Part I:1

BLUETOOTH TEST MODE

This document describes the test mode for hardware and low-level functionality tests of Bluetooth devices. The test mode includes transmitter tests (packets with constant bit patterns) and loop back tests.

CONTENTS

1 GENERAL DESCRIPTION

The test mode supports testing of the bluetooth transmitter and receiver. It is intended mainly for certification/compliance testing of the radio and baseband layer and may be used also for regulatory approval or in production and after sales testing.

A device in test mode must not support normal operation. For security reasons the test mode is designed such that it offers no benefit to the user. Therefore, no data output or acceptance on a HW or SW interface is allowed.

1.1 TEST SETUP

The setup consists of a device under test (DUT) and a tester. Optionally additional measurement equipment may be used.

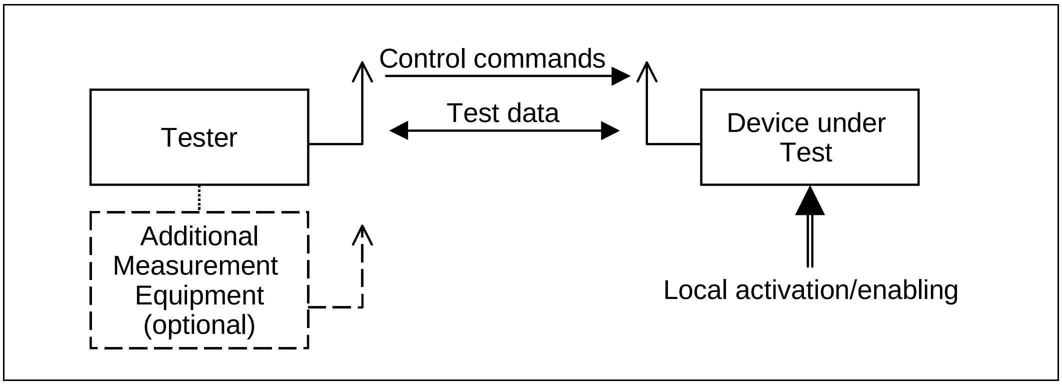

Figure 1.1: Setup for Test Mode

Tester and DUT form a piconet where the tester acts as master and has full control over the test procedure. The DUT acts as slave.

The control is done via the air interface using LMP commands (see Section 3 on page 803 and "Link Manager Protocol" on page 185). Hardware interfaces to the DUT may exist but are not subject to standardization.

The test mode is a special state of the Bluetooth model. For security and type approval reasons a device in test mode may not support normal operation. When the DUT leaves the test mode it enters the standby state. After power-off the Bluetooth device must return to standby state.

1.2 ACTIVATION

The activation may be carried out locally (via a HW or SW interface) or using the air interface.

- For activation over the air interface entering the test mode must be locally enabled for security and type approval reasons. The implementation of this local enabling is not subject to standardization.

  The tester sends an LMP command that forces the DUT to enter test mode. The DUT terminates all normal operation before entering the test mode.

  The DUT shall return an LMP_Accepted on reception of a activation command, LMP_Not_Accepted shall be returned if the DUT isn't locally enabled.
- If the activation is performed locally using a HW or SW interface, the DUT terminates all normal operation before entering the test mode.

  Until a connection to the tester exists, the device shall perform page scan and inquiry scan. Extended scan activity is recommended.

1.3 CONTROL

Control and configuration is performed using special LMP commands (see Section 3 on page 803). These commands must be rejected if the Bluetooth device is not in test mode. In this case an LMP_not_accepted is returned. The DUT shall return an LMP_accepted on reception of a control command when in test mode.

Vice versa a Bluetooth device in test mode must ignore all LMP commands not related to control of the test mode. LMP commands dealing with power control and the request for LMP features (LMP_features_req) are allowed in test mode; the normal procedures are also used to test the adaptive power control.

The DUT can be commanded to leave the test mode by an LMP_Detach command or by sending an LMP_test_control command with test scenario set to "exit test mode".

