Configuring the CC2640 for Bluetooth® Direct Test Mode

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ABSTRACT

This application note describes the hardware setup and software configuration for performing Direct Test Mode (DTM) using Bluetooth® (BT) test equipment with TI's SimpleLink™ Bluetooth low energy wireless MCUs. DTM is used to perform Bluetooth RF certification testing and is described in the Bluetooth Core Specification Version 4.2, Vol 6, Part F. The Bluetooth core specification can be obtained from http://www.bluetooth.com.

A setup guide is provided for the CC2640/CC2650 Bluetooth low energy wireless MCUs using the CC2650 SmartRF06 Development Kit (CC2650DK) and CC2650 Bluetooth low energy LaunchPad™ (CC2650LP). The procedures described in this document also apply to the CC1350 dual-band wireless MCU when running BLE software. Additional notes on configuring custom boards for performing DTM are added at the end of this document.

More information about TI's BLE products can be found at www.ti.com/ble.

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1 Creating Hexadecimal Files for Direct Test Mode (DTM)

To configure the CC2650DK or CC2650LP for DTM, program it with a dedicated hexadecimal file. The hex files can be compiled from Host Test example projects, which are released as part of BLE-Stack v2.2 software development kit (SDK). The steps to compile the Host Test example and the required changes to predefined symbols are listed below.

1. Download and install BLE-Stack v2.2.x SDK from http://www.ti.com/tool/ble-stack. Older SDK releases can be obtained from the Archived Releases link.

2. Install the tool chain according to the procedure referenced in the release notes.

3. The Host Test project for the CC2650DK and CC2650LP are at the respective folders:
   * For the CC2650DK: examples/cc2650em/host_test directory of the BLE SDK install
   * For the CC2650LP: examples/cc2650lp/host_test directory of the BLE SDK install

4. The procedure of compiling the example project is described in *TI BLE Software Developer's Guide* (SDG) (SWRU393). The guide is included in the BLE-Stack v2.2 SDK. Depending on the required testing, some Bluetooth v4.1 and v4.2 LE features may need to be enabled in the Host Test project. See the *Configuring Bluetooth low energy Protocol Stack Features* section in the SDG.

5. The following changes to predefined symbols are required. Configuration for APP and STACK projects are listed below. The procedure for modifying predefined symbols is in the SDG.

   (a) For the CC2650EM-7ID, CC2650EM-5XD, CC2650EM-4XS, and CC2650LP, these common changes are required:

APP Project	STACK Project
Remove: POWER_SAVING	Remove: POWER_SAVING
Remove: NPI_USE_SPI	
Add: NPI_USE_UART	

   (b) For the CC2650EM-5XD, these additional changes are required in the APP project:
   * Remove: CC2650DK_7ID
   * Add: CC2650DK_5XD

   (c) For the CC2650EM-4XS: these additional changes are required in the APP project:
   * Remove: CC2650DK_7ID
   * Add: CC2650DK_4XS
   * Add: NPI_SPI_CONFIG=Board_SPI0

6. Upon successful compilation, the following hex files are generated:
   * For the CC2650DK:
     – host_test_cc2650em_app.hex
     – host_test_cc2650em_stack.hex
   * For the CC2650LP:
     – host_test_cc2650lp_app.hex
     – host_test_cc2650lp_stack.hex

2 Programming the DUT

The hex files compiled in the previous section must be programmed onto the DUT. The hex file puts the CC2650 into DTM (Direct Test Mode). No additional GPIO toggling or selection is required to put the CC2650 into DTM.

To program the hex files, use SmartRF Flash Programmer v2. It can be downloaded from http://www.ti.com/tool/flash-programmer. Refer to the BLE-Stack release notes for the required SmartRF Flash Programmer v2 version.

