

Radio Frequency (RF)

Bluetooth® Test Suite

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Abstract:

This document defines the test cases for qualification test of the Bluetooth Wireless Technology Radio layer.



Revision History

Revision History	Date	Comments
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Revision History	Date	Comments
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Revision History	Date	Comments
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Revision History	Date	Comments
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Revision History	Date	Comments
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5.0.1r01	2017-03-26	TSE 8334: Modify Initial Condition in RF/TRM/CA/BV-01-C [Output Power] FROM (2nd bullet item which currently says) "Hopping on" TO "IUT hopping on or off".
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5.1.0	2018-12-07	Approved by BTI. Prepared for TCRL 2018-2 publication.

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1 Scope

This Bluetooth document contains the Test Suite Structure (TSS) and Test Cases (TC) to test the Bluetooth RF layer including Enhanced Data Rate.

The objective of this Test Suite is to provide a basis for conformance tests for Bluetooth devices giving a high probability of air interface inter-operability between different manufacturer's Bluetooth devices.

2 References, Definitions, and Abbreviations

2.1 References

This Bluetooth document incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. Additional definitions and abbreviations can be found in [\[1\]](#) and [\[2\]](#).

- [1] Specification of the Bluetooth System v2.1 + EDR or later, Core System Package, Volume 2, Part A
- [2] Volume 1, Part A, Test Strategy and Terminology Overview
- [3] ICS Proforma for Radio (RF)
- [4] ETS 300 328: “Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and sing wide band modulation techniques; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive v 1.9.1 (2015-02)”
- [5] FCC Part 15: CFR 47, Part 15 “Radio Frequency Device”, Sections 15.205, 15.209, 15.247
- [6] Specification of the Bluetooth System, Core System Package, Volume 2, Part B, Baseband (BB)

3 Test Suite Structure (TSS)

3.1 Test Strategy

The Bluetooth RF is layer 1 of the Bluetooth protocol stack.

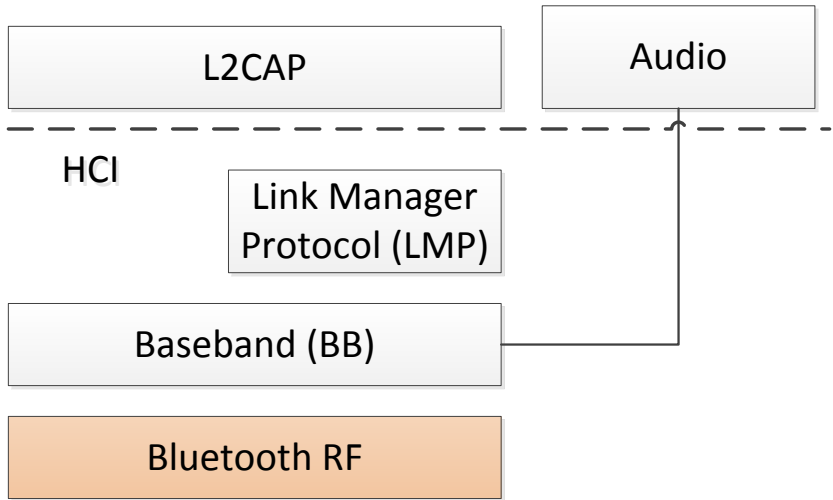


Figure 3.1: Bluetooth protocol stack, Basic Layers

Bluetooth RF Test Suite Structure

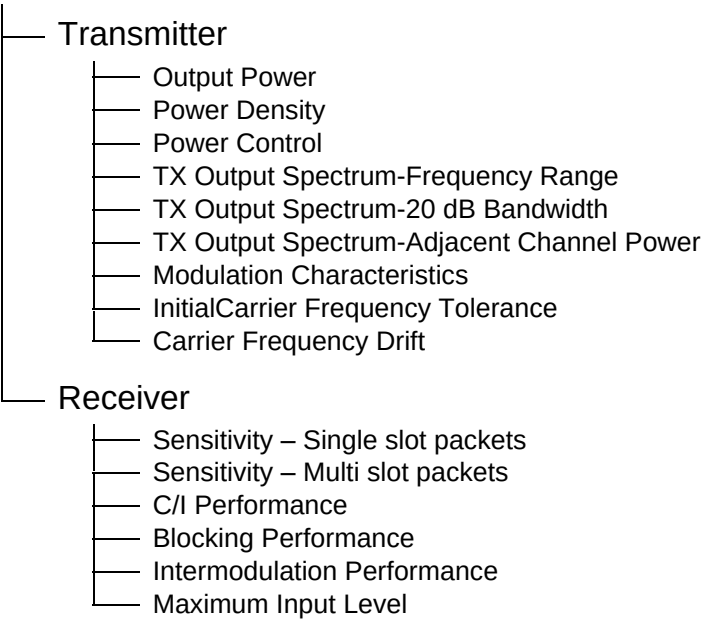


Figure 3.2: Test suite structure for Bluetooth RF

Bluetooth EDR RF Test Suite Structure

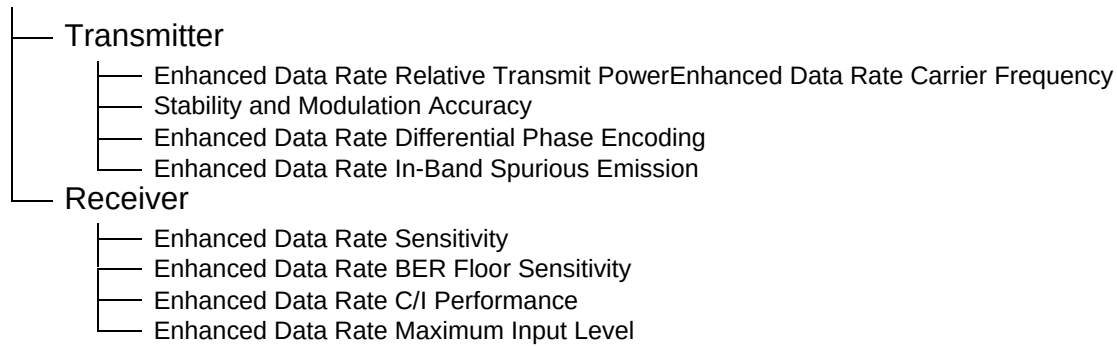


Figure 3.3: Test suite structure for Bluetooth EDR RF

3.2 Test Groups

The test groups are organized in 3 levels. The first level defines the protocol groups representing the protocol services. The second level, separates the protocol services in functional modules. The last level in each branch contains the standard ISO subgroups BV and BI (not shown in [Figure 3.3](#)).

3.2.1 Protocol Groups

The protocol group identifies the kind of test for Bluetooth RF test purposes:

- Transmitter
- Receiver

3.2.2 Main Test Groups

The main test groups are the capability group, the valid behavior group and the invalid behavior group.

3.2.2.1 Capability (CA) tests

This sub group provides testing of the major IUT capabilities aiming to ensure that the claimed capabilities are correctly supported, according to the ICS.

3.2.2.2 Valid Behavior (BV) tests

This sub group provides testing to verify that the IUT reacts in conformity with the Bluetooth standard, after receipt or exchange of a valid Protocol Data Units (PDUs). Valid PDUs means that the exchange of messages and the content of the exchanged messages are considered as valid.

3.2.2.3 Invalid Behavior (BI) tests

This sub group provides testing to verify that the IUT reacts in conformity with the Bluetooth standard, after receipt of a syntactically or semantically invalid PDU.

4 Test Cases

4.1 Introduction

4.1.1 Test Case Identification Conventions

Test cases shall be assigned unique identifiers per the conventions in [2]. The convention used here is **<spec abbreviation>/<IUT role>/<class>/<feat>/<func>/<subfunc>/<cap>/<xx>-<nn>-<y>**.

Bolded ID parts shall appear in the order prescribed. Non-bolded ID parts (if applicable) shall appear between the bolded parts. The order of the non-bolded parts may vary from test suite to test suite, but shall be consistent within each individual test suite.

Identifier Abbreviation	Spec Identifier <spec abbreviation>
RF	Radio
Identifier Abbreviation	Feature Identifier <feat>
RCV	Receiver Tests
TRM	Transmitter Tests

Table 4.1: RF TC Naming Conventions

4.1.2 Conformance

When conformance is claimed, all capabilities indicated as mandatory for this Specification shall be supported in the specified manner (process-mandatory). This also applies for all optional and conditional capabilities for which support is indicated. All mandatory capabilities, and optional and conditional capabilities for which support is indicated, are subject to verification as part of the Bluetooth Qualification program.

The Bluetooth Qualification Program may employ tests to verify implementation robustness. The level of implementation robustness that is verified varies from one Specification to another and may be revised for cause based on interoperability issues found in the market.

Such tests may verify:

- That claimed capabilities may be used in any order and any number of repetitions that is not excluded by the Specification, OR
- That capabilities enabled by the implementations are sustained over durations expected by the use case, OR
- That the implementation gracefully handles any quantity of data expected by the use case, OR
- That in cases where more than one valid interpretation of the Specification exist, the implementation complies with at least one interpretation and gracefully handles other interpretations OR
- That the implementation is immune to attempted security exploits.

A single execution of each of the required tests is required in order to constitute a pass verdict. However, it is noted that in order to provide a foundation for interoperability, it is necessary that a qualified implementation consistently and repeatedly pass any of the applicable tests.



In any case, where a member finds an issue with the Test Plan Generator, the Test Case as described in the Test Suite, or with the Test System utilized, the Member is required to notify the responsible party via an errata request such that the issue may be addressed.

4.2 Provisional RF Testing

Certain deviations from the test procedures shall be permitted for an interim period, as specified in Section 6.2, 'Provisional RF Testing'.

4.3 Common Test Case Conditions

Unless stated otherwise in individual test cases the following applies throughout this test suite:

1. The IUT is connected to the tester via a 50Ω connector. If there is no antenna interface, a temporary 50Ω interface or a suitable coupling device may be used.
2. The test case is to be performed at normal operating conditions.

4.4 Pass/Fail Verdict Conventions

Each test case has an Expected Outcome section, which outlines all the detailed pass criteria conditions that shall be met by the IUT to merit a Pass Verdict.

