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CE211245 - Bluetooth Low Energy (BLE) Indoor Positioning

Objective

This BLE example project demonstrates how to create an indoor navigation system using the BLE broadcasting mode that can be configured over GATT connection.

Overview

This example project configures the BLE Pioneer Kit as a time-multiplexed broadcaster and a connectable Indoor Positioning Service (IPS) server. The GAP role is set to broadcaster or peripheral; the GATT role set to server. By default, the device broadcasts the IPS data and then switches over to the connectable advertisement mode on a button press. The IPS data broadcast interval is 100 ms and the IPS broadcast mode is indicated using the blue LED on the BLE Pioneer kit. The connectable advertisement interval (to configure the IPS data over a GATT connection) is set to 20-30 ms for 180 seconds and BLE device switches over to IPS broadcast mode on an advertisement timeout or on a button press. The connectable advertisement mode is indicated by the green LED and the connected state is indicated by the red LED on the BLE Pioneer kit.

In this example project, Security Connection (mode 1, level 4 option) is enabled with the passkey-based authenticated MITM and automatic fallback to the legacy authenticated MITM mode if Security Connection is not supported by the peer device or selected BLE device family.

This example supports all the GATT sub-procedures defined in the IPS specification.

Requirements

Tool: PSoC Creator 4.0 or later

Programming Language: C (GCC 4.9 or later)

Associated Parts: PSoC 4 BLE parts

Related Hardware: CY8CKIT-042-BLE PSoC 4 Pioneer Kit with the CY8CKIT-143A PSoC® 4 BLE 256-KB Module and CY5677 CySmart BLE 4.2 USB Dongle that supports Security Connection

Design

This example project consists of the following components:

- BLE
- Universal Asynchronous Receiver Transmitter (UART)
- LEDs
- SW2

The schematic is shown in Figure 1.

This project demonstrates the functionality of the BLE Component configured as IPS Server. It is designed to work with CySmart.

After startup, the device initializes the BLE Component. To operate, the Component requires several callback functions in order to receive events from the BLE Stack. The AppCallBack() is used to receive general BLE events. Another callback (IpsCallBack()) is used to receive events specific to the service's attribute operations.

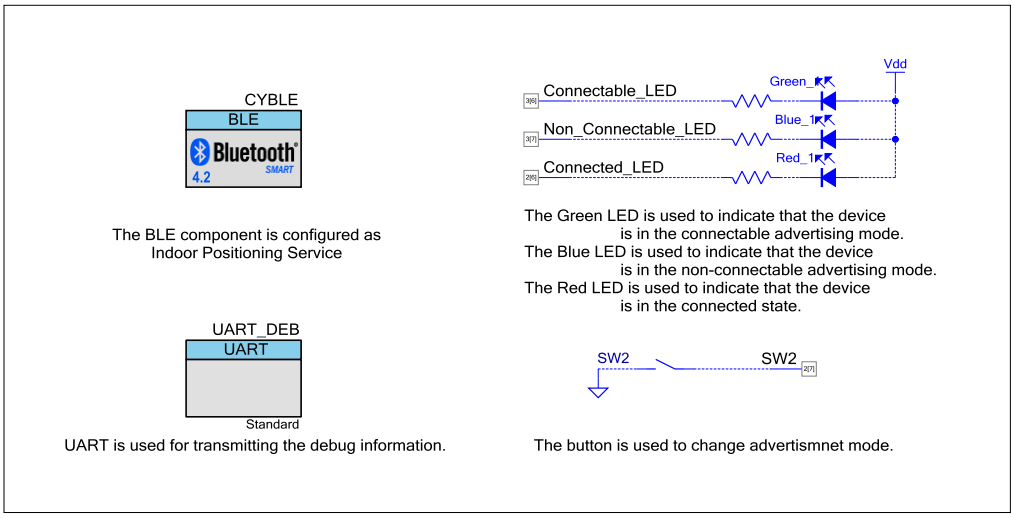
The CYBLE_EVT_STACK_ON event indicates the successful initialization of the BLE Stack. After this event is received, the Component starts fast advertising with the packet structure as configured in the BLE Component Customizer (see Figure 7).

You can connect to the IPS Server device with CySmart or any BLE 4.1- or BLE 4.2-compatible device configured in the GAP Central role and capable of discovering IPS. To connect to IPSServer, press the SW2 button on CY8CKIT-042 BLE to switch to connectable advertisement mode. The green LED indicates the connectable advertisement mode is enabled. The red LED indicates that Client is connected to the IPS Server.

The SW2 button on CY8CKIT-042 BLE is used to accept the password displayed on HyperTerminal. This can also be done by pressing 'y' on HyperTerminal. Optionally, the example project can use legacy Security Mode 1 Level 3 (Authenticated pairing with encryption).

UART is used to print the debug information and scan the commands from a terminal.

Figure 1. BLE Indoor Positioning Service Server Example Project Schematic



Design Considerations

This code example is designed for the PSoC 4 BLE family and associated with CY8CKIT-042 BLE. The design is easily portable to other PSoC BLE devices and kits, typically by just changing the device and components' pin assignments.

Hardware Setup

1. Connect the BLE Pioneer Kit to the computer's USB port, as shown in Figure 2.

Figure 2. Connect USB Cable to J13

2. Connect the BLE Dongle to one of the USB ports on the computer.

Figure 3. Connect BLE Dongle to USB Port

Software Setup

Using UART for Debugging

A HyperTerminal program is required in a PC to receive debugging 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 into which the kit is connected.
4. Configure the Baud rate, Parity, Stop bits, and Flow control information in the HyperTerminal configuration window. By default, the settings are following: Baud rate – 115200, Parity – None, Stop bits – 1 and Flow control – XON/XOFF. These settings have to match the configuration of the PSoC Creator UART component in the project.
5. Start communicating with the device as explained in the project description.

Components

Table 1 lists the PSoC Creator Components used in this example, as well as the placement used by each.

