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CE217634 - BLE Continuous Glucose Monitoring Sensor with PSoC 6 MCU with BLE Connectivity

Objective

This example project demonstrates the Bluetooth Low Energy (BLE) Continuous Glucose Monitoring Sensor application workflow.

Overview

The application uses the BLE Continuous Glucose Monitoring Profile to report CGM Measurement records to a client by the Continuous Glucose Monitoring Service and to manage the bonding by the Bond Management Service. Also, the application uses the Device Information Service to assert the Device Name and so on.

Requirements

Tool: PSoC Creator™ 4.2

Programming Language: C (Arm® GCC 5.4-2016-q2-update)

Associated Parts: All PSoC® 6 BLE parts

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

Hardware Setup

This example uses the kit's default configuration. See the kit guide to ensure the kit is configured correctly.

1. Connect the BLE Pioneer Kit to the computer's USB port.
2. Connect the BLE Dongle to one of the USB ports on the computer.

LED Behavior

If the V_{DDD} voltage is set to lesser than 2.7 V in the DWR settings **System** tab, only the red LED is used. The red LED blinks to indicate that the device is advertising. The red LED is OFF when a device is connected to a peer device. When the device is in Hibernate mode, the red LED stays ON.

LED behavior for V_{DDD} voltage greater than 2.7 V is described in the Operation section.

Software Setup

BLE Host Emulation Tool

This example requires the CySmart application. Download and install either the CySmart Host Emulation Tool PC application or the CySmart app for iOS or Android. You can test the 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

Terminal Tool

This example uses a terminal window. You must have terminal software, such as Tera Term or PuTTy.

Operation

The project sends the Continuous Glucose Monitoring Service characteristic's notifications or indications to the Central Client device, which displays the notifications to the user. Also, the device performs Bond Management service operations requested by the client.

The project is intended to work as a pair with any BLE-compatible device (for example, phone, tablet) with the appropriate software (for example, Android, iOS with an installed application that supports Continuous Glucose Monitoring Profile.)

Also, the Continuous Glucose Monitoring Sensor can be used with CySmart app for Windows. You need to match the security settings between the Continuous Glucose Monitor and CySmart Client and pair the devices (bondig) before writing (enabling notifications and so on) to the server's GATT database. For further instructions on how to use the CySmart application, see the CySmart User Guide.

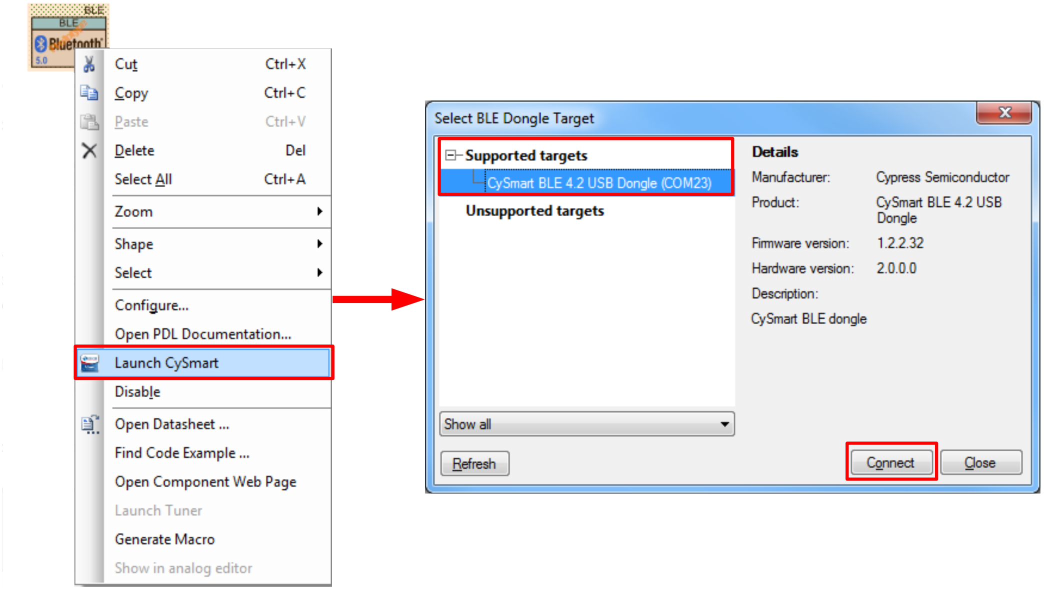
To connect to the Continuous Glucose Monitoring Sensor device, send a connection request to the device while the device is advertising. The green LED blinks while the device is advertising. The blue LED is turned ON when the device is connected. The red LED is turned ON when the device is disconnected to indicate that no client is connected to the device.

The Continuous Glucose Monitoring Sensor device requires authentication. The IO capability is a keyboard, that is, the device needs to enter the passkey when prompted by the client device through the UART interface (by any software, for example, HyperTerminal). When the client is paired with the Continuous Glucose Monitoring Sensor, enable the CGM Measurement characteristic notification and the Record Access Control Point (RACP) characteristic indication. Then, the RACP characteristic can be written to assert any RACP request (for details, see the Continuous Glucose Monitoring Profile and Service specifications adopted by Bluetooth SIG). When the RACP request is asserted, the client should wait for any CGM Measurement characteristic notifications and the RACP characteristic indication (depending on the asserted request), or write the Abort Operation command into the RACP characteristic. Before writing any CGM Specific Ops Control Point (SOCP) command, the SOCP indication should be enabled. The BLE stack timer is used for time simulations and LED blinking.

Operation Steps

1. Plug the CY8CKIT-062-BLE kit board into your computer's USB port.
2. Open a terminal window and perform following configuration: Baud rate – 115200, Parity – None, Stop bits – 1, Flow control – XON/XOFF. These settings must match the configuration of the PSoC Creator UART Component in the project.
3. 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.
4. Observe the green LED blinking while the device is advertising, and the output in the terminal window.
5. Do the following to test example, using the CySmart Host Emulation Tool application as Continuous Glucose Monitoring Client:
    a. Connect the BLE Dongle to your Windows PC. Wait for the driver installation to complete, if necessary.
    b. Right-click the BLE Component and select **Launch CySmart** to launch the CySmart Host Emulation tool. Alternatively, navigate to **Start** > **Programs** > **Cypress** and click **CySmart** to launch the tool..
    c. CySmart automatically detects the BLE dongle 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 1.

