Objective

This example demonstrates the Bluetooth Low Energy (BLE) Temperature Measurement Profile application workflow with PSoC® 6 MCU with BLE Connectivity (PSoC 6 BLE).

Overview

This example demonstrates the Health Thermometer Profile operation of the BLE Component. The device simulates thermometer readings and sends it over to the BLE Health Thermometer Service. It also simulates a battery level value and sends it over to the BLE Battery Service.

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. Refer to 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 less 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} > 2.7 volts is described in **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

The current temperature is increased and overlapped between 15 and 40 degree Celsius. The temperature unit flag is toggled on each temperature update. A fixed temperature type flag value of "Body (general)" is used.

The initial measurement interval value is set to 10 seconds. If a Central device writes a new value to the measurement interval, a Peripheral device updates the timer period and sends a notification on every measurement interval.

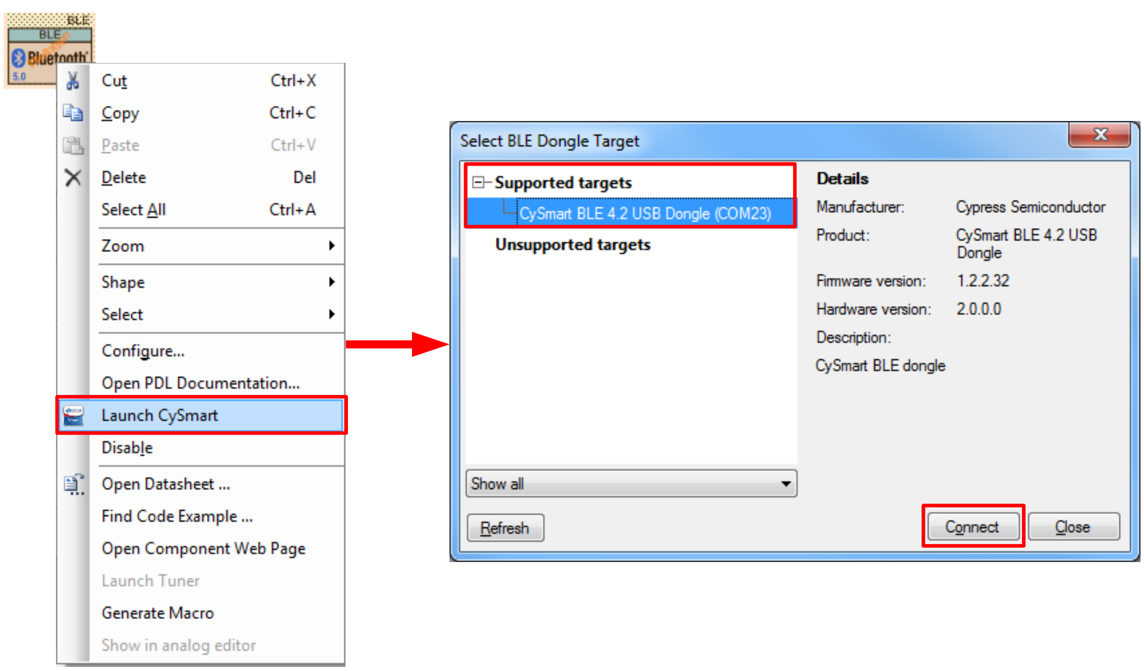
To indicate that the device is advertising, the green LED blinks. The red LED is turned ON after disconnection to indicate that no client is connected to the device. When a client is connected successfully, the red and green LEDs are turned OFF. When the measured battery voltage drops below the 10 percent limit, the blue LED will be ON.

For more details on the Health Thermometer Service characteristic data structures, see the HTS Specification.

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 application as Health Thermometer Service Client:
   a. Connect the BLE Dongle to your Windows PC. Wait for the driver installation to complete, if necessary.
   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**.
   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.

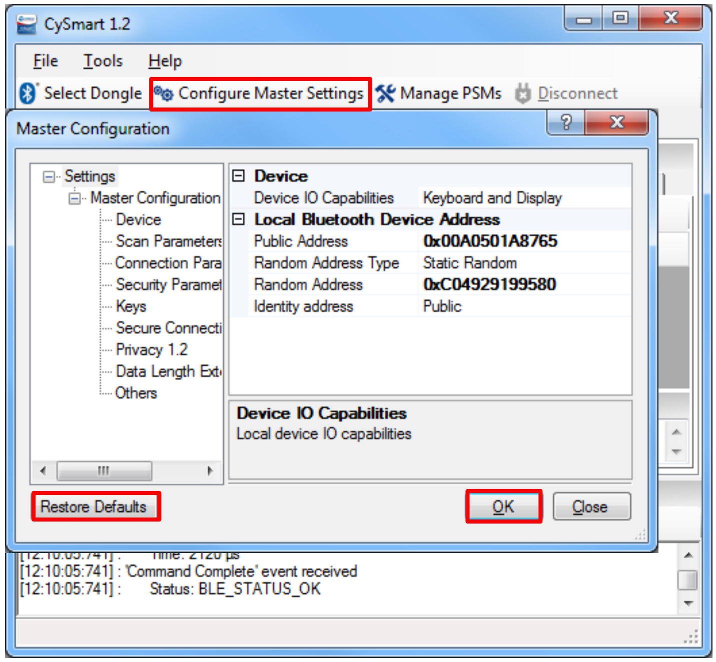
Figure 1. CySmart BLE Dongle Selection



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**.