2 TEST SCENARIOS

2.1 TRANSMITTER TEST

The Bluetooth device transmits a constant bit pattern. This pattern is transmitted periodically with packets aligned to the slave TX timing of the piconet formed by tester and DUT. The same test packet is repeated for each transmission.

The transmitter test is started when the master sends the first POLL packet. In non hopping mode agreed frequency is used for this POLL packet.

The tester transmits at his TX slots (control commands or POLL packets). The slave starts burst transmission in the following slave TX slot. The master's polling interval is fixed and defined beforehand. The device under test shall transmit its burst according to the normal timing even if no packet from the tester was received.

The burst length may exceed the length of a one slot packet. In this case the tester may take the next free master TX slot for polling. The timing is illustrated in Figure 2.1.

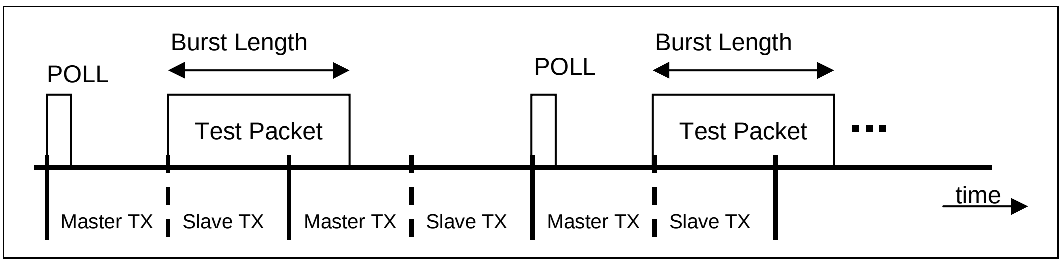

Figure 2.1: Timing for Transmitter Test

2.1.1 Packet Format

The test packet is a normal Bluetooth packet, see Figure 2.2. For the payload itself see below.

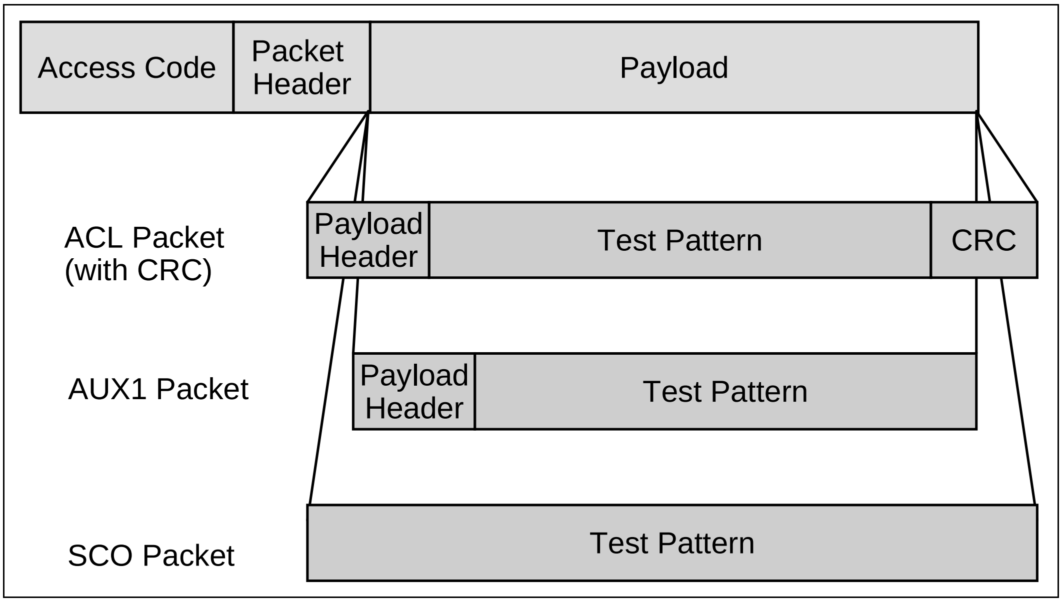

Figure 2.2: General Format of TX Packet

During configuration the tester defines:

- the packet type to be used
- payload length

For the payload length the restrictions from the baseband specification (see “Baseband Specification” on page 33.) apply. In case of ACL packets the payload structure defined in the baseband specification is preserved as well, see Figure 2.2.