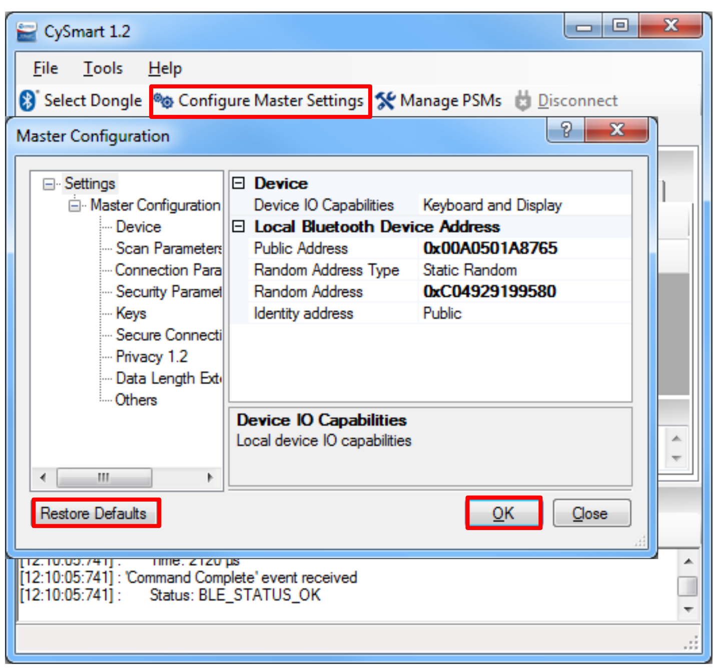
Figure 1. CySmart BLE Dongle Selection



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.

d. Select **Configure Master Settings** and then click **Restore Defaults**, as Figure 2 shows. Then, click **OK**.

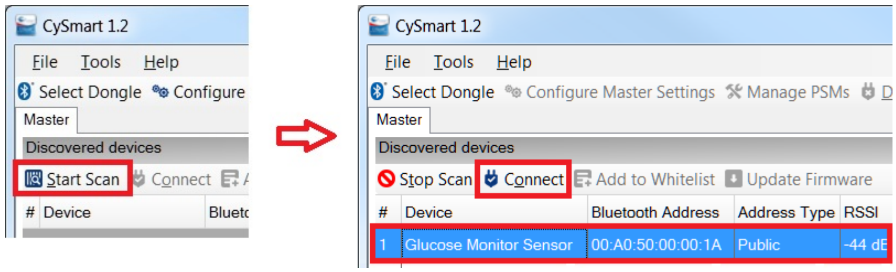
Figure 2. CySmart Master Settings Configuration



e. Press the reset switch on the Pioneer Kit to start BLE advertisement if no device is connected or the device is in Hibernate mode (red LED is ON). Otherwise, skip this step.

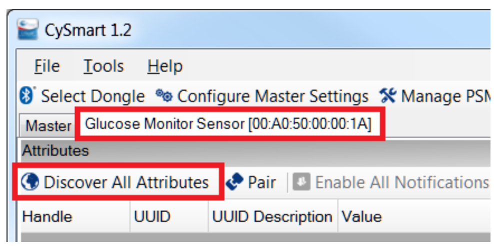
f. On the CySmart Host Emulation Tool, click **Start Scan**. Your device name (configured as **Glucose Monitor Sensor**) should appear in the Discovered devices list, as Figure 3 shows. Select the device and click **Connect** to establish a BLE connection between the CySmart Host Emulation Tool and your device.

Figure 3. CySmart Device Discovery and Connection



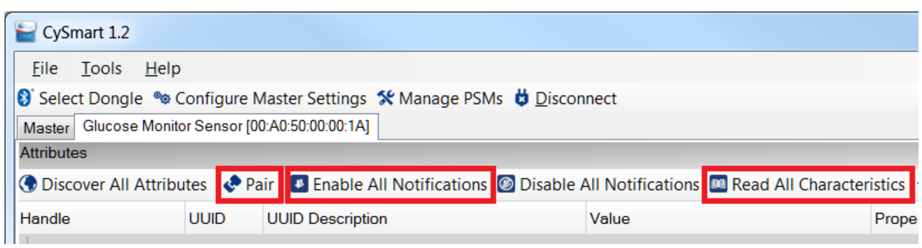
g. Once connected, switch to the **Glucose Monitor Sensor** device tab and click **Discover all Attributes** on the CySmart Host Emulation Tool, as shown in Figure 4.

Figure 4. CySmart Attribute Discovery



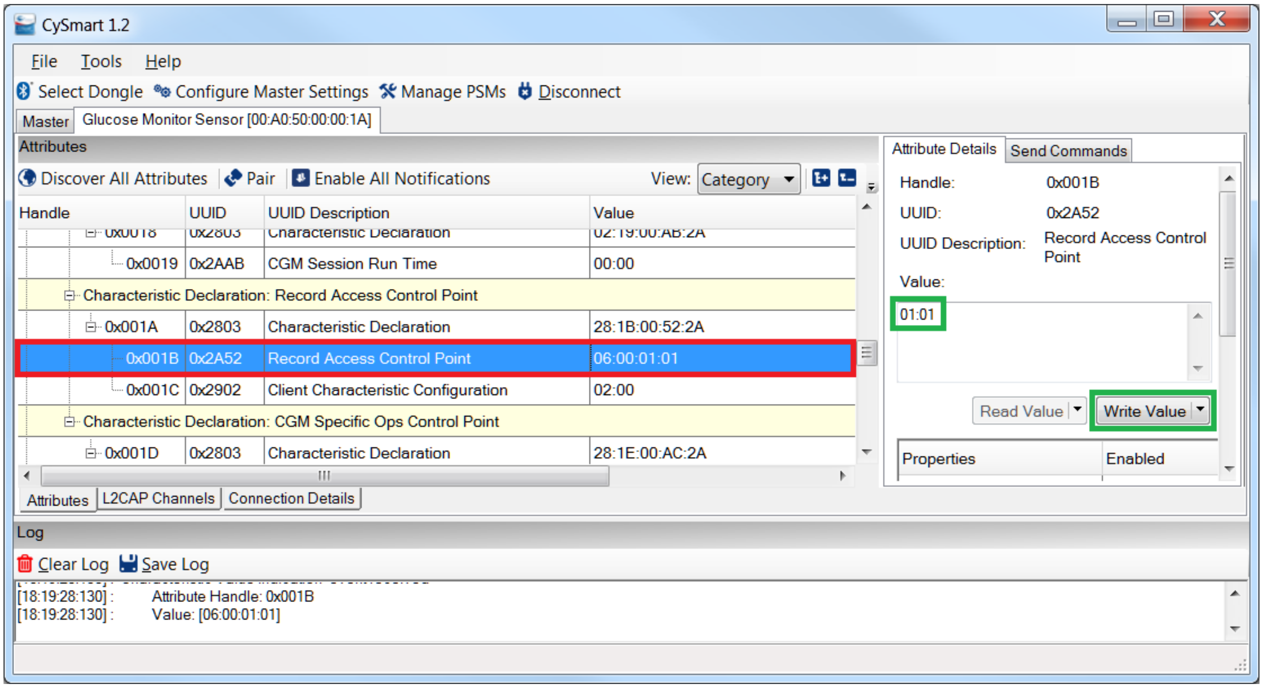
h. Click **Pair** after the discovery is completed, enter a 6-digit passkey through the terminal, click **Read All Characteristics**, and finally click **Enable All Notifications** in the CySmart app as shown in Figure 5.