The convention in this test suite is that, unless there is a specific set of fail conditions outlined in the test case, then IUT fails the test case as soon one of the pass criteria conditions cannot be met and in case this occurs the outcome of the test shall be the Fail Verdict.

4.5 Transmitter

4.5.1 RF/TRM/CA/BV-01-C [Output Power]

- Test Purpose

Verification of the maximum peak and average RF-output power.

- Reference

[1] 3

- Initial Condition

- IUT in test mode loop back or TX mode.
- IUT hopping on or off
- If IUT supports power control the tester sets the IUT's output power setting to maximum using LMP commands.

- Test Procedure

If multiple power classes are declared in the ICS, then this test shall be executed on each supported power class.

- a) Tester transmits longest supported DM or DH packet with full payload (1, 3 or 5 slot) with PRBS9 as payload to the IUT. (See Section 6.1 "Reference Signal Definition")
- b) If Hopping is off, IUT transmits at lowest operating TX frequency.



- c) The spectrum analyzer settings shall be as follows:
- Center frequency: the lowest operating frequency
 - Span: Zero Span
 - Resolution Bandwidth: 3 MHz
 - Video Bandwidth: 3 MHz
 - Detector: Peak
 - Mode: Clear/Write
 - Sweptime: depending on packet type (one complete packet)
 - Trigger: extern (to signaling unit.)
- d) Tester calculates average power P_{AV} over at least 20% to 80% of the duration of the burst
(position of p0 defines the begin of the burst)
or
if the measuring system is not able to determine the p0 bit in the burst:
Tester calculates average power P_{AV} over at least 20% to 80% of the duration of the burst. (The duration of the burst is the time between the leading and trailing 3 dB points compared to the average power).
- e) Repeat b) to d) while the analyzer center frequency is set to:
the mid operating frequency; and the highest operating frequency.
These frequencies are defined in Section 6.3.2, "Frequencies for testing, loopback, hopping off."

NOTE:

When using test equipment that can follow the hopping sequence the low, mid, and upper frequencies can be tested when hopped to.

- f) The antenna gain G (in dBi) is added to the results (in dBm) measured in part a) to e) to calculate average equivalent isotropic radiated power $P_{AV \text{ EIRP}}$.
- Test Condition
Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

$$P_{AV \text{ EIRP}} < 100 \text{ mW (20 dBm) EIRP}$$

If the IUT is a power class 1 equipment:

- $P_{AV} > 1 \text{ mW (0 dBm)}$



If the IUT is a power class 2 equipment:

- $0.25 \text{ mW} (-6 \text{ dBm}) < P_{AV} < 2.5 \text{ mW} (4 \text{ dBm})$

If the IUT is a power class 3 equipment:

- $P_{AV} < 1 \text{ mW} (0 \text{ dBm})$

- Notes

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.2 RF/TRM/CA/BV-02-C [Power Density]

- Test Purpose

Verification of the maxim RF-output power density.

- Reference

[\[4\]](#)

- Initial Condition

- IUT in test mode loop back or TX mode.
- Hopping on.
- If IUT supports power control the tester sets the IUT's output power setting to maximum using LMP commands.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) Tester transmits longest supported DM or DH packet with full payload (1, 3 or 5 slot) with PRBS9 as payload to the IUT. (See Section 6.1 "Reference Signal Definition".)
- b) The spectrum analyzer settings shall be as follow:
 - Center frequency: 2441 MHz
 - Span: 240 MHz
 - Resolution Bandwidth: 100 kHz
 - Video Bandwidth: 100 kHz
 - Detector: Peak
 - Mode: Maxhold



- Sweeptime: 1 sec per 100 kHz span
- Trigger: freerun.

If the measurement equipment is not able to store one sample for each 100 kHz frequency range, the span may be split for several measurements.

- c) A trace is done and the peak value of the trace is found.
 - d) The spectrum analyzer is set to Zero Span, the center frequency is set to the frequency found in step c), and the sweep time is set to 1 minute. A single sweep shall be running.
 - e) The power density is calculated as the peak value of the trace captured in step d).
 - f) The antenna gain G (in dBi) is added to the results (in dBm) measured in part a) to e).
- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

Power Density < 100 mW (20dBm) per 100 kHz EIRP.

- Notes

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.3 RF/TRM/CA/BV-03-C [Power Control]

- Test Purpose

Verification of the TX power control.

- Reference

[1] 3

- Initial Condition

- IUT in test mode loop back or TX mode.
- Hopping off.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) Tester sets IUT to lowest operating TX frequency using LMP commands.
- b) Tester transmits DH1 packets with PRBS9 as payload to the IUT. (See Section 6.1 “Reference Signal Definition”.)
- c) The spectrum analyzer settings shall be as follow:
 - Center frequency: the lowest operating frequency
 - Span: Zero Span
 - Resolution Bandwidth: 3 MHz
 - Video Bandwidth: 3 MHz
 - Detector: Peak
 - Mode: Clear/Write
 - Sweeptime: one complete DH1 packet
 - Trigger: extern (to signaling unit)
- d) Tester calculates average power PAV over at least 20% to 80% of the duration of the burst (position of p0 defines the begin of the burst)
 or
 if the measuring system is not able to determine the p0 bit in the burst:
 Tester calculates average power PAV over at least 20% to 80% of the duration of the burst. (The duration of the burst is the time between the leading and trailing 3 dB points compared to the average power).
- e) Decrease IUT output power for one power step.
 The next measurement shall start after the IUT has reached the new power step (see IXIT statement, default value = 1 second, see Section 5.)
- f) Repeat step b) to f) until minimum possible output power step of the IUT is reached.
- g) Tester increases IUT's output power one step using LMP command. Repeat step b) to e). Step size is recorded by the tester.
- h) Repeat step h) to the maximum possible output power setting of the IUT.
- i) Repeat step b) to h) while the IUT receives (f_{RX}) / loops back (FTX) at:
 the mid operating frequency; and the highest operating frequency.
- j) These frequencies are defined Section 6.3.2, “Frequencies for testing, loopback, hopping off.”

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.



- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

Expected Outcome refers to the step size and to the minimum output power. The latter depends on the power class of the IUT.

Step size of the power control: $2\text{dB} \leq \text{step size} \leq 8\text{ dB}$

For power class 1 equipment:

- At minimum power step: $\text{PAV} < 4\text{dBm}$

- Notes

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.4 RF/TRM/CA/BV-04-C [TX Output Spectrum – Frequency Range]

- Test Purpose

Verification if the emissions inside the operating frequency range are within the limits.

- Reference

[1] 3

- Initial Condition

- IUT in test mode loop back or TX mode.
- Hopping off.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- IUT is set to lowest TX frequency.
- Tester transmits longest supported DM or DH packet with full payload (1, 3 or 5 slot) with PRBS9 as payload to the IUT. (See Section 6.1 “Reference Signal Definition”.)
- The spectrum analyzer settings shall be set as:
 - Resolution bandwidth (RBW): 100 kHz
 - Video bandwidth: 300 kHz



- Center frequency: lowest supported TX frequency
- Start frequency: see [Table 4.1](#)
- Stop frequency: see [Table 4.1](#)
- Detector: Peak
- Mode: averaging
- Sweep time: 2s (at least one burst per sample)
- Trigger: extern (to signaling unit)
- Number of sweeps: 50.

TX channel	Start frequency/MHz	Stop frequency/MHz
Lowest	2399	2405
Highest	2475	2485

Table 4.1: Start and Stop Frequency

- d) Find lowest frequency below the operating frequencies at which spectral power density drops below the level of -80 dBm/Hz e.i.r.p (-30 dBm if measured in a 100 kHz bandwidth). This frequency is called fL. It shall be recorded in the test report.
 - e) Set IUT to transmit on highest TX frequency.
 - f) Set spectrum analyzer center frequency to highest TX frequency. The other spectrum analyzer settings shall be as in step c).
 - g) Find highest frequency above the operating frequencies at which spectral power density drops below the level of -80 dBm/Hz e.i.r.p (-30 dBm if measured in a 100 kHz bandwidth). This frequency is called fH. It shall be recorded in the test report.
- IUT Test Condition
Common Test Case Conditions defined in Section [4.3](#) apply.
 - Expected Outcome
Pass Verdict
All values as measured shall fulfil the following conditions.
fL, fH within the allowed frequency band:
2.4 GHz – 2.4835 GHz
 - Notes
The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test

system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.5 RF/TRM/CA/BV-05-C [TX Output Spectrum – 20 dB Bandwidth]

- Test Purpose

Verification if the emissions inside the operating frequency range are within the limits.

- Reference

[1] 3.1.2.1

[5] Regulatory Requirement FCC Part 15.247, a(1ii)

- Initial Condition

- IUT in test mode loop back or TX mode.
- Hopping off.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

a) The IUT is set to transmit at:

- the lowest operating frequency.

The related receiving frequency is defined in Section 6.3.2, “Frequencies for testing, loopback, hopping off”

b) Tester transmits longest supported DM or DH packet with full payload (1, 3 or 5 slot) with PRBS9 as payload to the IUT. (See Section 6.1 “Reference Signal Definition”.)

c) The spectrum analyzer settings shall be as follows:

- Resolution bandwidth (RBW): 10 kHz
- Video bandwidth: 30 kHz
- Center frequency: f_{TX} center (lowest TX operating frequency)
- Span: 3.0 MHz
- Detector: Peak
- Mode: Maxhold
- Sweep time: ≥ 1 sec. per sweep.
- Trigger: freerun

- Number of sweeps: 10.
- d) Find the highest power value in the transmit channel (peak of the emission.)
- e) Find lowest frequency below the operating frequency at which transmit power drops 20 dB below the level measured in step d). This frequency is called f_L . It shall be recorded in the test report.
- f) Find highest frequency above the operating frequencies at transmit power drops 20 dB below the level measured in step d). This frequency is called f_H . It shall be recorded in the test report.
- g) The difference between the frequencies $\Delta f := |f_H - f_L|$ measured in the former steps is the 20 dB bandwidth. It shall be recorded in the test report.
- h) Repeat steps b) to g) while the IUT transmits (fTX) at:
 - the mid operating frequency; and
 - the highest operating frequency.