The settings for the CC2650DK and CC2650LP are the same, as shown below:

1. In the Connected devices panel, select the DUT.
   - For the CC2650DK, select "CC2650" under the "XDS100v3"
   - For the CC2650LP, select "CC2650" under the "XDS110"
2. Main Tab -> Flash image(s). Select "Multiple".
3. Use "Browse" to select the APP project hex file.
   - For the CC2650DK: host_test_cc2650em_app.hex
   - For the CC2650LP: host_test_cc2650lp_app.hex
4. Use Browse again to select the STACK project hex file. •
   - For the CC2650DK: host_test_cc2650em_stack.hex
   - For the CC2650LP: host_test_cc2650lp_stack.hex
5. Main Tab -> Actions (see Figure 1)
   (a) Erase. Select Pages in image
   (b) Program. Select "Entire source file"
   (c) Verify. Select "Readback"
6. Image Overrides. Check "Keep CCFG"
7. Click on the ▶ icon below the Verify box to start programming.
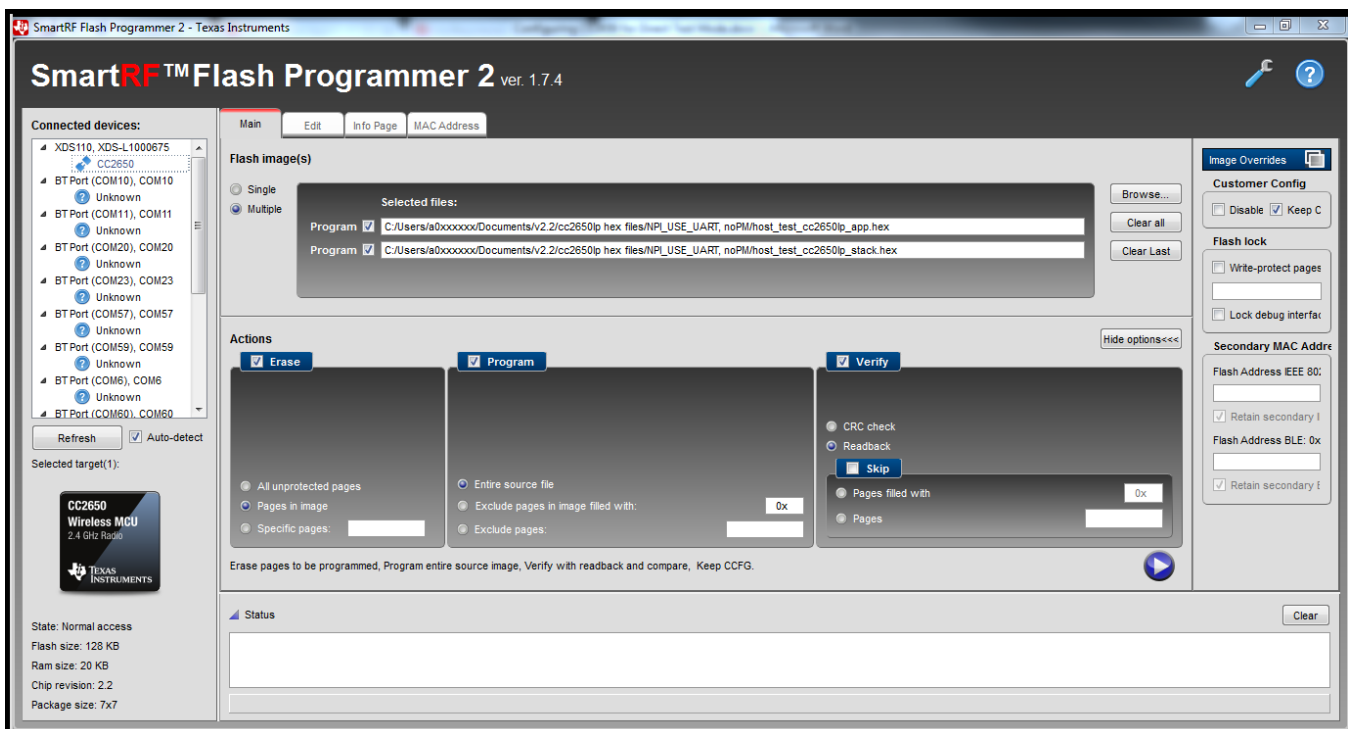

