AN220929

Getting Started with EZ-BLE WICED Modules

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Associated Project: Yes

Associated Part Family: CYBLE-0130XX-00

Software Version: WICED® SMART™ SDK v2.2.3

Related Application Notes: For a complete list of the application notes, click here.

AN220929 introduces you to Cypress' EZ-BLE™ WICED family of Bluetooth modules. EZ-BLE modules are fully qualified and certified Bluetooth Low Energy (BLE) solutions. These modules provide a complete Bluetooth solution, integrating a Bluetooth radio system, two crystals, antenna, and passive components required for BLE operation. This application note helps you explore the EZ-BLE Module architecture and development tools and shows you how to create your first project with the WICED Smart SDK, the development tool used for all WICED-based EZ-BLE Modules. This application note also guides you to more resources to accelerate in-depth learning about EZ-BLE WICED solutions.

Contents

1 Introduction

Bluetooth Low Energy (BLE) is an ultra-low-power wireless standard defined by the Bluetooth Special Interest Group (SIG) for low-power, short-range communication. It features a physical layer, protocol stack, and profile architecture, all designed and optimized for the lowest power consumption. BLE operates in the 2.4-GHz ISM band, with a data rate up to 1 Mbps for 4.2 compliant devices, and up to 2 Mbps for BLE 5.0 compliant devices.

BLE is used in a wide range of applications. The use of BLE in these applications also varies widely in production volume, from very low- to high-volume end products. The use of fully qualified, certified, BLE modules removes time-consuming RF board design and costly qualification/certification processes. As such, modules have quickly become the design preference.

WICED (pronounced “wik-id”) is Cypress IoT platform that enables rapid development and deployment of connected IoT products. Wireless Internet Connectivity for Embedded Devices (WICED) in conjunction with EZ-BLE modules provides a great feature set to simplify development and release of BLE-enabled products by eliminating the complexity of wireless RF hardware design, allowing customers to focus on their IoT product development.

The WICED SMART™ SDK is pre-integrated, pre-tested and continuously updated, containing:

- WICED APIs and drivers to make wireless connectivity easy and flexible
- Proven production ready stacks (e.g., networking, security)
- Pre-integrated world-class IoT cloud platforms (e.g., Amazon AWS, IBM BlueMix)

The EZ-BLE module and WICED ecosystem accelerate your time-to-market, by providing:

- Partners who are experts in product development with the WICED SDK
- Partners who are experts in integrating embedded systems with mobile and cloud applications
- A professional, highly engaged community

The Cypress EZ-BLE WICED Module family provides fully integrated, qualified, and certified BLE systems that integrate 24-MHz crystal oscillators, passive components, on-board chip or trace antennas, and the WICED BLE chip, which includes the Bluetooth radio, analog-to-digital converter inputs, PWM control, serial communication protocols (I^2C, SPI, UART), memory, and an ARM® Cortex®-M3 microcontroller.

EZ-BLE WICED Modules enable quick time-to-market by eliminating time-consuming and costly RF hardware development, certification, and qualification processes, offering an effective alternative to completing a BLE system design from the ground up.

EZ-BLE WICED Modules provide the most cost-effective solution for sensor-based Internet of Things (IoT) solutions, while providing world-class RF performance by utilizing the latest Cypress WICED silicon devices.

2 More Information

This section provides a list of EZ-BLE Module learning resources that can help you to get started and develop complete applications with your EZ-BLE Module.

2.1 EZ-BLE WICED Module Datasheet

The EZ-BLE WICED Module datasheets list the features, pinouts, device-level specifications, and fixed-function peripheral electrical specifications of the EZ-BLE WICED Modules.

2.2 EZ-BLE WICED Evaluation Boards

Each EZ-BLE WICED Module offers a low-cost Arduino-compatible evaluation board to provide an easy-to-use vehicle to develop and evaluate EZ-BLE WICED Modules without requiring custom hardware design. These evaluation boards are standalone Arduino-compatible baseboards, capable of interfacing to Arduino-compatible shields.

2.3 Silicon Device Datasheet

Cypress WICED BLE datasheets lists the features, pinouts, device-level specifications, and fixed-function peripheral electrical specifications of all Cypress WICED BLE devices. Datasheets for applicable WICED BLE devices discussed in this application note can be found at the below links:

- CYW20737 Single-Chip Bluetooth Low Energy-Only System-On-Chip

2.4 Cypress WICED Bluetooth Community

Whether you're a customer, partner, or a developer interested in the latest Cypress innovations, the Cypress WICED Bluetooth Community offers you a place to learn, share and engage with both Cypress experts and other embedded engineers around the world.

2.5 Application Notes

Application notes assist you with understanding specific features of your device for designing your BLE application. For a complete list, visit Cypress WICED BLE application notes.

2.6 Technical Support

If you have any questions, our technical support team is happy to assist you. You can create a support request by visiting Cypress Technical Support.

If you are in the United States, you can talk to our technical support team by calling our toll-free number: +1-800-541-4736. You can also use the following support resources if you need quick assistance.

- Self-help
  - Local sales office locations

3 EZ-BLE WICED Module Overview

This application note introduces the reader specifically to the EZ-BLE WICED Module solution and how to get started. If you are looking for a detailed overview of the Bluetooth Low Energy standard, see AN91267 - Getting Started with PSoC® 4 BLE.

EZ-BLE WICED Modules offer fully integrated and fully certified BLE solutions allowing rapid development and deployment of your BLE product. This section provides an overview of the EZ-BLE WICED Modules available today. For detailed information on each module referenced in this section, see Appendix B: EZ-BLE Module Product Details**.**

All EZ-BLE WICED Modules ship with all required components to achieve full BLE functionality, including:

- PCB substrate
- Cypress WICED BLE IC
  - Refer to the Module datasheet for references and links to the datasheet of the silicon used in each module.
- Crystal oscillators
  - 24.0-MHz external crystal oscillator
  - EZ-BLE WICED BLE Modules do not contain a 32-kHz external crystal oscillator, but utilize the integrated oscillator on the silicon device. Each module does provide an option for an external 32-kHz input if desired.
- Chip or Trace antenna
- Passive components (resistor, capacitor, inductor)
- RF Shield, unless otherwise noted

3.1 EZ-BLE WICED Module Family Features

Table 1 summarizes the features and capabilities of every EZ-BLE WICED Module available from Cypress.

Table 1. EZ-BLE WICED Module Features and Capabilities

Features	Details
BLE Subsystem	BLE radio and link-layer hardware
CPU	ARM Cortex-M3 32-bit processor
Flash Memory	Up to 128 KB (module dependent)
SRAM	60 KB
ROM	320-KB ROM, containing BLE stack and specific BLE profiles
GPIOs	Up to 14 (module-dependent)
CapSense®	None (See Getting Started with EZ-BLE Creator Modules for this functionality)
CapSense Gestures	None (See Getting Started with EZ-BLE Creator Modules for this functionality)
ADC	10-bit auxiliary ADC with nine analog channels
Opamps	None (See Getting Started with EZ-BLE Creator Modules for this functionality)
Comparators	None (See Getting Started with EZ-BLE Creator Modules for this functionality)
Current DACs	None (See Getting Started with EZ-BLE Creator Modules for this functionality)
Power Supply Range	1.62 V to 3.6 V (module dependent)
Low-Power Modes	Deep-Sleep (HIDOFF) mode at 1.5 µA typical Stop mode at 50 µA typical
Serial Communication	I^{2}C, SPI, Peripheral-UART (application interface), HCI-UART (programming)
I^{2}S Communication Interface	Module dependent
Pulse-Width Modulator (PWM)	4
Universal Digital Blocks (UDBs)	None (See Getting Started with EZ-BLE Creator Modules for this functionality)
Clocks	32-kHz LPCLK (Low Power Clock)
Power Supply Monitoring	Power-on reset (POR)
Integrated Crystal Oscillators	24-MHz integrated on module 32-kHz connection available (optional)
Antenna Type	Trace or Chip Antenna (module dependent)
Certifications	FCC, ISED, MIC, CE, unless otherwise noted in the datasheet Each EZ-BLE WICED Module has a Cypress Knowledge Base Article, which contains the regulatory testing reports and certificates for all countries the module is certified against. See the More Information section of the module datasheet for links to this information.

3.2 EZ-BLE WICED Module Low Power Modes

EZ-BLE WICED Modules support the following power modes as illustrated in Table 2:

- Active mode: This is the primary mode of operation. In this mode, all peripherals are available.
- Sleep mode: In this mode, the CPU is in Sleep mode; SRAM is in retention. A GPIO interrupt or timer interrupt from the local oscillator (LO) can transition the device from sleep state to active state. Peripherals are not available in this state. Bluetooth connections can be maintained in this state.
- Deep-Sleep mode, also known as HIDOFF: In this mode, the baseband and core are powered OFF by disabling internal LDO output (LDOOUT). Only a GPIO interrupt can wake the device and transition it to active state. This mode minimizes chip power consumption and is intended for long periods of inactivity. Bluetooth connections cannot be maintained in this state because the baseband and core are powered OFF.

Table 2. Power Modes

Mode	Interval	Current Consumption (Typical)	Code Execution	SRAM Retention	Maintain Bluetooth Connection	Peripherals Available	Clock Sources Available	Wake-Up Sources
Active (CPU Only)[1]	–	3.56 mA @ 24 MHz	Yes	Yes	–	–	LO, 24 MHz	-
Sleep	–	50 µA	No	Yes	Yes	None	LO	GPIO, Internal LO Timer
Deep Sleep	–	1.5 µA	No	No	No	None	None	GPIO
Advertisement Only	20 ms[2]	1.9 mA	Yes	Yes	–	All	LO, 24 MHz	GPIO, Internal LO Timer
Active Connection	10 ms[2]	1.85 mA	Yes	Yes	Yes	All	LO, 24 MHz	
Active Connection	1,000 ms[2]	80 µA	Yes	Yes	Yes	All	LO, 24 MHz	
Active Connection	4,000 ms[2]	70 µA	Yes	Yes	Yes	All	LO, 24 MHz	

3.3 EZ-BLE WICED Module Device Security

EZ-BLE WICED Modules provide mechanisms for implementing security and authentication schemes using the following:

- RSA (Public Key Cryptography)
- X.509 (excluding parsing)
- Hash functions: MD5, SHA-1, SHA-224, SHA-256, SHA-384, SHA-512
- Message authentication code: HMAC MD5, HMAC SHA-1

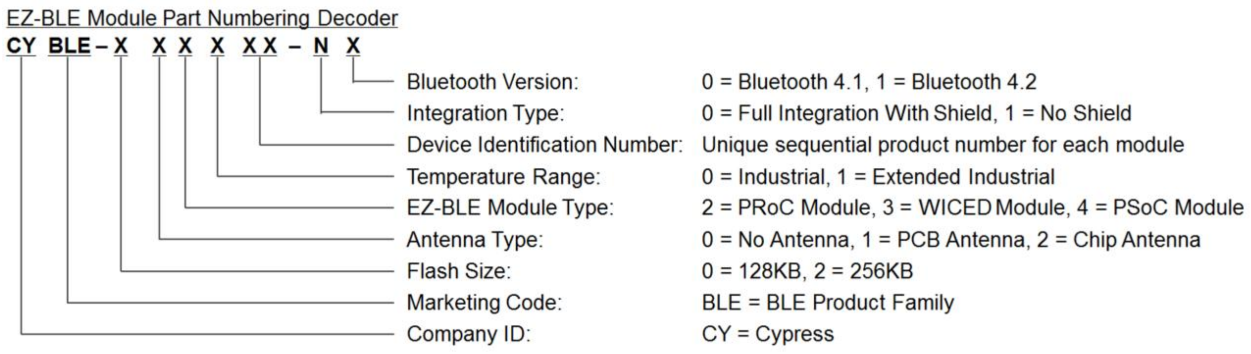
[1] CPU is active with no RF activity, and no peripheral interface.

[2] The module is in Sleep mode when there is no radio activity. Typically, radio activity (TX and RX) will be approximately 1 ms. The module is in Sleep mode for the remaining time during the interval specified.

3.4 EZ-BLE WICED Marketing Part Number Overview

Each device within the EZ-BLE WICED Module family has a unique Marketing Part Number (MPN) used for ordering. The MPN format is shown in Figure 1.

Figure 1. EZ-BLE Module Marketing Part Numbering Format



EZ-BLE Module Part Numbering Decoder

CY BLE – X X X X XX – N X

Bluetooth Version:	0 = Bluetooth 4.1, 1 = Bluetooth 4.2
Integration Type:	0 = Full Integration With Shield, 1 = No Shield
Device Identification Number:	Unique sequential product number for each module
Temperature Range:	0 = Industrial, 1 = Extended Industrial
EZ-BLE Module Type:	2 = PRoC Module, 3 = WICED Module, 4 = PSoC Module
Antenna Type:	0 = No Antenna, 1 = PCB Antenna, 2 = Chip Antenna
Flash Size:	0 = 128KB, 2 = 256KB
Marketing Code:	BLE = BLE Product Family
Company ID:	CY = Cypress

Table 3 summarizes the features and capabilities of each specific EZ-BLE WICED Module MPN available from Cypress. Click on the specific part number for more detailed information on the device or refer to Appendix B: EZ-BLE Module Product Details.

Table 3. EZ-BLE Module MPN Features and Capabilities

Marketing Part Number	BLE Silicon Device	Module Size (mm)	Range[3]	Regulatory Certification	BLE Standard	Antenna Type	Package	GPIOs (Maximum)	Serial Flash (KB)	SRAM (KB)	I^2S	PWM	10-bit ADC	CapSense (# of Sensors)	UDB	Comparator	Opamps
CYBLE-013025-00	CYW20737	14.52 x 19.2 x 2.25	75	Yes	4.1	Trace	31-SMT	14	128	60	No	4	Yes	No	-	-	-
CYBLE-013030-00	CYW20737	14.52 x 19.2 x 2.25	75	Yes	4.1	Trace	31-SMT	14	-	60	No	4	Yes	No	-	-	-

[3] Measured in meters and is specified as Full Line-of-Sight (LoS) in a Noise-Free environment.

4 Development Tools

Cypress supports EZ-BLE WICED Modules with high-quality, integrated software tools. These include the following software:

1. WICED SMART SDK and IDE (used for EZ-BLE modules based on CYW20737 silicon)
2. CySmart PC application
3. CySmart Android app
4. CySmart iOS app

4.1 WICED SMART SDK and IDE

The WICED SMART SDK provides an Eclipse-based IDE and complete software library for developing on CYW20737-based EZ-BLE modules. This tool enables a simple build and download process as well as debugging capabilities on supported development kits. It also includes the graphical **WICED Bluetooth Designer** tool for quickly defining new BLE designs and custom GATT database structures.

Note, this SDK is **only** applicable to EZ-BLE WICED Modules, and **should not be used** with EZ-BT WICED Modules or EZ-BLE Creator modules.

The WICED SMART SDK includes the following:

- Bluetooth 4.1 software stack including GAP, ATT, GATT, and SMP profiles
- Generic profile-level API
- Drivers to access onboard peripherals including UART, SPI, I^{2}C, ADC, PWM, Keyscan, etc.
- Reference applications for the devices with profiles defined by the Bluetooth SIG
- WICED SMART API documentation and related documents
- Utilities to support development in Windows, OS X, and Linux environments
- Drivers and detailed information to access the five sensors on the WICED_SENSE2 evaluation kit

The WICED SMART SDK runs on 32- and 64-bit versions of Microsoft Windows, OS X, and Linux. The SDK is distributed as both a standalone 7-zip file suitable for all operating systems and a bundle with the WICED Integrated Development Environment as an executable installer for Windows and Mac operating systems. The development computer requires a single USB port to connect to the WICED SMART tag.

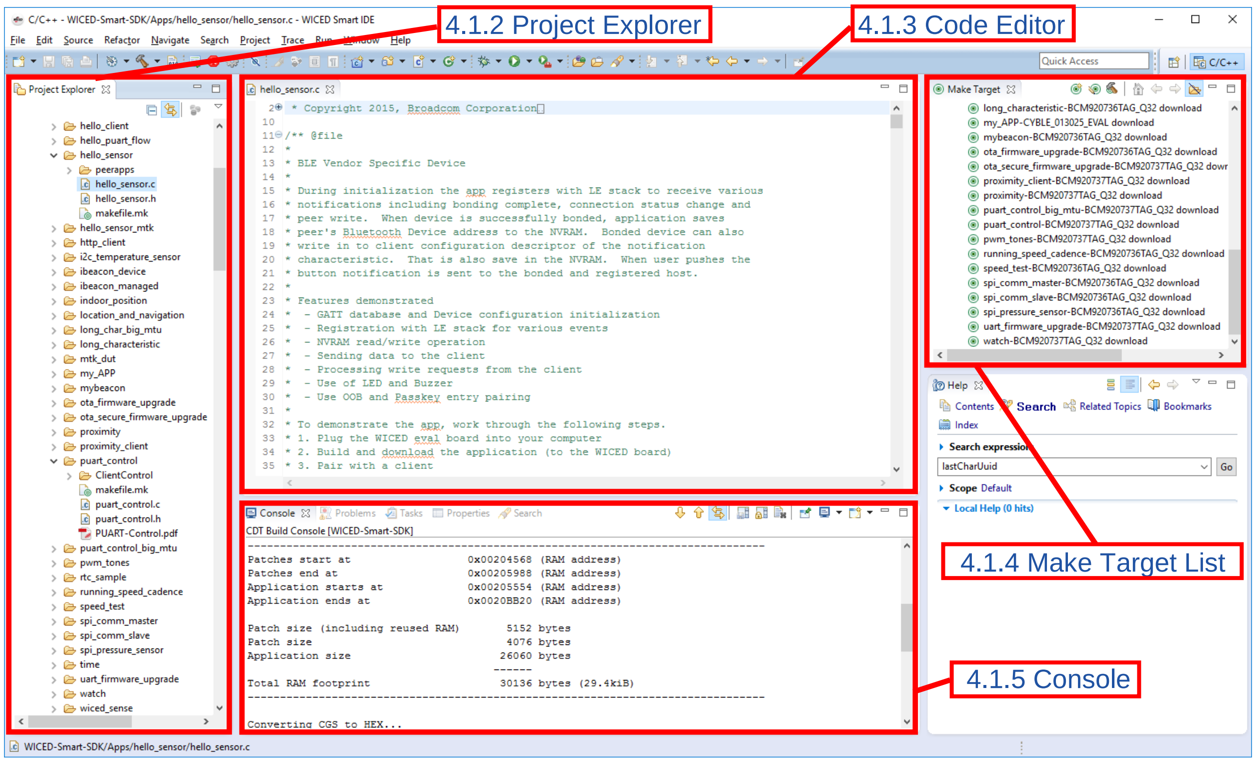
Note that a 32-bit version of Java is required to run the Eclipse-based IDE.

4.1.1 WICED SMART IDE Overview

The WICED SMART SDK comes with an Eclipse-based IDE that provides a comprehensive environment for creating, building, programming, and debugging WICED BLE applications. Figure 2 below shows the default layout with various sections of the IDE.

Building and downloading WICED SMART projects requires a slightly different procedure than some IDEs and toolchains use, so it is a good idea to familiarize yourself with the application early.

Figure 2. WICED SMART IDE Layout



```
 * Copyright 2015, Broadcom Corporation

/** @file
 *
 * BLE Vendor Specific Device
 *
 * During initialization the app registers with LE stack to receive various
 * notifications including bonding complete, connection status change and
 * peer write.  When device is successfully bonded, application saves
 * peer's Bluetooth Device address to the NVRAM.  Bonded device can also
 * write in to client configuration descriptor of the notification
 * characteristic.  That is also save in the NVRAM.  When user pushes the
 * button notification is sent to the bonded and registered host.
 *
 * Features demonstrated
 *  - GATT database and Device configuration initialization
 *  - Registration with LE stack for various events
 *  - NVRAM read/write operation
 *  - Sending data to the client
 *  - Processing write requests from the client
 *  - Use of LED and Buzzer
 *  - Use OOB and Passkey entry pairing
 *
 * To demonstrate the app, work through the following steps.
 * 1. Plug the WICED eval board into your computer
 * 2. Build and download the application (to the WICED board)
 * 3. Pair with a client
```

CDT Build Console [WICED-Smart-SDK]

```
--------------------------------------------------------------------------------
Patches start at                  0x00204568 (RAM address)
Patches end at                    0x00205988 (RAM address)
Application starts at             0x00205554 (RAM address)
Application ends at               0x0020BB20 (RAM address)

Patch size (including reused RAM)       5152 bytes
Patch size                              4076 bytes
Application size                       26060 bytes
                                      ------
Total RAM footprint                    30136 bytes (29.4kiB)
--------------------------------------------------------------------------------

Converting CGS to HEX...
```

4.1.2 Project Explorer

This pane in the IDE provides access to all of the source files for the projects active in the current workspace. The WICED SDK comes with a significant set of example projects inside the */Apps* subfolder where the SDK is installed. All of these projects are visible in the Project Explorer view by default. When you create a new project as described in Section 7 (My First EZ-BLE WICED Module Design), it will be added to this list of projects.

The standard workspace root folder is the SDK installation root folder, containing the following items:

- */Apps* folder with all example projects and any created projects
- */build* folder with build output files (created when using “Make” targets as intended)
- */Doc* folder with various SDK-related HTML and PDF reference materials
- */Drivers* folder with FTDI USB-to-UART bridge device drivers for Microsoft Windows
- */include* folder with header files supporting various chipset hardware features
- */Platforms* folder with board-specific toolchain and build definition files
- */Tools* folder with various toolchain binaries and helper applications used for building and downloading
- */Wiced-Smart* folder with header and source files for many application-visible APIs
- Top-level Makefile template and make scripts for building all WICED SMART projects
- Changelog, license, version, and general README text files

Once you get started, the */Apps* folder containing your project(s) will be the most relevant location. However, the documentation and header/source files provide a lot of helpful reference information during development as well.

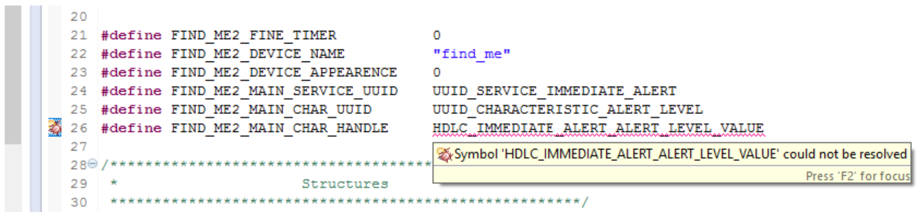
4.1.3 Code Editor

This pane allows editing all source code present in any project in the workspace. Open-source files are arranged by tabs for easy navigation. The Eclipse IDE foundation provides comprehensive syntax highlighting features, code completion, and other helpful functionality.

4.1.3.1 Eliminating False Code Analysis Errors

The ARM-GCC toolchain that WICED SMART uses to compile source files is not directly accessible to the Eclipse editor's built-in code analysis tools. Instead, the IDE uses a different compiler for live analysis, and this may result in identified errors that are not actually errors. For example, you may encounter this error while following the example project instructions contained in this guide:

Figure 3. Incorrect Code Analysis Error Identification



```
#define FIND_ME2_FINE_TIMER            0
#define FIND_ME2_DEVICE_NAME           "find_me"
#define FIND_ME2_DEVICE_APPERENCE      0
#define FIND_ME2_MAIN_SERVICE_UUID     UUID_SERVICE_IMMEDIATE_ALERT
#define FIND_ME2_MAIN_CHAR_UUID        UUID_CHARACTERISTIC_ALERT_LEVEL
#define FIND_ME2_MAIN_CHAR_HANDLE      HDLC_IMMEDIATE_ALERT_ALERT_LEVEL_VALUE

/*************************************
 *                        Structures
 *********************************************************/
```

Symbol 'HDLC_IMMEDIATE_ALERT_ALERT_LEVEL_VALUE' could not be resolved

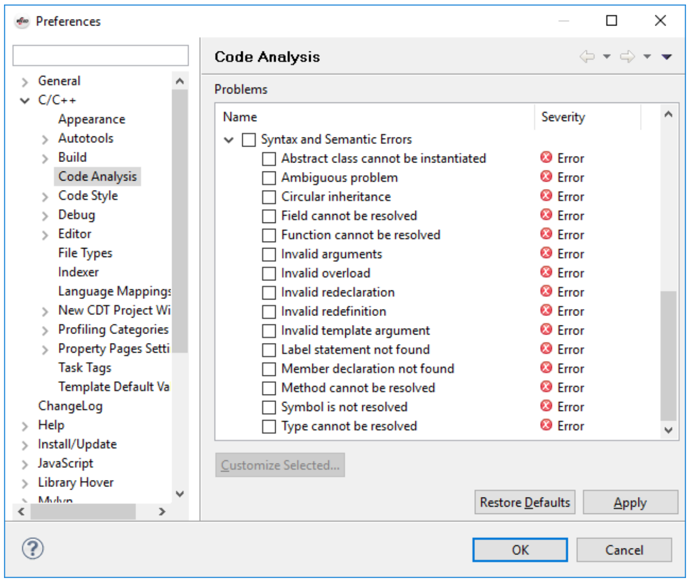
Press 'F2' for focus

The best test for syntax errors in your code is the compile process, as any real warnings or errors will be included in the build output. However, you can selectively disable the code analysis features that trigger these errors by following these simple steps:

1. Click the **Window** menu, then "Preferences" item.
2. Expand **C/C++** and select the **Code Analysis** entry.
3. Uncheck the **Syntax and Semantic Errors** box (may need to scroll down in the "Problems" section to see this).
4. Click **OK** to save changes.

Figure 4 shows what the final Preferences subsection looks like after disabling all of the Code Analysis syntax errors as described above.

Figure 4. Disabling Syntax and Semantic Analysis



Code Analysis

Problems

Name	Severity
☐ Syntax and Semantic Errors	
☐ Abstract class cannot be instantiated	Error
☐ Ambiguous problem	Error
☐ Circular inheritance	Error
☐ Field cannot be resolved	Error
☐ Function cannot be resolved	Error
☐ Invalid arguments	Error
☐ Invalid overload	Error
☐ Invalid redeclaration	Error
☐ Invalid redefinition	Error
☐ Invalid template argument	Error
☐ Label statement not found	Error
☐ Member declaration not found	Error
☐ Method cannot be resolved	Error
☐ Symbol is not resolved	Error
☐ Type cannot be resolved	Error

4.1.3.2 Improving Search Results

Because the workspace includes multiple example projects and many SDK resources, global code searches often return more information than you need. To mitigate this, you can configure narrower search parameters to allow searching a single project at a time by defining working sets:

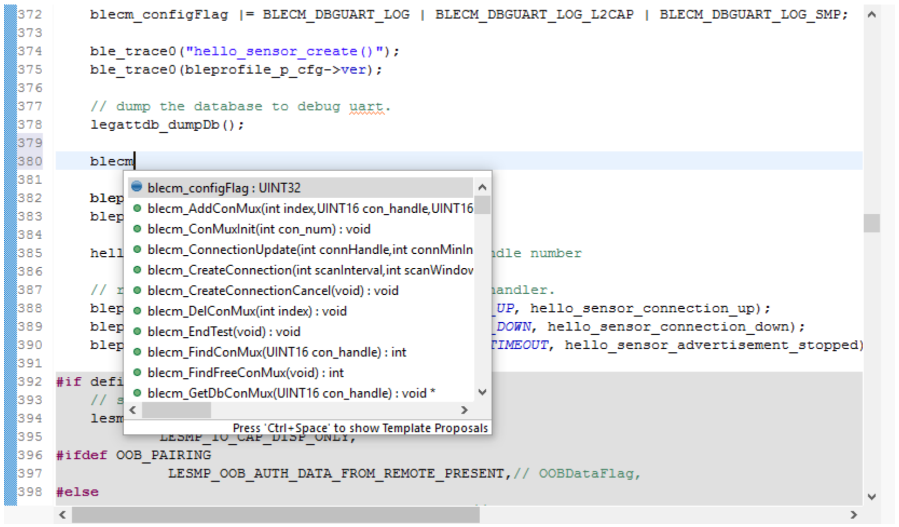
1. Click the **Search** menu, then "Search…" item (or press **Ctrl** + **H**).
2. Click the **Customize...** button and disable all items except "File Search", and then click **OK**.
3. Click the **Choose…** button next to the "Working set" selection field.
4. Click the **New…** button to define a new working set, and then choose "C/C++" and click **Next**.
5. Expand **Wiced-Smart-SDK** > **Apps** and select your project folder.
6. Enter a working set name (e.g., the same name as your project).
7. Click **Finish** to complete the working set definition.
8. Click the **Selected Working Sets** option and enable only the new set, then click **OK**.
9. Change the **Scope** setting to "Working set" if it does not change automatically.
10. Search as desired with these settings to obtain results only within your project.

You can still perform global searches simply by changing the scope back to "**Workspace**" at any time, or by highlighting any text in the code editor and pressing **Ctrl** + **Alt** + **G**.

4.1.3.3 Taking Advantage of Code Completion

The WICED SMART SDK provides numerous APIs to use all of the features available on supported target chipsets, and it can be challenging to keep the names and parameters straight. To help with this, use the **Ctrl** + **Space** shortcut key after typing the first few letters or prefix of a function name; Eclipse will pop up a quick list of potential completed names, as shown in the figure below.