These frequencies and the related RX frequencies are defined in Section 6.3.2, “Frequencies for testing, loopback, hopping off.”

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

The Transmit spectrum shall fulfil the following mask:

- If the highest power value measured in step d) is equal or higher than 0 dBm:

$$f = |f_H - f_L| \leq 1.0 \text{ MHz}$$

- If the highest power value measured in step d) is lower than 0 dBm:

$$f = |f_H - f_L| \leq 1.5 \text{ MHz}$$

- Notes

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.6 RF/TRM/CA/BV-06-C [TX Output Spectrum – Adjacent Channel Power]

- Test Purpose

Verification if the emissions inside the operating frequency range are within the limits.



- Reference

[1] 3.1.2.1

- Initial Condition

- IUT in test mode loop back.
- Hopping off.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

The transmit frequency is defined by the index M (transmit frequency $f(M)$ is calculated according to Section 6.3, "Frequencies for testing" substituting M for k). In the same way, the measurement frequency is defined by the index N.

- IUT is set to transmit on (f_{TX}) = $f(3)$ ($M = 3$)
- Set $N := 0$.
- Tester transmits DH1 packets with PRBS9 as payload to the IUT (See Section 6.1, Reference Signal Definition).
- The Spectrum Analyzer shall be set as follows:
 - Span: Zero Span
 - Center frequency: $f(N) - 450$ kHz
 - Resolution bandwidth: 100 kHz
 - Video bandwidth: 300 kHz
 - Detector: Average
 - Mode: maxhold
 - Sweep time: 100 ms
 - Number of sweeps: 10
- Determine maximum value P_{TXn} of the trace.
- Increase center frequency for 100 kHz.
- Repeat step e) to f) until center frequency = $f(N) + 450$ kHz.
- Calculate $P_{TX}(f) = \sum(P_{TXi})$, $i = 1 \dots 10$.
- Increase center frequency by 1 MHz: $N := N+1$ AND skip to next frequency if the increased frequency equals to f_{TX} or " $f_{TX} - 1$ MHz" or " $f_{TX} + 1$ MHz".
- Repeat step c) to i) until $f(N)$ is above the maximum TX frequency.
- Set the IUT transmit frequency (f_{TX}) to:



- the mid operating frequency; and
- the frequency $f(M_{\max} - 3)$ where $f(M_{\max})$ corresponds to the highest operating frequency.

These frequencies (mid, high) and the related RX frequencies for polling are defined in Section 6.3.2, “Frequencies for testing, loopback, hopping off”

l) Set $N := 0$.

m) Repeat steps c) to j).

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

The IUT is transmitting on channel M and the adjacent channel power is measured on channel number N. N is chosen to cover the whole regulatory range, see Section 6.3.1, “Operating frequency bands”.

- $P_{TX}(f) \leq -20 \text{ dBm}$ for $|M-N| = 2$
- $P_{TX}(f) \leq -40 \text{ dBm}$ for $|M-N| \geq 3$

For each operating frequency M, exceptions in up to three bands are allowed where $|M-N| \geq 3$. For exceptions, $P_{tx}(f) \leq -20 \text{ dBm}$.

- Notes

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.7 RF/TRM/CA/BV-07-C [Modulation Characteristics]

- Test Purpose

Verification of the modulation index.

- Reference

[1] 3.1.1

- Initial Condition

- IUT in test mode loop back with whitening turned off or TX mode.



- Hopping off.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) IUT transmits (f_{TX}) at: lowest operating frequency
- b) Tester transmits longest supported DM or DH packet with full payload (1, 3 or 5 slot) with 11110000...-Bit pattern as payload.

The measurement bandwidth of the tester shall be at least 1.3 MHz. Passband ripple to ± 550 kHz: shall be a maximum of 0.5 dB (peak to peak)

It is recommended that the test equipment should use a measurement filter with the following specification:

Transition band minimum attenuations:

- ± 650 kHz: -3 dB
 - ± 1 MHz: -14 dB
 - ± 2 MHz: -44 dB
- c) Tester determines the position of bit p0 (see Section 6.7, "Definition of the position of Bit p0") in the packets looped back by the IUT. This is the timing reference to identify the bits in the payload field.
 - d) Tester calculates for each "00001111" 8 bit sequence in the payload the average frequency over the frequency values of the 8 bits. To determine the correct deviation value of each bit it shall be oversampled at least four times. Then take the average over these at least four samples as the deviation for each bit. For each second, third, sixth and seventh of the 8 bits the deviation from the average frequency within the bit period is recorded as Δf_{1max} .
 - e) The average of all the Δf_{1max} deviation values measured before is calculated, and recorded as Δf_{1avg} .
 - f) Tester transmits longest supported DM or DH packet with full payload (1, 3 or 5 slot) with 101010...-Bit pattern as payload.
 - g) Tester determines the position of bit p0 (see Section 6.7, "Definition of the position of Bit p0") in the packets looped back by the IUT. This is the timing reference to identify the bits in the payload field.
 - h) Starting with the second payload bit, the STE calculates for each "01010101" 8 bit sequence in the payload the average frequency over these 8 bits. For each of the 8 bits the maximum deviation from this average within the bit period is recorded as Δf_{2max} .
 - i) The average of all the maximum deviation values measured before is calculated, and recorded as Δf_{2avg} .
 - j) Repeat step b) to i) for at least 10 packets.



k) Repeat steps b) to j) while the IUT transmits (f_{TX}) at:

- the mid operating frequency; and
- the highest operating frequency.

These frequencies and the related RX frequencies are defined in Section 6.3.2, "Frequencies for testing, loopback, hopping off".

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

The average of all frequency deviations Δf_{1avg} , as measured, shall be within 140 kHz and 175 kHz.

At least 99.9% of all frequency deviations Δf_{2max} , as measured, shall be greater than 115 kHz.

The ratio of all frequency deviations Δf_{2avg} , as measured, and Δf_{1avg} shall not lie below 80%.

$$140 \text{ kHz} \leq \Delta f_{1avg} \leq 175 \text{ kHz}$$

$$\Delta f_{2max} \geq 115 \text{ kHz for at least 99.9\% of all } \Delta f_{2max}$$

$$\frac{\Delta f_{2avg}}{\Delta f_{1avg}} \geq 0.8$$

- Notes

Whitening shall be disabled while the test case is performed.

Alternatively it is allowed to use TX mode instead of loop back mode for sending the 1010. bit pattern and 1111000 ... bit pattern, if possible.

The figure of 99.9% was used to compensate the influence of the statistical distribution of the measured values as each single value is considered in the verdict.

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.



It is allowed for the tester to change the order of the test sequence in loopback and TX test mode. The tester can send and measure packets with either payload in any order.

4.5.8 RF/TRM/CA/BV-08-C [Initial Carrier Frequency Tolerance]

- Test Purpose

Verification of the transmitter carrier frequency accuracy

- Reference

[1] 3.1.1

- Initial Condition

- IUT in test mode loop back or TX mode.
- Hopping on.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- IUT transmits DH1 packets with PRBS9 as payload to the tester.
- Tester measures packets received at the lowest operating frequency. The measurement bandwidth of the tester shall be at least 1.3MHz. Passband ripple to +550kHz: shall be a maximum of 0.5 dB (peak to peak)

It is recommended that the test equipment should use a measurement filter with the following specification:

Transition band minimum attenuations:

+/- 650 kHz: -3 dB

+/- 1 MHz: -14 dB

+/-2 MHz: -44dB

- Tester determines the position of bit p0 (see Section 6.7, "Definition of the position of Bit p0") in the packets looped back by the IUT. This is the timing reference to identify the bits in the payload field.
- The tester makes an integration of the packet's 4 preamble bits and the first bit after the 4th preamble bit on the IUT's f_{TX} channel. The measurement shall start at the center of the first preamble bit until the center of the first bit following the 4th preamble bit.
- The IUT's carrier frequency shall be assumed to be the result of this integration done in d) and is named f₀.
- Repeat step b) to e) for at least 10 packets.

g) Repeat steps c) to f) with packets measured:

- the mid operating frequency; and
- the highest operating frequency.

(These frequencies can be found in Section 6.3.2, “Frequencies for testing, loopback, hopping off”.)

When using test equipment that can follow the hopping sequence the low, mid, and upper frequencies can be tested when hopped to.

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

Each of the IUT's carrier frequency f_0 as measured shall be within ± 75 kHz from the IUT's chosen nominal carrier frequency f_{TX} .

$$f_{TX} - 75 \text{ kHz} \leq f_0 \leq f_{TX} + 75 \text{ kHz}.$$

- Notes

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.9 RF/TRM/CA/BV-09-C [Carrier Frequency Drift]

- Test Purpose

Verification of the transmitter center frequency drift within a packet.

- Reference

[1] 3.1.1

- Initial Condition

- IUT in loop back mode with whitening turned off or TX mode.
- Hopping on.

It shall be defined after which time the measurement starts.



- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- IUT transmits packets with a 1010-sequence as payload. All supported packets (DH1/3/5) with the longest supported payload length are used.
- Tester measures packets received at the lowest operating frequency. The measurement bandwidth of the tester shall be at least 1.3MHz. Passband ripple to +550KHz: shall be a maximum of 0.5dB (peak to peak)

It is recommended that the test equipment should use a measurement filter with the following specification:

Transition band minimum attenuations:

+/- 650 kHz: -3 dB

+/- 1 MHz: -14 dB

+/- 2 MHz: -44dB

- Tester determines the position of bit p0 (see Section 6.7, "Definition of the position of Bit p0") in the packets looped back by the IUT. This is the timing reference to identify the bits in the payload field.
- The tester makes an integration of the packet's 4 preamble bits and the first bit after the 4th preamble bit on the IUT's f_{TX} channel. The measurement shall start at the center of the first preamble bit until the center of the first bit following the 4th preamble bit. The IUT's carrier frequency shall be assumed to be the result of this integration and is named f₀.
- Tester integrates the frequency deviations of every 10 bit symbols in the payload body (k-th measurement leads to f_k). The measurement shall start with the 2nd payload bit, so that the first 10 bit block includes payload bit 2-11.
- Repeat step b) to e) for at least 10 packets.
- Repeat step b) to f) for all supported packet lengths (DH1/3/5 packets)
- Repeat steps c) to g) with packets measured at:
 - mid operating frequency; and
 - highest operating frequency.

