Title: Direct Test Mode 介绍

1. 简介

DTM(Direct Test Mode)是 SIG 联盟在蓝牙核心规范中制定的一种用于蓝牙射频性能测试的模式。DTM 测试主要分为发射测试和接收测试，发射测试能够获得被测蓝牙产品的发射功率、频偏等；接收测试则可以测试被测蓝牙产品的接收灵敏度等。本文将介绍 DTM 测试环境的搭建和测试流程。

2. 测试环境搭建

2.1. 硬件连线

连线如下图所示：

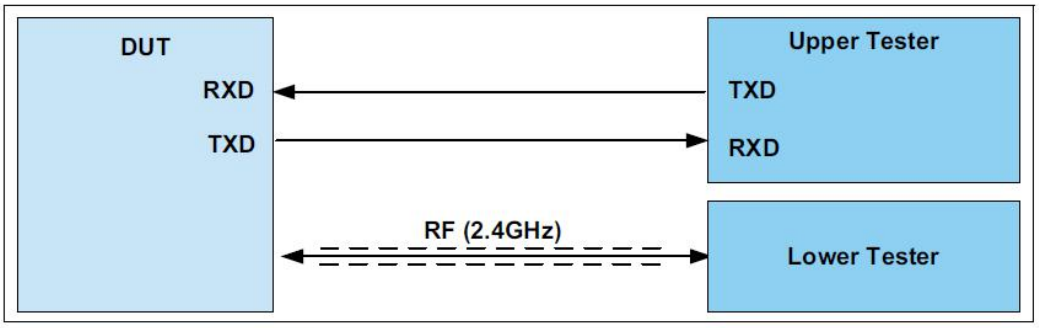
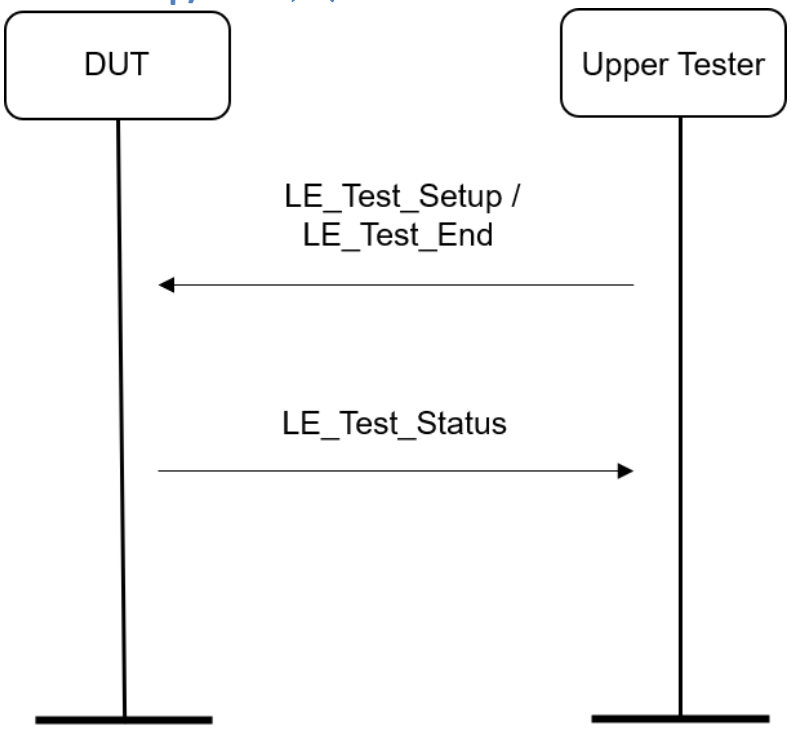


Figure 1.2: RF PHY test setup for Direct Test Mode (UART control)

- DUT ，即被测蓝牙产品。
- Upper Tester 为上位机，该上位机通过 UART 发送符合 DTM 规范的指令，控制 DUT 进行接收或者发送测试。
- Lower Tester 为下位机，该下位机通过 RF 接收或者发送无线数据包，协助开展 DTM 测试。