Figure 5. CySmart Pair, Read All Characteristics and Enable All Notification



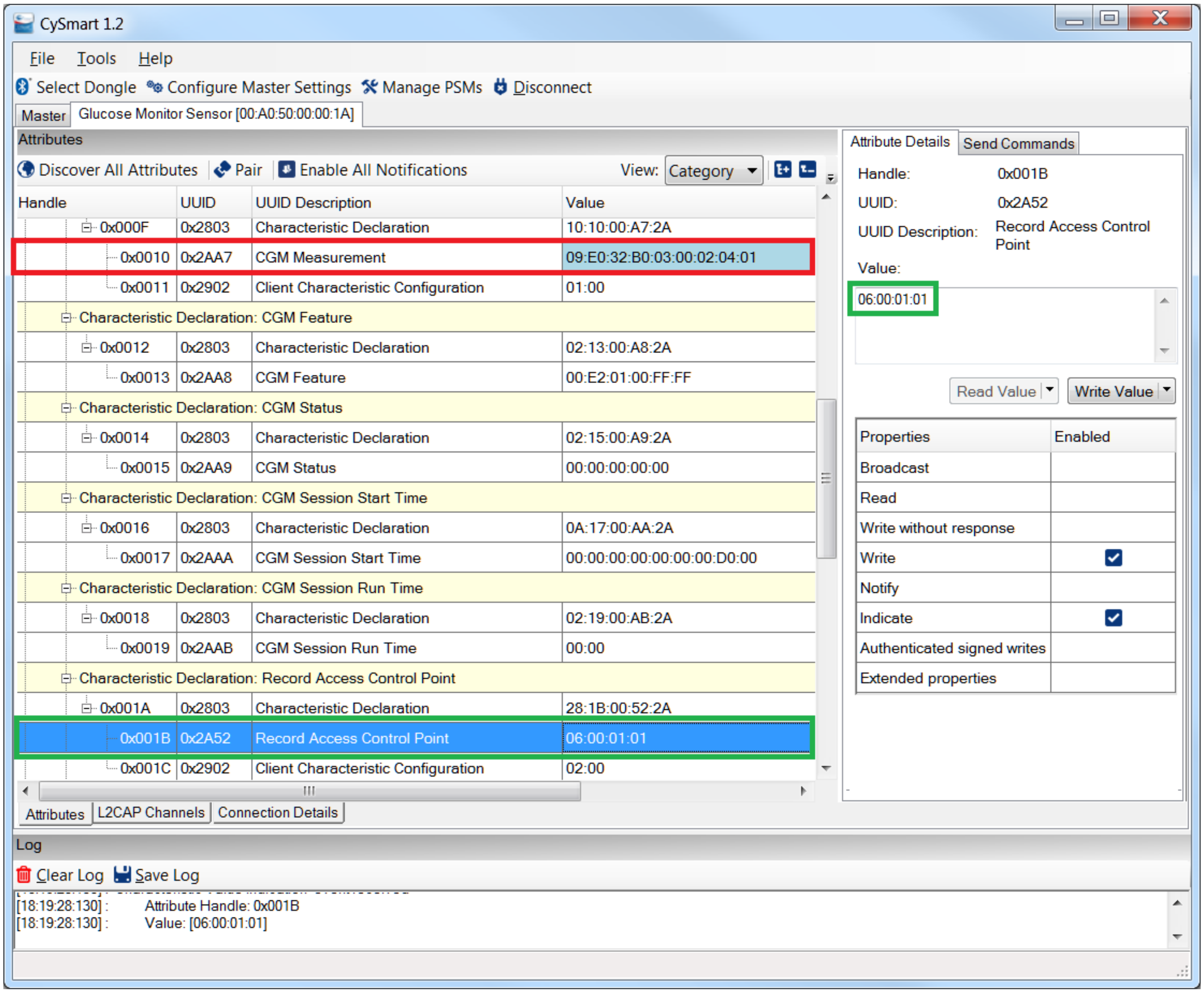
i. Select the Record Access Control Point (RACP) characteristic value and write command **01 01**, which means "Report All Glucose Measurement Records" (for a detailed description of all these commands, see CGMS Specification).

Figure 6. Writing to Record Access Control Point in CySmart.



j. Observe the server sending three CGM Measurement characteristic notifications with the simulated data and the RACP indication “06 00 01 01”, which means “The < Report All Glucose Measurement Records > command is performed successfully”:

Figure 7. Receiving notification in CySmart.



6. The CySmart mobile app (Android/iOS) does not have Indoor Positioning Service implementation, but still can be used in the GATT Data Base mode for testing this example. You can repeat the test flow for CySmart mobile app mentioned in step 5. For more details. see the Android and iOS CySmart User Guide.

7. Use the UART debug port to view verbose messages:

   a. The code example ships with the UART debug port enabled. To disable it, set the macro `DEBUG_UART_ ENABLED` in *common.h* to `DISABLED` and rebuild the code.

   b. The output of the debug serial port looks like the sample below:

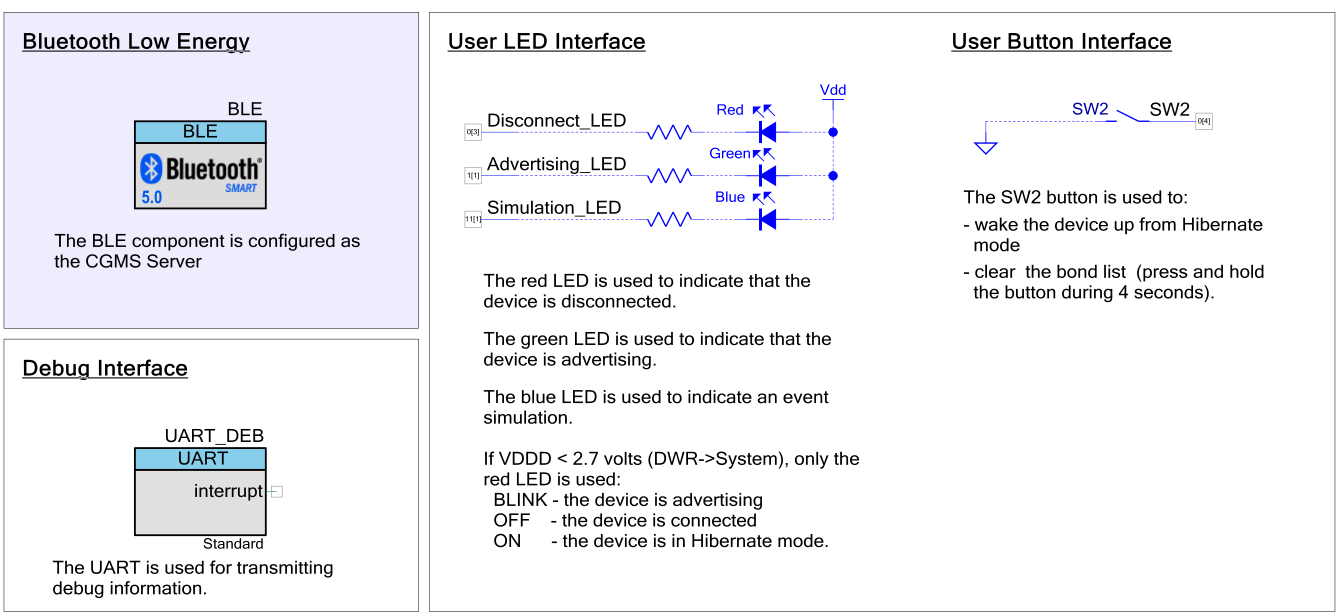
```
BLE Continuous Glucose Monitoring Sensor Example
CY_BLE_EVT_STACK_ON, StartAdvertisement
CY_BLE_EVT_SET_DEVICE_ADDR_COMPLETE
CY_BLE_EVT_LE_SET_EVENT_MASK_COMPLETE
CY_BLE_EVT_GET_DEVICE_ADDR_COMPLETE: 00a05000001a
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GAPP_ADVERTISEMENT_START_STOP, state: 2
CY_BLE_EVT_GAP_KEYS_GEN_COMPLETE

CY_BLE_EVT_GATT_CONNECT_IND: 3, 7
CY_BLE_EVT_GAP_DEVICE_CONNECTED: connIntv = 8 ms
```

```
CY_BLE_EVT_GATTS_XCNHG_MTU_REQ
CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: 3
CY_BLE_EVT_GAP_AUTH_REQ: bdHandle=7, security=3, bonding=1, ekeySize=10, err=0
CY_BLE_EVT_GAP_SMP_NEGOTIATED_AUTH_INFO: bdHandle=7, security=2, bonding=1, ekeySize=10, err=0
CY_BLE_EVT_GAP_PASSKEY_ENTRY_REQUEST
Enter the passkey displayed on the peer device:
Enter a 6-digit passkey:
157965
CY_BLE_EVT_GAP_ENCRYPT_CHANGE: 0
CY_BLE_EVT_GAP_KEYINFO_EXCHNGE_CMPLT
CY_BLE_EVT_GAP_AUTH_COMPLETE: security:2, bonding:1, ekeySize:10, authErr 0
CY_BLE_EVT_PENDING_FLASH_WRITE
CY_BLE_EVT_GATTS_INDICATION_ENABLED
CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: f
RACP Indication is Enabled
CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: 21
RACP Indication is Enabled
CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: 1e
Glucose Notification is Enabled
CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: 13
RACP characteristic is written: 01 01
Opcode: Report stored records
Operator: All records
Cgmt Ntf: 09 e3 32 b0 01 00 02 04 01
Cgmt Ntf: 09 e2 32 b0 02 00 02 04 01
Cgmt Ntf: 09 e0 32 b0 03 00 02 04 01
RACP Ind: 06 00 01 01
RACP Indication is Confirmed
CY_BLE_EVT_GATT_DISCONNECT_IND: 3, 7
CY_BLE_EVT_GAP_DEVICE_DISCONNECTED: bdHandle=7, reason=13, status=0
CY_BLE_EVT_GAPP_ADVERTISEMENT_START_STOP, state: 2
Store bonding data, status: 160012, pending: 2
Store bonding data, status: 0, pending: 0
```

Design and Implementation

Figure 8 shows the top design schematic.

Figure 8. BLE Continuous Glucose Monitoring Code Example Schematic



The project demonstrates the core functionality of the BLE Component configured as the Continuous Glucose Monitoring Server.

After a startup, the device initializes the BLE Component. In this project, three callback functions are required for the BLE operation. The callback function (`AppCallBack()`) is required to receive generic events from the BLE Stack and service-specific callbacks `CgmsCallBack()` and `BmsCallBack()` are required to receive Continuous Glucose Monitoring and Bond Management service-specific events accordingly. The `CY_BLE_EVT_STACK_ON` event indicates successful initialization of the BLE Stack. After this event is received, the Component starts advertising with the packet structure as configured in the BLE Component customizer. The BLE Component stops advertising when a 180-second advertising period expires.

The Continuous Glucose Monitoring Sensor device can be connected to any BLE-compatible device (4.0 or later), configured as the GAP Central role and GATT Client, which supports the Continuous Glucose Monitoring Profile. Also, the Device Information Service may be optionally used.

While connected to the client and between the connection intervals, the device is put into Sleep mode.

Pin Assignments

Table 1 lists the pin assignments and connections required on the development board for supported kits.

Table 1. Pin Assignment

Pin Name	Development Kit	Comment
	PSoC6	
\UART_DEB:rx\	P5[0]	
\UART_DEB:tx\	P5[1]	
\UART_DEB:rts\	P5[2]	
\UART_DEB:cts\	P5[3]	
Disconnect_LED	P0[3]	The red color of the RGB LED
Advertising_LED	P1[1]	The green color of the RGB LED
Simulation_LED	P11[1]	The blue color of the RGB LED
SW2	P0[4]	

Components and Settings

Table 2 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 2. PSoC Creator Components

Component	Instance Name	Purpose	Non-default Settings
Bluetooth Low Energy (BLE)	BLE	The BLE component is configured as the Continuous Glucose Monitoring Sensor server	See the Parameter Settings section
Digital Input Pin	SW2	This pin is used to connect the user button (**SW2**).	**[General tab]** Uncheck HW connection Drive mode: Resistive Pull Up
Digital Output pin	Disconnect_LED Advertising_LED Simulation_LED	These GPIOs are configured as firmware-controlled digital output pins that control LEDs.	**[General tab]** Uncheck HW connection Drive mode: Strong Drive
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

The BLE Component is configured as the Continuous Glucose Monitoring Server in the GAP Peripheral role. Also, the Bond Management and Device Information Services are included.