These frequencies can be found in Section 6.3.2, "Frequencies for testing, loopback, hopping off"

When using test equipment that can follow the hopping sequence the low, mid, and upper frequencies can be tested when hopped to.

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.



- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

The transmitter center frequency is not allowed to drift more than the limits given in [Table 4.2](#).

Type of Packet	Frequency Drift
One slot packet	± 25 kHz
Three slot packet	± 40 kHz
Five slot packet	± 40 kHz

Table 4.2: Frequency Drift within a packet

The frequency drift limits apply to the difference between the average frequency of the 4 preamble bits f_0 and the average frequency of any 10 bits in the payload field of the returned packets f_k .

The maximum drift rate applies to the difference between any two 10-bit groups separated by 50 μ s within the payload field of the returned packets.

$$|f_{k+5} - f_k| \leq 20000 \text{ Hz, } k=1 \dots \text{max.}$$

- Notes

Whitening shall be disabled while the test case is performed.

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required.

However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.10 RF/TRM/CA/BV-10-C [EDR Relative Transmit Power]

- Test Purpose

This test ensures the difference in average transmit power during frequency modulated [GFSK] and phase modulated [DPSK] portions of a packet is within an acceptable range.

- Reference

[\[1\]](#) 3.2.4

- Initial Condition

- IUT in test mode loop back or TX mode, with whitening off.



- Hopping off (transmit and receive frequencies are defined in Section 6.3.2.
- If IUT supports power control the tester sets the IUT's output power setting to maximum using LMP commands.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) IUT transmits longest supported $\pi/4$ -DQPSK packet type (2-DHx or 2-EVx) with maximum length payload containing PRBS9.
- b) IUT transmits at lowest operating TX frequency.
- c) The spectrum analyzer shall be set as follows:
 - Center frequency: IUT transmit frequency
 - Span: Zero Span
 - Resolution Bandwidth: 3 MHz
 - Video Bandwidth: 3 MHz
 - Detector: Average (Sample may also be used)
 - Mode: Clear Write (continuous update)
 - Sweptime: depending on packet type (one complete packet)
 - Trace Average: 10
- d) Tester calculates average power PGFSK over at least 80% of the GFSK portion (Access Code & Header period) of the packet.
- e) Tester calculates the average power PDPSK over at least 80% of the DPSK portion of the packet (Synchronization sequence and payload)
- f) Repeat step d) to f) while the IUT transmits at:
 - the mid operating frequency; and
 - the highest operating frequency.
- g) If power control is supported, repeat steps c) through f) with IUT transmitting minimum output power. If the IUT does not support power control, continue to step h).
- h) If 8DPSK modulation is supported by the IUT, repeat steps b) to h) while the IUT transmits longest supported 8DPSK packet type (3-DHx or 3-EVx) with maximum length payload containing PRBS9.

- Test Conditions

Common Test Case Conditions defined in Section 4.3 apply.



- Expected Outcome

Pass Verdict

For all pairs of results: $(\text{PGFSK} - 4\text{dB}) < \text{PDPSK} < (\text{PGFSK} + 1\text{dB})$

4.5.11 RF/TRM/CA/BV-11-C [EDR Carrier Frequency Stability and Modulation Accuracy]

- Test Purpose

This test verifies the transmitter carrier frequency stability and modulation accuracy.

- Reference

[1] 3.2.1.4, 3.2.3

- Initial Condition

- IUT in test mode loop back or TX mode, with whitening off.
- Hopping off (transmit and receive frequencies are defined in Section 6.3.2.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) IUT transmits the longest supported $\pi/4$ -DQPSK packet type (2-DH1, 2-DH3, 2-DH5, 2-EV3, or 2-EV5). The user payload bytes contain PRBS9 pseudo-random data. The number of user payload bytes is 31 for 2-DH1 packets, 58 for 2-EV3 packets, 356 for 2-DH3 packets, 358 for 2-EV5 packets or 656 for 2-DH5 packets.
- b) IUT transmits at the lowest operating frequency.
- c) Tester calculates the initial center frequency error for a packet transmitted by the IUT using the following method applied to the basic rate portion of the packet:
 - a. Tester determines the start time of the first preamble bit p0 using the measurement method.
 - b. Tester calculates the frequency deviations at the bit centers (referenced to p0) of the packet header bits, relative to the ideal carrier frequency.
 - c. Tester selects those bits from the header that have the same value as both the previous and following bits so are not significantly affected by inter-symbol interference (there will be at least 18 bits of this type). The tester may also select other bits from the header, but the frequency deviations of these bits shall be compensated to remove inter-symbol interference.
 - d. Tester calculates the average frequency deviation $\Delta\omega_1$ of those selected packet header bits that represent a transmitted '1'.
 - e. Tester calculates the average frequency deviation $\Delta\omega_2$ of those selected packet header bits that represent a transmitted '0'.
 - f. Tester calculates the initial frequency error $\omega_i = (\Delta\omega_1 + \Delta\omega_2)/2$.



- d) Tester compensates the Enhanced Data Rate portion of the packet for the initial frequency error ω_i of the packet.
- e) Tester applies a square-root raised cosine measurement filter with a roll-off factor of 0.4 and a 3 dB bandwidth of ± 500 kHz to the Enhanced Data Rate portion of the packet.
- f) Tester partitions the output of the measurement filter into non-overlapping blocks of 50 μ secs beginning at the nominal start of the synchronization symbol following the reference symbol and finishing at the nominal end of the final payload CRC symbol (the number of user payload bytes has been chosen to make this an integral number of blocks).
- g) For each block, tester calculates the sampling phase ϵ_0 and frequency error ω_0 for the RMS DEVM for the block, as defined Appendix C of the Enhanced Data Rate RF Specification (note that this computation includes information from the symbol immediately before the block in order to generate the 50 differential error vectors). The frequency error ω_0 and the RMS DEVM for each block are recorded.
- h) For each block, tester calculates the DEVM for each symbol in the block using the sampling phase ϵ_0 and frequency error ω_0 for the block as calculated in step g). The DEVM for each symbol is recorded.
- i) Repeat steps c) to h) for further packets transmitted by the IUT until a total of 200 blocks have been measured (any remaining blocks from the end of the final packet should be discarded).
- j) Repeat steps b) to i) while the IUT transmits at:
 - The mid operating frequency; and
 - The highest operating frequency
- k) If 8DPSK modulation is supported by the IUT, repeat steps b) to j) using the longest supported 8DPSK packet type (3-DH1, 3-DH3, 3-DH5, 3-EV3, or 3-EV5). The user payload bytes contain PRBS9 pseudo-random data. The number of user payload bytes is 11 for 3-DH1 packets, 88 for 3-EV3 packets, 536 for 3-DH3 packets, 538 bytes for 3-EV5 packets or 986 for 3-DH5 packets.

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

If the IUT does not support 8DPSK modulation then the outcomes based on this modulation do not apply.

All values as measured shall fulfil the following conditions:

1. Carrier frequency stability:
 - 75 kHz $\leq \omega_i \leq$ +75 kHz, for all packets
 - 75 kHz $\leq (\omega_i + \omega_0) \leq$ +75 kHz, for all blocks
 - 10 kHz $\leq \omega_0 \leq$ +10 kHz, for all blocks



2. RMS DEVM:

$\text{RMS DEVM} \leq 0.20$, for all $\pi/4$ -DQPSK blocks

$\text{RMS DEVM} \leq 0.13$, for all 8DPSK blocks

3. Peak DEVM:

$\text{DEVM} \leq 0.35$ for all $\pi/4$ -DQPSK symbols

$\text{DEVM} \leq 0.25$ for all 8DPSK symbols

4. 99% DEVM:

$\text{DEVM} \leq 0.30$, for 99% of $\pi/4$ -DQPSK symbols

$\text{DEVM} \leq 0.20$, for 99% of 8DPSK symbols

- Notes

The tester shall check that the correct packet type (for loop back and TX test modes) and payload (for loop back test mode only) have been transmitted by the IUT; any invalid packets should be discarded to avoid corruption of the measurements.

For measurements based on basic rate symbols:

- The requirements on the measurement bandwidth of the tester are the same as used in TRM/CA/BV-07-C Modulation Characteristics.
- The method for measuring the position of bit p0 in the basic rate signal is that same as used in TRM/CA/BV-07-C Modulation Characteristics.
- The minimum sampling rate for the basic rate portion of the packet is 8 samples per bit period in order to obtain a sufficiently accurate estimate of the initial frequency error (interpolation may be used to obtain this sampling rate from a lower initial sampling rate).
- It is recommended that the tester uses combinations of UAP and AM_ADDR values that result in non-whitened packet headers with at least five 1's and at least five 0's (including the HEC, but prior to FEC) to ensure a good estimate of initial carrier frequency.

For measurements based on Enhanced Data Rate symbols:

- The number of user payload bytes has been chosen to be as close as possible to the maximum packet size, subject to the constraint that the synchronization symbols, the two payload header bytes (for n-DHx packets), the user payload and the two CRC bytes constitute an integer number of DEVM blocks. This ensures that the modulation accuracy of all symbols, other than the trailer symbols, is measured.
- The PRBS9 pseudo random generator is initialized with a seed of all ones at the beginning of each test packet. The first PRBS9 output bit represents the least significant bit of the first user payload byte.
- The definition of the square-root raised cosine measurement filter is given in [RF Spec]. The measurement filter frequency response shall be accurate of ± 0.25 dB up to 0.65 MHz from the

carrier frequency and shall provide at least 40 dB suppression for frequencies more than 0.8 MHz from the carrier frequency. The measurement filter requirement is referenced to the connector on the IUT, so includes the contributions due to all aspects of the signal processing applied by the tester.

- The tester shall give an RMS DEVM of less than 3% and a Peak DEVM of less than 8% when a test signal from a reference signal generator is applied and the defined test procedure is followed. This requirement shall be met when the test signal has any frequency error up to ± 75 kHz and any symbol rate error up to ± 20 ppm.

