Objective

This example demonstrates the operation of Bluetooth Low Energy (BLE) Battery Service (BAS) using the BLE_PDL Component.

Overview

The design implements a Custom Profile in a GATT server and generic attribute profile (GAP) peripheral roles with the Battery and Device Information services. The Battery Service is used for software simulation of the battery level. The simulated battery level value is continuously changed from 2 to 20 percent.

Requirements

Tool: PSoC Creator™ 4.2 or later

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

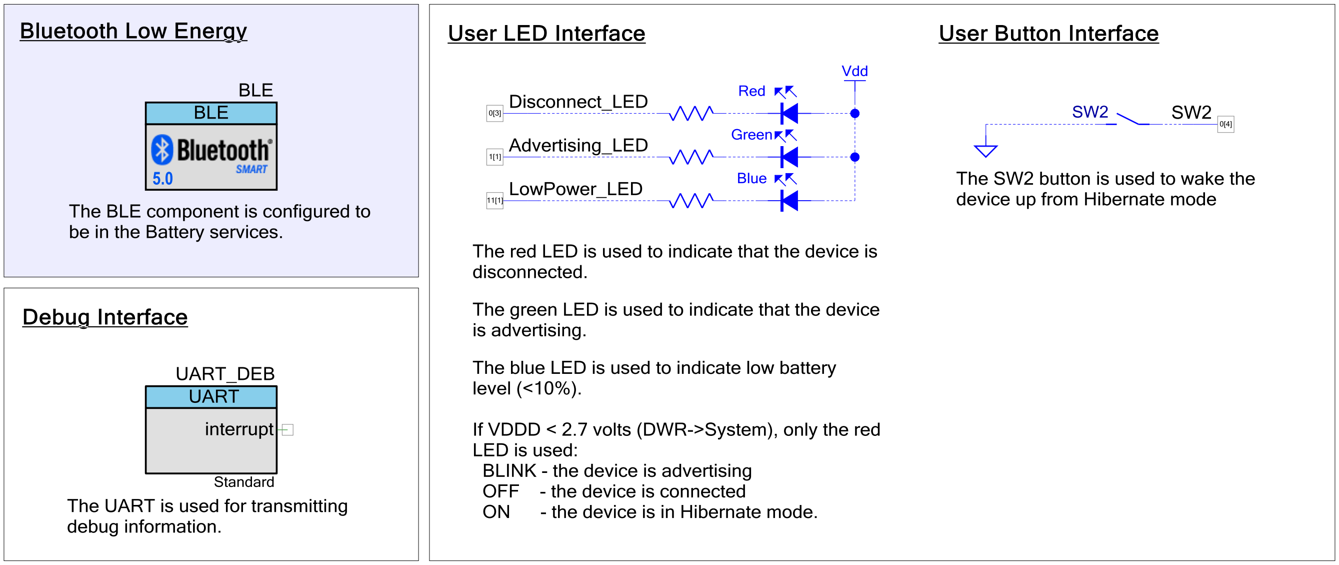
Associated Parts: All PSoC® 6 MCU with BLE Connectivity (PSoC 6 BLE) parts

Related Hardware: CY8CKIT-062 PSoC 6 BLE Pioneer Kit

Design

Figure 1 shows the top design schematic.

Figure 1. BLE Battery Level Code-Example Schematic



The BLE component is configured to be in the Battery services.

The UART is used for transmitting debug information.

The red LED is used to indicate that the device is disconnected.

The green LED is used to indicate that the device is advertising.

The blue LED is used to indicate low battery level (<10%).

If VDDD < 2.7 volts (DWR->System), only the red LED is used:
BLINK - the device is advertising
OFF - the device is connected
ON - the device is in Hibernate mode.

The SW2 button is used to wake the device up from Hibernate mode

After a start, the device performs the BLE Component initialization. Two callback functions are required in this project for the BLE operation:

- `AppCallBack()` is required to receive generic events from the BLE stack.
- `BasCallBack()` is required to receive events from the BAS service.

The `CY_BLE_GAPP_StartAdvertisement()` function is called after the `CY_BLE_EVT_STACK_ON` event to start advertising with the packet shown in Figure 7.

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

On an advertisement event timeout, if the device is not connected to a client, the device goes to Low-Power mode (Sleep mode) and waits for a **SW2** button press to wake up the device again and start advertising. While the device is in Hibernate mode, the red LED is turned ON.

Design Considerations

This code example is designed for the PSoC 6 MCU with BLE family and associated with CY8CKIT-062 PSoC 6 BLE. The design is easily portable to other PSoC MCU with BLE devices and kits, typically by just changing the device and components' pin assignments.

Hardware Setup

The code example was created for the CY8CKIT-062 PSoC 6 BLE Pioneer Kit.

