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CE217641 - BLE Proximity Profile with PSoC 6 MCU with BLE Connectivity

Objective

This example project demonstrates the Bluetooth Low Energy (BLE) Proximity Profile application workflow.

Overview

This example project demonstrates the Proximity operation of the BLE PSoC Creator™ Component. The Proximity Reporter uses the BLE Proximity Profile with one instance of the Link Loss Service and one instance of the Tx Power Service to display alerts on the device if connection to the client is lost. The Proximity Reporter operates with other devices which implement the Proximity Monitor Profile role. The device uses Limited Discovery mode during which it is visible to the BLE clients. The device remains in Deep Sleep mode between the BLE connection intervals.

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 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.

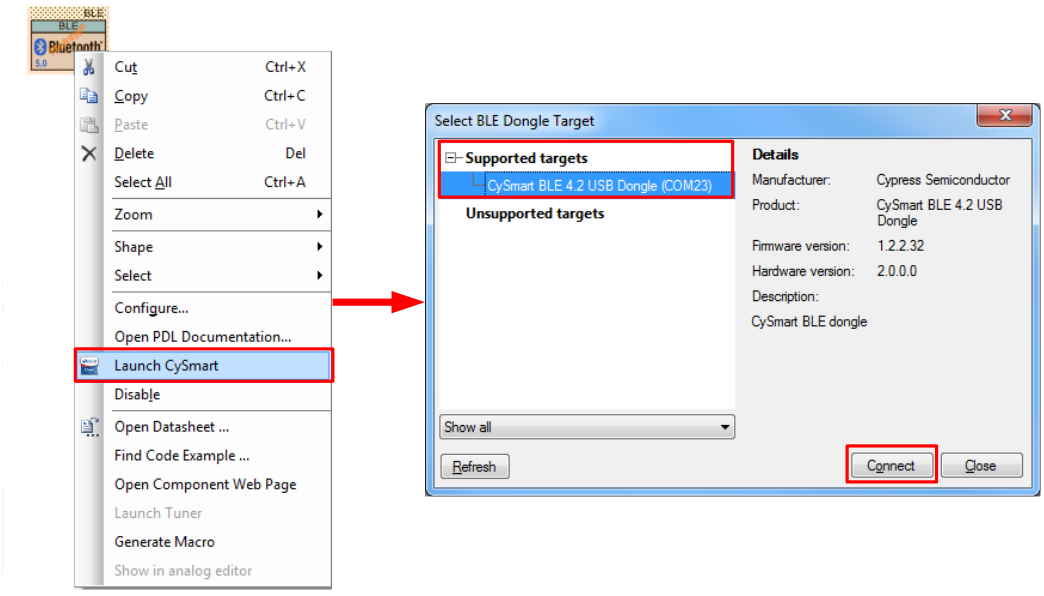
Operation

You can connect to the Proximity Reporter device with the BLE 4.0 compatible device configured in the GAP Central role and capable of discovering the Link Loss Service with Alert Level Characteristic and Tx Power Service with Tx Power Level Characteristic. To connect to the Proximity Reporter device, send a connection request to the device while the device is advertising. When the client connects successfully, all the LEDs turn OFF. If the client is connected to the Proximity Reporter, the Alert Level Characteristic can be written to configure alerts on the Link Loss. When the Alert Level is set to `CY_BLE_MILD_ALERT` and the Link Loss is detected, the blue LED starts blinking, which demonstrates “Mild Alert”. When the Alert Level is set to `CY_BLE_HIGH_ALERT` and the Link Loss is detected, the blue LED turns ON – that is “High Alert”. When the device starts alerting, there are two options to disable the alerts. The first option is to wait for a 20-second timeout to expire; the second option is when the client reestablishes connection with the Proximity Reporter before the alert timeout expires. Note that the device will be advertising in parallel, alerting and it will be available for a connection. However, the green LED will not blink during a 20-second alerting timeout and will resume blinking after the timeout if no client connects to the Proximity Reporter. The blinking green LED indicates that the device is advertising. The glowing red LED indicates that no client has been connected to the device within a 30-second advertising period.

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 blinks 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:
   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, you can 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.

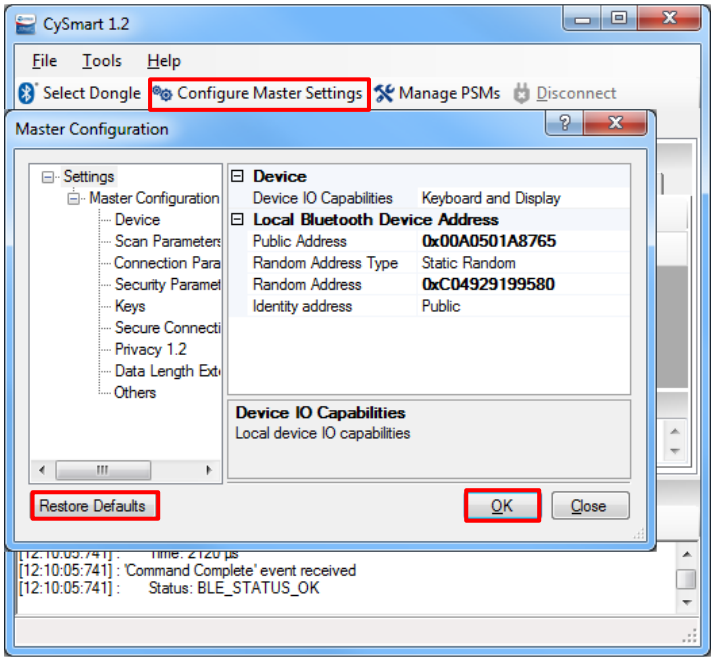
Figure 1. CySmart BLE Dongle Selection



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**.

