CONTENTS

1 INTRODUCTION

Direct Test Mode is used to control the Device Under Test (DUT) and provides a report back to the Tester.

Direct Test Mode shall be set up using one of two alternate methods:

1. over HCI (as defined in Section 2) or
2. through a 2-wire UART interface (as defined in Section 3)

Each DUT shall implement one of the two Direct Test Mode methods in order to test the Low Energy PHY layer. Figure 1.1 illustrates the alternatives for Direct Test Mode setup.

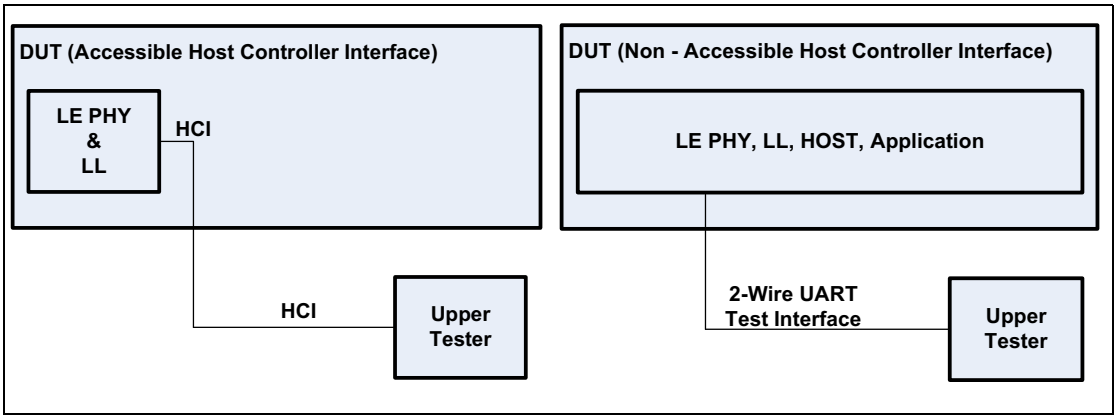

Figure 1.1: Setup alternatives for LE Direct Test Mode: Designs with accessible HCI (left) and designs without accessible HCI (right)

Figure 1.2 illustrates the Bluetooth LE Direct Test Mode setup principle using a 2-wire UART interface.

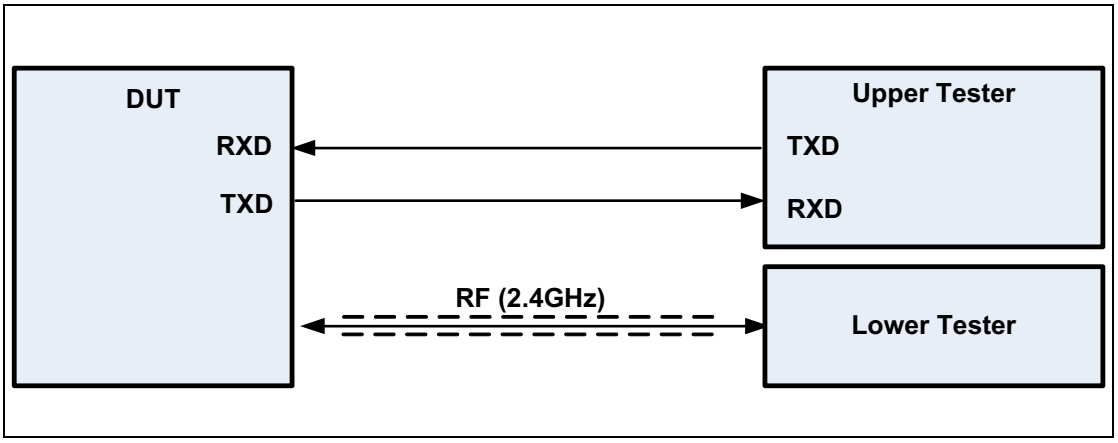

Figure 1.2: RF PHY test setup for Direct Test Mode (UART control)

2 LOW ENERGY TEST SCENARIOS

2.1 TEST SEQUENCES

These sequences are used as routines and used to control an LE DUT with an accessible HCI or a 2-wire UART interface for RF testing.