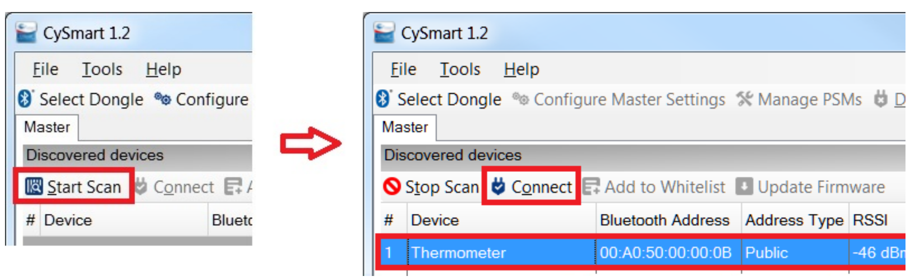
Figure 2. CySmart Master Settings Configuration



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

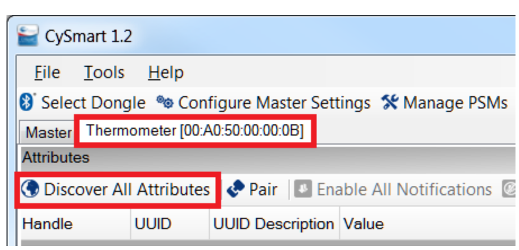
f. On the CySmart Host Emulation Tool, click **Start Scan**. Your device name (configured as **Health Thermometer Sensor**) should appear in the Discovered devices list, as Figure 3 shows. Select the device and click **Connect** to establish a BLE connection between the CySmart Host Emulation Tool and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

Figure 3. CySmart Device Discovery and Connection



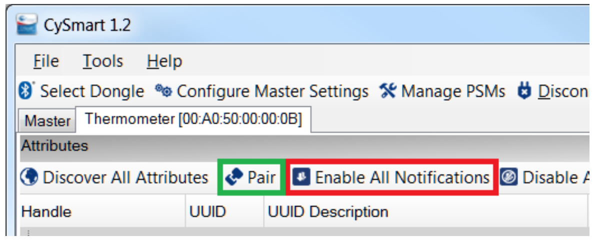
g. Once connected, switch to the '**Thermometer'** device tab and '**Discover all Attributes**' on your design from the CySmart Host Emulation Tool, as shown in Figure 4.

Figure 4. CySmart Attribute Discovery



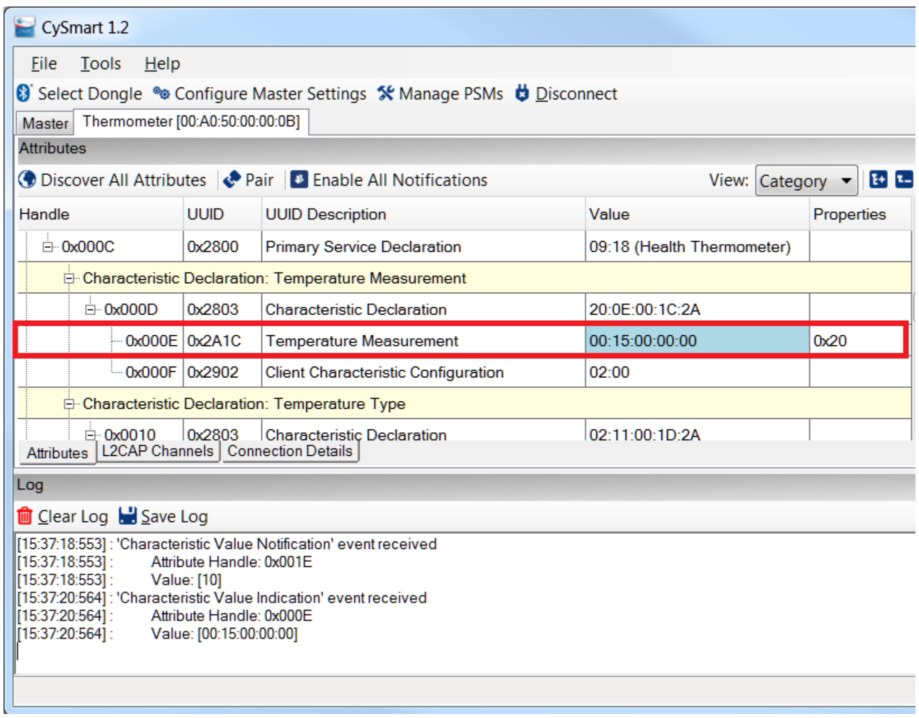
h. Click **Pair** after discovery finishes, then **Enable All Notifications** in the CySmart app as shown in Figure 5.

Figure 5. CySmart Pair and Enable All Notification



i. Observe the Temperature Measurement characteristic indications with measured (first) and simulated (to show changes) data.

Figure 6. Temperature Measurement characteristic indication in CySmart.



6. Do the following to test example, using the CySmart mobile app as Heals Thermometer Service Client:

   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 in order to wake up the device from Hibernate mode.

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

   d. The BLE device measures and sends the die temperature. You can notice the temperature unit changing every 10 seconds between °C (Celsius) and ºF (Fahrenheit).

