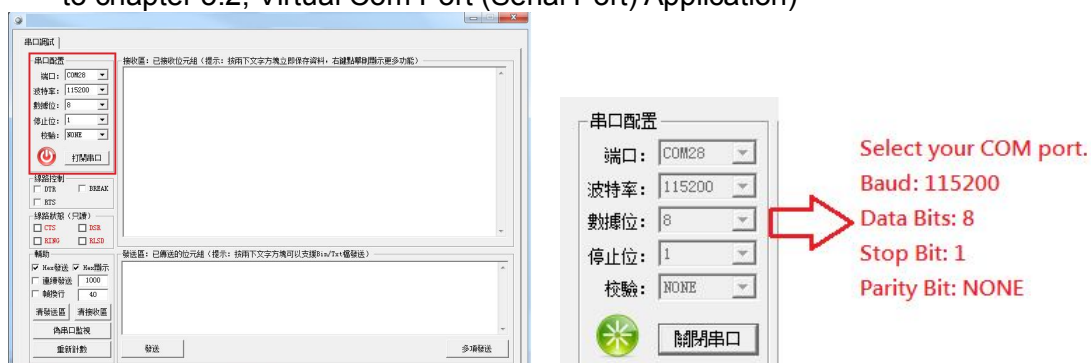
** In the Pre Programmed Firmware of **BLE LaunchPad (BT01-2)**, it uses the Advertising Name in **BLE LaunchPad CC2541**.

** You can find the name in **BLE LaunchPad CC2541** on your App and the minor digits is BDA (Bluetooth Device Address) of the LaunchPad, e.g., F0:C7:7F:ED:0E:8F.

EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit

Step 2

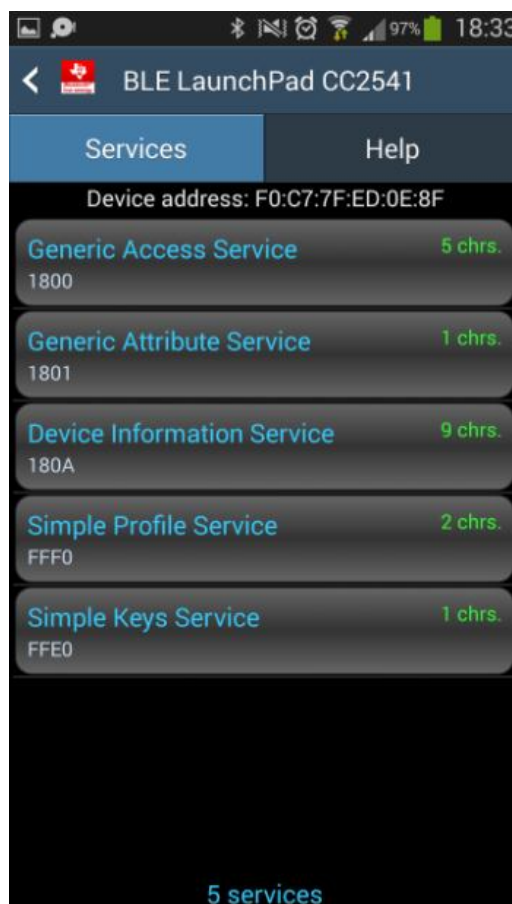
Ensure your Virtual Com Port (Serial Port) Application is ready to work. (Refer to chapter 5.2, Virtual Com Port (Serial Port) Application)



** The demonstration uses the baud in 115200 and the format is 8-N-1.

Step 3

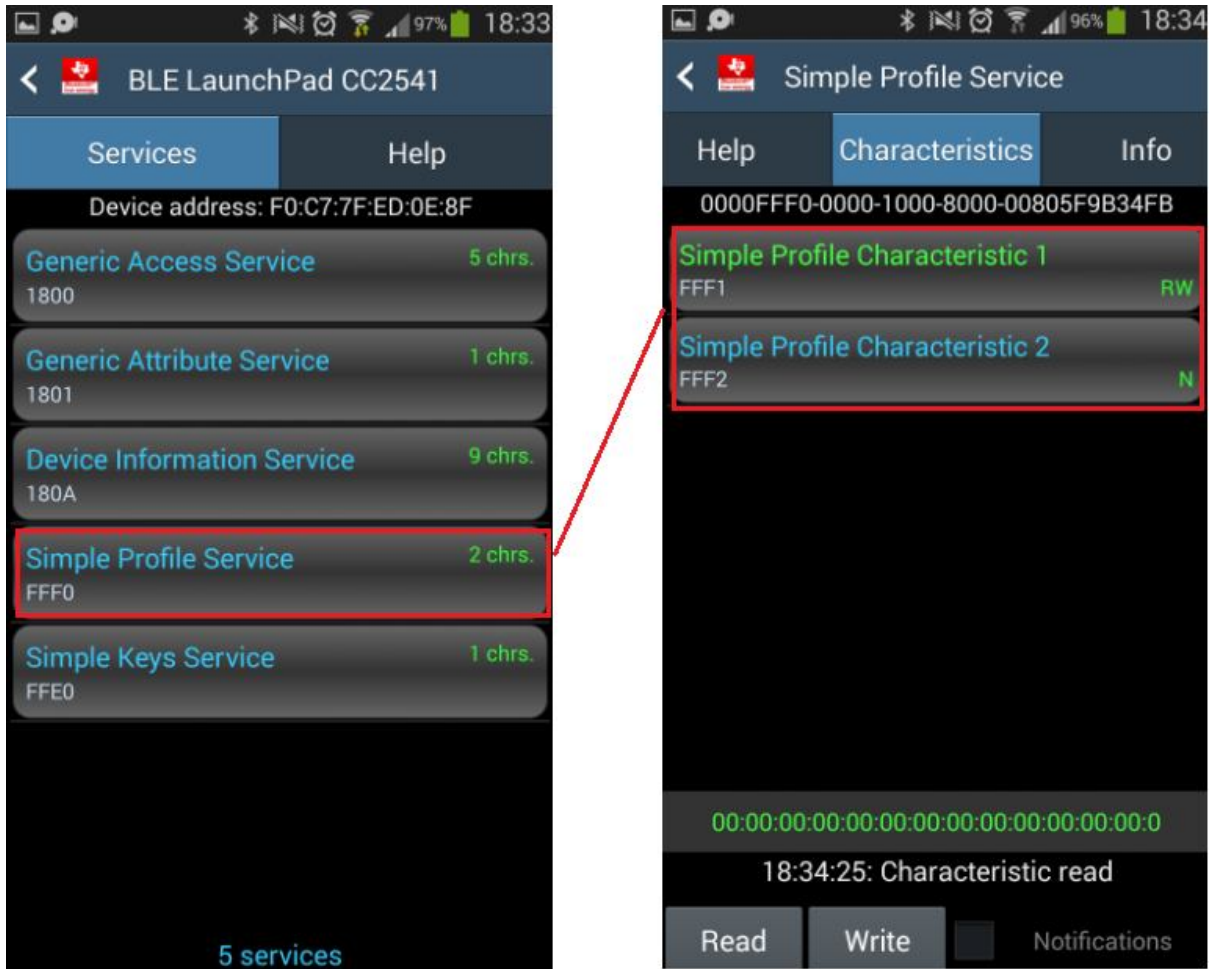
After connecting the LaunchPad by App, you can find all of Service List as below.



Step 4

For the service of BLE-UART bridge, it will show as “Simple Profile Service” by TI App. You can refer to the picture below.

