AN14163

Bluetooth Direct Test Mode (DTM)

Rev. 3.0 — 2 July 2025 Application note

Document information

Information	Content
Keywords	Bluetooth Low Energy (Bluetooth LE), Direct Test Mode (DTM), Device Under Test (DUT)
Abstract	Explains how to perform DTM tests using HCI commands.

1 About this document

Direct Test Mode (DTM) is used to control the Device Under Test (DUT) and provide a report back to the Tester. With this mode, the operation of the radio at the physical level, such as Transmission power and receiver sensitivity, Frequency offset and drift, Modulation characteristics, Packet error rate can be tested. More details on DTM are described in the Bluetooth Core Specification, Volume 6, Part F ref.[2].

This document explains how to perform DTM tests using HCI commands.

1.1 Supported products

The following products support the feature:

- 88W8887 ref.[3]
- 88W8897P ref.[4]
- 88W8977 ref.[5]
- 88W8987 ref.[6]
- 88W8997 ref.[7]
- 88Q9098/88Q9098S ref.[8]
- 88W9098ref.[9]
- AW611 ref.[10]
- AW690 ref.[11]
- AW692 ref.[12]
- AW693 ref.[13]
- IW416 ref.[14]
- IW610 ref.[15]
- IW611 ref.[16]
- IW612 ref.[17]
- IW620 ref.[18]
- IW693 ref.[1]

1.2 Notation conventions

This document employs the following notation conventions:

- Commands and examples of command outputs are shown in paragraphs with grey background color

```
This is an example of command
```

- Terms related to commands use a `monospace` font:
  - `parameter`
  - `option`
  - `command name`
- File names, directory names and paths are shown in *italics:*
  - *<file name>.<extension>*
  - *<directory>*
  - *path/to/directory/and/file*

2 Setup

The following hardware is required to test DTM:

- Laptop
- Bluetooth RF tester
- NXP supported product (Section 1.1) or device under test (DUT)
- RS232 cable/RF cable
- Micro USB to USB-A cable (for UART and debug connection)

Figure 1 shows the setup for DTM testing.

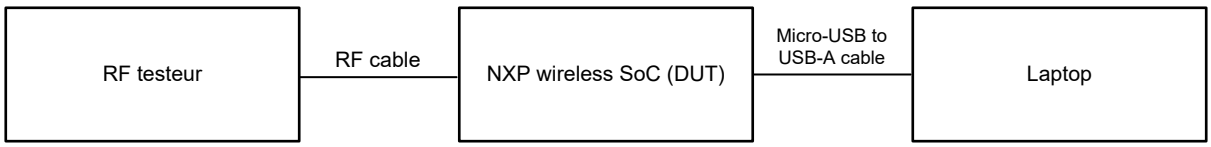

Figure 1. DTM setup

3 Commands

The following HCI commands are used for DTM:

- HCI_LE_Transmitter_Test
- HCI_LE_Receiver_Test
- HCI_LE_Test_End

3.1 HCI_LE_Transmitter_Test

This command is used to start a test where the DUT generates test reference packets at a fixed interval.

Command syntax:

```
hcitool -i hci0 cmd <OGF> <OCF> <TX_Channel> <Test_Data_Length> <Packet_Payload> <PHY>
```

Table 1 and Table 2 provide information about the command and return parameters.

Table 1. HCI_LE_Transmitter_Test command parameters

Parameter	Description
OGF	0x08
OCF	0x001E = v1 [Bluetooth SIG version 4.2 and above] 0x0034 = v2 [Bluetooth SIG version 5.0 and above]
TX_Channel	TX channel 1 octet N = (F-2402) / 2 Range (N) = 0x00 to 0x27 Frequency range (F) = 2402 MHz to 2480 MHz
Test_Data_Length	Length in bytes of payload data in each packet 1 octet Range = 0x00 to 0xFF
Packet_Payload	Payload content of the test reference packets. 1 octet 0x00 = PRBS9 sequence '11111111100000111101…' (in transmission order)
PHY (Applicable if OCF = 0x0034)	PHY requested 1 octet 0x01 = Transmitter set to use the LE 1M PHY 0x02 = Transmitter set to use the LE 2M PHY 0x03 = Transmitter set to use the LE Coded PHY with S=8 data coding 0x04 = Transmitter set to use the LE Coded PHY with S=2 data coding

Table 2. Return parameters

Parameter	Description
Status	Status 1 octet 0x00 = success 0x1 to 0xFF = error
Events	Command complete, event returned.