4.5.12 RF/TRM/CA/BV-12-C [EDR Differential Phase Encoding]

- Test Purpose

Verification that the modulator correctly differential phase encodes the data.

- Reference

[\[1\]](#) 3.2.1.2

- Initial Condition

- IUT in TX mode with whitening turned off
- Hopping off (transmit and receive frequencies are defined in Section [6.3.2](#).)
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) IUT transmits 2-DH1 or 2-EV3 packets to the tester with maximum length payload containing PRBS9.
- b) IUT transmits at lowest operating frequency.
- c) Tester demodulates 100 packets and compares each payload with the expected PRBS9 data.
- d) If 8DPSK modulation is supported by the IUT repeat steps b) and c) using 3-DH1 or 3-EV3 packets with maximum length payload containing PRBS9.

- Test Condition

Common Test Case Conditions defined in Section [4.3](#) apply.

- Expected Outcome

Pass Verdict

The expected outcome of this test is zero errors detected by the tester in 99% of the packets.

- Notes

The PRBS9 pseudo random generator is initialized with a seed of all ones at the beginning of each test packet. The first PRBS9 output bit represents the least significant bit of the first user payload byte.



4.5.13 RF/TRM/CA/BV-13-C [EDR In-band Spurious Emissions]

- Test Purpose

Verification that the level of unwanted signals from the DPSK transmitter, within the frequency range used by the device, is below the required level.

- Reference

[1] 3.2.2.1

- Initial Condition

- IUT in test mode loop back or TX mode, with whitening off.
- Hopping off (transmit and receive frequencies are defined in Section 6.3.2).
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

The transmit frequency is defined by the index M (transmit frequency $f(M)$ is calculated according to Section 6.3, (substituting M for k). In the same way the measurement frequency is defined by the index N. N is chosen to cover the whole regulatory range, see Section 6.3.1.

- Tester transmits longest supported $\pi/4$ -DQPSK packet type (2-DHx or 2-EVx) with maximum length payload containing PRBS9.
- IUT is set to transmit on $(f_{TX}) = f(3)$ ($M = 3$)
- Set $N := 0$
- The Spectrum Analyzer shall be set as follows:
 - Span: Zero Span
 - Center frequency: $f(N) - 450$ kHz
 - Resolution bandwidth: 100 kHz
 - Video bandwidth: 300 kHz
 - Detector: Average
 - Mode: Max Hold
 - Gating: Edge
 - Gating Delay, Length: Adjust to include the guard period, the DPSK portion of the packet and the power down ramp
 - Sweep time: Setting dependent on packet length (one complete packet)
 - Number of sweeps: 10

- e) If $|M-N| > 1$,
 - i) Set center frequency to $f(N) - 450\text{kHz}$ and set $n := 1$
 - ii) Determine maximum value PTX_n of the trace
 - iii) Increase center frequency by 100 kHz and set $n := n+1$
 - iv) Repeat steps ii) and iii) until center frequency $> f(N) + 450\text{kHz}$
 - v) Calculate $\text{PTX}(f) = \sum(\text{PTX}_i)$, $i = 1 \dots 10$
- f) If $(M-N) = +1$,
 - i) Set center frequency to $f(N) - 450\text{kHz}$ and set $n := 1$
 - ii) Determine maximum value PTX_n of the trace
 - iii) Increase center frequency by 100 kHz and set $n := n+1$
 - iv) Repeat steps ii) and iii) until center frequency $> f(N) - 50\text{kHz}$
 - v) Calculate $\text{PTX} - 26\text{dB}(f) = \text{Sum}(\text{PTX}_i)/5$, $i = 1 \dots 5$
- g) If $(M-N) = 0$,
 - i) Set center frequency to $f(N) - 450\text{kHz}$ and set $n := 1$
 - ii) Determine maximum value PTX_n of the trace
 - iii) Increase center frequency by 100 kHz and set $n := n+1$
 - iv) Repeat steps ii) and iii) until center frequency $> f(N) + 450\text{kHz}$
 - v) Calculate $\text{PTX}_{\text{ref}}(f) = \max(\text{PTX}_i)$, $i = 1 \dots 10$
- h) If $(M-N) = -1$,
 - i) Set center frequency to $f(N) + 50\text{kHz}$ and set $n := 1$
 - ii) Determine maximum value PTX_n of the trace
 - iii) Increase center frequency by 100 kHz and set $n := n+1$
 - iv) Repeat steps ii) and iii) until center frequency $> f(N) + 450\text{kHz}$
 - v) Calculate $\text{PTX} - 26\text{dB}(f) = \text{Sum}(\text{PTX}_i)/5$, $i = 1 \dots 5$
- i) Set $N := N+1$
- j) Repeat steps d) to h) until $f(N)$ is above the maximum TX frequency.
- k) Repeat steps c) to i) with the IUT transmit frequency (f_{TX}) set to:
 - The mid operating frequency; and
 - The frequency $f(M_{\text{max}}-3)$, where $f(M_{\text{max}})$ is the highest operating frequency
 - These frequencies and the related receive frequencies are defined in Section [6.3.2](#).

- l) If 8DPSK modulation is supported by the IUT, repeat steps b) to j) while the IUT transmits longest supported 8DPSK packet type (3-DHx or 3-EVx) with maximum length payload containing PRBS9.

- Test Conditions

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

- $PTX-26dB(f) \leq PTX_{ref} - 26 \text{ dB}$ for $|M-N| = 1$
- $PTX(f) \leq -20 \text{ dBm}$ for $|M-N| = 2$
- $PTX(f) \leq -40 \text{ dBm}$ for $|M-N| \geq 3$.

For each operating frequency M, exceptions in up to three bands are allowed where $|M - N| \geq 3$. For exceptions, $P_{tx}(f) \leq -20 \text{ dBm}$.

- Notes

This test is similar to TRM/CA/BV-06-C except here the measurement is gated to cover only the DPSK portion of the packet.

4.5.14 RF/TRM/CA/BV-14-C [Enhanced Power Control]

- Test Purpose

Verification of the TX Enhanced power control.

- Reference

[1] 3

- Initial Condition

- IUT in test mode loop back or TX mode may be used, whitening off.
- Hopping off.
- The tester puts the IUT at maximum output power using the LMP_power_control_req PDU with the power adjustment_req set to "go to max."

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) Tester sets IUT to lowest operating TX frequency using LMP commands.
- b) Tester transmits DH1 packets with PRBS9 as payload to the IUT. (See Section 65, "Reference Signal Definition")



- c) The spectrum analyzer settings shall be as follows:
 - Center frequency: the lowest operating frequency
 - Span: Zero Span
 - Resolution Bandwidth: 3 MHz
 - Video Bandwidth: 3 MHz
 - Detector: Peak
 - Mode: Clear/Write
 - Sweeptime: one complete packet as selected under step b)
 - Trigger: extern (to signaling unit)
- d) Tester calculates average power PAV over at least 20% to 80% of the duration of GFSK header of the burst (position of p0 defines the beginning of the burst).
- e) Repeat steps b) to e) for the IUT transmitting 2-DH1 and 3-DH1 packet types (EDR packets) if they are supported.
- f) Tester uses the power change request LMP command to decrease the IUT output power for one power step.

The next measurement shall start after the Tester has received the power change response for the power change request from the IUT.

- g) Repeat step b) to g) until minimum output power of the IUT is indicated by the Power change response for all supported modulations.

The power step size of each modulation, if the response indicates a power change for the modulation, and the difference between the GFSK header of the different modulations, are recorded for each step.

- h) Tester uses the power change request LMP command to increase the IUT output power one step.

The next measurement shall start after the Tester has received the power change response for the power change request from the IUT.

- i) Repeat step b) to f) and i) until the maximum output power of the IUT is indicated by the Power change response for all modulations supported.

The power step size of each modulation, if the response indicates a power change for the modulation, and the difference between the GFSK header of the different modulations, are recorded for each step.

- j) Repeat step b) to j) while the IUT transmits
 (f_{TX}) / loops back $(f_{RX} - f_{TX})$ at: the mid operating frequency; and the highest operating frequency.

These frequencies are defined in Section 6.3.2, "Frequencies for testing, loopback, hopping off".

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.



- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

Expected outcome depends on the power class of the IUT.

- Step size for the enhanced power control requests for all supported modulations $2\text{dB} \leq \text{step size} \leq 8\text{ dB}$.
- The power differences between GFSK headers of the supported modulations at every stage within 10dB ($\leq 10\text{dB}$).
- For power class 1 equipment: At minimum power step of all supported modulations: $P_{AV} \leq 4\text{dBm}$.
- The Maximum power level for each of the supported modulations measured in stage e) at the start of the test is within +/- 3dB of the power measured at the end of the test sequence when the IUT has reported maximum power for each of the supported modulations.

- Notes

The test case should be performed using loopback mode. If so, the test system shall ensure that the test case is not failed due to not correctly recognized return packets or payload failure, i.e: The test system shall provide a means to check the correct packet type. In addition it is recommended that the payload content is checked as well if required. However, if it is required and the test system does not provide a means to distinguish packet types, the TX mode might be used instead if supported by both, test system and IUT.

4.5.15 RF/TRM/CA/BV-15-C [EDR Guard Time]

- Test Purpose

Verify the duration of the guard time between the basic rate packet header and the Enhanced Data Rate synchronization sequence.

- Reference

[6] 6.6.1

- Initial Condition

- IUT in test mode loop back or TX mode (or manual configuration if loopback is not available), whitening off.
- Hopping off.
- IUT transmits at maximum output power back to the Lower Tester

- Test Procedure

- IUT transmits maximum length 2-DH1 or 2-EV3 packets containing PRBS9.
- Lower Tester demodulates a packet.
- Lower Tester determines the start time of the first preamble bit p0 using the measurement method defined in section 6.6 of the Radio Frequency Test Suite [5].