The BLE Component is also configured to have:

- Public Device Address: 00A050-00001a
- Device name: Glucose Monitor Sensor
- Appearances: Generic Glucose Meter
- Security Level: Authenticated pairing with encryption
- I/O capabilities: Keyboard
- Bonding requirements: Bonding

Figure 9. General Settings

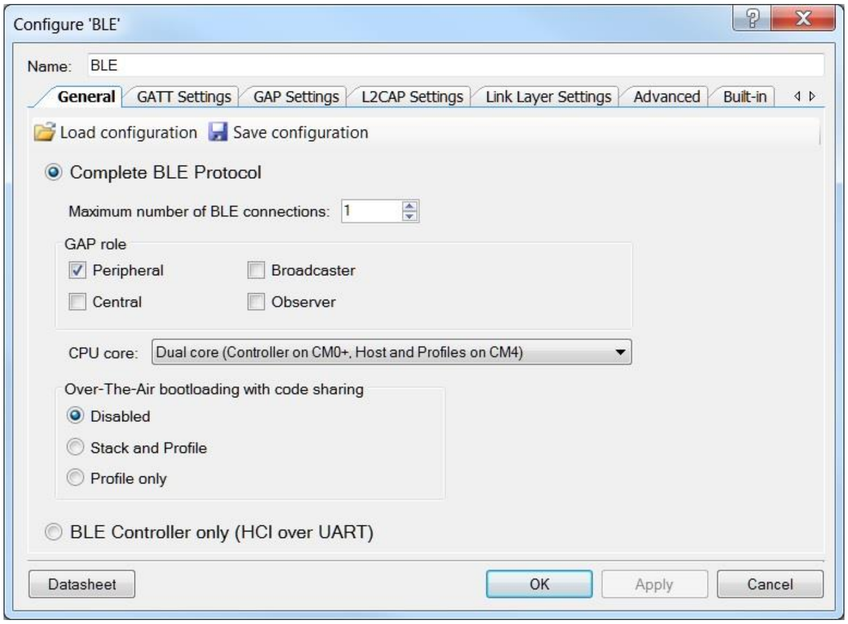