Figure 1. Settings for Programming the CC2650DK and CC2650LP

3 Hardware Setup

Most BT/BLE testers support USB and RS232 modes to control the device under test (DUT). This section describes the steps of using both RS232 and USB modes for the CC2650DK; and RS232 modes for the CC2650LP. Below is the list of items required to conduct direct test mode (DTM):

- BT/BLE RF tester
- Micro USB cable
- RF coaxial cable with the following connectors
  - CC2650DK: SMA-to-SMA
  - CC2650LP: SWG-to-SMA
- CC2650DK (SmartRF06EB+CC2650EM) or CC2650LP
- For RS232 mode only: RS232 level translator board

3.1 Hardware Setup for the CC2650DK (SmartRF06EB+CC2650EM) in RS232 Mode

This setup uses UART pins (RF1.7_UART_RX and RF1.9_UART_TX) to interface the BT/BLE tester's control port in RS232 mode. The control port could be a USB port or equipment under test (EUT) control port, depending on the equipment used. Refer to the tester user guide for details on which port to use. The USB port on the CC2650DK is used to supply 3.3 V to the CC2650.

1. Mount the CC2650EM onto SmartRF06EB.
2. Remove all 10 jumpers on P408 to avoid interference from XDS100v3.
3. Connect a micro USB cable between the CC2650DK and any USB power source or PC.
4. Connect the RS232 level translator board to the RS232 connector from the BT/BLE tester's USB/EUT control port.
5. Connection between the CC2650DK and RS232 level translator board:

CC2650DK	RS232 Level Translator Board
P408.12 (RF1.7_UART_RX)	TX pin (OUT)
P408.14 (RF1.9_UART_TX)	RX pin (IN)
P409.1 (VDD_SENSE)	VDD pin
P409.4 (GND)	GND pin

6. Unmount C14. Mount C24 and J1 to select RF connector (J1) as the RF output path, as shown in Figure 2.

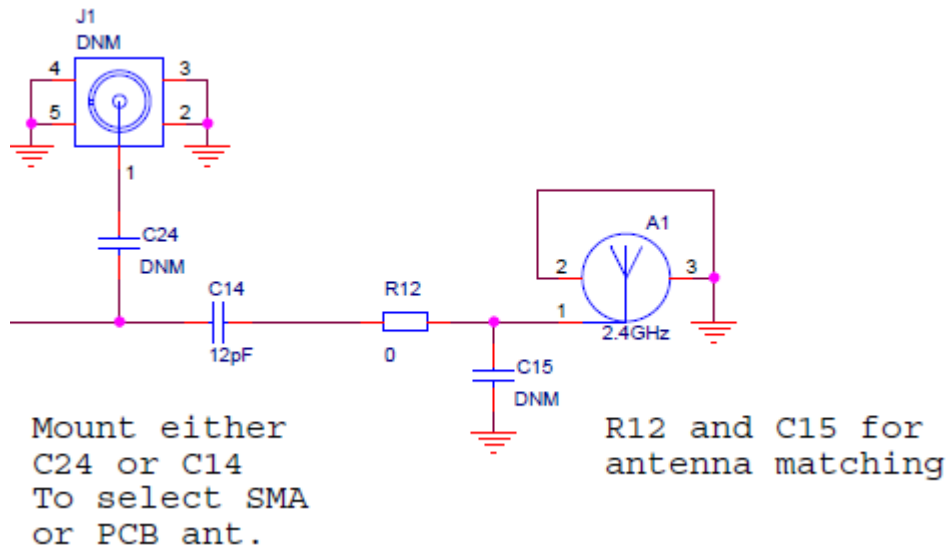7. Connect a SMA-to-SMA RF coaxial cable between J1 and RF port of tester.