Table 1. List of PSoC Creator Components

Component	Hardware Resources
BLE	BLE Sub-System
UART	GPIO rx – P1[4], tx – P1[5]
Connectable_LED	GPIO P3[6]
Non_Connectable_LED	GPIO P3[7]
Connected_LED	GPIO P2[6]
SW2	GPIO P2[7]

Parameter Settings

BLE Component

The BLE Component is configured as IPS Server in the GAP Peripheral role with the settings shown in the figures below. Because there is no Indoor Positioning Profile specification defined, a Custom profile is used.

Figure 4. GATT Settings

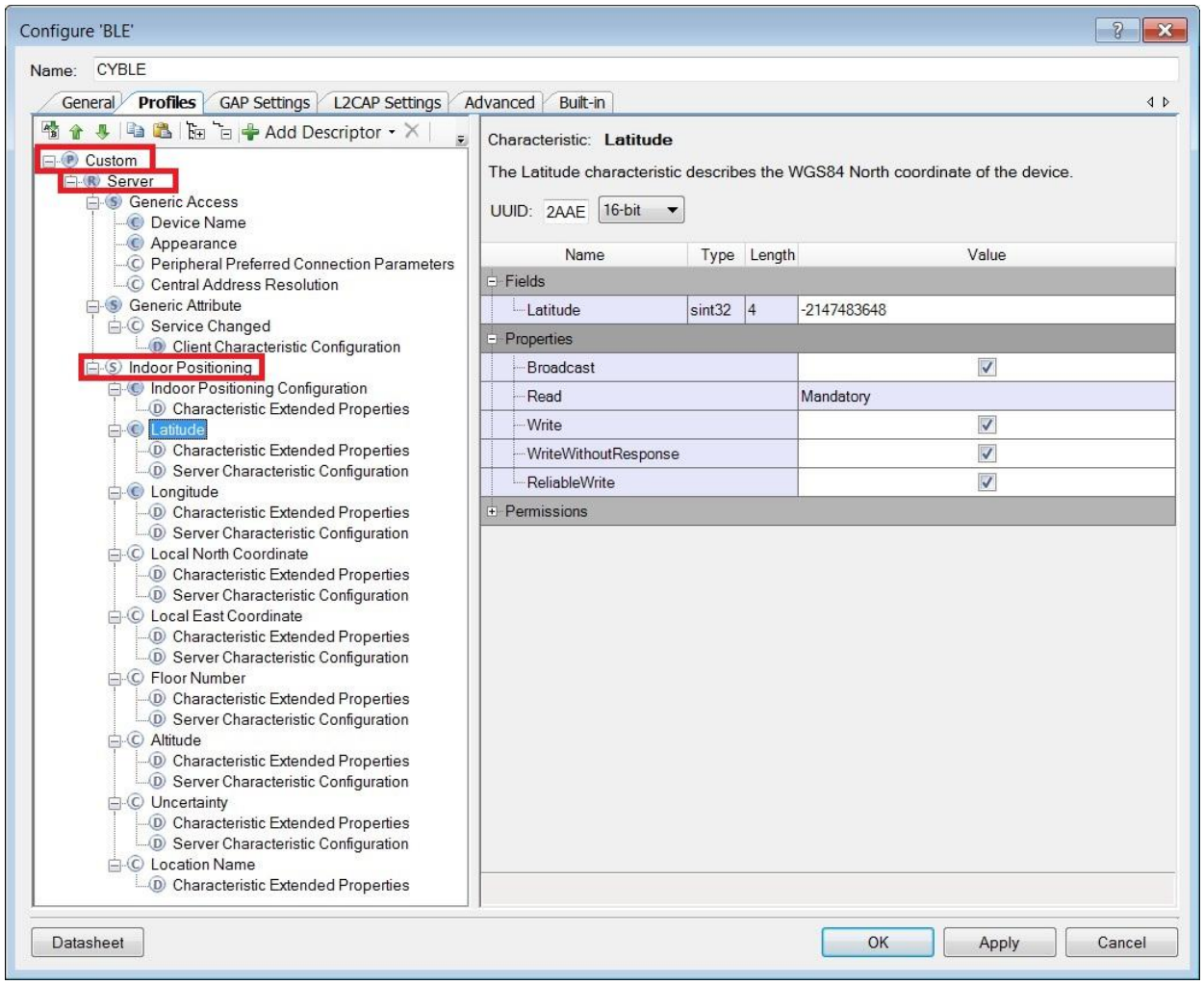