Figure 10. GATT Settings

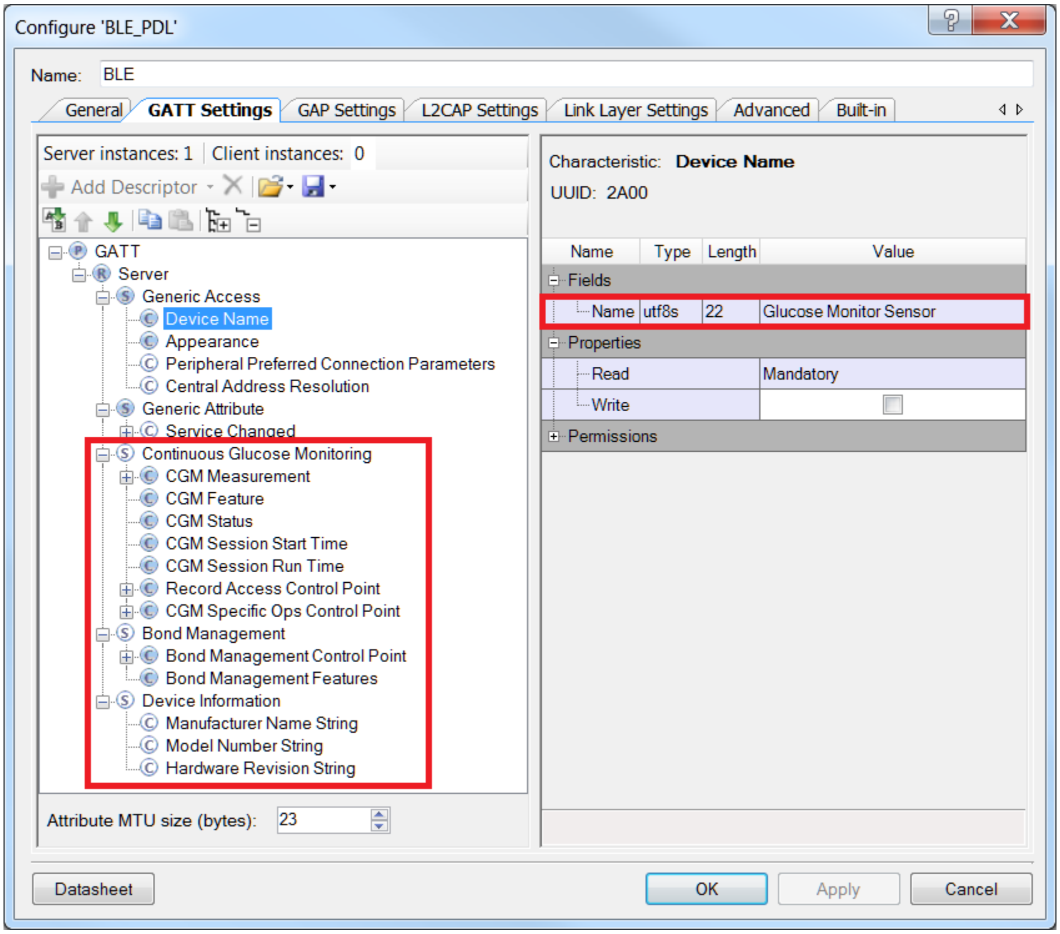


Figure 11. GAP Settings

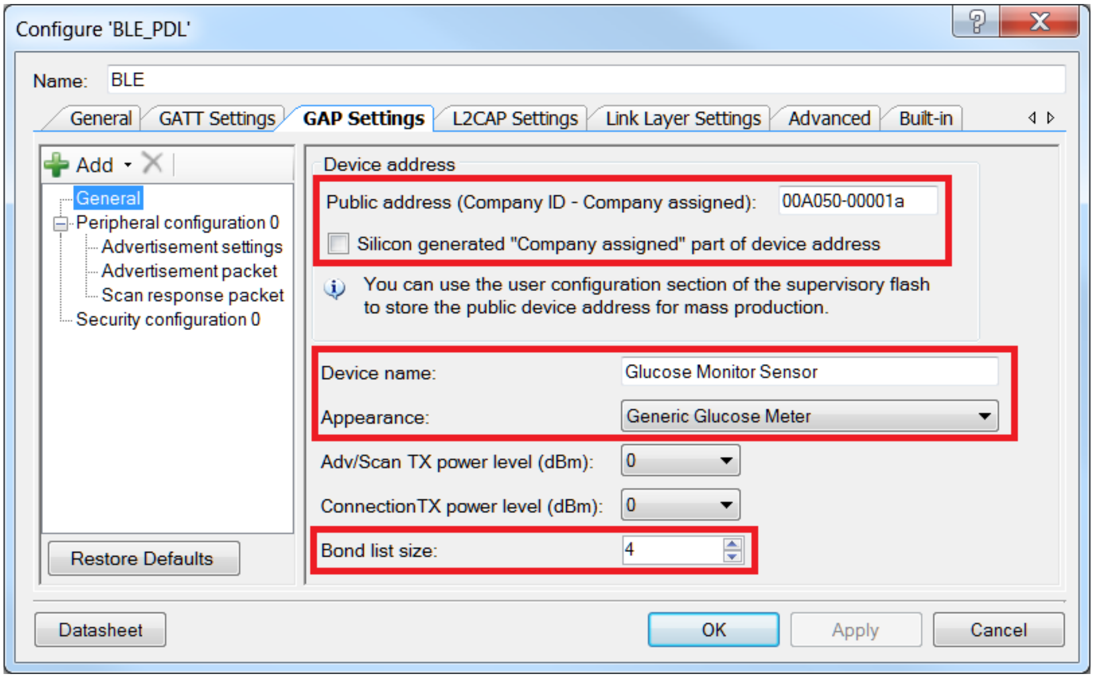


Figure 12. GAP Settings → Advertisement Setting

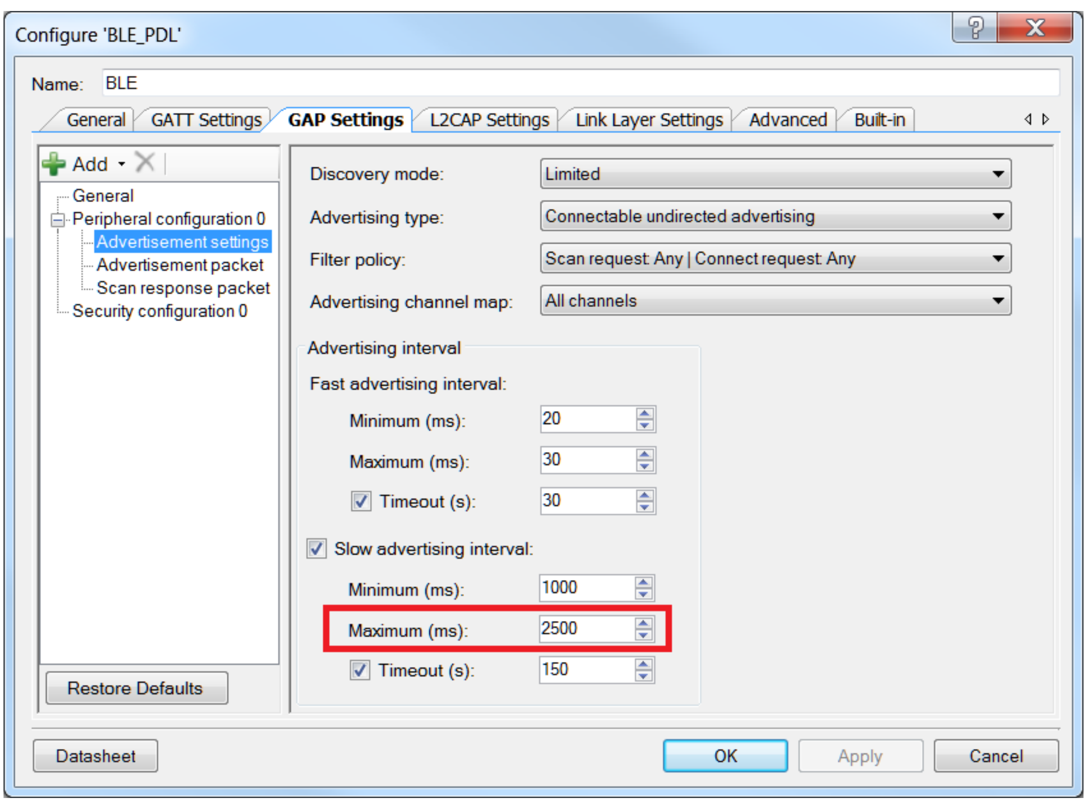
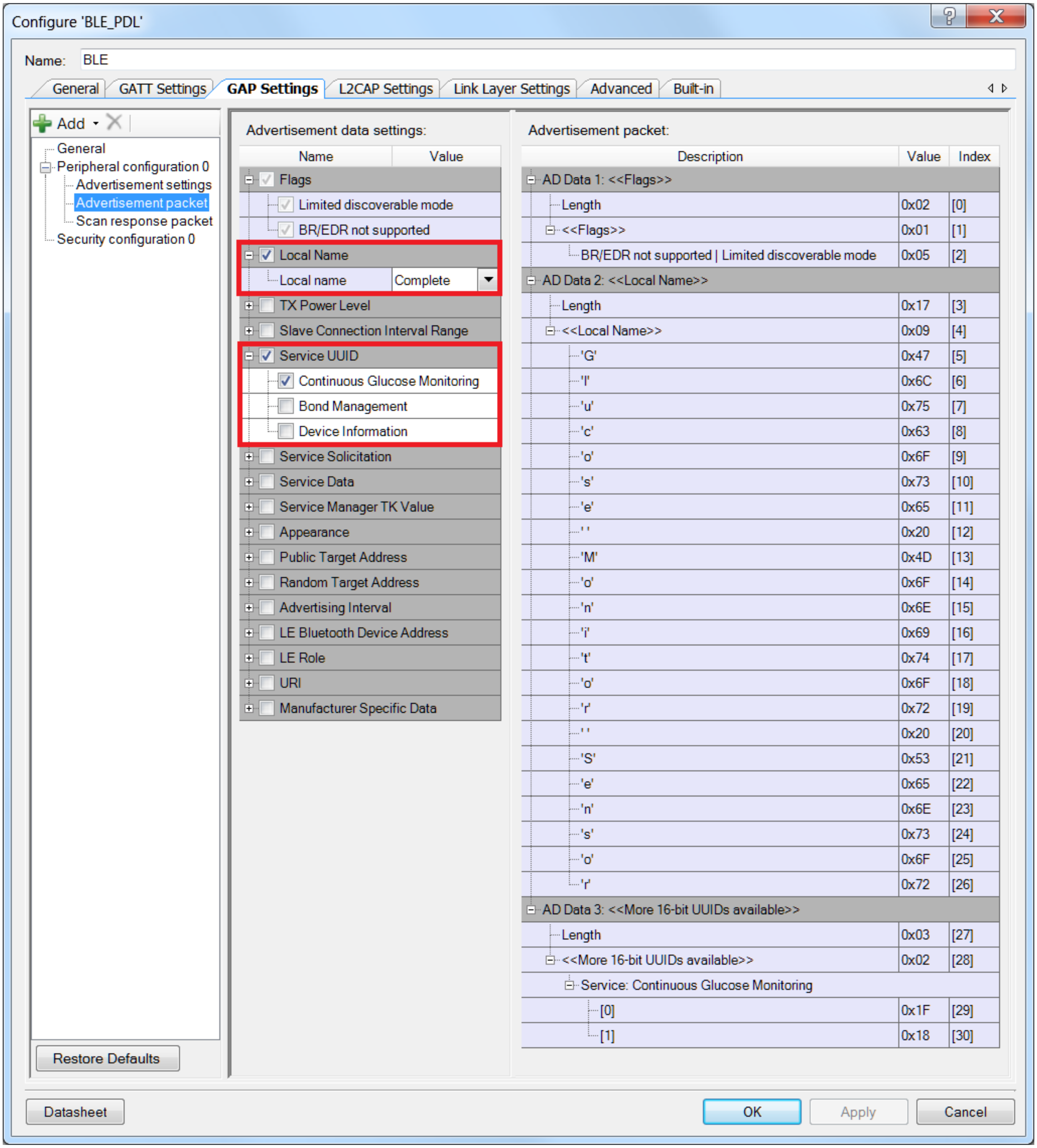
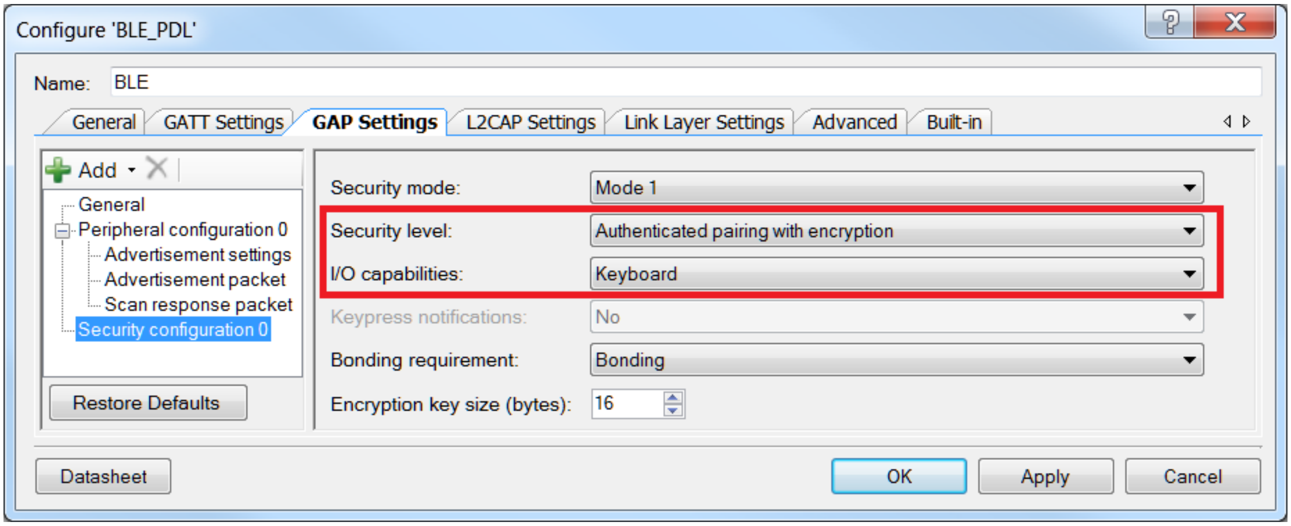