For the transmitter test mode only packets without FEC should be used, i.e. HV3, DH1, DH3, DH5and AUX1packets. Support of packet type is only mandatory up to the longest implemented packet type.

In transmitter test mode the packets exchanged between tester and DUT are not scrambled with the whitening sequence. Whitening is turned of when the DUT has accepted to enter the transmitter test mode and is turned on when the DUT has accepted to exit the transmitter test mode, see Figure 2.3.[1]

1. Note: Implementations must ensure that retransmissions of the LMP_accepted messages use the same whitening status.

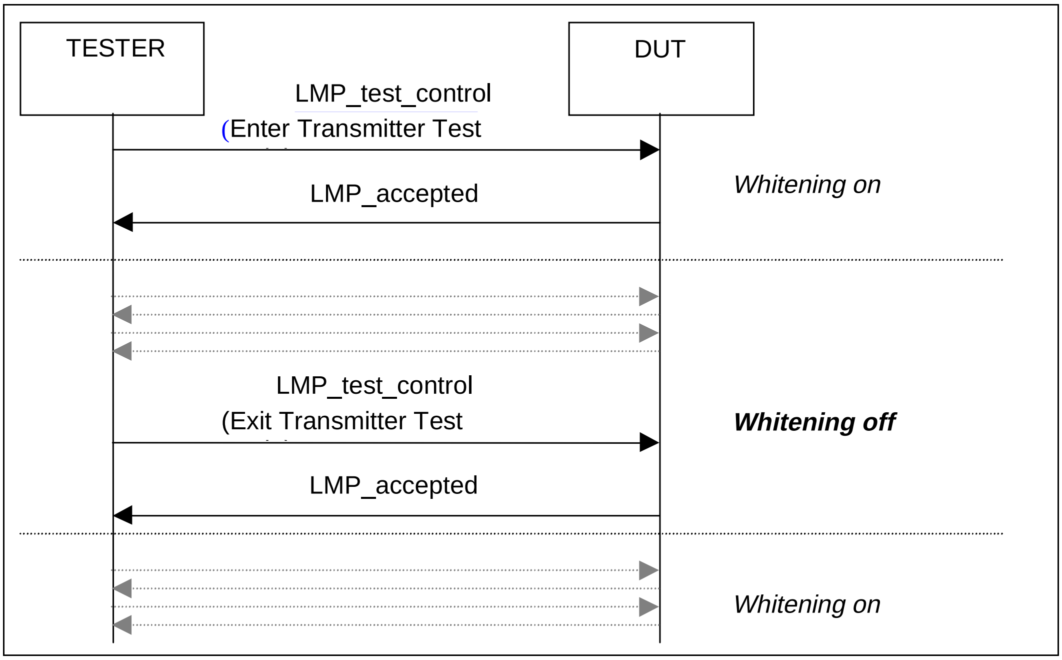

Figure 2.3: Use of whitening in Transmitter mode

2.1.2 Pseudorandom Sequence

In case of pseudorandom bit sequence, the same sequence of bits is used for each transmission(i.e. the packet is repeated, see above) . A PRBS-9 Sequence[2] is used, see [2] and [3].

The properties of this sequence are as follows (see [3])The sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage (see Figure 2.4), and the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs, i.e. the shift register is initialized with nine ones.