Figure 5. GAP Settings

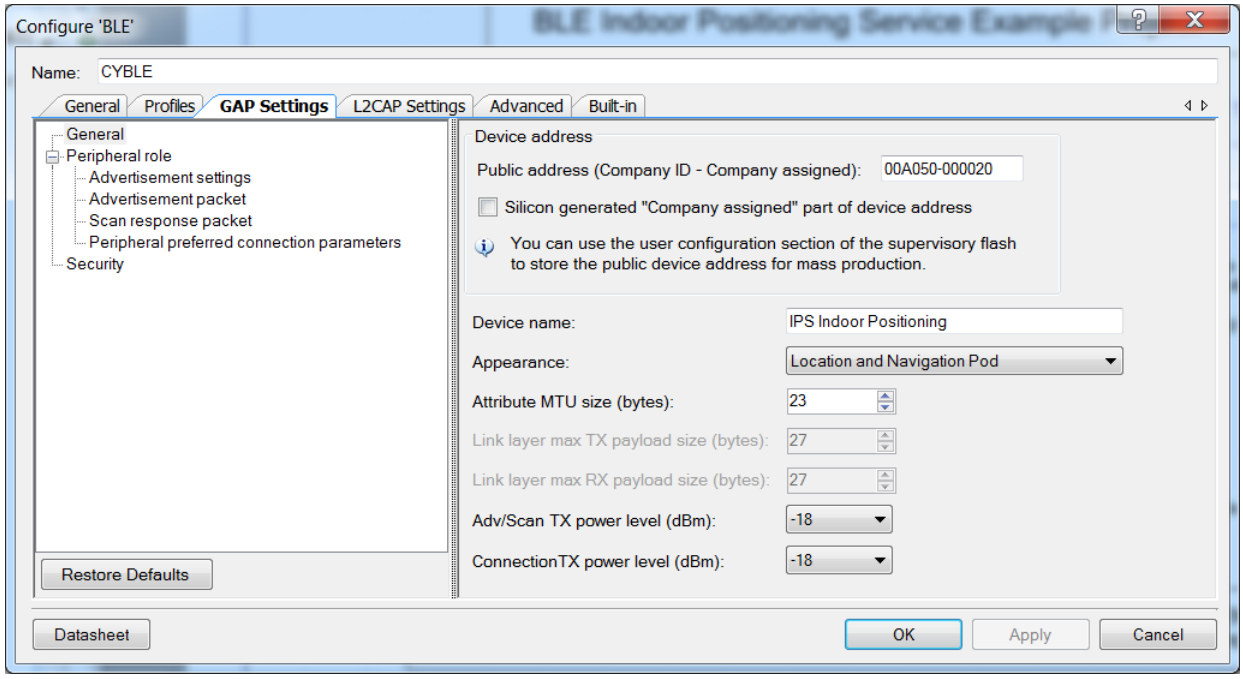


Figure 6. GAP Settings: Advertisement Settings

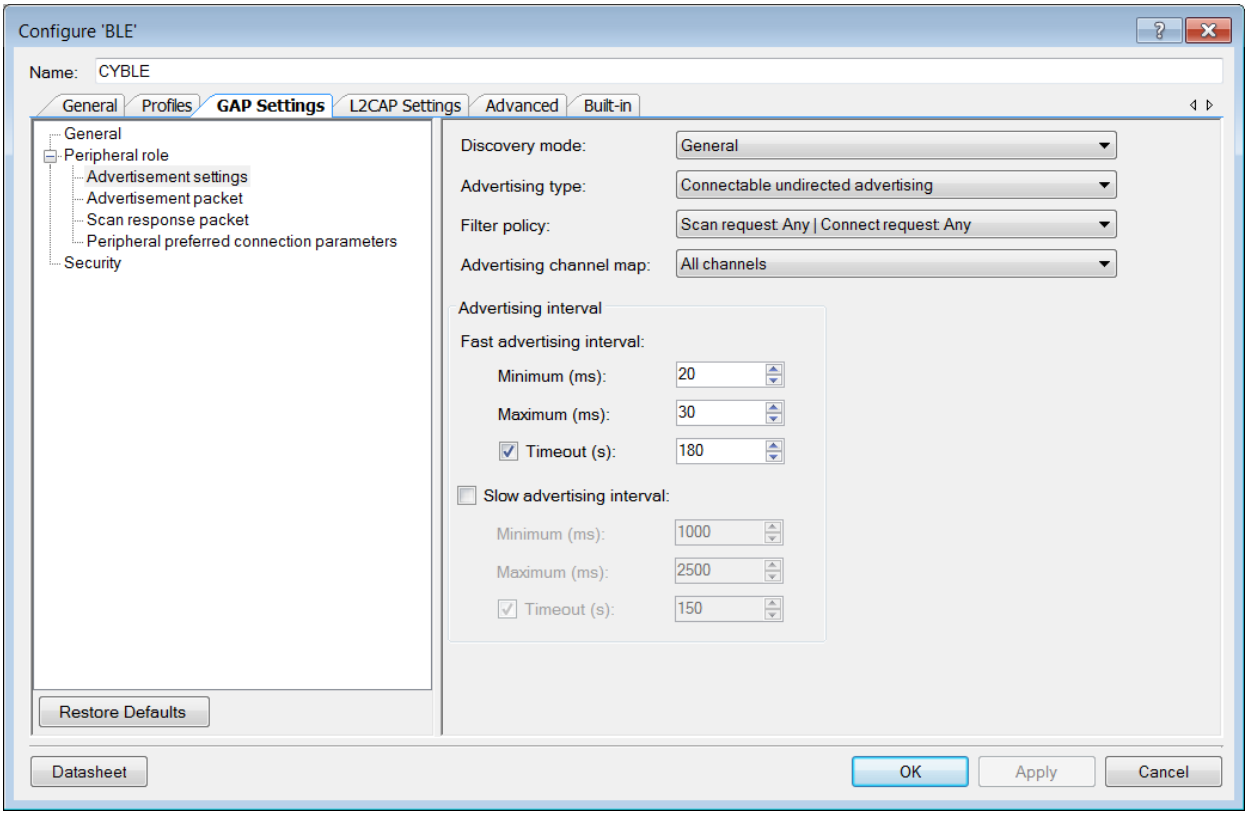


Figure 7. GAP Settings: Advertisement Packet

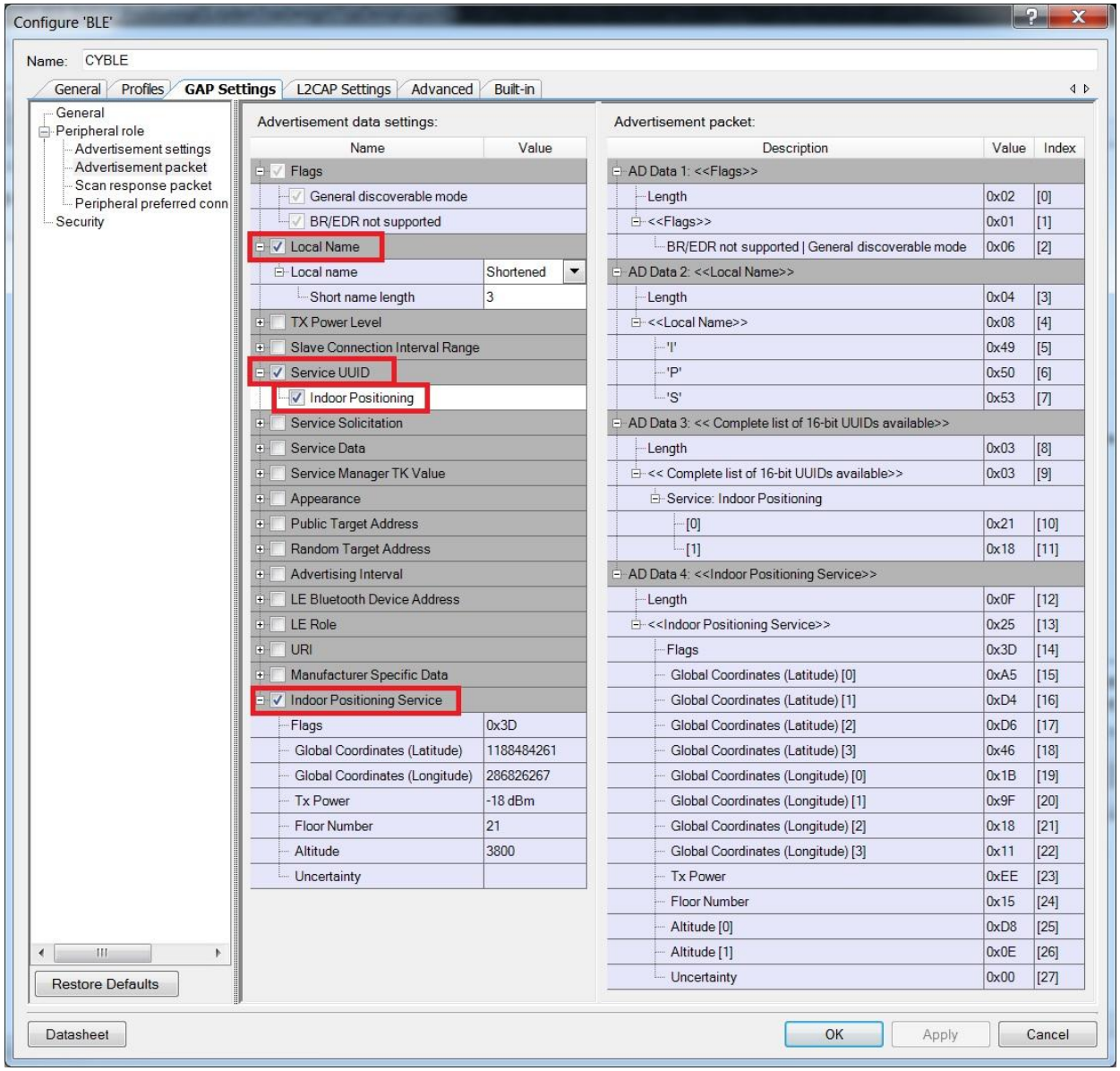
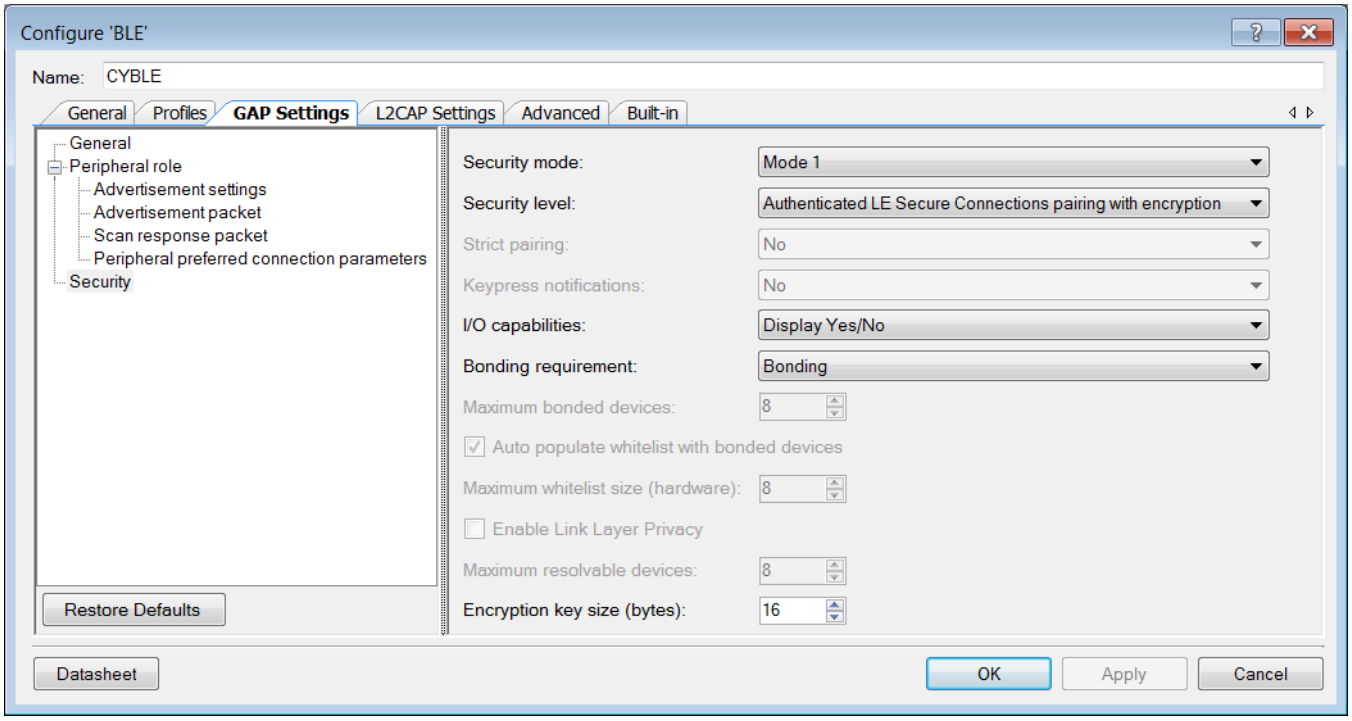