Figure 13. GAP Settings → Advertisement Packet



The Scan response packet settings are also configured to include the Local Name and all service UUIDs into the Scan response packet

Figure 14. GAP Settings → Security Configuration



Switching the CPU Cores Usage

This section describes how to switch between different CPU cores usage (Single core/Dual core) in the BLE PDL examples.

The BLE component has the CPU Core parameter that defines the cores usage. It can take the following values:

- **Single core (Complete Component on CM0+)** – only CM0+ will be used.
- **Single core (Complete Component on CM4)** – only CM4 will be used.
- **Dual core (Controller on CM0+, Host and Profiles on CM4)** – CM0+ and CM4 will be used: CM0+ for the Controller and CM4 for the Host and Profiles.

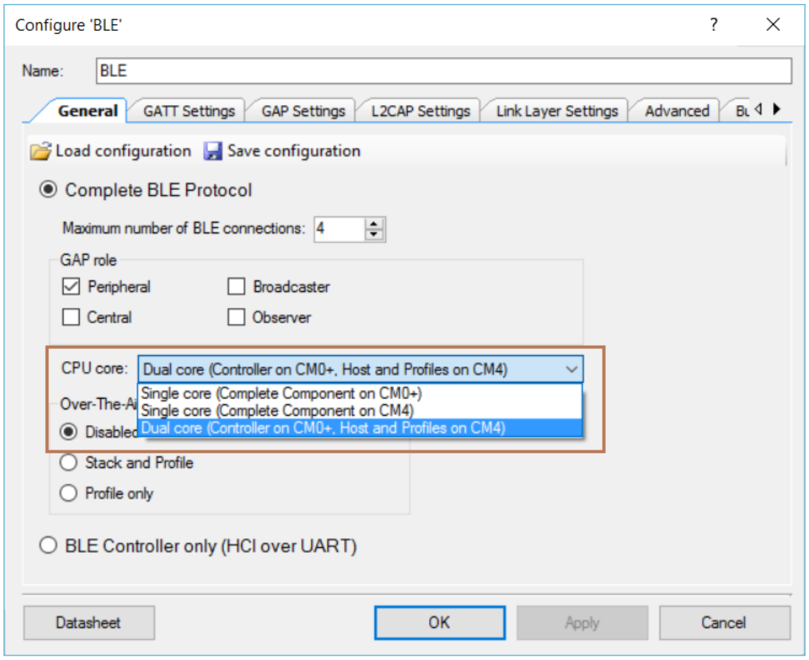
The BLE example structure allows easy switching between different CPU cores options. Important to remember:

- All application host-files must be run on the host core.
- The BLE subsystem (BLESS) interrupt must be assigned to the core where the controller runs.
- All additional interrupts (SW2, etc.) used in the example must be assigned to the host core.