- Number of shift register stages9
- Length of pseudo-random sequence 2^9-1 = 511 bits
- Longest sequence of zeros8 (non-inverted signal)

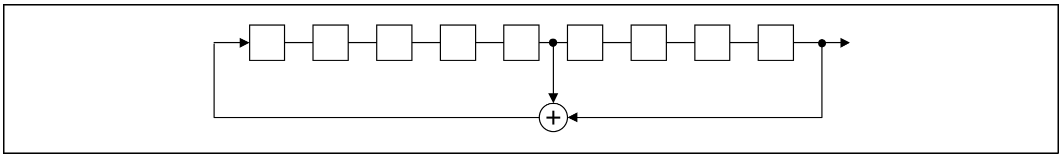

Figure 2.4: Linear Feedback Shift Register for Generation of the PRBS sequence

2. Recently some uncertanties about japanese regulatory requirements have been reported. If necessary for regulatory type approval in Japan, some features might be added – e.g. a longer PN sequence.

2.1.3 Reduced Hopping Sequence

To support quick testing of the radio over the complete frequency range a reduced hopping mode is defined. Implementation of this mode is optional for Bluetooth devices and modules.

Reduced hopping uses only five frequencies on which a sequential hopping is done on (channel: 0, 23, 46, 69 and 93 is used[3]), see Figure 2.5.

Channel	→ 0 →	23 →	46 →	69 →	93
CLK_{27-1} mod 5 =	0	1	2	3	4

Figure 2.5: Reduced hopping sheme

The timing is based on the Bluetooth clock of the tester. The value of CLK_{27-1} (i.e. not using CLK_0, representing half slots) modulo 5 is used to determine the transmit frequency.

2.1.4 Control of Transmit Parameters

The following parameters can be set to configure the transmitter test:

1. Bit pattern:
   - constant zero
   - constant one
   - alternating 1010...[4]
   - pseudorandom bit pattern
   - transmission off
2. Frequency selection:
   - single frequency
   - Hopping Europe/USA
   - Hopping Japan
   - Hopping France
   - Hopping Spain
   - Reduced Hopping (implementation in Bluetooth devices and modules is optional)
3. TX frequency
   - $k \Rightarrow f := (2402 + k)$ MHz

3. The range is chosen to test the whole frequency range covering normal 79 channel, Spanish, French and Japanese hopping shemes. The frequency assignment rule is the same as for the fixed TX frequency: $f = (2402 + k)$ MHz.

4. It is recommended that the sequence starts with a one, but as this is irrelevant for measurements, it is also allowed to start with a zero.

4. Default poll period in TDD frames (n * 1.25 ms)
5. Packet Type
6. Length of Test Sequence (user data of packet definition in Baseband Specification” on page 33.)

2.1.5 Power Control

If adaptive power control is tested, the normal LMP commands will be used. The DUT starts to transmit at the maximum power and reduces/increases its power by one step on every command received.

2.1.6 Switch between different Frequency Settings

A change in the frequency selection becomes effective when the LMP procedure is completed:

The tester switches to a new frequency or hopping pattern after the LMP_accepted message has been received.

The DUT switches after the LMP accepted message has been sent.

Note: Loss of the LMP_accepted packet will eventually lead to a loss of frequency synchronization that cannot be recovered. Similar problems occur in normal operation, when the hopping pattern changes.

2.2 LOOP BACK TEST

The device under test receives normal baseband packets. The received packets are decoded in the DUT and the payload is sent back using the same packet type. The return packet is sent back in either the TX slot directly following the transmission of the tester, or it is delayed and sent back in the slot after the next transmission of the tester (see Figure 2.7 to Figure 2.9 on page 801).

Alternatively it is possible to implement a delayed loopback instead. Then the return packet is delayed to the following TX slot. There is no signalling to determine or control the mode. The device behaviour must be fixed or adjusted by other means, but must not change randomly.

The following rules apply (for illustration see Figure 2.6 on page 800):

- Clearly, if the synch word was not detected, there will be no reply.
- If the header error check (HEC) fails, the DUT replies with a NULL packet with the ARQN bit set to NACK. It is not mandatory to return a NULL packet in this case; the DUT may send nothing.
- If the packet contains an LMP message relating to the control of the test mode this command is executed and the packet is not returned, still though

ACK or NACK is returned as usual procedure. Other LMP commands are ignored and no packet is returned.