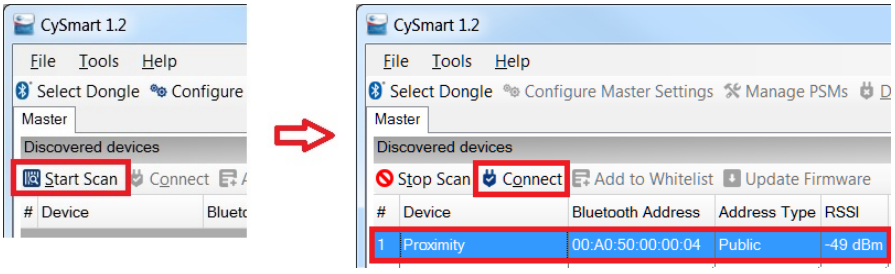
Figure 2. CySmart Master Settings Configuration



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

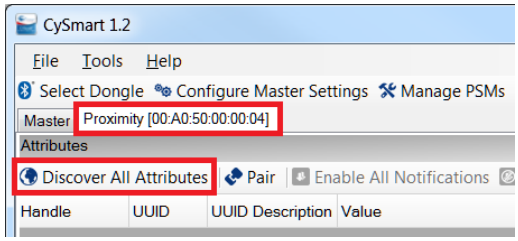
f. On the CySmart Host Emulation Tool, click **Start Scan**. Your device name (configured as **Proximity Sensor**) should appear in the Discovered devices list, as Figure 3 shows. Select the device and click **Connect** to establish a BLE connection between the CySmart Host Emulation Tool and your device.

Figure 3. CySmart Device Discovery and Connection



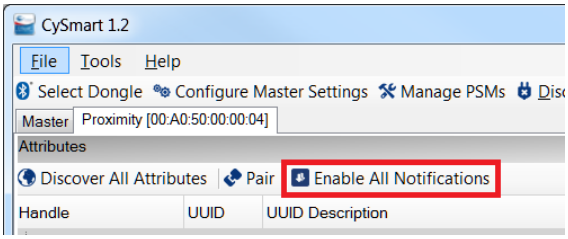
g. Once connected, switch to the **Proximity <device>** tab and **Discover All Attributes** on your design from the CySmart Host Emulation Tool, as shown in Figure 4.

Figure 4. CySmart Attribute Discovery



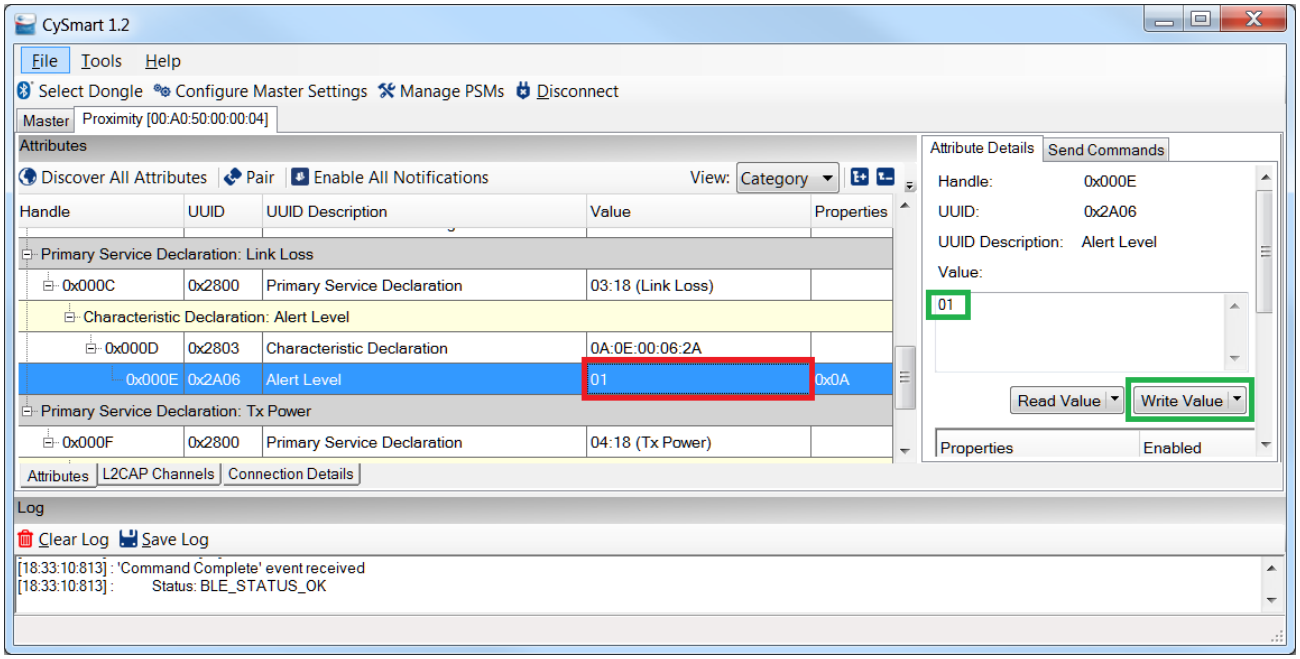
h. Click **Enable All Notifications** in the CySmart app as shown in Figure 5.

Figure 5. CySmart Pair and Enable All Notification



i. Select the **Alert Level** characteristic value, and enter **1** (for example, mild alert).

Figure 6. Writing Alert Level Characteristic Value



j. Observe the blue LED blinking when the link is lost. To simulate a Link Loss, decrease the Tx power level of the device to the lowest possible value using the mechanical button. The Tx power level decreases whenever you press the button, and the client receives the notification about the change in Tx Power Level Characteristic. Note that the Tx power level will not decrease below 20 dBm. Another option is to move the device away from the client so that the connection is lost.