Figure 5. Code Completion Example



```
    blecm_configFlag |= BLECM_DBGUART_LOG | BLECM_DBGUART_LOG_L2CAP | BLECM_DBGUART_LOG_SMP;

    ble_trace0("hello_sensor_create()");
    ble_trace0(bleprofile_p_cfg->ver);

    // dump the database to debug uart.
    legattdb_dumpDb();

    blecm

    blep
    blep

    hell                                                   dle number

    // r                                                   andler.
    blep                                                   UP, hello_sensor_connection_up);
    blep                                                   DOWN, hello_sensor_connection_down);
    blep                                                   TIMEOUT, hello_sensor_advertisement_stopped)

#if defi
    // s
    lesm
             LESMP_IO_CAP_DISP_ONLY,
#ifdef OOB_PAIRING
             LESMP_OOB_AUTH_DATA_FROM_REMOTE_PRESENT,// OOBDataFlag,
#else
```

```
blecm_configFlag : UINT32
blecm_AddConMux(int index,UINT16 con_handle,UINT16
blecm_ConMuxInit(int con_num) : void
blecm_ConnectionUpdate(int connHandle,int connMinIn
blecm_CreateConnection(int scanInterval,int scanWindov
blecm_CreateConnectionCancel(void) : void
blecm_DelConMux(int index) : void
blecm_EndTest(void) : void
blecm_FindConMux(UINT16 con_handle) : int
blecm_FindFreeConMux(void) : int
blecm_GetDbConMux(UINT16 con_handle) : void *
Press 'Ctrl+Space' to show Template Proposals
```

Try code completion with any of the following API method prefixes (not a comprehensive list):

- `blecm` – Core BLE application functions, callbacks, and some connection management
- `bleprofile` – Profile-specific behavior, NVRAM access, sleep requests, and other functions
- `gpio` – General-purpose I/O (GPIO) features
- `leatt` – GATT Client and Server callbacks, responses, and constants
- `legattdb` – GATT Client and Server operations

- `lesmp` – Security Manager Protocol (SMP) features such as pairing/bonding
- `lel2cap` – L2CAP connectivity features (includes some connection and ATT-related behavior)
- `puart` – Peripheral UART features
- `devlpm` – Low-power-mode features
- `adc` – Analog/Digital Conversion (ADC) features
- `pwm` – Pulse Width Modulation (PWM) features

4.1.4 Make Target List

This pane contains individual build targets for all of the example projects that come pre-installed with the WICED SMART SDK, as well as make targets for any new projects that you create. Each build target provides a unique combination of the following items:

- Project name (e.g., “find_me”)
- Target platform (e.g., “CYBLE_013025_EVAL”)
- Operational arguments (e.g., “download”, “UART=COM5”, and others)

Double-clicking on a make target will trigger the build process for that target. You can also use the **F9** keyboard shortcut in the Eclipse IDE to rebuild the last selected make target.

The project name and target platform are separated by a dash (“–”), while the name/target and all subsequent operational arguments are separated by spaces. Possible arguments are described in the output from the “help” target, which you can build at any time to see details. The output from this target is reproduced here for quick reference:

```
Usage: make <target> [download]  [recover] [DEBUG=1|0] [VERBOSE=1] [UART=yyyy] [JOBS=x] [PLATFORM_NV=EEPROM|SFLASH]
[BT_DEVICE_ADDRESS=zzzzzzzzzzzz|random]

  <target>
    One each of the following mandatory [and optional] components separated by '-'
      * Application (Apps in sub-directories are referenced by subdir.appname)
      * Hardware Platform (BCM920737TAG_Q32 BCM920736 BCM920736TAG_Q32 CYBLE_013025_EVAL)
      * [BASE location] (BASErom BASEram BASEflash)
      * [SPAR location] (SPARrom SPARram SPARflash)
      * [Toolchain] (RealView Wiced CodeSourcery)

  [download]
    Download firmware image to target platform

  [build]
    Builds the firmware and OTA images.

  [recover]
    Recover a corrupted target platform

  [DEBUG=1|0]
    Enable or disable debug code in application. When DEBUG=1, watchdog will be disabled,
    sleep will be disabled and the app may optionally wait in a while(1) for the debugger
    to connect

  [VERBOSE=1]
    Shows the commands as they are being executed

  [JOBS=x]
    Sets the maximum number of parallel build threads (default=4)

  [UART=yyyy]
    Use the uart specified here instead of trying to detect the Wiced-Smart device.
    This is useful when you are working on multiple smart devices simultaneously.

  [PLATFORM_NV=EEPROM|SFLASH]
    The non-volatile storage. Default is EEPROM.

  [BT_DEVICE_ADDRESS=zzzzzzzzzzzz|random]
    Use the 48-bit Bluetooth address specified here instead of the default setting from
    Platform/*/*.btp file. The special string 'random' (without the quotes) will generate
    a random Bluetooth device address on every download.

  Notes
    * Component names are case sensitive
    * 'Wiced', 'SPI', 'UART' and 'debug' are reserved component names
    * Component names MUST NOT include space or '-' characters
    * Building for release is assumed unless '-debug' is appended to the target

  Example Usage
    Build for Release
       make proximity-BCM920737TAG_Q32 build

    Build, Download and Run using the default programming interface
       make proximity-BCM920737TAG_Q32 download

    Build, Download and Run using specific UART port, with a specific Bluetooth decice address
       make proximity-BCM920737TAG_Q32 download UART=COMx BT_DEVICE_ADDRESS=20736A1C0FFE

    Build, Download to Serial Flash and Run using default programming interface, select a random Bluetooth device address
       make proximity-BCM920737TAG_Q32 download PLATFORM_NV=SFLASH BT_DEVICE_ADDRESS=random

    Clean output directory
       make clean
```

Any single project may have one or more defined make targets. For instance, one target might perform only the compile step, while another performs both compile and download, and another may explicitly provide the programming COM port to avoid the serial port detection step if the port is known.

Here are some examples of make targets that come with the SDK:

- glucose_meter-BCM920736TAG_Q32 download
- ibeacon_device-BCM920736TAG_Q32 download
- puart_control-BCM920737TAG_Q32 download

The platforms shipped with the SDK are used with the various WICED "Tag" evaluation products that are built around the CYW2073x chipsets. However, for EZ-BLE WICED Module evaluation, we will be working with the CYBLE-013025-EVAL board instead, which requires a different platform definition. Section 7.3 (My First EZ-BLE WICED Module Design) provides instructions on where to obtain and how to install this platform, or you can refer to KBA 220379 on the Cypress website.

4.1.5 Console

This pane provides access to compiler output, which is helpful for status updates and critical for error analysis. The same area of the IDE window also allows a quick look at search results after performing a search, and enabled code analysis warnings or errors, and tasks identified by “TODO” comments in source files.

4.1.5.1 Debug Trace Output

One other key feature that the console pane optionally provides is specially decoded output from debug traces. This feature allows one-way output during normal code execution on the module. This debug output typically comes out the HCI UART TX pin (though it may be reconfigured in code to use the peripheral UART TX pin if PUART is not otherwise used). It allows **printf**-like formatting of output strings with between zero and six variable arguments in addition to the format string, via the following set of functions:

- `ble_trace0(string)`
- `ble_trace1(string, arg1)`
- `ble_trace2(string, arg1, arg2)`
- `...`
- `ble_trace6(string, arg1, arg2, arg3, arg4, arg5, arg6)`

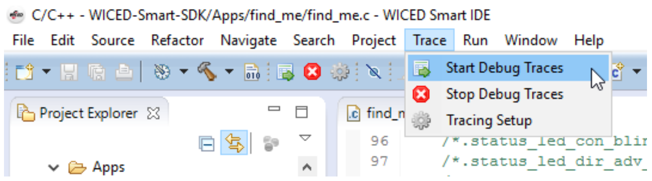
This set of functions behaves like the typical variable-argument **printf** function in C, except that the maximum supported variable argument count is six.

Most examples and the automatically generated code from the WICED Bluetooth Designer tool use this debug trace output for simple execution flow monitoring. Since it is not possible to perform true break/step debugging with the WICED SMART SDK, this type of debug output is immensely helpful during the development phase.

To use debug tracing with the CYBLE-013025-EVAL board, follow this procedure:

1. Set SW1 positions 1-4 (PUART) to the OFF state and positions 5-6 (HCI UART) to the ON state.
2. Compile and download the firmware into the module (application will begin executing immediately).
3. Set SW1 position 6 (HCI UART RX) to the OFF state to disconnect it from the host.
4. Use the **Trace** menu and select **Start Debug Traces** to begin capturing and decoding data.

Figure 6. Starting Debug Traces

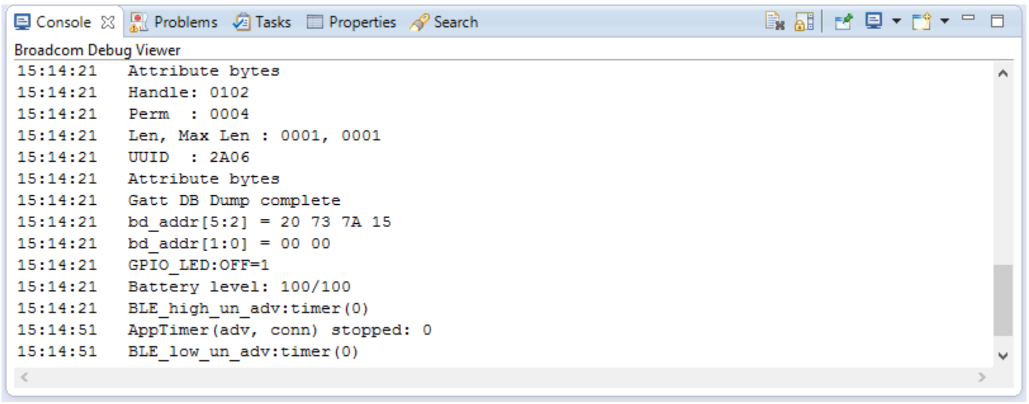


```
/*.status_led_con_blir
/*.status_led_dir_adv_
```

5. Optionally, reboot the board with the SW2 (RESET) button if you need to capture boot-time output.
6. When finished, use the **Trace** menu and **Stop Debug Traces** item to detach the console and release the serial port to allow downloading firmware again.

The console output with debug traces enabled in the “find_me” example illustrated in this document looks like Figure 7 below. The standard behavior begins with a `create()` message followed by a GATT database structure dump, and then the module begins advertising.

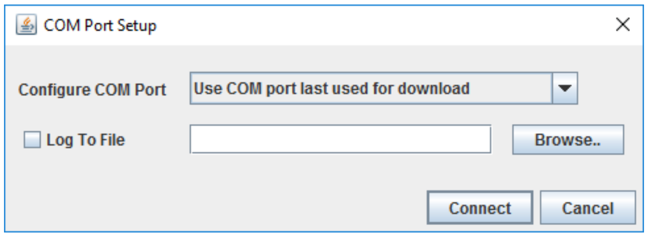
Figure 7. Example Debug Trace Output



```
15:14:21   Attribute bytes
15:14:21   Handle: 0102
15:14:21   Perm  : 0004
15:14:21   Len, Max Len : 0001, 0001
15:14:21   UUID  : 2A06
15:14:21   Attribute bytes
15:14:21   Gatt DB Dump complete
15:14:21   bd_addr[5:2] = 20 73 7A 15
15:14:21   bd_addr[1:0] = 00 00
15:14:21   GPIO_LED:OFF=1
15:14:21   Battery level: 100/100
15:14:21   BLE_high_un_adv:timer(0)
15:14:51   AppTimer(adv, conn) stopped: 0
15:14:51   BLE_low_un_adv:timer(0)
```

If necessary, you can also use the **Trace** menu and **Tracing Setup** item to enable logging to a file, or to configure whether to use a specific serial port or the last one automatically determined by the download process.

Figure 8. Example Debug Trace Output



Configure COM Port: Use COM port last used for download

☐ Log To File

If your make target specifies the port with a `UART=COM`*n* argument, you should also manually select the debug trace port to match this because the IDE will not perform the discovery process necessary to make it work otherwise.

Follow these guidelines when using debug traces for the smoothest experience:

1. Ensure that the HCI UART RX pin is **disconnected** from the host before capturing traces. This prevents the module from booting back into HCI/programming mode unexpectedly if/when a chipset reset occurs.
2. Ensure that the HCI UART RX pin is **reconnected** to the host before attempting to download firmware again.
3. Ensure that you **stop** debug traces *before* attempting to download updated firmware into the module.
4. Ensure that you configure the debug trace port manually if your target also specifies the COM port manually.
5. Ensure that you configure the debug trace setup options only when tracing is disabled. Reconfiguring it while enabled is not possible.

4.2 CySmart PC Application

The CySmart Host Emulation Tool is a Windows application that emulates a BLE Central device using the CY5670 or CY5677 USB dongle. It provides a platform for you to test your EZ-BLE WICED Module Peripheral implementation over GATT or L2CAP connection-oriented channels by allowing you to discover and configure BLE services, characteristics, and attributes on your Peripheral.

The CySmart PC application provides only BLE functions; it cannot communicate over any non-low-energy Bluetooth protocols (RFCOMM, SCO, etc.) that are supported on EZ-BT WICED Modules.

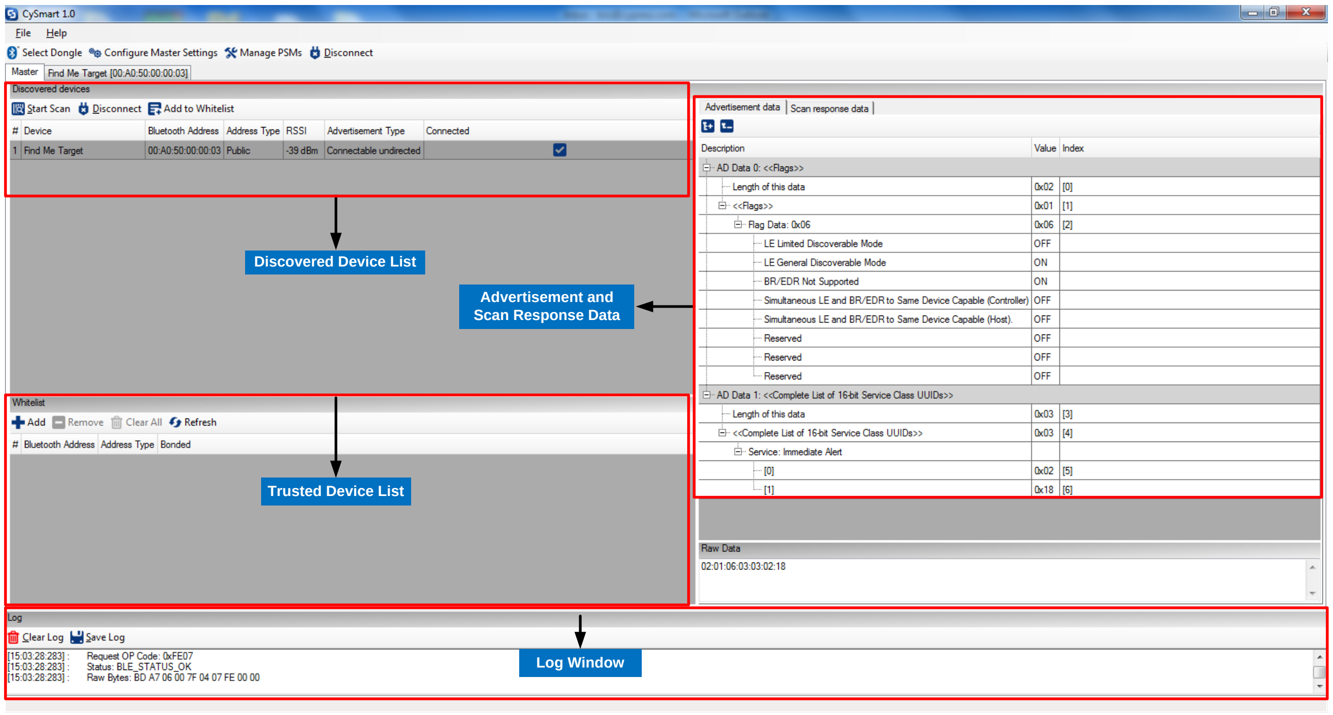
Operations that you can perform with CySmart Host Emulation Tool include, but are not limited to:

- Scan BLE Peripherals to discover available devices to which you can connect.
- Discover available BLE attributes including services and characteristics on the connected Peripheral device.
- Perform read and write operations on characteristic values and descriptors.
- Receive characteristic notifications and indications from the connected Peripheral device.

- Establish a bond with the connected Peripheral device using BLE Security Manager procedures.
- Establish a BLE L2CAP connection-oriented session with the Peripheral device and exchange data per the Bluetooth 4.1 specification.

Figure 9 and Figure 10 show the user interface of CySmart Host Emulation Tool. For more information on how to set up and use this tool, see the CySmart user guide from the **Help** menu.

Figure 9. CySmart Host Emulation Tool Master Device Tab



#	Device	Bluetooth Address	Address Type	RSSI	Advertisement Type	Connected
1	Find Me Target	00:A0:50:00:00:03	Public	-39 dBm	Connectable undirected	✓

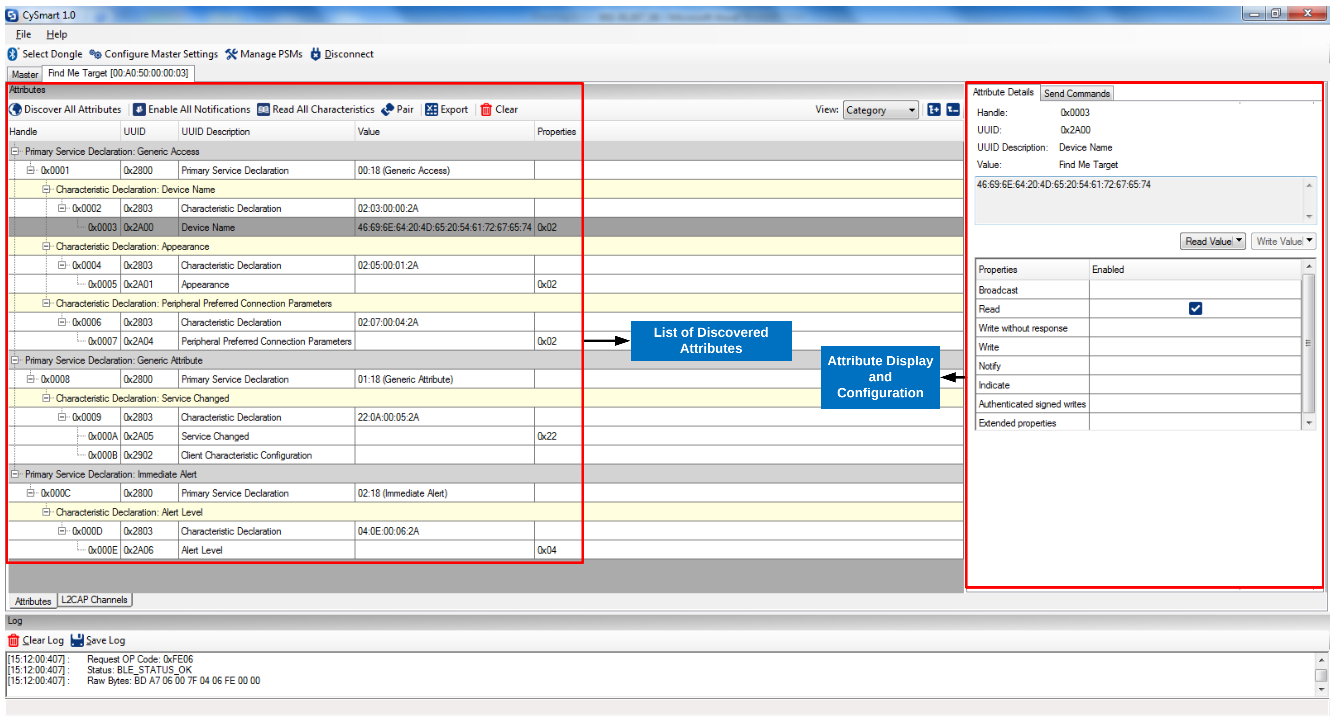
Description	Value	Index
AD Data 0: <<Flags>>		
Length of this data	0x02	[0]
<<Flags>>	0x01	[1]
Flag Data: 0x06	0x06	[2]
LE Limited Discoverable Mode	OFF	
LE General Discoverable Mode	ON	
BR/EDR Not Supported	ON	
Simultaneous LE and BR/EDR to Same Device Capable (Controller)	OFF	
Simultaneous LE and BR/EDR to Same Device Capable (Host).	OFF	
Reserved	OFF	
Reserved	OFF	
Reserved	OFF	
AD Data 1: <<Complete List of 16-bit Service Class UUIDs>>		
Length of this data	0x03	[3]
<<Complete List of 16-bit Service Class UUIDs>>	0x03	[4]
Service: Immediate Alert		
[0]	0x02	[5]
[1]	0x18	[6]

```
02:01:06:03:03:02:18
```

#	Bluetooth Address	Address Type	Bonded

```
[15:03:28:283] :      Request OP Code: 0xFE07
[15:03:28:283] :      Status: BLE_STATUS_OK
[15:03:28:283] :      Raw Bytes: BD A7 06 00 7F 04 07 FE 00 00
```

Figure 10. CySmart Host Emulation Tool Peripheral Device Attributes Tab



Handle	UUID	UUID Description	Value	Properties
Primary Service Declaration: Generic Access				
0x0001	0x2800	Primary Service Declaration	00:18 (Generic Access)	
Characteristic Declaration: Device Name				
0x0002	0x2803	Characteristic Declaration	02:03:00:00:2A	
0x0003	0x2A00	Device Name	46:69:6E:64:20:4D:65:20:54:61:72:67:65:74	0x02
Characteristic Declaration: Appearance				
0x0004	0x2803	Characteristic Declaration	02:05:00:01:2A	
0x0005	0x2A01	Appearance		0x02
Characteristic Declaration: Peripheral Preferred Connection Parameters				
0x0006	0x2803	Characteristic Declaration	02:07:00:04:2A	
0x0007	0x2A04	Peripheral Preferred Connection Parameters		0x02
Primary Service Declaration: Generic Attribute				
0x0008	0x2800	Primary Service Declaration	01:18 (Generic Attribute)	
Characteristic Declaration: Service Changed				
0x0009	0x2803	Characteristic Declaration	22:0A:00:05:2A	
0x000A	0x2A05	Service Changed		0x22
0x000B	0x2902	Client Characteristic Configuration		
Primary Service Declaration: Immediate Alert				
0x000C	0x2800	Primary Service Declaration	02:18 (Immediate Alert)	
Characteristic Declaration: Alert Level				
0x000D	0x2803	Characteristic Declaration	04:0E:00:06:2A	
0x000E	0x2A06	Alert Level		0x04

Handle:	0x0003
UUID:	0x2A00
UUID Description:	Device Name
Value:	Find Me Target

46:69:6E:64:20:4D:65:20:54:61:72:67:65:74

Properties	Enabled
Broadcast	
Read	✓
Write without response	
Write	
Notify	
Indicate	
Authenticated signed writes	
Extended properties	

```
[15:12:00:407] :    Request OP Code: 0xFE06
[15:12:00:407] :    Status: BLE_STATUS_OK
[15:12:00:407] :    Raw Bytes: BD A7 06 00 7F 04 06 FE 00 00
```

4.3 CySmart Mobile App

In addition to the PC tool, you can download the CySmart mobile app for iOS or Android from the respective app stores. This app uses the iOS Core Bluetooth framework and the Android built-in platform framework for BLE respectively to configure your BLE-enabled smartphone as a Central device that can scan and connect to Peripheral devices.

The CySmart mobile app provides only BLE functions; it cannot communicate over any non-low-energy Bluetooth protocols (RFCOMM, SCO, etc.) that are supported on EZ-BT WICED Modules.

The mobile app supports SIG-adopted BLE standard profiles through an intuitive GUI and abstracts the underlying BLE service and characteristic details. Figure 11 and Figure 12 show a set of CySmart app screenshots for the Heart Rate Profile user interface.

Figure 11. CySmart iOS App Heart Rate Profile Example

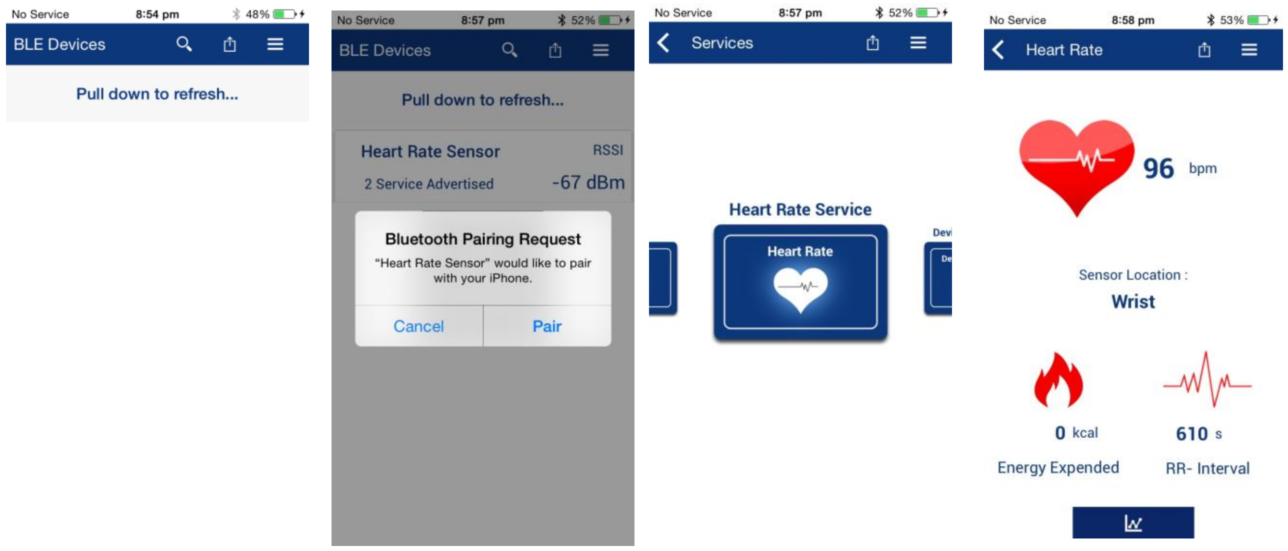
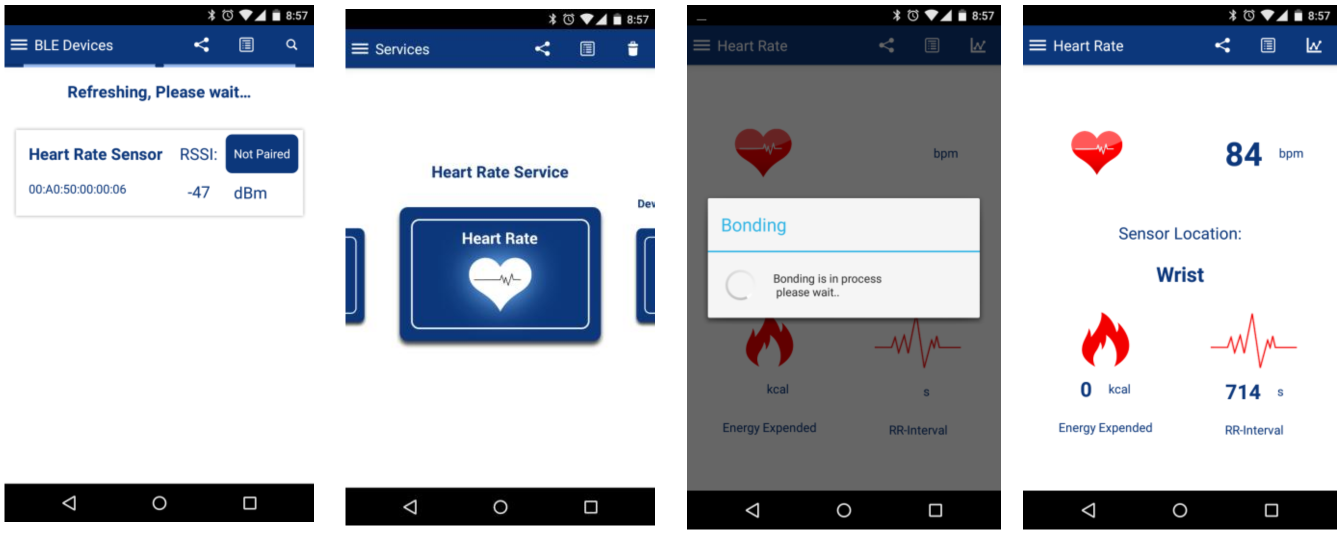


Figure 12. CySmart Android App Heart Rate Profile Example



5 Development Kits and Evaluation Boards

Cypress provides easy-to-use evaluation boards to help you develop your EZ-BLE WICED Module design.

5.1 EZ-BLE WICED Module Evaluation Boards

Each EZ-BLE WICED Module provides an evaluation board that can be used to develop and test the performance of the Cypress EZ-BLE WICED Module. EZ-BLE WICED evaluation boards are Arduino-compatible baseboards, designed to work as stand-alone evaluation vehicles, or in conjunction with Arduino-compatible shields.

EZ-BLE WICED evaluation boards allow you to evaluate Cypress EZ-BLE Modules without having to design custom hardware to mount the Cypress EZ-BLE Module.

Table 4 lists available EZ-BLE WICED Modules and their corresponding evaluation board part numbers. Click on your evaluation board for additional information.

