

## Objective

This example demonstrates the implementation of multi-slave functionality of the PSoC® 6 MCU with BLE Connectivity (PSoC 6 BLE) device.

## Overview

This code example implements Bluetooth Low Energy (BLE) multi-slave functionality that consists of the following:

- Device Information Service
- Health Thermometer Service
- Custom service for RGB LED with color and intensity control
- 128-bit long characteristic read write custom service and
- A custom notification service

This code example also shows the connectivity between the PSoC 6 BLE, acting as a Peripheral and GATT Server, and four BLE enabled devices (a personal computer running the CySmart BLE Host Emulation tool or mobile device running the CySmart mobile application) acting as a Central and GATT Client.

This code example assumes that you are familiar with the PSoC 6 MCU with BLE Connectivity device and the PSoC Creator™ IDE. If you are new to PSoC 6 BLE, see the application note [AN210781 – Getting Started with PSoC 6 MCU with Bluetooth Low Energy \(BLE\) Connectivity](#).

## Requirements

**Tool:** PSoC Creator™ 4.2; Peripheral Driver Library (PDL) 3.0.1

**Programming Language:** C (Arm® GCC 5.4.2016-q2-update)

**Associated Parts:** All PSoC 6 MCU BLE devices with dual core parts

**Related Hardware:** [CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit](#)

## Hardware Setup

This example uses the kit's default configuration. Refer to the [kit guide](#) to ensure the kit is configured correctly.

## Software Setup

This code example requires CySmart application. Download and install either the [CySmart Host Emulation Tool](#) PC application or the CySmart app for [iOS](#) or [Android](#). You can test behavior with any of the two options, but the CySmart app is simpler. Scan one of the following QR codes from your mobile phone to download the CySmart app.

iOS



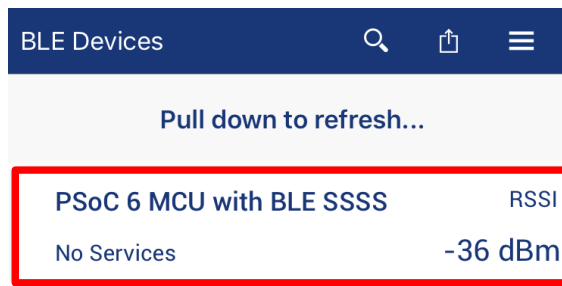
Android



## Operation

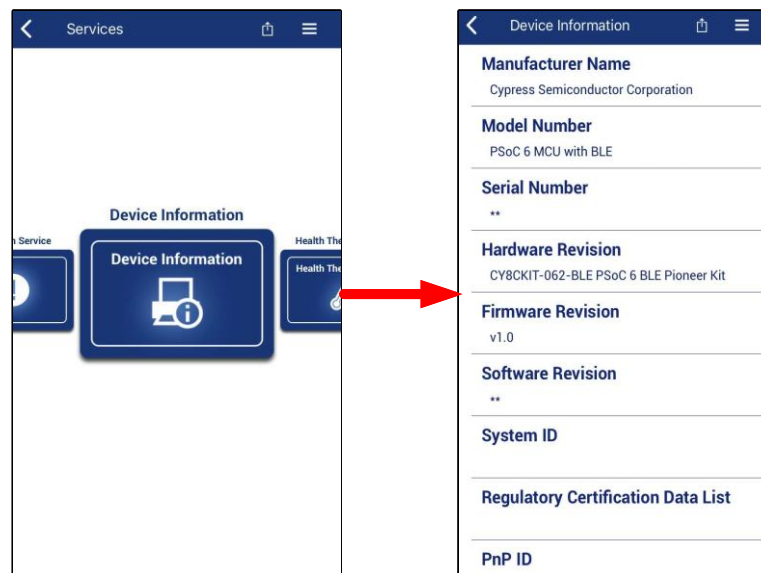
1. Plug the CY8CKIT-062-BLE kit board into your computer's USB port.
2. Build the project and program it into the PSoC 6 MCU device. Choose **Debug** > **Program**. For more information on device programming, see PSoC Creator Help. Flash for both CPUs is programmed in a single program operation.
3. Do the following to test using the CySmart mobile app:
  - a. Press the reset switch on CY8CKIT-062-BLE to start BLE advertisement. The advertisement LED (LED8) will start blinking to indicate that BLE advertisement has started.
  - b. Turn ON Bluetooth on your Android or iOS device. Launch the CySmart app.
  - c. Pull down the CySmart app home screen to start scanning for BLE Peripherals; your device appears in the CySmart app home screen as shown in [Figure 1](#). Select your device to establish a BLE connection.

Figure 1. Device Selection



- d. To connect another device (mobile or PC), repeat steps b and c. Up to four Central devices can be connected to PSoC 6 BLE device.
- e. On one or more of the connected devices, select the 'Device Information' profile to get information about manufacturer and/or vendor of device, as [Figure 2](#) shows.

Figure 2. Locating Device Information Using CySmart Mobile Application



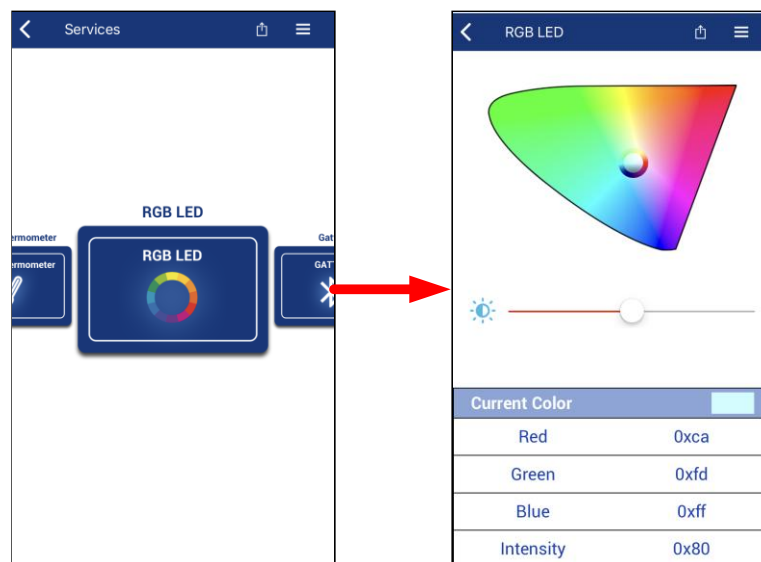
- f. Select the 'Health Thermometer' profile to get the temperature information as shown in [Figure 3](#).

Figure 3. Locating and Using Health Thermometer Service Using CySmart Application



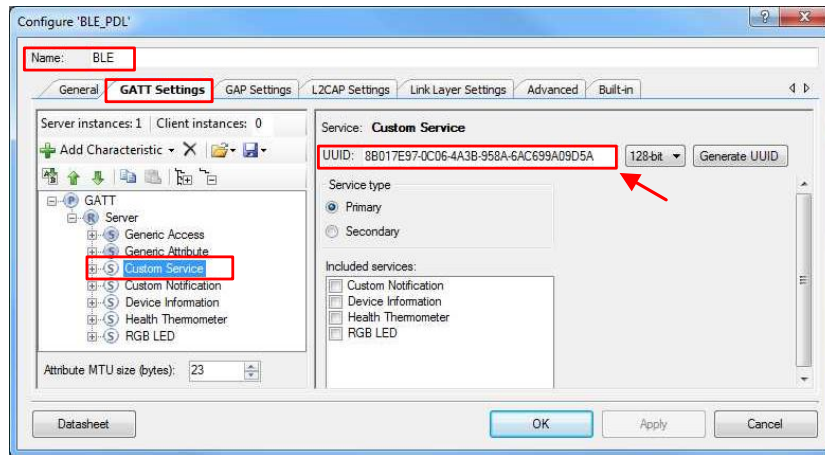
- g. Select the 'RGB LED' profile to change the color of the RGB LED (LED5) present in the kit as shown in Figure 4.