Do the following to switch the CPU Cores usage:

1. In the BLE customizer **General** tab, select appropriate CPU core option.

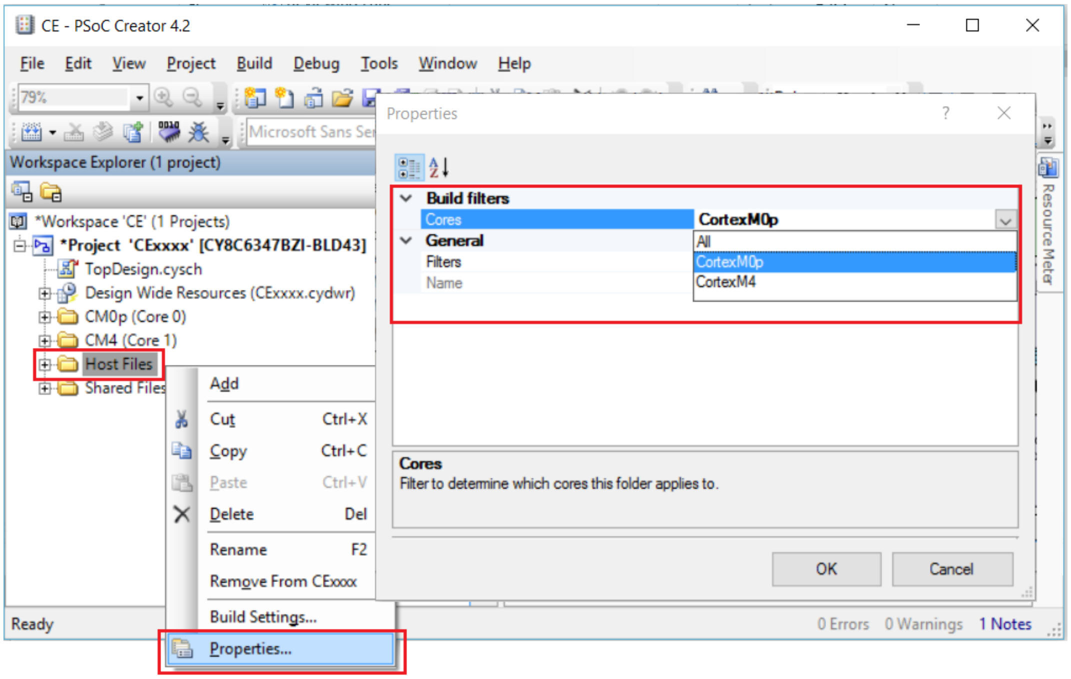
Figure 15. Select CPU Core



2. Identify the CPU on which host files will run. In the workspace explorer panel, right-click **Host Files**, choose **Properties**. Set the **Cores** property corresponding to the CPU core chosen in step 1, as shown in Figure 16.

   - For **Single core (Complete Component on CM0+)** option – CM0+
   - For **Single core (Complete Component on CM4)** option – CM4
   - For **Dual core (Controller on CM0+, Host and Profiles on CM4)** option – CM4

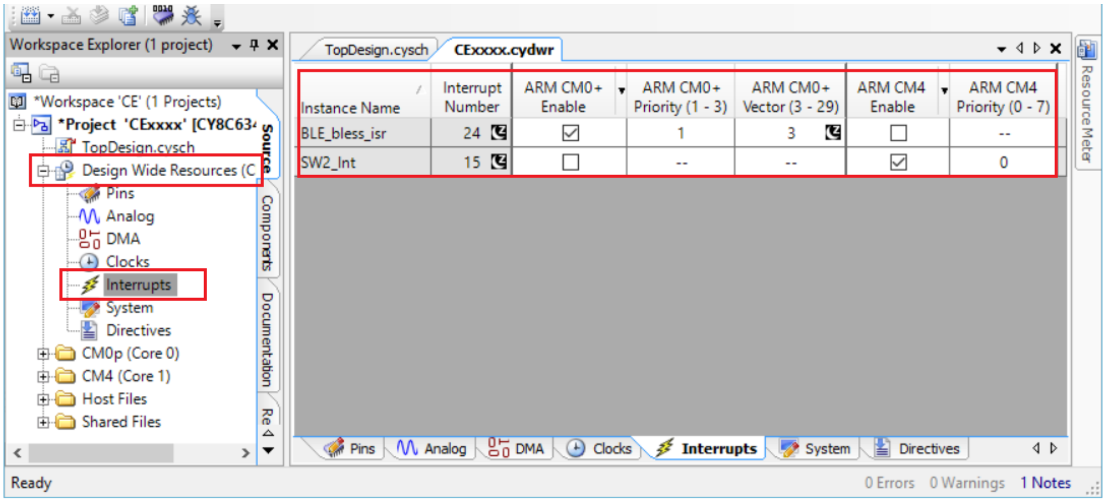
Figure 16. Change Core Properties



3. Assign BLE_bless_isr and other peripheral (button – SW2, timer(s), and so on) interrupts to the appropriate core in **DWR** > **Interrupts** tab:

- For **Single core (Complete Component on CM0+)** option: BLE_bless_isr and peripheral interrupts on **CM0+**
- For **Single core (Complete Component on CM4)** option: BLE_bless_isr and peripheral interrupts on **CM4**
- For **Dual core (Controller on CM0+, Host and Profiles on CM4)** option: BLE_bless_isr interrupt on **CM0+,** other peripheral interrupts on **CM4**

Figure 17. Assign Interrupts



Reusing This Example

This example is designed for the CY8CKIT-062-BLE pioneer kit. To port the design to a different PSoC 6 MCU device, kit, or both, change the target device using the Device Selector and update the pin assignments in the Design Wide Resources Pins settings as needed.

Related Documents

Application Notes		
AN210781	Getting Started with PSoC 6 MCU with Bluetooth Low Energy (BLE) Connectivity	Describes PSoC 6 BLE, and how to build a basic code example.
AN215656	PSoC 6 MCU Dual-CPU System Design	Presents the theory and design considerations related to this code example.
Software and Drivers		
CySmart – Bluetooth® LE Test and Debug Tool		CySmart is a Bluetooth® LE host emulation tool for Windows PCs. The tool provides an easy-to-use Graphical User Interface (GUI) to enable the user to test and debug their Bluetooth LE peripheral applications.
PSoC Creator Component Datasheets		
Bluetooth Low Energy (BLE_PDL) Component		The Bluetooth Low Energy (BLE_PDL) Component provides a comprehensive GUI-based configuration window to facilitate designing applications requiring BLE connectivity.
Device Documentation		
PSoC® 6 MCU: PSoC 63 with BLE. Datasheet.		PSoC® 6 MCU: PSoC 63 with BLE Architecture Technical Reference Manual
Development Kit (DVK) Documentation		
CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit		

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**	6086770	NPAL	06/07/2018	New spec

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