EVK-CC2541 BLE LaunchPad (BT01-2)



**** UUID 0xFFF1:**

- Description is Simple Profile Characteristic 1.
- This operation transmission way is:
App → AIR Transmission →
LaunchPad → Virtual Com Port Application
- The maximum payload is 20 Bytes.

**** UUID 0xFF2:**

- Description is Simple Profile Characteristic 2.
- This operation transmission way is:
Virtual Com Port Application → LaunchPad → AIR Transmission → App
- The maximum payload is 20 Bytes.

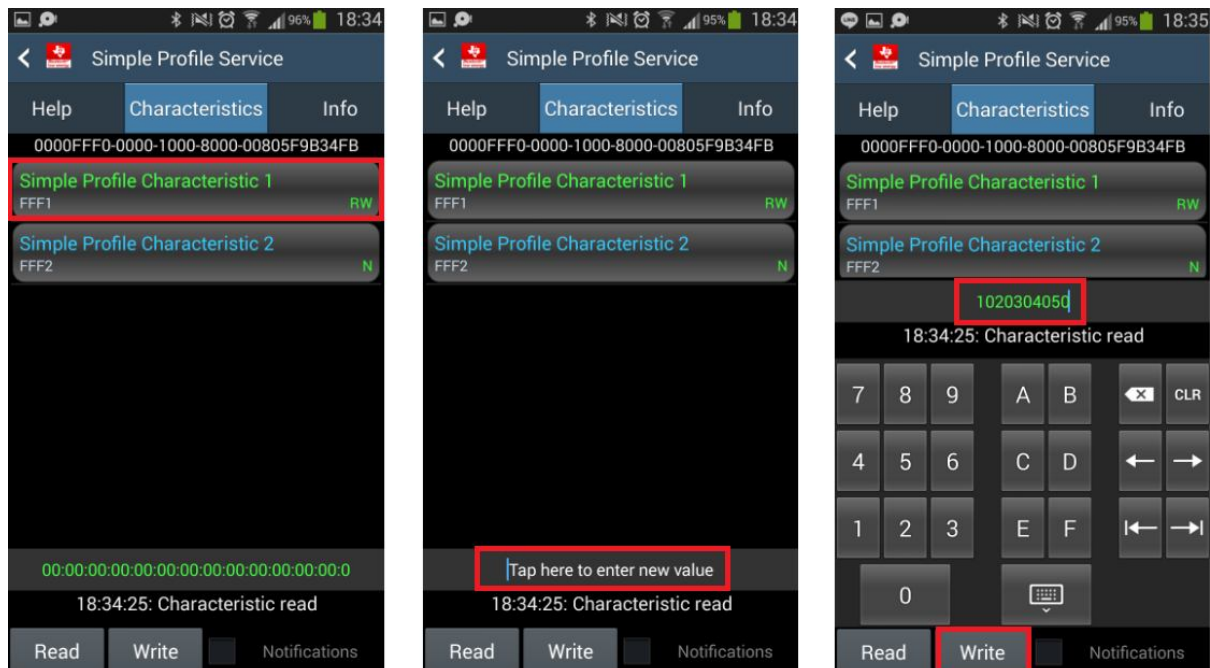
Step 5

UUID 0xFF1 Operation

(App → AIR Transmission →
LaunchPad → Virtual Com Port Application)

- Select (Click once) the section of UUID 0xFFF1 on App.
- Click the data bar on the bottom area of screen.
- Edit the value by keyboard.
- Press "Write" button to send the data.

EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit



** In this instance, we use 5 bytes data and the data structure is in 10 20 30 40 50.

- After the operation, you can observe the data is transmitted to your virtual com port application.



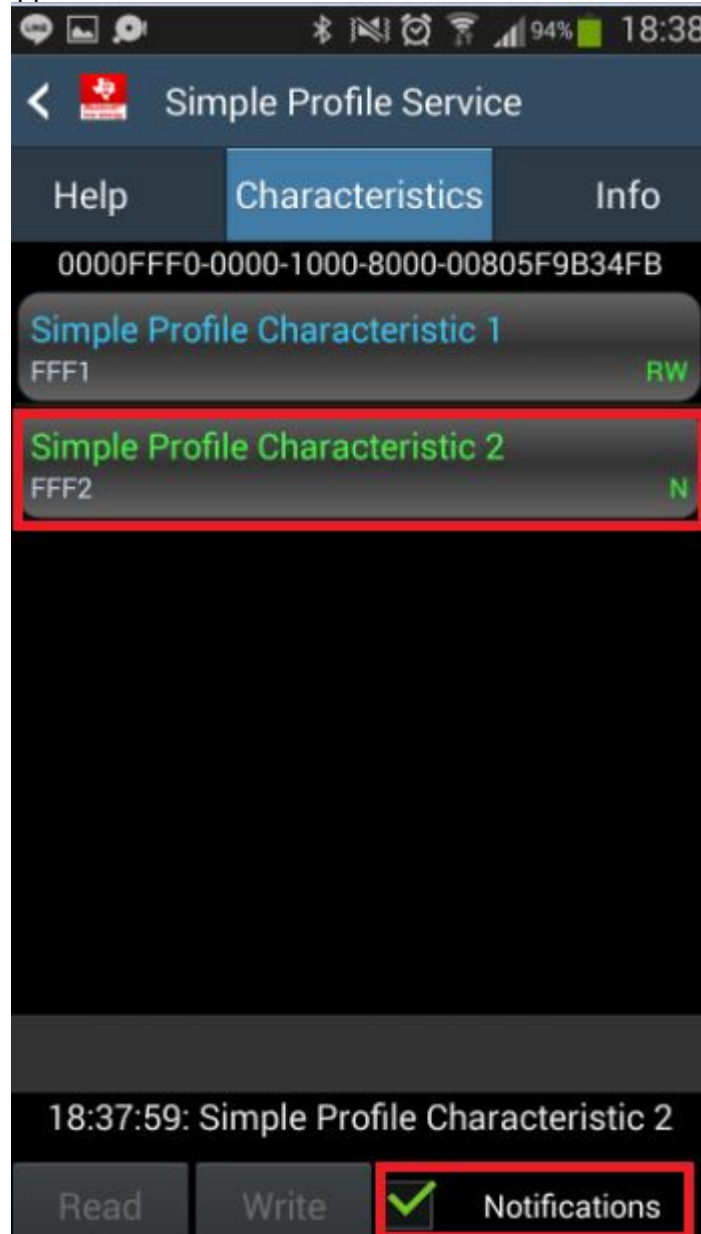
Step 6

UUID 0xFFFD Operation

(Virtual Com Port Application → LaunchPad → AIR Transmission → App)