Figure 2. Mount C24 and J1 to RF Connector

8. Switch P502 (source selection switch) to the USB position.

9. Switch P501 (main power switch) to the ON position, as shown in Figure 3.

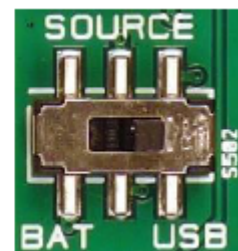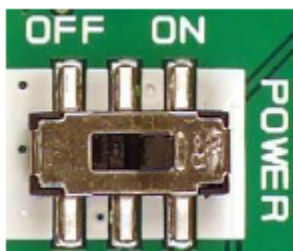

Figure 3. Positions for Switch P501 and P502

10. The full setup should look similar to the one shown in Figure 4. The use of an SMA connector on the CC2650DK's J1 is preferred. In Figure 4, the coaxial cable is soldered directly onto PCB.
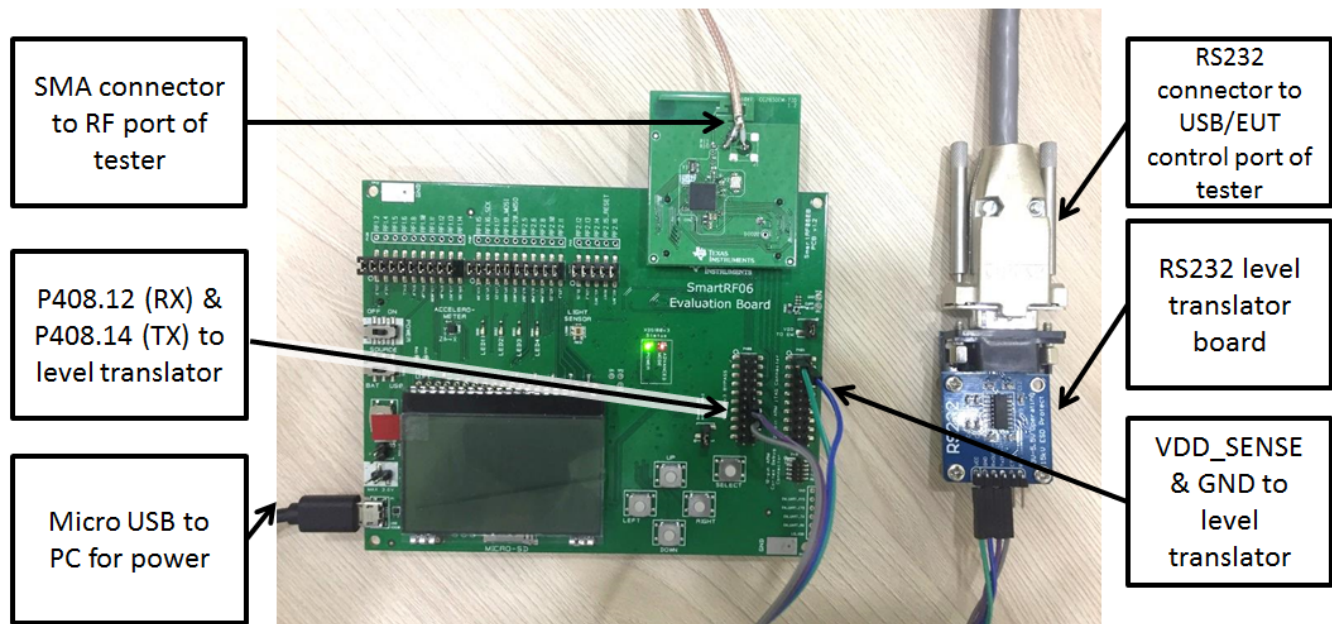
Figure 4. Hardware Setup for the CC2650DK in RS232 Mode

3.2 *Hardware Setup for the CC2650DK (SmartRF06EB+CC2650EM) in USB Mode*

This setup uses the USB port on the CC2650DK directly with the USB/EUT control port of the tester in USB mode. The USB port on the CC2650DK is also used to supply 3.3 V to the CC2650.

