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# CE220272 - PSoC 6 MCU with BLE Connectivity: Direct Test Mode

## Objective

This code example demonstrates Direct Test Mode (DTM) over the Host Controller Interface (HCI) using PSoC® 6 MCU with Bluetooth Low Energy (BLE) Connectivity.

## Overview

This example implements the Direct Test Mode (DTM) as per BLE specification v5.0, Vol 6, Part F. The DTM allows testing the physical (PHY) layer of the BLE radio by requesting the device to transmit or receive certain test packets. It is used for RF qualification tests and production line tests without the need of going through the complete BLE protocol stack.

DTM is run over the standard Host Controller Interface (HCI). HCI is the protocol layer that bridges the BLE Host with the Controller.

This code example assumes that you are familiar with the PSoC 6 MCU and the PSoC Creator™ Integrated Design Environment (IDE). If you are new to PSoC 6 MCU, you can find an introduction in AN210781 – Getting Started with PSoC 6 MCU with Bluetooth Low Energy (BLE) Connectivity.

## Requirements

**Tool:** PSoC Creator 4.2

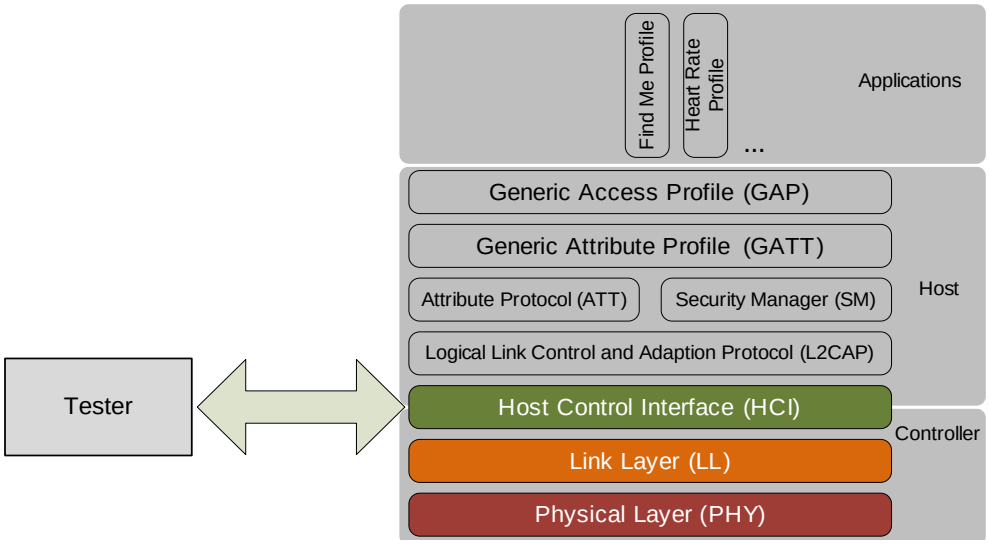
**Programming Language:** C (Arm® GCC 5.4.1)

**Associated Parts:** All PSoC 6 MCUs with BLE Connectivity (PSoC 6 BLE)

**Related Hardware:** CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit

## Design

Figure 1. Direct Test Mode (DTM) over Host Controller Interface (HCI)



DTM setup has two parts:

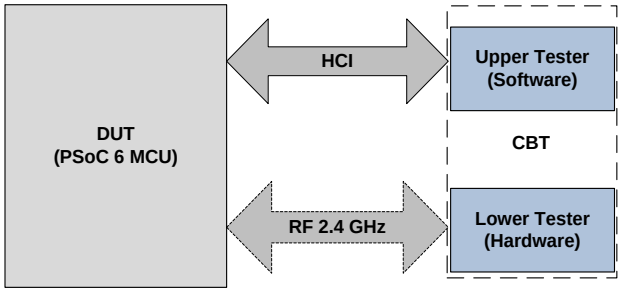
1. Device under Test (DUT): The device whose radio must be tested, such as PSoC 6 MCU on CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit.
2. Tester: The system that performs the test on DUT.

The Tester in DTM can be divided into two parts, as shown in Figure 2:

1. Upper Tester: The part of the tester that communicates commands with the DUT over the HCI interface.
2. Lower Tester: The part of the tester that communicates commands with the DUT over RF.

Most commercially available testers contain both Upper tester and Lower tester, along with software tools to configure tests and read reports.