- d) Lower Tester determines the start time of the reference symbol of the Enhanced Data Rate portion of the packet from the Enhanced Data Rate synchronization sequence. The start time of the reference symbol is defined as 1 μ s before the time when the symbol following the reference symbol becomes the dominant contributor to the transmitter's instantaneous phase. The required method of determining the start time of the reference symbol is provided in the Notes section.
 - e) Lower Tester determines the guard time, that is the time difference between the end of the last header symbol (defined as 126 microseconds after p0) and the start of the reference symbol of the Enhanced Data Rate portion, referenced to the output of the IUT transmitter.
 - f) Repeat steps b) to e) for 100 packets
 - g) If Enhanced Data Rate 3 Mbps payload data rate is supported by the IUT, repeat steps b) to f) using maximum length 3-DH1 or 3-EV3 packets containing PRBS9 data.
- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

95% of the measured guard times of the packets must fall within the range $4.75 - \epsilon \mu\text{s} < \text{guard time} < 5.25 + \epsilon \mu\text{s}$, where $\epsilon = 0.15 \mu\text{s}$ is the allowed uncertainty due to the measurement process.

- Notes

The Lower Tester should use all the symbols in the synchronization sequence to determine the timing of the reference symbol.

Background of Method of Measurement

The method of determining the start time of the reference symbol is based on the following observation.

According to Section 3.2.1.3 of [5], the lowpass equivalent information bearing signal $v(t)$ is given by:

$$v(t) = \sum_k S_k p(t - kT)$$

Symbol K becomes the dominant contributor to the transmitter phase when:

$$p(t - KT) > \left(\sum_k p(t - kT) \right) - p(t - KT)$$

$$2p(t - KT) > v(t)$$

The instantaneous frequency of the signal will be:

$$f = f_c + \frac{d}{dt} \tan^{-1} \left(\frac{\text{imag}(v(t))}{\text{real}(v(t))} \right)$$

It can be shown that:

$$2p(t - KT) = vt \Rightarrow \frac{df}{dt} = 0$$

At the point where symbol K becomes the dominant contributor then the instantaneous frequency will have an extreme value.

The position of the start of the reference symbol, s_0 , is calculated using an averaging based on the position of all the frequency extremes in the sync word.

Required Measurement Method

The required method of measuring the start of the reference symbol and thus the guard time is defined below.

Set the test equipment to vector analyzer mode and turn on FM demodulation with symbol rate 1 MHz. Trigger by any means to achieve reliable viewing of the guard period. Look for and identify the synchronization sequence. The start of the reference symbol is defined to be one micro-second preceding the first frequency extreme of the synchronization sequence.

For the 10 frequency extreme values in the sync word, the i 'th frequency extreme value time is $t(i)$ in μsec , this is the start of symbol i .

$$1 \leq i \leq 10$$

The start of symbol s_0 is then

$$t_0 = \frac{1}{10} \sum_{i=1}^{10} (t(i) - i \times \text{symbol time})$$

where symbol time is 1 μsec .

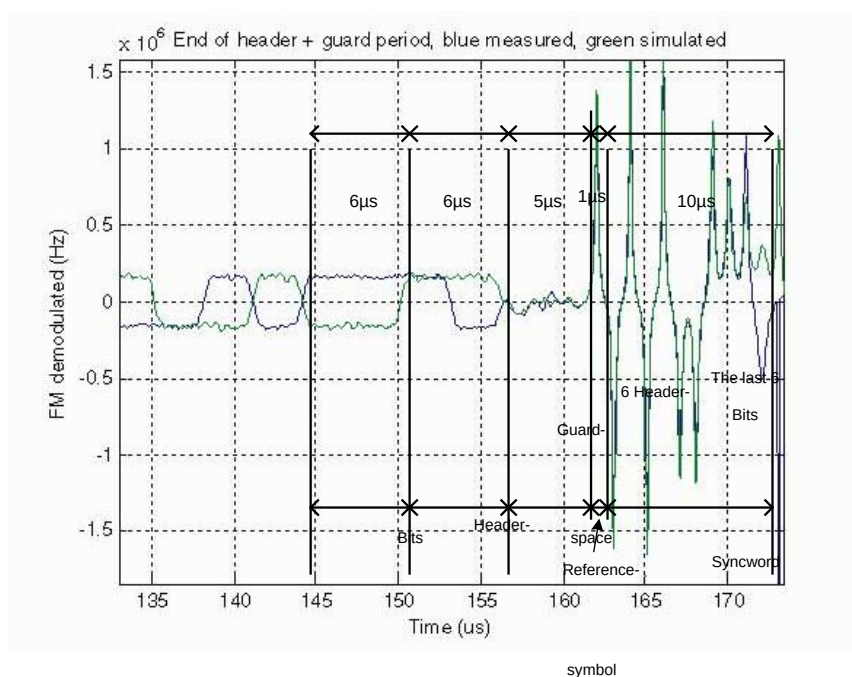


Figure 4.1: Instantaneous Frequency of Signal about the Guard Time

Instantaneous Frequency of Signal about the Guard Time is a plot of how the instantaneous frequency will look during the last bits of the header and the EDR sync word:

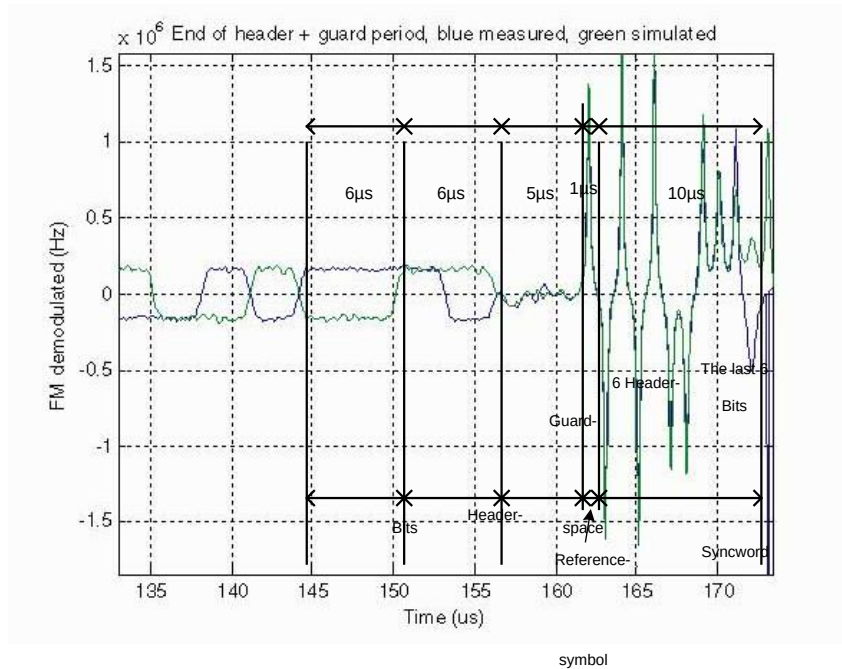


Figure 4.2: Instantaneous Frequency of Signal about the Guard Time

4.5.16 RF/TRM/CA/BV-16-C [EDR Synchronization Sequence and Trailer]

- Test Purpose

Verify the synchronization sequence and trailer symbols that are transmitted in Enhanced Data Rate packets.

- Reference

[6] 6.6.1

- Initial Condition

- IUT in test mode loop back or TX mode (or manual configuration if loopback is not available), whitening off.
- Hopping off.
- IUT transmits at maximum output power back to the Lower Tester

- Test Procedure

- IUT transmits maximum length 2-DH1 or 2-EV3 packets containing PRBS9 data.
- Lower Tester demodulates a packet, including the synchronization sequence and the two trailer symbols.
- Lower Tester compares the demodulated bits corresponding to the synchronization sequence with the correct bit sequence defined in [1] and compares the demodulated trailer bits with zeros.
- Repeat step b) to c) for 50 packets.

- e) If Enhanced Data Rate 3 Mbps payload data rate is supported by the IUT, repeat steps b) to d) with maximum length 3-DH1 or 3-EV3 packets containing PRBS9 data.

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

For each modulation, the Expected Outcome over all 50 tested packets is zero bit errors in the synchronization sequences and no more than one bit error in all the trailer symbols.

4.6 Receiver

4.6.1 RF/RCV/CA/BV-01-C [Sensitivity – single slot packets]

- Test Purpose

The sensitivity is tested using a non-ideal transmitter (one-slot packet). This test case defines the signal sent to the IUT in detail. The IUT shall meet the required sensitivity for this non-ideal signal.

- Reference

[1] 4.1.1

- Initial Condition

- IUT in test mode. Loop back.
- Hopping off.
- IUT transmits at maximum output power back to the tester.
- The tester's transmit power is chosen such that the input power to the IUT receiver is – 70 dBm.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) IUT receives (f_{RX})/loops back (f_{TX}) at:
 - the lowest operating frequency.
- b) The tester continuously sends DH1 packets to the IUT. The Payload is PRBS9.
- c) The properties of the packets are chosen according to Table 4.4. Beside those parameters, the reference signal settings of Section 6.1, “Reference Signal Definition” have to be used. The tester transmits the first 20 ms using the first parameter set (see Table 4.4). The second 20 ms are transmitted with parameter set 2 and so forth. After the 10th set of parameters has been used, the tester continues using the first set again.
- d) The returned packets are received and the BER is measured by the tester according to Section 6.6 “Bit error rate (BER) measurements” (minimum number of samples, 1 600 000 returned payload bits.)

- e) Repeat steps b) to d) while the IUT receives (f_{RX}) /loops back (f_{TX}) at:
- the mid operating frequency; and
 - the highest operating frequency.

These frequencies and the related RX frequencies are defined in Section 6.3.2, “Frequencies for testing, loopback, hopping off”.

Set of Parameters	Carrier Frequency offset	Modulation index	Symbol Time Period Error
1	75 kHz	0.28	- 20 ppm
2	14 kHz	0.30	- 20 ppm
3	- 2 kHz	0.29	+ 20 ppm
4	1 kHz	0.32	+ 20 ppm
5	39 kHz	0.33	+ 20 ppm
6	0 kHz	0.34	- 20 ppm
7	-42 kHz	0.29	- 20 ppm
8	74 kHz	0.31	- 20 ppm
9	-19 kHz	0.28	- 20 ppm
10	-75 kHz	0.35	+ 20 ppm

Table 4.3: Dirty Transmitter Single Slot Packets

Additionally, to the described dirty transmitter signal parameters in Table 4.4, a synchronized sine wave frequency modulation (alternate packets will switch start phase between 0 and 180 degrees) with a deviation of $\pm 25\text{kHz}$ and a modulation frequency of 1,6kHz shall be modulated on the signal to realize the carrier frequency drift.