1. Mount the CC2650EM onto the SmartRF06EB.
2. Keep all 10 jumpers on P408 mounted.
3. Connect a micro USB cable between the CC2650DK and the USB/EUT control port of the tester.
4. Unmount C14. Mount C24 and J1 to select the RF connector (J1) as the RF output path. See Figure 2.
5. Connect an SMA-to-SMA RF coaxial cable between the J1 and RF port of the tester.
6. Switch P502 (source selection switch) to the USB position.
7. Switch P501 (main power switch) to the ON position. See Figure 3.
8. The full setup should look similar to the one in Figure 5. Using an SMA connector on the CC2650DK J1 is preferred. In Figure 5, the coaxial cable is soldered directly onto PCB).
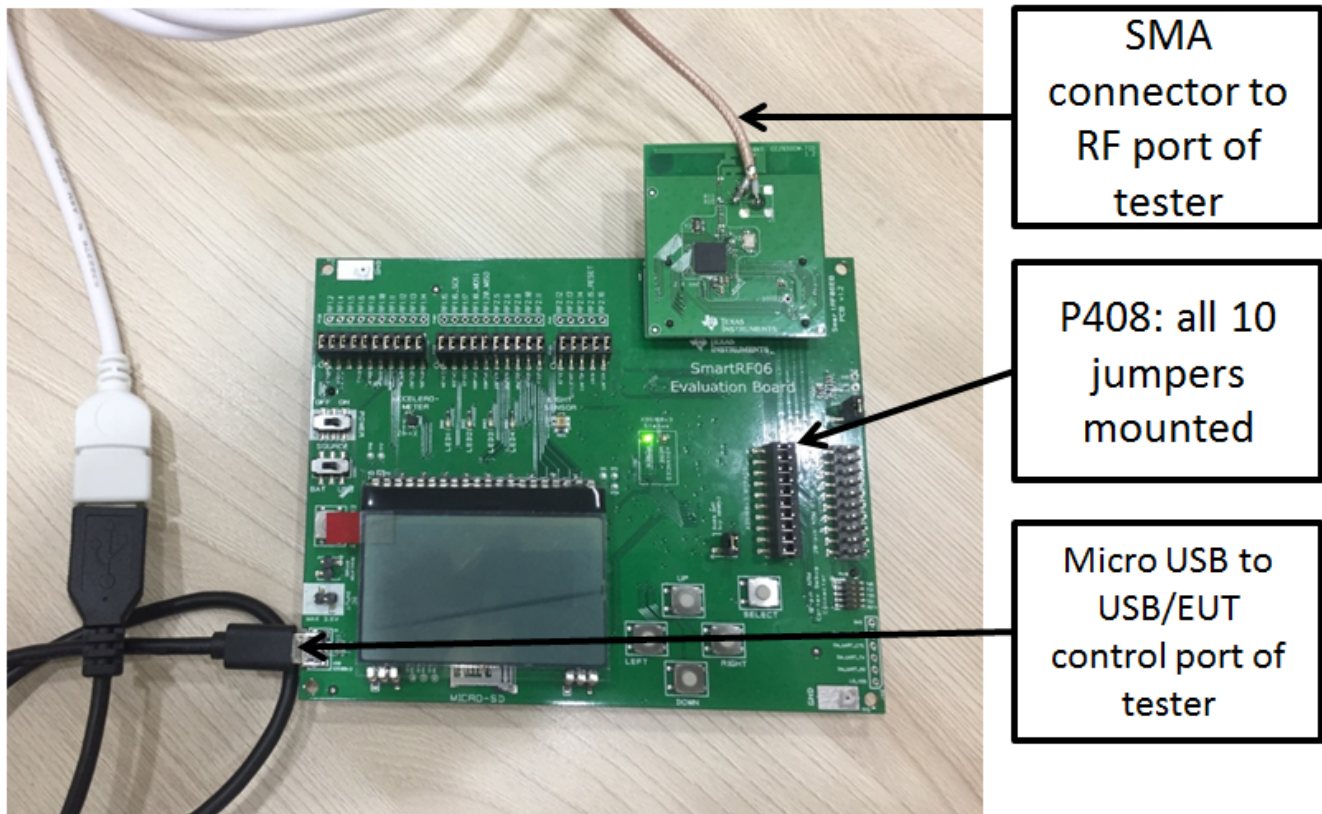
Figure 5. Hardware Setup for the CC2650DK in USB Mode