Figure 7. CySmart App on Android

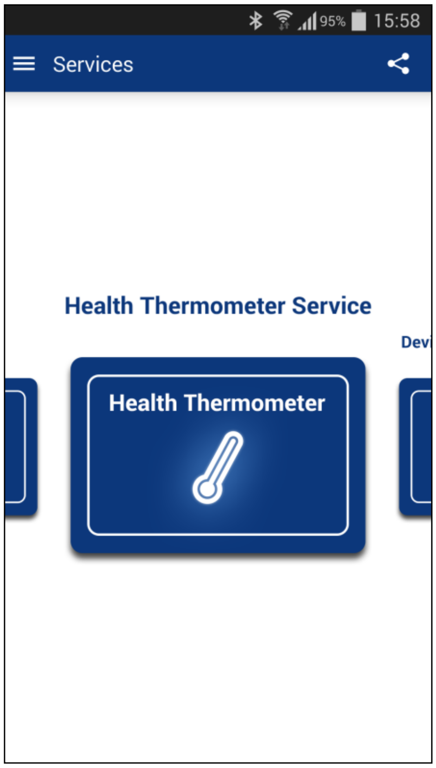


Figure 8. CySmart App on iOS Measurement Unit Is in Celsius

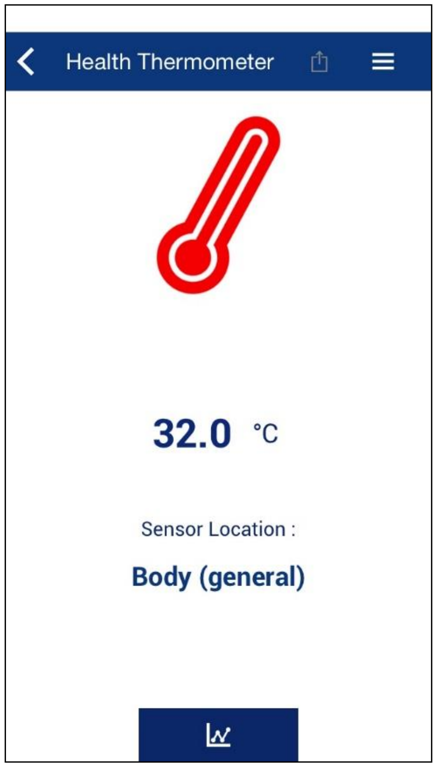
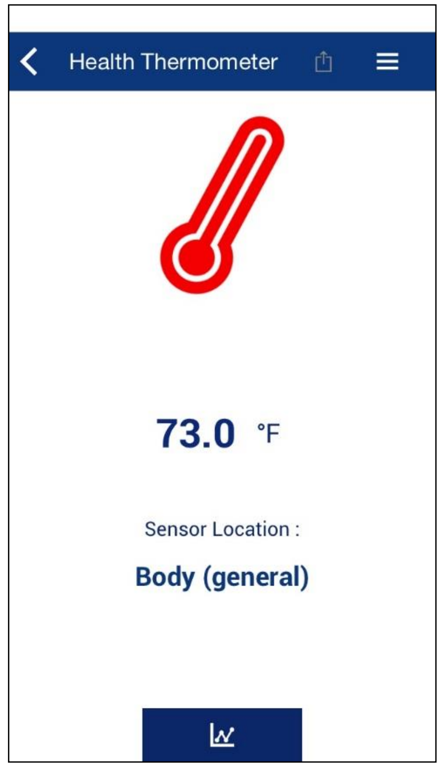


Figure 9. CySmart App on iOS Measurement Unit Is in Fahrenheit



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 Temperature Measurement Example project

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: 00a05000000b

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: 0, 4

CY_BLE_EVT_GAP_DEVICE_CONNECTED: connIntv = 7 ms

CY_BLE_EVT_GATTS_XCNHG_MTU_REQ

CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: 3

SimulBatteryLevelUpdate: 3

CY_BLE_EVT_GAP_AUTH_REQ: bdHandle=4, security=3, bonding=1, ekeySize=10, err=0

CY_BLE_EVT_GAP_SMP_NEGOTIATED_AUTH_INFO: bdHandle=4, security=1, bonding=1, ekeySize=10, err=0

