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## Objective

This code example demonstrates how to maximize the BLE throughput on PSoC® 6 MCU with Bluetooth Low Energy (BLE) Connectivity device.

## Overview

This example uses the BLE GATT layer notification to achieve maximum throughput between a GATT server and a GATT client. The example has two projects:

1. CE222046\_GATT\_Out (GATT server): Data transfer using GATT Notification on a Characteristic – Outgoing data.
2. CE222046\_GATT\_In (GATT client): Data transfer using GATT Notification on a Characteristic – Incoming data.

The GATT server device initializes a buffer of 495 bytes. Once the connection is established between the GATT client and GATT server, the GATT client device enables the notification on the Server. The Server then keeps sending data continuously. The BLE data throughput is calculated by the Client device and displayed on a UART terminal emulator.

## Requirements

**Tool:** PSoC Creator™ 4.2

**Programming Language:** C (Arm® GCC 5.4.1)

**Associated Parts:** All PSoC 6 MCUs with BLE Connectivity

**Related Hardware:** CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit

## Design

There are two projects for GATT Notifications: CE222046\_GATT\_In and CE222046\_GATT\_Out. The CE222046\_GATT\_In serves the role of GATT client and a GAP Central device. The CE222046\_GATT\_Out project serves as a GATT server and GAP Peripheral.

The GATT client establishes a connection with the GATT server and enables the notification on the Server side. The Server uses the GATT notification on a custom Characteristic to send data to the GATT client device continuously. The GATT client receives the data sent by the Server and calculates the amount of data received in 10 seconds. The calculated throughput is displayed on a UART terminal emulator once is every 10 seconds.

Figure 1 (a) and (b) shows the project schematic for CE222046\_GATT\_In and CE222046\_GATT\_Out projects respectively.

Refer to the [Parameter Settings](#) section for details about the configuration settings of the components used in the two projects.