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

$\text{BER} \leq 0.1\%$ (minimum number of samples, 1 600 000 returned payload bits.)



- Uncertainties

It shall be fixed if the measurement equipment can support a dirty transmitter as specified in this test case.

- Notes

If suitable test equipment is available this test case should be done with hopping on.

4.7 Receiver

4.7.1 RF/RCV/CA/BV-01-C [Sensitivity – single slot packets]

- Test Purpose

The sensitivity is tested using a non-ideal transmitter (one-slot packet). This test case defines the signal sent to the IUT in detail. The IUT shall meet the required sensitivity for this non-ideal signal.

- Reference

[1] 4.1.1

- Initial Condition

- IUT in test mode. Loop back.
- Hopping off.
- IUT transmits at maximum output power back to the tester.
- The tester's transmit power is chosen such that the input power to the IUT receiver is – 70 dBm.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) IUT receives (f_{RX})/loops back (f_{TX}) at:
 - the lowest operating frequency.
- b) The tester continuously sends DH1 packets to the IUT. The Payload is PRBS9.
- c) The properties of the packets are chosen according to [Table 4.4](#). Beside those parameters, the reference signal settings of Section [6.1](#), “Reference Signal Definition” have to be used. The tester transmits the first 20 ms using the first parameter set (see [Table 4.4](#)). The second 20 ms are transmitted with parameter set 2 and so forth. After the 10th set of parameters has been used, the tester continues using the first set again.
- d) The returned packets are received and the BER is measured by the tester according to Section [6.6](#) “Bit error rate (BER) measurements” (minimum number of samples, 1 600 000 returned payload bits.)
- e) Repeat steps b) to d) while the IUT receives (f_{RX}) /loops back (f_{TX}) at:
 - the mid operating frequency; and
 - the highest operating frequency.

These frequencies and the related RX frequencies are defined in Section 6.3.2, “Frequencies for testing, loopback, hopping off”.

Set of Parameters	Carrier Frequency offset	Modulation index	Symbol Time Period Error
1	75 kHz	0.28	- 20 ppm
2	14 kHz	0.30	- 20 ppm
3	- 2 kHz	0.29	+ 20 ppm
4	1 kHz	0.32	+ 20 ppm
5	39 kHz	0.33	+ 20 ppm
6	0 kHz	0.34	- 20 ppm
7	-42 kHz	0.29	- 20 ppm
8	74 kHz	0.31	- 20 ppm
9	-19 kHz	0.28	- 20 ppm
10	-75 kHz	0.35	+ 20 ppm

Table 4.4: Dirty Transmitter Single Slot Packets

Additionally, to the described dirty transmitter signal parameters in Table 4.4, a synchronized sine wave frequency modulation (alternate packets will switch start phase between 0 and 180 degrees) with a deviation of ± 25 kHz and a modulation frequency of 1,6kHz shall be modulated on the signal to realize the carrier frequency drift.

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

$BER \leq 0.1\%$ (minimum number of samples, 1 600 000 returned payload bits.)

- Uncertainties

It shall be fixed if the measurement equipment can support a dirty transmitter as specified in this test case.



- Notes

If suitable test equipment is available this test case should be done with hopping on.

4.7.2 RF/RCV/CA/BV-02-C [Sensitivity - multi-slot packets]

- Test Purpose

Multi-slot packets are sent to the IUT at the sensitivity level. (maximum allowed length). This test case defines the signal sent to the IUT in detail. The IUT shall meet the required sensitivity for this non-ideal signal.

- Reference

[1] 4.1.1

- Initial Condition

- IUT in test mode loop back.
- Hopping off.
- IUT transmits at maximum output power back to the tester.
- The tester's transmit power is chosen such that the input power to the IUT receiver is – 70 dBm.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) IUT receives (f_{RX})/loops back (f_{TX}) at the lowest operating frequency.
- b) The tester continuously sends DH5 packets (if 5-slot packets are not supported, but 3-slot packets are: DH3 packets are used instead) to the IUT. Payload is the PRBS9.
- c) The properties of the packets are chosen according to [Table 4.5](#). Beside those parameters the reference signal settings of Section 6.1, “Reference Signal Definition” have to be used. The tester transmits the first 20 ms using the first parameter set (see [Table 4.5](#)). The second 20 ms are transmitted with parameter set 2 and so forth. After the 10th set of parameters has been used the tester continues using the first set again.
- d) The returned packets are received and the BER is measured by the tester according to Section 6.6 “Bit error rate (BER) measurements” (minimum number of samples, 1 600 000 returned payload bits.)
- e) Repeat steps b) to d) while the IUT receives (f_{RX})/loops back (f_{TX}) (f_{TX}) at:
 - the mid operating frequency; and
 - the highest operating frequency.

These frequencies and the related RX frequencies are defined in Section 6.3.2 “Frequencies for testing, loopback, hopping off”.



Set of Parameters	Carrier Frequency offset	Modulation index	Symbol Time Period Error
1	75 kHz	0.28	- 20 ppm
2	14 kHz	0.30	- 20 ppm
3	- 2 kHz	0.29	+ 20 ppm
4	1 kHz	0.32	+ 20 ppm
5	39 kHz	0.33	+ 20 ppm
6	0 kHz	0.34	- 20 ppm
7	-42 kHz	0.29	- 20 ppm
8	74 kHz	0.31	- 20 ppm
9	-19 kHz	0.28	- 20 ppm
10	-75 kHz	0.35	+ 20 ppm

Table 4.5: Dirty Transmitter Multi Slot Packets

Additionally, to the described dirty transmitter signal parameters in [Table 4.5](#), a frequency modulation with a deviation of ± 40 kHz and a synchronized sine wave modulation frequency (alternate packets will switch start phase between 0 and 180 degrees) of 500 Hz for 3 slot packets and 300 Hz for 5 slot packets shall be modulated on the signal to realize the carrier frequency drift.

- Test Condition

Common Test Case Conditions defined in [Section 4.3](#) apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

$BER \leq 0.1\%$ (minimum number of samples, 1 600 000 returned payload bits.)

- Uncertainties

It shall be fixed if the measurement equipment can support a dirty transmitter as specified in this test case.

- Notes

If suitable test equipment is available this test case should be done with hopping on.



4.7.3 RF/RCV/CA/BV-03-C [C/I Performance]

- Test Purpose

Verification of the receiver's performance in presence of co-/adjacent channel interference

- Reference

[1] 4.1.1

- Initial Condition

- IUT in test mode loop back.
- Hopping off.
- IUT transmits at maximum output power back to the tester.
- f_{image} is declared by the manufacturer of the IUT in the IXIT table (see Section 5, “Test Case Mapping”).

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- IUT receives (f_{RX}) / loops back (f_{TX}) at low operating frequency (see Table 4.6.)
- Tester transmits at the same time:
 - Wanted signal (Reference Bluetooth signal, see Section 6.1, “Reference Signal Definition”): DH1 packet with PRBS9 as payload for interfering signal on Co-channel and adjacent 1 MHz and 2 MHz :10 dB over the reference sensitivity level (see Section 6.8 “Definition of the reference sensitivity level”), for interfering signal on all other frequencies: 3 dB over the reference sensitivity level.
 - Bluetooth modulated interfering signal with PRBS15 as payload (see Section 6.5 “Reference Signal Definition”). This interfering signal is operating at $f_i = f_{\text{RX}}$. For the interference power level see Table 4.7.
- The returned packets are received and the BER is measured by the tester according to Section 6.6 “Bit error rate (BER) measurements” (minimum number of samples, 1 600 000 returned payload bits.)
- Repeat step b) to c) for all frequencies $f_i + k$ MHz, that are regular Bluetooth transmit frequencies.
- Repeat step b) to d) for the wanted signal at the frequencies (Mid operating frequency, high operating frequency) that are specified in Table 4.6.

Low operating frequency		Mid operating frequency		High operating frequency	
IUT f_{RX}	IUT f_{TX}	IUT f_{RX}	IUT f_{TX}	IUT f_{RX}	IUT f_{TX}
2405 MHz	2405 MHz	2441 MHz	2441 MHz	2477 MHz	2477 MHz

Table 4.6: Low, Mid, and High Operating Frequency



Interferer Frequency	Ratio
Co-Channel interference, C/I co-channel	11 dB
Adjacent (1 MHz) interference, C/I _{1MHz}	0 dB
Adjacent (2 MHz) interference, C/I _{2MHz}	-30 dB
Adjacent (≥ 3 MHz) interference, C/I _{≥ 3MHz}	-40 dB
Image frequency Interference ^{1,2} , C/I _{Image}	-9 dB
Adjacent (1 MHz) interference to in-band mirror frequency, C/I _{Image$\pm$1MHz}	-20 dB

Table 4.7: Interferer and wanted signal settings

Note 1:

In-band image frequency, declared by the manufacturer of the IUT.

Note 2:

If the image frequency $\neq n \cdot 1$ MHz, then the image reference frequency is defined as closest $n \cdot 1$ MHz frequency.

Note 3:

If two adjacent channel specifications from [Table 4.7](#) are applicable to the same channel, the more relaxed specification applies.

- Test Condition
Common Test Case Conditions defined in [Section 4.3](#) apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

$BER \leq 0.1 \%$

Frequencies where the BER is greater than 10^{-3} are called spurious response frequencies. For each RX frequency, five spurious response frequencies are allowed. On these spurious response frequencies a relaxed interference requirement $C/I = -17$ dB shall be met. This relaxation does not apply to the following measurements:

- Co-Channel interference, $C/I_{\text{co-channel}}$
- Adjacent (1 MHz) interference, C/I_{1MHz}
- Image frequency Interference, C/I_{Image}

4.7.4 RF/RCV/CA/BV-04-C [Blocking Performance]

- Test Purpose

Verification of the receiver's performance in presence of interference.