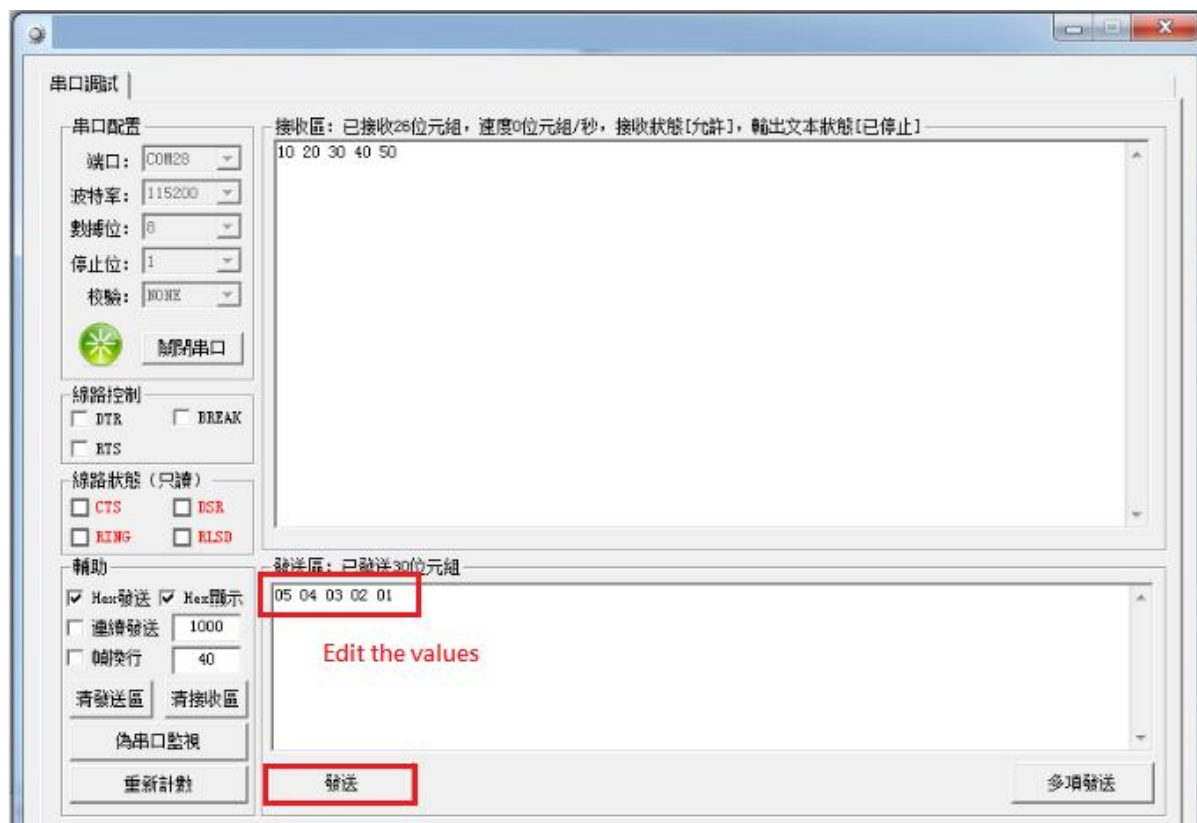
EVK-CC2541 BLE LaunchPad (BT01-2)
Bluetooth Low Energy Development Kit

- Select (Click once) the section of UUID 0xFFFF2 on App.
- UUID 0xFFFF2 uses the property in Notification. Please enable the configuration of Notification by selecting the check mark on right- down area of the App screen.



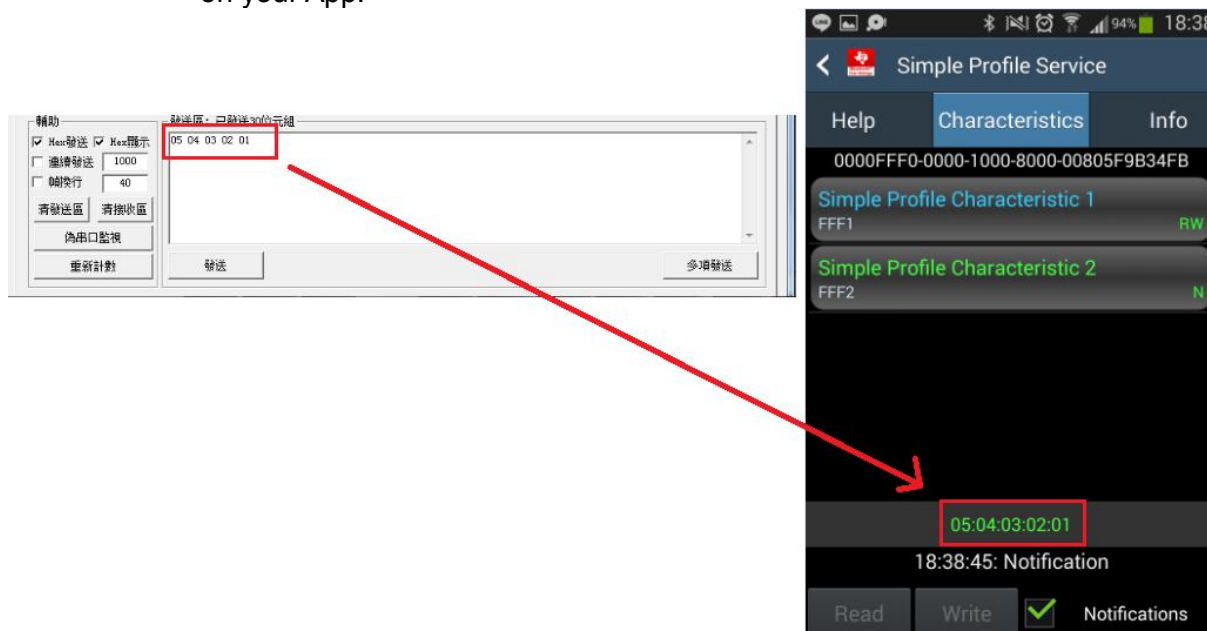
- Edit the value you want to transmit on the virtual com port application and then press "Send" button.

EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit



** In this instance, we use 5 bytes data and the data structure is in 05 04 03 02 01.

- After the operation, you can observe the data is transmitted to UUID 0xFFFF2 on your App.



2. Button State via BLE

The LaunchPad embeds two physical buttons for application. Similar to BLE-UART bridge function we describe above, we will demonstrate Button State via BLE implementation by using two environments (tools). Before the two descriptions below, please setup your hardware and software in chapter 5.2. You also need to refer several prior steps in description of BLE-UART bridge function for connecting LaunchPad and finding services.

a. Using **BLE-USB Dongle (BT02-2)** and **TI BTool**:

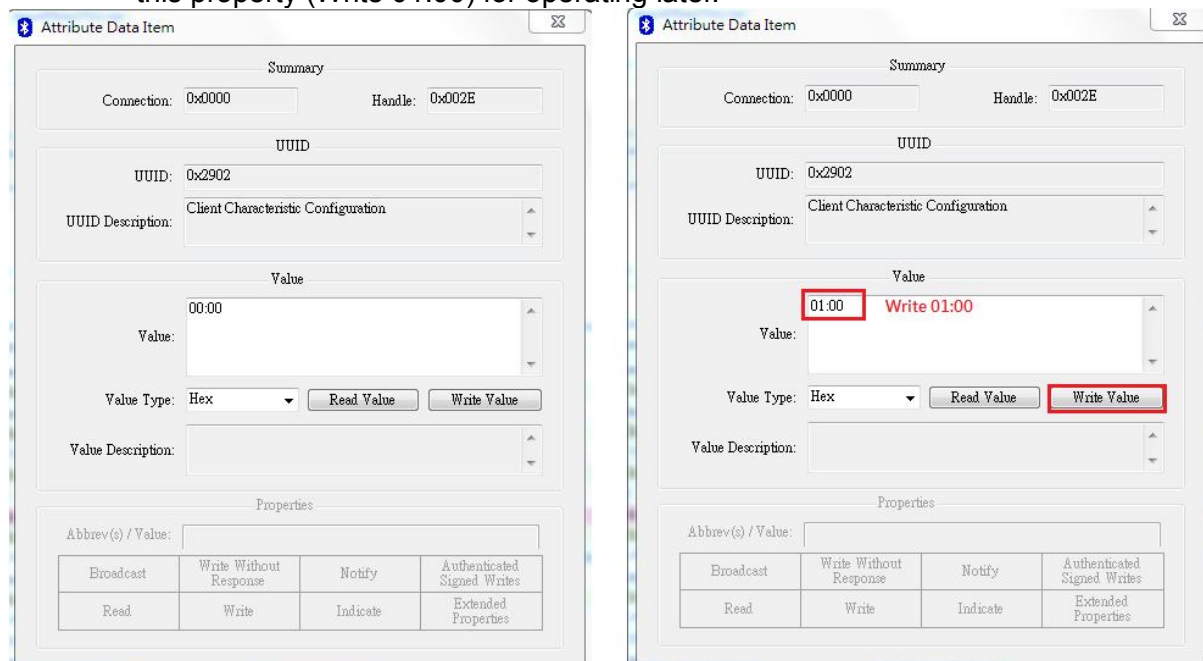
After connecting the LaunchPad by BTool, you can find the service of Button State in UUID 0xFFE1 shown in the picture below.