Table 4. EZ-BLE Modules and Corresponding Evaluation Board Part Numbers

EZ-BLE WICED Module Part Number	EZ-BLE WICED Evaluation Board Part Number
CYBLE-013025-00	CYBLE-013025-EVAL
CYBLE-013030-00	CYBLE-013025-EVAL

Each EZ-BLE WICED evaluation board contains the following components:

- Cypress EZ-BLE Module – soldered directly to the evaluation board
- PCB substrate
- Arduino-compatible baseboard headers
- USB-to-UART Bridge
- USB connection (for WICED SMART SDK PC interface, programming, and EZ-Serial interface)
- Connection headers for HCI-UART direct connection (as needed)
  - A configuration switch network is provided to configure the UART connection to the USB connector. This switch network can be configured to enable either HCI-UART or Peripheral-UART to the USB connector.
- Header connection for current consumption measurement
- Configuration headers for setting the desired power supply level
- Power supply jumper for current consumption measurement
- Reset and switch
- User-defined switch element
- Inductors (for power supply noise reduction) – refer to your EZ-BLE WICED Module datasheet for recommended external components)

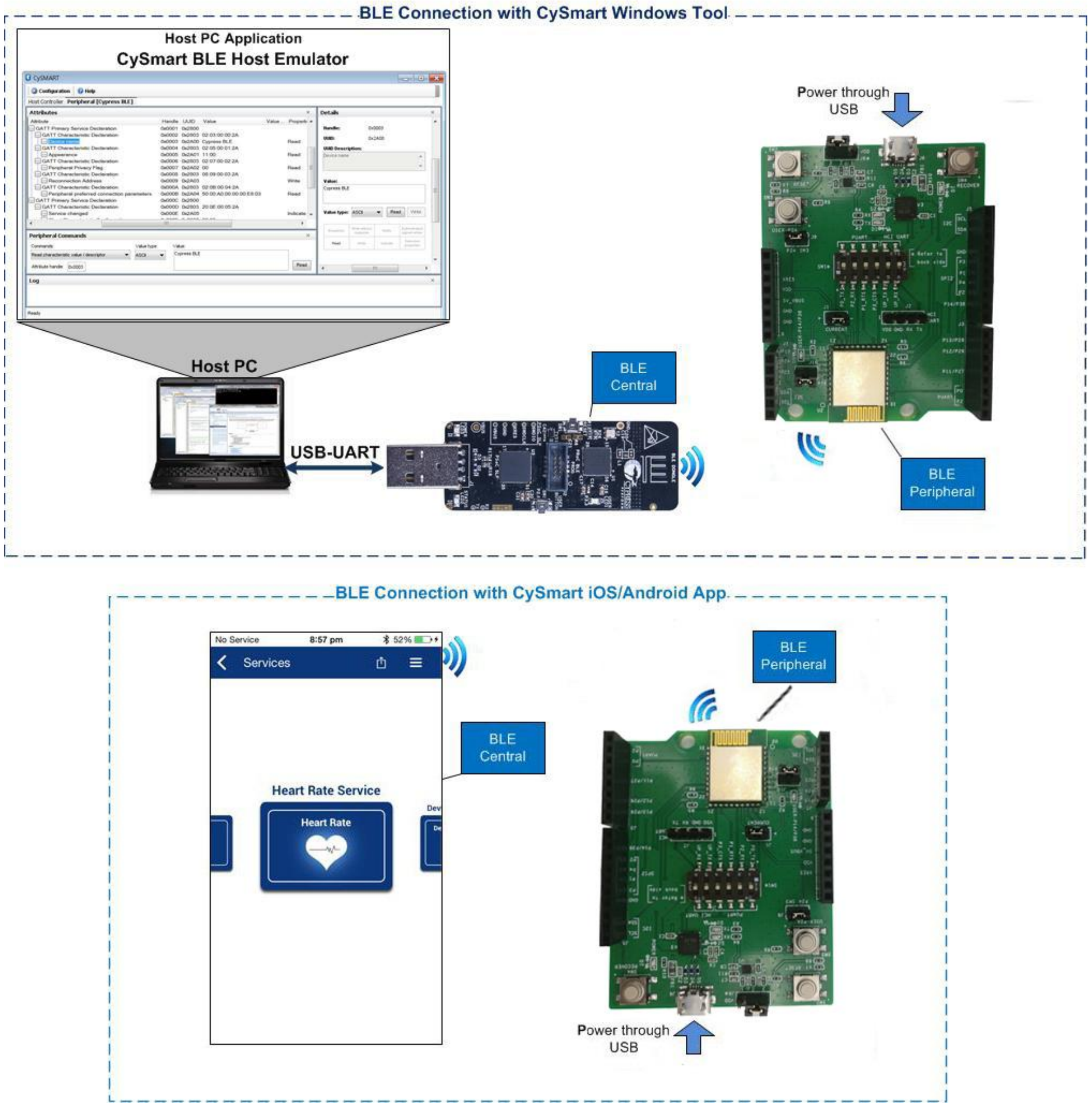
EZ-BLE WICED evaluation boards are designed to simulate the placement and connection of the EZ-BLE Modules in a final application. All host-side layout pattern recommendations (as shown in each specific module’s datasheet) are followed for each evaluation board.

See Appendix C: EZ-BLE WICED Evaluation Board Details for details on the connections available for each of the EZ-BLE WICED evaluation boards.

6 EZ-BLE WICED Module Development Setup (WICED SMART SDK)

Figure 13 shows the hardware and software tools required for evaluating BLE Peripheral designs using the EZ-BLE WICED Module evaluation boards. The EZ-BLE WICED evaluation board is a self-contained Peripheral device that can communicate with either a CySmart iOS/Android app or the CySmart Host Emulation Tool that acts as a Central device. The CySmart Host Emulation Tool also requires a BLE dongle (black board in Figure 13) for its operation. The dongle is included in the CY5677 kit.

Figure 13. BLE Functional Setup with EZ-BLE WICED Evaluation Board



The My First EZ-BLE WICED Module Design section will walk you through a step-by-step configuration and programming of the EZ-BLE WICED Module by creating a simple Peripheral application.

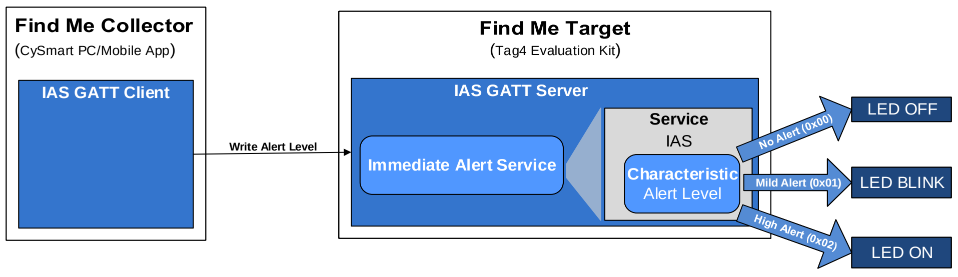
7 My First EZ-BLE WICED Module Design

This section gives you a step-by-step process for building a simple design with the CYBLE-013025-EVAL kit using the WICED SMART SDK and IDE.

7.1 About the Design

This design implements the BLE Find Me Profile in the Target role that consists of an Immediate Alert Service (IAS). Alert levels triggered by the Find Me Locator are indicated by varying the state of a LED on the evaluation board, as Figure 14 shows. A single status LED indicates the state of the alert level.

Figure 14. My First EZ-BLE WICED Module Design



7.2 Prerequisites

Before you get started with the implementation, make sure that you have the following software and hardware available:

- WICED SMART SDK v2.2.3 or later
- CySmart Host Emulation Tool or CySmart iOS/Android app
- CYBLE-013025-EVAL EZ-BLE WICED Evaluation Board

You can create your first EZ-BLE WICED Module design in four steps:

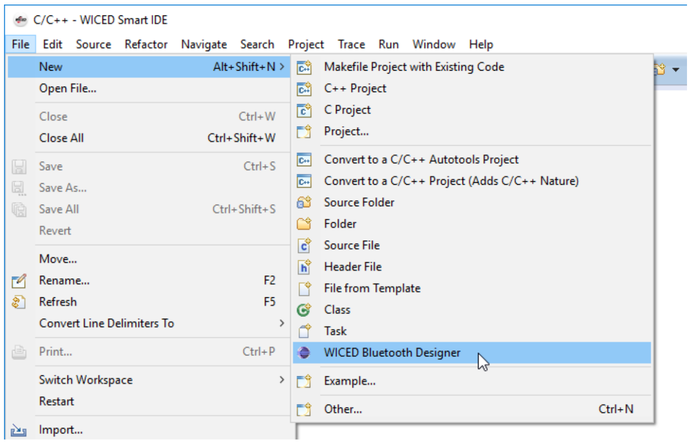
1. Configure the design in the WICED SMART SDK's WICED Bluetooth Designer.
2. Write the firmware to initialize and handle BLE events.
3. Program the EZ-BLE WICED Module on the Evaluation Kit.
4. Test your design using the CySmart Host Emulation Tool or mobile application.

7.3 Part 1: Configure the Design

This section takes you on a step-by-step guided tour of the design process. It starts with creating a new project and guides you through the Bluetooth Designer. You can skip this section if you simply wish to try the example project provided with this application note without going through the build process, and you already have the WICED SMART SDK installed on your computer.

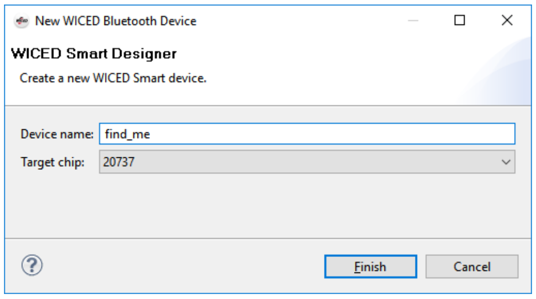
1. Install WICED SMART SDK v2.2.3 or newer on your PC. If you are using Windows, the automatic installer option provides the easiest way to do this. Other options are available as described in Section 4.1.
2. Start the WICED SMART IDE, and from the **File** menu, choose **New** > **WICED Bluetooth Designer**, as Figure 15 shows.

Figure 15. Creating a New Project



3. Enter an appropriate name for your project (this example uses “**find_me**”), and select '20737' as the target. The target chip for any given EZ-BLE Module can be found in the module datasheet.

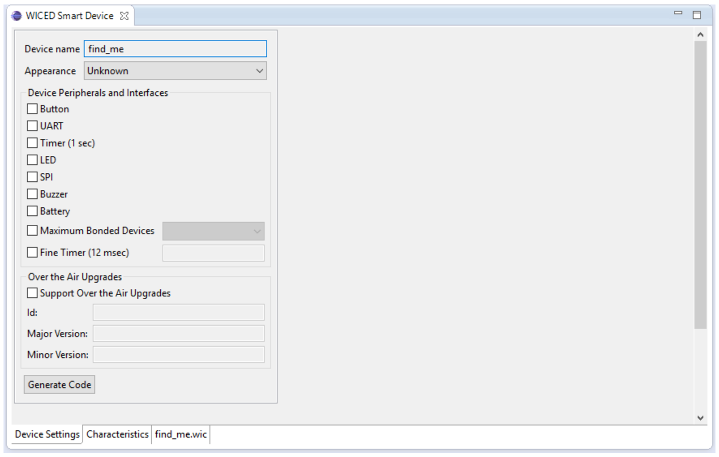
Figure 16. Project Name and Target Chip



Device name: find_me
Target chip: 20737

4. Click **Finish**. Your workspace opens into with a new WICED Smart Device tab as shown in Figure 17. This tab is the graphical interface for editing the *find_me.wic* file that defines the functionality of your project at a high level using the WICED Bluetooth Designer tool.

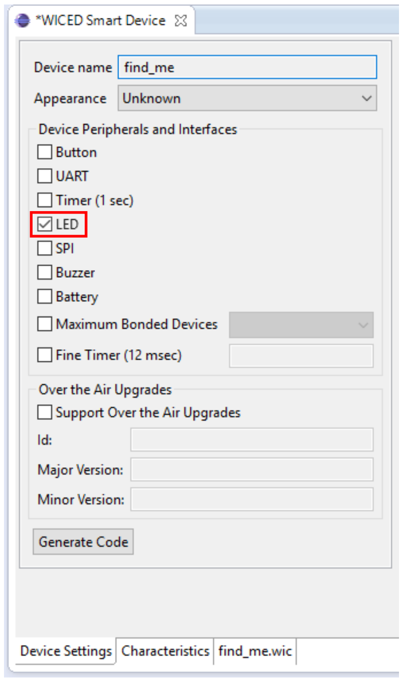
Figure 17. New Bluetooth Designer View



Device name: find_me
Appearance: Unknown

5. Because the project uses the LED on the kit to indicate the alert level for the Immediate Alert Service, check the 'LED' box on the Device Settings tab to enable the LED peripheral driver, as shown in Figure 18.

Figure 18. Enabling LED Support in the Bluetooth Designer


*WICED Smart Device

Device name: find_me

Appearance: Unknown

Device Peripherals and Interfaces
- [ ] Button
- [ ] UART
- [ ] Timer (1 sec)
- [x] LED
- [ ] SPI
- [ ] Buzzer
- [ ] Battery
- [ ] Maximum Bonded Devices
- [ ] Fine Timer (12 msec)

Over the Air Upgrades
- [ ] Support Over the Air Upgrades

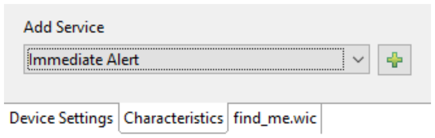
Id:

Major Version:

Minor Version:

6. Click the **Characteristics** tab at the bottom of the Bluetooth Designer view to switch to the area that allows you to define the GATT structure. Select the **Immediate Alert** entry from the list of services under the **Add Service** title on the **Characteristics** tab, then click the 'plus' icon to the right, as shown in Figure 19.

Figure 19. Adding the Immediate Alert Service to the GATT Database

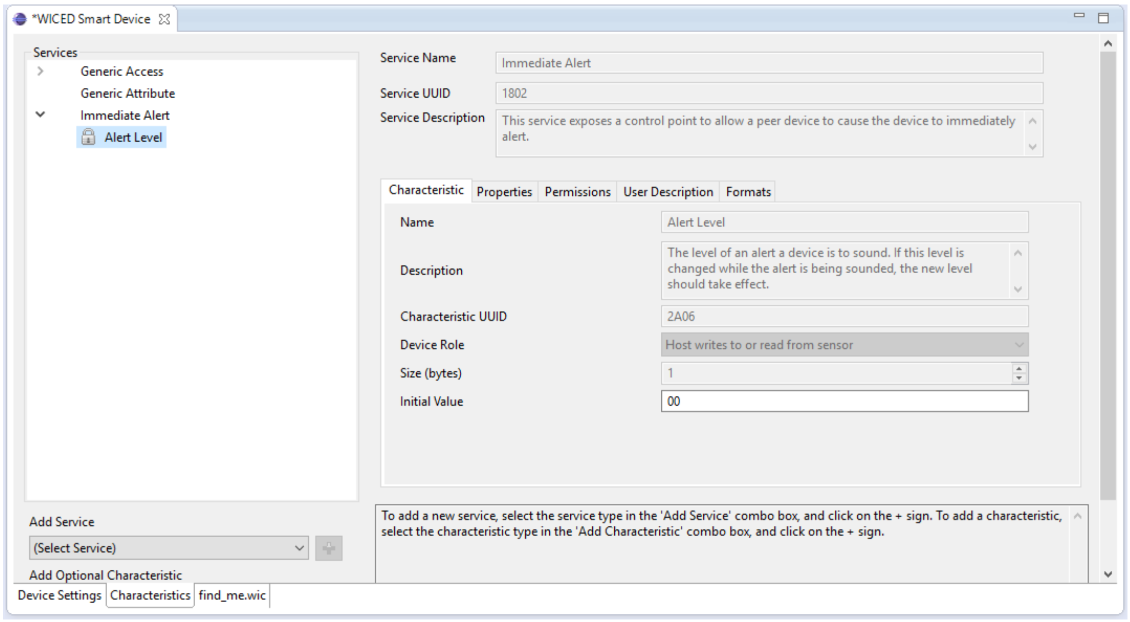

Add Service: Immediate Alert

This adds the service to the GATT structure after the two required services (Generic Access and Generic Attribute). Because this is a predefined service, the required Alert Level characteristic is also added for you and given the correct permissions.

The WICED SMART SDK supports a number of standard Bluetooth SIG profiles, and also supports generation of custom profiles/services to suit the needs of your application. The Find Me example project in this application note is specifically focused on the Immediate Alert service profile.

7. Expand the new 'Immediate Alert' entry in the list of services on the left, then select the 'Alert Level' characteristic entry to view detailed information about that characteristic. No changes are required at this time (nor are they available because the characteristic is predefined), but take note of the information available the view shown in Figure 20.

Figure 20. Viewing Characteristic Definition Details



*WICED Smart Device

Services
- Generic Access
- Generic Attribute
- Immediate Alert
  - Alert Level

Service Name: Immediate Alert
Service UUID: 1802
Service Description: This service exposes a control point to allow a peer device to cause the device to immediately alert.

Characteristic | Properties | Permissions | User Description | Formats

Name: Alert Level
Description: The level of an alert a device is to sound. If this level is changed while the alert is being sounded, the new level should take effect.
Characteristic UUID: 2A06
Device Role: Host writes to or read from sensor
Size (bytes): 1
Initial Value: 00

Add Service: (Select Service)
Add Optional Characteristic

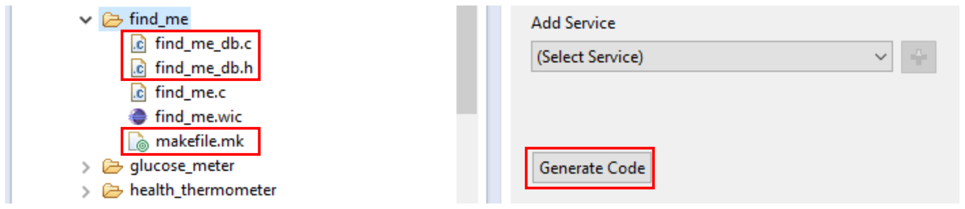
To add a new service, select the service type in the 'Add Service' combo box, and click on the + sign. To add a characteristic, select the characteristic type in the 'Add Characteristic' combo box, and click on the + sign.

Device Settings | Characteristics | find_me.wic

8. Scroll down inside the main Bluetooth Designer view's **Characteristic** tab (or **Device Settings** tab) and click the **Generate Code** as shown in Figure 21.

   This generates or updates three files (GATT database header and source file and the project's makefile) in the project source folder. If these files already exist, the originals will be copied to backup files and then replaced with new ones. You will use these files later in Section 7.4.

Figure 21. Generating Source Files



   If your own projects require the use of additional source files, add these to the *makefile.mk* file manually. See Appendix F: Makefile Customization for details on makefile customization.

9. If you have not installed the SDK platform definition files for the CYBLE-013025-EVAL board before, then you should do so now. The platform defines the functional GPIO assignments, NVRAM type, and some other low-level values that control the firmware image download process for a specific target device. This custom platform definition is required to properly use the CYBLE-013025-EVAL board, but it is not currently bundled with the WICED SMART SDK. To install it, follow these steps:

   a. Visit http://www.cypress.com/knowledge-base-article/platform-files-cyble-013025-eval-kba220379 and download the *CYBLE_013025_EVAL Platform files.zip* platform archive. (This page also contains the instructions below.)

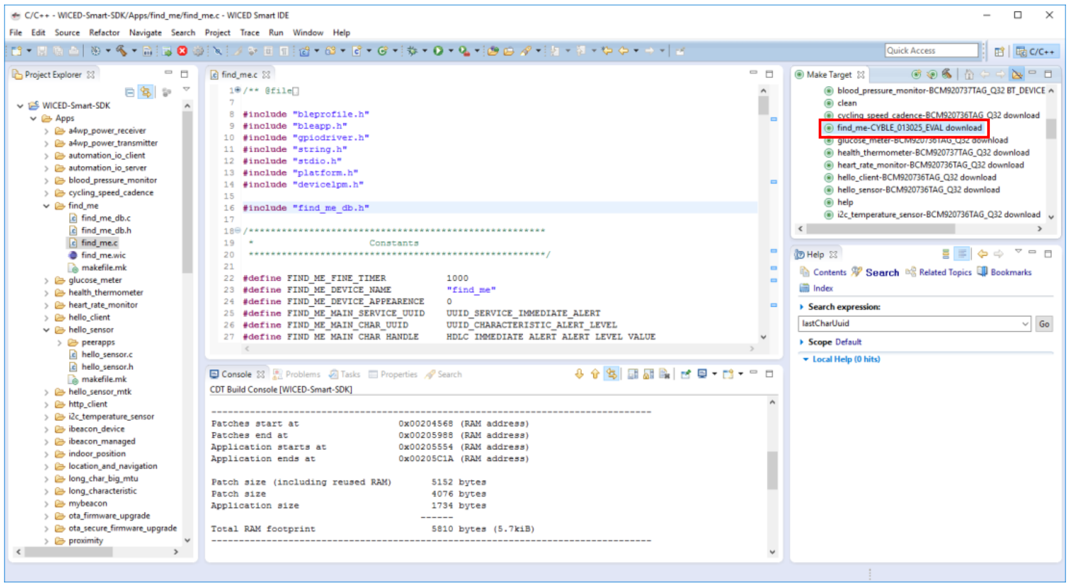
   b. Extract the downloaded file to your computer.

   c. Navigate to the **CYBLE_013025_EVAL Platform files** location and copy the *CYBLE_013025_EVAL* folder into the *\WICED-Smart-SDK\Platforms\* location inside the SDK's main installation folder.

d. Navigate to the *CYBLE_013025_EVAL Platform files\include _ platforms* location and copy the *CYBLE_013025_EVAL* folder into the *\WICED-Smart-SDK\include\Platforms\* location inside the SDK's main installation folder.

10. Identify the project's make target entry in the list near the top right of the IDE. If you used the 'find_me' name for the project as what is in this guide, then the make target will be named **find_me-CYBLE_013025_EVAL download** in the list, as Figure 22 shows. The Make Target list provides the mechanism that you use for compiling and downloading firmware to the target device. The default Make Target is added when you create a new project is suitable for re-flashing; however, the build system supports some custom arguments to assist with troubleshooting or special cases. These arguments are discussed in Section 4.1.4 (Make Target List).

Figure 22. Default *Download* Make Target for Find Me Project



```
/** @file

#include "bleprofile.h"
#include "bleapp.h"
#include "gpiodriver.h"
#include "string.h"
#include "stdio.h"
#include "platform.h"
#include "devicelpm.h"

#include "find_me_db.h"

/*******************************************************
 *                    Constants
 *******************************************************/

#define FIND_ME_FINE_TIMER          1000
#define FIND_ME_DEVICE_NAME         "find_me"
#define FIND_ME_DEVICE_APPEARENCE   0
#define FIND_ME_MAIN_SERVICE_UUID   UUID_SERVICE_IMMEDIATE_ALERT
#define FIND_ME_MAIN_CHAR_UUID      UUID_CHARACTERISTIC_ALERT_LEVEL
#define FIND_ME_MAIN_CHAR_HANDLE    HDLC_IMMEDIATE_ALERT_ALERT_LEVEL_VALUE
```

CDT Build Console [WICED-Smart-SDK]

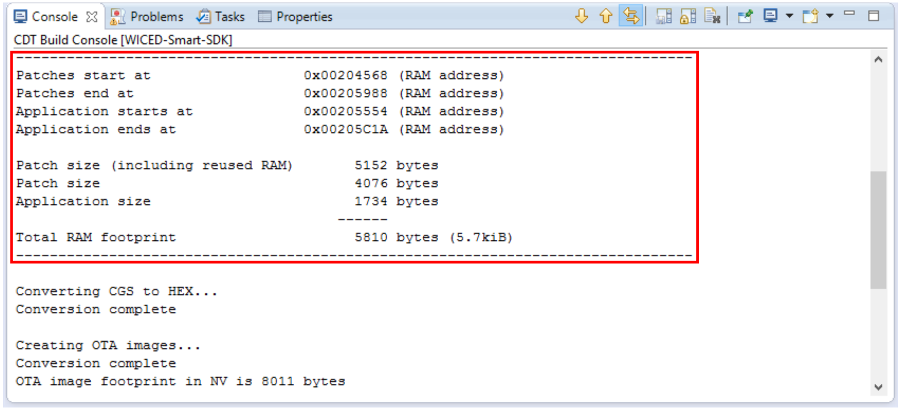
```
--------------------------------------------------------------------------------
Patches start at                  0x00204568 (RAM address)
Patches end at                    0x00205988 (RAM address)
Application starts at             0x00205554 (RAM address)
Application ends at               0x00205C1A (RAM address)

Patch size (including reused RAM)       5152 bytes
Patch size                              4076 bytes
Application size                        1734 bytes
                                      ------
Total RAM footprint                     5810 bytes (5.7kiB)
--------------------------------------------------------------------------------
```

Make Target:

- blood_pressure_monitor-BCM920737TAG_Q32 BT_DEVICE
- clean
- cycling_speed_cadence-BCM920736TAG_Q32 download
- find_me-CYBLE_013025_EVAL download
- glucose_meter-BCM920736TAG_Q32 download
- health_thermometer-BCM920737TAG_Q32 download
- heart_rate_monitor-BCM920736TAG_Q32 download
- hello_client-BCM920736TAG_Q32 download
- hello_sensor-BCM920736TAG_Q32 download
- help
- i2c_temperature_sensor-BCM920736TAG_Q32 download

11. To confirm that the unmodified auto-generated code compiles successfully, double-click the **find_me-CYBLE_013025_EVAL download** make target and observe the output from the compile process. If everything is working normally, the project will build successfully and show a memory usage summary, as shown in Figure 23. However, it will not download because no suitable target device is connected and ready to flash, as shown in Figure 24.

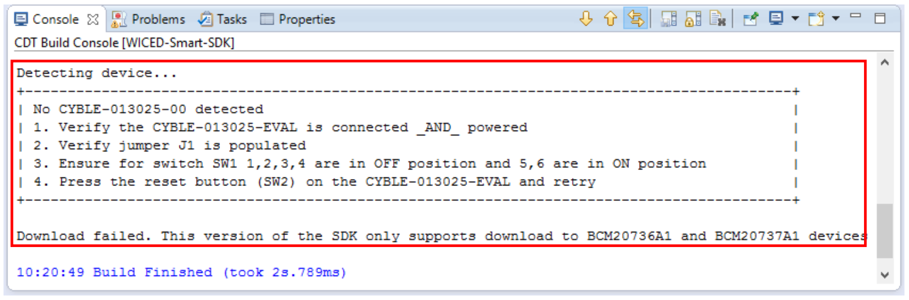
Figure 23. Successful Build and Memory Footprint



CDT Build Console [WICED-Smart-SDK]

```
--------------------------------------------------------------------------------
Patches start at                  0x00204568 (RAM address)
Patches end at                    0x00205988 (RAM address)
Application starts at             0x00205554 (RAM address)
Application ends at               0x00205C1A (RAM address)

Patch size (including reused RAM)       5152 bytes
Patch size                              4076 bytes
Application size                        1734 bytes
                                      ------
Total RAM footprint                     5810 bytes (5.7kiB)
--------------------------------------------------------------------------------

Converting CGS to HEX...
Conversion complete

Creating OTA images...
Conversion complete
OTA image footprint in NV is 8011 bytes
```

Figure 24. Expected Download Failure After Compiling



```
Detecting device...
+------------------------------------------------------------------------------------------+
| No CYBLE-013025-00 detected                                                              |
| 1. Verify the CYBLE-013025-EVAL is connected _AND_ powered                               |
| 2. Verify jumper J1 is populated                                                         |
| 3. Ensure for switch SW1 1,2,3,4 are in OFF position and 5,6 are in ON position          |
| 4. Press the reset button (SW2) on the CYBLE-013025-EVAL and retry                       |
+------------------------------------------------------------------------------------------+

Download failed. This version of the SDK only supports download to BCM20736A1 and BCM20737A1 devices

10:20:49 Build Finished (took 2s.789ms)
```

Note that the Application Size value shown in the memory footprint output should not exceed approximately 25 KB when using EZ-BLE WICED Modules based on the CYW20737 device. The chip will not boot or run properly with applications larger than this.

In addition, the WICED SMART IDE may show some symbol resolution errors in the main code window. Often, these symbols can be resolved correctly, and the IDE is misidentifying issues in the code due to differences between the code analysis toolchain and the one used for the final build process. For instructions on how to disable these errors, see Section 4.1.3.1 (Eliminating False Code Analysis Errors).

7.4 Part 2: Write the Firmware

The EZ-BLE WICED Module contains ROM, RAM, and Serial Flash (SFLASH). The ROM area of the module contains the full Bluetooth Low Energy stack. The RAM area is used for applying patches to the ROM-stored stack as well as for running application code. The on-module SFLASH is non-volatile memory, which stores the application code for embedded module configurations (i.e., not needing a host device to load the application program into RAM). The application provides the configuration for the stack such as advertisement content and interval or output power during transmission. Also, the application focuses on application-specific functionality while the stack deals with the low-level details. For example, the stack transparently handles a GATT Client read request or discovery.

Stack patches and most application logic are stored outside of the chip itself in SFLASH memory. This is also the memory used for temporary image storage during an over-the-air (OTA) firmware update process. This non-volatile storage area is integrated on the EZ-BLE WICED Module.

The following main steps are required to develop an application for an EZ-BLE WICED Module:

- Define the data to be exchanged between the Client and Server, and prepare a GATT database. (In this example, this is already accomplished using the WICED Bluetooth Designer tool in Part 1 to add the Immediate Alert Service and Alert Level characteristic.)
- Determine whether additional devices such as a UART-connected MCU or an SPI-connected peripheral sensor will be included in the solution. The UART and GPIO configurations of the application depend on the connected Peripheral devices. In the example project, you have enabled the LED with the WICED Bluetooth Designer tool in Part 1: Configure the Design; the generated code includes pre-configured GPIO settings based on this selection.
- Adjust the application configuration to provide the parameters required by the application. Common changes include transmit power, advertisement parameters, and device name.
- Define and code the functions for the BLE Stack callbacks required by the application. The application typically requires notifications from the stack when certain Bluetooth events occur such as connection establishment, disconnection, GATT write operations, or bonding.

Three main firmware blocks are required for designing BLE standard profile applications using the WICED SMART SDK:

1. System initialization
2. BLE stack event handlers
3. BLE service-specific event handlers

The following sections discuss these blocks with respect to the design that you configured in Part 1: Configure the Design. Many of the functions involved in these are auto-generated for you based on the settings chosen in the WICED Bluetooth Designer; however, some of these functions need to have additional code added in order to achieve the specific behavior that your application requires.

Unlike other platforms, the WICED SMART BLE stack does not require or provide an application-level “main loop” function that repeats forever. Instead, the main loop is handled internally along with low-power transitions, and all application behavior must be fully event-driven based on interrupts triggered by timers, wireless (BLE) activity, or wired (GPIO, UART, etc.) activity.