Figure 4. Locating and Using RGB LED Service Using CySmart Application



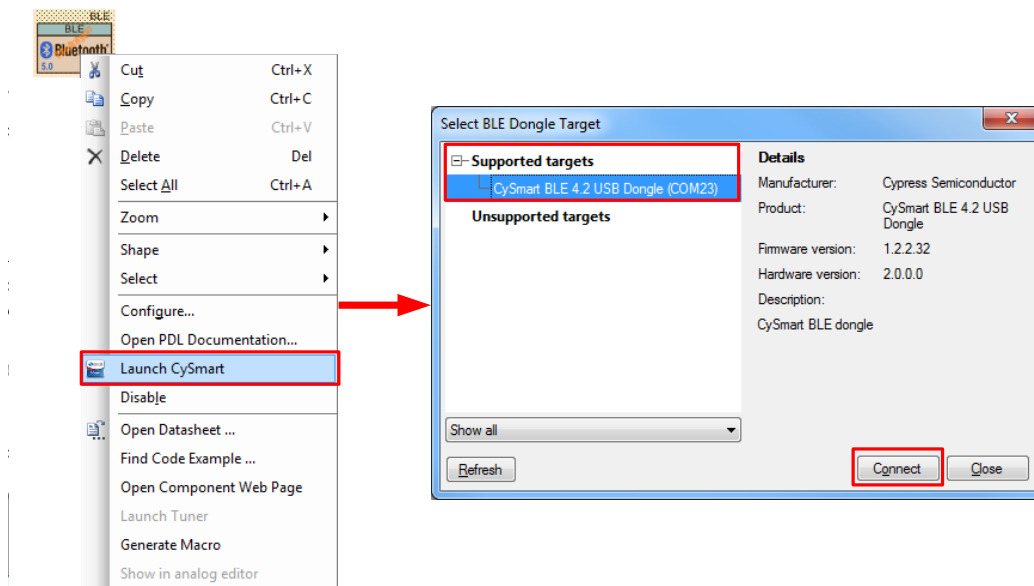
- h. Custom Service and Custom Notification Service can be accessed through the 'GattDB' profile. The service can be identified using its Universally Unique Identifier (UUID).
- i. Locate the Custom Service characteristic (UUID 8B017E97-0C06-4A3B-958A-6AC699A09D5A). Using this service, a GAP Central device can read or write 128-bit data. You can get the UUID as Figure 5 shows.

Figure 5. Locating UUID



- j. Locate the Custom Notification Service characteristic (UUID 4A8AA88D-C98C-411C-852E-DB06351DAF56). This service is used to notify the GAP central device that last modified any of the characteristics. The data payload contains two bytes of information.  
 XXXY → XX device id. (0 → Default, 1 to 4)  
       → YY characteristics (0 → Default, 1 → Custom Service, 2 → RGB LED)
4. Do the following to test using the CySmart Host Emulation Tool:
  - a. Connect the BLE Dongle to your Windows PC. Wait for the driver installation to complete, if not done already.
  - b. Launch the CySmart Host Emulation Tool by right-clicking on the BLE Component and selecting **Launch CySmart**. Alternatively, you can launch the tool by navigating to **Start > Programs > Cypress** and clicking on **CySmart**.  
 CySmart automatically detects BLE Dongles connected to the PC. Click **Refresh** if the BLE Dongle does not appear in the **Select BLE Dongle Target** pop-up window. Click **Connect**, as shown in Figure 6.

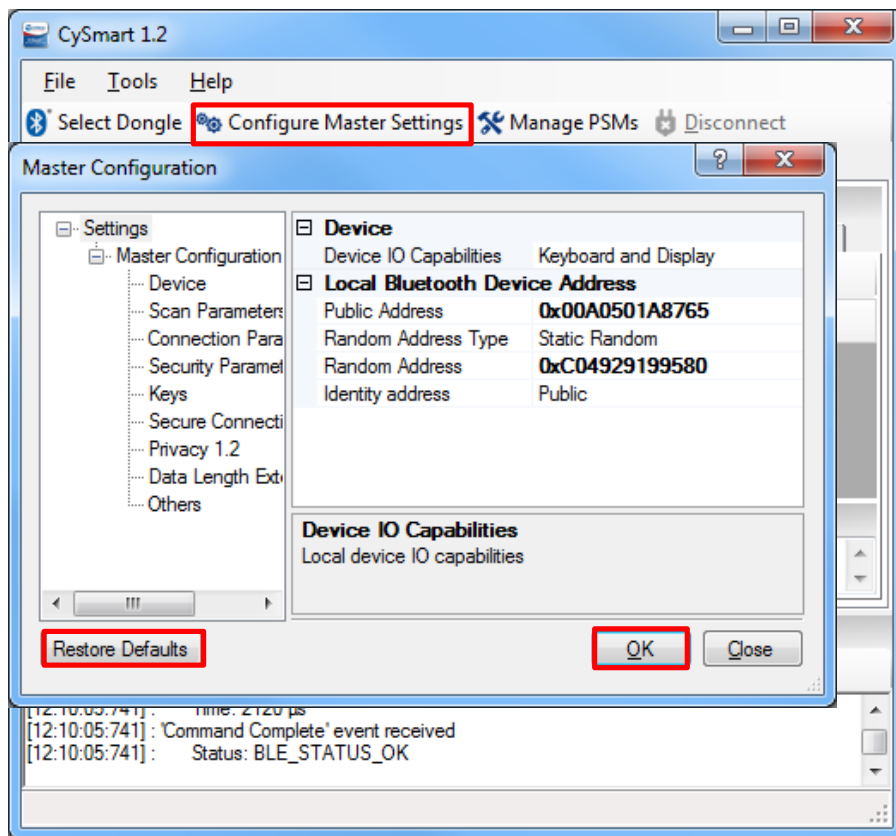
Figure 6. CySmart BLE Dongle Selection



**Note:** If the dongle firmware is outdated, you will be alerted with an appropriate message. You must upgrade the firmware before you can complete this step. Follow the instructions in the window to update the dongle firmware.

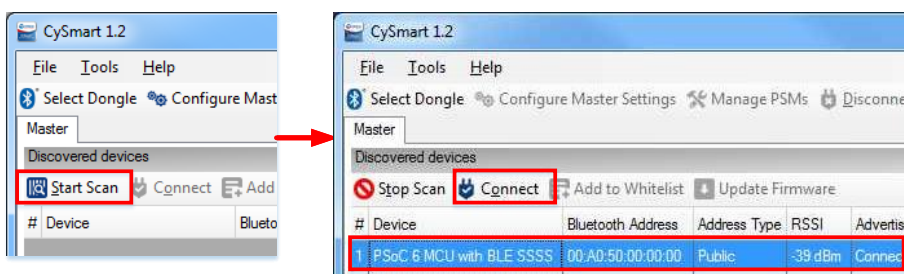
- c. Select **Configure Master Settings** and then click **Restore Defaults**, as Figure 7 shows. Then click **OK**.