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

Table 1. Pin Assignment

Pin Name	Development Kit	Comment
	CY8CKIT-062	
\UART_DEB:rx\	P5[0]	
\UART_DEB:tx\	P5[1]	
\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
LowPower_LED	P11[1]	The blue color of the RGB LED
SW2	P0[4]	

LED Behavior for V_{DDD} voltage < 2.7 V

If the V_{DDD} voltage is set to less than 2.7 V in the DWR settings of the **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.

Software Setup

Using UART for Debugging

A HyperTerminal program is required in a PC to receive debug information. If you don't have a HyperTerminal program installed, download and install any serial port communication program. Freeware such as HyperTerminal, Bray's Terminal, or PuTTY is available on the web.

1. Connect the PC and kit with a USB cable.
2. Open the device manager program in your PC, find the COM port in which the kit is connected, and note the port number.
3. Open the HyperTerminal program and select the COM port to which the kit is connected.
4. Configure the Baud rate, Parity, Stop bits, and Flow control information in the HyperTerminal configuration window. The default settings: Baud rate – 115200, Parity – None, Stop bits – 1 and Flow control – XON/XOFF. These settings must match the configuration of the PSoC Creator UART component in the project.
5. Start communicating with the device as explained in the project description.

The UART debugging can be disabled by setting the `DEBUG_UART_ENABLED` to `DISABLED` in *common.h*.

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 examples' structure allows easy switching between different CPU cores options.

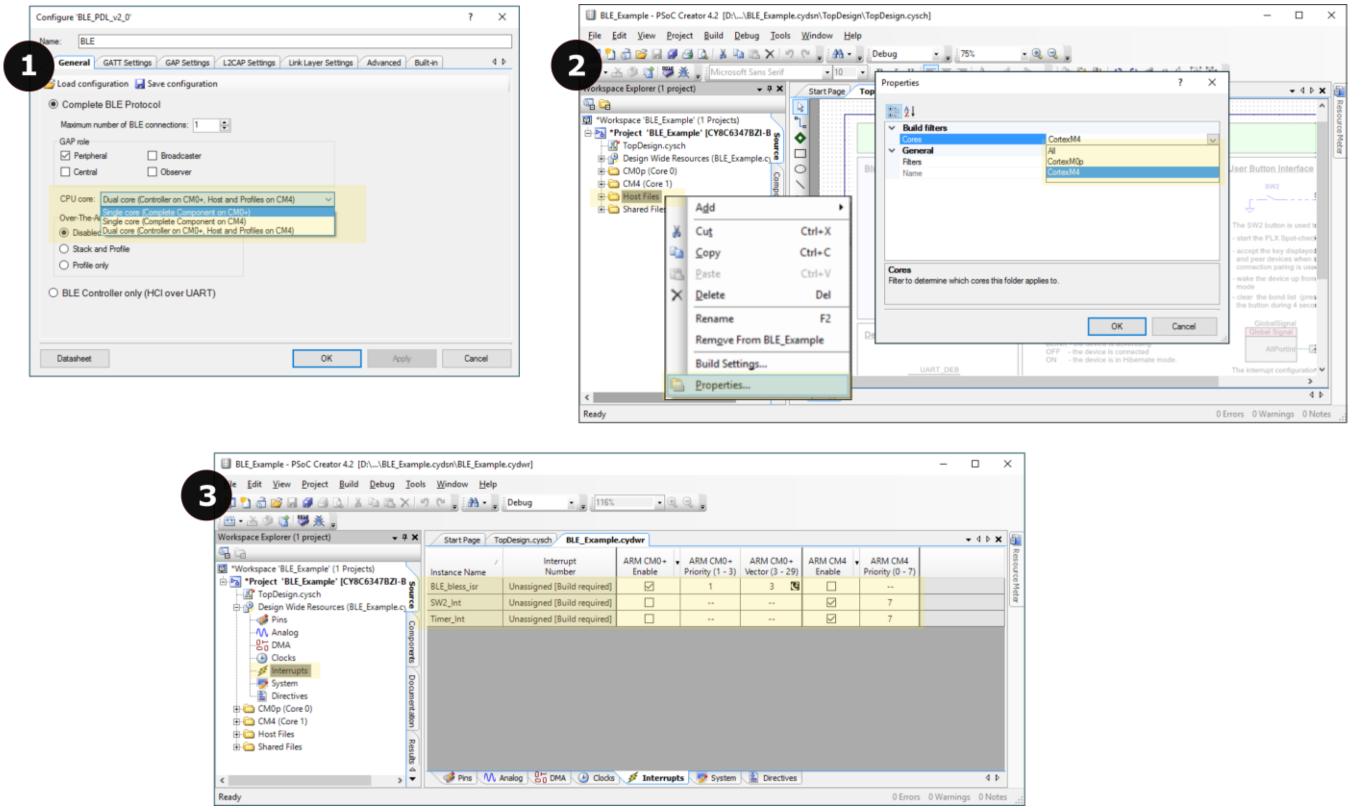
Important to remember:

- 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, 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 Component Customizer **General** tab, select appropriate CPU core option.
2. Change the core properties to CortexM4 or CortexC0p for the project folder Host Files based on the CPU core option selected in step 1. It should be:
   - 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
3. Assign the BLE_bless_isr and other peripheral (button – SW2, timer(s) etc.) 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 2. Steps for Switching the CPU Cores Usage



1. Configure 'BLE_PDL_v2_0'

Name: BLE

General | GATT Settings | GAP Settings | L2CAP Settings | Link Layer Settings | Advanced | Built-in

● Complete BLE Protocol

Maximum number of BLE connections: 1

GAP role

☑ Peripheral ☐ Broadcaster
☐ Central ☐ Observer

CPU core: Dual core (Controller on CM0+, Host and Profiles on CM4)

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

Over-The-Air: ● Disabled ○ Stack and Profile ○ Profile only

○ BLE Controller only (HCI over UART)

2. BLE_Example - PSoC Creator 4.2 [D:\...\BLE_Example.cydsn\TopDesign\TopDesign.cysch]

Workspace 'BLE_Example' (1 Projects) – Project 'BLE_Example' [CY8C6347BZI-B...] – TopDesign.cysch, Design Wide Resources, CM0p (Core 0), CM4 (Core 1), Host Files, Shared Files

Properties – Build filters – Cores: CortexM4 (All, CortexM0p, CortexM4)

Cores: Filter to determine which cores this folder applies to.

3. BLE_Example - PSoC Creator 4.2 [D:\...\BLE_Example.cydsn\BLE_Example.cydwr] – Interrupts

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	Unassigned [Build required]	☑	1	3	☐	--
SW2_Int	Unassigned [Build required]	☐	--	--	☑	7
Timer_Int	Unassigned [Build required]	☐	--	--	☑	7

Components

Table 2 lists the PSoC Creator Components used in this example and the hardware resources used by each of the components.

Table 2. PSoC Creator Components List

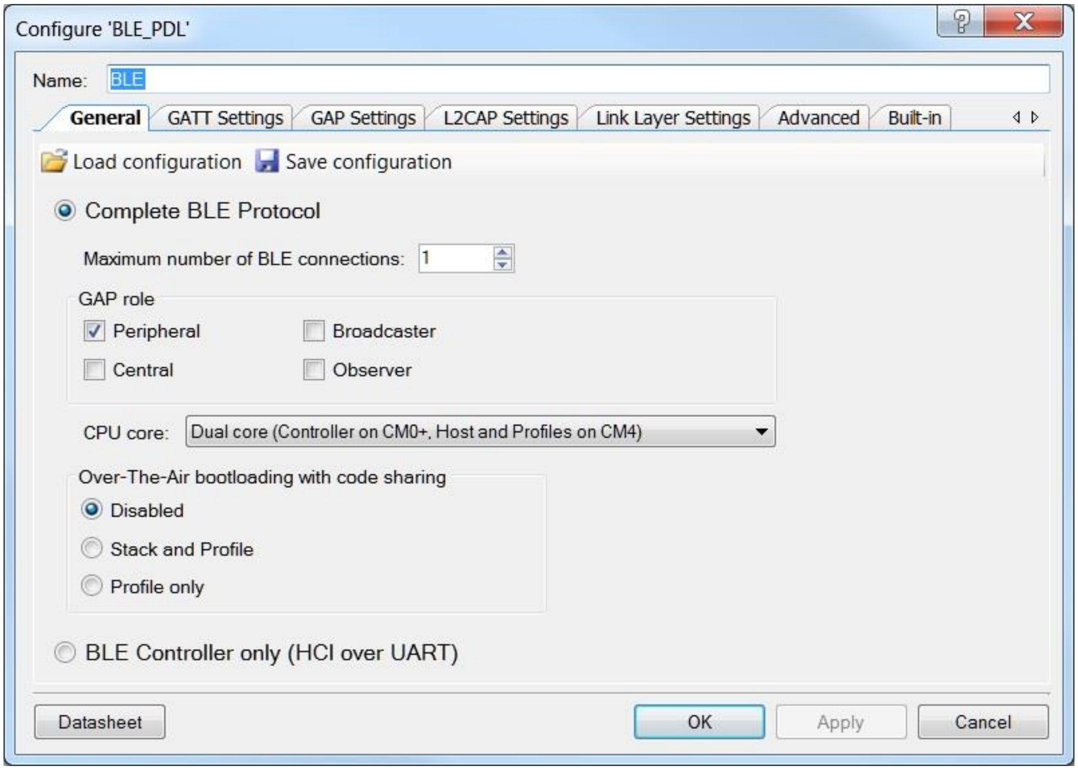
Component	Hardware Resources
UART_DEB	1 SCB
BLE	1 BLE, 1 Interrupt
SW2	1 pin
Disconnect_LED, Advertising_LED, LowPower_LED	3 pins

Parameter Settings

BLE_PDL Component

The BLE Component implements a custom profile in the peripheral GAP role with the Battery and Device Information services. The Device Information Service is added with the manufacture name string characteristic.