7.4.1 System Initialization

When the EZ-BLE WICED Module starts up, it initializes the BLE stack and executes the application initialization function named `APPLICATION_INIT`. This initialization function must call the `bleapp_set_cfg` function, which provides the BLE stack with pointers to application data structures, including the GATT database, application configuration, UART configuration, GPIO configuration, and a pointer to a `create` function that is called when the application starts.

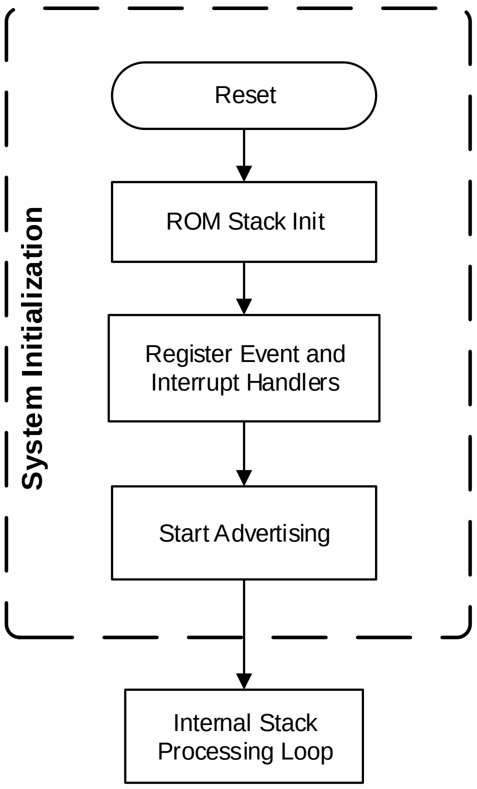
The ROM image in the module also contains some basic application logic. The full source code for these functions is included in the WICED SMART SDK in the */Wiced-Smart/bleapp/app* directory. The new application is flexible in what portions of the ROM code to use. If the ROM code completely matches the requirements, the `APPLICATION_INIT` function should simply point to the data structures and then *create* functions from the ROM code. However, most designs will need more customized behavior than this provides.

The following data structures are present in every EZ-BLE WICED application:

- The GATT database identifies data objects to the BLE stack that are exchanged between the peripheral and the client application.
- Application configuration, which specifies parameters shared between the application and the BLE stack.
- UART and GPIO configurations. In some cases, the application requires a connection to a Peripheral device (for example, a measurement sensor). Although drivers for most Peripheral buses are included in the CYW20737 ROM, some code must be written to support the hardware. For example, some applications may require processing of data received over the UART or SPI interfaces.

Figure 25 shows the flowchart and firmware source code for system initialization.

Figure 25. System Initialization Flow Chart


System Initialization
Reset
ROM Stack Init
Register Event and Interrupt Handlers
Start Advertising
Internal Stack Processing Loop

Before looking at the application initialization routines, look over the large configuration structure near the top of the *find_me.c* source file:

Code 1. find_me_cfg: Main Project Configuration Structure

```
const BLE_PROFILE_CFG find_me_cfg =
{
    /*.fine_timer_interval            =*/ FIND_ME_FINE_TIMER, // ms
    /*.default_adv                    =*/ 4,     // HIGH_UNDIRECTED_DISCOVERABLE
    /*.button_adv_toggle              =*/ 0,     // pairing button make adv toggle (if 1) or always on (if 0)
    /*.high_undirect_adv_interval     =*/ 32,    // slots
    /*.low_undirect_adv_interval      =*/ 1024,  // slots
    /*.high_undirect_adv_duration     =*/ 30,    // seconds
    /*.low_undirect_adv_duration      =*/ 300,   // seconds
    /*.high_direct_adv_interval       =*/ 0,     // seconds
    /*.low_direct_adv_interval        =*/ 0,     // seconds
    /*.high_direct_adv_duration       =*/ 0,     // seconds
    /*.low_direct_adv_duration        =*/ 0,     // seconds
    /*.local_name                     =*/ FIND_ME_DEVICE_NAME, // [LOCAL_NAME_LEN_MAX];
    /*.cod                            =*/ BIT16_TO_8(FIND_ME_DEVICE_APPEARENCE),0x00, // [COD_LEN];
    /*.ver                            =*/ "1.00",         // [VERSION_LEN];
    /*.encr_required                  =*/ 0,     //(SECURITY_ENABLED | SECURITY_REQUEST),    // data
encrypted and device sends security request on every connection
    /*.disc_required                  =*/ 0,     // if 1, disconnection after confirmation
    /*.test_enable                    =*/ 1,     // TEST MODE is enabled when 1
    /*.tx_power_level                 =*/ 0x04,  // dbm
    /*.con_idle_timeout               =*/ 30,    // second  0-> no timeout
    /*.powersave_timeout              =*/ 0,     // second  0-> no timeout
    /*.hdl                            =*/ {FIND_ME_MAIN_CHAR_HANDLE, 0x00, 0x00, 0x00, 0x00}, //
[HANDLE_NUM_MAX];
    /*.serv                           =*/ {FIND_ME_MAIN_SERVICE_UUID, 0x00, 0x00, 0x00, 0x00},
    /*.cha                            =*/ {FIND_ME_MAIN_CHAR_UUID, 0x00, 0x00, 0x00, 0x00},
    /*.findme_locator_enable          =*/ 0,     // if 1 Find me locator is enable
    /*.findme_alert_level             =*/ 0,     // alert level of find me
    /*.client_grouptype_enable        =*/ 0,     // if 1 grouptype read can be used
    /*.linkloss_button_enable         =*/ 0,     // if 1 linkloss button is enable
    /*.pathloss_check_interval        =*/ 0,     // second
    /*.alert_interval                 =*/ 0,    // interval of alert
    /*.high_alert_num                 =*/ 0,    // number of alert for each interval
    /*.mild_alert_num                 =*/ 0,    // number of alert for each interval
    /*.status_led_enable              =*/ 1,    // if 1 status LED is enable
    /*.status_led_interval            =*/ 0,    // second
    /*.status_led_con_blink           =*/ 0,    // blink num of connection
    /*.status_led_dir_adv_blink       =*/ 0,    // blink num of dir adv
    /*.status_led_un_adv_blink        =*/ 0,    // blink num of undir adv
    /*.led_on_ms                      =*/ 0,    // led blink on duration in ms
    /*.led_off_ms                     =*/ 0,    // led blink off duration in ms
    /*.buz_on_ms                      =*/ 100,  // buzzer on duration in ms
    /*.button_power_timeout           =*/ 0,    // seconds
    /*.button_client_timeout          =*/ 0,    // seconds
    /*.button_discover_timeout        =*/ 0,    // seconds
    /*.button_filter_timeout          =*/ 0,    // seconds
#ifdef BLE_UART_LOOPBACK_TRACE
    /*.button_uart_timeout            =*/ 15,   // seconds
#endif
};
```

This configuration structure allows simple control over default advertisement parameters, some of the profile-specific behavior, encryption requirements, power output, and hardware peripherals. In many cases, the SDK provides APIs that allow you to trigger behavior with custom settings rather than the values that are set here. However, you can often use these configuration values as-is and avoid further complexity in your code.

The 'find_me' example described in this guide does not require any modifications to this structure.

The first visible entry point in the 'find_me' example application you have created here is the `APPLICATION_INIT` function, as shown in Code 2 here:

Code 2. `APPLICATION_INIT`: ROM-Driven Initialization

```
// Application initialization
APPLICATION_INIT()
{
    bleapp_set_cfg((UINT8 *)gatt_database,
                   gatt_database_len,
                   (void *)&find_me_cfg,
                   (void *)&find_me_puart_cfg,
                   (void *)&find_me_gpio_cfg,
                   find_me_create);
}
```

This small function simply calls the `bleapp_set_cfg` function as described above, with pointers to various application-specific implementations of the GATT database, application configuration, UART configuration, GPIO configuration, and the `create` function.

Note that this function already exists and does not need to be added to your project source file. The `blapp_set_cfg` function is declared in the *bleapp.h* standard SDK library include file, although the implementation is in ROM.

These key structures, values, and functions used as arguments here are implemented in two different parts of the automatically generated source files coming from the WICED Bluetooth Designer tool.

The *find_me.c* source file contains the following:

- The `find_me_cfg` variable, which has the `BLE_PROFILE_CFG` structure type, and defines default advertisement and connection intervals, security requirements, transmit power, device name, appearance, timeouts, and other settings.
- The `find_me_puart_cfg` variable, which has the `BLE_PROFILE_PUART_CFG` structure type, and defines the peripheral UART baud rate and pin assignment.
- The `find_me_create` function, which runs once after the BLE stack itself has initialized, and is ready to hand off the execution to the application-level initialization routine.

The *find_me_db.c/.h* source files contain the following:

- The `gatt_database` variable, which is a contiguous byte array and defines the complete GATT structure to be used by the Server.
- The `gatt_database_len` variable, which defines the length of the GATT database definition in bytes.
- The `find_me_gpio_cfg` variable, which has the `BLE_PROFILE_GPIO_CFG` structure type and defines the GPIO configuration used by the application.

These files and the data structures and functions they contain make up all of the application-specific functionality currently in the application.

The next function to look at is `find_me_create`, which runs after the ROM-driven BLE stack initialization finishes. This function sets up all of the application-specific behavior and registers many application callbacks to occur when various link layer, GAP, or GATT events occur within the stack as shown in Code 3.

Code 3. `find_me_create`: Application-Driven Initialization

```
// Create device
void find_me_create(void)
{
    extern UINT8 bleprofile_adv_num;
    extern UINT8 bleprofile_scanrsp_num;

    ble_trace0("create()");
    ble_trace0(bleprofile_p_cfg->ver);

    bleprofile_adv_num = 0x0;
    bleprofile_scanrsp_num = 0x0;

    // dump the database to debug uart.
    legattdb_dumpDb();

    bleprofile_Init(bleprofile_p_cfg);
    bleprofile_GPIOInit(bleprofile_gpio_p_cfg);

    // Initialized ROM code which will monitor the battery
    blebat_Init();

    // Read NVRAM
    bleprofile_ReadNVRAM(VS_BLE_HOST_LIST, sizeof(find_me_hostinfo), (UINT8 *)&find_me_hostinfo);

    // register connection up and connection down handler.
    bleprofile_regAppEvtHandler(BLECM_APP_EVT_LINK_UP, find_me_connection_up);
    bleprofile_regAppEvtHandler(BLECM_APP_EVT_LINK_DOWN, find_me_connection_down);
    bleprofile_regAppEvtHandler(BLECM_APP_EVT_ADV_TIMEOUT, find_me_advertisement_stopped);

    // handler for Encryption changed.
    blecm_regEncryptionChangedHandler(find_me_encryption_changed);

    // handler for Bond result
    lesmp_regSMPResultCb((LESMP_SINGLE_PARAM_CB) find_me_smp_bond_result);

    // register to process client writes
    legattdb_regWriteHandleCb((LEGATTDB_WRITE_CB)find_me_write_handler);

    // register interrupt handler
    bleprofile_regIntCb((BLEPROFILE_SINGLE_PARAM_CB) find_me_interrupt_handler);

    //registers timer
    find_me_reg_timer();

    // advertise first vendor specific service
    if(sizeof(find_me_uuid_main_service) > 1)
    {
        // total length should be less than 31 bytes
        BLE_ADV_FIELD adv[3];
        BLE_ADV_FIELD scr[1];

        // flags
        adv[0].len     = 1 + 1;
        adv[0].val     = ADV_FLAGS;
        adv[0].data[0] = LE_LIMITED_DISCOVERABLE | BR_EDR_NOT_SUPPORTED;

        adv[1].len     = sizeof(find_me_uuid_main_service) + 1;
        adv[1].val      = sizeof(find_me_uuid_main_service) == 16 ?
                                ADV_SERVICE_UUID128_COMP : ADV_SERVICE_UUID16_COMP;
        memcpy(adv[1].data, &find_me_uuid_main_service[0], sizeof(find_me_uuid_main_service));

        // Tx power level
        adv[2].len      = TX_POWER_LEN+1;
        adv[2].val      = ADV_TX_POWER_LEVEL;
        adv[2].data[0] = bleprofile_p_cfg->tx_power_level;

                // name
        scr[0].len       = strlen(bleprofile_p_cfg->local_name) + 1;
        scr[0].val       = ADV_LOCAL_NAME_COMP;
        memcpy(scr[0].data, bleprofile_p_cfg->local_name, scr[0].len - 1);

        bleprofile_GenerateADVData(adv, 3);
        bleprofile_GenerateScanRspData(scr, 1);
    }

    blecm_setTxPowerInADV(0);

    // start device advertisements.  By default Advertisements will contain flags, device name,
    // appearance and main service UUID.
    bleprofile_Discoverable(HIGH_UNDIRECTED_DISCOVERABLE, NULL);

    // ToDo: Do your initialization on app startup
}
```

The `find_me_write_handler` callback function is of particular interest because it lets the application process incoming GATT write operations. This will be discussed in more detail in the next section.

Take note of how the `find_me_create` initialization function ends, which occurs right before the stack gets execution control again. The code sets advertisement output power to +0 dBm and begins fast undirected/connectable advertisements. Because of this, a remote device is able to connect to the find_me Peripheral, which will trigger a new callback (the `find_me_connection_up` event handler registered above) and allow further application-specific behavior.

7.4.2 BLE Stack Event Handlers

The BLE stack residing on EZ-BLE WICED Modules requires individual event handler callbacks for most types of BLE activity. In the previous section, the `find_me_create` function registers application functions to handle some of these events like connection, disconnection, advertisement timeout, and GATT write. This section describes the purpose and functionality of each of these callbacks within the context of the 'find_me' example project.

Unlike the single BLE event handler 'master' function found in PSoC®/PRoC™-based BLE designs, the EZ-BLE WICED stack does not bundle every application-level event into one top-level callback function. Instead, most events have dedicated callbacks that must be registered independently, as shown in Code 3 above. If you are exploring EZ-BLE WICED solutions after previously learning PSoC/PRoC EZ-BLE solution practices, keep this architectural difference in mind.

The first event handler to examine is `find_me_connection_up`, which is called when a new BLE connection is established. Aside from some debug output through the module's trace UART mechanism, this function performs the following notable operations:

1. Stores the connection handle in a global variable
2. Calls the generic `__on_connection_up` function (internally tests for existing bonded device entry)
3. Stops advertising to prevent additional incoming connection attempts
4. Checks encryption requirements and requested bonding as necessary

The Bluetooth Designer tool also provides some "TODO" code comments to help explain where certain customizations should go.

Code 4. `find_me_connection_up`: New Connection Event Handler

```
// Connection up callback function is called on every connection establishment
void find_me_connection_up(void)
{
    find_me_connection_handle = (UINT16)emconninfo_getConnHandle();
    UINT8 *bda = (UINT8 *)emconninfo_getPeerPubAddr();
    // Save address of the connected device and print it out.
    memcpy(find_me_remote_addr, bda, sizeof(find_me_remote_addr));

    ble_trace3("connection_up: %08x%04x h=%d",
                (find_me_remote_addr[5] << 24) + (find_me_remote_addr[4] << 16) +
                (find_me_remote_addr[3] << 8) + find_me_remote_addr[2],
                (find_me_remote_addr[1] << 8) + find_me_remote_addr[0],
                find_me_connection_handle);


    // Prepare generated code for connection - write persistent values from __HOSTINFO to GATT DB
    __on_connection_up();

    // ToDo: Write custom persistent values into GATT database using functions
    // changed_<service_name>_<char_name>() generated by smart designer

    // If device supports a single connection, stop advertising
    bleprofile_Discoverable(NO_DISCOVERABLE, NULL);

    // If security is required for every connection following function will start bonding or
    // will setup encryption.  No indications or notifications should be sent until
    // encryption is done.
    if (bleprofile_p_cfg->encr_required & SECURITY_REQUEST)
    {
        if (emconninfo_deviceBonded())
        {
            ble_trace0("device bonded");
        }
        else
        {
            ble_trace0("device not bonded");
            lesmp_sendSecurityRequest();
        }
    }
}
```

The next stack event handler to examine is `find_me_connection_down`, which is called when the BLE connection is closed intentionally or drops unexpectedly. This function clears the connection handle value back to zero and resumes connectable advertising at a low (infrequent) rate.

Code 5. `find_me_connection_down`: Connection Terminated Event Handler

```
// Connection down callback
void find_me_connection_down(void)
{
    ble_trace1("connection_down:handle:%d", find_me_connection_handle);

    find_me_connection_handle = 0;

    // If disconnection was caused by the peer, start low advertisements
    bleprofile_Discoverable(LOW_UNDIRECTED_DISCOVERABLE, NULL);

    ble_trace2("ADV start: %08x%04x",
                  (find_me_remote_addr[5] << 24 ) + (find_me_remote_addr[4] <<16) +
                  (find_me_remote_addr[3] << 8 ) + find_me_remote_addr[2],
                  (find_me_remote_addr[1] << 8 ) + find_me_remote_addr[0]);
}
```

Next, check the `find_me_advertisement_stopped` handler, which is called when the stack automatically terminates advertising after the configured timeout period elapses. The default advertisement timeouts for fast ('high') and slow ('low') rates are defined in the `find_me_cfg` structure near the top of *find_me.c* file, and are 30 and 300 seconds respectively. The code in this event handler ensures that advertisements always resume automatically whenever either mode times out.

Code 6. `find_me_advertisement_stopped`: Advertisement Timeout Event Handler

```
// Callback function indicates to the application that advertising has stopped.
// restart advertisement if needed
void find_me_advertisement_stopped(void)
{
    ble_trace0("ADV stop!!!!");
    // If disconnection was caused by the peer, start low advertisements
    bleprofile_Discoverable(LOW_UNDIRECTED_DISCOVERABLE, NULL);
}
```

After this handler, there are two which concern bonding and encryption. First is the `find_me_smp_bond_result` event shown in Code 7, which occurs after the remote peer successfully bonds with the local device. The auto-generated code in this function calls the `find_me_add_bond` function to store the bonded device address in the `hostinfo` structure, then writes that structure into the non-volatile memory for later retrieval (remember that the `__on_connection_up` function call inside `find_me_connection_up` searches for previous bond information to initialize client-specific persistent GATT values).

Code 7. `find_me_smp_bond_result`: Bonding Event Handler

```
// Process SMP bonding result.  If pairing is successful with the central device,
// save its BDADDR in the NVRAM and initialize associated data
void find_me_smp_bond_result(LESMP_PARING_RESULT  result)
{
    ble_trace1("smp_bond_result %02x", result);

    if (result == LESMP_PAIRING_RESULT_BONDED)
    {
        // saving bd_addr in nvram
        UINT8 *bda;
        UINT8 writtenbyte;

        bda = (UINT8 *)emconninfo_getPeerPubAddr();

        // initialize persistent values in the hostinfo to add bonded peer
        find_me_add_bond(bda);

        // ToDo: initialize persistent variables in HOSTINFO

        //now write hostinfo into NVRAM
        writtenbyte = bleprofile_WriteNVRAM(VS_BLE_HOST_LIST, sizeof(find_me_hostinfo),
                        (UINT8 *)&find_me_hostinfo);
        ble_trace1("NVRAM write:%04x", writtenbyte);
    }
}
```

Another security-related function is the `find_me_encryption_changed` handler, which is called when the stack encryption state changes. This typically occurs during the bonding process after the link is successfully encrypted. While it is not strictly necessary to catch this event, the auto-generated function makes it easy to modify as your application requires, and also triggers a connection parameter update to more power-efficient values (100-500 ms interval and longer supervision timeout).

Code 8. `find_me_encryption_changed`: Encryption State Change Event Handler

```
// Notification from the stack that encryption has been set.
void find_me_encryption_changed(HCI_EVT_HDR *evt)
{
    UINT8 *bda = emconninfo_getPeerPubAddr();

    ble_trace2("encryption changed %08x%04x",
                (bda[5] << 24) + (bda[4] << 16) +
                (bda[3] << 8) + bda[2],
                (bda[1] << 8) + bda[0]);

    // ToDo: do your on-encryption-change actions here.

    // Slow down the pace of master polls to save power.  Following request asks
    // host to setup polling every 100-500 msec, with link supervision timeout 5 seconds.
    bleprofile_SendConnParamUpdateReq(80, 400, 0, 500);
}
```

After the security-related events, the `find_me_write_handler` function shown in Code 9 processes GATT write events that occur when a connected remote client writes a new value to any supported GATT characteristic. Note that this high-level code first gets a few details about the written attribute, then passes that information to a function called `__write_handler`. This function's implementation is found in the GATT-specific *find_me_db.c* file, which you will look through in the next section.

An important feature of the `__write_handler` function is that it returns a boolean value indicating whether to write updated host details to non-volatile RAM. This might be the case for a client characteristic configuration value set by a bonded peer, or for the Device Name characteristic (if the “write” permission is enabled). The Find Me example project described in this application note does not use this functionality.

Code 9. `find_me_write_handler`: Top-Level GATT Write Event Handler

```
// Process write request or command from peer device
int find_me_write_handler(LEGATTDB_ENTRY_HDR *p)
{
    UINT8  writtenbyte;
    UINT16 handle   = legattdb_getHandle(p);
    int    len      = legattdb_getAttrValueLen(p);
    UINT8  *attrPtr = legattdb_getAttrValue(p);
    BOOL changed;

    ble_trace1("write_handler: handle %04x", handle);

    changed = __write_handler(handle, len, attrPtr);

    // Save update to NVRAM if it has been changed.
    if (changed)
    {
        writtenbyte = bleprofile_WriteNVRAM(VS_BLE_HOST_LIST,
                        sizeof(find_me_hostinfo), (UINT8 *)&find_me_hostinfo);
        ble_trace1("NVRAM write:%04x", writtenbyte);
    }
    return 0;
}
```

Two final callbacks remain in this section, neither of which are required for specific behavior in this example application. First is the `find_me_interrupt_handler` function shown in Code 10, which handles any configured GPIO interrupt. Second is the `find_me_indication_cfm` handler shown in Code 11, which is triggered when a remote GATT Client device confirms receipt of an 'indication' transfer. These functions are predefined in empty 'stub' form to provide a foundation for adding related behavior, but the Find Me project does not use them.

Code 10. `find_me_interrupt_handler`: GPIO Interrupt Handler Stub

```
// Three Interrupt inputs (Buttons) can be handled here.
// If the following value == 1, Button is pressed. Different than initial value.
// If the following value == 0, Button is depressed. Same as initial value.
// Button1 : value&0x01
// Button2 : (value&0x02)>>1
// Button3 : (value&0x04)>>2
void find_me_interrupt_handler(UINT8 value)
{
    // ToDo: handle the interrupts here.
}
```

Code 11. `find_me_indication_cfm`: Top-Level Indication Confirmation Event Handler

```
// Process indication confirmation.  if client service indication, each indication
// should be acknowledged before the next one can be sent.
void find_me_indication_cfm(void)
{
}
```

A few of the example projects that come with the WICED SMART SDK use one or both of these functions, including the following:

- `hello_sensor`
- `ota_firmware_upgrade`
- `puart_control`
- `automation_io_server`
- `pwm_tones`

One final callback remains in the main *find_me.c* file, which is discussed in the next section because it is specific to the Immediate Alert Service (IAS).

7.4.3 BLE Service-Specific Event Handler

A service-specific behavior occurs when a remote client interacts with particular GATT attributes in pre-defined ways. In this project, the **Alert Level** characteristic value is the only one of importance for peripheral behavior modification.

The code generated by the WICED Bluetooth Designer tool implements characteristic write handling through different layers, some of which were dscussed in the previous section. First, the `create` function registers the `find_me_write_handler` top-level handler function to be called when a GATT write occurs. This function obtains details about the attribute and its new value, and then passes this information to the `__write_handler` mid-level function shown in Code 12.

Code 12. `__write_handler`: Mid-Level GATT Write Event Handler

```
// Updates __HOSTINFO by the value written by peer.
// Returns true if any persistent value is changed
BOOL __write_handler(UINT16 handle, int len, UINT8 *attrPtr)
{
    BOOL res = FALSE;
    if (handle == HDLC_IMMEDIATE_ALERT_ALERT_LEVEL_VALUE)
    {
        if (len > 1)
        {
            ble_trace2("bad length:%d handle:%04x", len, handle);
        }
        else
        {
            //call custom on_write function
            ble_trace1("write handle:%04x", handle);
            res = on_write_immediate_alert_alert_level(len, attrPtr);
        }
    }
    return res;
}
```

The `__write_handler` function checks to see which handle was written, and then finally calls the appropriate application callback function with the value length and pointer to data as arguments. This brings you to the final link in the GATT write execution chain, the `on_write_immediate_alert_alert_level` callback shown in Code 13 below. This function is the only one you need to modify to provide the intended user experience for this Find Me example project.

Code 13. `on_write_immediate_alert_alert_level`: Original IAS “Alert Level” GATT Write Event Handler

```
// It will be called at the write handler and should return TRUE if any persistent value is changed
BOOL on_write_immediate_alert_alert_level(int len, UINT8 *attrPtr)
{
    // Todo: do your actions here when value is written by the peer
    // and return TRUE if any persistent value is changed
    return FALSE;
}
```

Note that the WICED Bluetooth Designer tool will automatically create these callbacks for any writable characteristics that are defined.

The modifications required concern updates to the LED behavior based on a single-byte value written to the Alert Level characteristic. Specifically, you need to watch for three alert values:

- 0x00 = No alert (LED OFF)
- 0x01 = Mild alert (LED blinking)
- 0x02 = High alert (LED ON)

To accomplish this, first, add one GPIO configuration line to the end of the `find_me_create` function towards the beginning of the file:

Code 14. Preparing LED GPIO for Output Logic Control in the `create` Function

```
    ...

    // ToDo: Do your initialization on app startup
    gpio_configurePinWithSingleBytePortPinNum(GPIO_PIN_LED, GPIO_OUTPUT_ENABLE, 1);
}
```

The specifically named `gpio_configurePinWithSingleBytePortPinNum` API method sets the drive mode and (when applicable) output logic state of a single numbered pin. The `GPIO_PIN_LED` constant is pre-defined by the platform definition file, but in the case of the CYBLE-013025-EVAL board, it is set to **14** because the active LOW LED on this board is connected to P14. The `GPIO_OUTPUT_ENABLE` constant sets the pin to output mode, and the final **1** argument initializes it to the HIGH (VDD) logic state. The pin is now ready to be used for driving the LED.

Next, replace the content of the `on_write_immediate_alert_alert_level` callback with the code shown here:

Code 15. `on_write_immediate_alert_alert_level`: Updated IAS "Alert Level" GATT Write Event Handler

```
// It will be called at the write handler and should return TRUE if any persistent value is changed
BOOL on_write_immediate_alert_alert_level(int len, UINT8 *attrPtr)
{
    // check the first byte of the value written to this characteristic
    switch (attrPtr[0])
    {
    case 0x00:
        // alert level = 0x00 (none), turn LED off
        bleprofile_KillLEDTimer();
        bleprofile_LEDOff();
        break;
    case 0x01:
        // alert level = 0x01 (mild), blink LED at 1 Hz cycle (units are 12.5ms)
        bleprofile_LEDBlink(40, 40, 0);
        break;
    case 0x02:
        // alert level = 0x02 (high), turn LED on
        bleprofile_KillLEDTimer();
        bleprofile_LEDOn();
        break;
    }

    // return FALSE since no persistent value is changed
    return FALSE;
}
```

These API calls take advantage of the built-in LED management library, which includes non-blocking 'blink' support and simple ON/OFF control. It is also possible to control the LED pin directly with lower-level GPIO functions.

7.4.4 Low-Power Implementation

Most BLE applications require minimal power consumption to support long life. The WICED SMART SDK automatically handles most low-power transitions internally, and it is not possible to force entry into a low-power state regardless of any other tasks. However, the SDK does provide a mechanism to either allow or prevent otherwise automatic entry into Sleep mode. Using this mechanism is optional, but usually desirable.

Without any low-power modifications, this 'find_me' example project will consume at least 3.5 mA constantly on average since the CPU will never sleep. This level of consumption is typically much higher than a small device powered by a coin cell can sustain.

The simplest solution to allow automatic sleep mode usage in this project requires making a single modification to the configuration setting structure, particularly the fine timer interval:

Code 16. Updating Fine Timer Interval to Non-Zero Value

```
/*******************************************************
 *                      Constants
 *******************************************************/

#define FIND_ME_FINE_TIMER           1000
```

```
#define FIND_ME_DEVICE_NAME            "find_me"
#define FIND_ME_DEVICE_APPEARENCE      0
#define FIND_ME_MAIN_SERVICE_UUID      UUID_SERVICE_IMMEDIATE_ALERT
```

The default value for this interval is 0, which effectively results in disabling sleep, even if the application does not make use of any fine timer functions (which this example does not). A value of 1000 indicates a 1-second interval (as this is measurement is miliseconds), and with this, the module can properly sleep automatically. With this configuration change, this 'find_me' example project will consume approximately the following amounts of current, on average:

- 1.8 mA during fast advertising (on boot, for up to 30 seconds)
- 106 µA during slow advertising (30 seconds after boot or immediately after disconnection)
- 250 µA while connected to a remote peer @ 100 ms connection interval

7.4.4.1 Managing Low-Power Operation in the Application

Sometimes, you need more control over sleep states, particularly if you are using certain peripherals. For example, the peripheral UART interface is disabled while in sleep mode, so if you need to remain awake due to expected incoming UART data, automatic sleep mode may not be suitable.