Figure 7. CySmart Master Settings Configuration



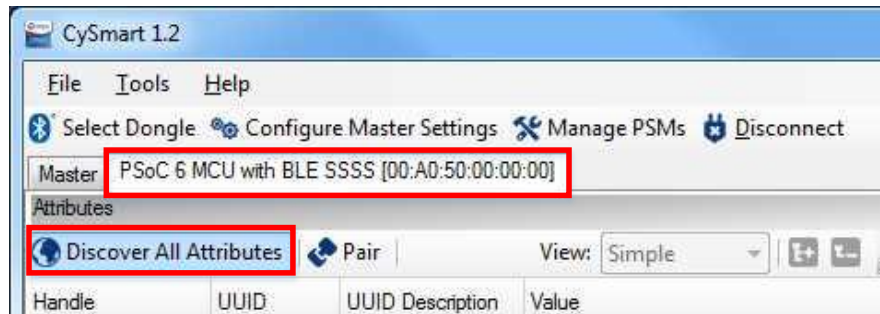
- d. Press the reset switch on the Pioneer Kit to start BLE advertisement if no device is connected or device is in Hibernate mode (red LED (LED9) is ON). Otherwise, skip this step.
- e. On the CySmart Host Emulation Tool, click **Start Scan**. Your device name (configured as 'PSoC 6 MCU with BLE SSSS') should appear in the Discovered devices list, as Figure 8 shows. Select the device and click **Connect** to establish a BLE connection between the CySmart Host Emulation Tool and your device.

Figure 8. CySmart Device Discovery and Connection



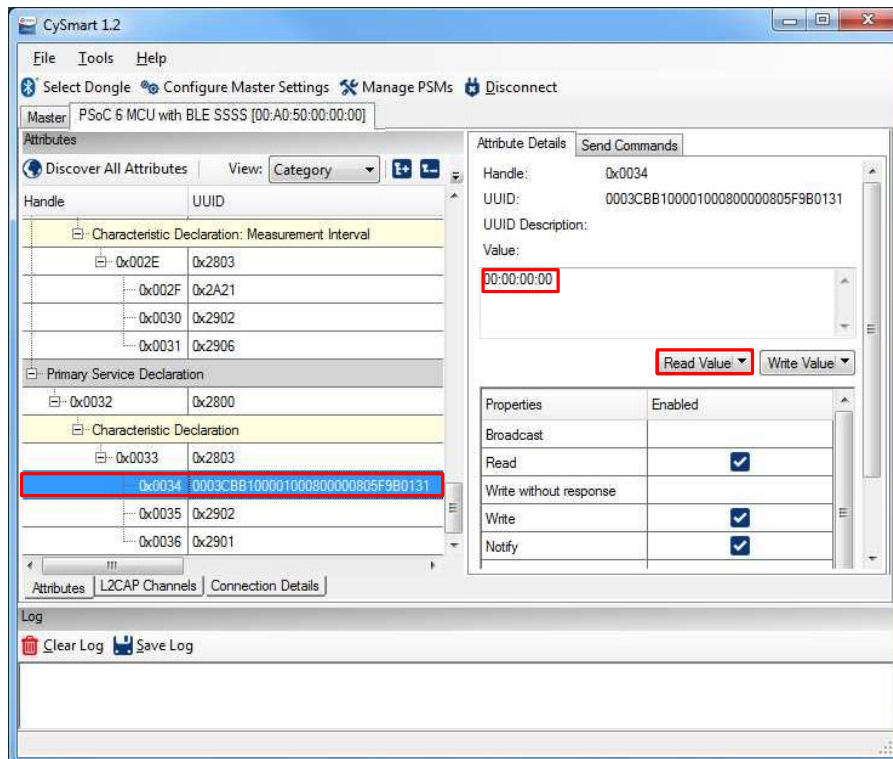
- f. Once connected, switch to the '**PSoC 6 MCU with BLE SSSS**' device tab and '**Discover all Attributes**' on your design from the CySmart Host Emulation Tool, as shown in Figure 9.

Figure 9. CySmart Attribute Discovery



- g. Locate the RGB LED Control Characteristic (UUID 0x0003CBB1-0000-1000-8000-00805F9B0131). Click **Read Value** to read the existing 4-byte onboard RGB LED color information, as shown in Figure 10. The four bytes indicate red, green, blue, and the overall intensity, respectively. Modify the four bytes of data in the Value field to FF:00:00:FF and click **Write Value**. You will see the corresponding change in the color (Red) and intensity (full intensity) of the RGB LED on the Pioneer Board.

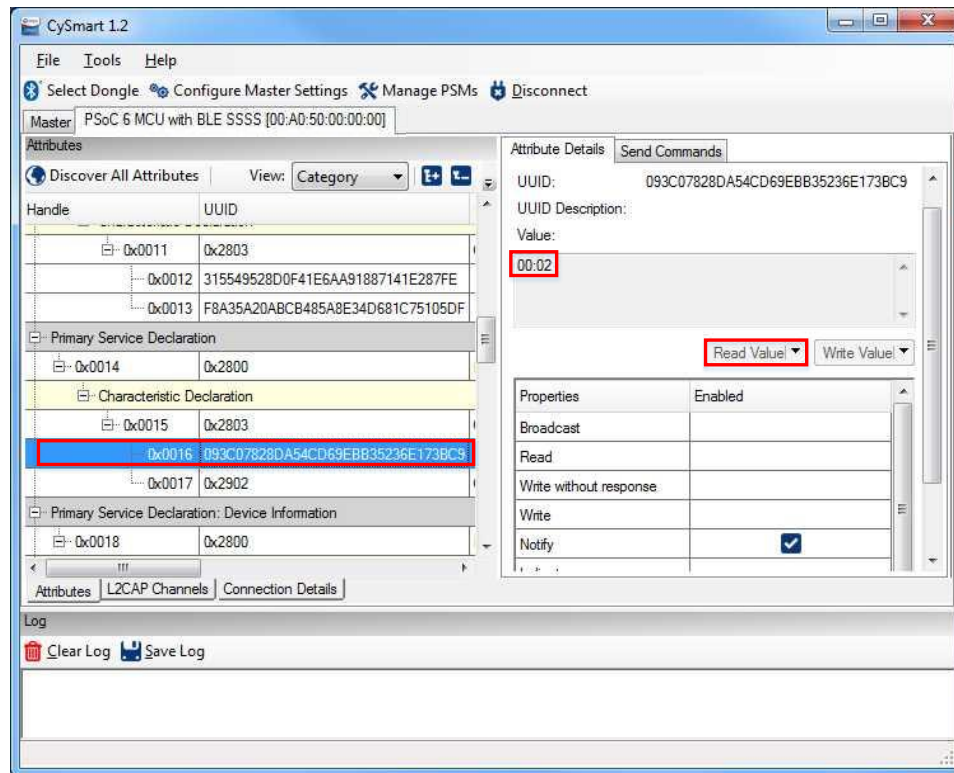
Figure 10. Locating RGB LED Characteristics



- h. Locate the Custom Service control Characteristic (UUID: 8B017E97-0C06-4A3B-958A-6AC699A09D5A). Click **Read Value** to read 128-bit data from the GATT database. Click **Write Value** to write new data into the GATT database.
- i. Locate the Custom Notification characteristic (UUID: 4A8AA88D-C98C-411C-852E-DB06351DAF56) as shown in Figure 11. This service notifies whenever any connected device modifies any data in GATT database. See step 3-j above for information about payload.

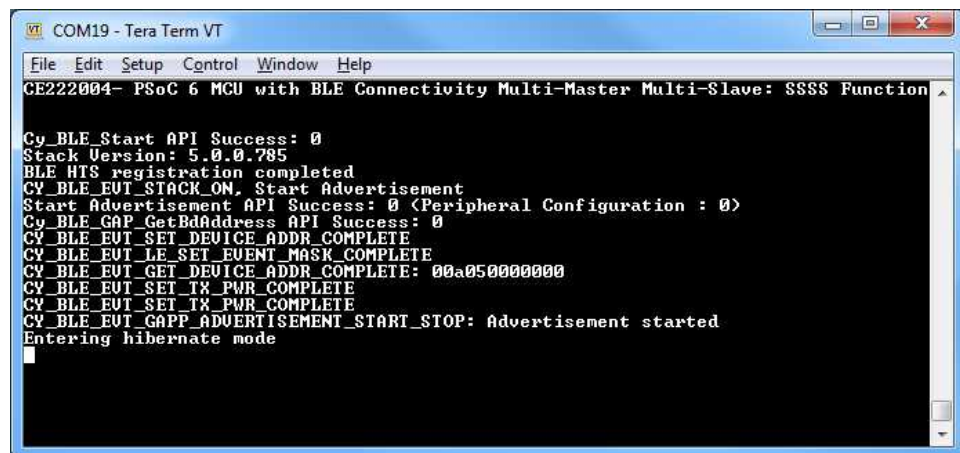


Figure 11. Locating Custom Notification characteristics



- j. If the device is in Hibernate mode, press switch SW2 to restart advertisement.
5. Use the UART debug port to view verbose messages:
    - a. The code example ships with the UART debug port disabled. To enable it, set the macro `DEBUG_UART_ENABLED` in `debug.h` to `ENABLED` and rebuild the code.
    - b. Use a serial terminal application and connect to the **KitProg2 USB-UART** COM port. Configure the application to access the COM port at 115200 bps baud rate.
    - c. Program the board. The debug messages will appear in the terminal window as shown in Figure 12.