The following mapping shall be performed from the RF testing commands to HCI commands and events or 2-wire UART commands and events:

RF Test Command / Event	HCI Command / Event	2-wire UART Command / Event
LE_TRANSMITTER_TEST	LE Transmitter Test command	LE Transmitter Test
LE_RECEIVER_TEST	LE Receiver Test command	LE Receiver Test
LE_TEST_END	LE Test End command	LE Test End
LE_STATUS	Command Complete event	LE Test Status
LE_PACKET_REPORT	Command Complete event	LE Packet Report

Table 2.1: Mapping table of HCI / 2-wire Commands/Events

The HCI commands and events used in Direct Test Mode are defined in [Vol. 2] Part E, Section 7.8

2.2 MESSAGE SEQUENCE CHARTS

Transmitter Test

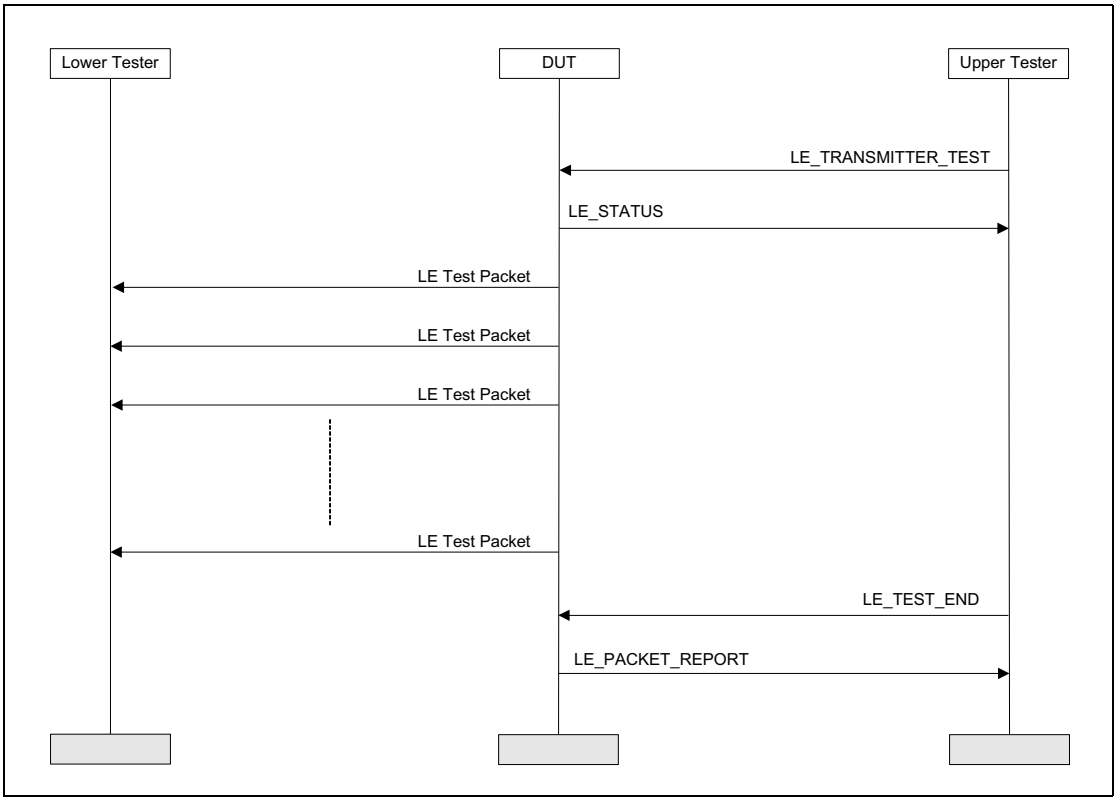

Figure 2.1: Transmitter Test MSC

Receiver Test

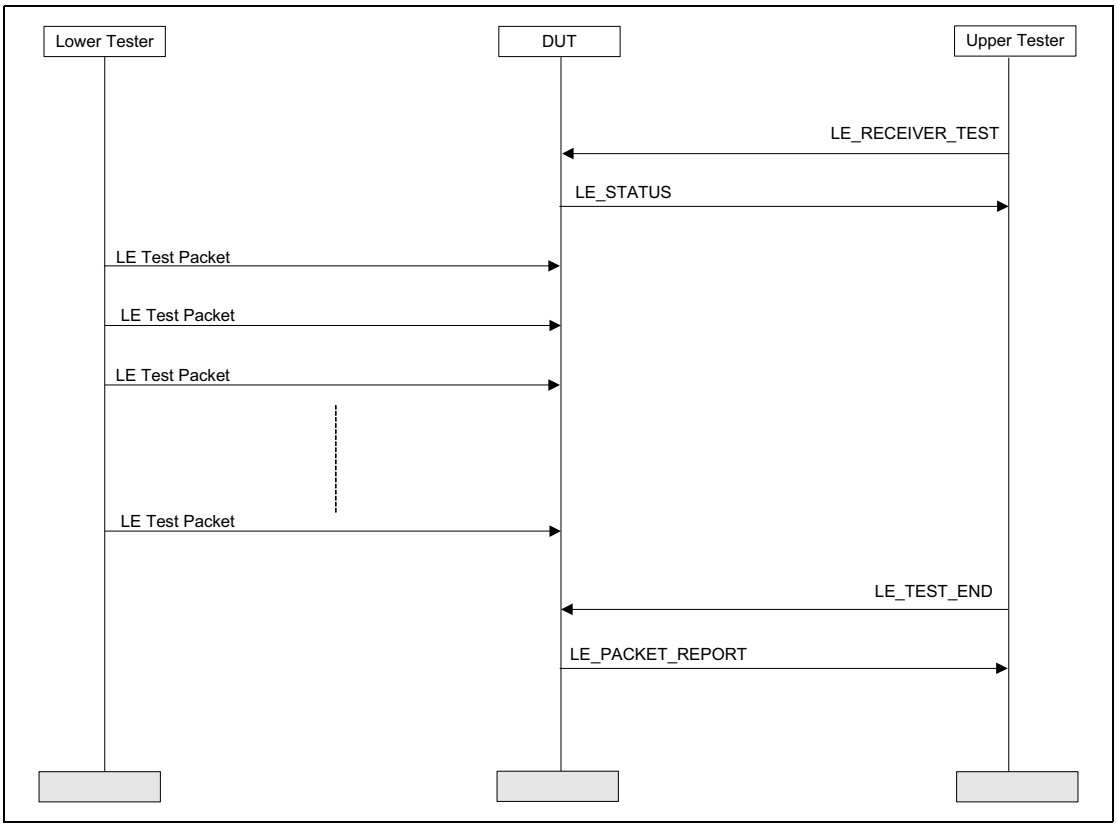

Figure 2.2: Receiver Test MSC

3 UART TEST INTERFACE

3.1 UART INTERFACE CHARACTERISTICS

The UART interface characteristics shall be set to use the following parameters:

- Baud rate: One of the following shall be supported by the DUT:
  1200, 2400, 9600, 14400, 19200, 38400, 57600, 115200
- Number of data bits: 8
- No parity
- 1 stop bit
- No flow control (RTS or CTS)

3.2 UART FUNCTIONAL DESCRIPTION

The Upper Tester shall always initiate any a test scenario using the UART interface. The DUT shall respond to the commands from the Upper Tester.