Figure 1 (a). PSoC Creator Project Schematic: CE222046\_GATT\_In

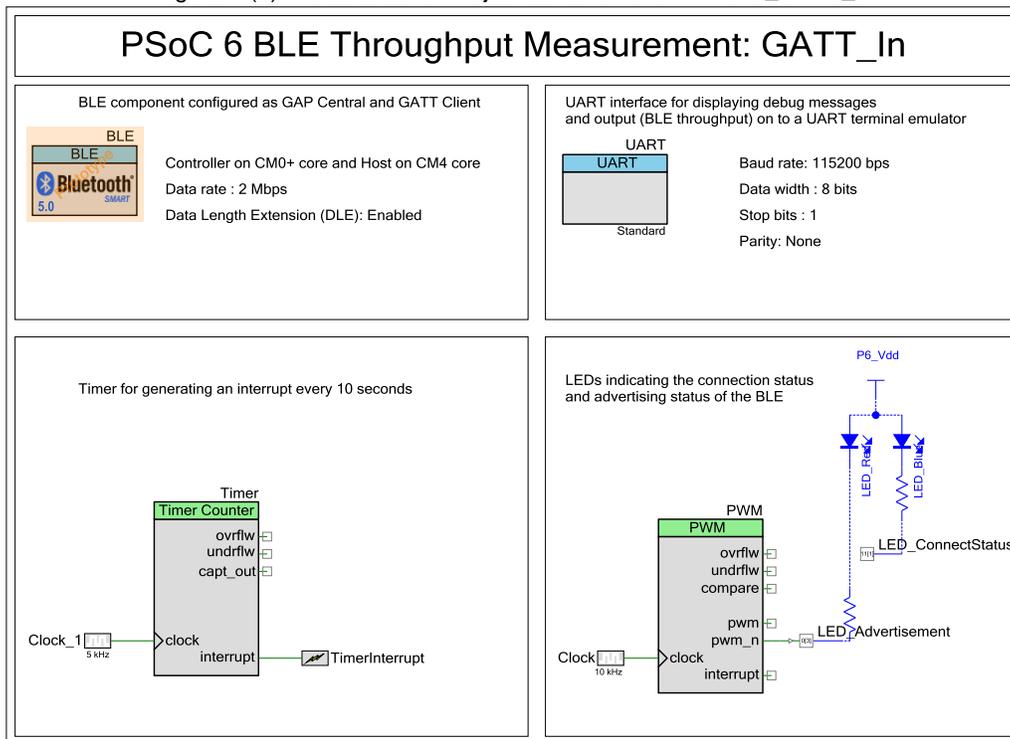
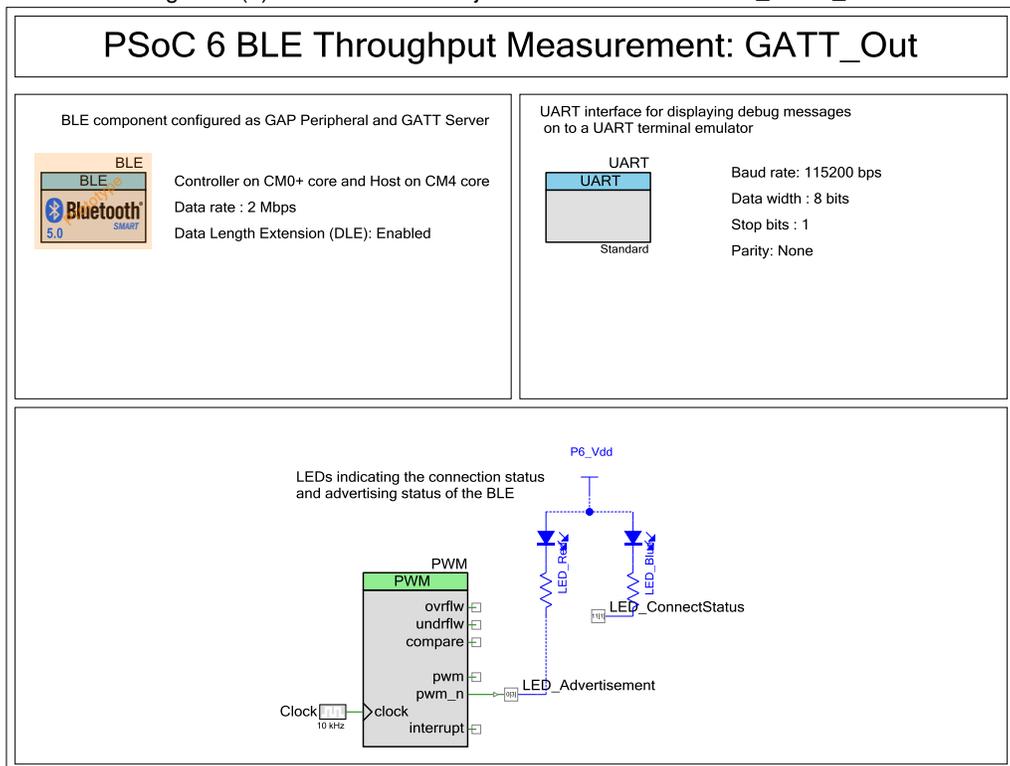


Figure 2 (b). PSoC Creator Project Schematic: CE222046\_GATT\_Out



## Hardware Setup

Use the CY8CKIT-062-BLE PSoC 6 Pioneer Kit to program and test this code example. Two kits are required to test this code example: one each for CE222046\_GATT\_In project and CE222046\_GATT\_Out project. The kit is used in its default configuration. If you have modified the hardware configuration, see the Pioneer Kit guide for the steps to revert to the default configuration.

## Software Setup

This project uses [Tera Term](#) as a UART terminal emulator for displaying the measured BLE Throughput. You can use any other serial terminal emulator as well for this project.

## Operation

1. Connect two Pioneer Boards to your PC using the provided USB cable through the USB connector (J10).
2. Build the projects CE222046\_GATT\_In and CE222046\_GATT\_Out and program them into the PSoC 6 MCU on two different kits. Choose **Debug > Program**. For more information on device programming, see Pioneer Kit guide. Flash for both CPUs is programmed in a single program operation.