6. Do the following to test example using the CySmart mobile app:

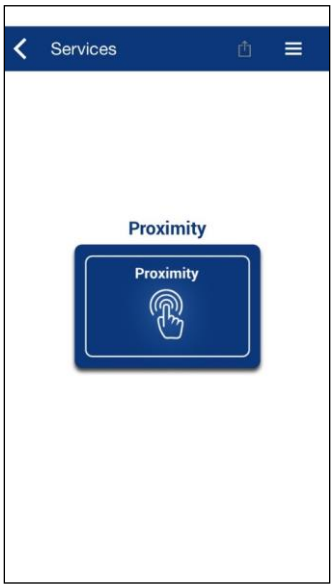
   a. Launch CySmart mobile app and swipe down the screen to refresh the list of BLE devices available nearby.

   b. Make sure that the development kit is advertising (green LED is blinking): you may need to press the **SW1** button to wake up the device from the Hibernate mode.

   c. Once the Proximity device appears on the BLE devices list, connect to it and choose **Proximity** in the service selector.

Figure 7. CySmart Android App Connecting to Proximity Service

Figure 8. CySmart iOS App Connected to Proximity Service and Recognized as Proximity Profile



d. A dropdown list is provided to control the Alert Level on the Link Loss event.

Figure 9. Alert Level Selector on CySmart iOS App

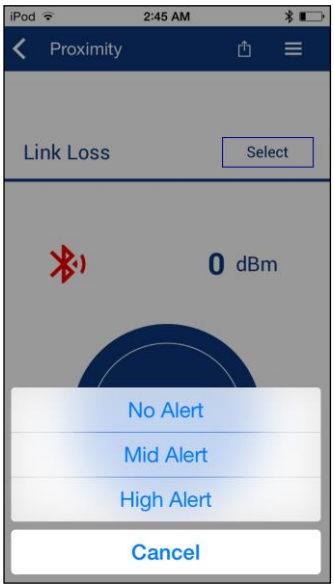
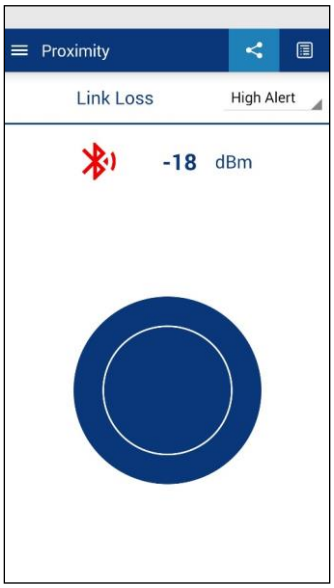


Figure 10. CySmart Android App with Actual Values of Alert Level and Tx Power Level



e. To trigger the Link Loss event, terminate the connection with the development kit from within the CySmart app: move two screens backwards and return to the device selection list. Notice the blue LED blinking according to the value set from the drop-down list.