2.2. 交互时序图

2.2.1. Setup/End 命令



- 上位机发出 Setup 或者 End 指令，Setup 指令可用来设置测试参数；End 指令用以结束本次测试
- DUT 回应执行结果

2.2.2 发送测试

Transmitter Test

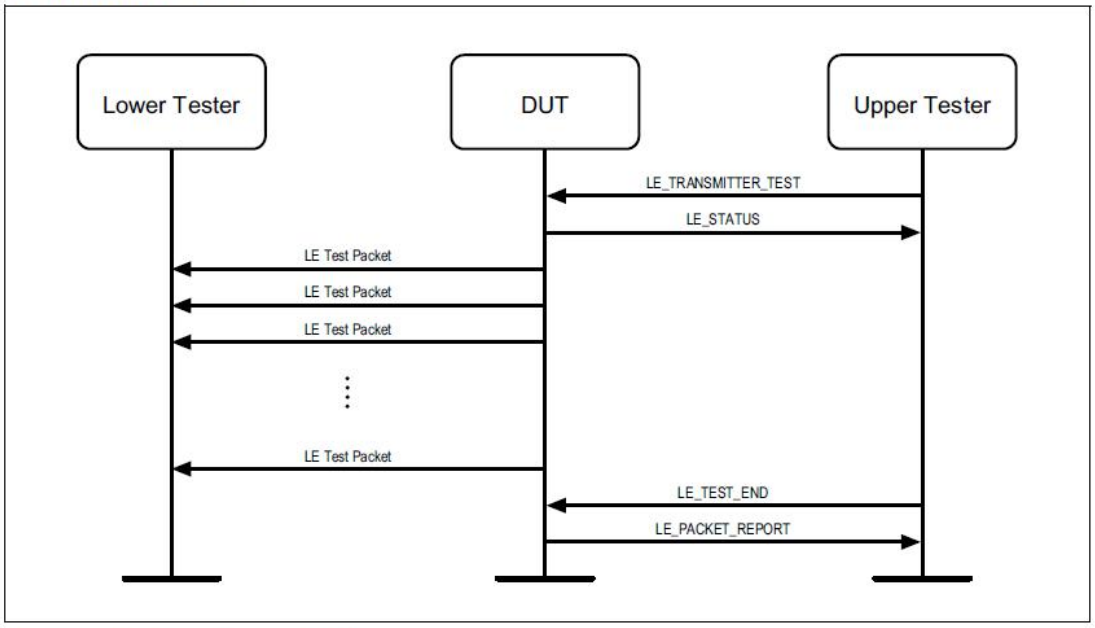


Figure 2.1: Transmitter Test MSC

- 上位机发出 Setup 指令设置测试参数
- DUT 回应执行结果
- 上位机发出发送测试指令
- DUT 回应执行结果
- DUT 开始发送无线数据包
- 下位机接收无线数据包
- 上位机发出 End 指令
- DUT 通过 Events 上报测试数据