The Upper Tester sends test commands to the DUT. The DUT shall respond with a status event or the packet reporting event.

The Upper Tester shall not transmit further commands before it receives a response from the DUT. If the Upper Tester does not receive a response from the DUT within the time $t_{TIMEOUT}$, the Upper Tester shall transmit a reset command to the DUT and display an appropriate error message.

On reception of a reset command, the DUT shall reset all parameters to their default state.

Definitions

- All Commands and Events consist of 16 bits (2 octets).
- The most significant bit is bit number 15.
- The least significant bit is bit number 0.
- The most significant octet is from bit 15 to 8.
- The least significant octet is from bit 7 to 0.
- Commands and Events are sent most significant octet (MSO) first, followed by the least significant octet (LSO).

3.3 COMMANDS AND EVENTS

3.3.1 Command and Event Behavior

Table 3.1 outlines the set of commands which can be received by the DUT and the corresponding response events that can be transmitted by the DUT.

Command (DUT RXD)	Event (DUT TXD)
LE_Reset	LE_Test_Status SUCCESS LE_Test_Status FAIL
LE_Receiver_Test	LE_Test_Status SUCCESS LE_Test_Status FAIL
LE_Transmitter_Test	LE_Test_Status SUCCESS LE_Test_Status FAIL
LE_Test_End	LE_Packet_Report LE_Test_Status FAIL

Table 3.1: 2-Wire command and event behavior

3.3.2 Commands

Command packet format is as shown in Figure 3.1.