In order to manage low-power operation in your application, you will need some or all of the following APIs:

- `devlpm_init()`
- `devlpm_registerForLowPowerQueries(callback, context)`
- `devlpm_enableWakeFrom(source)`
- `devlpm_enterLowPowerMode()`
- `bleprofile_PrepareHidOff()`

These functions enable Sleep/Deep Sleep low-power entry, wake sources, and an application-level callback, which you can use to keep the CPU from entering Sleep or Deep Sleep states. To add some additional low-power support to your project, first place the following initialization code into the `find_me_create` function:

Code 17. `find_me_create`: Application-Driven Initialization

```
// Create device
void find_me_create(void)
{
    ...

    bleprofile_Init(bleprofile_p_cfg);
    bleprofile_GPIOInit(bleprofile_gpio_p_cfg);

    // Initialize low-power system and application control callback
    devlpm_init();
    devlpm_registerForLowPowerQueries(find_me_lpm_queriable, 0);

    // Initialized ROM code which will monitor the battery
    blebat_Init();

    ...
}
```

Next, add a new `find_me_lpm_queriable` callback function declaration and implementation to handle queries about allowable sleep states:

Code 18. `find_me_lpm_queriable`: Application-Driven Sleep Prevention

```
/******************************************************
 *              Function Prototypes
 ******************************************************/
    ...
static void find_me_encryption_changed( HCI_EVT_HDR *evt );
static int  find_me_write_handler( LEGATTDB_ENTRY_HDR *p );
static void find_me_interrupt_handler( UINT8 value );
UINT32 find_me_lpm_queriable(LowPowerModePollType type, UINT32 context);

    ...

// Callback called by the FW when ready to sleep/deep-sleep.
// Do not allow any sleep if UART transmissions are ongoing.
// Do not allow deep sleep if BLE activity is ongoing.
UINT32 find_me_lpm_queriable(LowPowerModePollType type, UINT32 context)
{
    UINT32 result = 0; // assume sleep disabled

    // check sleep type query
    switch (type)
    {
        case LOW_POWER_MODE_POLL_TYPE_SLEEP:
            // return 0 to prevent standard sleep, otherwise max microsecond count to allow
            // (other processes may wake earlier than your specified max)
            result = 0xFFFFFFFF; // max
            break;

        case LOW_POWER_MODE_POLL_TYPE_POWER_OFF:
            // return 0 to prevent deep sleep, non-zero to allow
            result = 1; // allow
            break;
    }

    // should not reach this point since only two types of sleep exist
    return result;
}
```

Notice the basic logic in this implementation. There are two possible types of Sleep queries; the 'sleep' type concerns standard sleep, while the 'power off' type concerns Deep Sleep (also known as HIDOFF). You should not allow standard Sleep if you need continuing UART operation, but BLE advertising and connectivity will continue to function in this state. You should not allow Deep Sleep if you need any BLE activity to continue.

Finally, to demonstrate the ultra-low-power Deep Sleep state, you can optionally make the following modification to the `find_me_connection_down` method so that the firmware enters Deep Sleep after the client disconnects:

Code 19. `find_me_connection_down` Modification: Deep Sleep After Disconnection

```
// Connection down callback
void find_me_connection_down(void)
{
    ble_trace1("connection_down:handle:%d", find_me_connection_handle);

    find_me_connection_handle = 0;

    // If disconnection was caused by the peer, start low advertisements
    //bleprofile_Discoverable(LOW_UNDIRECTED_DISCOVERABLE, NULL);

    // If disconnection was caused by the peer, enter deep sleep mode
    bleprofile_PrepareHidOff();

    ...
```

The average current while in Deep Sleep mode should be on the order of 1.5 µA.

Note that if you change the 'power off' (Deep Sleep) query result assignment to '0' in the `find_me_lpm_queriable` function, the `bleprofile_PrepareHidOff()` API will not put the module into Deep Sleep despite being explicitly called, because the application-level query function is still called and the result is tested before the chipset enters Deep Sleep.

The `devlpm_enterLowPowerMode()` API behaves similarly to this, requesting entry into standard Sleep mode when called. However, it is often not necessary to use this function explicitly because internal power management routines will automatically attempt to enter Sleep mode as often as reasonably possible.

The `devlpm_enableWakeFrom()` API can be used to set up specific wake sources, such as GPIOs, to be used in conjunction with any configured GPIO interrupts. If Sleep states do not need GPIO intervention but can be logically controlled by application code, then this API is not needed.

7.4.4.2 Eliminating Leakage Current

Depending on the peripheral connections present in your final hardware design, you may need to make special considerations to avoid leakage on the P0 pin (PUART TX if peripheral UART is enabled). This pin defaults to a digital-mode high-impedance “floating” state in the ROM-based initialization code, and will leak a noticeable amount of current if left unconnected in this state.

There are three basic ways to eliminate leakage on this pin:

1. Externally drive or pull the P0 pin to a known state
2. Enable peripheral UART operation in your application (PUART initialization will set P0 to digital output mode)
3. Configure P0 to a non-floating state manually in your application code

On the CYBLE-013025-EVAL board, you can pull P0 high by setting SW1 position 1 to the ON state. This will connect P0 (PUART TX) to the on-board USB-to-UART bridge IC’s RX pin, which is weakly pulled high. However, you should ensure that you do not also simultaneously set SW1 position 5 to the ON state and enable PUART operation in the application. This could potentially result in PUART TX and HCI UART TX to drive in opposite logic states, resulting in a short between VDD and GND and possibly damaging the module.

You can configure P0 to an internally pulled state by adding the following single line of code to the end of the `find_me_create` function:

Code 20. `find_me_create` Modification: Configure P0 to Known State

```
    ...

    // start device advertisements.  By default Advertisements will contain flags, device name,
    // appearance and main service UUID.
    bleprofile_Discoverable(HIGH_UNDIRECTED_DISCOVERABLE, NULL);

    // ToDo: Do your initialization on app startup
    gpio_configurePinWithSingleBytePortPinNum(GPIO_PIN_LED, GPIO_OUTPUT_ENABLE, 1);
    gpio_configurePinWithSingleBytePortPinNum(0, GPIO_PULL_UP, 1);
}
```

This call to the `gpio_configurePinWithSingleBytePortPinNum()` API will internally pull P0 to the HIGH logic state and eliminate leakage.

7.5 Part 3: Program the Device

This section shows how to program the EZ-BLE WICED Evaluation Board. The CYBLE-013025-00 module on this evaluation board includes a UART-based bootloader in the onboard chipset ROM, and therefore does not require an external programmer of any kind.

Note: The source project for this design is available on this application note’s webpage.

7.5.1 Host UART Interface Selection and Preparation

Host access to the HCI UART interface required for programming is available using either the built-in USB-to-UART bridge or the 4-pin **J2** header on the module and an external UART device. The SW1 six-position DIP switch controls whether the USB-to-UART bridge is connected to the HCI UART or Peripheral UART pins on the module, and therefore you must set it properly to provide the correct pin routing.

Table 5. SW1 DIP Switch Settings for Programming

Programming Interface	SW1 Positions						Detail
	1	2	3	4	5	6	
Built-in USB-to-UART	OFF	OFF	OFF	OFF	ON	ON	PUART disconnected, HCI UART connected
J2 and external UART	*any*	*any*	*any*	*any*	OFF	OFF	PUART irrelevant, HCI UART disconnected

Switch positions 1, 2, 3, and 4 control the Peripheral UART connection to the USB-to-UART bridge IC on the evaluation board, while positions 5 and 6 control the HCI UART connection to the same USB-to-UART bridge IC. You should not set all six SW1 positions to ON under any circumstances, as this will directly connect both module UARTs RX and TX pairs together. This could result in a state where both TX pins are driving in opposite directions, causing an internal short between VDD and GND.

7.5.2 Boot Modes and Effective Operational States

Beginning from a power-on or reset, the boot sequence for the CYW20737 chipset inside the EZ-BLE WICED Module follows the process defined below:

1. Code in ROM executes and initializes the device processor, clock domains, peripherals, etc.
2. The following checks then occur:
   a. The boot ROM checks for connected EEPROM and for a valid configuration, issuing several commands on the I2C pins. If no configuration or EEPROM is found via I^2C, it will check Serial Flash (SFLASH) for a valid configuration via SPI.
   b. The boot ROM calculates the checksum of the first 11 bytes of the Static Section (SS) of the non-volatile memory. If the checksum fails, it will increment through certain locations in memory until it finds a valid SS to use. If it does not find one, it will only boot from ROM. The first three bytes of the SS in use should always be 0x01 0x00 0x08. The mini-driver contained in the WICED SMART SDK will ensure that the SS section of the non-volatile memory contains the correct information.
3. The chipset then proceeds to either application mode or programming (HCI) mode depending first on the state of the HCI_UART RX pin, and secondarily on whether a valid configuration was found in the previous step:
   a. If HCI_UART RX is asserted, the chipset will boot into programming (HCI) mode regardless of whether a valid configuration was found in nonvolatile memory.
   b. If HCI_UART RX is not asserted and a valid configuration is found in either memory location, the Boot ROM will continue to load the rest of the configuration, patch data, and user application code from the external non-volatile memory.
   c. If HCI_UART RX is not asserted and no valid configuration was found, the Boot ROM will stop executing further instructions.

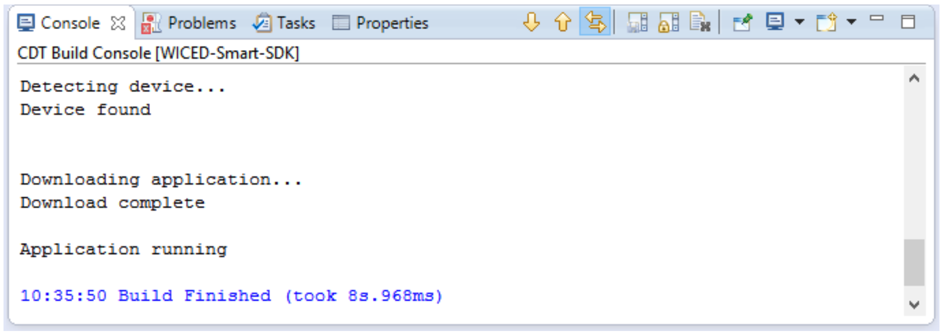
To ensure that you have placed the module into the correct mode for programming, press the SW2 RESET button on the evaluation board after adjusting the DIP switch positions and/or external UART connection as described in the previous section.

7.5.3 Compiling and Downloading into the Module

Now that you have completed the code updates and prepared the programming interface, all that remains is to compile and flash the firmware image into the target device. To do this, simply double-click on the make target that you defined previously (***find_me-CYBLE_013025_EVAL download***).

After a brief compile process, the Console output in the WICED SMART IDE should indicate success, as shown in Figure 26.

Figure 26. Programming the Firmware



CDT Build Console [WICED-Smart-SDK]

```
Detecting device...
Device found


Downloading application...
Download complete

Application running

10:35:50 Build Finished (took 8s.968ms)
```

If you do not see this success message, ensure that you have correctly connected and configured the programming interface from the host as described in the previous sections, and try downloading again. If it continues to fail, refer to the recovery steps outlined below.

7.5.4 Performing a Recovery Procedure

In some cases, the normal firmware download procedure does not succeed even though all connections and switches are correct. This may happen as a result of SFLASH corruption due to incorrect application design, or attempting to load too-large of a firmware image (application size should not exceed ~26 KB), or power loss during a normal firmware download process. If this happens, you may need to recover the device. To do this:

1. Copy and paste the original make target to a new entry.
2. Name the new target the same, but replace 'download' with ’recover' and add `UART=COMxx` as an additional argument. The `COMxx` value should be the host serial port that is connected to the HCI UART programming interface on the module. The final make target name should be similar to this:

```
find_me-CYBLE_013025_EVAL recover UART=COM17
```

3. Press and hold the **Recover** button on the evaluation board, and press and release the **Reset** button. Release the Recover button after a moment. This will cause the module to boot into a recovery mode.
4. Double-click on the new make target to perform a recovery download. The application should now boot properly.

7.6 Part 4: Test Your Design

This section describes how to test your BLE design using the CySmart mobile apps and PC tool. The setup for testing your design using the EZ-BLE WICED evaluation board is shown in Figure 13.

1. Turn ON Bluetooth on your iOS or Android device.
2. Launch the CySmart app. Press the reset switch on the EZ-BLE WICED evaluation board to start BLE advertisements from your design.
3. Pull down the CySmart app home screen to start scanning for BLE Peripherals. Your device name will now appear in the CySmart app home screen. Select your device to establish a BLE connection.
4. Select the **Find Me** Profile from the carousel view.
5. Select one of the Alert Level values on the Find Me Profile screen and observe the state of the LED on your EZ-BLE WICED evaluation board change based on your selection.

A step-by-step configuration screenshot of the CySmart mobile app is shown in Figure 27 and Figure 28.

Figure 27. Testing with CySmart iOS App

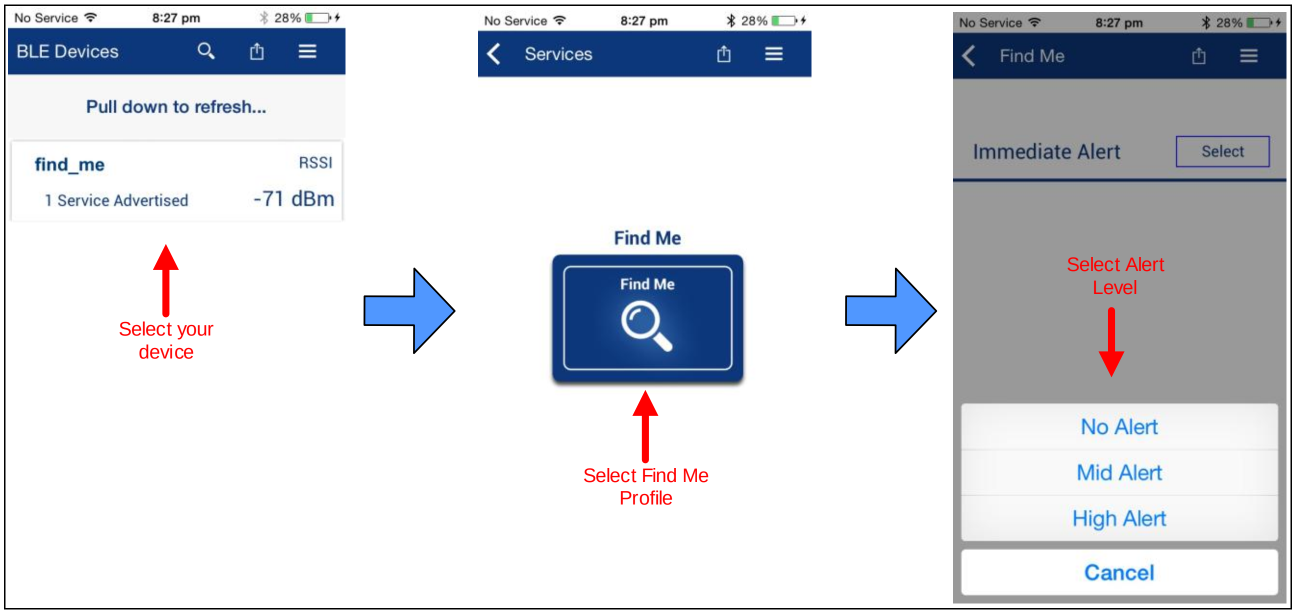
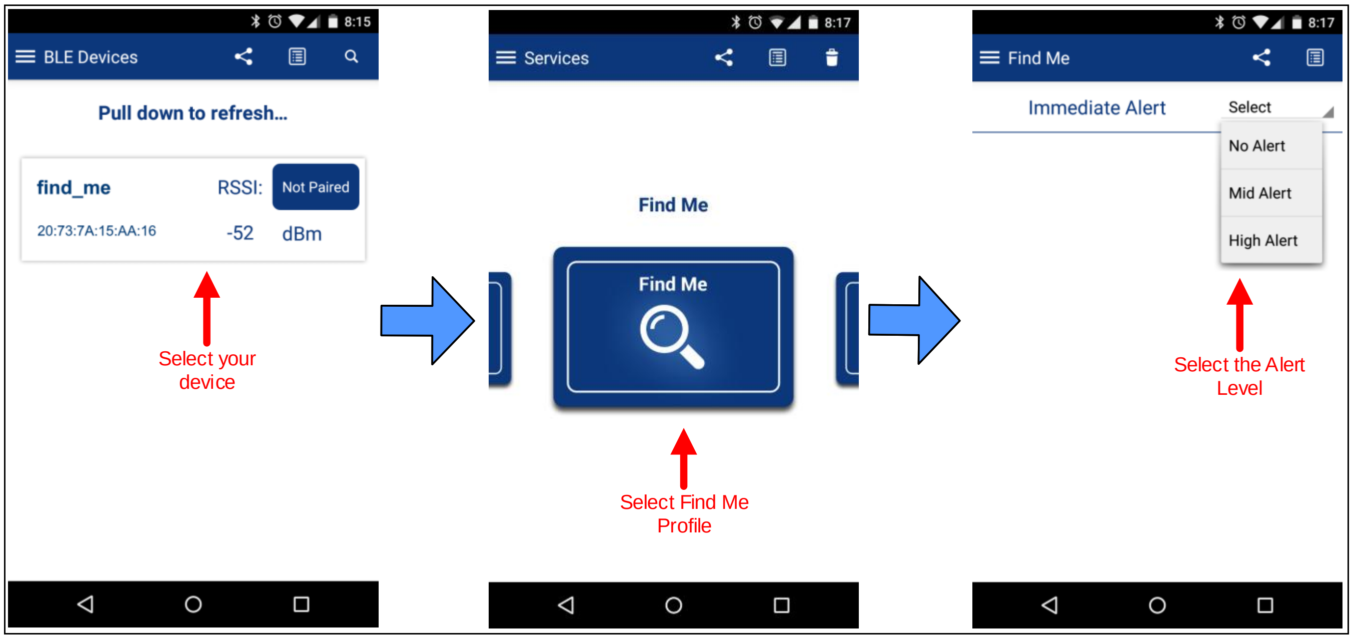


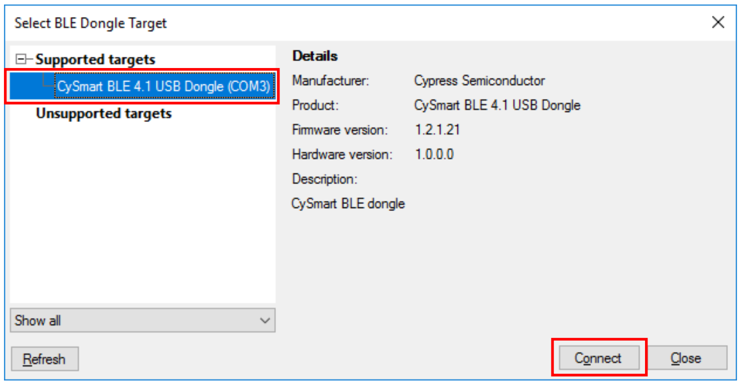
Figure 28. Testing with CySmart Android App



Similar to the CySmart mobile app, you can also use the CySmart Host Emulation Tool on a PC to establish a BLE connection with your design and perform read or write operations on BLE Characteristics. This method requires the CY5677 kit.

1. Connect the BLE dongle to your Windows machine. Wait for the driver installation to complete.
2. Launch the CySmart Host Emulation Tool; it automatically detects the BLE Dongle. Click **Refresh** if the BLE Dongle does not appear in the **Select BLE Dongle Target** pop-up window. Click **Connect,** as shown in Figure 29.

Figure 29. CySmart BLE Dongle Selection



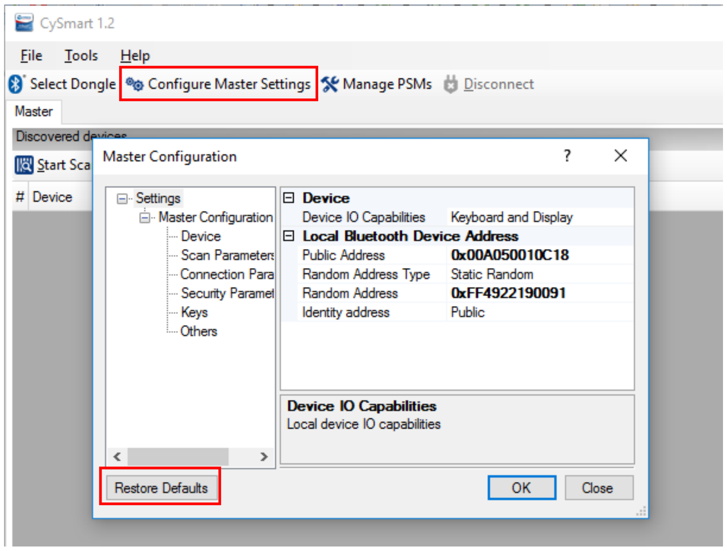
Details

Manufacturer:	Cypress Semiconductor
Product:	CySmart BLE 4.1 USB Dongle
Firmware version:	1.2.1.21
Hardware version:	1.0.0.0
Description:	

CySmart BLE dongle

3. Select **Configure Master Settings** and restore the values to the default settings, as shown in Figure 30.

Figure 30. CySmart Master Settings Configuration

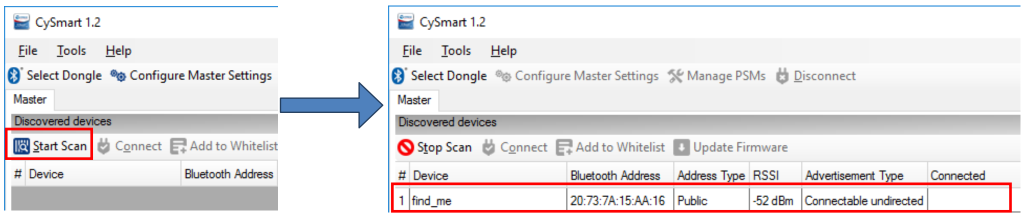


Device	
Device IO Capabilities	Keyboard and Display
Local Bluetooth Device Address	
Public Address	0x00A050010C18
Random Address Type	Static Random
Random Address	0xFF4922190091
Identity address	Public

Device IO Capabilities
Local device IO capabilities

4. Press the reset switch on the EZ-BLE WICED Evaluation board to start BLE advertisements from your design. Note that the HCI UART must not be connected when you reset or power on the board, or else the module will boot into programming mode instead of application mode. To accomplish this, set positions 5 and 6 of SW1 to the OFF position. For information on all DIP switch settings, see Table 11 in Appendix C (EZ-BLE WICED Evaluation Board Details).
5. On the CySmart Host Emulation Tool, click Start Scan. Your device name should appear in the Discovered devices list, as shown in Figure 31..

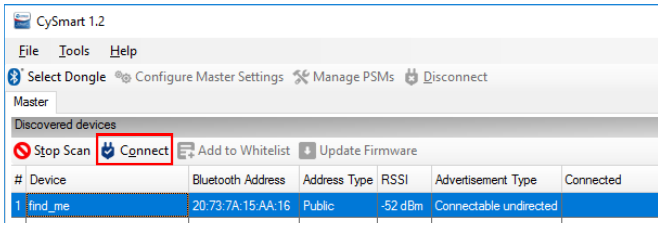
Figure 31. CySmart Device Discovery



#	Device	Bluetooth Address	Address Type	RSSI	Advertisement Type	Connected
1	find_me	20:73:7A:15:AA:16	Public	-52 dBm	Connectable undirected	

6. Select your device and click **Connect** to establish a BLE connection between the CySmart Host Emulation Tool and your device, as shown in Figure 32.

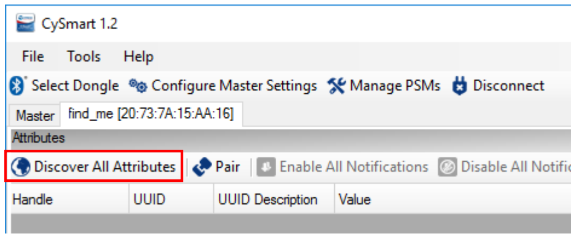
Figure 32. CySmart Device Connection



#	Device	Bluetooth Address	Address Type	RSSI	Advertisement Type	Connected
1	find_me	20:73:7A:15:AA:16	Public	-52 dBm	Connectable undirected	

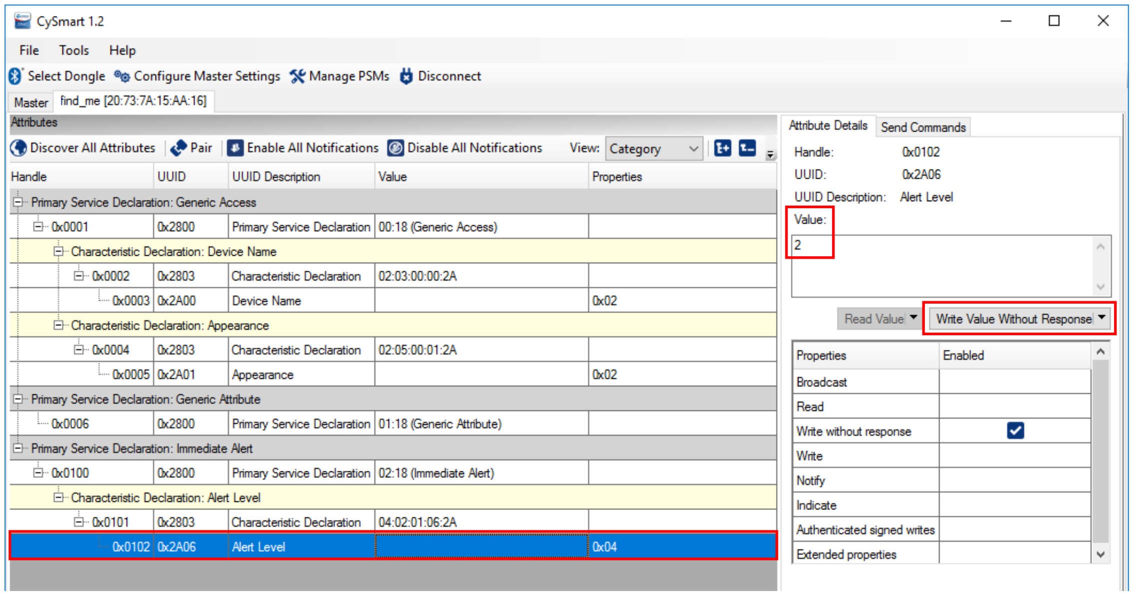
7. Once connected, discover all the Attributes on your design from the CySmart Host Emulation Tool, as shown in Figure 33.

Figure 33. CySmart Attribute Discovery



8. Write a value of 0, 1, or 2 to the Alert Level Characteristic under the Immediate Alert Service, as Figure 34 shows. Observe the state of the LED on your device change per your Alert Level Characteristic configuration.

Figure 34. Testing with CySmart Host Emulation Tool



Handle	UUID	UUID Description	Value	Properties
Primary Service Declaration: Generic Access				
0x0001	0x2800	Primary Service Declaration	00:18 (Generic Access)	
Characteristic Declaration: Device Name				
0x0002	0x2803	Characteristic Declaration	02:03:00:00:2A	
0x0003	0x2A00	Device Name		0x02
Characteristic Declaration: Appearance				
0x0004	0x2803	Characteristic Declaration	02:05:00:01:2A	
0x0005	0x2A01	Appearance		0x02
Primary Service Declaration: Generic Attribute				
0x0006	0x2800	Primary Service Declaration	01:18 (Generic Attribute)	
Primary Service Declaration: Immediate Alert				
0x0100	0x2800	Primary Service Declaration	02:18 (Immediate Alert)	
Characteristic Declaration: Alert Level				
0x0101	0x2803	Characteristic Declaration	04:02:01:06:2A	
0x0102	0x2A06	Alert Level		0x04

Handle: 0x0102
UUID: 0x2A06
UUID Description: Alert Level
Value:
2

Properties	Enabled
Broadcast	
Read	
Write without response	✓
Write	
Notify	
Indicate	
Authenticated signed writes	
Extended properties	

7.7 Design Source

The functional WICED SMART SDK project for the BLE example design described in this application note is distributed on this application note's web page.

8 Module Placement and Enclosure Considerations

EZ-BLE WICED Modules are designed to be soldered to a host PCB to provide seamless BLE connectivity. To maximize the RF performance of the final product, care needs to be taken on the placement of the module and antenna. This section describes in detail the recommended placement of the module on a host board to ensure optimal RF performance. This section also details the effect of metallic or nonmetallic enclosure and metal obstructions near the module.

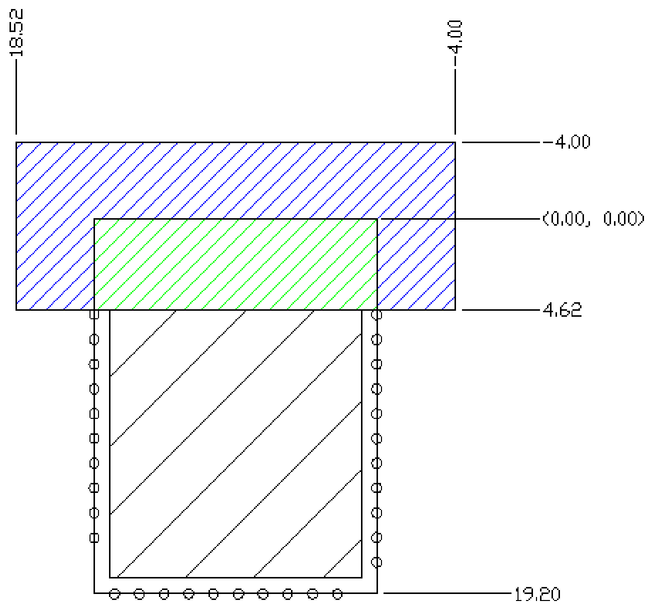
8.1 Antenna Ground Clearance

A monopole antenna requires that no ground plane is present below the antenna. The ground plane below it will not allow the field to propagate. This is defined as the Ground Clearance requirement. However, after some distance, a ground must be present for a monopole antenna. Defining this region is a very significant step for any antenna design. The Ground Clearance region defines the bandwidth and efficiency of the antenna.

Each specific EZ-BLE WICED Module marketing part number specifies the Ground Clearance used for the design of the module, and offers recommended additional ground keep-out area to maximize the RF performance. The examples below reference the CYBLE-013025-00 module specifically. For details on other modules, see the specific module datasheet.