2.2.2. 接收测试

Receiver Test

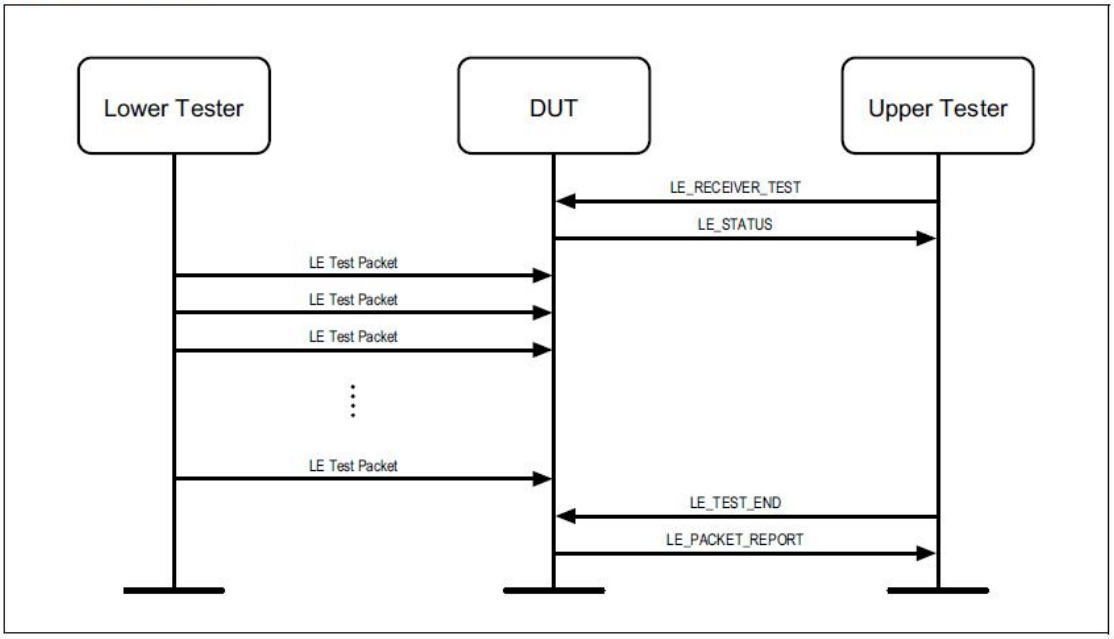


Figure 2.2: Receiver Test MSC

- 上位机发出 Setup 指令设置测试参数
- DUT 回应执行结果
- 上位机发出接收测试指令
- DUT 回应执行结果
- 下位机开始发送无线数据包
- DUT 接收无线数据包
- 上位机发出 End 指令
- DUT 通过 Events 上报测试数据

3. DTM 指令 UART 规范

DTM 规范的命令格式有两种：UART 和 HCI 格式。目前常用的格式为 UART，HCI 格式在本文中暂按下不表。

定义：

- 所有的 Commands 和 Events 由 2 个字节组成

- 小端格式传输，高位在前，低位在后
- 上位机发送 Commands，DUT 回应 Events

3.1. Commands

3.1.1. Setup、End 指令格式

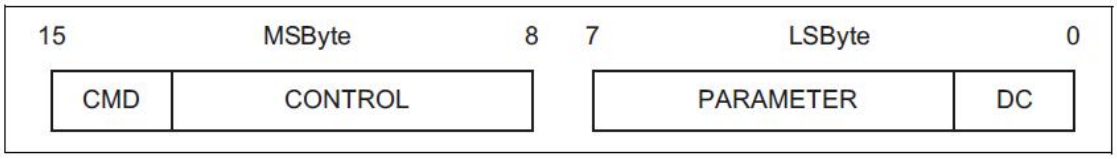


Figure 3.2: Command message format for Test Setup and Test End commands

	说明	备注
CMD(Bit15 ~ Bit14)	**00：Test Setup**	**本小节介绍**
	01: Receive Test	
	10: Transmit Test	
	11: Test End	**本小节介绍**
Control(Bit13 ~ Bit8)	控制指令	具体参见 Core Spec 5.0 中 DIRECT TEST MODE 章节
Paramter(Bit7 ~ Bit2)	控制指令参数	具体参见 Core Spec 5.0 中 DIRECT TEST MODE 章节
DC(Bit1 ~ Bit0）	RFU	

- 当指令为 **Setup** 指令时，上述 Control 与 Paramter 字段组合关系为

Test Setup Command: *Size: 12 Bits*

Control (6 bits)	Parameter (6 bits)	Description
0x00	0x00	RESET; the upper 2 bits of the data length for any Transmitter or Receiver commands following are set to 00, the PHY is set to LE 1M, and the receiver assumes the transmitter has a standard modulation index
	0x01 – 0x3F	Reserved for future use
0x01	0x00 – 0x03	Set the upper 2 bits of the data length for any Transmitter or Receiver commands following (to enable a length greater than 0x3F to be used)
	0x04 – 0x3F	Reserved for future use
0x02	0x00	Reserved for future use
	0x01	PHY set to LE 1M
	0x02	PHY set to LE 2M
	0x03	PHY set to LE Coded; transmitter is to use S=8 data coding
	0x04	PHY set to LE Coded; transmitter is to use S=2 data coding
	0x05 – 0x3F	Reserved for future use
0x03	0x00	Receiver assumes transmitter has a standard modulation index
	0x01	Receiver assumes transmitter has a stable modulation index
	0x02 - 0x3F	Reserved for future use
0x04	0x00\	Read the test case supported features. The Test Status event will return the state of the test case supported features as detailed in the Test Status event (Section 3.4.1).
	Any other value	Reserved for future use

Control (6 bits)	Parameter (6 bits)	Description
0x05	0x00	Read supportedMaxTxOctets (see [Vol 6] Part B, Section 4.5.10)
	0x01	Read supportedMaxTxTime (see [Vol 6] Part B, Section 4.5.10)
	0x02	Read supportedMaxRxOctets (see [Vol 6] Part B, Section 4.5.10)
	0x03	Read supportedMaxRxTime (see [Vol 6] Part B, Section 4.5.10)
	Any other value	Reserved for future use