Figure 8. Security Settings

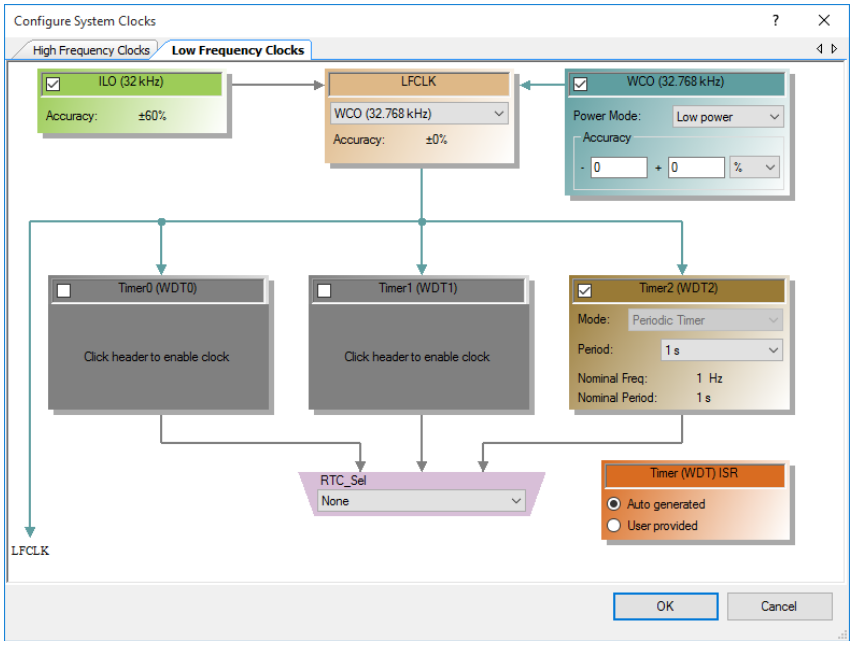


Design-Wide Resources

Watch Dog Timer (WDT)

WDT works over the low-power Deep Sleep mode; therefore it is used as a general timer. WDT Timer2 is configured in the **Low Frequency Clocks** tab of the Clocks configuration in the Design Wide Resources (DWR).

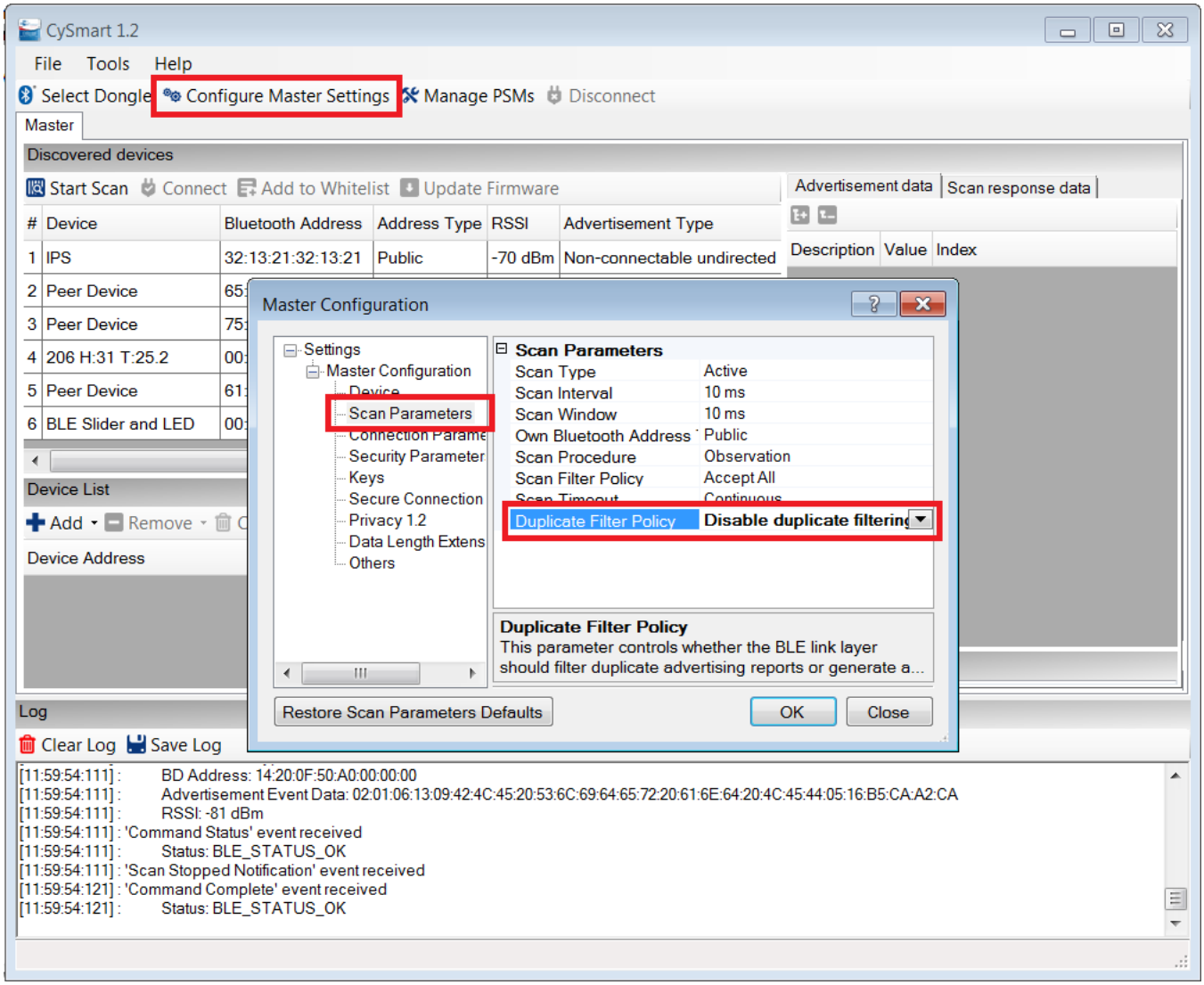
Figure 9. WDT Timer2 Settings



Operation

1. Build and program BLE Indoor Positioning Service Server project into CY8CKIT-042 PSoC® 4 Pioneer Kits with PSoC 4 BLE devices.
2. Run HyperTerminal (such as Putty).
3. To use the CySmart Windows application as Indoor Positioning Service Client, connect the CySmart BLE dongle to a USB port on the PC (Figure 3).
4. Launch the CySmart application and select the connected dongle in the dialog window.
5. Set the **Duplicate Filter Policy = Disable duplicate filtering** in **Master Configuration > Scan parameters** window. See Figure 10.