| | | | | | |
|--------|--------|--------|-------------------------------------|-----------------|----------|
| 0x0000 | 0x002B | 0x2800 | GATT Primary Service Declaration | E0:FF | |
| 0x0000 | 0x002C | 0x2803 | GATT Characteristic Declaration | 10:2D:00:E1:FF | |
| 0x0000 | 0x002D | 0xFFE1 | Key Press State | | Nfy 0x10 |
| 0x0000 | 0x002E | 0x2902 | Client Characteristic Configuration | 00:00 | |
| 0x0000 | 0x002F | 0x2901 | Characteristic User Description | Key Press State | |

** UUID 0xFFE1

- Description is Key Press State.
- This operation transmission way is:
 Button Activities on LaunchPad → AIR Transmission →
 BLE-USB Dongle → BTool

UUID 0xFFE1 uses the property in Notification. Please enable the configuration of this property (Write 01:00) for operating later.



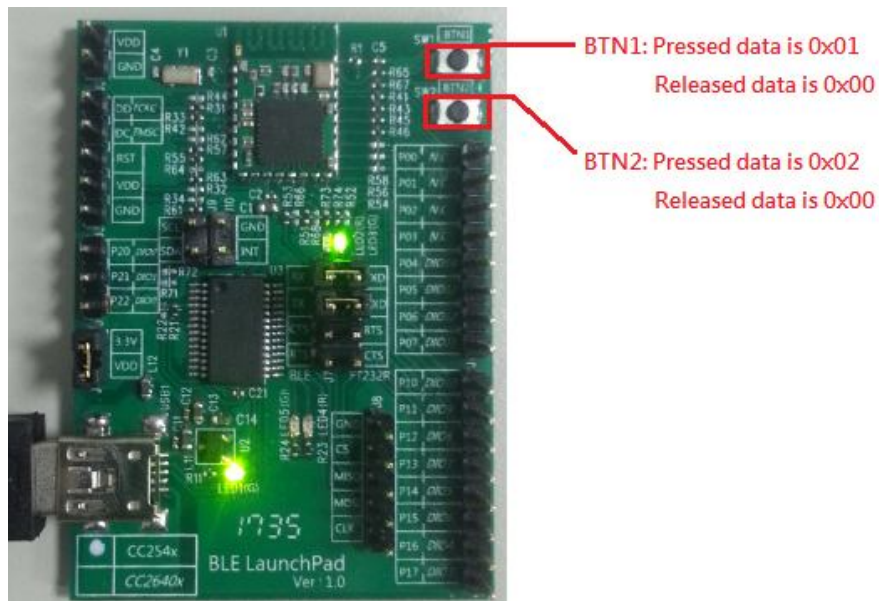
| | | | | | |
|--------|--------|--------|-------------------------------------|-----------------|----------|
| 0x0000 | 0x002B | 0x2800 | GATT Primary Service Declaration | E0:FF | |
| 0x0000 | 0x002C | 0x2803 | GATT Characteristic Declaration | 10:2D:00:E1:FF | |
| 0x0000 | 0x002D | 0xFFE1 | Key Press State | | Nfy 0x10 |
| 0x0000 | 0x002E | 0x2902 | Client Characteristic Configuration | 01:00 | |
| 0x0000 | 0x002F | 0x2901 | Characteristic User Description | Key Press State | |

For the **UUID 0xFFE1 Operation**

(Button Activities on LaunchPad → AIR Transmission →
 BLE-USB Dongle → BTool)

- Operate (Press / Release) the physical buttons BTN1 or BTN2 on the LaunchPad.

EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit



- By changing the states of Button Activities on LaunchPad, you can observe the different states (values) in the UUID 0xFFE1. In the picture below, we capture four states including the initial state (No BTN is pressing), BTN1 is pressing, BTN2 is pressing and BTN1 + BTN2 are pressing.

| | | | | | | |
|--------|--------|--------|-------------------------------------|-----------------|--------------------|----------|
| 0x0000 | 0x002B | 0x2800 | GATT Primary Service Declaration | E0 FF | | |
| 0x0000 | 0x002C | 0x2803 | GATT Characteristic Declaration | 10 2D 00 E1 FF | | |
| 0x0000 | 0x002D | 0xFFE1 | Key Press State | 00 | No BTN is pressing | Nfy 0x10 |
| 0x0000 | 0x002E | 0x2902 | Client Characteristic Configuration | 01 00 | | |
| 0x0000 | 0x002F | 0x2901 | Characteristic User Description | Key Press State | | |

| | | | | | | |
|--------|--------|--------|-------------------------------------|-----------------|------------------|----------|
| 0x0000 | 0x002B | 0x2800 | GATT Primary Service Declaration | E0 FF | | |
| 0x0000 | 0x002C | 0x2803 | GATT Characteristic Declaration | 10 2D 00 E1 FF | | |
| 0x0000 | 0x002D | 0xFFE1 | Key Press State | 01 | BTN1 is pressing | Nfy 0x10 |
| 0x0000 | 0x002E | 0x2902 | Client Characteristic Configuration | 01 00 | | |
| 0x0000 | 0x002F | 0x2901 | Characteristic User Description | Key Press State | | |

| | | | | | | |
|--------|--------|--------|-------------------------------------|-----------------|------------------|----------|
| 0x0000 | 0x002B | 0x2800 | GATT Primary Service Declaration | E0 FF | | |
| 0x0000 | 0x002C | 0x2803 | GATT Characteristic Declaration | 10 2D 00 E1 FF | | |
| 0x0000 | 0x002D | 0xFFE1 | Key Press State | 02 | BTN2 is pressing | Nfy 0x10 |
| 0x0000 | 0x002E | 0x2902 | Client Characteristic Configuration | 01 00 | | |
| 0x0000 | 0x002F | 0x2901 | Characteristic User Description | Key Press State | | |