**Note:** During the build process, do not replace *stdio\_user.h* and *stdio\_user.c* file if prompted by PSoC Creator.

3. Open two instances of UART terminal emulator. This example uses Tera Term as the UART terminal. Set the baud rate to 115200 bps. Use the default settings for other serial port parameters. Connect the KitProg2's COM port of the two kits to the UART terminals: one for CE222046\_GATT\_In project and other for CE222046\_GATT\_Out project.
4. Press the reset switch (SW1) on the kit with CE222046\_GATT\_In project programmed. The scanning for the Peripheral is indicated by blinking of red LED on the Kit. The status of scanning is also displayed on the UART terminal.
5. Similarly, press the reset switch (SW1) on the kit with CE222046\_GATT\_Out project programmed. The advertisement status by the Peripheral is indicated by blinking of red LED on the Kit. The status of advertisement is also displayed on the UART terminal.
6. The GATT client connects automatically to the GATT server device. Once they are connected, the blue LEDs on both the kits turn ON indicating that the connection has been established successfully.
7. The measured BLE throughput is then displayed on the UART terminal connected to the CE222046\_GATT\_In project. The measured BLE throughput is updated every 10 seconds.

Figure 3 and Figure 4 shows the sample output screenshots.

Figure 3. Output Screenshot of CE222046\_GATT\_Out Project

```

*****CE222046: PSoC 6 MCU BLE Throughput Measurement *****
Role : Server <GATT OUT>
*****
Advertising...
Connected to Device 00:A0:50:A4:21:69
Notification Enabled.
  
```

Figure 4. Output Screenshot of CE222046\_GATT\_In Project

```

*****CE222046: PSoC 6 MCU BLE Throughput Measurement *****
Role : Client <GATT IN>
*****
Scanning for GAP Peripheral with address: 0x00A050AABBFF...
Found target device with address: 0x00A050AABBFF
Scan stopped as device was found. Initiating Connection...
Connected to Device
Throughput is: 1203 kbps.
Throughput is: 1306 kbps.
Throughput is: 1316 kbps.
  
```

The sections that follow discuss the Components, parameter settings, and resources used to make the example.

## Components

Table 1 lists the PSoC Creator Components used in this example (both common and specific for each project), how they are used in the design, and the non-default settings required so they function as intended.

Table 1. PSoC Creator Components

Component	Instance Name	Purpose	Non-default Settings
BLE	BLE	BLE Communication	Refer to the <a href="#">Parameter Settings</a> section for other parameters
UART	UART	Print string messages on a terminal window	<b>Baud Rate (bps):</b> 115200 <b>Tx/Rx Mode:</b> Tx only
Digital Output Pin	LED_ConnectStatus	Drive blue RGB LED	<b>HW connection:</b> Uncheck
Digital Output Pin	LED_Advertisement	Drive red RGB LED	Default setting only
TCPWM	PWM	Generate a signal with 50% duty cycle and with a period of 1 second.	<b>Period 0:</b> 9999 <b>Compare 0:</b> 5000
TCPWM (used in CE222046_GATT_In project)	Timer	Generate an interrupt every 10 seconds	<b>Period:</b> 50000 <b>Interrupt Source:</b> Overflow/Underflow
Interrupt (used in CE222046_GATT_In project)	TimerInterrupt	Set the core and priority for the interrupt	Default setting only

## Parameter Settings

This section discusses the non-default configuration settings used by the BLE component in CE222046\_GATT\_In and CE222046\_GATT\_Out projects.

### BLE Component settings in CE222046\_GATT\_In

CE222046\_GATT\_In is configured as GAP Central device with BLE controller run by the CM0+ core and Host on the CM4 core. It acts a GATT client with a custom service: Throughput Custom Service. It uses an MTU size of 512 bytes in order to maximize the BLE throughput.

In the Link Layer Settings, Data Length Extension (DLE) is enabled by setting TX and RX payload size to 251 bytes. The data rate is set to 2 Mbps. Figure 5 through Figure 8 show the configuration settings used for CE222046\_GATT\_In project.