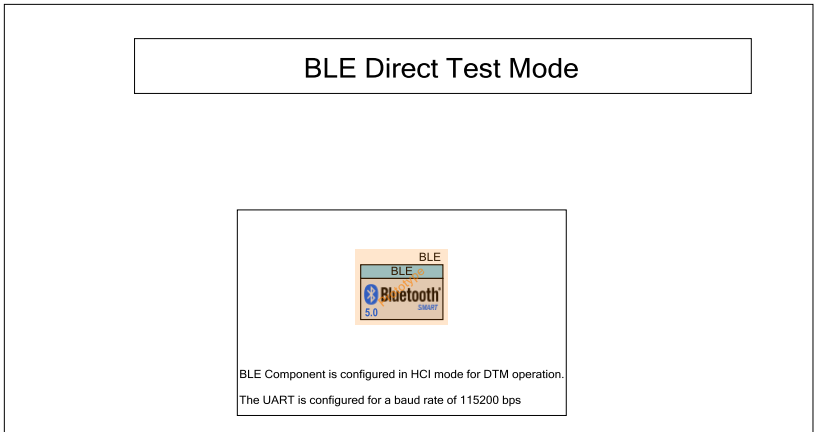
Figure 2. Block Diagram for DTM over HCI




The underlying physical communication for the HCI protocol is UART. Through UART, commands and responses are communicated between PSoC 6 MCU and the tester. When HCI mode is selected in the BLE Component, a UART block in PSoC 6 MCU is reserved for this use. The corresponding UART signals are exposed in the project's design wide resources (*.cydwr*). These signals need to be assigned to appropriate GPIOs on PSoC 6 MCU and connected to UART signals of the external tester.

When the BLE Component is configured for HCI mode, there is no further application code to be written to implement the DTM mode, except enabling global interrupts, starting BLE Component and processing the BLE events. The appropriate response to commands from the tester is handled by the BLE stack as part of the BLE Component.

Figure 3. PSoC Creator Schematic



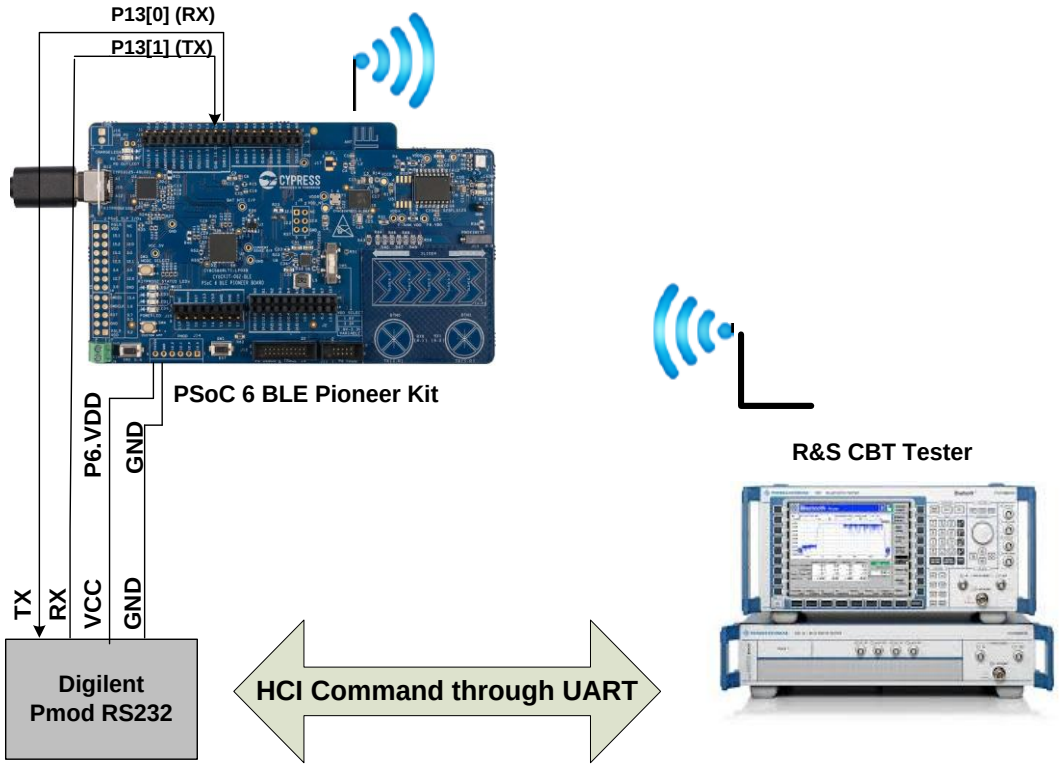

The project consists of the following file:

***main_cm0p.c*** enables global interrupts, starts the BLE Component, and then processes BLE events in the main loop. All other processing is handled by the BLE Component.

## Hardware Setup

The Upper Tester communicates with the DUT over RS232. To use the PSoC 6 BLE Pioneer Kit with these testers, a RS232 voltage translator is required. One such module is Digilents's Pmod RS232. The UART signals from the PSoC 6 MCU on PSoC 6 BLE Pioneer Kit are connected to the pins on this module and the UART port of the module is used to connect to the Upper Tester. The setup is shown in Figure 4.

Figure 4. Hardware Setup




## Software Setup

No additional software setup is required for this code example. Follow the DTM Tester software instructions to run the test.

## Operation

1. Connect the Pioneer Baseboard to your PC using the provided USB cable through the USB connector (**J10**).
2. Program the Pioneer Baseboard with the *CE220272_BLE_Direct_Test_Mode* project. See the CY8CKIT-062-BLE kit guide for details on how to program firmware into the device.
3. Connect the pins corresponding to the PSoC 6 MCU's UART signals to an RS232 translator as shown in Figure 4.
4. Connect the CBT tester to the PSoC 6 BLE Pioneer Kit via the RS232 translator using an RS232 cable.
5. If you are using the PSoC 6 MCU with the U.FL connector as the antenna, then connect this to the U.FL connector of the CBT tester using a cable.