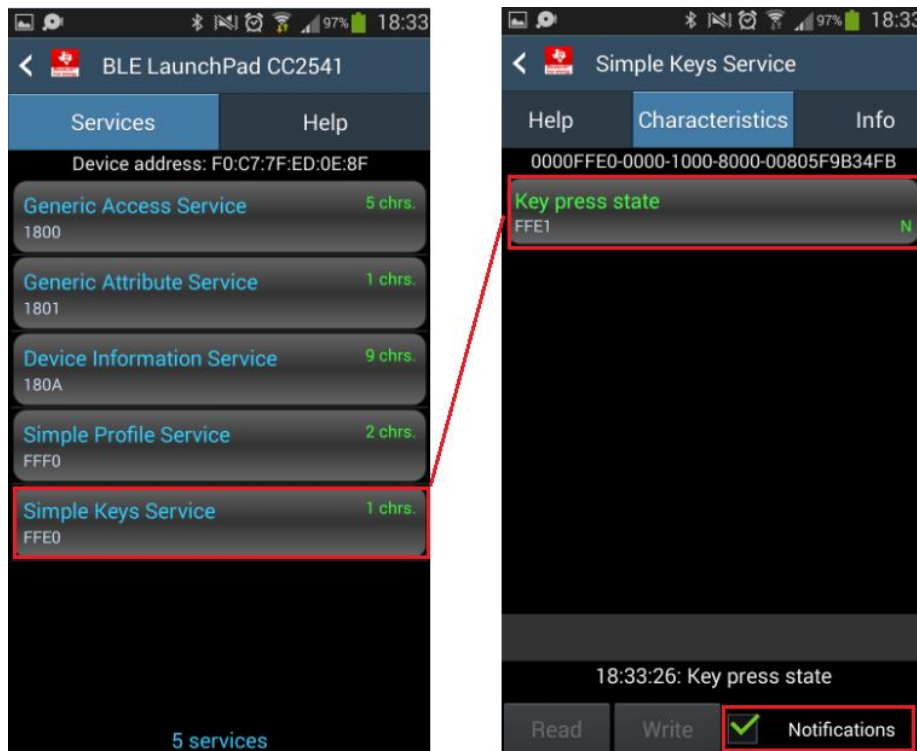
| | | | | | | |
|--------|--------|--------|-------------------------------------|-----------------|----------------------------|----------|
| 0x0000 | 0x002B | 0x2800 | GATT Primary Service Declaration | E0 FF | | |
| 0x0000 | 0x002C | 0x2803 | GATT Characteristic Declaration | 10 2D 00 E1 FF | | |
| 0x0000 | 0x002D | 0xFFE1 | Key Press State | 03 | BTN1 and BTN2 are pressing | Nfy 0x10 |
| 0x0000 | 0x002E | 0x2902 | Client Characteristic Configuration | 01 00 | | |
| 0x0000 | 0x002F | 0x2901 | Characteristic User Description | Key Press State | | |

b. Using Phone Device and TI BLE App:

After connecting the LaunchPad by App, you can find all of Service List and the service of Button State shown in the picture below.

UUID 0xFFE1 uses the property in Notification. Please enable the configuration of Notification by selecting the check mark on right- down area of the App screen.

EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit



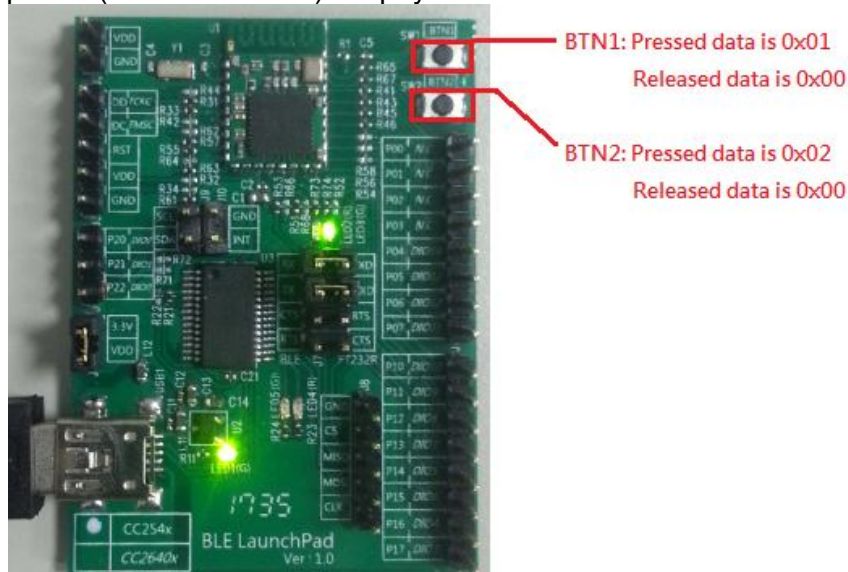
**** UUID 0xFFE1**

- Description is Key Press State.
- This operation transmission way is:
Button Activities on LaunchPad → AIR Transmission → App

For the UUID 0xFFE1 Operation

(Button Activities on LaunchPad → AIR Transmission → App)

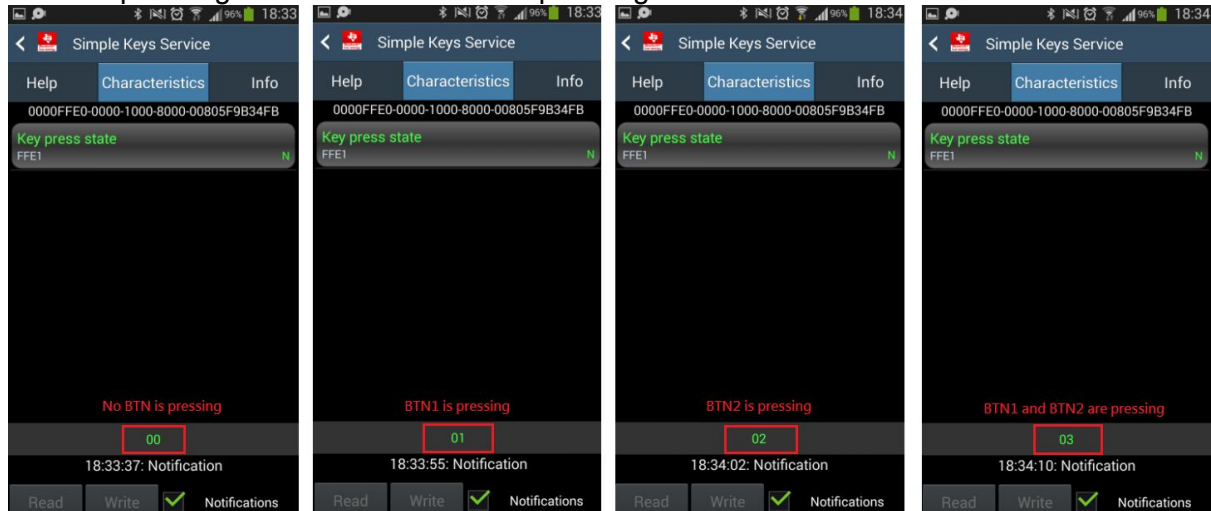
- Operate (Press / Release) the physical buttons BTN1 or BTN2 on the LaunchPad.