The example below references a PCB trace antenna implementation (shown in the green hatched area), but the same rules and properties apply for chip antennas used on other Cypress EZ-BLE Modules. The specific PCB trace antenna shown in Figure 35 requires a Ground Clearance area of 4.62 mm × 14.52 mm. To maximize the RF performance, an additional 4 mm of ground clearance is recommended. This is denoted in the blue hatched area. This additional ground clearance is not required, but may improve the RF performance if implemented.

Figure 35. Antenna Clearance



In Figure 35, the PCB trace antenna is placed at the edge of the module. The green area in Figure 35 does not have any ground on any layer. The module placement in a host board needs to ensure that no traces or ground layers of the host board comes within this region. Any ground plane below a monopole antenna degrades the radiation and adversely affects the RF efficiency.

8.2 Module Placement in a Host System

The EZ-BLE Module is soldered to a host board and a clearance must be provided for the antenna where no routing or ground is allowed on any layer. Placing the module at the edge of the host board is recommended because it provides the best RF performance and simplifies the requirement of not routing signal or ground traces under the antenna Ground Clearance region. Figure 36 shows four placement options on a host board, with option 1 being the most efficient.

Figure 36. Module Placement in a Host Board

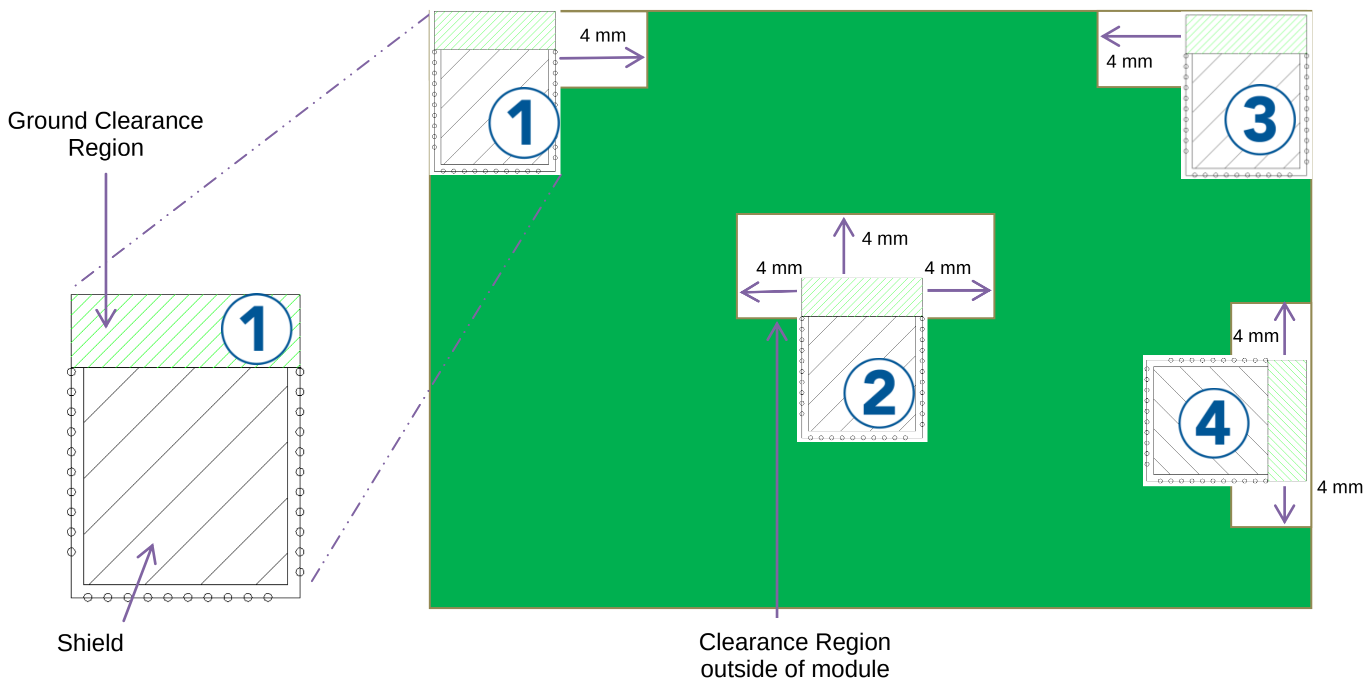


Figure 36 shows an example of four positions of the module in a host board, “1”, “2”, “3”, and “4”. The white area shown around the module is the additional clearance area. For the antenna in question, it is recommended to provide a clearance area of 4 mm in each direction. For details on the recommended clearance area for your EZ-BLE Module, see the specific module datasheet.

As can be seen in Figure 36, when placing the module at the edge (placement options “1” or “3”) of the host board, the additional clearance area is only required facing inwards towards the center of the main board. In all cases, there must be no possibility of signal or ground traces to be beneath the antenna Ground Clearance region. Conversely, if the module is placed in the middle (placement option “2”) of the host board, the clearance area must be provided in order to achieve an optimal RF performance.

Placement option “1” or “3” are the best options shown in Figure 36, because it removes the need to reroute signal or ground traces away from the Ground Clearance region of the module (because no GPIO are located at the top left or right corner of the module). Furthermore, it minimizes additional clearance area if optimal RF performance is desired, because the antenna faces outward with the antenna exposed to open space.

In placement option “4”, although the module is placed at the edge of the host board, the antenna is not exposed to the maximum amount of free space.

Placement option “2” not only wastes PCB real estate, but also provides diminished RF performance compared to position “1” and “3”.

8.3 Enclosure Effects on Antenna Performance

Antennas used in consumer products are sensitive to the PCB RF ground size, the product’s plastic casing, and metallic enclosures. This section describes the effect of each of these environmental factors on RF performance.

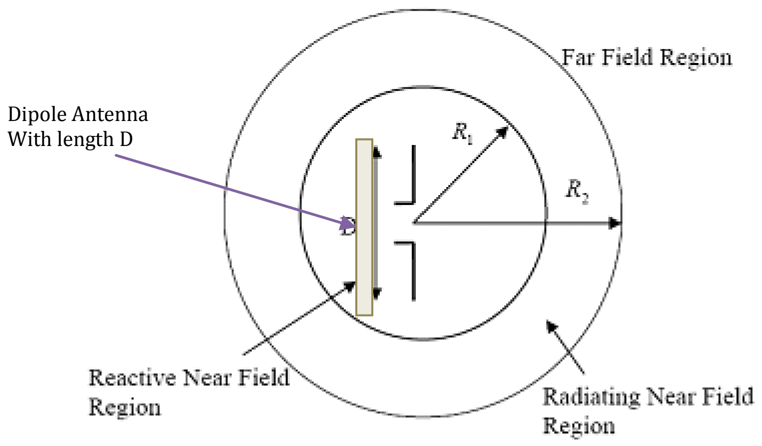
8.3.1 Antenna Near-Field and Far-Field

Every antenna contains two regions surrounding it: 1) the near-field and 2) the far-field.

The near-field is the region where the radiated field has not yet formed. In this region, the electric and magnetic fields are not orthogonal to each other. This region is very close to the antenna. The near-field region has two regions: the *reactive near-field region* and the *radiating near-field region*. The transition to a far-field region happens in the radiating near-field region.

The radiation field is formed after the transition to the far-field region. In this region, the relative angular variation of the field does not depend on the distance. This means that if you plot the angular radiation field at a distance from the antenna in the far-field region, their shapes remain the same. Only with distance, the field strength decreases. However, the shape of the radiation pattern remains the same with respect to the angular variation. This region is called the far-field region. An object in the far field does not affect the radiation pattern much. However, any obstruction in the near-field can completely change the radiation pattern. If the obstruction is metal, the effect on the radiation pattern is much more pronounced. Figure 37 shows the regions for a dipole antenna.

Figure 37. Near and Far Field


Far Field Region
Dipole Antenna With length D
R_1
R_2
Reactive Near Field Region
Radiating Near Field Region

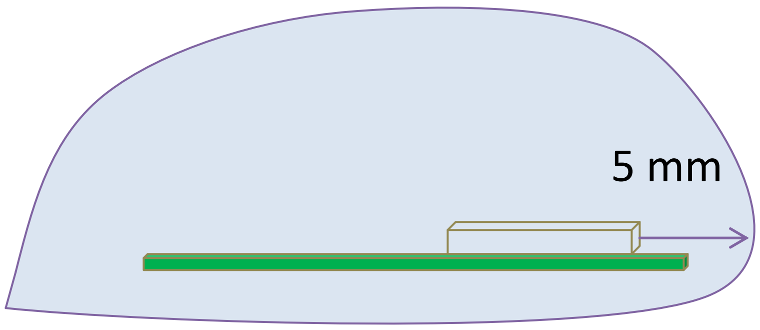
For a module based on a 2.4-GHz chip antenna, the near-field extends up to 4 mm.

8.3.2 Effect of Nonmetallic Enclosure

Any plastic enclosure changes the resonating frequency of the antenna. The antenna can be modeled as an LC resonator whose resonant frequency decreases when either L (inductance) or C (capacitance) increases. A larger RF ground plane and plastic casing increase the effective capacitance and thus reduce the resonant frequency. See the application note AN91445 for more details on the effect of an enclosure.

Figure 38 details a module antenna in a plastic enclosure. The clearance from the antenna to the plastic enclosure can be as little as 2 mm. However, clearance of this amount can affect the tuning of the antenna. This can be resolved by retuning the antenna; however for a module solution, it is not recommended to attempt retuning of the antenna. To minimize effects on the module antenna, it is recommended to have a minimum clearance of 5 mm.

Figure 38. EZ-BLE WICED Module Inside of a Plastic Mouse Enclosure

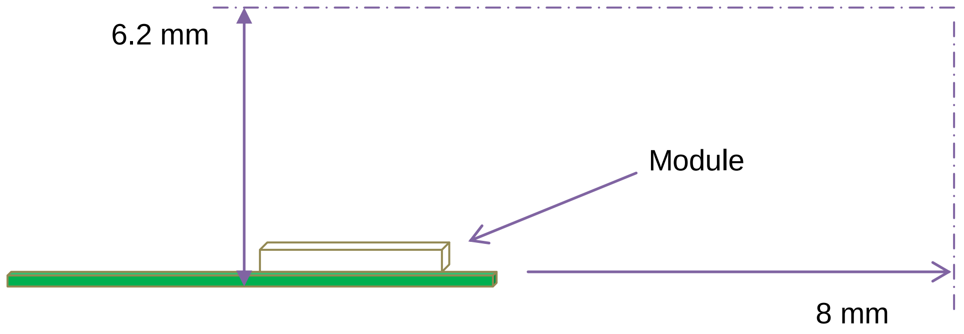


8.3.3 Effect of Metallic Objects

An antenna is sensitive to the presence of metallic objects in its vicinity. A metallic object shorts the electric field and thus changes the radiation field. Depending on the size of the obstruction, electromagnetic waves go through different diffraction patterns or may be completely shielded by the metallic object.

Metallic objects in the near-field can have a drastic impact on the radiation pattern. The thickness of the CYBLE-013025-00 module is 2.25 mm (including the shield) and the near field of this module extends up to 4 mm from the antenna. Therefore, it is recommended that any metallic obstruction be at least 6.2 mm away from the PCB plane to avoid negative effects to the RF performance. Cypress recommends an 8-mm gap from the module PCB plane to any metallic enclosure. Figure 39 details the required clearance from the EZ-BLE WICED Module to small metal obstructions.

Figure 39. Clearance from Small Metal Obstructions



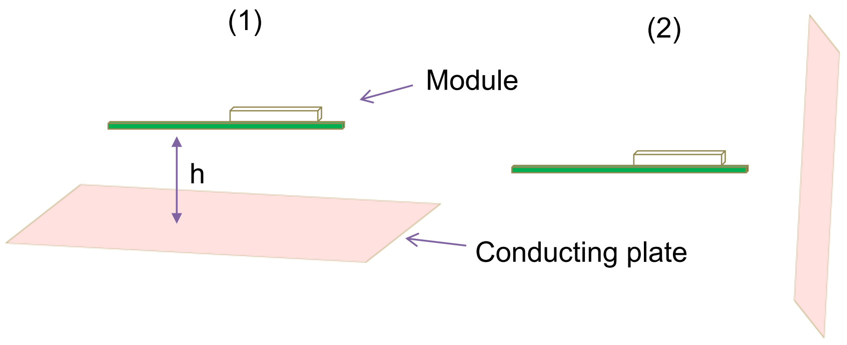
8.3.4 Recommendations for Placement over a Large Metal Plane

The other effect of metal is the formation of an image antenna. The best practice in this case is to orient the metal orthogonal to the antenna to ensure minimum effects. If the length or width of the plane approaches the size of the module, it is considered a large metal object near the antenna. Figure 40 details two placement options for this scenario. Of these two placement options, option "1" should be avoided.

It is recommended to not have any large metallic objects parallel to the antenna. This has a drastic effect because the image antenna is of opposite polarity. The interference caused by such an antenna is destructive to RF radiation.

If it is not possible to avoid a large metallic object running parallel to the module plane, you should maintain a distance (h) of at least 30 mm. This will ensure that the interference caused by the image antenna will not be completely destructive. The radiation will be strongly directional below the 30-mm distance; the efficiency will dramatically drop at a distance (h) below 8 mm. At a distance (h) of around 2 mm, the radiation efficiency can go below 20%.

Figure 40. Clearance from a Large Metal Plane



8.4 Guidelines for Enclosures and Ground Plane

Use the following best practices with respect to enclosure design and ground planes:

- Ensure that there is no component, mounting screw or ground plane near the tip or the length of the antenna located on the EZ-BLE WICED Module.
- Ensure that no battery cable, microphone cable, or trace crosses the antenna trace on the PCB.
- Ensure that the antenna is not completely covered by a metallic enclosure. If the product has a metallic casing or shield, the casing should not cover the antenna. No metal is allowed in the antenna near the field.

- Ensure that paint on plastic enclosures is nonmetallic near the antenna.
- Ensure that the orientation of the antenna is in-line with the final product orientation (if possible) so that radiation is maximized in the desired direction. The polarization and position of the receive antenna should be taken into account so that the module can be oriented to maximize the radiation.
- Ensure that there is no ground directly below the antenna Ground Clearance region of the module.

9 Manufacturing with EZ-BLE WICED Modules

EZ-BLE WICED Modules are intended to be used with traditional Surface Mount Technology (SMT) manufacturing lines and are compatible with industry-standard reflow profiles for Pb-free solders.

9.1 SMT Manufacturing Pick-and-Place

The modules should be picked up from the topside of the module using industry-standard pick-and-place machinery and nozzles. The ideal location for picking up the module is on the shield area of the module. For the optimal location for your EZ-BLE WICED Module, see the module’s datasheet.

Each module MPN has a unique center-of-mass detailed in each product’s datasheet. This center-of-mass is the area that represents the optimal location to pick up the unit with the nozzle. Using the center-of-mass guidelines for the pick-and-place location minimizes SMT line disturbances caused by units releasing prematurely from the nozzle.

Figure 41 shows an image of a nozzle used by Cypress for manufacturing the CYBLE-013025-EVAL Evaluation Board product. See the center-of-mass dimensions in each module’s datasheet to select an appropriate nozzle for your manufacturing line equipment.

Figure 41. Nozzle Used by Cypress for Evaluation Board Production

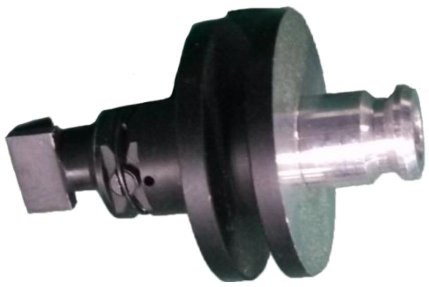
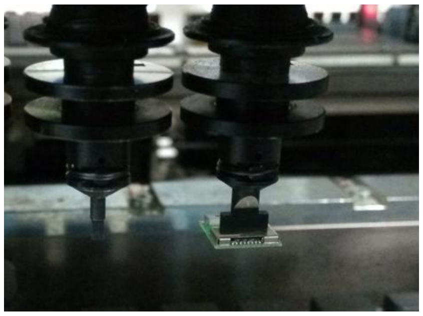


Figure 42 shows an image of a Cypress EZ-BLE Module being picked up at the center-of-mass by the nozzle referenced above.

Figure 42. Image of Nozzle Used by Cypress for Evaluation Board Production



9.2 Manufacturing Solder Reflow

EZ-BLE WICED Modules are compatible with industry-standard reflow profiles for Pb-free solder. Table 6 details the solder reflow specifications for all modules.

Table 6. EZ-BLE WICED Module Solder Reflow Specification

Module Package	Maximum Peak Temperature	Time at Maximum Temperature
All Packages	260 °C	30 seconds

10 Summary

This application note explores the EZ-BLE WICED Module solutions, architectures, development tools, host board placement and orientation, and production manufacturing. EZ-BLE WICED Modules are fully integrated BLE solutions that allow rapid development and production release for customer applications. The core of the EZ-BLE WICED Modules is the Cypress WICED Bluetooth Smart ICs, integrating the Bluetooth radio, analog and digital peripheral functions, memory, and an ARM Cortex-M3 microcontroller. The Cypress EZ-BLE Module family provides multiple module options to service the needs of any customer application.

11 Related Application Notes

- AN91445 – Antenna Design Guide
- AN96841 – Getting Started With EZ-BLE Creator Modules

About the Author

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Title:	Senior Business Unit Director
Background:	David Solda has a BS in Computer/Electrical Engineering, a BS in Mathematics, and an MBA from Santa Clara University, California.

Appendix A. Cypress Terms of Art

This section lists the most commonly used terms that you might hear while working with Cypress's PSoC family of devices.

PSoC – PSoC is a programmable, embedded design platform that includes a CPU, such as the 32-bit ARM Cortex-M0, with both analog and digital programmable blocks. It accelerates embedded system design with reliable, easy-to-use solutions, such as touch sensing and enables low-power designs.

PRoC BLE – PRoC BLE is a 32-bit, 48-MHz ARM Cortex-M0 BLE solution with CapSense, 12-bit ADC, four timers, counters, pulse-width modulators (TCPWM), thirty-six GPIOs, two serial communication blocks (SCBs), LCD, and I2S. PRoC BLE includes a royalty-free BLE stack compatible with Bluetooth 4.1 and provides a complete, programmable, and flexible solution for HID, remote controls, toys, beacons, and wireless chargers. In addition to these applications, PRoC BLE provides a simple, low-cost way to add BLE connectivity to any system.

PSoC 4 BLE – A PSoC 4 IC with an integrated BLE radio that includes a royalty-free BLE protocol stack compatible with the Bluetooth 4.1 or 4.2 specifications.

EZ-BLE™ PRoC Module (EZ-BLE PRoC) – EZ-BLE PRoC Module is a fully integrated, fully certified, 10 mm × 10 mm × 1.8 mm, programmable, Bluetooth Smart or Bluetooth Low Energy (BLE) module designed for ease-of-use and reducing time-to-market. It contains Cypress's PRoC BLE chip, two crystals, chip antenna, shield and passive components. EZ-BLE PRoC Module provides a simple and low cost way to add a microcontroller, CapSense touch controller and Bluetooth Smart connectivity to any system.

EZ-BLE™ PSoC Module (EZ-BLE PSoC) – An integrated, easy-to-use, fully certified Bluetooth Smart module designed to reduce time-to-market and development cost. Contains PSoC 4 BLE, two crystals, an antenna and passive components.

EZ-BLE™ WICED Module (EZ-BLE WICED) - EZ-BLE WICED Modules are fully integrated, fully certified, Bluetooth Smart or Bluetooth Low Energy (BLE) module designed for ease-of-use and reducing time-to-market. It contains Cypress's WICED BLE chip, one crystal, PCB trace antenna, shield and passive components. EZ-BLE WICED Module provides a simple and low cost way to add a microcontroller and Bluetooth Smart connectivity to any system.

EZ-BT™ WICED Modules (EZ-BT WICED) - EZ-BT WICED Modules are fully integrated, fully certified, Bluetooth Smart Ready (Bluetooth Basic Rate, Enhanced Data Rate, and Bluetooth Low-Energy) modules designed for ease-of-use and reducing time-to-market. They contain Cypress' WICED dual-mode chip, one crystal, PCB trace antenna, shield and passive components. EZ-BT WICED Modules provide a simple and low-cost way to add a microcontroller and Bluetooth Smart Ready connectivity to any system.

PSoC Creator™ – PSoC 3, PSoC 4, and PSoC 5LP Integrated Design Environment (IDE) software that installs on your PC and allows concurrent hardware and firmware design of PSoC systems, or hardware design followed by export to other popular IDEs.

WICED SMART SDK – Cypress' WICED (Wireless Connectivity for Embedded Devices) is a full-featured platform with proven Software Development Kits (SDKs) and turnkey hardware solutions from partners to readily enable Wi-Fi and Bluetooth connectivity in system design.

Appendix B. EZ-BLE WICED Module Product Details

The information contained for each module part number includes the following:

- Physical image for each EZ-BLE WICED Module marketing part number
- Pinout and functionality for each EZ-BLE WICED Module marketing part number
- Recommended host PCB layout footprint for each EZ-BLE WICED Module marketing part number
- Recommended additional clearance area for each EZ-BLE WICED Module marketing part number

To jump to your specific EZ-BLE WICED Module, click the marketing part number in the below list:

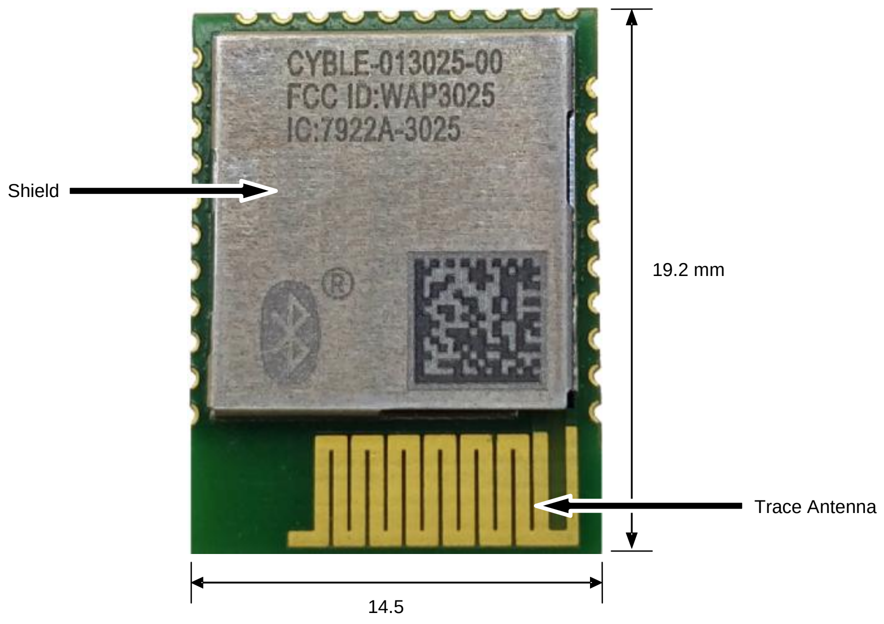
- CYBLE-0130XX-00

B.1 EZ-BLE WICED Part Number Details

B.1.1 CYBLE-0130XX-00

The CYBLE-0130XX-00 is available in two marketing part numbers: CYBLE-013025-00 (includes 128 KB of SFLASH) and the CYBLE-013030-00 (which does not contain nonvolatile memory on the module). Figure 43 shows a physical picture of the CYBLE-0130XX-00 EZ-BLE WICED Module.

Figure 43. CYBLE-0130XX-00 Module Top View

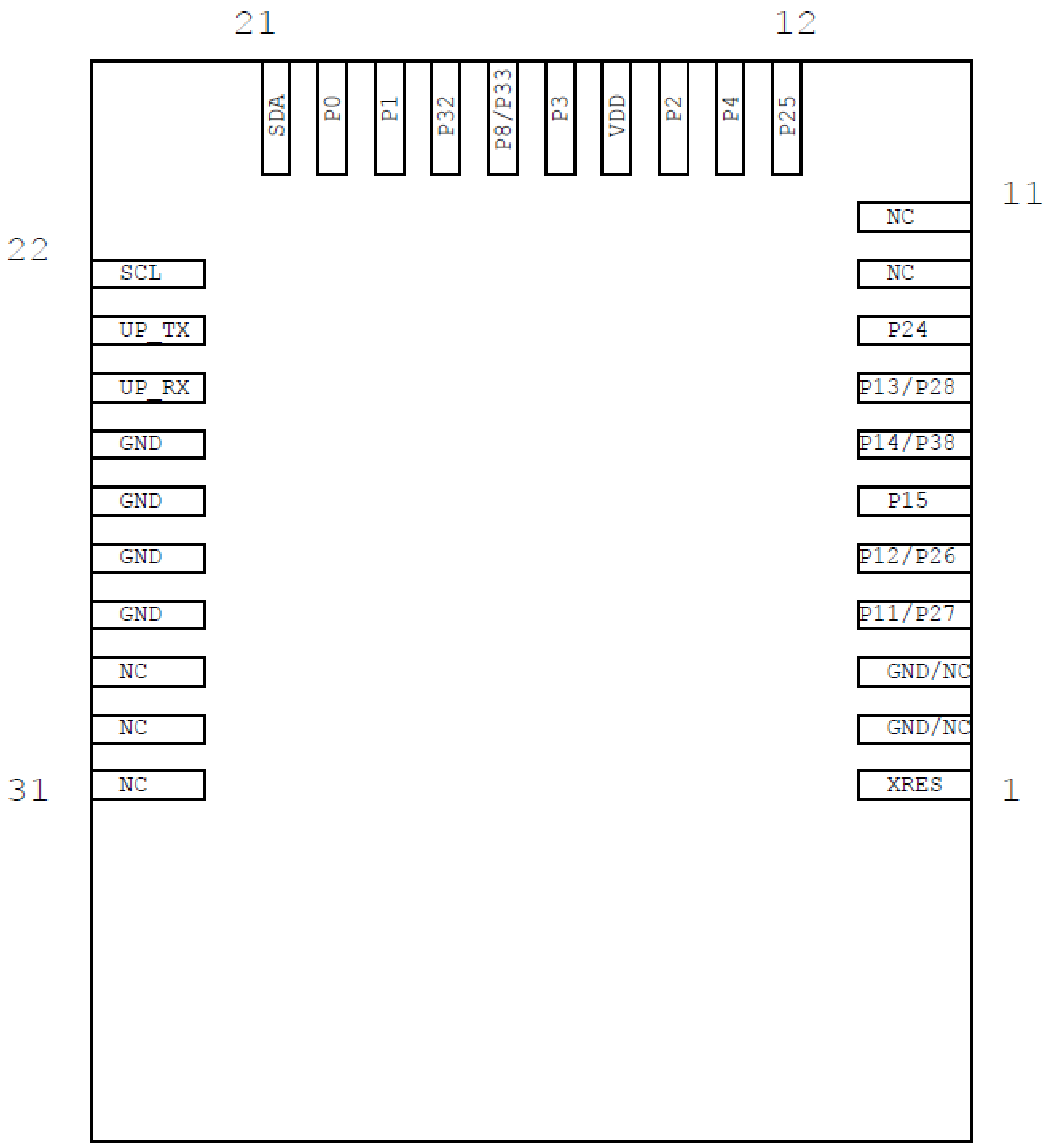


For more details on this module’s dimensions, external component connections, and module placement recommendations, see the CYBLE-0130XX-00 datasheet specification.

B.1.1.1 Pinout and Functionality

The CYBLE-0130XX-00 module is designed to mount as a component on an end-product PCB. Only a portion of the available I/O of the CYW20737 WICED BLE silicon device is exposed on the CYBLE-0130XX-00 module in order to minimize the module footprint size. The CYBLE-0130XX-00 module contains 31 connections on the bottom side of the module. Figure 44 details the bottom side connections available on the CYBLE-0130XX-00 module.

Figure 44. CYBLE-0130XX-00 Module Bottom View (Seen from Bottom)



A list of the available I/Os and supported functionality for each I/O of the CYBLE-013025-00 is shown in Table 7.

Table 7. CYBLE-013025-00 Module Available Connections and Functionality

Solder Pad	Pad/Silicon Pin Name	Functionality							
		UART	SPI[4]	I2C	ADC	PWM	CLK/XTAL	GPIO	OTHER
1	XRES	External Reset (Active Low)							
2	GND/NC	Ground Connection/No Connect							
3	GND/NC	Ground Connection/No Connect							
4	P11/P27[5]		SPI2_MOSI (P27) (master/slave)		Yes (P11 only)	PWM1 (P27)	XTALI32K (P11)	Yes	
5	P12/P26[12]		SPI2_CS (P26) (slave)		Yes (P12 only)	PWM0 (P26)	XTALO32K (P12)	Yes	
6	P15				Yes			Yes	SWDIO
7	P14/P38[12]		SPI2_MOSI (P38) (master/slave)		Yes	PWM2 (P14)		Yes	
8	P13/P28[12]				Yes	PWM3 (P13) PWM2 (P28)		Yes	
9	P24	PUART_TX	SPI2_CLK (master/slave)					Yes	
10	NC	No Connect							
11	NC	No Connect							
12	P25	PUART_RX	SPI2_MISO (master/slave)					Yes	
13	P4	PUART_RX	SPI2_MOSI (master/slave)					Yes	
14	P2	PUART_RX	SPI2_MOSI (master) / SPI2_CS (slave)					Yes	
15	VDD	Power Supply Input (2.3 V ~ 3.63 V)							
16	P3	PUART_CTS	SPI2_CLK (master/slave)					Yes	
17	P8/P33[12]	No Connect (Used for on-module memory SPI Interface for CYBLE-013025-00)							
18	P32	No Connect (Used for on-module memory SPI Interface for CYBLE-013025-00)							
19	P1	PUART_RTS	SPI2_MISO (master/slave)		Yes			Yes	

[4] The CYBLE-013025-00 contains a single SPI (SPI2) peripheral supporting both master and slave configurations. SPI1 is used for on-module serial memory interface.

[5] This chip pin for this connection is dual-bonded. Use of the internal chip super-mux is required to configure the desired output signal on these connections.