   If you are using the PSoC 6 MCU with a PCB antenna (present on the PSoC 6 BLE Pioneer Kit), then connect an antenna to the SMA connector of the CBT tester.
6. In the CBT tester, send the communication commands to start and run the test.
7. At the end of the test, the RF performance test results are displayed on the CBT tester.

# Components

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

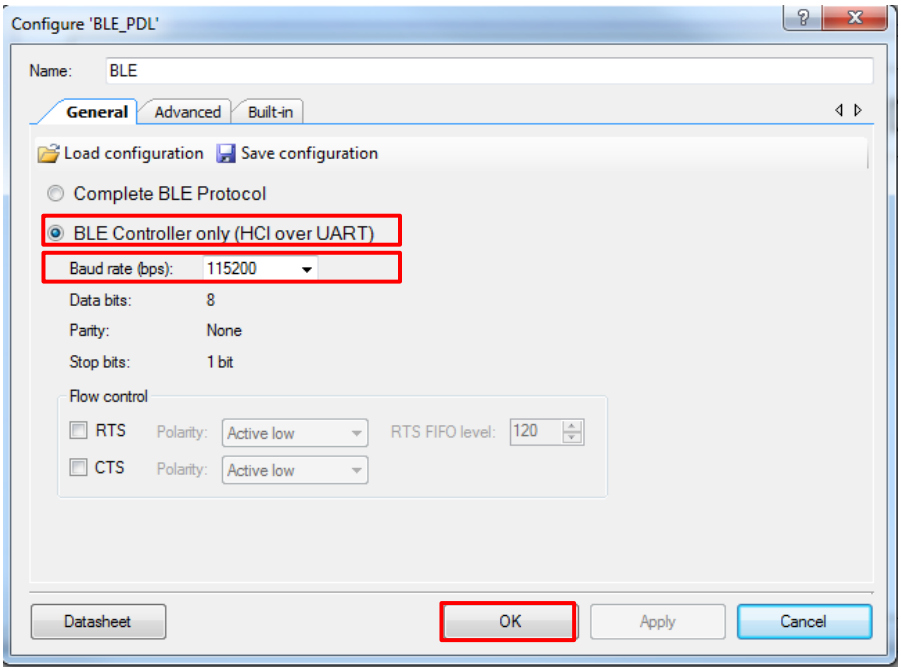
Table 1. List of PSoC Creator Components

| Component | Version | Placement / Hardware Resources |
|---|---|---|
| Bluetooth Low Energy (BLE) | V2.0 | Bluetooth Low Energy Subsystem |

## Parameter Settings

PSoC 6 MCU with BLE Connectivity supports DTM using the HCI interface. HCI is enabled from the **General** tab in the BLE Component. Note that as soon as HCI mode is selected, the profiles related tabs become hidden because GAP and GATT layer are not used in HCI mode.

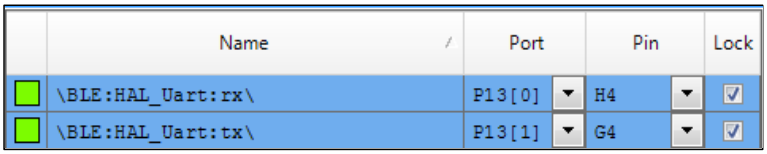
Figure 5. HCI Mode in BLE Component




## Design-Wide Resources

Under **Pins** tab of **Design Wide Resources** (*.cydwr*) assign the pins as shown in Figure 6.

Figure 6. PSoC 6 MCU UART Pin Assignment



## Related Documents

| | |
|---|---|
| **Application Notes** | |
| AN210781 – Getting Started with PSoC 6 MCU with Bluetooth Low Energy (BLE) Connectivity | Describes the PSoC 6 MCU with BLE Connectivity and how to build your first PSoC Creator project |
| AN91445 – Antenna Design guide | Provides guidelines on how to design an antenna for BLE applications |
| **PSoC Creator Component Datasheets** | |
| Bluetooth Low Energy | Facilitates designing applications requiring BLE connectivity |
| **Device Documentation** | |
| PSoC 6 MCU: PSoC 63 with BLE Datasheet | PSoC 6 MCU: PSoC 63 with BLE Architecture Technical Reference Manual |
| **Development Kit (DVK) Documentation** | |
| CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit | |

## Document History

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Document Number: 002-20272

| Revision | ECN | Orig. of Change | Submission Date | Description of Change |
|---|---|---|---|---|
| ** | 5815771 | VKVK | 08/23/2017 | New Code Example |
| *A | 6001013 | VKVK | 12/21/2017 | Updated template and minor text changes. Updated project to PSoC Creator 4.2 Beta |
| *B | 6074768 | VKVK | 03/15/2018 | Updated the project with PSoC Creator 4.2<br>Updated template |

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