CY_BLE_EVT_STACK_BUSY_STATUS: 1

CY_BLE_EVT_GAP_ENCRYPT_CHANGE: 0

CY_BLE_EVT_STACK_BUSY_STATUS: 0

CY_BLE_EVT_GAP_KEYINFO_EXCHNGE_CMPLT

CY_BLE_EVT_GAP_AUTH_COMPLETE: security:1, bonding:1, ekeySize:10, authErr 0

CY_BLE_EVT_PENDING_FLASH_WRITE

Store bonding data, status: 140001, pending: 1

Store bonding data, status: 140001, pending: 1

Store bonding data, status: 0, pending: 0

SimulBatteryLevelUpdate: 4

CY_BLE_EVT_GATTS_INDICATION_ENABLED

Store bonding data, status: 0, pending: 0

CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: b

HTS event: 100b5, CY_BLE_EVT_HTSS_INDICATION_ENABLED: char: 0

Store bonding data, status: 0, pending: 0

CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: f

BAS event: 10032, CY_BLE_EVT_BASS_NOTIFICATION_ENABLED 0 4: serviceIndex=0

Store bonding data, status: 0, pending: 0

CY_BLE_EVT_GATTS_READ_CHAR_VAL_ACCESS_REQ: handle: 20

MeasureTemperature: 15 C HTS event: 100b7, CY_BLE_EVT_HTSS_INDICATION_CONFIRMED

SimulBatteryLevelUpdate: 5

SimulBatteryLevelUpdate: 6

MeasureTemperature: 60 F HTS event: 100b7, CY_BLE_EVT_HTSS_INDICATION_CONFIRMED

SimulBatteryLevelUpdate: 7

SimulBatteryLevelUpdate: 8

MeasureTemperature: 17 C HTS event: 100b7, CY_BLE_EVT_HTSS_INDICATION_CONFIRMED

SimulBatteryLevelUpdate: 9

SimulBatteryLevelUpdate: 10

MeasureTemperature: 64 F HTS event: 100b7, CY_BLE_EVT_HTSS_INDICATION_CONFIRMED

SimulBatteryLevelUpdate: 11

SimulBatteryLevelUpdate: 12

MeasureTemperature: 19 C HTS event: 100b7, CY_BLE_EVT_HTSS_INDICATION_CONFIRMED

SimulBatteryLevelUpdate: 13

SimulBatteryLevelUpdate: 14

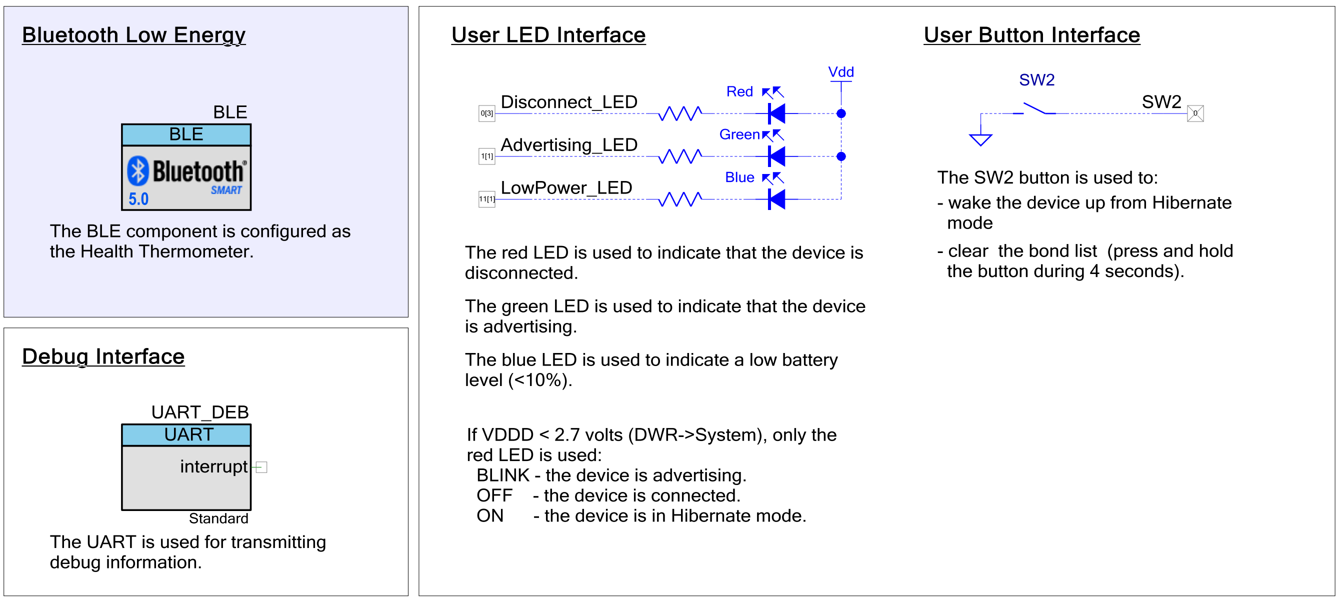
MeasureTemperature: 68 F HTS event: 100b7, CY_BLE_EVT_HTSS_INDICATION_CONFIRMED

Design and Implementation

This example demonstrates the Health Thermometer Profile operation of the BLE Component. The device simulates thermometer readings and sends it over to the BLE Health Thermometer Service. It also simulates a battery level value and sends it over to the BLE Battery Service.

Figure 10 shows the top design schematic.

Figure 10. BLE Temperature Measurement Code Example Schematic



The project demonstrates the core functionality of the BLE Component configured as a Health Thermometer GATT Server.

The callback function `AppCallBack()` is required to receive generic events from the BLE Stack. `CyBle_GAPP_StartAdvertisement()` API is called after `CY_BLE_EVT_STACK_ON` event to start advertising with the packet structure as configured in the BLE Component customizer. `HtsCallBack()` callback function receives events from the Health Thermometer Service. The other callback function `BasCallBack()` is required for receiving events from the BAS Services.

On an advertisement timeout, the system remains in Sleep mode. Press mechanical button **SW2** on the CY8CKIT-062 PSoC 6 BLE Pioneer Kit to wake up the system and start advertising.

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
	PSoC 6	
\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
LowPower_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.	Refer to 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 LowPower_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 Health Thermometer in the GAP Peripheral role. Also, the Battery and Device Information Services are included.