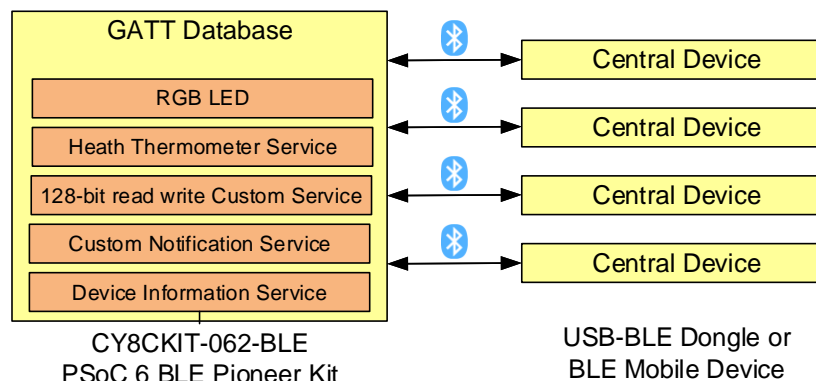
Figure 12. Debug Messages on COM Port



## Design and Implementation

The PSoC 6 MCU device is a BLE GATT Server. It can connect to as many as four GAP Central devices, as shown in [Figure 13](#). All of the connected GAP Central devices can access the GATT database.

Figure 13. Service Relationship



This code example features the following:

- BLE connectivity:
  - Advertisement and connection with four Central devices
  - Five services (RGB LED, Health Thermometer Service, Device Information, read write 128-bit long Custom Service and Custom Notification Service)
  - Data transfer over BLE using notifications, read, and write
- RGB LED color and intensity control using configurable digital blocks of PSoC 6 MCU.
- ADC scans two differential channels and averages multiple samples without the need for CPU intervention for accurate temperature measurement from a thermistor circuit.
- Device information service gives manufacturer and/or vendor information about the device.
- Custom service is used to transfer 128-bit data.
- Custom notification is used to send notification to all the connected devices about any changes. It sends two-byte data, first is to notify which device modified the data and second byte is to notify, what characteristic data has been modified.
- Low-power operation using the Deep Sleep mode with MCWDT and GPIO interrupts.
- The kit Orange (LED8) and Red (LED9) LEDs are used to show the status:
  - If device is in Hibernate mode RED LED will be ON.
  - Orange LED will blink if BLE is advertising.

[Figure 14](#), [Figure 15](#), and [Figure 16](#) show the TopDesign schematic of this code example.