- The payload FEC is decoded and the payload is coded again for transmission. This allows testing the FEC handling. If the pure bit error rate shall be determined the tester chooses a packet type without FEC.
- The CRC is evaluated. In case of a failure, the payload is returned with ARQN = NACK. The CRC for the return packet is calculated for the returned payload.

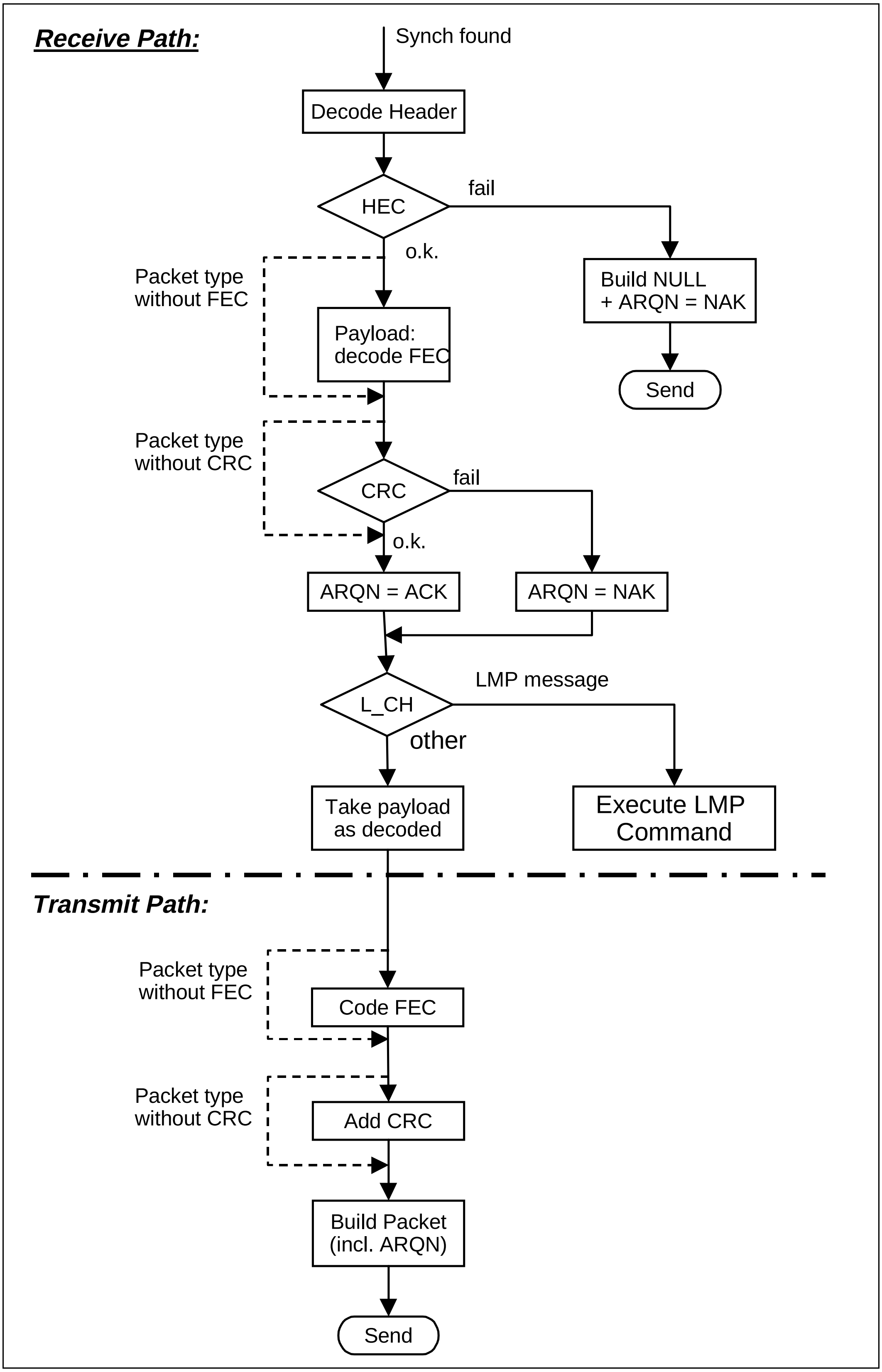