Figure 10. Master Configuration -> Scan parameters



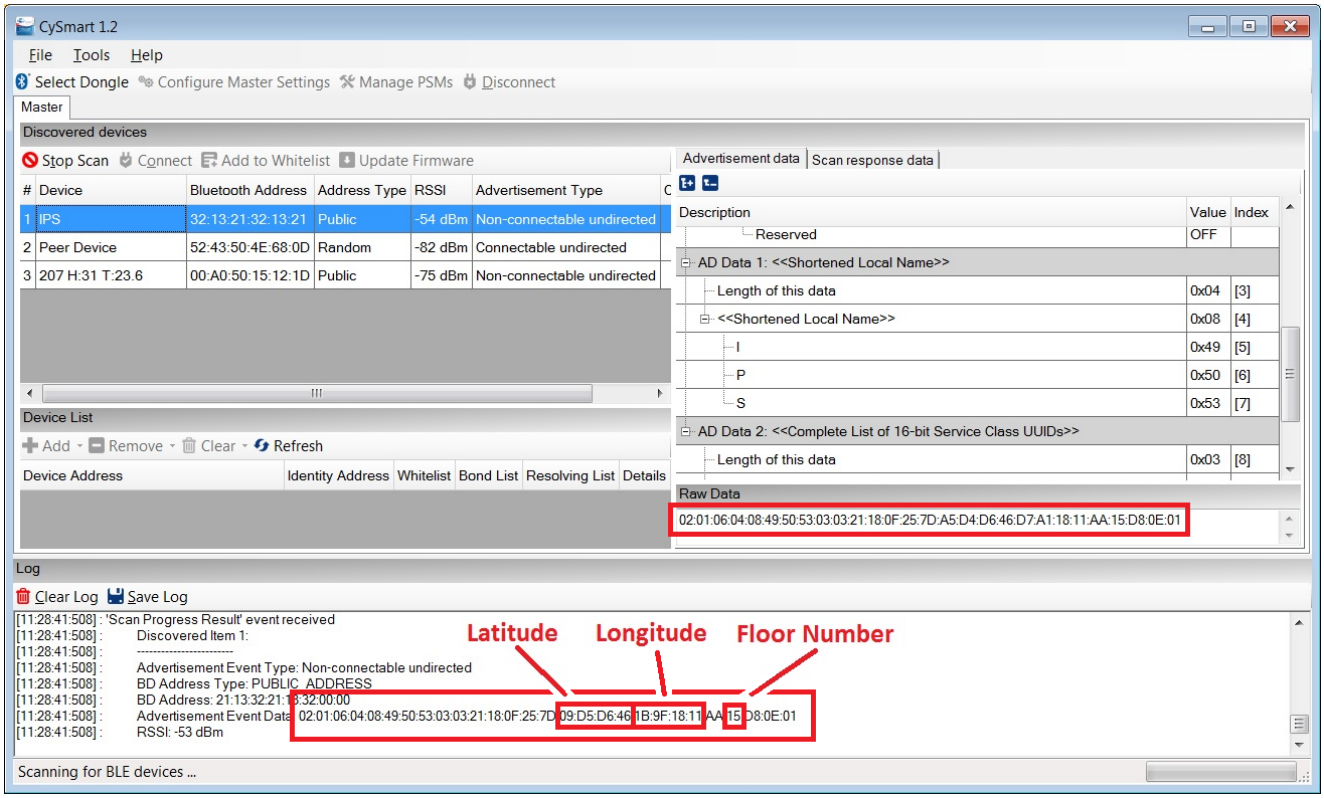
6. Reset the development kit to start advertising by pressing the **SW1** button.
7. Click the **Start Scan** button to discover available devices.
8. Select **IPS** in the list of available devices.

9. Observe simulated Latitude and Longitude values in the HyperTerminal program.
10. Observe the advertisement data in the **Raw Data** and **Log** windows (Figure 11). Advertisement data contains values of all Indoor Positioning Service characteristics, defined in Indoor Positioning Service Specification. The values of Latitude and Longitude are saved in a specific format described in Indoor Positioning Service Specification. The accordance between these formats is shown in Table 2.

Table 2. Accordance Between Different Formats of Latitude and Longitude

Latitude		Longitude	
49.808800	0x46D6D4A5	24.041500	0x11189F1B
49.808804	0x46D6D509	24.041508	0x11189F7F
49.808808	0x46D6D56D	24.041517	0x11189FE3
49.808813	0x46D6D5D1	24.041525	0x1118A047
49.808817	0x46D6D635	24.041533	0x1118A0AB
49.808821	0x46D6D699	24.041542	0x1118A10F
49.808825	0x46D6D6FD	24.041550	0x1118A173
49.808829	0x46D6D761	24.041559	0x1118A1D7
49.808834	0x46D6D7C5	24.041567	0x1118A23B
49.808838	0x46D6D829	24.041575	0x1118A29F
49.808842	0x46D6D88D	24.041584	0x1118A303
49.808846	0x46D6D8F1	24.041592	0x1118A367
49.808850	0x46D6D955	24.041601	0x1118A3CB
49.808854	0x46D6D9B9	24.041609	0x1118A42F
49.808859	0x46D6DA1D	24.041617	0x1118A493
49.808863	0x46D6DA81	24.041626	0x1118A4F7
49.808867	0x46D6DAE5	24.041634	0x1118A55B
49.808871	0x46D6DB49	24.041642	0x1118A5BF
49.808875	0x46D6DBAD	24.041651	0x1118A623
49.808880	0x46D6DC11	24.041659	0x1118A687
49.808884	0x46D6DC75	24.041668	0x1118A6EB