Figure 14. TopDesign Schematic: BLE, UART, MCWDT and GPIO

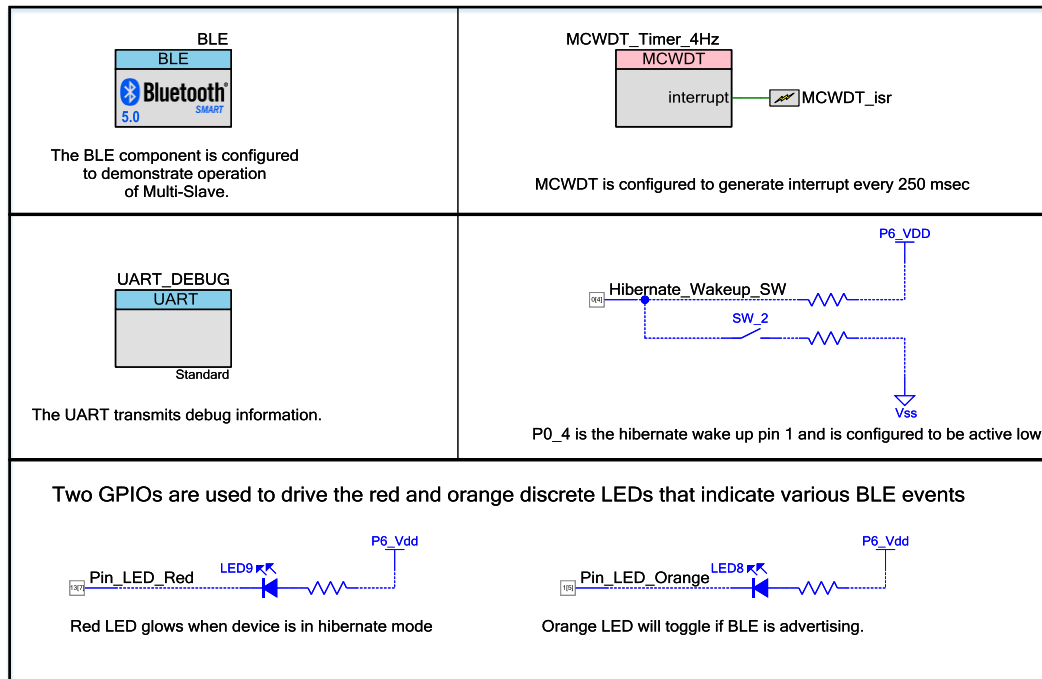


Figure 15. TopDesign Schematic: ADC and GPIO for Thermometer

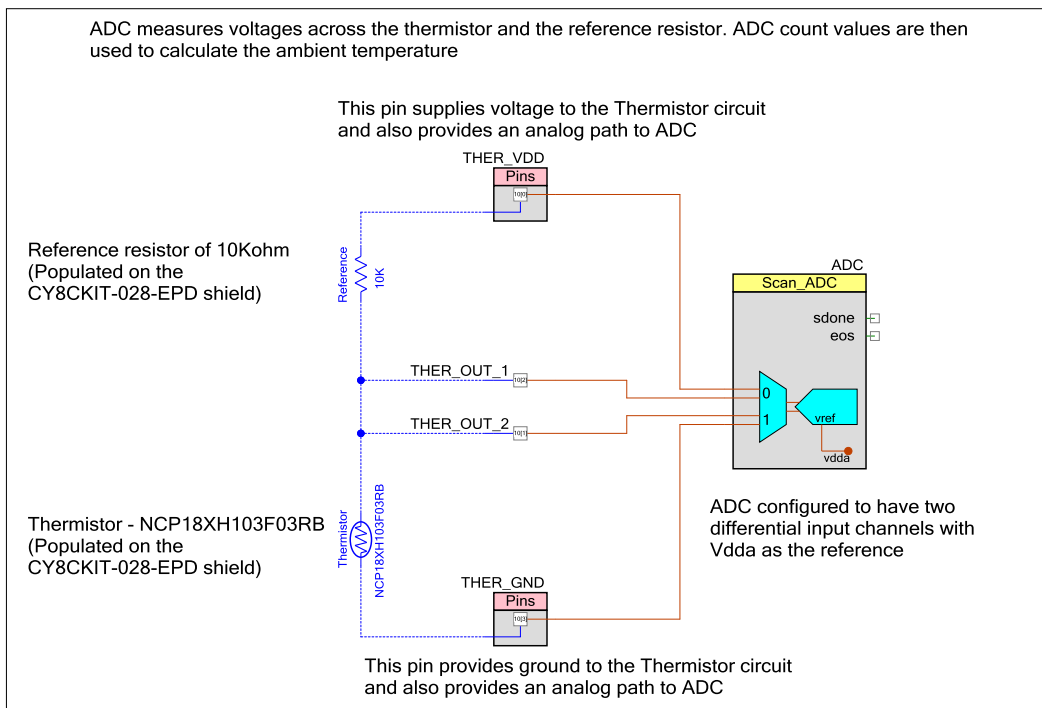
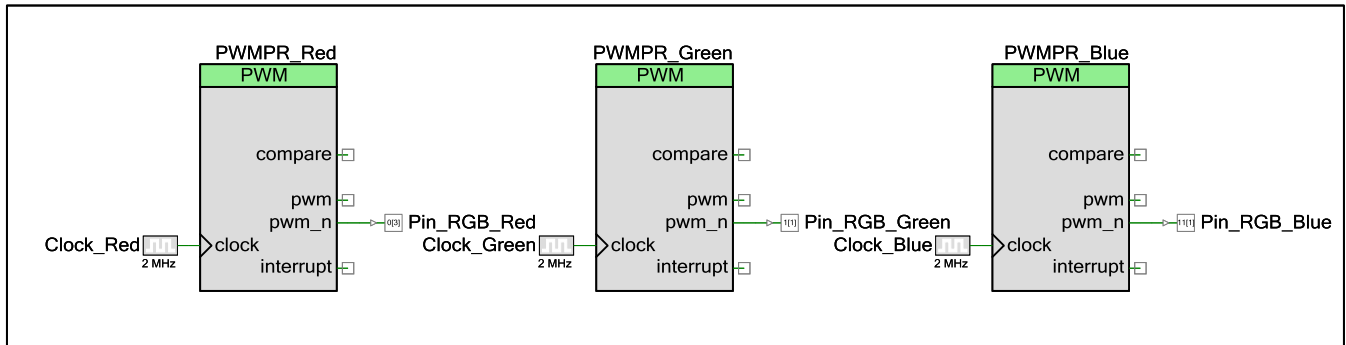


Figure 16. TopDesign Schematic: PWMs and GPIOs

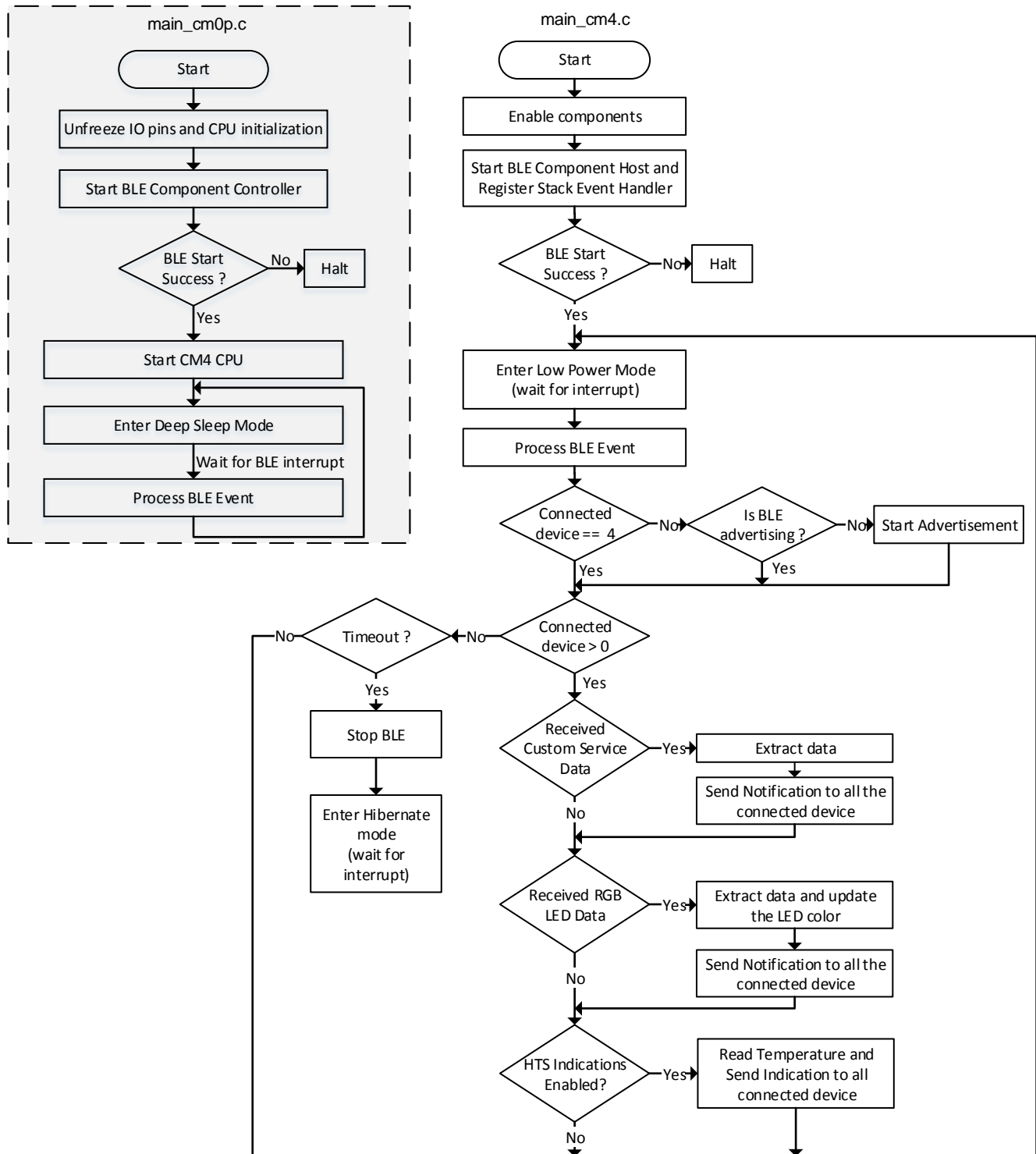


The code example consists of the following files:

- *main\_cm0p.c* contains functions that start the BLE controller, enable the CM4 core, services, and BLE stack events
- *main\_cm4.c* contains the main function for CM4 core, which is the entry point and execution of the application. The main function calls the initialization functions that configure the hardware and continuously processes BLE events and temperature calculation.
- *temperature.c/h* contains functions that are used to measure temperature.
- *led.c/h* contains functions that control the status LEDs.
- *ble\_application.c/h* contains functions related to BLE communication and operation. They include the definition of the event callback functions that are registered with the BLE Component at startup. The stack event callback function is used to process BLE-related events from the BLE stack sent to the application layer for processing. These files contain functions to send RGB LED notifications to the GATT Client device, and to process the read and write commands on the RGB LED characteristic by the GATT Client device. In addition, a Health Thermometer Service (HTS)-specific callback function handles HTS-specific events.
- *rgb\_led\_service.c/h* contains functions related to the RGB LED service.
- *health\_thermometer\_service.c/h* contains functions related to HTS.
- *custom\_notification.c/h* contains functions related to Custom Notification service.
- *custom\_service.c/h* contains functions related to Custom service.
- *debug.c/h* contains functions for the debug and UART functionality.

Figure 17 shows the firmware flow of this code example.