Figure 2.6: DUT Packet Handling in Loop Back Test

The timing for normal and delayed loopback is illustrated in Figure 2.7 to Figure 2.9:

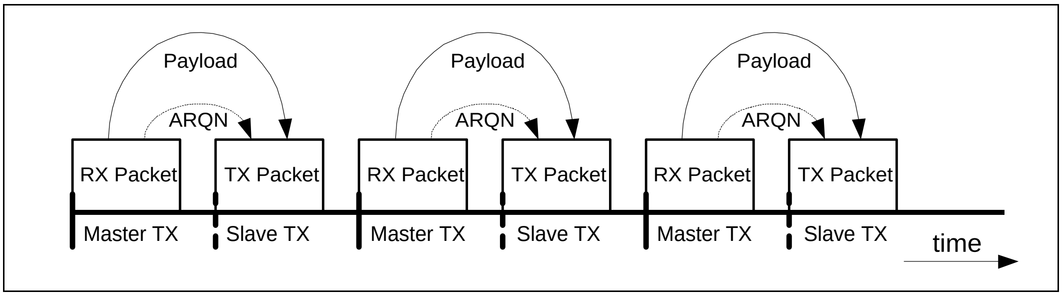

Figure 2.7: Payload & ARQN handling in normal loopback.

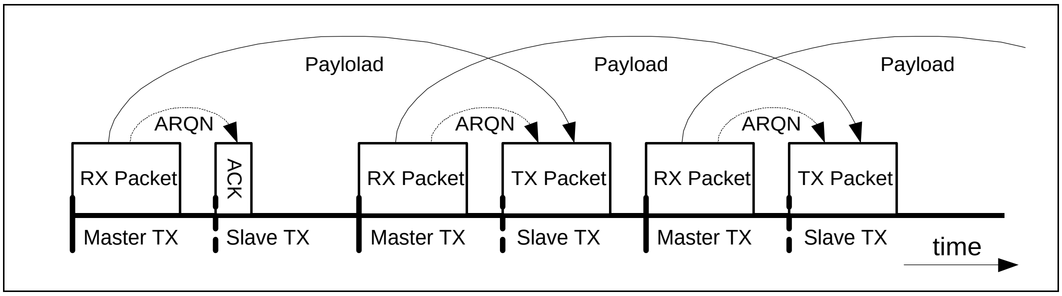

Figure 2.8: Payload & ARQN handling in delayed loopback - start.

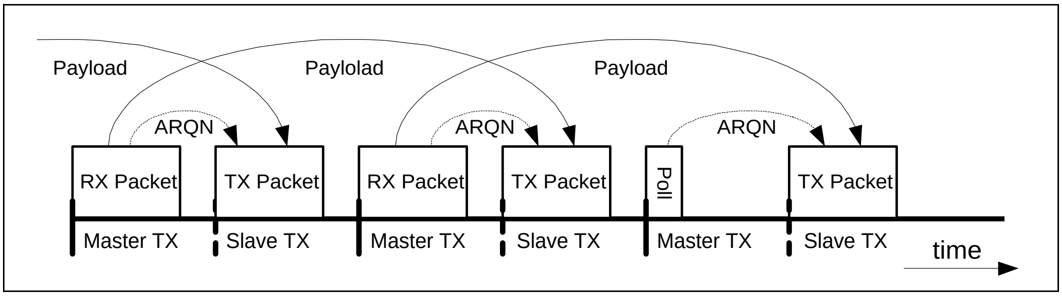

Figure 2.9: Payload & ARQN handling in delayed loopback - end.