Figure 11. CySmart window



11. Press the **SW2** button on the BLE Pioneer kit to set the connectable advertisement mode for Indoor Positioning Service. This mode is indicated by the green LED on the BLE Pioneer kit.
12. Click **Stop Scan** and **Start Scan** in CySmart. Select the IPS device.
13. Click **Pair**. Response **Yes** to a pairing request received from the peer device.
14. Compare the displayed passkeys on both devices. Click **Yes** on CySmart and '**y**' on the terminal (or **SW2** button) to confirm the Numeric comparison pairing procedure.
15. Click **Discover All Attributes**, then click **Read All Characteristics** in the CySmart application. Observe the received characteristic values.
16. Change the Floor Number characteristic value to 22 (for example) and click **Write value**, then click **Read Value**. Observe the changes in CySmart and HyperTerminal. See Figure 12.
17. Change the Indoor Positioning Configuration characteristic value to 51 and click **Write Value**, then click **Read Value**. Observe the result in CySmart and HyperTerminal (Figure 12). Value 51 sets only Latitude, Longitude, and Floor Number in the advertisement packet. For details, see Indoor Positioning Service Specification.
18. Click the **Disconnect** button, then click the **Start Scan** button to discover available devices.
19. Select **IPS** in the list of available devices.
20. Observe charged advertisement packet and data in the **Raw Data** and **Log** windows. The packet contains only values of Latitude, Longitude, and Floor Number, as was set above.

If you have problems with using the CySmart Central Emulation Tool, refer to CySmart User Guide.

Figure 12. Value writing.

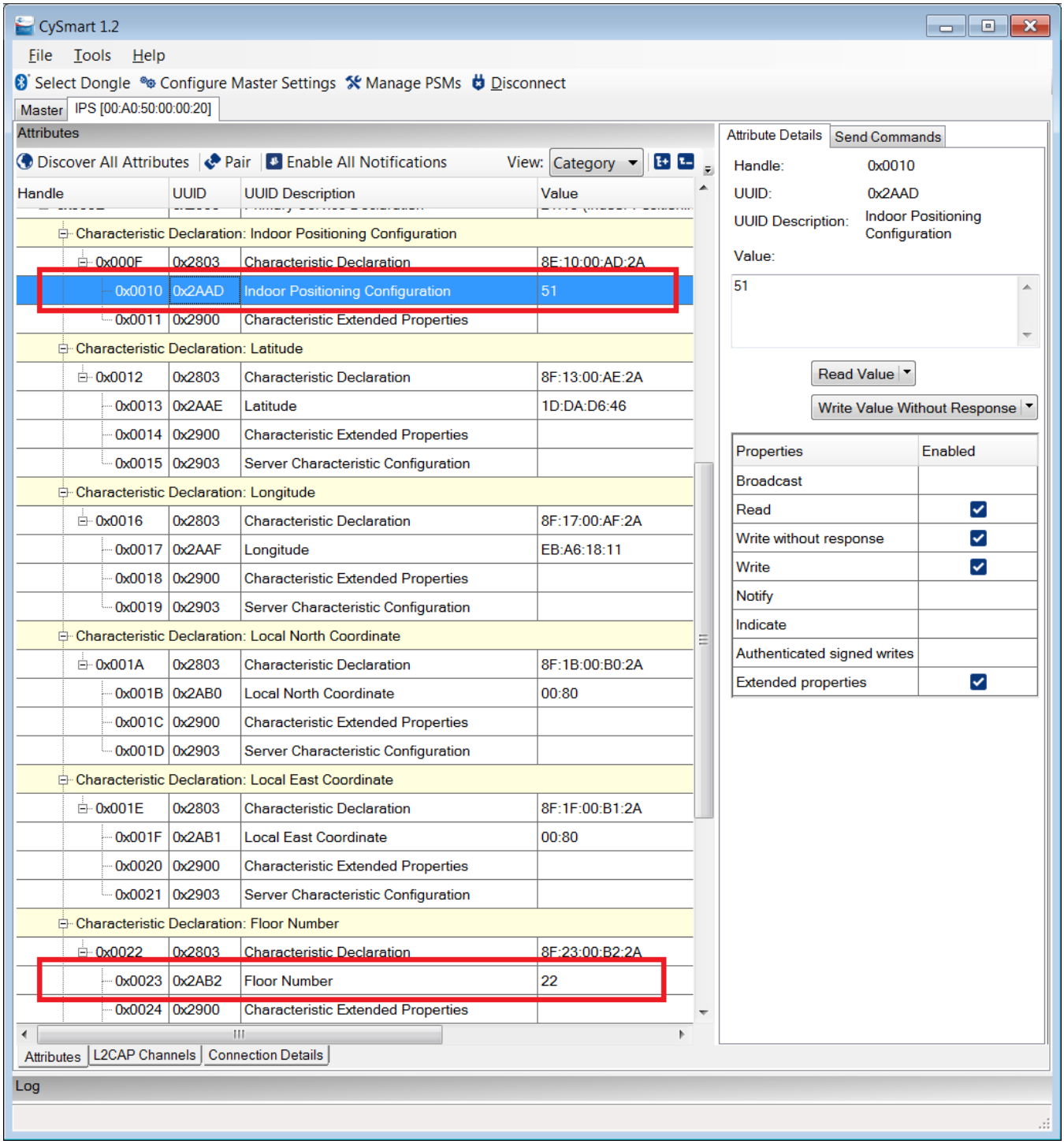
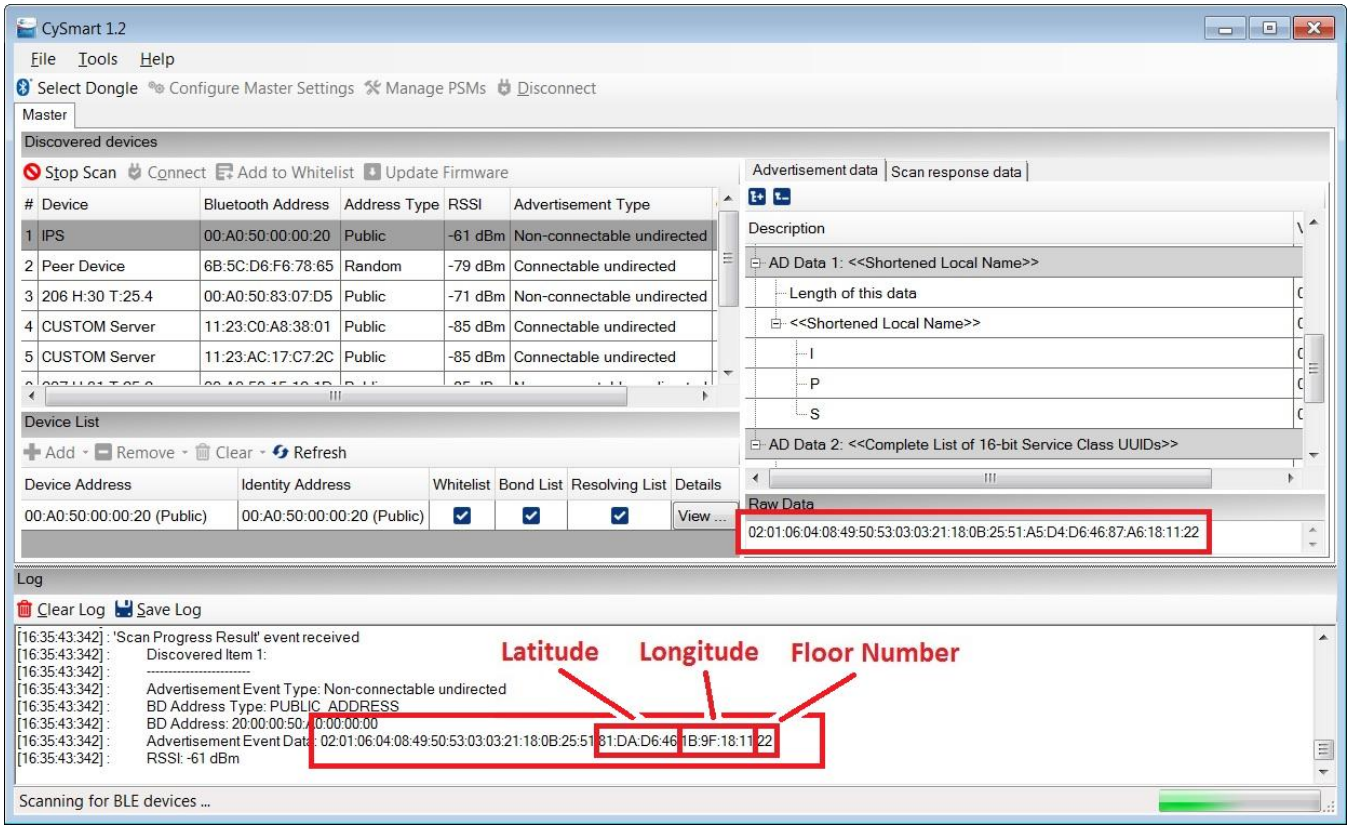