Figure 17. Firmware Flowchart



## Components and Settings

Table 1 lists the PSoC Creator Components used in this example, 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
Bluetooth Low Energy (BLE)	BLE	The BLE Component is configured to act as four Peripherals and GATT Servers.	Refer to <a href="#">Parameter Setting</a> section
Digital Input Pin	Hibernate_Wakeup_SW	This pin is used to generate interrupts when the user button ( <b>SW2</b> ) is pressed.	<b>[General tab]</b> Uncheck HW connection Drive mode: Resistive Pull Up
Analog Pin	THER_OUT_1, THER_OUT_2	These GPIOs connect the thermistor circuit output to the ADC input.	Default
Analog and Digital Output Pin	THER_VDD	These GPIOs provide power to the thermistor circuit and provides an analog path to the ADC.	<b>[General tab]</b> Check Analog Check Digital Output Uncheck HW connection Initial drive state: High
Analog and Digital Output Pin	THER_GND	These GPIOs provide ground to the thermistor circuit and provides an analog path to the ADC.	<b>[General tab]</b> Check Analog Check Digital Output Uncheck HW connection Initial drive state: Low
Digital Output pin	Pin_LED_Red Pin_LED_Orange	These GPIOs are configured as firmware-controlled digital output pins that control LEDs.	<b>[General tab]</b> Uncheck HW connection Drive mode: Strong Drive
	Pin_RGB_Red Pin_RGB_Blue Pin_RGB_Green		
TCPWM	PWMPR_Red PWMPR_Blue PWMPR_Green	These PWMs are used to control the brightness of the LEDs..	<b>[General tab]</b> PWM Mode: PWM Pseudo Random
Scanning SAR ADC	ADC	The ADC measures the voltages across a thermistor and a series reference resistor using two differential channels.	Refer to <a href="#">Parameter Setting</a> section
MCWDT	MCWDT_Timer_4Hz	The MCWDT Counter0 is configured to generate periodic interrupts at 0.5-second intervals	Refer to <a href="#">Parameter Setting</a> section
SysInt	MCWDT_isr	This Component is configured to extract interrupts from MCWDT.	Default
UART (SCB)	UART_DEBUG	This Component is used to print messages on a terminal program.	Default

For information on the hardware resources used by a Component, see the Component datasheet.

## Parameter Settings

For more information on Component configuration options, see the respective Component datasheets. [Figure 18](#) through [Figure 23](#) show the modified settings for the BLE Component.