EVK-CC2541 BLE LaunchPad (BT01-2)

Bluetooth Low Energy Development Kit

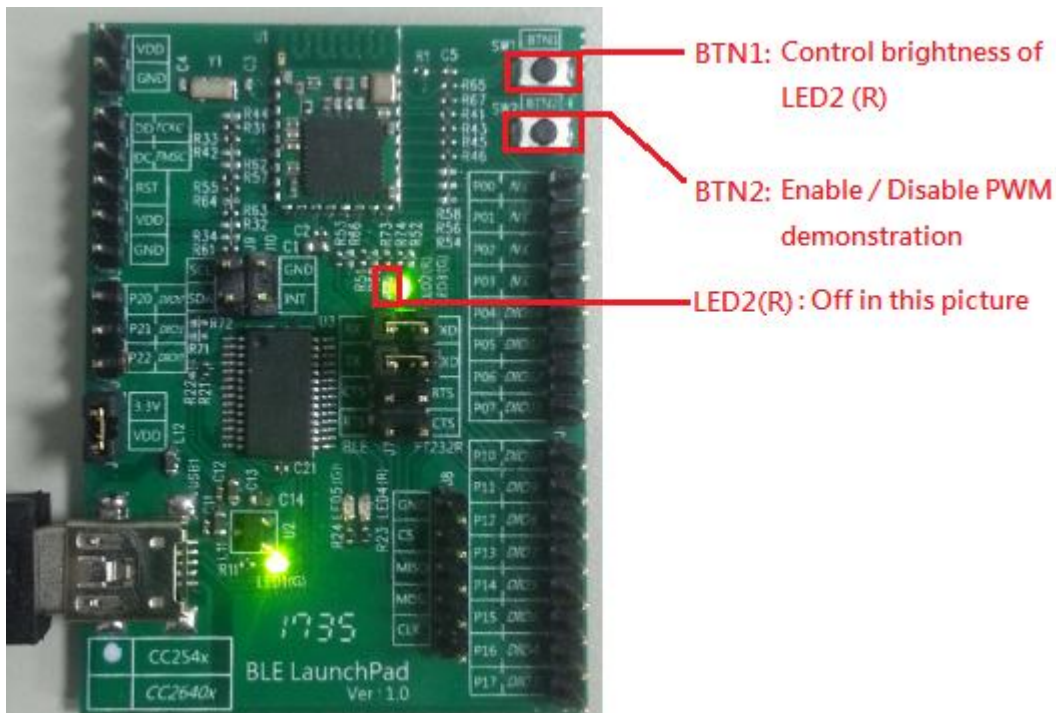
- By changing the states of Button Activities on LaunchPad, you can observe the different states (values) in the UUID 0xFFE1. In the picture below, we capture four states including the initial state (No BTN is pressing), BTN1 is pressing, BTN2 is pressing and BTN1 + BTN2 are pressing.



3. LED brightness by PWM

The LaunchPad using TI CC2541 contains variety of peripherals including several Timers. PWM (Pulse-width modulator) function is one application by using Timer.

In this demonstration, we use BTN1 and BTN2 to control PWM function and drive the LED2 (R) which connects to Port 1.3 of CC2541.



EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit

The operation of LED brightness:

While the LaunchPad is powered on, the LED2 (R) will be in off state.

Step 1

Enable the PWM function by pressing BTN2 once.

The LED2 (R) will be lit Red and in minimum level of brightness.

Step 2

Press BTN1 to increase the level of brightness. In this demonstration, it offers 8 levels for brightness from minimum to maximum.

Step 3

You can disable the demonstration by pressing BTN2 once.

Please refer to the picture below for the brightness level of LED2 (R) by PWM function.



LED2(R) is off



LED2(R) is in minimum brightness



LED2(R) is in medium brightness



LED2(R) is in maximum brightness

Chapter 6 Developing, Flash Programming and Debugging

6.1 Introduction

BLE LaunchPad (BT01-2) contains a Bluetooth module BT01-2 using TI Bluetooth low energy controller CC2541. TI CC2541 is a 8051-based System-on-Chip (SoC) and with 256 KB In-System-Programmable Flash.

To develop your Bluetooth Low Energy Application, TI supports variety of hardware or software tools. In the LaunchPad, it offers standard pitch 2.54mm Pin Headers for connecting to these tools easily.

6.2 Hardware and Software Tools

Hardware tool

CC Debugger

- TI website:

<http://www.ti.com/tool/CC-DEBUGGER>

- Description:

The CC Debugger is primarily used for Flash programming and debugging software running on CCxxxx 8051-based System-on-Chip (SoC) devices from Texas Instruments.



Software tool

BLE-STACK (For CC2540 / CC2541)

- TI website:
<http://www.ti.com/tool/ble-stack>
- Description:
TI Bluetooth low energy BLE-Stack software stack for TI's C2540 and CC2541 devices is a full-featured Bluetooth 4.0 stack that includes all necessary software to get started on the development of single-mode Bluetooth Smart applications.
The BLE-Stack is available royalty-free to customers using TI's C2540/41 Bluetooth low energy system-on-chip (SoC) family

SmartRF Flash Programmer

- TI website:
<http://www.ti.com/tool/flash-programmer>
- Description:
TI SmartRF Flash Programmer can be used to program the flash memory in Texas Instruments 8051-based low-power RF wireless MCUs and for upgrading the firmware and bootloader on the SmartRF05 Evaluation Board, SmartRF Transceiver Evaluation Board (TrxEB) and the CC-Debugger.

IAR Embedded Workbench for 8051

- Website:
www.iar.com
- Description:
All embedded software for the CC2540 and CC2541 is developed using Embedded Workbench for 8051 from IAR Software.

6.3 Hardware Connection

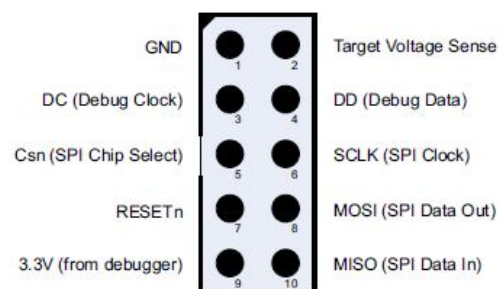
By using CC Debugger and software tools to develop with the LaunchPad, you will need to connect the CC Debugger to the LaunchPad at first.

The LaunchPad offers standard pitch 2.54mm Pin Headers (J3) for connecting to CC Debugger. The detail connection diagram is shown below.