Figure 11. General Settings

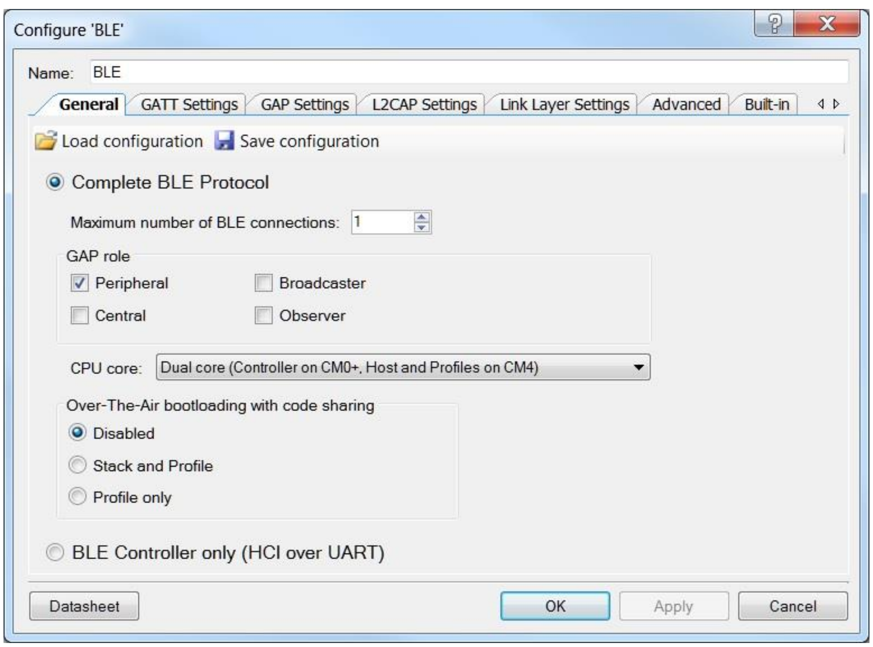


Figure 12. GATT Settings

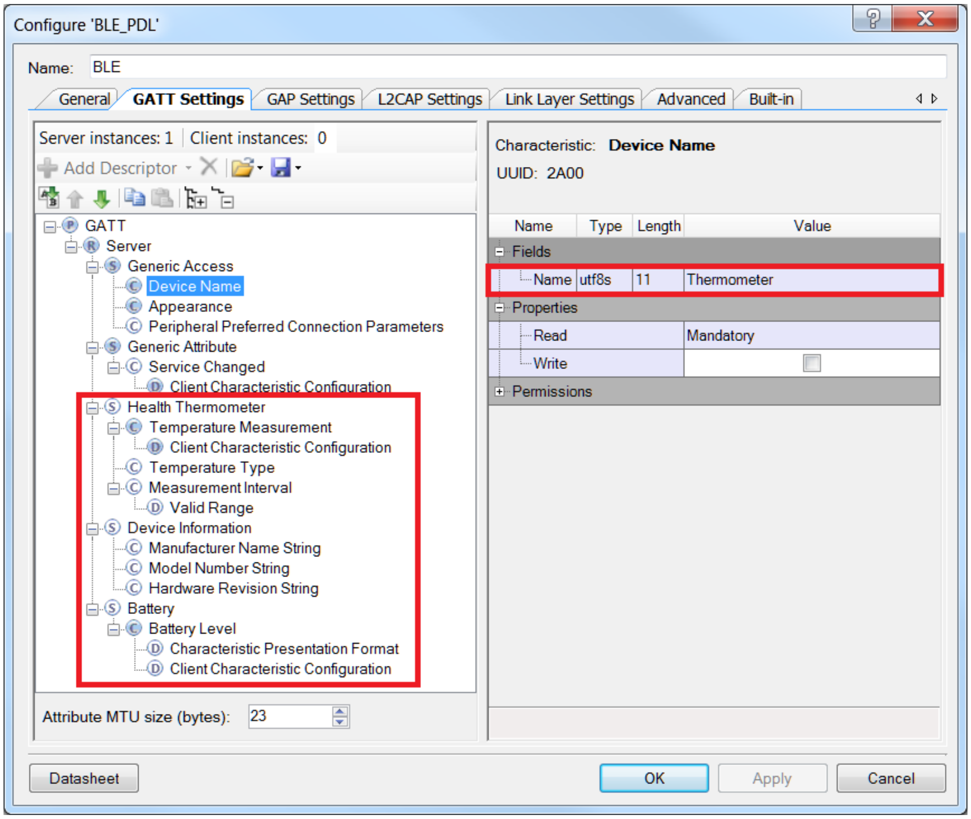


Figure 13. GAP Settings

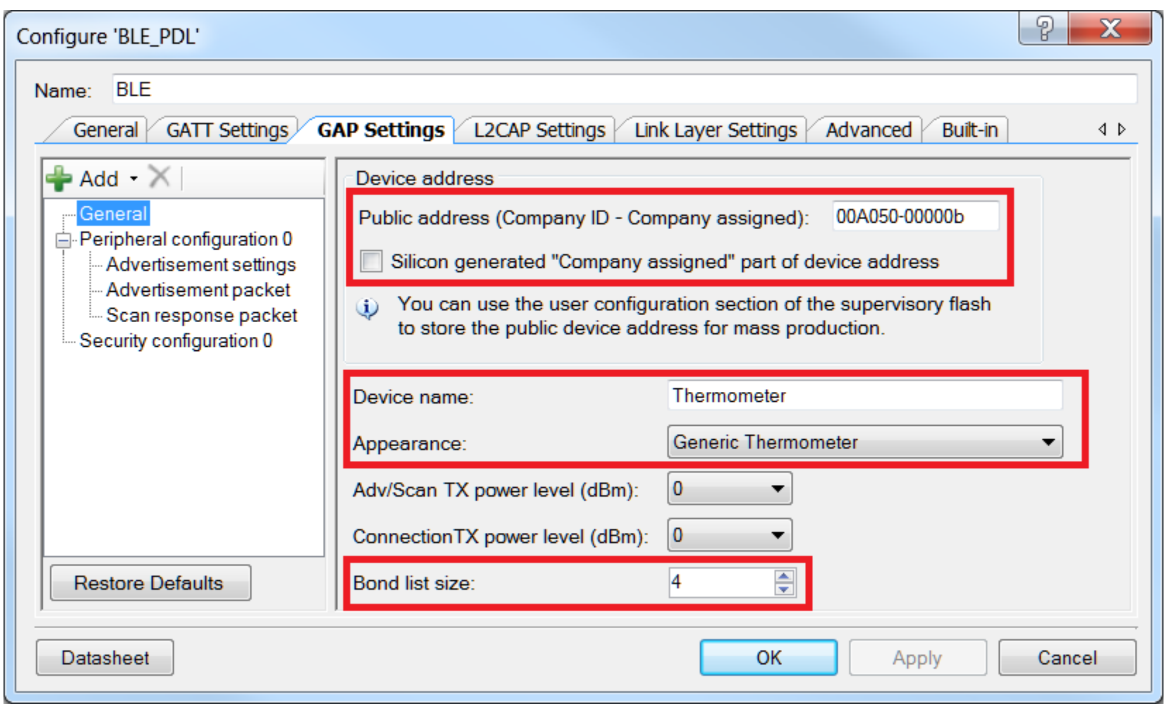


Figure 14. GAP Settings: Advertisement Settings