Solder Pad	Pad/Silicon Pin Name	Functionality							
		UART	SPI[4]	I2C	ADC	PWM	CLK/XTAL	GPIO	OTHER
20	P0	PUART_TX	SPI2_MOSI (master/slave)		Yes			Yes	
21	SDA			I2C_SDA				Yes	
22	SCL			I2C_SCL				Yes	
23	UP_TX	UART_TX							
24	UP_RX	UART_RX							
25	GND	Ground Connection							
26	GND	Ground Connection							
27	GND	Ground Connection							
28	GND	Ground Connection							
29	NC	No Connect							
30	NC	No Connect							
31	NC	No Connect							

Table 8 details the available I/Os and supported functionality for each I/O of the CYBLE-013030-00 module. NOTE that the only difference between the CYBLE-013025-00 (128 KB SFLASH) and the CYBLE-013030-00 (No Flash) is the amount of flash on-board the module. This fact also allows for the SPI1 connection to exist on the CYBLE-013030-00 module.

Table 8. CYBLE-013030-00 Module Available Connections and Functionality

Solder Pad	Pad/Silicon Pin Name	Functionality							
		UART	SPI[6]	I2C	ADC	PWM	CLK/XTAL	GPIO	OTHER
1	XRES	External Reset (Active Low)							
2	GND/NC	Ground Connection/No Connect							
3	GND/NC	Ground Connection/No Connect							
4	P11/P27[7]		SPI2_MOSI (P27) (master/slave)		Yes (P11 only)	PWM1 (P27)	XTALI32K (P11)	Yes	
5	P12/P26[14]		SPI1_MISO (P26, master) SPI2_CS (P26, slave)		Yes (P12 only)	PWM0 (P26)	XTALO32K (P12)	Yes	
6	P15				Yes			Yes	SWDIO
7	P14/P38[14]		SPI2_MOSI (P38) (master/slave)		Yes	PWM2 (P14)		Yes	
8	P13/P28[14]				Yes	PWM3 (P13) PWM2 (P28)		Yes	
9	P24	PUART_TX	SPI1_MISO (master) SPI2_CLK (master/slave)					Yes	
10	NC	No Connect							
11	NC	No Connect							

[6] The CYBLE-013030-00 contains a two SPI peripherals (SPI1 and SPI2). SPI2 supports both master and slave configurations. SPI1 supports only master configuration. If external SPI memory is used with the CYBLE-013030-00 module, SPI1 must be the interface used to the memory.

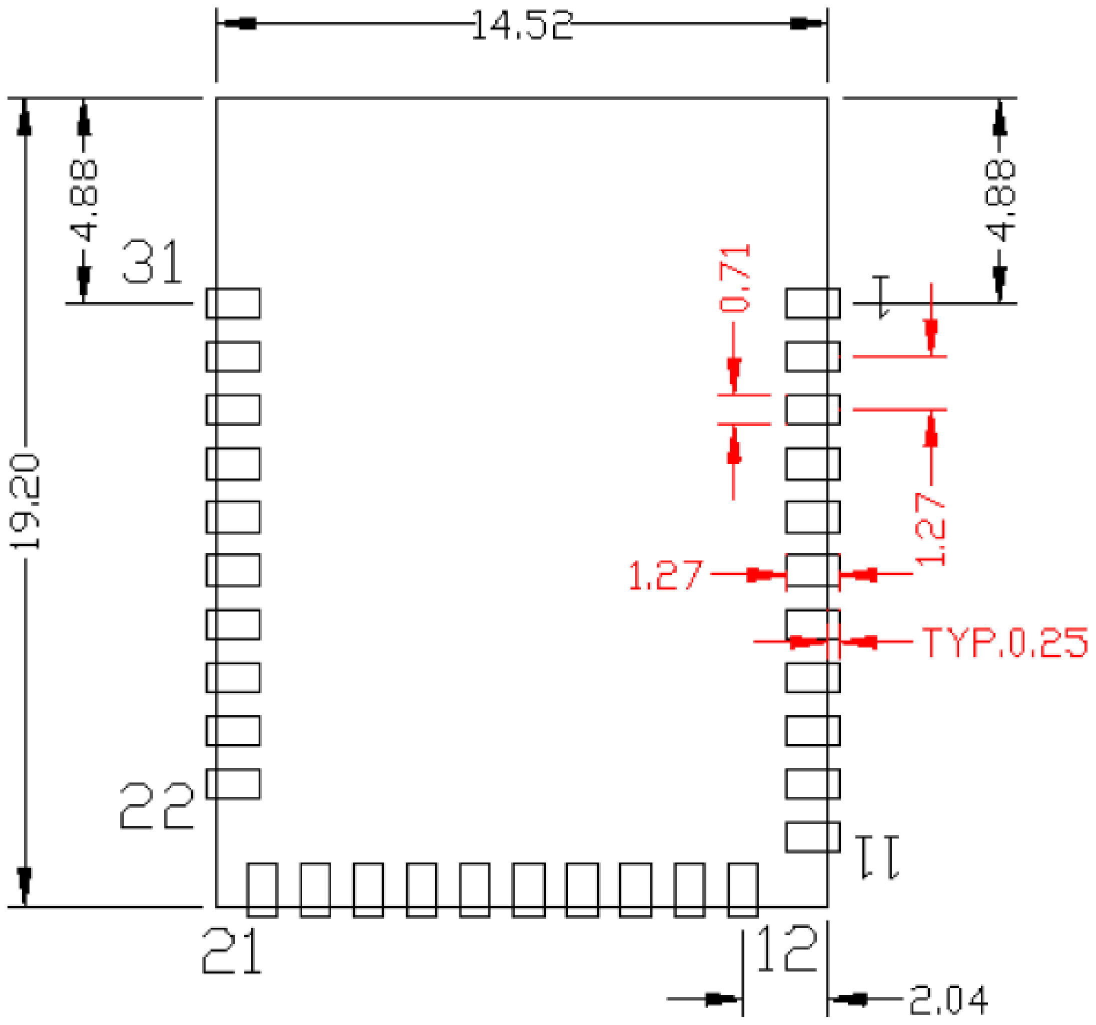
[7] This chip pin for this connection is dual-bonded. Use of the internal chip super-mux is required to configure the desired output signal on these connections.

Solder Pad	Pad/Silicon Pin Name	Functionality							
		UART	SPI[6]	I2C	ADC	PWM	CLK/XTAL	GPIO	OTHER
12	P25	PUART_RX	SPI2_MISO (master/slave)					Yes	
13	P4	PUART_RX	SPI2_MOSI (master/slave)					Yes	
14	P2	PUART_RX	SPI2_MOSI (master) / SPI2_CS (slave)					Yes	
15	VDD	Power Supply Input (2.3 V ~ 3.63 V)							
16	P3	PUART_CTS	SPI2_CLK (master/slave)					Yes	
17	P8/P33[14]	PUART_RX (P33)	SPI2_MOSI (P33, slave) SPI1_CS (P33, master)		Yes		ACLK1 (P33)	Yes	
18	P32	PUART_TX	SPI1_MISO (slave) SPI1_CS (slave)		Yes		ACLK0	Yes	
19	P1	PUART_RTS	SPI2_MISO (master/slave)		Yes			Yes	
20	P0	PUART_TX	SPI2_MOSI (master/slave)		Yes			Yes	
21	SDA		SPI1_MOSI (master)	I2C_SDA				Yes	
22	SCL		SPI1_CLK (master)	I2C_SCL				Yes	
23	UP_TX	UART_TX							
24	UP_RX	UART_RX							
25	GND	Ground Connection							
26	GND	Ground Connection							
27	GND	Ground Connection							
28	GND	Ground Connection							
29	NC	No Connect							
30	NC	No Connect							
31	NC	No Connect							

B.1.1.2 Host Recommended PCB Layout

To assist in the host PCB layout design for the CYBLE-0130XX-00, Cypress provides three host PCB landing pattern reference drawings in Figure 45, Figure 46, and in Figure 47, and Table 9. Figure 45 provides a dimensioned view of the host PCB layout. Figure 46 provides the location to the center edge of each solder pad relative to the origin of the module (upper right PCB outline). Figure 47 and Table 9 provides the location to each solder pad center location for the host PCB layout. Dimensions shown are in mm unless otherwise stated.

Figure 45. Host Board Required PCB Layout Pattern (Dimensioned View)



Note: Pad length shown includes overhang of the host pad beyond the module pad outline. The minimum recommended pad length on the host PCB is 1.27 mm.

Figure 46. Host Board Required PCB Layout Pattern: To Pad Center Edge Relative to Origin

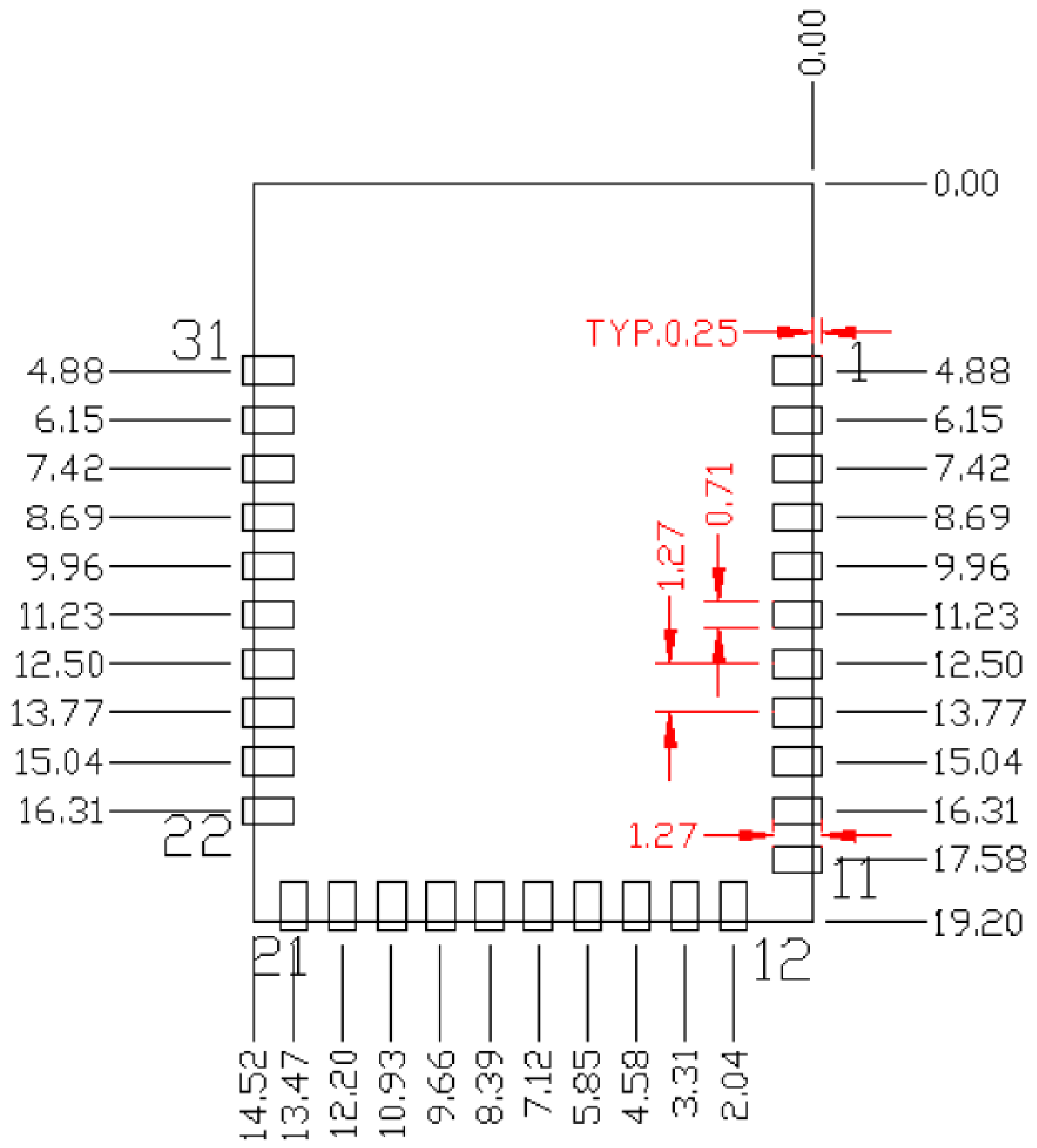


Figure 47. Host Board Required PCB Layout Pattern To Pad Center Relative to Origin

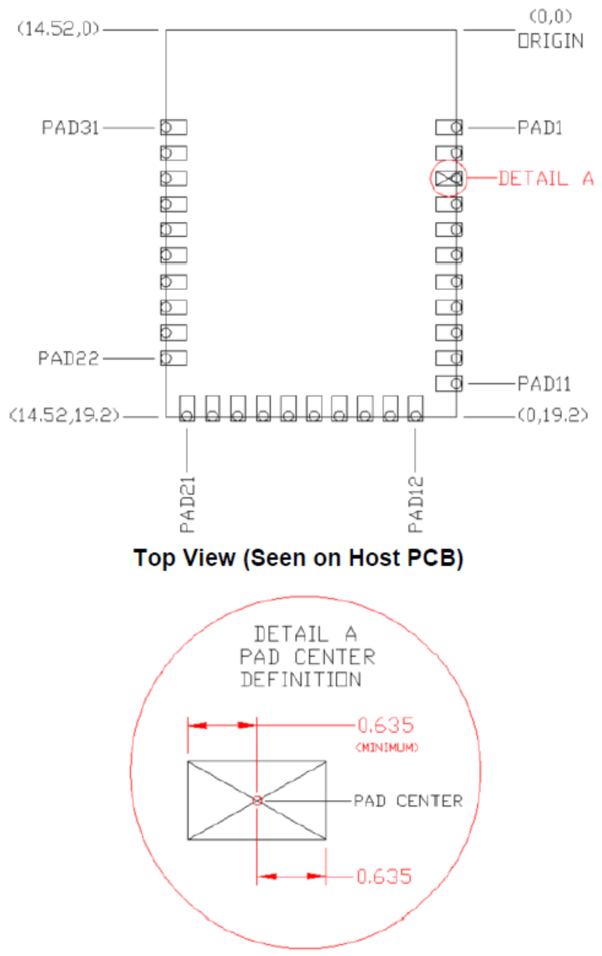
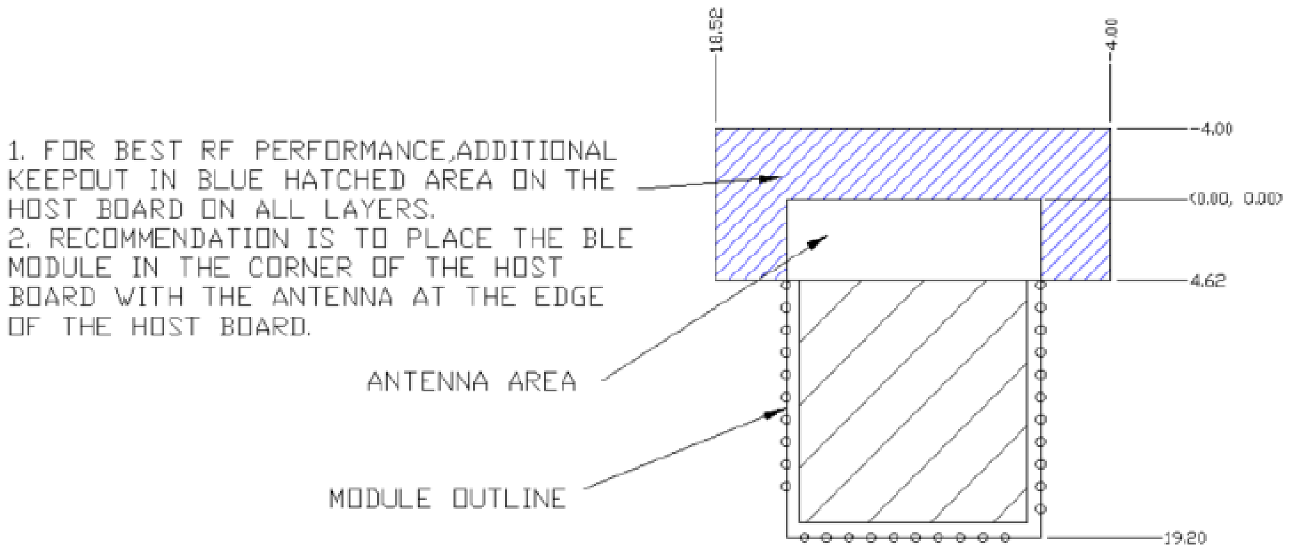


Table 9. Location to Pad Center from Origin (dimensions in mm and mils)

Solder Pad (Center of Pad)	Location (X,Y) from Origin (mm)	Location (X,Y) from Origin (mils)
1	(0.39, 4.88)	(15.35, 192.13)
2	(0.39, 6.15)	(15.35, 242.13)
3	(0.39, 7.42)	(15.35, 292.13)
4	(0.39, 8.69)	(15.35, 342.13)
5	(0.39, 9.96)	(15.35, 392.13)
6	(0.39, 11.23)	(15.35, 442.13)
7	(0.39, 12.50)	(15.35, 492.13)
8	(0.39, 13.77)	(15.35, 542.13)
9	(0.39, 15.04)	(15.35, 592.13)
10	(0.39, 16.31)	(15.35, 642.13)
11	(0.39, 17.58)	(15.35, 492.13)
12	(2.04, 18.82)	(80.31, 740.94)
13	(3.31 , 18.82)	(130.31 , 740.94)
14	(4.58 , 18.82)	(180.31 , 740.94)
15	(5.85 , 18.82)	(230.31 , 740.94)
16	(7.12 , 18.82)	(280.31 , 740.94)
17	(8.39 , 18.82)	(330.31 , 740.94)
18	(9.66 , 18.82)	(380.31 , 740.94)
19	(10.93 , 18.82)	(430.31 , 740.94)
20	(12.20 , 18.82)	(480.31 , 740.94)
21	(13.47, 18.82)	(530.31, 740.94)
22	(14.14, 16.31)	(556.69, 642.12)
23	(14.14, 15.04)	(556.69, 592.12)
24	(14.14, 13.77)	(556.69, 542.12)
25	(14.14, 12.50)	(556.69, 492.12)
26	(14.14, 11.23)	(556.69, 442.12)
27	(14.14, 9.96)	(556.69, 392.12)
28	(14.14, 8.69)	(556.69, 342.12)
29	(14.14, 7.42)	(556.69, 292.12)
30	(14.14, 6.15)	(556.69, 242.12)
31	(14.14, 4.88)	(556.69, 192.12)

Figure 48 below details additional host board keep out area to achieve optimal RF performance with the CYBLE-0130XX-00 module (denoted in blue hatched area).

Figure 48. Host Board Additional Keep Out Area for Optimal RF Performance


1. FOR BEST RF PERFORMANCE,ADDITIONAL KEEPOUT IN BLUE HATCHED AREA ON THE HOST BOARD ON ALL LAYERS.
2. RECOMMENDATION IS TO PLACE THE BLE MODULE IN THE CORNER OF THE HOST BOARD WITH THE ANTENNA AT THE EDGE OF THE HOST BOARD.
ANTENNA AREA
MODULE OUTLINE
18.52
-4.00
-4.00
(0.00, 0.00)
4.62
19.20

Appendix C. EZ-BLE WICED Evaluation Board Details

Appendix C provides detailed information on each EZ-BLE WICED Evaluation Boards. The information contained for each subsection below includes the following:

- Physical image for each EZ-BLE WICED Evaluation marketing part number
- What's included on the specific EZ-BLE WICED Evaluation board

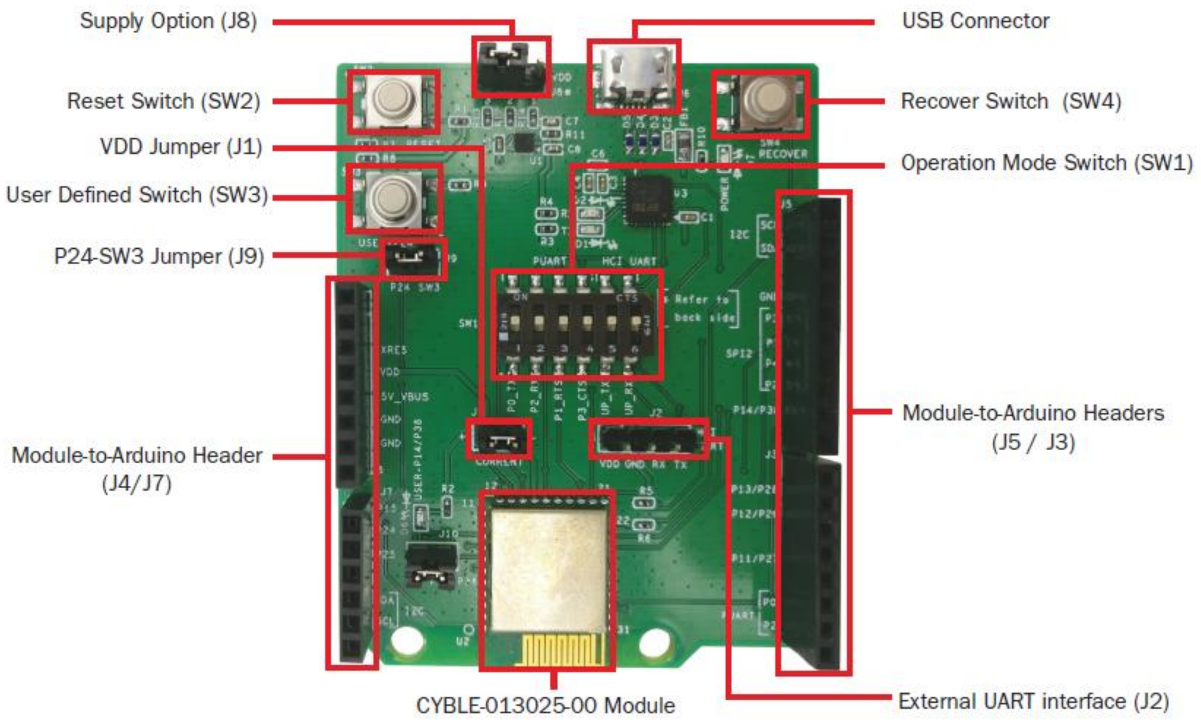
To jump to your specific EZ-BLE WICED Evaluation board, click the marketing part number in the below list:

- CYBLE-013025-EVAL

C.1.1 CYBLE-013025-EVAL

The CYBLE-013025-EVAL is the evaluation board for both the CYBLE-013025-00 and the CYBLE-013030-00 EZ-BLE WICED Modules. Figure 49 shows the CYBLE-013025-EVAL board and calls out the main components and connections available on the board.

Figure 49. CYBLE-013025-EVAL Evaluation Board


Supply Option (J8)
USB Connector
Reset Switch (SW2)
Recover Switch (SW4)
VDD Jumper (J1)
Operation Mode Switch (SW1)
User Defined Switch (SW3)
P24-SW3 Jumper (J9)
Module-to-Arduino Headers (J5 / J3)
Module-to-Arduino Header (J4/J7)
CYBLE-013025-00 Module
External UART interface (J2)

The section below explains the main items shown in Figure 49 above.

Note: Connections not called out on J3, J4, J5, and J7 Arduino compatible headers are NC (No Connect), where no physical connection is present between the CYBLE-013025-00 EZ-BLE WICED Module and the associated headers.

The CYBLE-013025-EVAL includes the following elements:

Active Devices

- EZ-BLE WICED Module: The EZ-BLE WICED Module is mounted to the evaluation board as shown in Figure 49.
- USB-to-UART bridge device: A USB-to-UART bridge device is provided on the evaluation board to translate USB communication to UART communication. The UART communication is routed based on the configuration settings of SW1, as described below.

Connectors and Headers

- USB receptacle: The USB connection on the CYBLE-013025-EVAL board provides power to the evaluation board, and also provides communication to the board via USB, which is translated to UART communication and routed to either the HCI UART or PUART connection on the EZ-BLE WICED Module depending on the configuration of SW1.
- Power Supply Option Header (J8): J8 allows for configuration of three different power supplies to the EZ-BLE WICED Module. All power is sourced from the USB connection, as mentioned above, but the power supply directly inputted to the CYBLE-013025-00 module can be configured to either 2.3 V, 3.3 V, or 3.6 V using the provided three-pin header. The power supply input is configured by shorting two neighboring header positions or leaving the header open. Table 10 details the available power supply options and the associated header position connections required.

Table 10. J8 Header Power Supply Connection Options

2.3 V Supply	Leave connections open; do not short any header connections
3.3 V Supply	Short J8 header positions 2 & 3
3.6 V Supply	Short J8 header positions 1 & 2
All Other Configurations	Not Allowed

- Arduino-compatible base headers – headers J3/J4/J5/J7: The CYBLE-013025-EVAL provides Arduino-compatible base headers that can be used for Arduino shield interfacing. The associated signals that are routed out to these headers are noted on the PCB silk screen on both the top and bottom side of the evaluation board.
- HCI UART direct connection header (J2): The J2 header provides all HCI UART communication lines to the user. This allows for connection to the EZ-BLE WICED Module without having to connect through USB. This can be used to connect a host controller evaluation board directly to the EZ-BLE WICED Module HCI UART connection. HCI UART connections are not brought out to the Arduino-compatible headers.
- Power consumption measurement header (J1): J1 is provided to allow for easy power consumption measurement reading with a multi-meter or current measurement probe.
- User Element Disconnection Headers (J9 and J10): J9 (USER SW2) and J10 (USER D6 - LED) are provided to allow for disconnection of these elements from the CYBLE-013025-00 module. In both cases, the GPIO that is routed to these USER elements is also routed to the Arduino-compatible headers. This may be desired if you plan to use either of these GPIOs through the Arduino-compatible headers.

Switches and LEDs

- SW1 (UART configuration switch): SW1 controls the configuration of which UART connection is active, HCI UART or Peripheral UART (PUART). SW1 is a six-position switch, and provides the following configuration states:

Table 11. SW1 UART Communication Configuration Options

SW1	Switch Position State	
	Position 1, 2, 3, and 4 are set to **ON** Position	Position 1, 2, 3, and 4 are set to **OFF** Position
Position 5 and 6 are set to **ON** Position	**CONFIGURATION IS NOT ALLOWED**	HCI UART Communication Programming Mode
Position 5 and 6 are set to **OFF** Position	Peripheral UART (PUART) Communication Application Mode	Application Mode

Notes on the above table are below:

- It is not allowed to have all six switch positions set to the **ON** state. This would lead to both HCI UART and PUART being actively connected to the EZ-BLE WICED Module, and could lead to a VDD to GND short.
- The HCI UART Communication Configuration (Positions 5 and 6 = **ON**; Positions 1-4 = **OFF**) is the mode that the evaluation board should be in when interfacing to the WICED SMART SDK, with the goal of downloading a compiled image to the EZ-BLE WICED Module.
- The PUART/Application Mode (Positions 5 and 6 = **OFF**; Positions 1-4 = **ON**) is the configuration mode to use when running application code from SFLASH on the EZ-BLE WICED Module. NOTE that the EZ-BLE WICED Module will not boot from SFLASH if HCI UART Mode is active on SW1. This mode also provides the PUART communication interface, which can be used for terminal communication on a PC.
- The Application mode (All switch positions = **OFF**) allows the EZ-BLE WICED Module to boot from SFLASH and run application code developed and programmed into the module previously. This mode disables both the HCI UART and PUART communication from host PC. PUART communication can still be accomplished through the Arduino-compatible headers if desired. Similarly, HCI communication can be accomplished through the J2 header.

- SW2 (RESET switch): SW2 is a tactile switch that is connected directly to the XRES connection of the CYBLE-013025-00 module. Activating this switch will reset the EZ-BLE WICED Module.
- SW3 (USER switch): SW3 is provided as an element that the user can configure as desired. The SW3 element is connected to P24 on the CYBLE-013025-00 module (solder pad 9).
- SW4 (RECOVER switch): SW4 is provided to recover a module that has the standard programming bootloader and/or application image corrupted or erased. Recovery mode is activated by holding this button down while pressing and releasing SW2 (RESET). Recovery mode is not typically necessary during normal development.
- D1 and D2 LEDs are provided to display programming activity while in progress.
- D7 LED is provided to show that power is provided from the host PC.
- D6 USER LED is provided for user-configured behavior as desired. The D6 LED is connected to the module P14/P26 connection (solder pad 7).

Appendix D. Code Examples

The WICED SMART SDK comes with a set of example projects that demonstrate a variety of BLE and peripheral functionality. These projects are available in the Project Explorer inside the IDE, as Figure 50 shows.

Example projects can speed up your design process by starting you off with a complete design, instead of a blank page. Code examples include comments describing their functionality and basic demonstration instructions near the top of the main **.c** source file for each project.

Each example also has a dedicated make target available to provide an easy way to build and download onto a BLE module. However, these make targets should be renamed before use in order to provide compatibility with the CYBLE-013025-EVAL board. Simply change the "BCM92073x…" portion of the target name to "CYBLE_013025_EVAL" instead. For example:

Before: `puart_control-`**`BCM920737TAG_Q32`**` download`

After: `puart_control-`**`CYBLE_013025_EVAL`**` download`

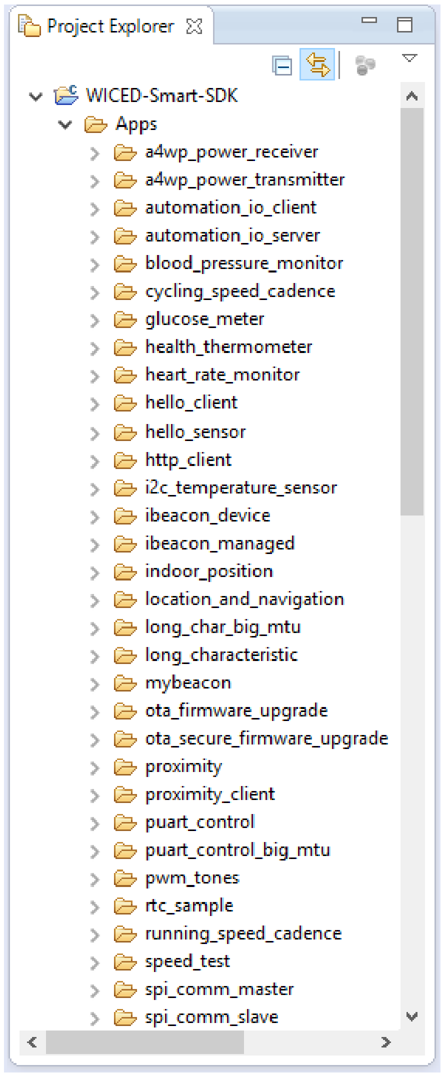
Some examples assume peripheral devices that are not present or that are routed differently on the CYBLE-013025-EVAL board compared to older "Tag" evaluation products, such as a button or a PWM-controlled piezo buzzer. The table below defines all built-in peripherals and their routed pin connections.