**** CC Debugger Target Connector**

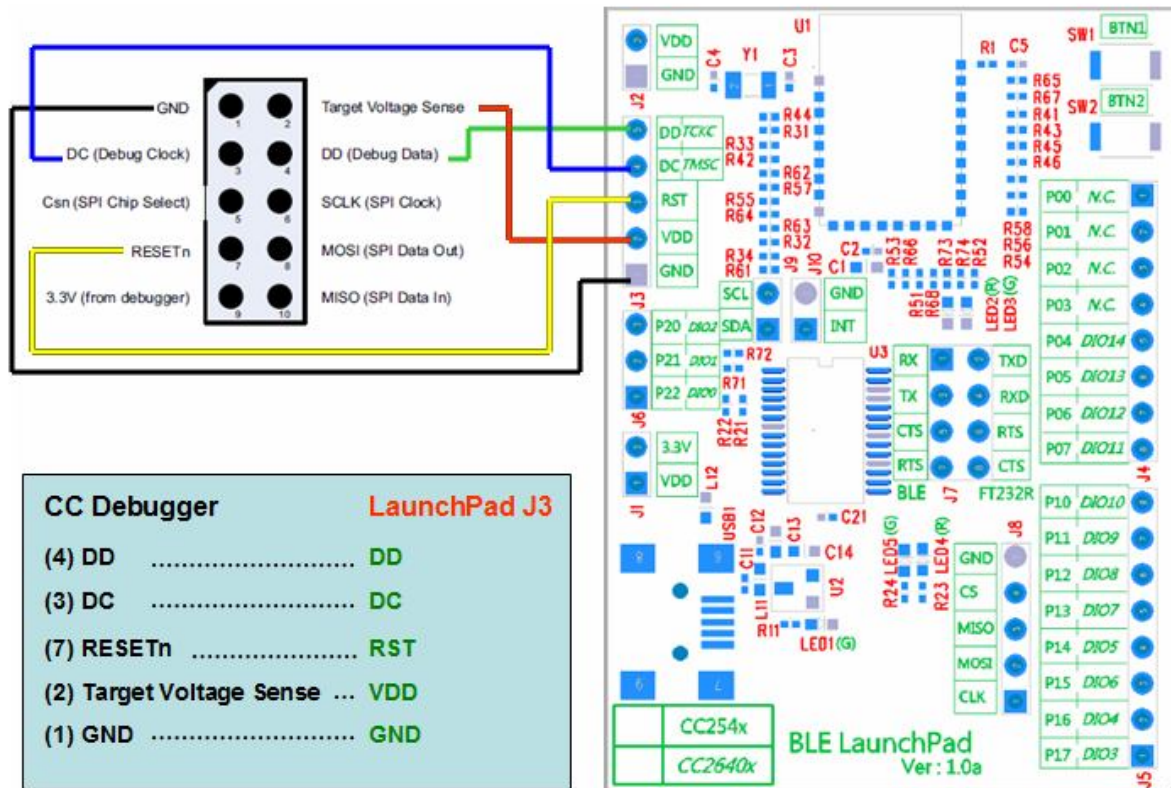


**** Connector Pin Definition**



EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit

** The Connection Definition between the CC Debugger and the LaunchPad J3



** Please ensure the VDD of LaunchPad is supplied by normal power, e.g., from J1 with 3.3V.

APPENDIX A

A-1. References and Other Useful Material

1. TI CC2541
 - Product website:
<http://www.ti.com/product/CC2541>
 - Data Sheet:
<http://www.ti.com/lit/ds/symlink/cc2541.pdf>
 - Software Developer's Guide:
<http://www.ti.com/lit/ug/swru271g/swru271g.pdf>
 - User's guide:
<http://www.ti.com/lit/ug/swru191f/swru191f.pdf>
2. BT01-2 Bluetooth Module
 - Product specification:
BT01-2 Product Specification 20160606 V1.1.pdf
3. FTDI FT232R
 - Product website:
<http://www.ftdichip.com/Products/ICs/FT232R.htm>
 - Data sheet:
http://www.ftdichip.com/Support/Documents/DataSheets/ICs/DS_FT232R.pdf

A-2. CC2541 Peripheral I/O Pin Mapping to the LaunchPad

In the LaunchPad, it offers several applications by using Peripheral on Pin Header or LED, e.g., UART, SPI and PWM on LED. In the hardware design, the LaunchPad uses the configuration of CC2541 as the definition and picture below.

Peripheral - UART Function

LaunchPad J7 (BLE side)

- RX connects to Port 0.2 of CC2541.
- TX connects to Port 0.3 of CC2541.
- CTS connects to Port 0.4 of CC2541.
- RTS connects to Port 0.5 of CC2541.

CC2541 needs to configure the I/O to peripheral function by USART0 ALT.1

Peripheral - SPI Function

LaunchPad J8

- CS connects to Port 1.4 of CC2541.
- CLK connects to Port 1.5 of CC2541.
- MOSI connects to Port 1.6 of CC2541.
- MISO connects to Port 1.7 of CC2541.

CC2541 needs to configure the I/O to peripheral function by USART1 ALT.2

EVK-CC2541 BLE LaunchPad (BT01-2) Bluetooth Low Energy Development Kit

Peripheral - PWM Function

LaunchPad LED2 (R)

- LED2 (R) connects Port 1.3 of CC2541.

CC2541 needs to configure the I/O to peripheral function by Timer 3 ALT.1, Channel 0.

| Periphery/ Function | P0 | | | | | | | | P1 | | | | | | | | P2 | | | | |
|--------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|----|----|----|----|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 4 | 3 | 2 | 1 | 0 |
| ADC | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | | | | | | | | | | | | | T |
| Operational amplifier | | | | | | O | - | + | | | | | | | | | | | | | |
| Analog comparator | | | + | - | | | | | | | | | | | | | | | | | |
| USART 0 SPI | | | C | SS | MO | MI | | | | | | | | | | | | | | | |
| Alt. 2 | | | | | | | | | | | MO | MI | C | SS | | | | | | | |
| USART 0 UART | | | RT | CT | TX | RX | | | | | | | | | | | | | | | |
| Alt. 2 | | | | | | | | | | | TX | RX | RT | CT | | | | | | | |
| USART 1 SPI | | | MI | MO | C | SS | | | | | | | | | | | | | | | |
| Alt. 2 | | | | | | | | | MI | MO | C | SS | | | | | | | | | |
| USART 1 UART | | | RX | TX | RT | CT | | | | | | | | | | | | | | | |
| Alt. 2 | | | | | | | | | RX | TX | RT | CT | | | | | | | | | |
| TIMER 1 | | 4 | 3 | 2 | 1 | 0 | | | | | | | | | | | | | | | |
| Alt. 2 | 3 | 4 | | | | | | | | | | | | 0 | 1 | 2 | | | | | |
| TIMER 3 | | | | | | | | | | | | 1 | 0 | | | | | | | | |
| Alt. 2 | | | | | | | | | 1 | 0 | | | | | | | | | | | |
| TIMER 4 | | | | | | | | | | | | | | | 1 | 0 | | | | | |
| Alt. 2 | | | | | | | | | | | | | | | | | 1 | | | | 0 |
| 32-kHz XOSC | | | | | | | | | | | | | | | | | Q1 | Q2 | | | |
| DEBUG | | | | | | | | | | | | | | | | | | | DC | DD | |
| OBSSSEL | | | | | | | | | | | 5 | 4 | 3 | 2 | 1 | 0 | | | | | |

** Please also refer to CC2541 User's Guide, Chapter 7.6 Peripheral I/O for details.

A-3. Service List of Demonstrated BLE-UART Bridge Application

In the Pre Programmed Firmware of LaunchPad, it offers several functions for demonstration. For the BLE service list of demonstration, please refer to the table below.

| Handle | Uuid | UuidDesc | Value | Properties |
|--------|--------|----------------------------------|----------------------|------------|
| 0x0001 | 0x2800 | GATT Primary Service Declaration | 00:18 | |
| 0x0002 | 0x2803 | GATT Characteristic Declaration | 02:03:00:00:2A | |
| 0x0003 | 0x2A00 | Device Name | BLE LaunchPad CC2541 | Rd 0x02 |
| 0x0004 | 0x2803 | GATT Characteristic Declaration | 02:05:00:01:2A | |
| 0x0005 | 0x2A01 | Appearance | 00:00 | Rd 0x02 |
| 0x0006 | 0x2803 | GATT Characteristic Declaration | 0A:07:00:02:2A | |
| 0x0007 | 0x2A02 | Peripheral Privacy Flag | 00 | Rd Wr 0x0A |

EVK-CC2541 BLE LaunchPad (BT01-2)