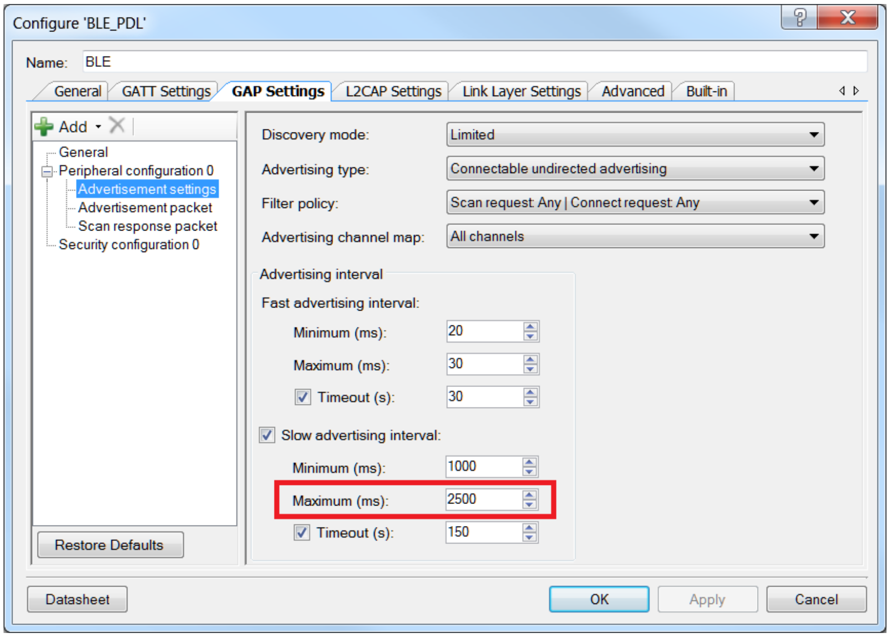


Figure 15. GAP Settings: Advertisement Packet

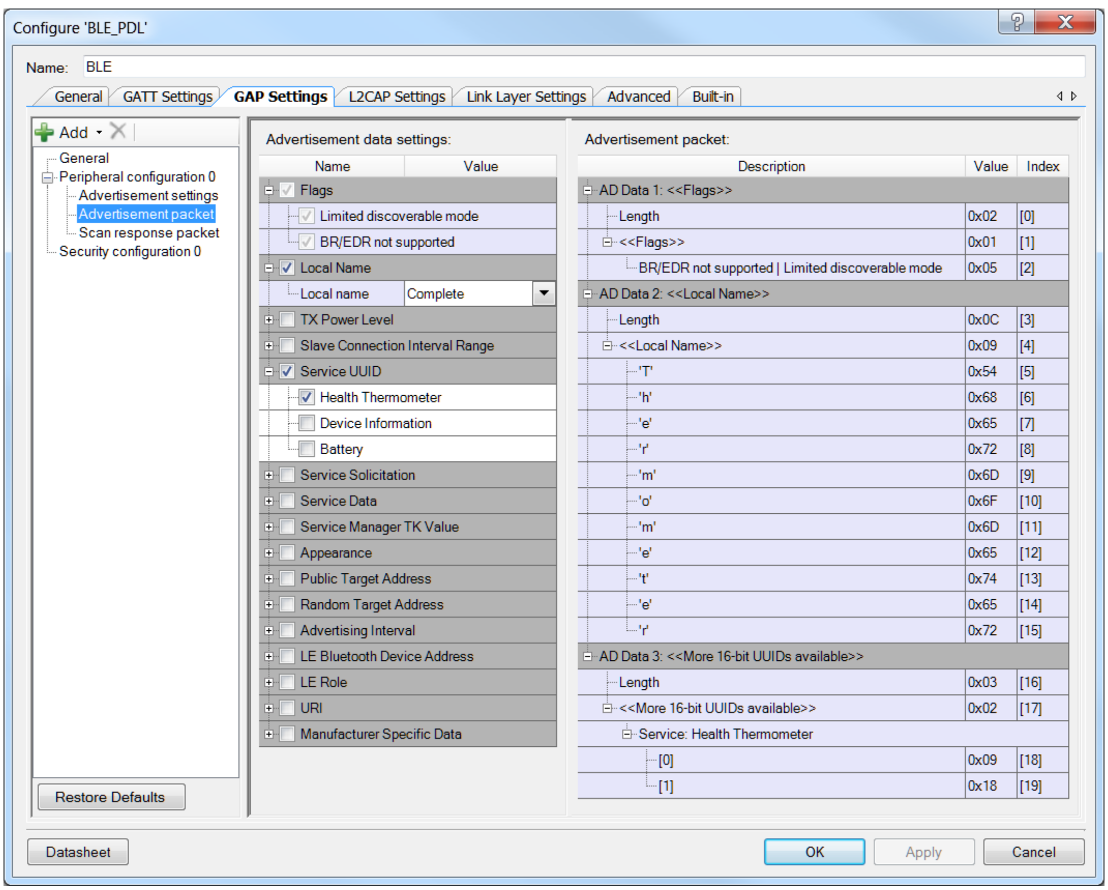
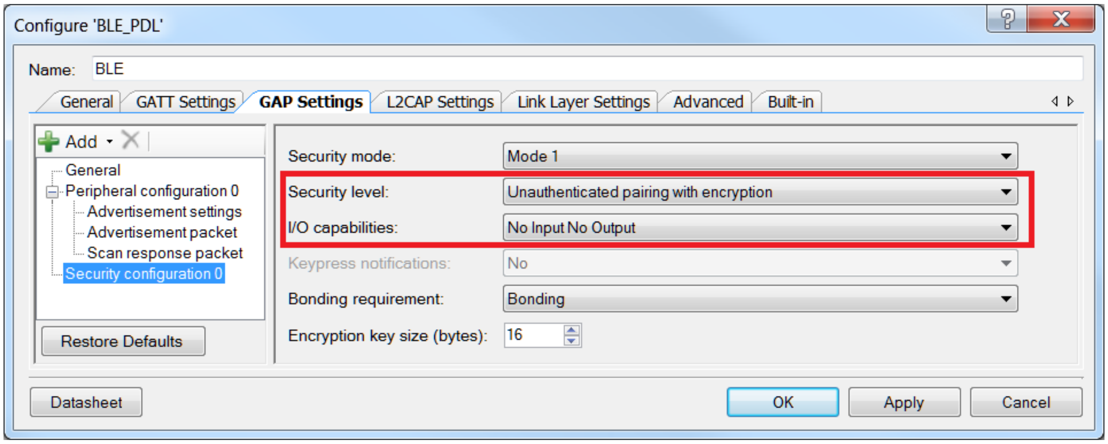


Figure 16. Security Settings



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+ 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.