Figure 3. General Settings



Configure 'BLE_PDL'

Name: BLE

● Complete BLE Protocol

Maximum number of BLE connections: 1

GAP role

☑ Peripheral ☐ Broadcaster

☐ Central ☐ Observer

CPU core: Dual core (Controller on CM0+, Host and Profiles on CM4)

Over-The-Air bootloading with code sharing

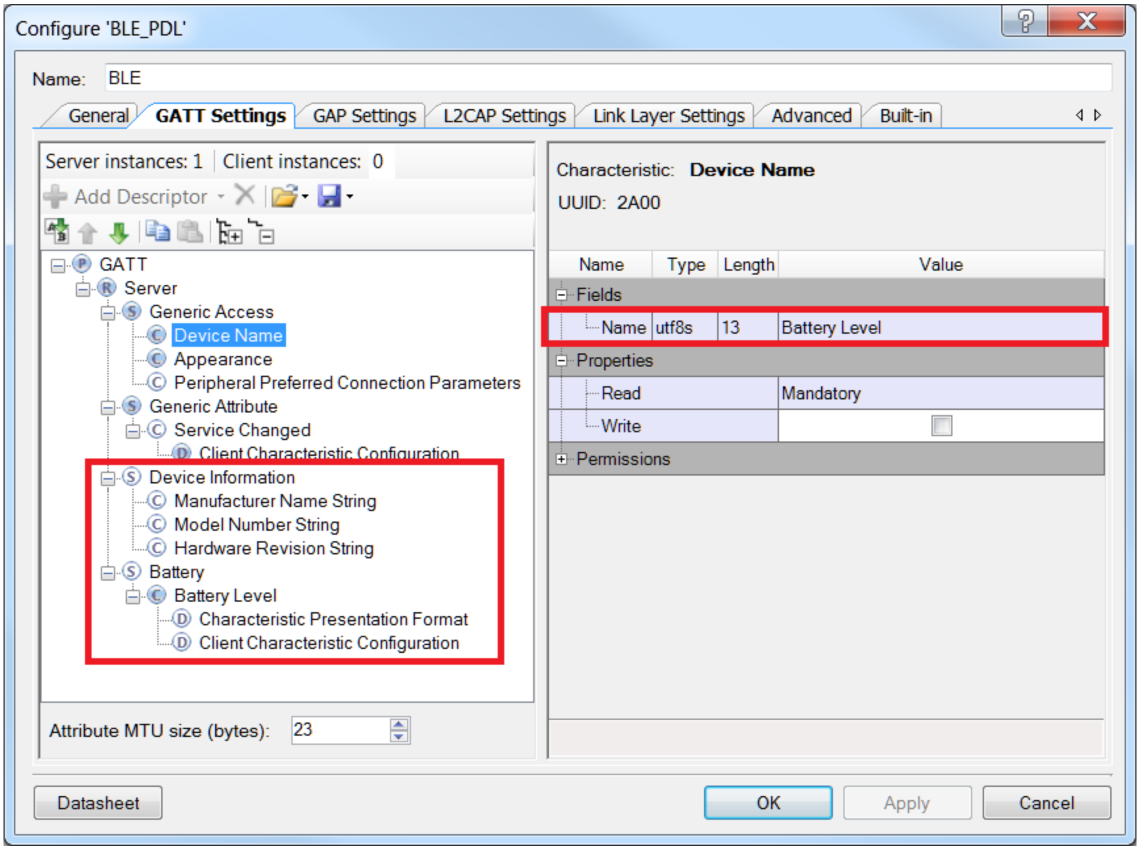
● Disabled

○ Stack and Profile

○ Profile only

○ BLE Controller only (HCI over UART)

Figure 4. GATT Settings



Configure 'BLE_PDL'

Name: BLE

Server instances: 1 | Client instances: 0

- GATT
  - Server
    - Generic Access
      - Device Name
      - Appearance
      - Peripheral Preferred Connection Parameters
    - Generic Attribute
      - Service Changed
        - Client Characteristic Configuration
    - Device Information
      - Manufacturer Name String
      - Model Number String
      - Hardware Revision String
    - Battery
      - Battery Level
        - Characteristic Presentation Format
        - Client Characteristic Configuration