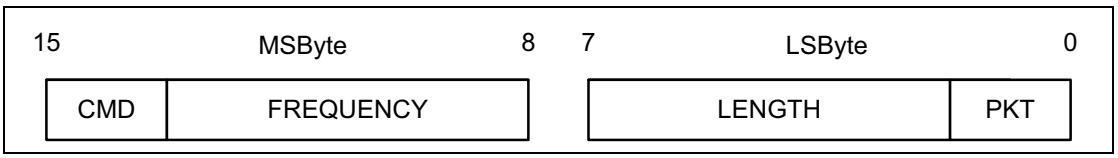

Figure 3.1: Command message format

CMD (command): *Size: 2 Bits*

Value b_1b_0	Parameter Description
00	Reset
01	Receiver Test
10	Transmitter Test
11	Test End

Frequency: *Size: 6 Bits*

Value	Parameter Description
N	When N = 0x00 – 0x27: N = (F-2402)/2 Frequency Range 2402 MHz to 2480 MHz Where N = 0x28 – 0x3F: Reserved

Length: *Size: 6 Bits*

Value	Parameter Description
N	When N = 0x00 – 0x25: Length in octets of payload data in each packet When N = 0x26 – 0x3F: Reserved

PKT (Packet Type): *Size: 2 Bits*

Value b_1b_0	Parameter Description
00	PRBS9 Packet Payload
01	11110000 Packet Payload
10	10101010 Packet Payload
11	Vendor specific

3.4 EVENTS

There are two types of events sent by the DUT:

1. LE_Test_Status_Event
2. LE_Test_Packet_Report_Event

Event packet format is as shown in Figure 3.2. This packet format is used for both Command Status Events and Packet Report Events.

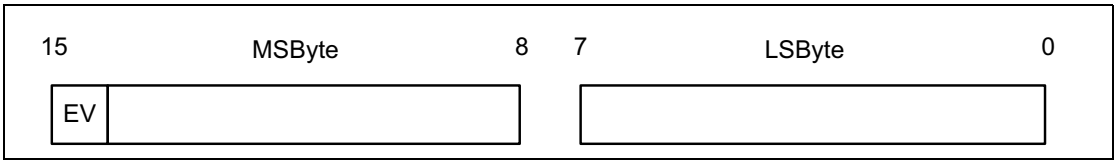

Figure 3.2: Event packet format

EV (Event): *Size: 1 Bit*

Value	Parameter Description
0	LE_Test_Status_Event
1	LE_Packet_Reporting_Event

3.4.1 LE_Test_Status_Event

The LE_Test_Status_Event packet format is as shown in Figure 3.3.

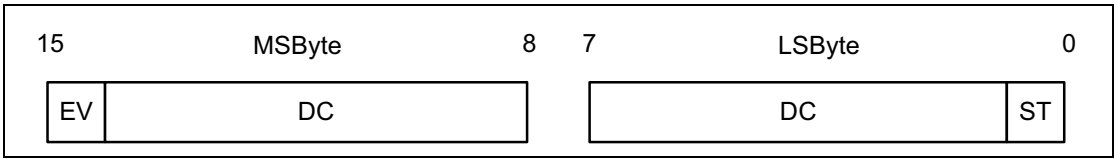

Figure 3.3: LE Test Status event

ST (status): *Size: 1 Bit*

Value	Parameter Description
0	Success
1	Error

DC (don't care): *Size: 14 Bits*

Value	Parameter Description
xxxxxxxxxxxxx	Value ignored

3.4.2 LE_Packet_Report_Event

The LE_Packet_Report_Event packet format is as shown in Figure 3.4. The *Packet Count* parameter indicates the number of received LE Test Packets. The *Packet Count* in the Packet Report ending a transmitter test shall be 0.

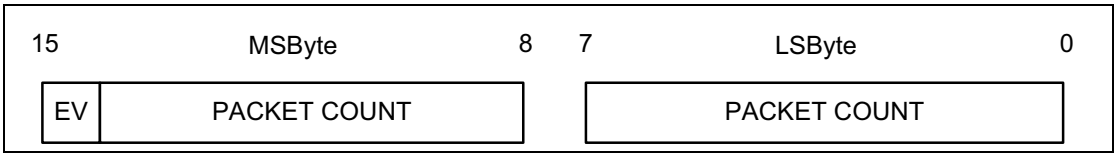

Figure 3.4: LE Packet Report event

PACKET COUNT: *Size: 15 Bits*

Value	Parameter Description
N	N is the number of packets received Range = 0 to 32767.