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 Proximity Profile 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: 00a050000004
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
Tx power level is set to 4 dBm
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GATT_CONNECT_IND: 0, 0
CY_BLE_EVT_GAP_DEVICE_CONNECTED: connIntv = 40 ms
CY_BLE_EVT_GATTS_XCNHG_MTU_REQ
CY_BLE_EVT_GET_TX_PWR_COMPLETE
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
Tx power level is set to 4 dBm
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
Tx power level is set to 0 dBm
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
Tx power level is set to -6 dBm
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
Tx power level is set to -12 dBm
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
Tx power level is set to -16 dBm
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
CY_BLE_EVT_SET_TX_PWR_COMPLETE
CY_BLE_EVT_GET_TX_PWR_COMPLETE
Tx power level is set to -20 dBm
CY_BLE_EVT_SET_TX_PWR_COMPLETE
Write LLS Alert Level request received
Alert Level for LLS is set to "Mild Alert"
CY_BLE_EVT_GATT_DISCONNECT_IND: 0, 0
CY_BLE_EVT_GAP_DEVICE_DISCONNECTED: bdHandle=0, reason=13, status=0
CY_BLE_EVT_GAPP_ADVERTISEMENT_START_STOP, state: 2
Device started alerting with "Mild Alert"
```

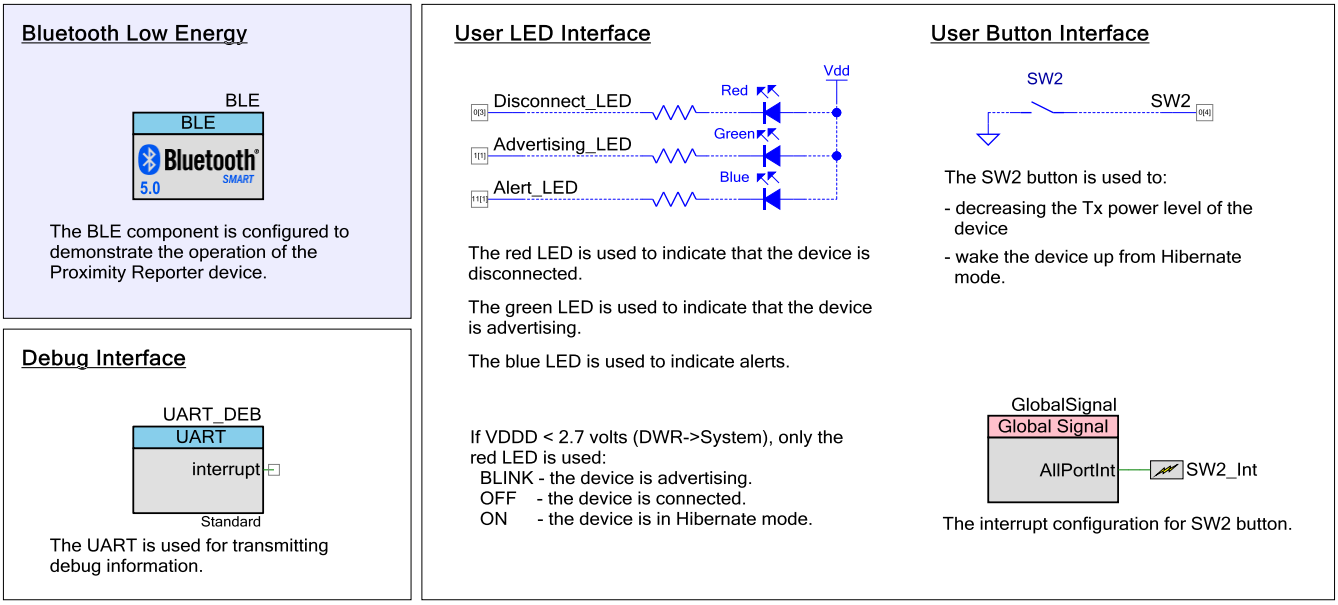
Design and Implementation