3.3 Hardware Setup for the CC2650LP in RS232 Mode

This setup uses the UART pins (DIO2 and DIO3) to interface with the USB/EUT control port of the tester in RS232 mode. The USB port on the CC2650LP is used to supply 3.3 V to the CC2650.

1. On P3, P4, and P5, keep jumpers M2 (3V3) and M6 (GND) only.
2. Remove all other jumpers on P3, P4, and P5. (9 jumpers to remove).
3. Connect a USB micro cable between the CC2650LP and any USB power source or PC.
4. Connect a RS232 level translator board to the RS232 connector from the BT/BLE tester's USB/EUT control port.
5. Connection between the CC2650LP and a RS232 level translator board:

CC2650LP	RS232 Level Translator Board
J1.7 (DIO2_RXD)	TX pin (OUT)
J1.5 (DIO3_TXD)	RX pin (IN)
P1.1 (3V3)	VDD pin
P1.2 (GND)	GND pin

6. Connect a SWG-to-SMA RF coaxial cable between J5 and RF port of the tester, as shown in Figure 6.
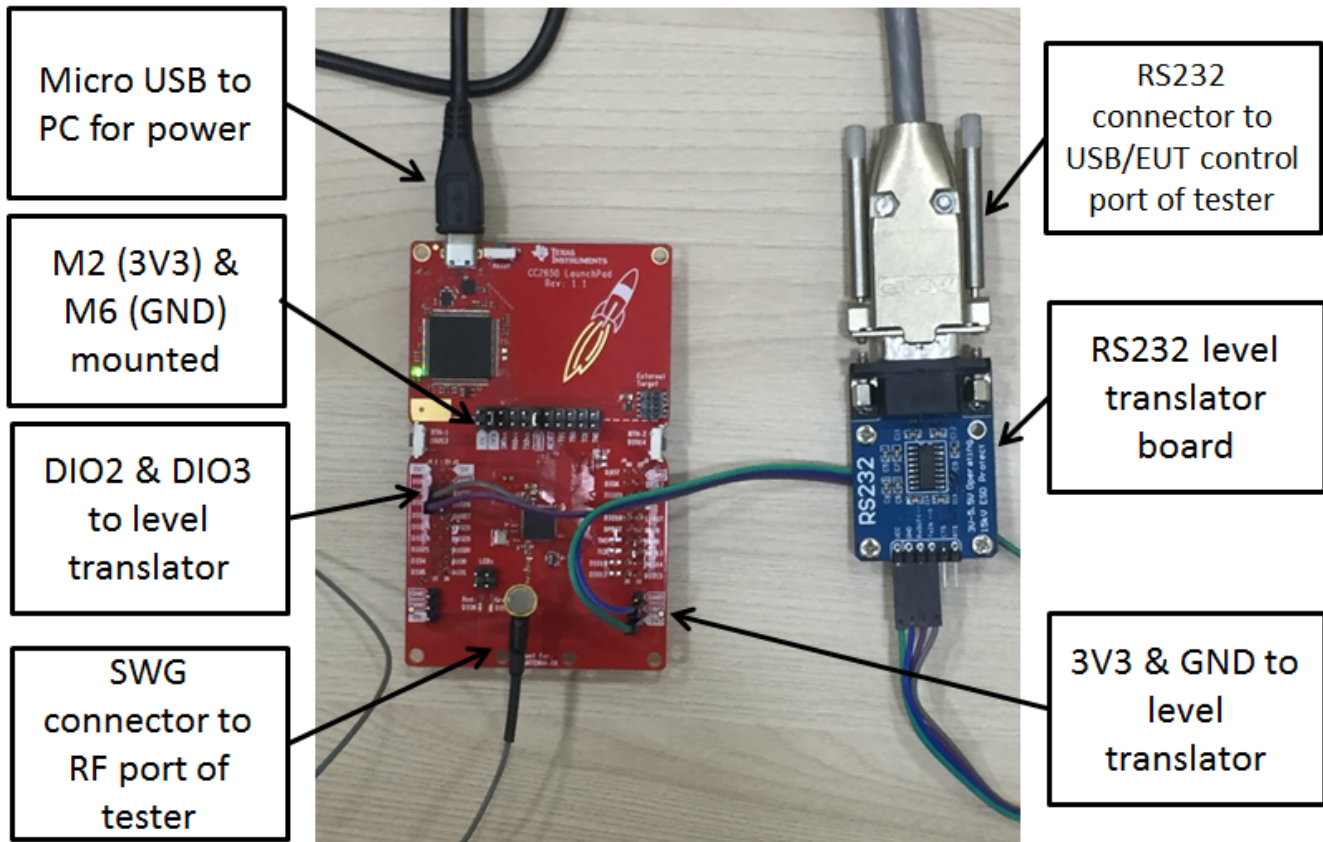