- 当指令为 **End** 指令时，上述 Control 与 Paramter 字段组合关系为

Test End Command: *Size: 12 Bits*

Control (6 bits)	Parameter (6 bits)	Description
0x00	0x00	Test End Command
0x00	0x01 – 0x3F	Reserved for future use
0x01 – 0x3F	0x00 – 0x3F	Reserved for future use

3.1.2. 发送、接收测试指令格式

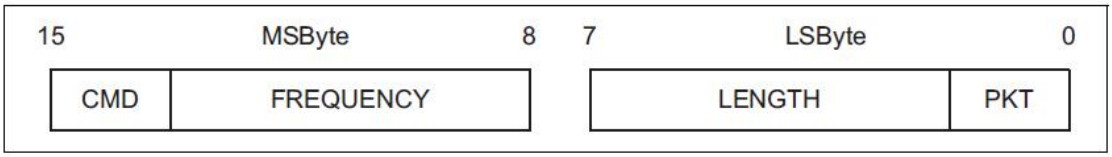


Figure 3.1: Command message format for Transmitter Test and Receiver Test commands

	说明	备注
CMD(Bit15 ~ Bit14)	00：Test Setup	
	01: Receive Test	**本小节介绍**
	10: Transmit Test	**本小节介绍**
	11: Test End	
Frequency(Bit13 ~ Bit8)	测试使用的频点信息	
Length(Bit7 ~ Bit2)	Payload 长度值的低 6 位，高两位在 Test Setup 命令中设置	
PKT(Bit1 ~ Bit0)	数据包格式	
	00：PRBS9 Packet Payload	
	01：11110000 Packet Payload	
	10：10101010 Packet Payload	
	11：On the LE Uncoded PHYs: Vendor Specific On the LE Coded PHY: 11111111	

3.2. Events

Events 由 DUT 发送，返回命令执行的结果。指令格式如下：

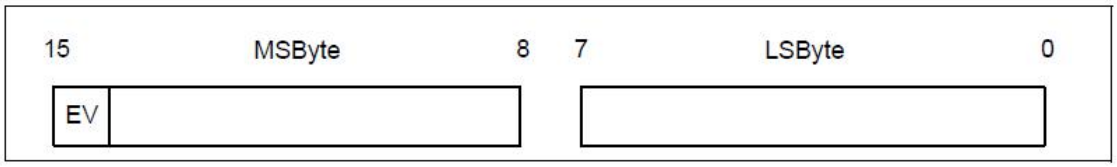


Figure 3.3: Event packet format

	说明	备注
EV(Bit15)	0: LE*Test*Status_Event	DUT 返回当前指令执行结果
	1: LE*Packet*Report_Event	DUT 返回测试数据，如发送测试指令返回发射功率、频偏数据；接收测试指令返回接收灵敏度数据
LE*Test*Status_Event		
Response(Bit14 ~ Bit1)	响应的控制指令与参数	具体参见 Core Spec 5.0 中 DIRECT TEST MODE 章节
ST(Bit0）	执行结果	
	0：成功； 1 - 失败	
LE*Packet*Report_Event		
Packet Count(Bit14 ~ Bit0)	收包个数 Range = 0 to 32767	

Response[1] *Size: 14 Bits*

Test Setup command control parameter	**Value bits 1 to 14**[2]	
0x04	Bit 1	LE Data Packet Length Extension feature supported
	Bit 2	LE 2M PHY supported
	Bit 3	Transmitter has a Stable Modulation Index
	Bits 4 to 14	Reserved for future use
0x05	Bits 1 to 14	Maximum transmit or receive time divided by 2 or maximum number of payload octets (depending on the parameter in the original query) that the local Controller supports for transmission of a single Link Layer Data Channel PDU. Range 0x00A4-0x2148 for times or 0x001B-0x00FF for number of octets (all other values reserved for future use).
All other values		Reserved for future use

[1] If the event has a status of "Error" or was generated in response to a command other than Test Setup, then this field is Reserved for future use.

[2] This field is described as having bits 1 to 14 rather than 0 to 13 to avoid confusion.

3.3. 指令扩展

用户可通过增加 DTM 规范中 Setup 指令的控制指令字段（Control）来扩展功能。