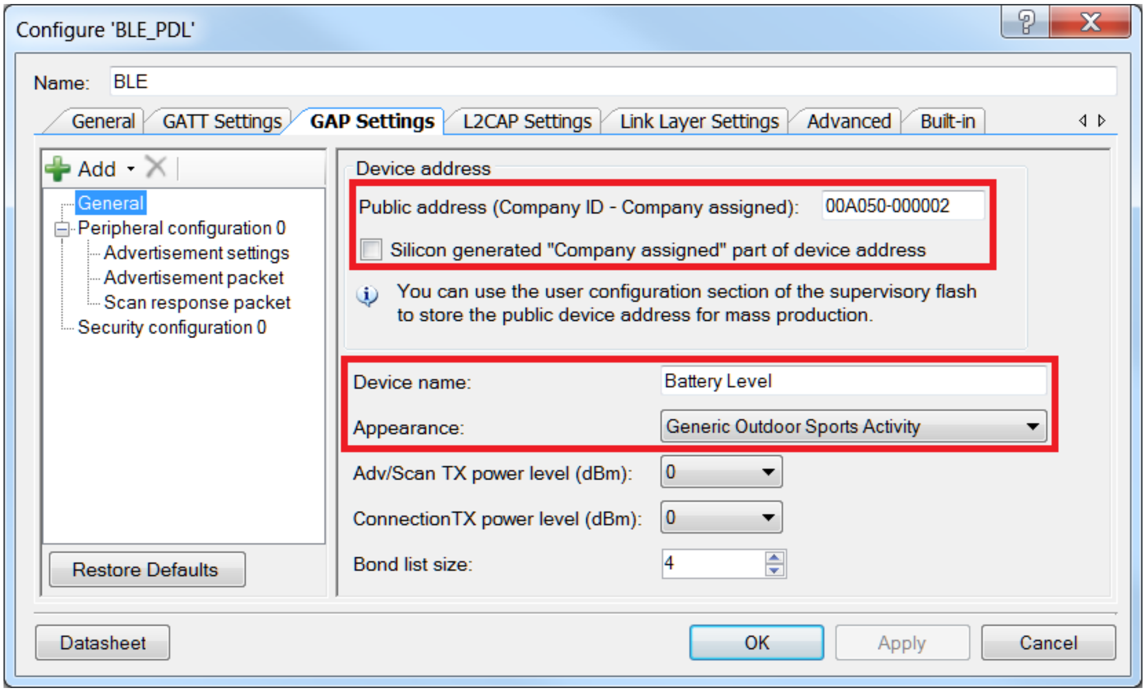
Attribute MTU size (bytes): 23

Characteristic: **Device Name**

UUID: 2A00

Name	Type	Length	Value
Fields			
Name	utf8s	13	Battery Level
Properties			
Read			Mandatory
Write			□
Permissions			

Figure 5. GAP Settings



Configure 'BLE_PDL'

Name: BLE

- General
- Peripheral configuration 0
  - Advertisement settings
  - Advertisement packet
  - Scan response packet
- Security configuration 0

Device address

Public address (Company ID - Company assigned): 00A050-000002

□ Silicon generated "Company assigned" part of device address

You can use the user configuration section of the supervisory flash to store the public device address for mass production.

Device name: Battery Level

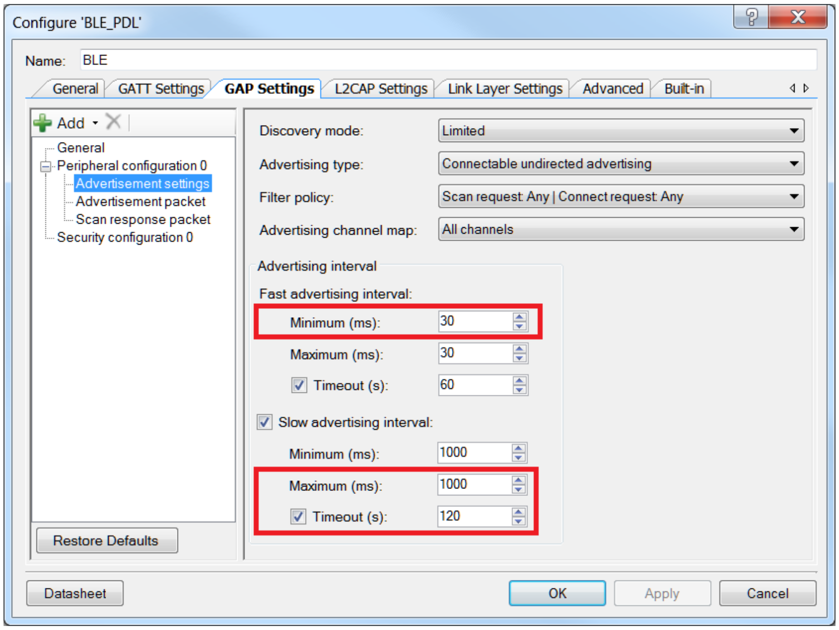
Appearance: Generic Outdoor Sports Activity

Adv/Scan TX power level (dBm): 0

ConnectionTX power level (dBm): 0

Bond list size: 4

Figure 6. GAP Settings: Advertisement Settings



Configure 'BLE_PDL'

Name: BLE

- General
- Peripheral configuration 0
  - Advertisement settings
  - Advertisement packet
  - Scan response packet
- Security configuration 0