3.2 HCI_LE_Receiver_Test

This command is used to start a test where the DUT receives test reference packets at a fixed interval. The tester generates the test reference packets. Two versions of the command with differing parameters are available.

Command syntax:

```
hcitool -i hci0 cmd <OGF> <OCF> <RX_Channel> <PHY> <Modulation_Index>
```

Table 3 and Table 4 provide information about the command and return parameters.

Table 3. HCI_LE_Receiver_Test command parameters

Parameter	Description
OGF	0x08
OCF	0x001D = v1 [Bluetooth SIG version 4.2 and above] 0x0033 = v2 [Bluetooth SIG version 5.0 and above]
RX_Channel	RX channel 1 octet N = (F-2402) / 2 Range (N) = 0x00 to 0x27 Frequency range (F) = 2402 MHz to 2480 MHz
PHY (Applicable if OCF = 0x0033)	PHY requested 1 octet 0x01 = Transmitter set to use the LE 1M PHY 0x02 = Transmitter set to use the LE 2M PHY 0x03 = Receiver set to use the LE Coded PHY
Modulation_Index (Applicable if OCF = 0x0033)	Assumption on the type of modulation index. 1 octet 0x00 = assumes the transmitter has a standard modulation index 0x01 = assumes the transmitter has a stable modulation index

Table 4. Return parameters

Parameter	Description
Status	Status 1 octet 0x00 = success 0x1 – 0xFF = error
Events	Command complete, event returned.

3.3 HCI_LE_Test_End

This command is used to stop a DTM test.

Command syntax:

```
hcitool -i hci0 cmd 08 1F
```

Table 5 and Table 6 provide information about the command and return parameters.

Table 5. HCI_LE_Test_End command parameter

Parameter	Description
OGF	0x08
OCF	0x001F

Table 6. Return parameters

Parameter	Description
Status	Status 1 octet 0x00 = success 0x001 to 0xFF = error
Num_Packets	Number of packets received in hexadecimal format Range from 0 to 65,535 2 octets
Events	Command complete, event returned.

4 Examples

This section provides DTM tests examples.

4.1 Bluetooth LE transmitter test

This example shows how to test Bluetooth LE TX.

Step 1 – Set up the test environment (Section 2).

Step 2 – Load the drivers and firmware onto the DUT.

Step 3 – Verify that the Bluetooth interface is running on the DUT.

```
hciconfig -a
```

Example of command output:

```
hci0: Type: Primary Bus: UART
      BD Address: 88:88:88:88:88:88 ACL MTU: 1021:7 SCO MTU: 120:6
      UP RUNNING
      RX bytes:1513 acl:0 sco:0 events:92 errors:0
      TX bytes:1282 acl:0 sco:0 commands:92 errors:0
```

In the following steps, the Bluetooth interface hci0 is used.

Step 4 – Connect the DUT to the spectrum analyzer.

Step 5 – Configure the spectrum analyzer.

Step 6 – Start the Bluetooth LE transmit test with the appropriate parameters.

Command syntax:

```
hcitool -i hci0 cmd 08 <OCF> <TX_Channel> <Test_Data_Length> <Packet_Payload> <PHY>
```

Example of command:

```
hcitool -i hci0 cmd 08 34 00 ff 00 02
```

Where:

- `34` = value of `OCF`
- `00` = value of `TX_Channel` for 2402 MHz
- `FF` = value of `Test_Data_Length`
- `00` = value of `Packet_Payload` for PRBS9 sequence
- `02` = value of `PHY` for Bluetooth LE 2M PHY

Example of command output:

```
< HCI Command: ogf 0x08, ocf 0x0034, plen 4
  00 FF 00 02
> HCI Event: 0x0e plen 4
  01 34 20 00
```

Step 7 – Stop the test.

```
hcitool -i hci0 cmd 08 1F
```

Example of command output:

```
< HCI Command: ogf 0x08, ocf 0x001f, plen 0
> HCI Event: 0x0e plen 6
  01 1F 20 00 00 00
```

4.2 Bluetooth LE receiver test

This example shows how to test Bluetooth LE RX.

Step 1 – Set up the test environment (Section 2).

Step 2 – Load the drivers and firmware onto the DUT.

Step 3 – Verify that the Bluetooth interface is running on the DUT.

```
hciconfig -a
```

Example of command output:

```
hci0: Type: Primary Bus: UART
      BD Address: 88:88:88:88:88:88 ACL MTU: 1021:7 SCO MTU: 120:6
      UP RUNNING
      RX bytes:1513 acl:0 sco:0 events:92 errors:0
      TX bytes:1282 acl:0 sco:0 commands:92 errors:0
```

In the following steps, the Bluetooth interface hci0 is used.