Table 12. CYBLE-013025-EVAL Pin Assignments

Pin	Function	Macro
P24	Button (active HIGH)	`GPIO_PIN_BUTTON`
P14	LED (active LOW)	`GPIO_PIN_LED`
P2	PUART RXD	`GPIO_PIN_UART_RX`
P0	PUART TXD	`GPIO_PIN_UART_TX`
P1	PUART RTS	`GPIO_PIN_UART_RTS`
P3	PUART CTS	`GPIO_PIN_UART_CTS`

These pins are defined in the custom platform files described in Step 9 of Section 7.3 (Part 1: Configure the Design), accessible via compiler macros to improve code portability. However, some projects may also use pin numbers directly. As you explore the examples that come with the SDK, be sure to double-check any instances of GPIO pin usage if you encounter compiler errors or missing peripheral functionality.

Figure 50. Code Examples in WICED SMART



- WICED-Smart-SDK
  - Apps
    - a4wp_power_receiver
    - a4wp_power_transmitter
    - automation_io_client
    - automation_io_server
    - blood_pressure_monitor
    - cycling_speed_cadence
    - glucose_meter
    - health_thermometer
    - heart_rate_monitor
    - hello_client
    - hello_sensor
    - http_client
    - i2c_temperature_sensor
    - ibeacon_device
    - ibeacon_managed
    - indoor_position
    - location_and_navigation
    - long_char_big_mtu
    - long_characteristic
    - mybeacon
    - ota_firmware_upgrade
    - ota_secure_firmware_upgrade
    - proximity
    - proximity_client
    - puart_control
    - puart_control_big_mtu
    - pwm_tones
    - rtc_sample
    - running_speed_cadence
    - speed_test
    - spi_comm_master
    - spi_comm_slave

Appendix E. Example Project *main.c*

```
 /** @file
  *
  * This file has been automatically generated by the WICED Smart Designer.
  * Device configuration and functions required for the BLE device.
  *
  */

#include "bleprofile.h"
#include "bleapp.h"
#include "gpiodriver.h"
#include "string.h"
#include "stdio.h"
#include "platform.h"
#include "devicelpm.h"

#include "find_me_db.h"

/******************************************************
 *                      Constants
 ******************************************************/

#define FIND_ME_FINE_TIMER           1000
#define FIND_ME_DEVICE_NAME          "find_me"
#define FIND_ME_DEVICE_APPEARENCE    0
#define FIND_ME_MAIN_SERVICE_UUID    UUID_SERVICE_IMMEDIATE_ALERT
#define FIND_ME_MAIN_CHAR_UUID       UUID_CHARACTERISTIC_ALERT_LEVEL
#define FIND_ME_MAIN_CHAR_HANDLE     HDLC_IMMEDIATE_ALERT_ALERT_LEVEL_VALUE

/******************************************************
 *                      Structures
 ******************************************************/

#pragma pack(1)
//host information for NVRAM
typedef PACKED struct
{
    //part of HOSTINFO generated by wizard
    __HOSTINFO generated;
    // ToDo: add your variables here which need to be saved in the NVRAM
}  HOSTINFO;
#pragma pack()

/******************************************************
 *                Function Prototypes
 ******************************************************/

static void find_me_create(void);
static void find_me_connection_up( void );
static void find_me_connection_down( void );
static void find_me_advertisement_stopped( void );
static void find_me_smp_bond_result( LESMP_PARING_RESULT result );
static void find_me_encryption_changed( HCI_EVT_HDR *evt );
static int  find_me_write_handler( LEGATTDB_ENTRY_HDR *p );
static void find_me_interrupt_handler( UINT8 value );
UINT32 find_me_lpm_queriable(LowPowerModePollType type, UINT32 context);

/******************************************************
 *                Variables Definitions
 ******************************************************/

const BLE_PROFILE_CFG find_me_cfg =
{
    /*.fine_timer_interval            =*/ FIND_ME_FINE_TIMER, // ms
    /*.default_adv                    =*/ 4,    // HIGH_UNDIRECTED_DISCOVERABLE
    /*.button_adv_toggle              =*/ 0,    // pairing button make adv toggle (if 1) or always on (if 0)
    /*.high_undirect_adv_interval     =*/ 32,   // slots
    /*.low_undirect_adv_interval      =*/ 1024, // slots
    /*.high_undirect_adv_duration     =*/ 30,   // seconds
    /*.low_undirect_adv_duration      =*/ 300,  // seconds
    /*.high_direct_adv_interval       =*/ 0,    // seconds
    /*.low_direct_adv_interval        =*/ 0,    // seconds
    /*.high_direct_adv_duration       =*/ 0,    // seconds
    /*.low_direct_adv_duration        =*/ 0,    // seconds
    /*.local_name                     =*/ FIND_ME_DEVICE_NAME, // [LOCAL_NAME_LEN_MAX];
    /*.cod                            =*/ BIT16_TO_8(FIND_ME_DEVICE_APPEARENCE),0x00, // [COD_LEN];
    /*.ver                          =*/ "1.00",         // [VERSION_LEN];
    /*.encr_required                =*/ 0,    //(SECURITY_ENABLED | SECURITY_REQUEST),    // data encrypted and
device sends security request on every connection
    /*.disc_required                =*/ 0,    // if 1, disconnection after confirmation
    /*.test_enable                  =*/ 1,    // TEST MODE is enabled when 1
    /*.tx_power_level               =*/ 0x04, // dbm
    /*.con_idle_timeout             =*/ 30,   // second  0-> no timeout
    /*.powersave_timeout            =*/ 0,    // second  0-> no timeout
    /*.hdl                          =*/ {FIND_ME_MAIN_CHAR_HANDLE, 0x00, 0x00, 0x00, 0x00}, // [HANDLE_NUM_MAX];
    /*.serv                         =*/ {FIND_ME_MAIN_SERVICE_UUID, 0x00, 0x00, 0x00, 0x00},
    /*.cha                          =*/ {FIND_ME_MAIN_CHAR_UUID, 0x00, 0x00, 0x00, 0x00},
    /*.findme_locator_enable        =*/ 0,    // if 1 Find me locator is enable
    /*.findme_alert_level           =*/ 0,    // alert level of find me
    /*.client_grouptype_enable      =*/ 0,    // if 1 grouptype read can be used
    /*.linkloss_button_enable       =*/ 0,    // if 1 linkloss button is enable
    /*.pathloss_check_interval      =*/ 0,    // second
    /*.alert_interval               =*/ 0,    // interval of alert
    /*.high_alert_num               =*/ 0,    // number of alert for each interval
    /*.mild_alert_num               =*/ 0,    // number of alert for each interval
    /*.status_led_enable            =*/ 1,    // if 1 status LED is enable
    /*.status_led_interval          =*/ 0,    // second
    /*.status_led_con_blink         =*/ 0,    // blink num of connection
    /*.status_led_dir_adv_blink     =*/ 0,    // blink num of dir adv
    /*.status_led_un_adv_blink      =*/ 0,    // blink num of undir adv
    /*.led_on_ms                    =*/ 0,    // led blink on duration in ms
    /*.led_off_ms                   =*/ 0,    // led blink off duration in ms
    /*.buz_on_ms                    =*/ 100,  // buzzer on duration in ms
    /*.button_power_timeout         =*/ 0,    // seconds
    /*.button_client_timeout        =*/ 0,    // seconds
    /*.button_discover_timeout      =*/ 0,    // seconds
    /*.button_filter_timeout        =*/ 0,    // seconds
#ifdef BLE_UART_LOOPBACK_TRACE
    /*.button_uart_timeout          =*/ 15,   // seconds
#endif
};

// Following structure defines UART configuration
const BLE_PROFILE_PUART_CFG find_me_puart_cfg =
{
    /*.baudrate   =*/ 115200,
#ifdef GATT_DB_ENABLE_UART
    /*.txpin      =*/ GPIO_PIN_UART_TX,
    /*.rxpin      =*/ GPIO_PIN_UART_RX,
#else
    /*.txpin      =*/ PUARTDISABLE | GPIO_PIN_UART_TX,
    /*.rxpin      =*/ PUARTDISABLE | GPIO_PIN_UART_RX,
#endif
};

// NVRAM save area
HOSTINFO find_me_hostinfo;
//pointer to the generated part of hostinfo assuming it is the beginning of the hostinfo
__HOSTINFO *p_hostinfo_generated = &find_me_hostinfo.generated;

UINT16  find_me_connection_handle      = 0;                // HCI handle of connection, not zero when connected
BD_ADDR find_me_remote_addr            = {0, 0, 0, 0, 0, 0}; // Address of currently connected client

// ToDo: Add your static variables here

/******************************************************
 *               Function Definitions
 ******************************************************/

// Application initialization
APPLICATION_INIT()
{
    bleapp_set_cfg((UINT8 *)gatt_database,
                   gatt_database_len,
                   (void *)&find_me_cfg,
                   (void *)&find_me_puart_cfg,
                   (void *)&find_me_gpio_cfg,
                   find_me_create);
}

// Create device
void find_me_create(void)
{
    extern UINT8 bleprofile_adv_num;
    extern UINT8 bleprofile_scanrsp_num;
    ble_trace0("create()");
    ble_trace0(bleprofile_p_cfg->ver);

    bleprofile_adv_num = 0x0;
    bleprofile_scanrsp_num = 0x0;

    // dump the database to debug uart.
    legattdb_dumpDb();

    bleprofile_Init(bleprofile_p_cfg);
    bleprofile_GPIOInit(bleprofile_gpio_p_cfg);

    // Initialized ROM code which will monitor the battery
    blebat_Init();

    // Read NVRAM
    bleprofile_ReadNVRAM(VS_BLE_HOST_LIST, sizeof(find_me_hostinfo), (UINT8 *)&find_me_hostinfo);

    // register connection up and connection down handler.
    bleprofile_regAppEvtHandler(BLECM_APP_EVT_LINK_UP, find_me_connection_up);
    bleprofile_regAppEvtHandler(BLECM_APP_EVT_LINK_DOWN, find_me_connection_down);
    bleprofile_regAppEvtHandler(BLECM_APP_EVT_ADV_TIMEOUT, find_me_advertisement_stopped);

    // handler for Encryption changed.
    blecm_regEncryptionChangedHandler(find_me_encryption_changed);

    // handler for Bond result
    lesmp_regSMPResultCb((LESMP_SINGLE_PARAM_CB) find_me_smp_bond_result);

    // register to process client writes
    legattdb_regWriteHandleCb((LEGATTDB_WRITE_CB)find_me_write_handler);

    // register interrupt handler
    bleprofile_regIntCb((BLEPROFILE_SINGLE_PARAM_CB) find_me_interrupt_handler);

    // register Low Power Mode
    devlpm_init();
    devlpm_registerForLowPowerQueries(find_me_lpm_queriable, 0);

    //registers timer
    find_me_reg_timer();

    // advertise first vendor specific service
    if(sizeof(find_me_uuid_main_service) > 1)
    {
        // total length should be less than 31 bytes
        BLE_ADV_FIELD adv[3];
        BLE_ADV_FIELD scr[1];

        // flags
        adv[0].len     = 1 + 1;
        adv[0].val     = ADV_FLAGS;
        adv[0].data[0] = LE_LIMITED_DISCOVERABLE | BR_EDR_NOT_SUPPORTED;

        adv[1].len     = sizeof(find_me_uuid_main_service) + 1;
        adv[1].val     = sizeof(find_me_uuid_main_service) == 16 ? ADV_SERVICE_UUID128_COMP : ADV_SERVICE_UUID16_COMP;
        memcpy(adv[1].data, &find_me_uuid_main_service[0], sizeof(find_me_uuid_main_service));

        // Tx power level
        adv[2].len     = TX_POWER_LEN+1;
        adv[2].val     = ADV_TX_POWER_LEVEL;
        adv[2].data[0] = bleprofile_p_cfg->tx_power_level;

        // name
        scr[0].len      = strlen(bleprofile_p_cfg->local_name) + 1;
        scr[0].val      = ADV_LOCAL_NAME_COMP;
        memcpy(scr[0].data, bleprofile_p_cfg->local_name, scr[0].len - 1);

        bleprofile_GenerateADVData(adv, 3);
        bleprofile_GenerateScanRspData(scr, 1);
    }

    blecm_setTxPowerInADV(0);

    // start device advertisements.  By default Advertisements will contain flags, device name,
    // appearance and main service UUID.
    bleprofile_Discoverable(HIGH_UNDIRECTED_DISCOVERABLE, NULL);
    // ToDo: Do your initialization on app startup
    gpio_configurePinWithSingleBytePortPinNum(GPIO_PIN_LED, GPIO_OUTPUT_ENABLE, 1);
}

// Callback called by the FW when ready to sleep/deep-sleep.
// Do not allow any sleep if UART transmissions are ongoing.
// Do not allow deep sleep if BLE activity is ongoing.
UINT32 find_me_lpm_queriable(LowPowerModePollType type, UINT32 context)
{
    UINT32 result = 0; // assume sleep disabled

    // check sleep type query
    switch (type)
    {
        case LOW_POWER_MODE_POLL_TYPE_SLEEP:
            // return 0 to prevent standard sleep, otherwise max microsecond count to allow
            // (other processes may wake earlier than your specified max)
            result = 0xFFFFFFFF; // max
            break;

        case LOW_POWER_MODE_POLL_TYPE_POWER_OFF:
            // return 0 to prevent deep sleep, non-zero to allow
            result = 1; // allow
            break;
    }

    // should not reach this point since only two types of sleep exist
    return result;
}

// Connection up callback function is called on every connection establishment
void find_me_connection_up(void)
{
    find_me_connection_handle = (UINT16)emconinfo_getConnHandle();
    UINT8 *bda = (UINT8 *)emconninfo_getPeerPubAddr();

    // Save address of the connected device and print it out.
    memcpy(find_me_remote_addr, bda, sizeof(find_me_remote_addr));

    ble_trace3("connection_up: %08x%04x h=%d",
                (find_me_remote_addr[5] << 24) + (find_me_remote_addr[4] << 16) +
                (find_me_remote_addr[3] << 8) + find_me_remote_addr[2],
                (find_me_remote_addr[1] << 8) + find_me_remote_addr[0],
                find_me_connection_handle);


    // Prepare generated code for connection - write persistent values from __HOSTINFO to GATT DB
    __on_connection_up();

    // ToDo: Write custom persistent values into GATT database using functions
    // changed_<service_name>_<char_name>() generated by smart disigner

    // If device supports a single connection, stop advertising
    bleprofile_Discoverable(NO_DISCOVERABLE, NULL);

    // If security is required for every connection following function will start bonding or
    // will setup encryption.  No indications or notifications should be sent until
    // encryption is not done.
    if (bleprofile_p_cfg->encr_required & SECURITY_REQUEST)
    {
        if (emconninfo_deviceBonded())
        {
            ble_trace0("device bonded");
        }
        else
        {
            ble_trace0("device not bonded");
            lesmp_sendSecurityRequest();
        }
    }
}

// Connection down callback
void find_me_connection_down(void)
{
    ble_trace1("connection_down:handle:%d", find_me_connection_handle);

    find_me_connection_handle = 0;
    // If disconnection was caused by the peer, start low advertisements
    bleprofile_Discoverable(LOW_UNDIRECTED_DISCOVERABLE, NULL);
    //bleprofile_PrepareHidOff();

    ble_trace2("ADV start: %08x%04x",
                  (find_me_remote_addr[5] << 24 ) + (find_me_remote_addr[4] <<16) +
                  (find_me_remote_addr[3] << 8 ) + find_me_remote_addr[2],
                  (find_me_remote_addr[1] << 8 ) + find_me_remote_addr[0]);
}

// Callback function indicates to the application that advertising has stopped.
// restart advertisement if needed
void find_me_advertisement_stopped(void)
{
    ble_trace0("ADV stop!!!!");

    // If disconnection was caused by the peer, start low advertisements
    bleprofile_Discoverable(LOW_UNDIRECTED_DISCOVERABLE, NULL);
}

// Process SMP bonding result.  If pairing is successful with the central device,
// save its BDADDR in the NVRAM and initialize associated data
void find_me_smp_bond_result(LESMP_PARING_RESULT  result)
{
    ble_trace1("smp_bond_result %02x", result);

    if (result == LESMP_PAIRING_RESULT_BONDED)
    {
        // saving bd_addr in nvram
        UINT8 *bda;
        UINT8 writtenbyte;

        bda = (UINT8 *)emconninfo_getPeerPubAddr();

        // initialize persistent values in the hostinfo to add bonded peer
        find_me_add_bond(bda);

        // ToDo: initialize persistent variables in HOSTINFO

        //now write hostinfo into NVRAM
        writtenbyte = bleprofile_WriteNVRAM(VS_BLE_HOST_LIST, sizeof(find_me_hostinfo), (UINT8 *)&find_me_hostinfo);
        ble_trace1("NVRAM write:%04x", writtenbyte);
    }
}

// Notification from the stack that encryption has been set.
void find_me_encryption_changed(HCI_EVT_HDR *evt)
{
    UINT8 *bda = emconninfo_getPeerPubAddr();

    ble_trace2("encryption changed %08x%04x",
                (bda[5] << 24) + (bda[4] << 16) +
                (bda[3] << 8) + bda[2],
                (bda[1] << 8) + bda[0]);

    // ToDo: do your on-encryption-change actions here.

    // Slow down the pace of master polls to save power.  Following request asks
    // host to setup polling every 100-500 msec, with link supervision timeout 5 seconds.
    bleprofile_SendConnParamUpdateReq(80, 400, 0, 500);
}

// Process write request or command from peer device
int find_me_write_handler(LEGATTDB_ENTRY_HDR *p)
{
    UINT8  writtenbyte;
    UINT16 handle   = legattdb_getHandle(p);
    int    len      = legattdb_getAttrValueLen(p);
    UINT8  *attrPtr = legattdb_getAttrValue(p);
    BOOL changed;

    ble_trace1("write_handler: handle %04x", handle);

    changed = __write_handler(handle, len, attrPtr);

    // Save update to NVRAM if it has been changed.
    if (changed)
    {
        writtenbyte = bleprofile_WriteNVRAM(VS_BLE_HOST_LIST, sizeof(find_me_hostinfo), (UINT8 *)&find_me_hostinfo);
        ble_trace1("NVRAM write:%04x", writtenbyte);
    }
    return 0;
}

// Three Interrupt inputs (Buttons) can be handled here.
// If the following value == 1, Button is pressed. Different than initial value.
// If the following value == 0, Button is depressed. Same as initial value.
// Button1 : value&0x01
// Button2 : (value&0x02)>>1
// Button3 : (value&0x04)>>2
void find_me_interrupt_handler(UINT8 value)
{
    // ToDo: handle the interrupts here.
}

// Process indication confirmation.  if client service indication, each indication
// should be acknowledged before the next one can be sent.
void find_me_indication_cfm(void)
{
}

//------ generated code

// It will be called at the write handler and should return TRUE if any persistent value is changed
BOOL on_write_immediate_alert_alert_level(int len, UINT8 *attrPtr)
{
    // check the first byte of the value written to this characteristic
    switch (attrPtr[0])
    {
    case 0x00:
        // alert level = 0x00 (none), turn LED off
        bleprofile_KillLEDTimer();
        bleprofile_LEDOff();
        break;
    case 0x01:
        // alert level = 0x01 (mild), blink LED at 1 Hz cycle for 120 seconds
        bleprofile_LEDBlink(500, 500, 120);
        break;
    case 0x02:
        // alert level = 0x02 (high), turn LED on
        bleprofile_KillLEDTimer();
        bleprofile_LEDOn();
        break;
    }

    // return FALSE since no persistent value is changed
    return FALSE;
}
```

Appendix F. Makefile Customization

The WICED SMART SDK build system uses a hierarchical Makefile structure when building each project. The root Makefile is found in the main SDK installation folder as *\WICED-Smart-SDK\Makefile*, and each project contains its own specific *makefile.mk* file along with the source files in its dedicated directory. To customize the build process for a specific project, always edit the project's own makefile.mk content instead of modifying the top-level file.

The most common changes that you may need to make are as follows:

1. **Adding new .c source files to be compiled and linked:**

   Splitting the source code into multiple files can greatly improve organization and maintainability as the project grows. To add more files to the build process beyond the initial set that is created from the WICED Bluetooth Designer tool, use the `APP_SRC` keyword:

   ```
   APP_SRC = find_me.c
   APP_SRC += find_me_db.c
   APP_SRC += extrafile1.c
   APP_SRC += extrafile2.c
   APP_SRC += subfolder/subfile1.c
   APP_SRC += subfolder/subfile2.c
   ```

   You can include as many extra files as you need. Note that the very first file should use the direct assignment operator ("="), while all subsequent files should use the append operator ("+=").

2. **Adding extra include folders into the search path:**

   Some projects require the use of additional libraries that assume particular 'include' folders are in the compiler's include search path. To avoid having to rewrite source files with explicit include paths throughout, use the `INCS` keyword along with the `$(DIR)` variable to denote the project's root folder:

   ```
   INCS += $(DIR)/library1/include
   INCS += $(DIR)/library2/include
   INCS += $(DIR)/some/other/include
   ```

   You can add as many extra include search folders as you need. Note that all additional folders should use the append operator ("+=") since the SDK's top-level Makefile assigns some folders already. Using the direct assignment operator ("=") will wipe out these default folders and break the compile process.

3. **Applying pre-built optional patches that are part of the WICED SDK:**

   Since the WICED SMART Bluetooth LE stack is part of the chipset ROM inside the module, updates and fixes to low-level functionality require the use of precompiled patches, which are loaded and applied during the boot process. These patches must be included especially during the compile process so that they are part of the final firmware binary image. To specify patches for this purpose, use the `APP_PATCHES_AND_LIBS` keyword:

   ```
   APP_PATCHES_AND_LIBS += config_nvram_fixes.a
   APP_PATCHES_AND_LIBS += disable_sw_timer_as_wake_source.a
   APP_PATCHES_AND_LIBS += bt_clock_based_periodic_timer.a
   ```

   Patches are optional and may be added in any order. You can find a description of all available patches that ship with the SDK in the following location:

   `\WICED-Smart-SDK\Wiced-Smart\tier2\brcm\libraries\lib\readme`

Appendix G. Regulatory Information

FCC:

FCC NOTICE:

Cypress EZ-BLE Modules, including integrated antennas, comply with Part 15 of the FCC Rules. When stated in the module datasheet, the modules meet the requirements for modular transmitter approval as detailed in FCC public Notice DA00-1407.transmitter Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

CAUTION

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Cypress Semiconductor may void the user's authority to operate the equipment.

Any certified modules provided by Cypress have been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help

LABELING REQUIREMENTS

The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the OEM enclosure specifying the appropriate Cypress Semiconductor FCC identifier for this product as well as the FCC Notice above. The FCC identifier for each module is listed in the module datasheet, and is of the form “**FCC ID: WAPxxxx”**, where “xxxx” denotes the module-specific FCC identifier.

In any case, the end product using a certified Cypress module must be labeled on the exterior with "Contains FCC ID: WAPxxxx", where “xxxx” is the module-specific FCC identifier.

ANTENNA WARNING

Please refer to the module datasheet for details on the specific antenna used for the module design. Each Cypress certified module may have a different Antenna design. When integrated in the OEMs product, these antennas require installation preventing end-users from replacing them with non-approved antennas. Any antenna not listed in the module datasheet must be tested to comply with FCC Section 15.203 for unique antenna connectors and Section 15.247 for emissions.

RF EXPOSURE

To comply with FCC RF Exposure requirements, the Original Equipment Manufacturer (OEM) must ensure to install the approved antenna in the previous.

The preceding statement must be included as a CAUTION statement in manuals, for products operating with the approved antennas listed in the module datasheet, to alert users on FCC RF Exposure compliance. Any notification to the end user of installation or removal instructions about the integrated radio module is not allowed.

The radiated output power of Cypress certified modules with antenna mounted is far below the FCC radio frequency exposure limits. Nevertheless, use Cypress modules in such a manner that minimizes the potential for human contact during normal operation.

End users may not be provided with the module installation instructions. OEM integrators and end users must be provided with transmitter operating conditions for satisfying RF exposure compliance.

Innovation, Science and Economic Development (ISED) Canada Certification

When indicated in the module datasheet, Cypress EZ-BLE modules are licensed to meet the regulatory requirements of Innovation, Science and Economic Development (ISED) Canada. Refer to the module datasheet for details on the specific IC identifier. The IC identifier will be of the form:

License: IC: 7922A-xxxx, where “xxxx” is the ID for a specific module.

Manufacturers of mobile, fixed or portable devices incorporating this module are advised to clarify any regulatory questions and ensure compliance for SAR and/or RF exposure limits. Users can obtain Canadian information on RF exposure and compliance from www.ic.gc.ca.

Cypress EZ-BLE modules have been designed to operate with the antennas listed in the module datasheet. Antennas not included in the module datasheet or having a gain greater than what is specified in the module datasheet are strictly prohibited for use with this device. The required antenna impedance is 50 ohms. The antenna used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

ISED NOTICE

Cypress EZ-BLE modules, including the built-in antenna complies with Canada RSS-GEN Rules. Cypress EZ-BLE modules meet the requirements for modular transmitter approval as detailed in RSS-GEN. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

Les modules Cypress EZ-BLE, y compris l'antenne intégrée, sont conformes aux Règles RSS-GEN de Canada. Les modules Cypress EZ-BLE répondent aux exigences d'approbation de l'émetteur modulaire, tel que décrit dans RSS-GEN. L'opération est soumise aux deux conditions suivantes: (1) Cet appareil ne doit pas causer d'interférences nuisibles, et (2) Cet appareil doit accepter toute interférence reçue, y compris les interférences susceptibles de provoquer un fonctionnement indésirable.

ISED INTERFERENCE STATEMENT FOR CANADA

Cypress EZ-BLE modules comply with Innovation, Science and Economic Development (ISED) Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Les modules Cypress EZ-BLE sont conformes aux normes RSS, exemptées de licences et exemptées de licence de l'Innovation, des Sciences et du Développement (ISED). Le fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne doit pas provoquer d'interférence, et (2) cet appareil doit accepter toute interférence, y compris les interférences susceptibles de provoquer un fonctionnement indésirable de l'appareil.

ISED RADIATION EXPOSURE STATEMENT FOR CANADA

Cypress EZ-BLE modules comply with ISED radiation exposure limits set forth for an uncontrolled environment. Please refer to the module datasheet for any details on integration requirements for radiation exposure.

Les modules Cypress EZ-BLE sont conformes aux limites d'exposition au rayonnement ISED prévues pour un environnement incontrôlé. Veuillez vous référer à la fiche technique du module pour tout détail sur les exigences d'intégration pour l'exposition au rayonnement.

LABELING REQUIREMENTS

The Original Equipment Manufacturer (OEM) must ensure that IC labeling requirements are met. This includes a clearly visible label on the outside of the OEM enclosure specifying the appropriate Cypress Semiconductor IC identifier for this product as well as the IC Notice above. The IC identifier is **7922A-xxxx**, where “xxxx” is the specific IC ID for a given module. In any case, the end product must be labeled in its exterior with "Contains **IC: 7922A-xxxx**", where “xxxx” is the module specific ID as indicated in the module datasheet.

Le fabricant d'équipement d'origine (OEM) doit s'assurer que les exigences d'étiquetage IC sont respectées. Cela comprend une étiquette clairement visible à l'extérieur de l'enceinte OEM spécifiant l'identifiant Cypress Semiconductor approprié pour ce produit ainsi que l'avis IC ci-dessus. L'identifiant IC est 7922A-xxxx, où "xxxx" est l'ID CI spécifique pour un module donné. En tout cas, le produit final doit être étiqueté dans son extérieur avec "Contient IC: 7922A-xxxx", où "xxxx" est l'ID spécifique du module comme indiqué dans la fiche technique du module.

EUROPEAN DECLARATION OF CONFORMITY

Hereby, Cypress Semiconductor declares that the EZ-BLE Bluetooth modules, when indicated on the module datasheet, comply with the essential requirements and other relevant provisions of Directive 2014. As a result of the conformity assessment procedure described in Annex III of the Directive 2014, the end-customer equipment should be labeled as follows:

CE

When indicated in the module datasheet, the module used in the specified reference design can be used in the following countries: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, The Netherlands, the United Kingdom, Switzerland, and Norway.

MIC JAPAN

When indicated, Cypress EZ-BLE modules are certified as a module with a specific type certification number detailed in the module datasheet. End products that integrate modules that are certified for Japan do not need additional MIC Japan certification for the end product.

End product can display the certification label of the embedded module as display in the specific module datasheet.

G.1 Module Regulatory Reports and Certificates

Table 13 details the knowledge base articles that contain the test reports and certificates for each EZ-BLE module. These knowledge base article can be found by visiting www.cypress.com and searching for the KBA number below, or by clicking on the hyperlinks in the below table.

Table 13. Regulatory Test Report and Certificate KBA Reference

EZ-BLE Module Part Number	Knowledge Base Article Containing Regulatory Reports and Certificates
CYBLE-013025-00	KBA219623
CYBLE-013030-00	

Document History

Document Title: AN220929 – Getting Started with EZ-BLE WICED Modules

Document Number: 002-20929

Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	5879338	DSO	10/27/2017	New application note

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