Figure 18. BLE: Protocol Configuration

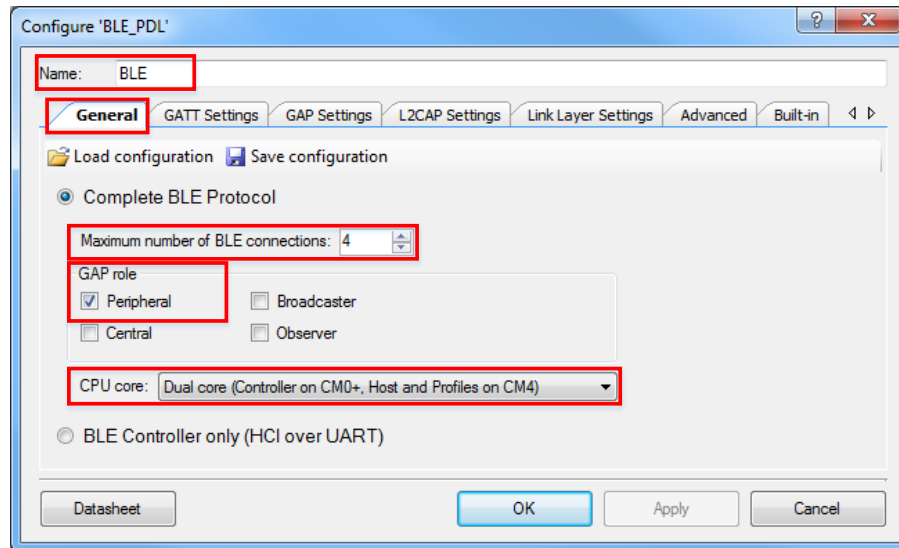


Figure 19. BLE: Adding Profiles

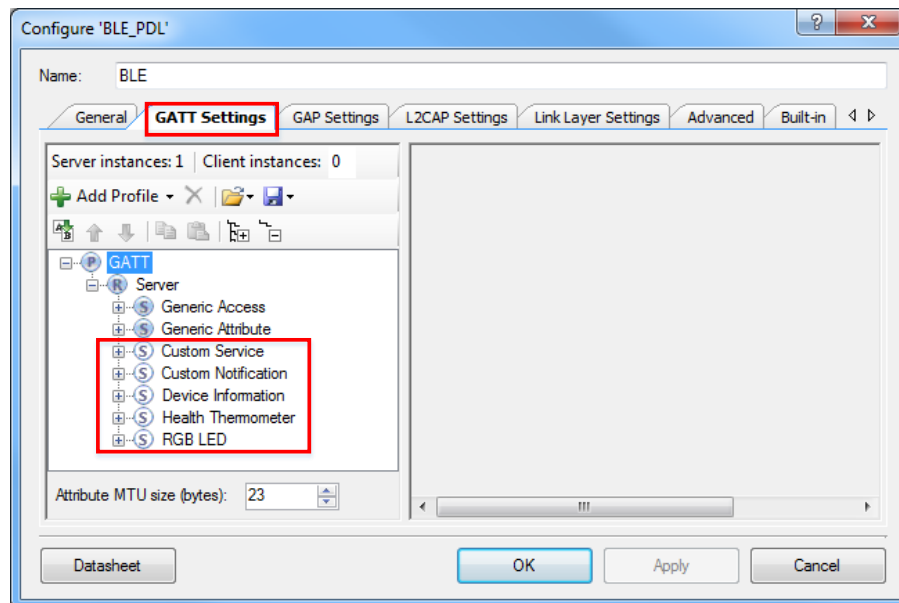


Figure 20. BLE: Device Configuration

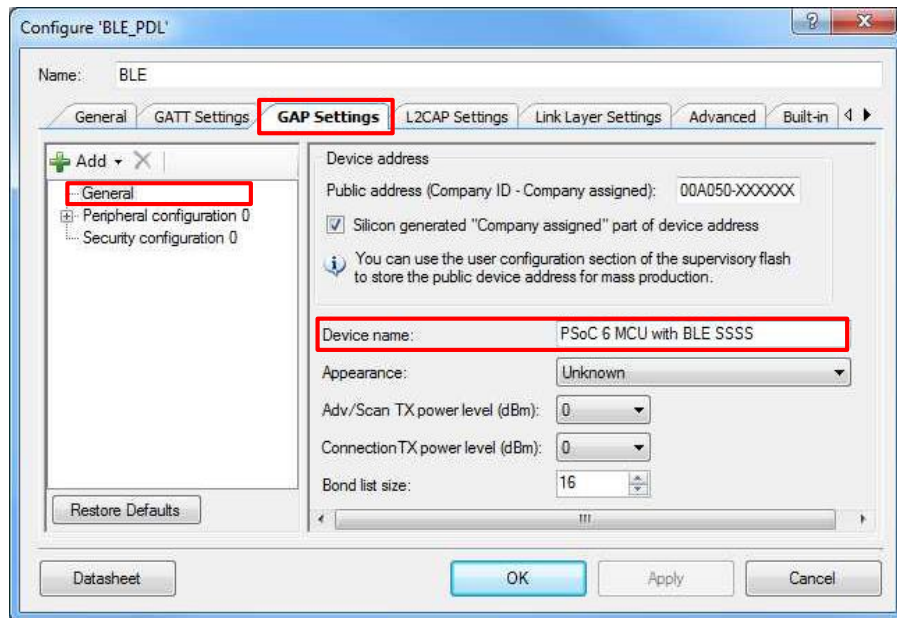


Figure 21. BLE: Advertisement Settings

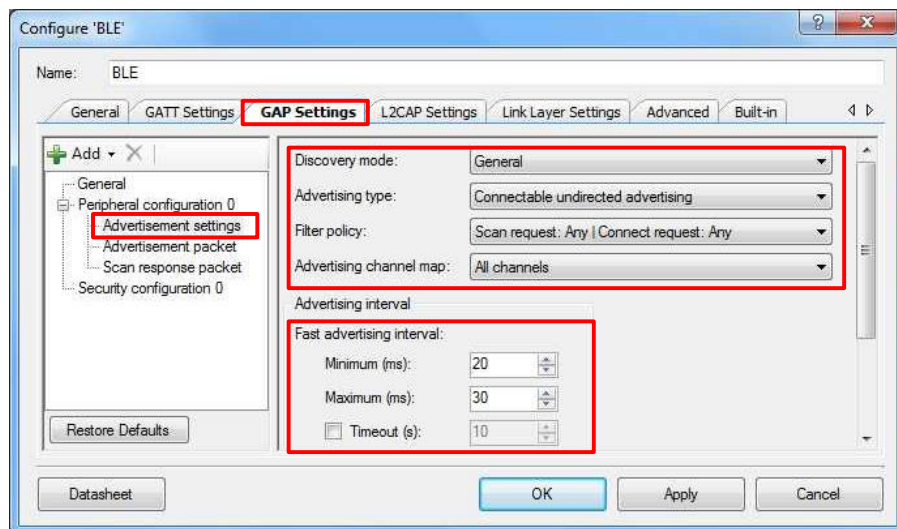


Figure 22. BLE: Advertisement Packet Settings

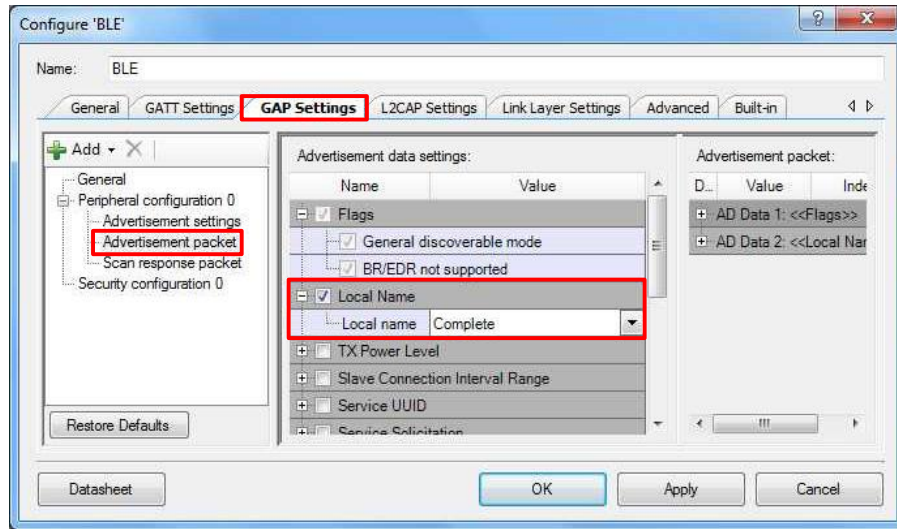
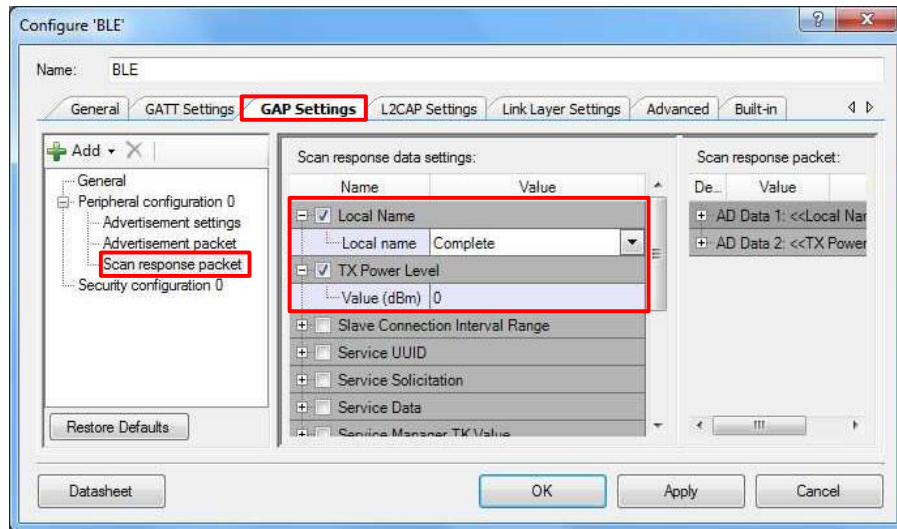


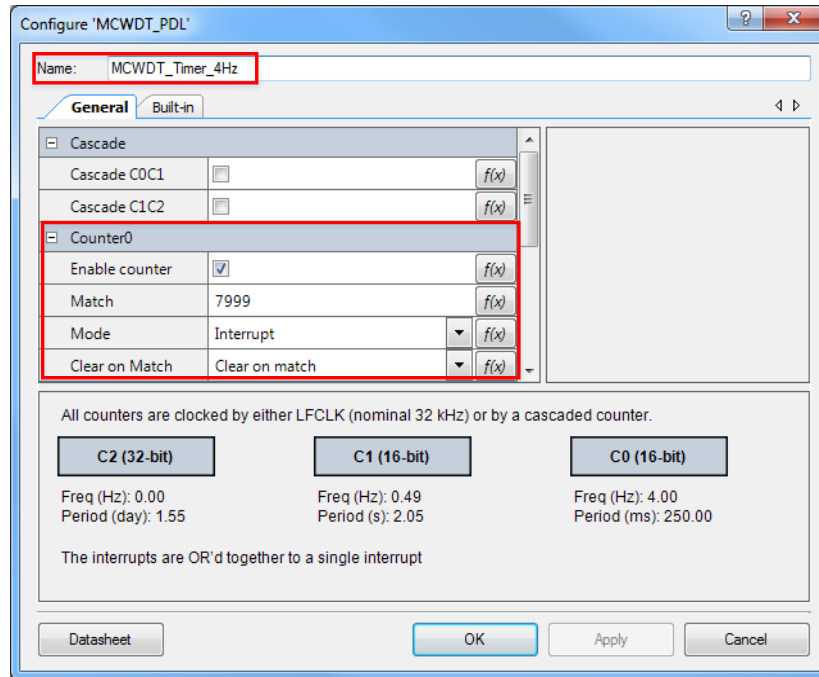
Figure 23. BLE: Response Packet Settings



MCWDT Counter 0 is configured to generate an interrupt every 250 ms as shown in Figure 24. Also, observe only Counter 0 is enabled.



Figure 24. MCWDT Component Configuration



Configure 'MCWDT\_PDL'

Name: MCWDT\_Timer\_4Hz

**General** Built-in

**Cascade**

Cascade C0C1	<input type="checkbox"/>	f(x)
Cascade C1C2	<input type="checkbox"/>	f(x)

**Counter0**

Enable counter	<input checked="" type="checkbox"/>	f(x)
Match	7999	f(x)
Mode	Interrupt	f(x)
Clear on Match	Clear on match	f(x)

All counters are clocked by either LFCLK (nominal 32 kHz) or by a cascaded counter.