This example project demonstrates the Proximity operation of the BLE PSoC Creator Component. The Proximity Reporter uses the BLE Proximity Profile with one instance of the Link Loss Service and one instance of the Tx Power Service to display alerts on the device if connection to the client is lost. The Proximity Reporter operates with other devices which implement the Proximity Monitor Profile role. The device uses Limited Discovery mode during which it is visible to BLE clients. The device remains in Deep Sleep mode between the BLE connection intervals.

Design

Figure 11 shows the top design schematic.

Figure 11. BLE Proximity Profile Code Example Schematic



The example project demonstrates the core functionality of the BLE Component configured as a Proximity Reporter.

To start the example project operation, build it and program into the CY8CKIT-062 PSoC® 6 BLE Pioneer Kit. After the startup, the device initializes the BLE, UART, and ISR Components. In this project, three callback functions are required for the BLE operation. The callback function `AppCallBack()` is required for receiving generic events from the BLE Stack and the functions `LlsServiceAppEventHandler()` and `TpsServiceAppEventHandler()` are required for receiving events from the Link Loss and Tx Power Services. The `CY_BLE_EVT_STACK_ON` event indicates successful initialization of the BLE Stack. After this event is received, the component starts advertising using the advertisement packet configured in the BLE Component customizer. The advertising stops once a 30-second advertising period expires. To resume advertising, press the mechanical button: this will resume advertising for another 30 seconds.

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

Pin Assignments

Pin assignments and connections required on the development board for supported kits are in Table 1.

Table 1. Pin Assignment

Pin Name	Development Kit	Comment
	CY8CKIT-062	
\UART_DEB:rx\	P5[0]	
\UART_DEB:tx\	P5[1]	

Pin Name	Development Kit	Comment
	CY8CKIT-062	
\UART_DEB:rts\	P5[2]	
\UART_DEB:cts\	P5[3]	
Advertising_LED	P1[1]	The green color of the RGB LED
Disconnect_LED	P0[3]	The red color of the RGB LED
Alert_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 to demonstrate operation of the Environmental Sensing Sensor device.	See the Parameter Settings section
Digital Input Pin	SW2	This pin is used to generate interrupts when the user button (**SW2**) is pressed.	**[General tab]** Uncheck HW connection Drive mode: Resistive Pull Up
Digital Output pin	Disconnect_LED Advertising_LED Alert_LED	These GPIOs are configured as firmware-controlled digital output pins that control LEDs.	**[General tab]** Uncheck HW connection Drive mode: Strong Drive
SysInt	SW2_Int	This Component is configured to extract interrupts from GlobalSignal.	**[Basic tab]** DeepSleepCapable = true