Note: The DUT is not responsible for any overflow conditions of the packet counter. That responsibility belongs with the RF PHY Tester or other auxiliary equipment.

3.5 TIMING – COMMAND AND EVENT

The timing requirements are as shown in Table 3.2.

Symbol	Parameter	Min.	Max.	Unit
b_{ERR}	Baud rate accuracy		±5	%
t_{MIN}	The time between the first and second octet of the command (end of stop bit to start of start bit)	0	5	ms
$t_{RESPONSE}$	The time from a DUT receiving a command (end of stop bit) until the DUT responds (start of start bit)	0	50	ms
$t_{TURN-AROUND}$	The time from when the tester receives a response (end of stop bit) until the tester sends another command (start of start bit)	5	-	ms
$t_{TIMEOUT}$	The time from when a tester sends a command (end of stop bit) until the tester times out (not having received end of the stop bit in the response)	51	100	ms

Table 3.2: Parameter requirements table for 2-wire UART interface

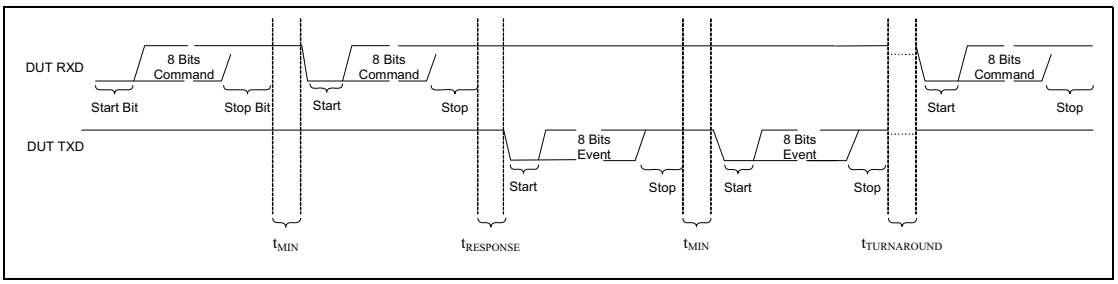

Figure 3.5: Command and event timing on 2-wire UART interface

The commands and events shall be transmitted with two 8-bit octets with a maximum time between the 2 transmissions. A timeout is required for no response or an invalid response from the DUT.

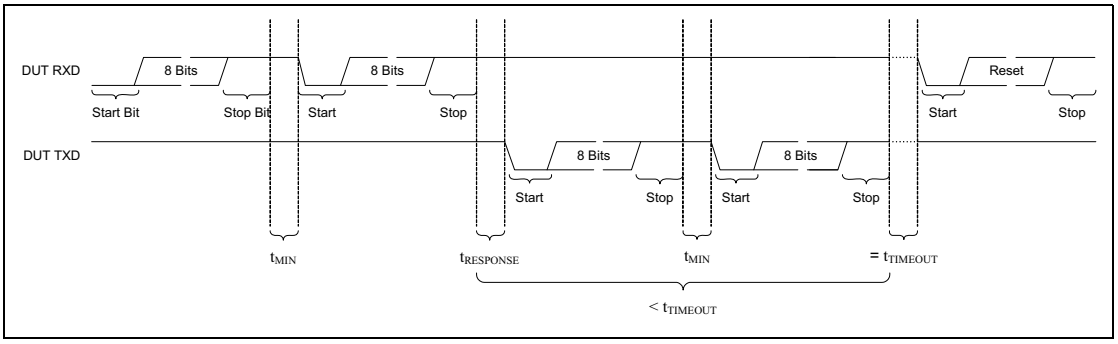

Figure 3.6: Command and event timing on 2-wire UART interface showing timeout

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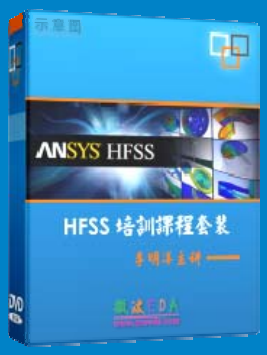

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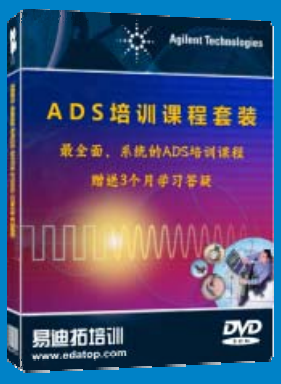

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