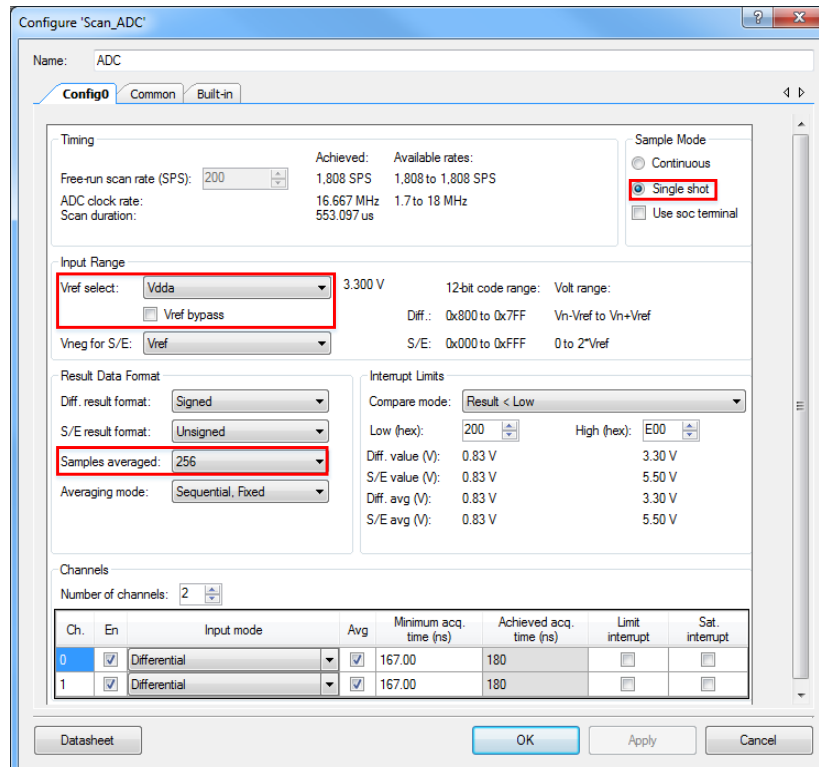
C2 (32-bit)	C1 (16-bit)	C0 (16-bit)
Freq (Hz): 0.00	Freq (Hz): 0.49	Freq (Hz): 4.00
Period (day): 1.55	Period (s): 2.05	Period (ms): 250.00

The interrupts are OR'd together to a single interrupt

Datasheet OK Apply Cancel

Figure 25 shows the Component settings for ADC.

Figure 25. ADC Component Settings



Configure 'Scan\_ADC'

Name: ADC

**Config0** Common Built-in

**Timing**

Free-run scan rate (SPS): 200

Achieved: 1,808 SPS

Available rates: 1,808 to 1,808 SPS

ADC clock rate: 16.667 MHz

Scan duration: 553.097 us

Sample Mode

☐ Continuous

☒ Single shot

☐ Use soc terminal

**Input Range**

Vref select: Vdda 3.300 V

☐ Vref bypass

12-bit code range: Volt range:

Vneg for S/E: Vref

S/E: 0x000 to 0xFFFF

Diff.: 0x800 to 0x7FF

Vn-Vref to Vn+Vref

0 to 2\*Vref

**Result Data Format**

Diff. result format: Signed

S/E result format: Unsigned

Samples averaged: 256

Averaging mode: Sequential, Fixed

**Interrupt Limits**

Compare mode: Result < Low

Low (hex): 200

High (hex): E00

Diff. value (V): 0.83 V

S/E value (V): 0.83 V

Diff. avg (V): 0.83 V

S/E avg (V): 0.83 V

3.30 V

5.50 V

3.30 V

5.50 V

**Channels**

Number of channels: 2

Ch	En	Input mode	Avg	Minimum acq. time (ns)	Achieved acq. time (ns)	Limit interrupt	Sat. interrupt
0	<input checked="" type="checkbox"/>	Differential	<input checked="" type="checkbox"/>	167.00	180	<input type="checkbox"/>	<input type="checkbox"/>
1	<input checked="" type="checkbox"/>	Differential	<input checked="" type="checkbox"/>	167.00	180	<input type="checkbox"/>	<input type="checkbox"/>

Datasheet OK Apply Cancel

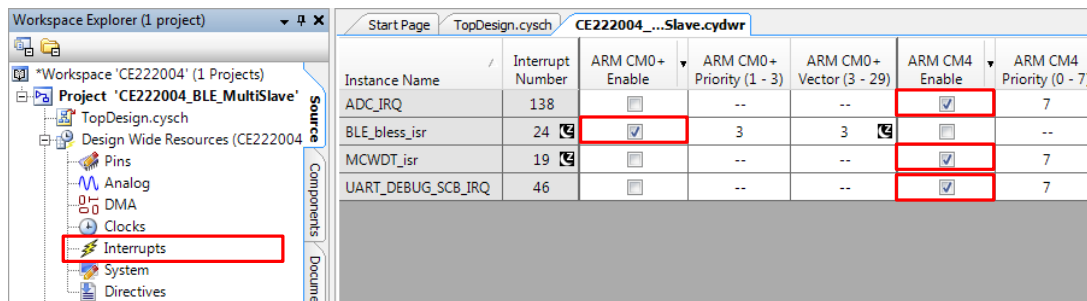
Table 2 shows the pin assignment for the project done through the **Pins** tab in the **Design Wide Resources** window. These assignments are compatible with CY8CKIT-062-BLE.

Table 2. DWR Pin Assignment Table

Instance Name	Pin
Hibernate_Wakeup_SW	P0[4]
Pin_LED_Orange	P1[5]
Pin_LED_Red	P13[7]
Pin_RGB_Blue	P11[1]
Pin_RGB_Green	P1[1]
Pin_RGB_Red	P0[3]
THER_GND	P10[3]
THER_VDD	P10[0]
THER_OUT_1	P10[2]
THER_OUT_2	P10[1]
UART_DEBUG:rx	P5[0]
UART_DEBUG:tx	P5[1]

Figure 26 shows the interrupt configuration for the project.

Figure 26. System Interrupt Configuration



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)
ADC_IRQ	138	<input type="checkbox"/>	--	--	<input checked="" type="checkbox"/>	7
BLE_bless_isr	24	<input checked="" type="checkbox"/>	3	3	<input type="checkbox"/>	--
MCWDT_isr	19	<input type="checkbox"/>	--	--	<input checked="" type="checkbox"/>	7
UART_DEBUG_SCB_IRQ	46	<input type="checkbox"/>	--	--	<input checked="" type="checkbox"/>	7

## Related Documents

Application Notes	
<a href="#">AN210781 – Getting Started with PSoC 6 MCU with BLE Connectivity</a>	Describes PSoC 6 MCU with BLE Connectivity devices and how to build your first PSoC Creator project
<a href="#">AN215656 – PSoC 6 MCU Dual-Core CPU system Design</a>	Describes the dual-core CPU architecture in PSoC 6 MCU, and shows how to build a simple dual-core design
<a href="#">AN219434 – Importing PSoC Creator Code into an IDE for a PSoC 6 MCU Project</a>	Describes how to import the code generated by PSoC Creator into your preferred IDE
Code Examples	
CE215118 - BLE Multi-Master Single Slave With PSoC 6 MCU with BLE Connectivity	
CE220167 - PSoC 6 MCU with Bluetooth Low Energy (BLE) Connectivity: BLE with User Interface	
PSoC Creator Component Datasheets	
<a href="#">Bluetooth Low Energy</a>	Facilitates designing applications requiring BLE connectivity.
<a href="#">MCWDT</a>	Provides MCWDT settings
<a href="#">Pins</a>	Supports connection of hardware resources to physical pins
<a href="#">SysInt</a>	Provides SysInt component settings
<a href="#">UART</a>	Provides asynchronous serial communications
<a href="#">Pins</a>	Supports connection of hardware resources to physical pins
<a href="#">Timer Counter (TCPWM)</a>	Supports fixed-function Timer/Counter implementation
<a href="#">Clock</a>	Supports local clock generation
<a href="#">Interrupt</a>	Supports generating interrupts from hardware signals
Device Documentation	
<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>
Development Kit (DVK) Documentation	
<a href="#">CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit</a>	

## Document History

Document Title: CE222004 – PSoC 6 MCU with BLE Multi-Master Multi-Slave: SSSS Function

Document Number: 002-22004

Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	6005498	AJYA	12/26/2017	New code example
*A	6079211	AJYA	03/02/2018	ADC Component and firmware updated

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