Figure 13. Advertisement Packet



Related Documents

Table 3 lists all relevant application notes, code examples, knowledge base articles, device datasheets, and Component datasheets.

Table 3. Related Documents

Application Notes		
AN94020	Getting Started with PRoC™ BLE	Introduces to PRoC™ BLE, an ARM® Cortex®-M0 based programmable radio-on-chip with Bluetooth Low Energy.
AN91184	PSoC 4 BLE - Designing BLE Applications	Shows how to design the Bluetooth® Low Energy (BLE) application based on PSoC 4 BLE, using standard profiles defined by the Bluetooth SIG included in the BLE Component in PSoC Creator. Demonstrates how to build an application with the BLE Health Thermometer Profile on the CY8CKIT-042-BLE kit.
Videos		
PSoC 4 BLE 101: Intro to Bluetooth Low Energy		This is the first installment of a series of getting-started videos on Cypress Bluetooth Low Energy solutions.
PSoC 4 BLE 101: 2 Configuring a Find Me Profile with BLE		Using Cypress Pioneer kit with a PSoC 4 Radio module. Alan Hawse walks you through a simple example for a find-me tag application.
PSoC 4 BLE 101: 3 Finishing the Find Me Application with Firmware		In this lesson, we take the Find Me profile you configured in the previous video and add the firmware required to make it work on the PSoC 4 BLE device.
PSoC 4 BLE 101: 4 Adding Battery Level Service and Testing with CySmart		This lesson takes the Find Me profile built in the first two lessons and adds a Battery Level service.
PSoC 4 BLE 101: 5 Using CapSense with Bluetooth Low Energy		In this BLE lesson, we show how to use PSoC Creator's Custom Service to quickly and easily add a CapSense® slider to a BLE (Bluetooth Low Energy) design.
PSoC 4 BLE 101: 6 Extending Battery Life with PSoC Low Energy Modes		Adds power savings into your BLE designs easily using PSoC and PSoC Creator. In the last lesson, we created Find Me peripheral with the Battery Level service.
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 customers to test their Bluetooth LE peripheral applications.
PSoC Creator Component Datasheets		
Bluetooth Low Energy (BLE) Component		The Bluetooth Low Energy (BLE) Component provides a comprehensive GUI-based configuration window to facilitate designing applications requiring BLE connectivity.
PSoC 4 Serial Communication Block (SCB) Component		Supports a PSoC 4 multifunction hardware block that implements I^2C, SPI, UART, and EZI2C communications
Device Documentation		
PSoC® 4: PSoC 4XX7_BLE Family Datasheet Programmable System-on-Chip (PSoC®)		
PSoC® 4: PSoC 4XX8_BLE Family Datasheet - Programmable System-on-Chip (PSoC®)		
PSoC® 4: PSoC 4XX8 BLE 4.2 Family Datasheet Programmable System-on-Chip (PSoC®)		
Development Kit (DVK) Documentation		
Bluetooth® Low Energy Pioneer Kit (CY8CKIT-042-BLE)		

Document History

Document Title: CE211245 - Bluetooth Low Energy (BLE) Indoor Positioning

Document Number: 002-11245

Revision	ECN	Date	Orig. of Change	Description of Change
**	5141104	08/23/2016	AZOV	New code example.

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198 Champion Court
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Phone : 408-943-2600
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