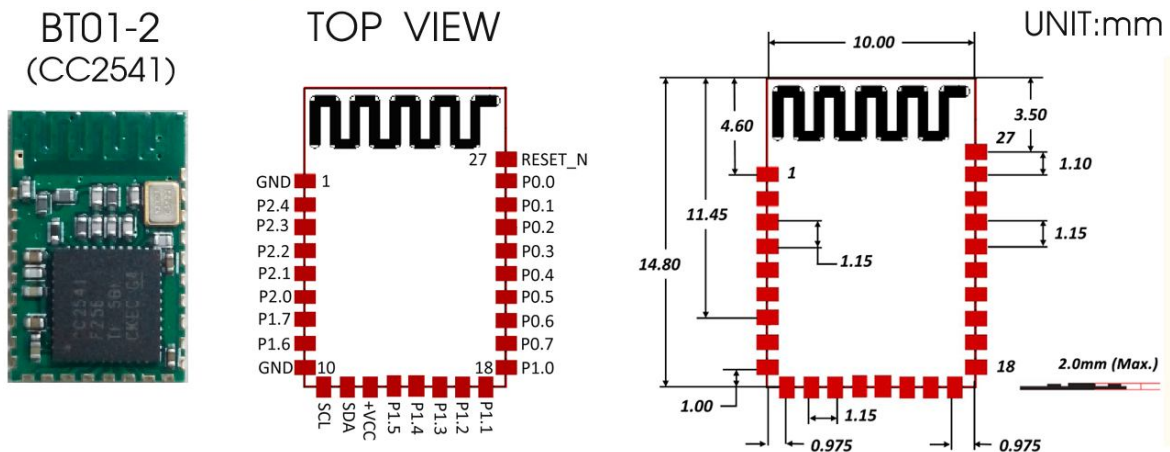
Bluetooth Low Energy Development Kit

| | | | | |
|--------|---------|---|---|------------|
| 0x0008 | 0x2803 | GATT Characteristic Declaration | 08:09:00:03:2A | |
| 0x0009 | 0x2A03 | Reconnection Address | | Wr 0x08 |
| 0x000A | 0x2803 | GATT Characteristic Declaration | 02:0B:00:04:2A | |
| 0x000B | 0x2A04 | Peripheral Preferred Connection Parameters | 50:00:A0:00:00:00:E8:03 | Rd 0x02 |
| 0x000C | 0x2800 | GATT Primary Service Declaration | 01:18 | |
| 0x000D | 0x2803 | GATT Characteristic Declaration | 20:0E:00:05:2A | |
| 0x000E | 0x2A05 | Service Changed | | Ind 0x20 |
| 0x000F | 0x2902 | Client Characteristic Configuration | 00:00 | |
| 0x0010 | 0x2800 | GATT Primary Service Declaration | 0A:18 | |
| 0x0011 | 0x2803 | GATT Characteristic Declaration | 02:12:00:23:2A | |
| 0x0012 | 0x2A23 | System ID | 8F:0E:ED:00:00:7F:C7:F0 | Rd 0x02 |
| 0x0013 | 0x2803 | GATT Characteristic Declaration | 02:14:00:24:2A | |
| 0x0014 | 0x2A24 | Model Number String | Model Number | Rd 0x02 |
| 0x0015 | 0x2803 | GATT Characteristic Declaration | 02:16:00:25:2A | |
| 0x0016 | 0x2A25 | Serial Number String | Serial Number | Rd 0x02 |
| 0x0017 | 0x2803 | GATT Characteristic Declaration | 02:18:00:26:2A | |
| 0x0018 | 0x2A26 | Firmware Revision String | Firmware Revision | Rd 0x02 |
| 0x0019 | 0x2803 | GATT Characteristic Declaration | 02:1A:00:27:2A | |
| 0x001A | 0x2A27 | Hardware Revision String | Hardware Revision | Rd 0x02 |
| 0x001B | 0x2803 | GATT Characteristic Declaration | 02:1C:00:28:2A | |
| 0x001C | 0x2A28 | Software Revision String | Software Revision | Rd 0x02 |
| 0x001D | 0x2803 | GATT Characteristic Declaration | 02:1E:00:29:2A | |
| 0x001E | 0x2A29 | Manufacturer Name String | Manufacturer Name | Rd 0x02 |
| 0x001F | 0x2803 | GATT Characteristic Declaration | 02:20:00:2A:2A | |
| 0x0020 | 0x2A2A | IEEE 11073-20601 Regulatory Certification Data List | FE:00:65:78:70:65:72:69:6D:65:6E:74:61:6C | Rd 0x02 |
| 0x0021 | 0x2803 | GATT Characteristic Declaration | 02:22:00:50:2A | |
| 0x0022 | 0x2A50 | PnP ID | 01:0D:00:00:00:10:01 | Rd 0x02 |
| 0x0023 | 0x2800 | GATT Primary Service Declaration | F0:FF | |
| 0x0024 | 0x2803 | GATT Characteristic Declaration | 0A:25:00:F1:FF | |
| 0x0025 | 0xFFFF1 | Simple Profile Char 1 | | Rd Wr 0x0A |
| 0x0026 | 0x2901 | Characteristic User Description | APP_to_BLE_UART_Tx | |
| 0x0027 | 0x2803 | GATT Characteristic Declaration | 10:28:00:F2:FF | |
| 0x0028 | 0xFFFF2 | Simple Profile Char 2 | | Nfy 0x10 |
| 0x0029 | 0x2902 | Client Characteristic Configuration | 00:00 | |
| 0x002A | 0x2901 | Characteristic User Description | BLE_UART_Rx_to_APP | |
| 0x002B | 0x2800 | GATT Primary Service Declaration | E0:FF | |
| 0x002C | 0x2803 | GATT Characteristic Declaration | 10:2D:00:E1:FF | |

EVK-CC2541 BLE LaunchPad (BT01-2) **Bluetooth Low Energy Development Kit**

| | | | | |
|--------|--------|-------------------------------------|-----------------|----------|
| 0x002D | 0xFFE1 | Key Press State | | Nfy 0x10 |
| 0x002E | 0x2902 | Client Characteristic Configuration | 00:00 | |
| 0x002F | 0x2901 | Characteristic User Description | Key Press State | |

A-4. BT01-2 Module Pin Assignment and Dimension



| Pin | Symbol | Pin Type | Description |
|-----|--------|-------------------------|---|
| 1 | GND | Power | System GND |
| 2 | P2.4 | Digital I/O, Analog I/O | Port 2.4 / 32.768 kHz XOSC |
| 3 | P2.3 | Digital I/O, Analog I/O | Port 2.3 / 32.768 kHz XOSC |
| 4 | P2.2 | Digital I/O | Port 2.2 / debug clock (DC) |
| 5 | P2.1 | Digital I/O | Port 2.1 / debug data (DD) |
| 6 | P2.0 | Digital I/O | Port 2.0 |
| 7 | P1.7 | Digital I/O | Port 1.7 |
| 8 | P1.6 | Digital I/O | Port 1.6 |
| 9 | GND | Power | System GND |
| 10 | SCL | Digital I/O | I2C clock |
| 11 | SDA | Digital I/O | I2C data |
| 12 | +VCC | Power | System Power-Input 2V–3.6V digital power-supply connection |
| 13 | P1.5 | Digital I/O | Port 1.5 |

EVK-CC2541 BLE LaunchPad (BT01-2)
Bluetooth Low Energy Development Kit

| | | | |
|----|---------|---------------|-----------------------------------|
| 14 | P1.4 | Digital I/O | Port 1.4 |
| 15 | P1.3 | Digital I/O | Port 1.3 |
| 16 | P1.2 | Digital I/O | Port 1.2 |
| 17 | P1.1 | Digital I/O | Port 1.1 (20-mA drive capability) |
| 18 | P1.0 | Digital I/O | Port 1.0 (20-mA drive capability) |
| 19 | P0.7 | Digital I/O | Port 0.7 |
| 20 | P0.6 | Digital I/O | Port 0.6 |
| 21 | P0.5 | Digital I/O | Port 0.5 |
| 22 | P0.4 | Digital I/O | Port 0.4 |
| 23 | P0.3 | Digital I/O | Port 0.3 |
| 24 | P0.2 | Digital I/O | Port 0.2 |
| 25 | P0.1 | Digital I/O | Port 0.1 |
| 26 | P0.0 | Digital I/O | Port 0.0 |
| 27 | RESET_N | Digital input | Reset, active-low |