Figure 5. CE222046\_GATT\_In: General Settings

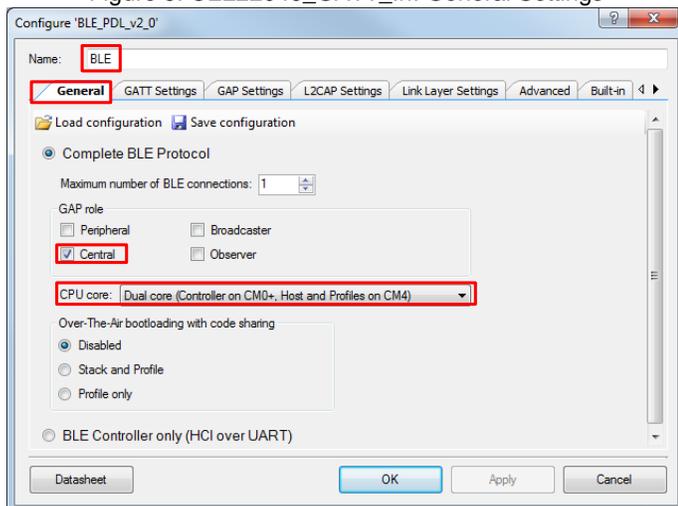


Figure 6. CE222046\_GATT\_In: GATT Settings

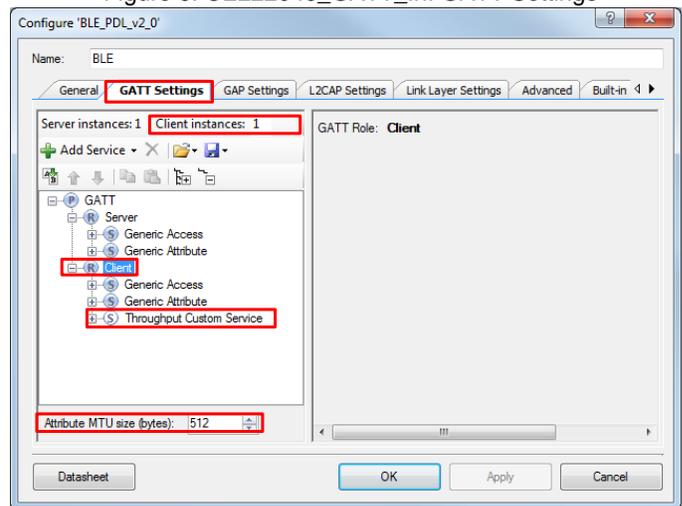


Figure 7. CE222046\_GATT\_In: GAP Settings

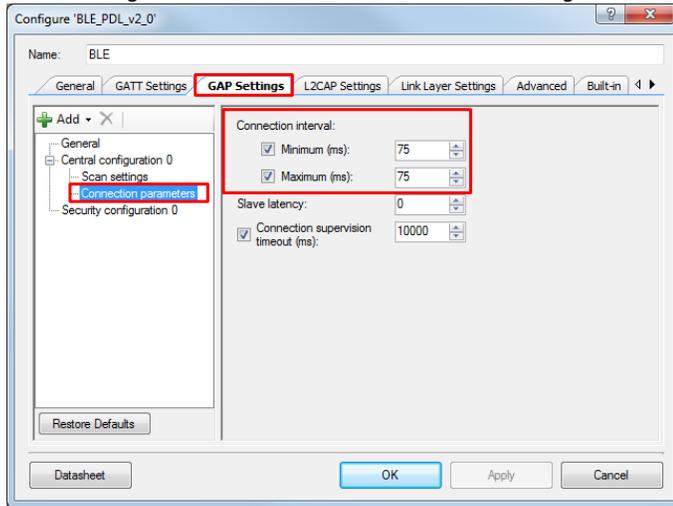
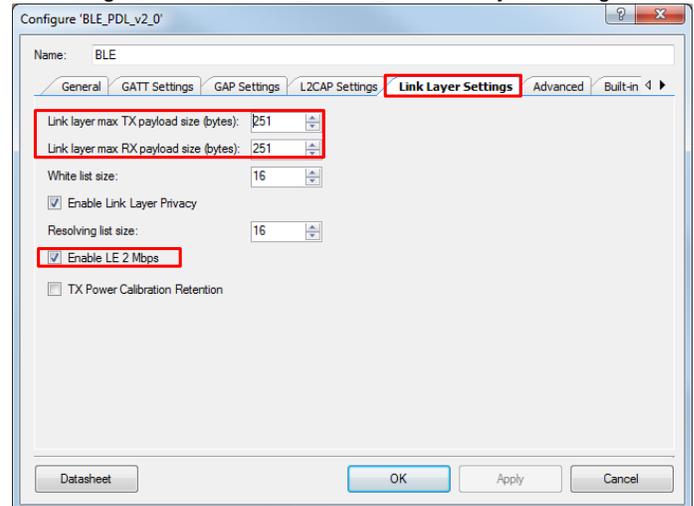


Figure 8. CE222046\_GATT\_In: Link Layer Settings



Under the GAP Settings tab, in the General parameter section enter the Device name as “GATT\_In”.