GSRef	GlobalSignal	This Component is used to detect if any of the interrupt enabled pins triggered an interrupt. It is a separate resource from the dedicated port interrupts, and it has the ability to wake up the chip from deep-sleep mode	**[Basic tab]** Global signal name: HWCombined Port Interrupt (AllPortInt)
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

Figure 12. General Settings

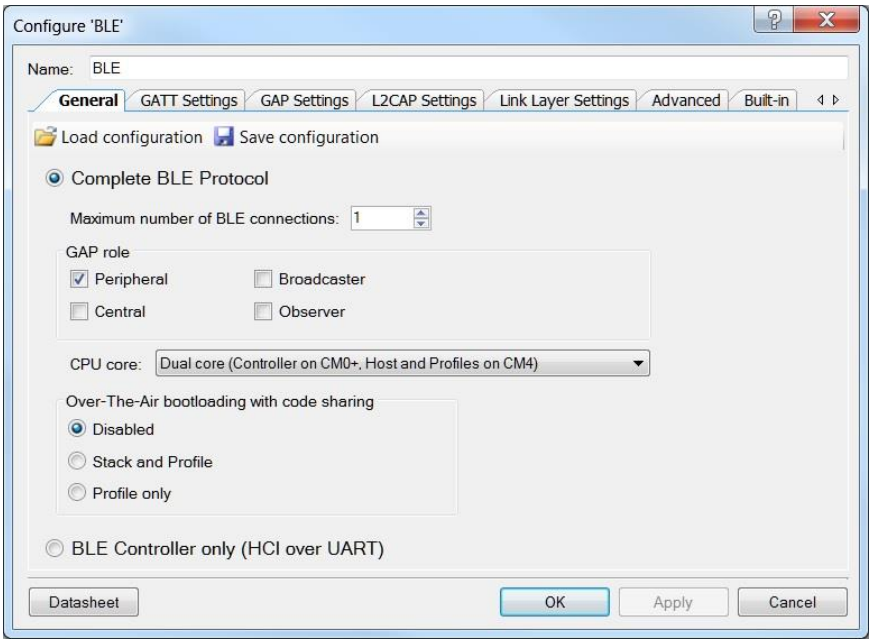


Figure 13. GATT Settings

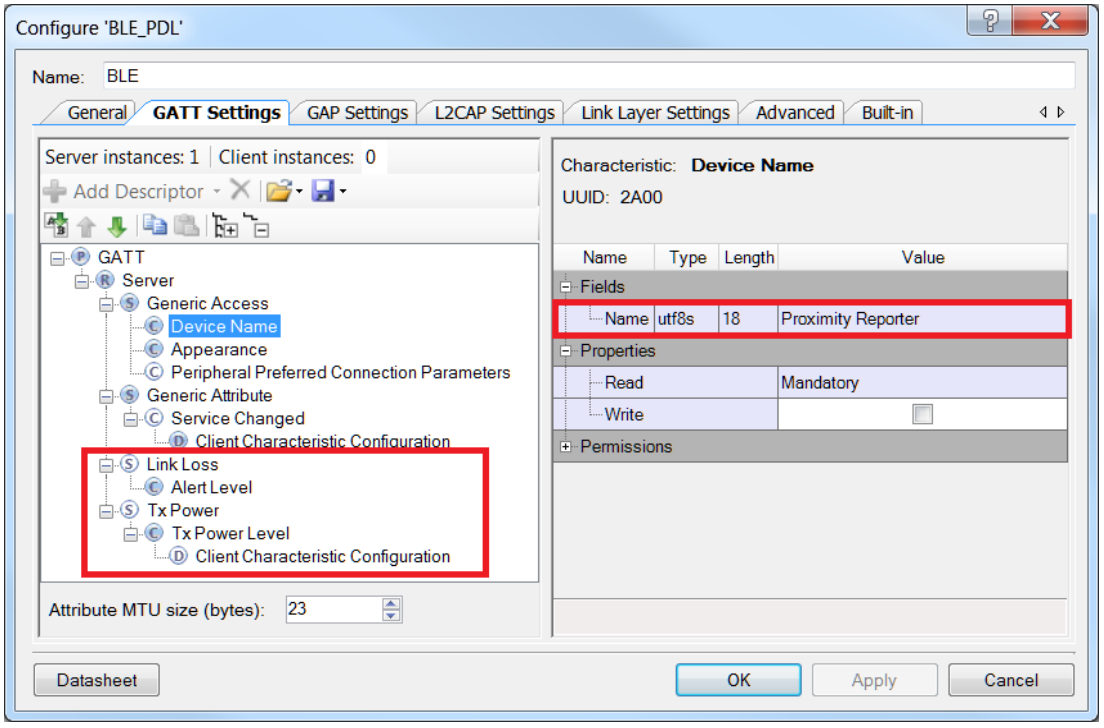


Figure 14. GAP Settings

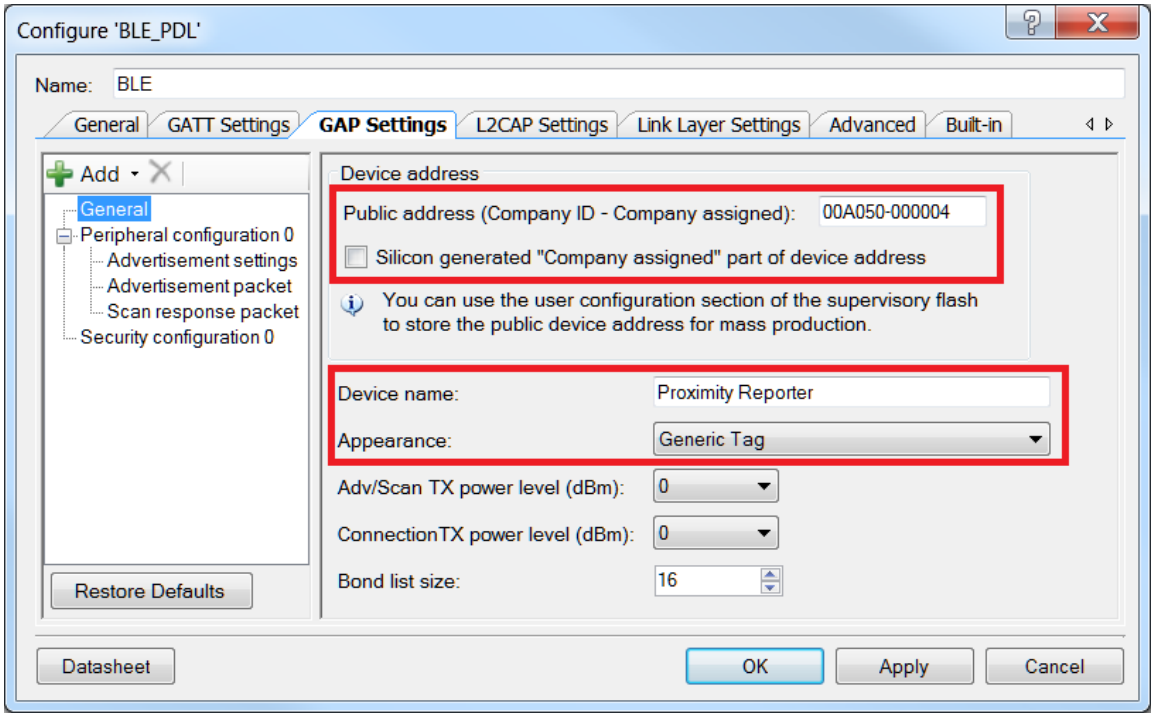


Figure 15. GAP Settings: Advertisement Settings

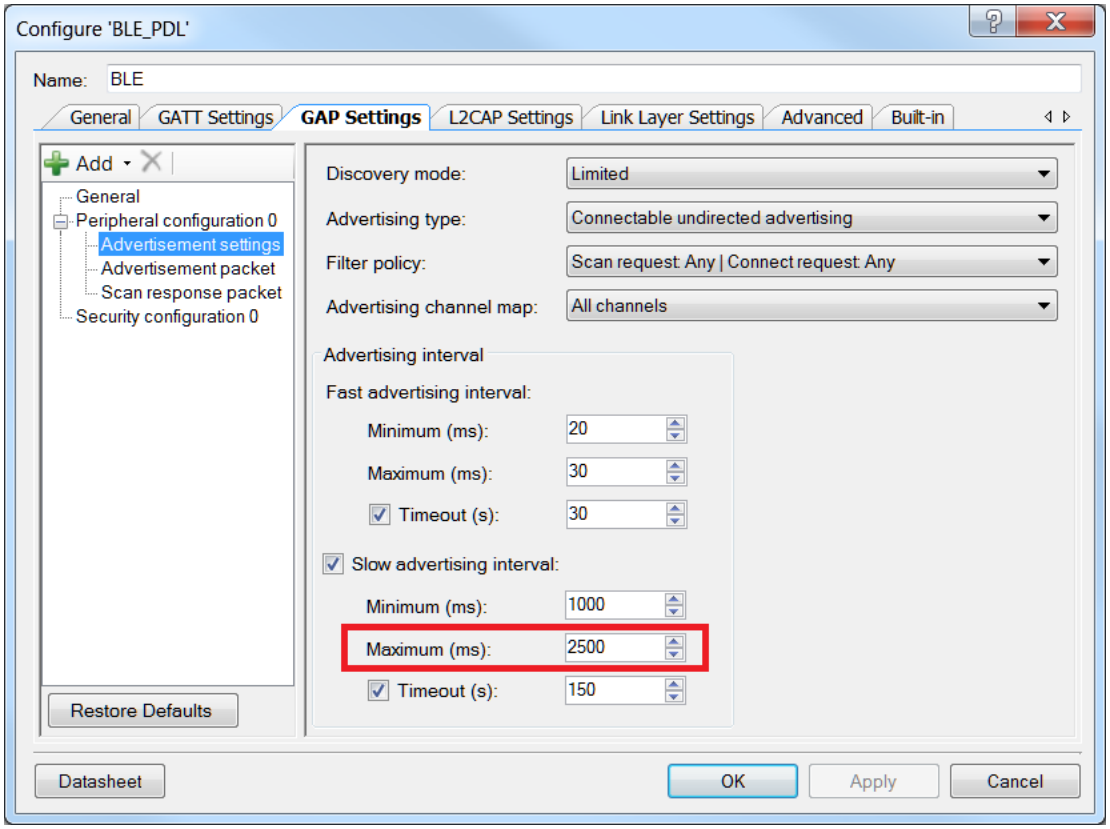


Figure 16. GAP Settings: Advertisement Packet

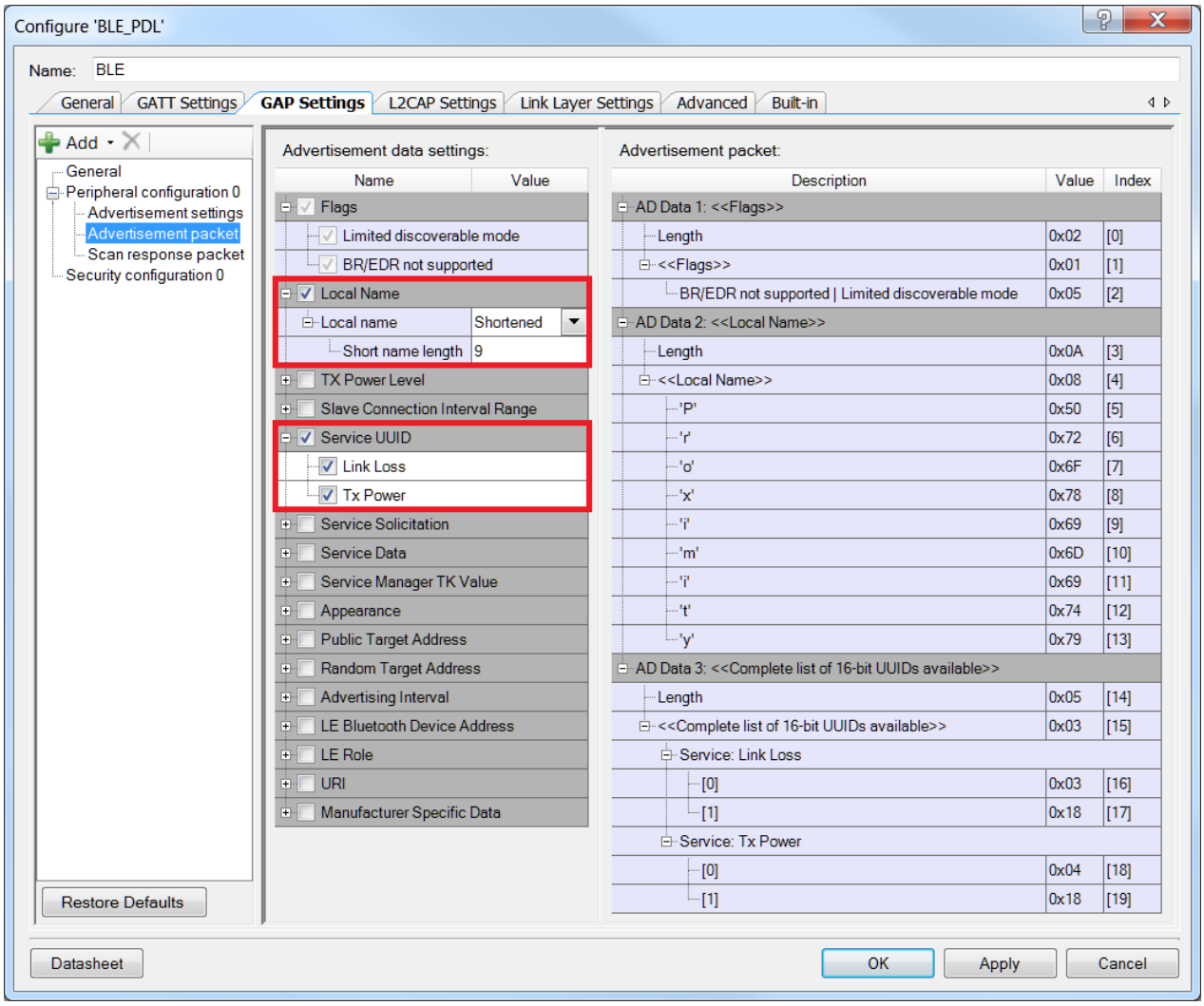
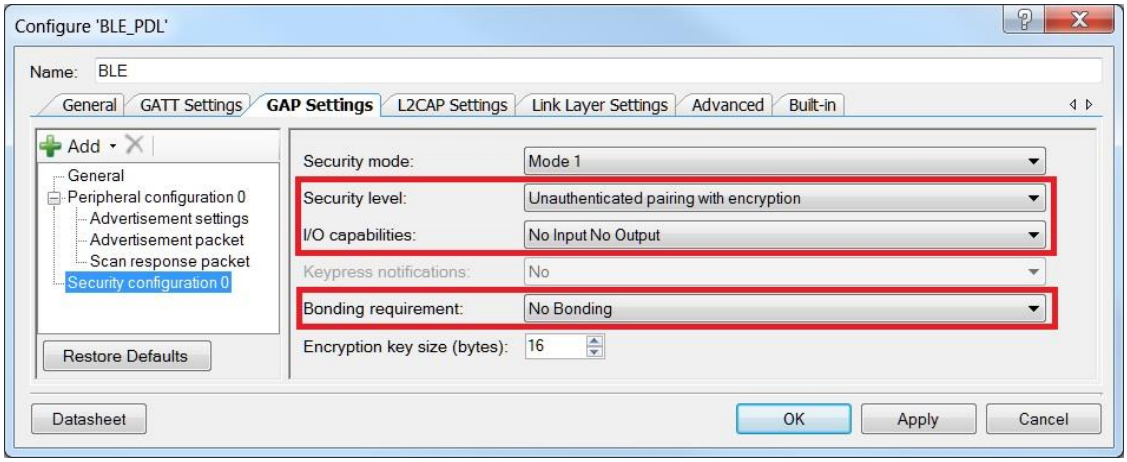


Figure 17. Security Settings



Switching the CPU Cores Usage

This section describes how to switch between different CPU cores usage (Single core and Dual core) in the BLE Peripheral Driver Library (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+ core will be used.
- **Single core (Complete Component on CM4)** – only CM4 core will be used.
- **Dual core (Controller on CM0+, Host and Profiles on CM4)** – both cores 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.

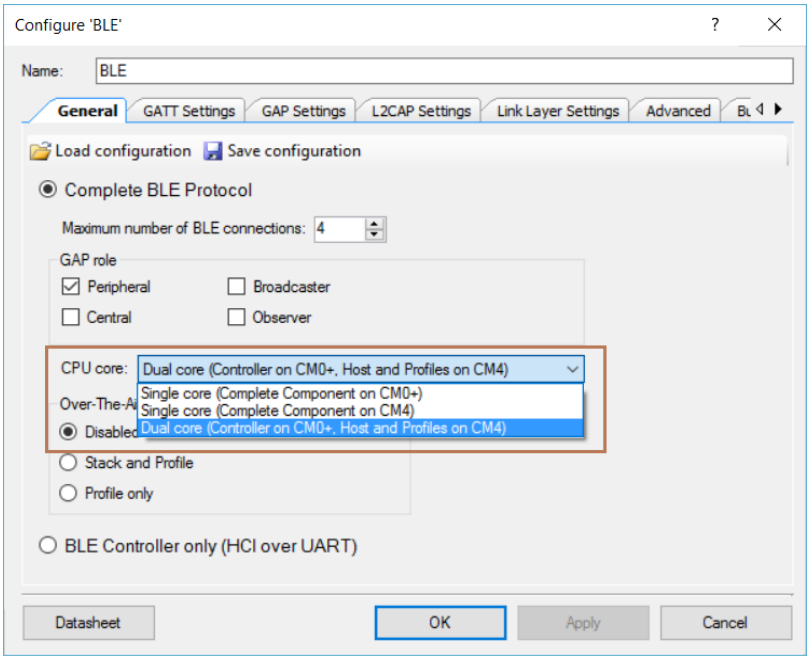
Important to remember:

- 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, MCWDT, and so on.) used in the example must be assigned to the host core.

Do the following to switch the CPU Cores usage:

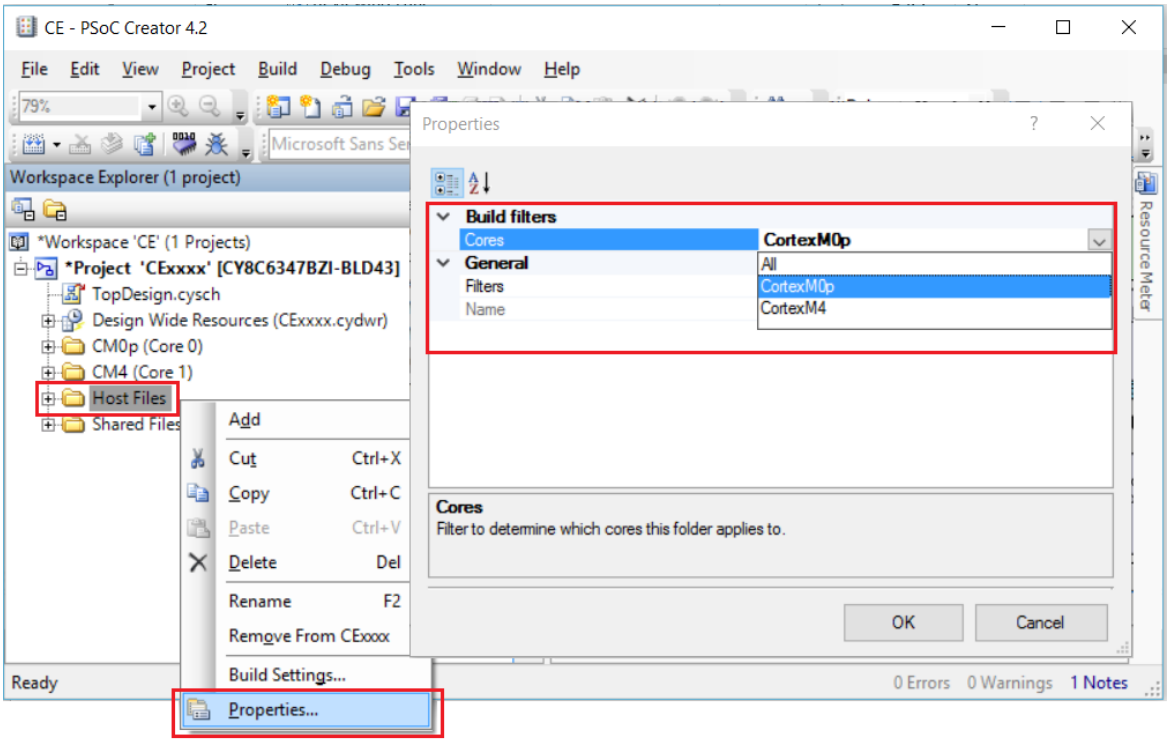
1. In the BLE Component Customizer **General** tab, select appropriate CPU core option.

Figure 18. Select CPU Core



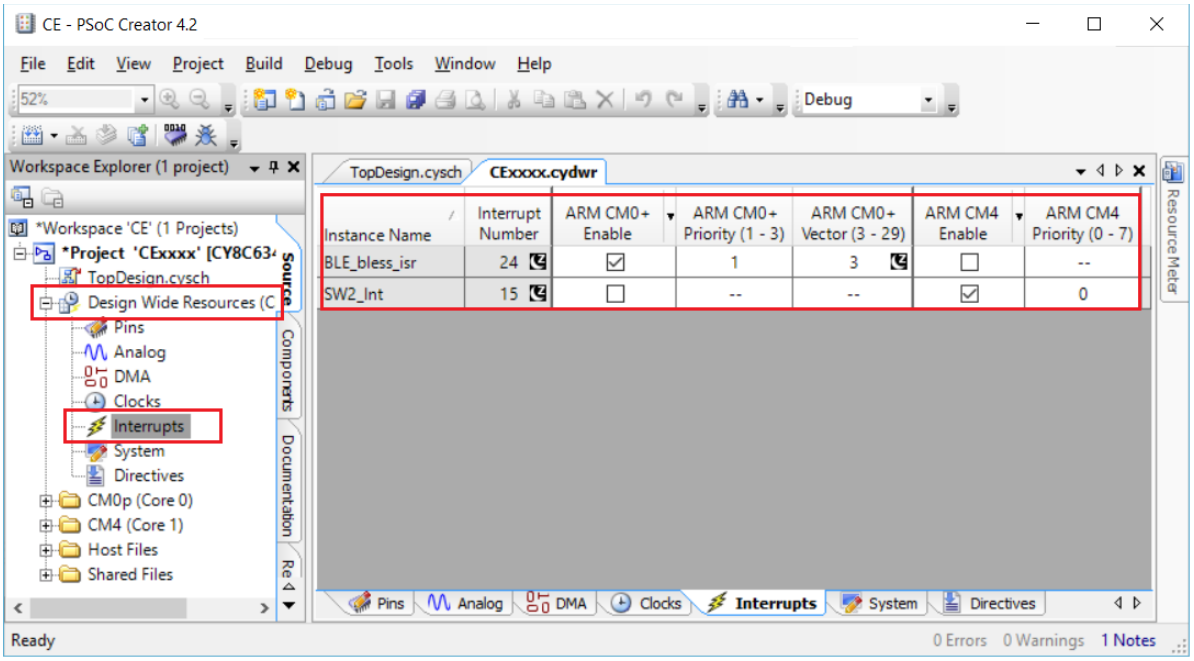
2. Identify the core on which host files will run. In the workspace explorer panel, right click **Host Files**, choose **Properties**. Set the **Cores** property corresponding to the CPU core chosen in step 1, as shown in Figure 19.
   - For **Single core (Complete Component on CM0+)** option – **CM0+**
   - For **Single core (Complete Component on CM4)** option – **CM4**
   - For **Dual core (Controller on CM0+, Host and Profiles on CM4)** option – **CM4**

Figure 19. Change Core Properties



3. Assign the BLE_bless_isr and other peripheral (button – SW2, timer(s), and so on) interrupts to 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 20. 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

Table 3. 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		

Document History

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Document Number: 002-17641

Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	6090386	NPAL	06/13/2018	New spec

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