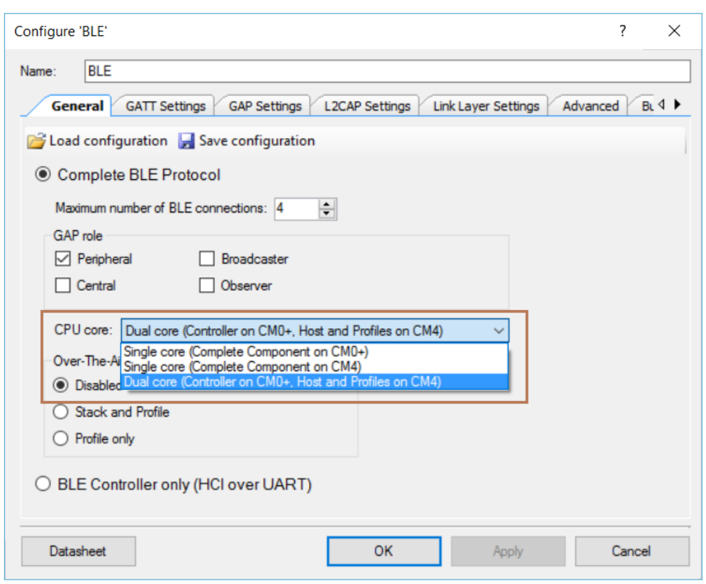
The BLE example structure allows easy switching between different CPU cores options. Important to remember:

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

Steps for switching the CPU Cores usage:

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

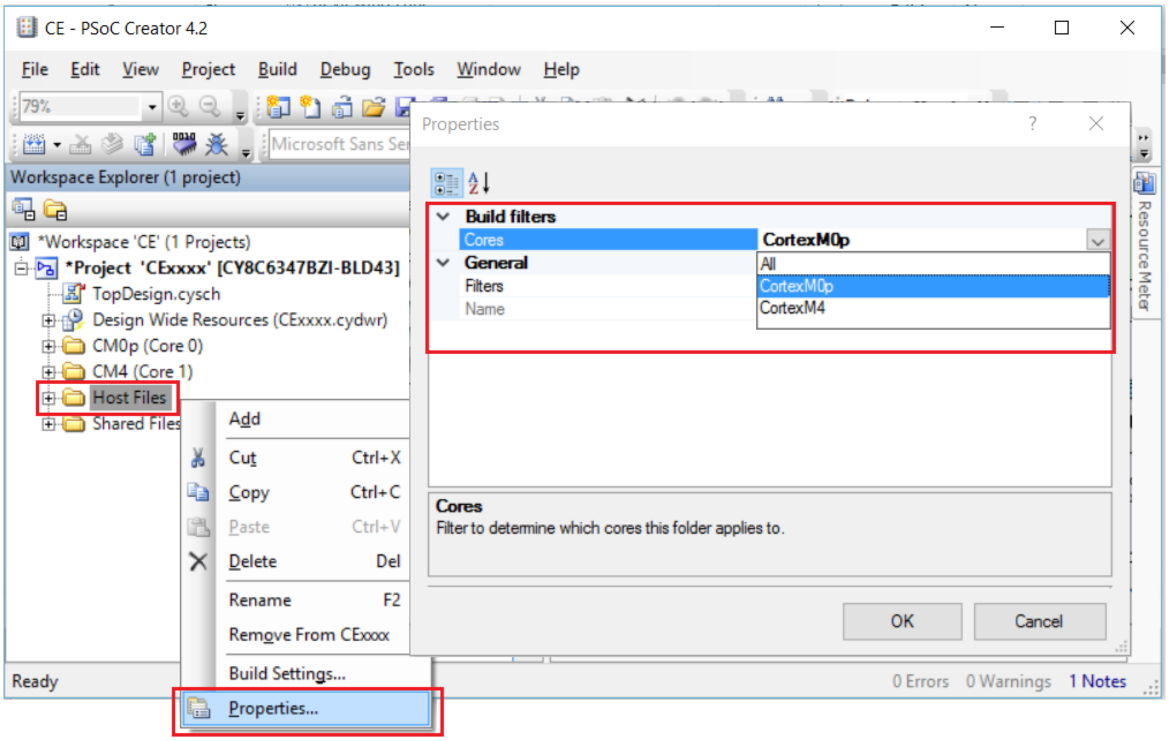
Figure 17. Select CPU Core



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 18.

   - 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

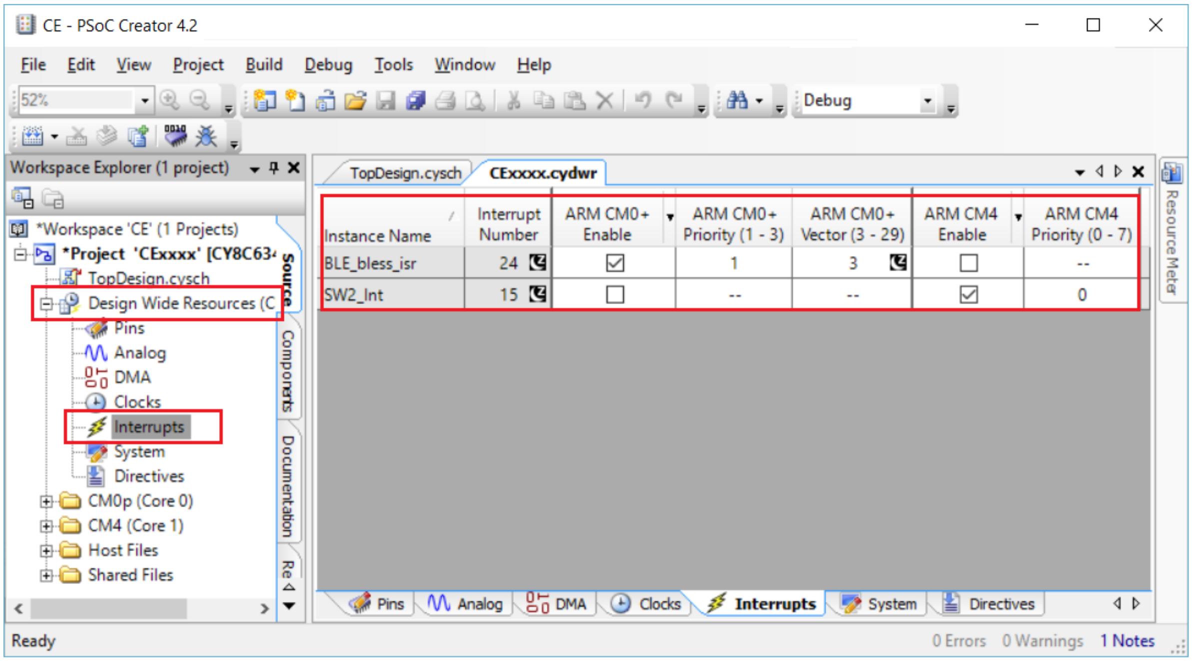
Figure 18. Change Core Properties



3. Assign BLE_bless_isr and other peripheral (button – SW2, timer(s) etc.) 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 19. 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 and/or kit, 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		

Document History

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**	6091562	NPAL	06/01/2018	New spec

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