In the GAP Settings tab, the connection interval is set to 75 ms. This value is used so that BLE bandwidth is used effectively. Each notification packet is of size 495 bytes, which takes a processing time of 2.34 ms (refer to [BLE Component datasheet](#) for details). Therefore, in a connection interval of 75 ms, 32 notification packets ( $75 \text{ ms} / 2.34 \text{ ms}$ ) are sent and only a nominal 0.05 packet is lost.

#### BLE Component settings in CE222046\_GATT\_Out

CE222046\_GATT\_Out is configured as GAP Peripheral device with BLE Controller run by the CM0+ core and Host on the CM4 core. It acts a GATT server with a custom service: BLE Throughput. It uses an MTU size of 512 bytes in order to maximize the BLE throughput.

In the Link Layer Settings, Data Length Extension (DLE) is enabled by setting TX and RX payload size to 251 bytes. The data rate is set to 2 Mbps. [Figure 9](#) through [Figure 14](#) show the configuration settings used for CE222046\_GATT\_Out project.

Figure 9. CE222046\_GATT\_Out: General Settings

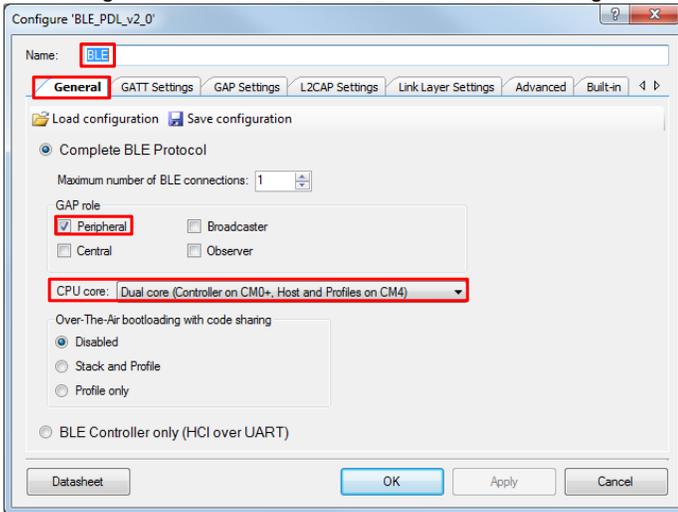


Figure 10. CE222046\_GATT\_Out: GATT Settings

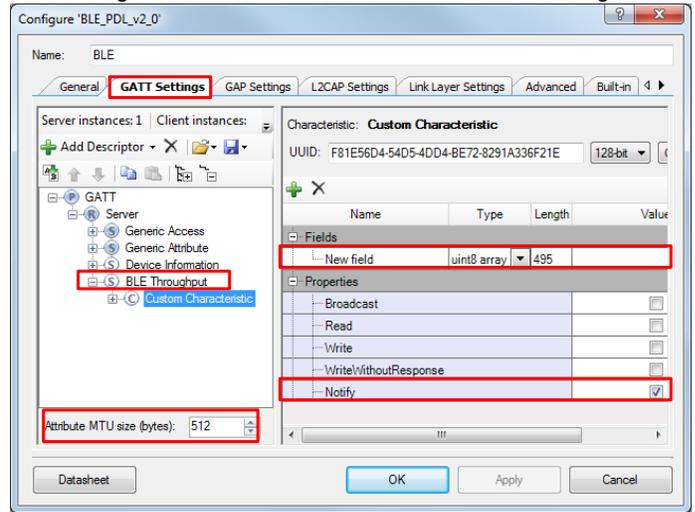


Figure 11. CE222046\_GATT\_Out: GAP Settings

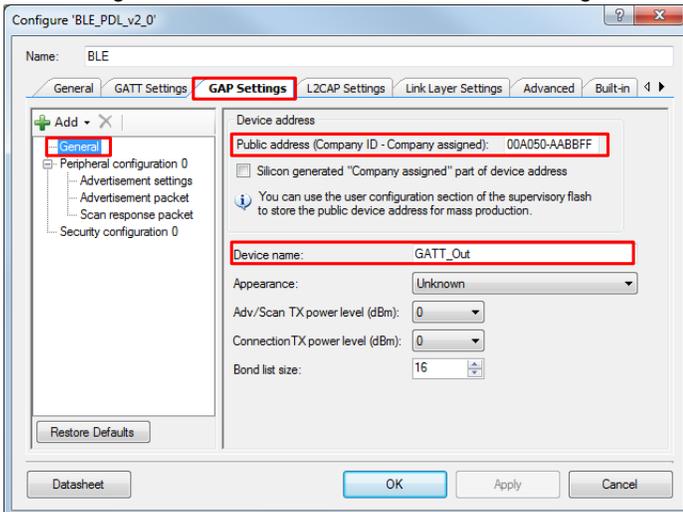


Figure 12. CE222046\_GATT\_Out: Link Layer Settings

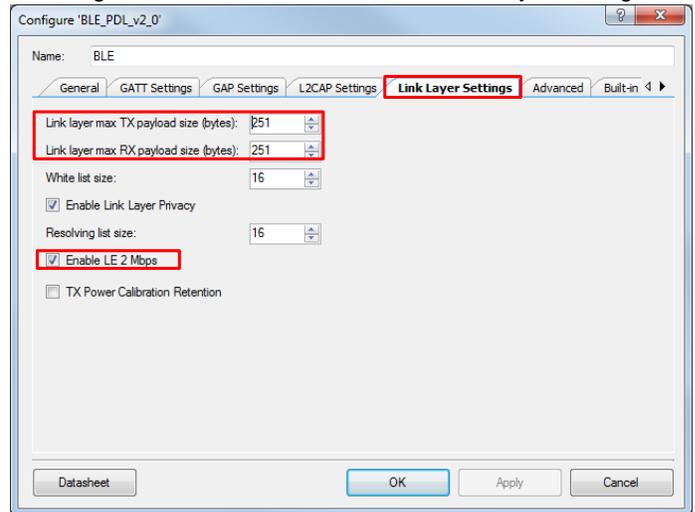


Figure 13. CE222046\_GATT\_Out: GAP Advertisement settings

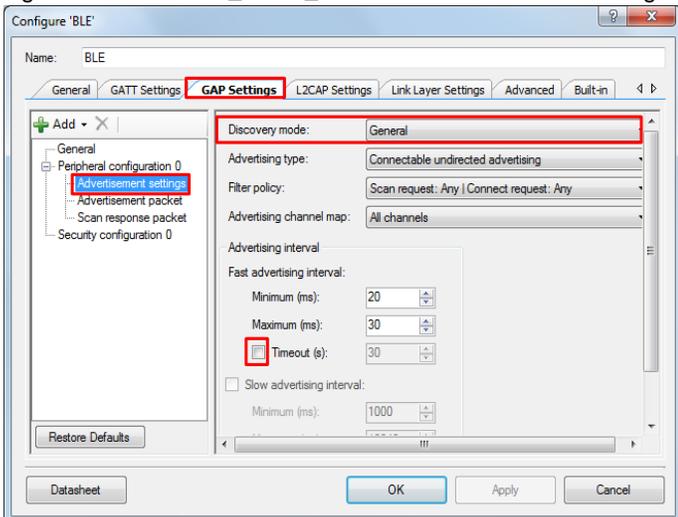
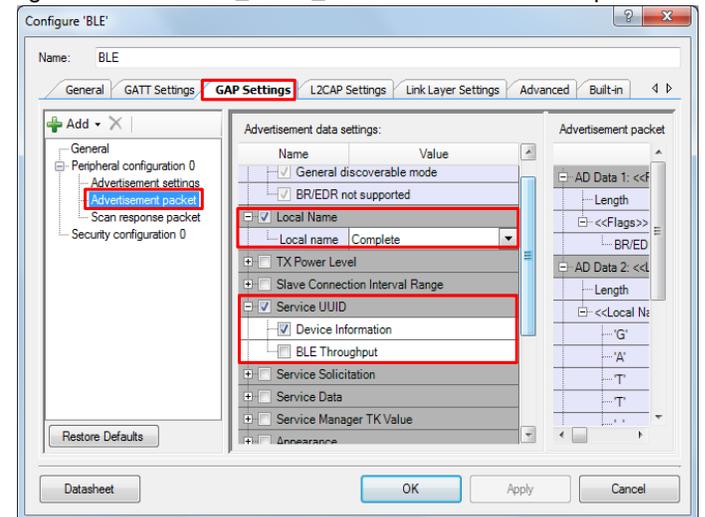