Discovery mode: Limited

Advertising type: Connectable undirected advertising

Filter policy: Scan request: Any | Connect request: Any

Advertising channel map: All channels

Advertising interval

Fast advertising interval:

Minimum (ms): 30

Maximum (ms): 30

☑ Timeout (s): 60

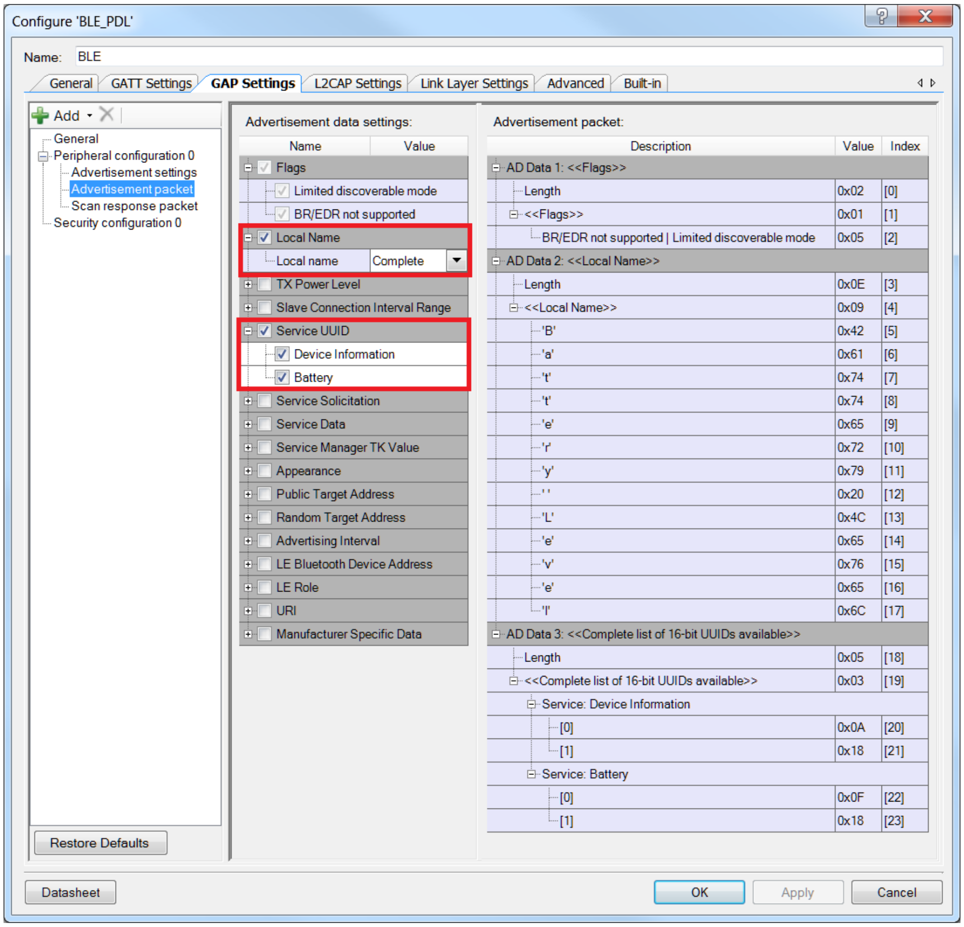
☑ Slow advertising interval:

Minimum (ms): 1000

Maximum (ms): 1000

☑ Timeout (s): 120

Figure 7. GAP Settings: Advertisement Packet



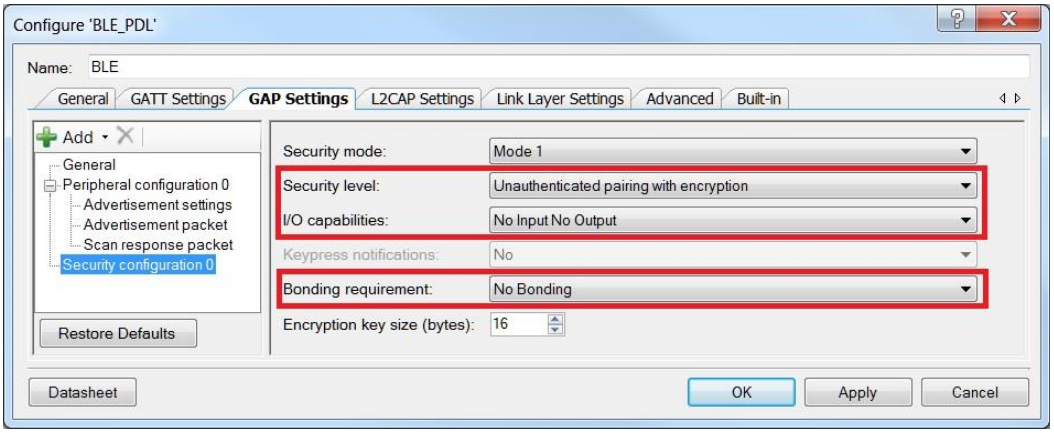
Advertisement data settings:

Name	Value
☑ Flags	
☑ Limited discoverable mode	
☑ BR/EDR not supported	
☑ Local Name	
Local name	Complete
□ TX Power Level	
□ Slave Connection Interval Range	
☑ Service UUID	
☑ Device Information	
☑ Battery	
□ Service Solicitation	
□ Service Data	
□ Service Manager TK Value	
□ Appearance	
□ Public Target Address	
□ Random Target Address	
□ Advertising Interval	
□ LE Bluetooth Device Address	
□ LE Role	
□ URI	
□ Manufacturer Specific Data	

Advertisement packet:

Description	Value	Index
AD Data 1: <<Flags>>		
Length	0x02	[0]
<<Flags>>	0x01	[1]
BR/EDR not supported | Limited discoverable mode	0x05	[2]
AD Data 2: <<Local Name>>		
Length	0x0E	[3]
<<Local Name>>	0x09	[4]
'B'	0x42	[5]
'a'	0x61	[6]
't'	0x74	[7]
't'	0x74	[8]
'e'	0x65	[9]
'r'	0x72	[10]
'y'	0x79	[11]
' '	0x20	[12]
'L'	0x4C	[13]
'e'	0x65	[14]
'v'	0x76	[15]
'e'	0x65	[16]
'l'	0x6C	[17]
AD Data 3: <<Complete list of 16-bit UUIDs available>>		
Length	0x05	[18]
<<Complete list of 16-bit UUIDs available>>	0x03	[19]
Service: Device Information		
[0]	0x0A	[20]
[1]	0x18	[21]
Service: Battery		
[0]	0x0F	[22]
[1]	0x18	[23]

Figure 8. Security Settings



Security mode: Mode 1

Security level: Unauthenticated pairing with encryption

I/O capabilities: No Input No Output

Keypress notifications: No

Bonding requirement: No Bonding

Encryption key size (bytes): 16

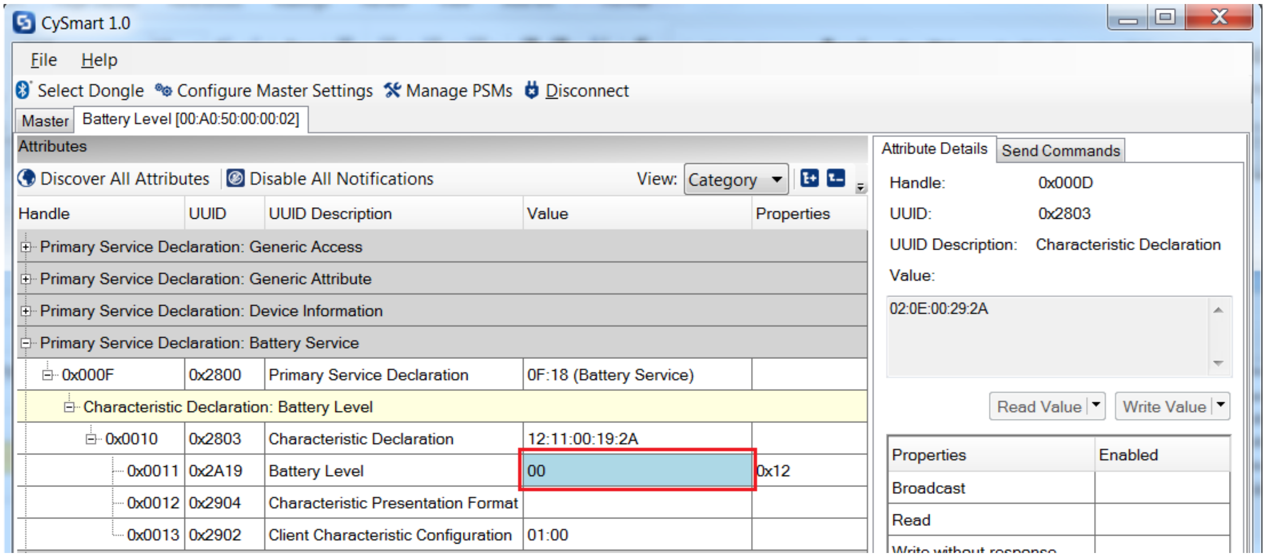
Operation

You can use the CySmart Central Emulation Tool on a Windows PC, Android, or iOS BLE 4.0-compatible device as a client to connect to this project.

To use the CySmart Windows application as a client:

1. Build and program the BLE Battery Level project into the CY8CKIT-062 PSoC 6 BLE Pioneer Kit.
2. Connect the CySmart BLE dongle to a USB port on the PC.
3. Launch the CySmart app and select the connected dongle in the dialog window.
4. Press **SW1** to reset the development kit and to start advertising.
5. Click **Start Scan** to discover available devices.
6. Select **Battery Level** from the list of available devices and connect to it.
7. Click **Pair**, then **Discover All Attributes**, then **Read All Characteristics**, and finally **Enable All Notifications** in the CySmart app.
8. Notice the values of the battery level descriptors.