Figure 6. Hardware Setup for the CC2650LP in RS232 Mode

4   Configuring the BT/BLE Tester

To configure the BT/BLE tester for RS232 mode, set the tester to RS232 mode, and use an RS232 connector cable from the USB/EUT control port. Use the following configuration for RS232 parameters:

- Baud rate: 115200
- Parity: None
- Data length: 8 bits
- Stop bits: 1 bit
- Handshaking: None

To configure the BT/BLE tester for USB mode, set the tester to USB->RS232 mode, and use a USB host connector cable from the USB/EUT control port. If the tester provides the option of using either Port A or Port B, select Port B.

5   Additional Notes for Configuring Custom Boards for DTM

TI recommends using RS232 mode when connecting custom boards to BT/BLE testers, as this minimizes complexities in hardware setup. A level translator board is required between the custom board and the RS232 connector from the BT/BLE tester.

On the custom board, ensure the following are in place prior to executing the RF tests:

1. Ensure the VDDS and VDDR rails are properly supplied. Most RS232 level translator boards do not provide VDD supply, and draw power from VDDS instead.
2. Connect UART_RXD, UART_TXD, VDDS, and GND between the custom board and RS232 level translator board.

Custom board	RS232 level translator board
UART_RXD	TX pin (OUT)
UART_TXD	RX pin (IN)
VDDS	VDD pin
GND	GND pin

3. The Host Test project can be used to compile codes for the custom board. Note the differences in the default UART_RXD and UART_TXD pins for the various packages.

Signal	CC2650F128RGZ 7 × 7 mm, 48 VQFN	CC2650F128RHB 5 × 5 mm, 32 VQFN	CC2650F128RSM 4 × 4 mm, 32 VQFN
UART_RXD	DIO_2	DIO_1	DIO_1
UART_TXD	DIO_3	DIO_0	DIO_2

4. If the custom board is unable to use the default DIO lines, UART_RXD and UART_TXD can be remapped to the available DIO lines by changing the defines for Board_UART_RX and Board_UART_TX in the respective header files.

Device	Header file
CC2650F128RGZ	CC2650DK_7ID.h
CC2650F128RHB	CC2650DK_5XD.h
CC2650F128RSM	CC2650DK_4XS.h

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