Figure 14. CE222046\_GATT\_Out: GAP Advertisement packet



The CE222046\_GATT\_Out device advertises with a public address of 00A050-AABBFF. The CE222046\_GATT\_In device scans for a GAP Peripheral (CE222046\_GATT\_Out) with this address and connects to it automatically.

### Design-Wide Resources

The projects in this example uses the KitProg2 USB-UART bridge to communicate with UART terminal emulator running on your PC. PSoC 6 Pioneer Kit uses the pin **P5[1]** as UART TX. Figure 15 shows the pins used in both CE222046\_GATT\_In and CE222046\_GATT\_Out projects.

Figure 15. Device Pin Assignments

	Name	Port	Pin	Lock
<input checked="" type="checkbox"/>	\UART:tx\	P5[1]	K6	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	LED_Advertisement	P0[3]	E3	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	LED_ConnectStatus	P11[1]	E5	<input checked="" type="checkbox"/>

Figure 16 and Figure 17 show the system interrupt configuration used in this example.

Figure 16. Interrupt Configuration for CE222046\_GATT\_In Project

Instance Name	Interrupt Number	ARM CM0+ Enable	ARM CM0+ Priority (1 - 3)	ARM CM0+ Vector (3 - 29)	ARM CM4 Enable	ARM CM4 Priority (0 - 7)
BLE_bless_isr	24	<input checked="" type="checkbox"/>	3	3	<input checked="" type="checkbox"/>	7
TimerInterrupt	90	<input type="checkbox"/>	--	--	<input checked="" type="checkbox"/>	7
UART_SCB_IRQ	46	<input checked="" type="checkbox"/>	3	8	<input checked="" type="checkbox"/>	7

Figure 17. Interrupt Configuration for CE222046\_GATT\_Out Project

Instance Name	Interrupt Number	ARM CM0+ Enable	ARM CM0+ Priority (1 - 3)	ARM CM0+ Vector (3 - 29)	ARM CM4 Enable	ARM CM4 Priority (0 - 7)
BLE_bless_isr	24	<input checked="" type="checkbox"/>	3	3	<input checked="" type="checkbox"/>	7
UART_SCB_IRQ	46	<input checked="" type="checkbox"/>	3	8	<input checked="" type="checkbox"/>	7

## Related Documents

<b>Application Notes</b>	
<a href="#">AN210781 – Getting Started with PSoC 6 MCU with Bluetooth Low Energy (BLE) Connectivity</a>	Describes the PSoC 6 MCU with BLE Connectivity device family.
<b>PSoC Creator Component Datasheets</b>	
<a href="#">Bluetooth Low Energy</a>	Facilitates designing applications requiring BLE connectivity
<a href="#">UART</a>	Provides asynchronous serial communications
<a href="#">Pins</a>	Supports connection of hardware resources to physical pins
<a href="#">Interrupt</a>	Provides an interface to connect hardware signals to a CPU interrupt request line.
<b>Device Documentation</b>	
<a href="#">PSoC 6 MCU: PSoC 63 with BLE Datasheet</a>	<a href="#">PSoC 6 MCU: PSoC 63 with BLE Architecture Technical Reference Manual</a>
<b>Development Kit (DVK) Documentation</b>	
<a href="#">CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit</a>	

## Document History

Document Title: CE222046 - PSoC 6 BLE Throughput Measurement

Document Number: 002-22046

Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	6005530	VKVK	12/26/2017	New code example
*A	6074748	VKVK	03/15/2018	Updated the project with PSoC Creator 4.2 Updated template

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