Figure 9. CySmart Windows App



Handle	UUID	UUID Description	Value	Properties
Primary Service Declaration: Generic Access				
Primary Service Declaration: Generic Attribute				
Primary Service Declaration: Device Information				
Primary Service Declaration: Battery Service				
0x000F	0x2800	Primary Service Declaration	0F:18 (Battery Service)	
Characteristic Declaration: Battery Level				
0x0010	0x2803	Characteristic Declaration	12:11:00:19:2A	
0x0011	0x2A19	Battery Level	00	0x12
0x0012	0x2904	Characteristic Presentation Format		
0x0013	0x2902	Client Characteristic Configuration	01:00	

Handle: 0x000D

UUID: 0x2803

UUID Description: Characteristic Declaration

Value:

02:0E:00:29:2A

Properties	Enabled
Broadcast	
Read	
Write without response	

For more information about the CySmart Central Emulation tool, see CySmart User Guide.

To use the CySmart mobile app as a Battery Service client:

1. Launch the CySmart mobile app on the Android or iOS BLE-compatible device.
2. Swipe down to refresh the list of BLE devices.
3. Connect to the **Battery Level** device and select **Battery Service** from the service list.
4. Notice that the value of the battery level is continuously changing from 2 to 20 percent. Also, you can notice that the blue color LED will be ON when a measured battery level is less than 10 percent.

Figure 10. CySmart iOS App Recognized Battery Service

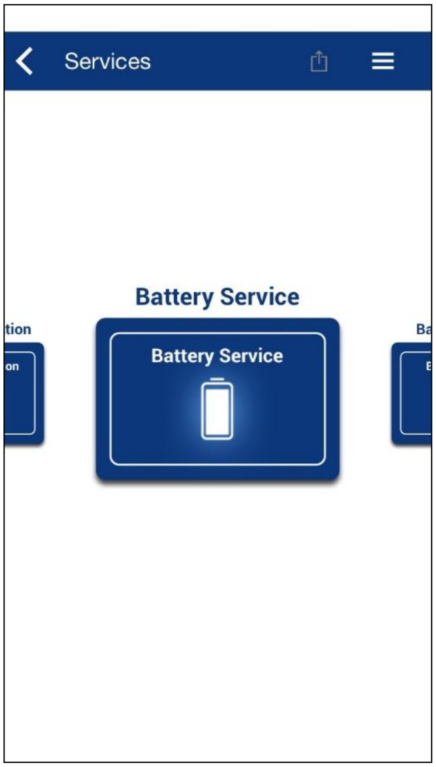
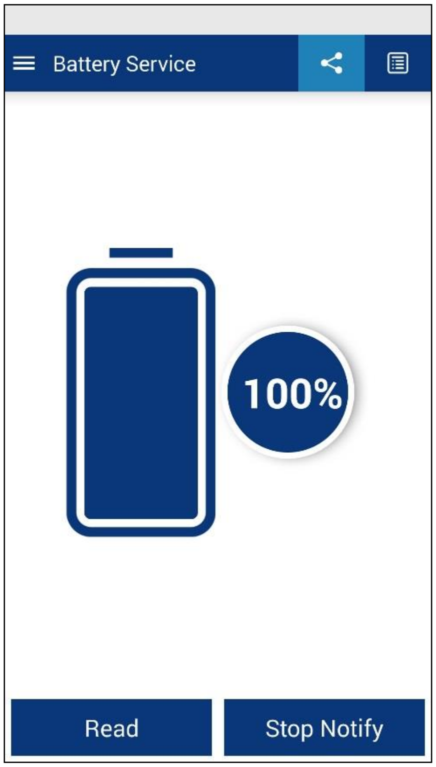


Figure 11. CySmart Android App Shows Battery Level



Related Documents

Application Notes		
AN210781	Getting Started with PSoC 6 MCU with Bluetooth Low Energy (BLE) Connectivity	Describes the PSoC 6 MCU with BLE Connectivity, and how to build a basic code example.
AN215656	PSoC 6 MCU Dual-Core CPU System Design	Presents the theory and design considerations related to this code example.
Software and Drivers		
CySmart – BLE Test and Debug Tool		CySmart is a BLE host emulation tool for Windows PCs. The tool provides an easy-to-use GUI to enable the user to test and debug their BLE 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 Programmable System-on-Chip		PSoC 6 MCU: PSoC 63 with BLE Architecture Technical Reference Manual (TRM)
Development Kit (DVK) Documentation		
CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit		

Document History

Document Title: CE215119 - BLE Battery Level with PSoC 6 MCU with BLE Connectivity

Document Number: 002-15119

Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	5968175	NPAL	11/21/17	New spec

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