Step 4 – Connect the DUT to the spectrum analyzer.

Step 5 – Configure the spectrum analyzer.

Step 6 – Start Bluetooth LE receive with the appropriate HCI_LE_Receiver_test command.

Command syntax:

```
hcitool -i hci0 cmd 08 <OCF> <RX_Channel> <PHY> <Modulation_Index>
```

Example of command:

```
hcitool -i hci0 cmd 08 33 00 02 00
```

Where:

- `33` = value of `OCF`
- `00` = value of `RX_Channel` for 2402 MHz
- `02` = value of `PHY` for Bluetooth LE 2M PHY
- `00` = value of `Modulation_Index` for standard modulation

Example of command output:

```
< HCI Command: ogf 0x08, ocf 0x0033, plen 3
  00 02 00
> HCI Event: 0x0e plen 4
  01 33 20 00
```

Step 7 – Stop Bluetooth LE test.

```
 hcitool -i hci0 cmd 08 1F
```

Example of command output:

```
< HCI Command: ogf 0x08, ocf 0x001f, plen 0
> HCI Event: 0x0e plen 6
  01 1F 20 00 00 00
```

5 Abbreviations

Table 7. Abbreviations

Abbreviation	Definition
BT	Bluetooth
DTM	Direct test mode
DUT	Device under test
HCI	Host Controller Interface
LE	Low Energy
RX	Receive
TX	Transmit

6 References

[1] Fact sheet – IW693: 2x2 Dual-band (5-7 GHz), 1x1 (2.4 GHz) Concurrent Dual Wi-Fi 6/6E and Bluetooth Combo Solution (link)

[2] Specification – Bluetooth Core specification (link)

[3] Webpage – 88W8887: 1x1 Dual-band Wi-Fi® 5 (802.11ac) and Bluetooth®5.2 Combo Solution (link)

[4] Webpage – 88W8897P: (Automotive): 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 5 (802.11ac) + Bluetooth® 5 Solution (link)

[5] Webpage – 88W8977: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 4 (802.11n) + Bluetooth® Solution (link)

[6] Webpage – 88W8987: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 5 (802.11ac) + Bluetooth® Solution (link)

[7] Webpage – 88W8997: 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 5 (802.11ac) + Bluetooth® Solution (link)

[8] Webpage – 88Q9098/88Q9098S: 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 6 (802.11ax) + Bluetooth® Automotive Solution (link)

[9] Webpage – 88W9098: 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 6 (802.11ax) + Bluetooth® (link)

[10] Webpage – AW611: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 6 (802.11ax) + Bluetooth® Automotive Solution (link)

[11] Webpage – AW690: Wi-Fi® 6 1x1 Concurrent Dual Wi-Fi (CDW) and Bluetooth® Combo SoC (link)

[12] Webpage – AW692: 2x2 Single-band (5 GHz) Concurrent Dual Wi-Fi® 6, 1x1 (2.4 GHz) Wi-Fi 6, and Bluetooth® Combo Solution (link)

[13] Webpage – AW693: 2x2 Dual-Band (5-7 GHz), 1x1 (2.4 GHz) Concurrent Dual Wi-Fi 6/6E and Bluetooth Combo Solution (link)

[14] Webpage – IW416: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 4 (802.11n) + Bluetooth® Solution (link)

[15] Webpage – IW610: 2.4/5 GHz Dual-band 1x1 Wi-Fi® 6 + Bluetooth Low Energy + 802.15.4 Tri-Radio Solution (link)

[16] Webpage – IW611: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 6 (802.11ax) + Bluetooth® Solution (link)

[17] Webpage – IW612: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 6 (802.11ax) + Bluetooth® + 802.15.4 Tri-radio Solution (link)

[18] Webpage – IW620: 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 6 (802.11ax) + Bluetooth® 5.1 Solution (link)

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8 Revision history

Table 8. Revision history

Document ID	Release date	Description
AN14163 v.3.0	2 July 2025	• Section 1.1 "Supported products": updated. • Section 2 "Setup ": updated. • Section 4.1 "Bluetooth LE transmitter test": updated. • Section 4.2 "Bluetooth LE receiver test": updated. • Section 6 "References": updated. ***Note:*** *AN14163 v.3.0 supersedes AN14372 v.1.0 published on AW692 and AW693 product pages on July 4, 2024.*
AN14163 v.2.0	4 July 2024	Security status changed to public. • Section 1.1 "Supported products": updated.
AN14163 v.1.0	19 April 2024	• Initial version

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