The whitening is performed in the same way as it is used in normal active mode.

The following parameters can be set: to configure the loop back test:

1. Packet Class[5]
   - ACL Packets
   - SCO Packets

5. This is included because in the future the packet type numbering may not remain unambigous.

2. Frequency Selection
   - single frequency (independent for RX and TX)
   - Hopping Europe/USA
   - Hopping Japan
   - Hopping France
   - Hopping Spain
   - Hopping reduced (optional)

Hopping reduced uses only five frequencies on which a sequential hopping is done on (channel: 0, 23, 46, 69 and 93 is used).

3. Power level: (To be used according radio specification requirements)
   - power control or fixed TX power

The switch of the frequency setting is done exactly as for the transmitter test (see Section 2.1.6 on page 798).

3 OUTLINE OF PROPOSED LMP MESSAGES

Table 3.1 lists all LMP messages used for test mode (see Link Manager Protocol, Section 6 on page 238).

LMP PDU	PDU number	Possible Direction	Contents	Position in Payload
LMP_test_activate	56	m → s		
LMP_test_control	57	m → s	test scenario hopping mode TX frequency RX frequency power control mode poll period packet type length of test data	2 3 4 5 6 7 8 9-10
LMP_detach	7	m → s		
LMP_accepted	3	m ← s		
LMP_not_accepted	4	m ← s		

Table 3.1: LMP messages used for Test Mode

Name	Length (bytes)	Type	Unit	Detailed
test scenario	1	u_int8		0 Pause (TX off) 1 Transmitter test – 0 pattern 2 Transmitter test – 1 pattern 3 Transmitter test – 1010 pattern 4 Pseudorandom bit sequence 5 Closed Loop Back – ACL packets 6 Closed Loop Back – SCO packets 7–254 reserved 255 Exit Test Mode
hopping mode	1	u_int8		0 RX/TX on single frequency 1 Hopping Europe/USA 2 Hopping Japan 3 Hopping France 4 Hopping Spain 5 Reduced Hopping (optional) 6–255 reserved
TX frequency (for DUT)	1	u_int8		f = [2402 + k] MHz
RX frequency (for DUT)	1	u_int8		f = [2402 + k] MHz

Table 3.2: Parameters used in LMP_Test_Control PDU

Name	Length (bytes)	Type	Unit	Detailed
Power control mode	1	u_int8		0 fixed TX output power 1 adaptive power control
poll period	1	u_int8	1.25 ms	
packet type	1	u_int8		numbering as in packet header, see Baseband Specification)
length of test sequence (=length of user data in Baseband Specification)	2	u_int16	1 byte	unsigned binary number

Table 3.2: Parameters used in LMP_Test_Control PDU

The control PDU is used for both transmitter and loop back tests. The following restrictions apply for the parameter settings:

Parameter	Restrictions Transmitter Test	Restrictions Loopback Test
TX frequency	$0 \leq k \leq 93$	$0 \leq k \leq 93$
RX frequency	same as TX frequency	$0 \leq k \leq 93$
poll period		not applicable (set to 0)
length of test sequence	depends on packet type: DH1: ≤ 28 byte DH3: ≤ 181 byte DH5: ≤ 339 byte AUX1: ≤ 29 Byte HV3: = 30 byte	not applicable (set to 0)

Table 3.3: Restrictions for Parameters used in LMP_Test_Control PDU

4 REFERENCES

[1] Bluetooth Link Manager Protocol.

[2] CCITT Recommendation O.153 (1992), Basic parameters for the measurement of error performance at bit rates below the primary rate.

[3] ITU-T Recommendation O.150 (1996), General requirements for instrumentation for performance measurements on digital transmission equipment.

[4] Bluetooth Baseband Specification.