- Reference

[1] 4.1.3

- Initial Condition

- IUT in test mode loop back.
- Hopping off.
- IUT: $f_{\text{RX}} = f_{\text{TX}} = 2460$ MHz.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) The tester continuously sends the wanted nominal signal (see Section 6.1, "Reference Signal Definition") to the IUT.
- b) This wanted signal is transmitted at 3 dB over the reference sensitivity level (see Section 6.8 "Definition of the reference sensitivity level") at $f_{\text{RX}} = 2460$ MHz.
- c) DH1 packets are used. The Payload is PRBS9.
- d) Additionally the tester produces a continuous wave interfering signal at frequency $f_i = 30$ MHz, at the IUT receiver input. The power levels of this interfering signal are 2 dB higher as defined in Table 4.8.
- e) Tester measures BER according to Section 6.6 "Bit error rate (BER) measurements" (minimum number of samples, 100 000 returned payload bits.) If the BER is measured to be > 0.1 %, the frequency of the blocking signal is recorded.
- f) Repeat step a) to e) for $30 \text{ MHz} \leq f_i \leq 12.75 \text{ GHz}$, where f_i is an integer multiple of 1 MHz.
- g) The signal level of the blocking signal is set as in Table 4.8 at the IUT receiver input and the BER (minimum number of samples, 1 600 000 returned payload bits) is measured with the same nominal signal as in b) but for all frequencies found in e). If BER is measured to be > 0.1 % the frequency of the blocking signal is recorded.

- h) The signal level of the blocking signal is reduced to –50 dBm at the IUT receiver input and the BER (minimum number of samples, 1 600 000 returned payload bits) is measured with the same nominal signal as in b) but for all frequencies found in g). If BER is measured to be > 0.1 % the frequency of the blocking signal is recorded.

Interfering Signal Frequency	Interfering Signal Power Level
30 MHz – 2000 MHz	-10 dBm
2000 – 2400 MHz	-27 dBm
2500 – 3000 MHz	-27 dBm
3000 MHz – 12.75 GHz	-10 dBm

Table 4.8: Power levels of the CW interfering signal

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

$BER \leq 0.1\%$ (minimum number of samples, 1 600 000 returned payload bits.)

The number of frequencies recorded in step g) shall not exceed 24 and the number of frequencies recorded in step h) shall not exceed 5.

4.7.5 RF/RCV/CA/BV-05-C [Intermodulation Performance]

- Test Purpose

Verification of the receiver's intermodulation characteristics.

- Reference

[1] 4.1.4

- Initial Condition

- IUT in test mode loop back. Hopping off.
- $f_{TX} = f_{RX}$ during the test case.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.



- a) IUT is set to transmit and receive at lowest supported frequency.
- b) The tester continuously sends the wanted nominal signal (see Section 6.1, “Reference Signal Definition”) to the IUT. This wanted signal is transmitted at 6 dB over the reference sensitivity level (see Section 6.8 “Definition of the reference sensitivity level”) at f_{TX} . DH1 packets are used. The Payload is PRBS9.
- c) Static sine wave signal at f_1 with a power level of -39 dBm.
- d) A Bluetooth modulated signal (see Section 6.1, “Reference Signal Definition”) at f_2 with a power level of -39 dBm and a payload of PRBS15.
- e) Such that $f_{TX}=2f_1-f_2$ and $\div f_2-f_1 \div = n * 1$ MHz, where n is 3,4 or 5.
The value of n (for which the TC is performed) is declared by the manufacturer in the IXIT table (see PICS proforma for Radio (RF)).
- f) Measure BER according to Section 6.6 “Bit error rate (BER) measurements” (minimum number of samples, 1 600 000 returned payload bits.)
- g) Repeat step b) to f) for the mid and highest operating frequencies f_{TX} supported by the IUT.
These frequencies are defined in Section 6.3.2 “Frequencies for testing, loopback, hopping off”
- Test Condition
Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

$$BER \leq 0.1\%$$

4.7.6 RF/RCV/CA/BV-06-C [Maximum Input Level]

- Test Purpose

Verification of the receiver performance.

- Reference

[1] 4.1.5

- Initial Condition

- IUT in test mode loop back.
- Hopping off.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) IUT receives (f_{RX}) / loops back (f_{TX}) at the lowest operating frequency.



- b) Tester sends DH1 packets with a nominal Bluetooth signal (see Section 6.1, “Reference Signal Definition”) (payload is the PRBS9) continuously at –20 dBm power at the receiver input of the IUT.
- c) Tester measures BER according Section 6.6 “Bit error rate (BER) measurements” (minimum number of samples, 1 600 000 returned payload bits.)
- d) Repeat steps b) to c) while the IUT receives (f_{RX}) / loops back (f_{TX}) at:
 - the mid operating frequency; and
 - the highest operating frequency.

These frequencies are defined in Section 6.3.2 “Frequencies for testing, loopback, hopping off”

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

$BER \leq 0.1 \%$ (minimum number of samples, 1 600 000 returned payload bits.)

4.7.7 RF/RCV/CA/BV-07-C [EDR Sensitivity]

- Test Purpose

Verification of the receiver sensitivity for the 10^{-4} bit error rate using a non-ideal transmitter.

- Reference

[1] 4.2.1

- Initial Condition

- IUT in test mode loop back, whitening on.
- Hopping off (transmit and receive frequencies are defined in Section 6.3.2.
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- a) The tester continuously sends $\pi/4$ -DQPSK packets with the longest supported packet type (2-DHx or 2-EVx) and with maximum length payload containing PRBS9.
- b) The tester transmit power is chosen such that the input power to the IUT receiver is -70dBm, measured over the DPSK modulated portion of the packets.



- c) The IUT receives (fRX) at:
- the lowest operation frequency
- d) The properties of the packets are chosen according to [Table 4.9](#). Except for these parameters the reference signal settings of [Annex 6.1 Reference Signal Definition](#) are used. The tester transmits the first 20 packets using the first parameter set of Table 1. The second 20 packets are transmitted with parameter set 2 and so forth. After the third set of parameters has been used, the tester continues using the first set again.
- e) The returned packets are received and the BER is measured by the tester according to Section [6.6](#) "Bit error rate (BER) measurements". After 1 600 000 bits have been received the BER is compared with threshold $7 \cdot 10^{-5}$. If the BER is less than this threshold then the tester shall proceed to step g) otherwise the tester shall proceed to step f).
- f) Sampling shall be continued until a minimum number of 16 000 000 bits payload bits are returned.
- g) Repeat steps d) to f) while the IUT receives (fRX) at:
- the mid operating frequency
 - the highest operating frequency

If 8DPSK is supported by the IUT then repeat steps b) to g) while the tester continuously sends 8DPSK packets with the longest supported packet type (3-DHx or 3-EVx) and with maximum length payload containing PRBS9.

Set of Parameters	Carrier Offset Frequency	Symbol Time Period Error
1	0 kHz	0 ppm
2	+65 kHz	+20 ppm
3	-65 kHz	-20 ppm

Table 4.9: Dirty Transmitter for Enhanced Data Rate Packets

Note: Additionally to the described dirty transmitter signal parameters in the above table, a frequency modulation with a deviation of ± 10 kHz and a synchronized sine wave modulation period of 100 μ s shall be modulated onto the signal starting at the beginning of the DPSK synchronization word to realize the worst case transmitter carrier frequency stability. The frequency modulation shall alternately switch starting phase between 0 and 180 degrees for successive packets.

- Test Condition

Common Test Case Conditions defined in Section [4.3](#) apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions at low, medium and high frequencies:

Either

$BER \leq 7 \cdot 10^{-5}$ after 1 600 000 bits (step e)

or

$BER \leq 10^{-4}$ after 16 000 000 bits (step f)

4.7.8 RF/RCV/CA/BV-08-C [EDR BER Floor Performance]

- Test Purpose

Verification of the receiver performance for the 10^{-5} bit error rate.

- Reference

[1] 4.2.2

- Initial Condition

- IUT in test mode loop back, whitening on.
- Hopping off (transmit and receive frequencies are defined Section 6.3.2.).
- The IUT shall transmit at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- The tester continuously sends $\pi/4$ -DQPSK packets, according to [Annex 6.1 Reference Signal Definition](#), with the longest supported packet type (2-DHx or 2-EVx) and with maximum length payload containing PRBS9.
- The tester transmit power is chosen such that the input power to the IUT receiver is -60dBm, measured over the DPSK modulated portion of the packets.
- The IUT receives (fRX) at:
 - the lowest operating frequency
- The returned packets are received and the BER is measured by the tester according to Section 6.6 "Bit error rate (BER) measurements". After 8 000 000 bits have been received the BER is compared with the threshold $7 \cdot 10^{-6}$. If the BER is less than this threshold then the tester shall proceed to step f) otherwise the tester shall proceed to step e).
- Sampling shall be continued until a minimum of 160 000 000 payload bits are returned.

- f) Repeat step d) and e) while the IUT receives (fRX) at:
 - the mid operating frequency
 - the highest operating frequency
- g) If 8DPSK is supported by the IUT then repeat steps b) to f) while the tester continuously sends 8DPSK packets, according to [Annex 6.1 Reference Signal Definition](#), with the longest supported packet type (3-DHx or 3-EVx) and with maximum length payload containing PRBS9.
- Test Condition

Common Test Case Conditions defined in Section [4.3](#) apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions at low, medium and high frequencies.

Either

$BER \leq 7 \cdot 10^{-6}$ after 8 000 000 bits (step d)

or

$BER \leq 10^{-5}$ after 160 000 000 bits (step e).

4.7.9 RF/RCV/CA/BV-09-C [EDR C/I Performance]

- Test Purpose

Verification of the receiver performance in the presence of co-/adjacent channel interference.
- Reference

[\[1\]](#) 4.2.3
- Initial Condition
 - IUT in test mode loop back, whitening on.
 - Hopping off.
 - IUT transmits at maximum output power back to the tester.
 - flmage is declared by the manufacturer of the IUT in the IXIT table.
- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

 - a) The tester continuously sends as the wanted signal $\pi/4$ -DQPSK packets, according to Section [6.1](#), “Reference Signal Definition”, with the longest supported packet type (2-DHx or 2-EVx) and with maximum length payload containing PRBS9.

- b) The IUT receives (fRX) at:
- the lowest operation frequency + 3 MHz
- c) The tester transmit power at the input of the IUT (wanted signal) measured over the DPSK modulated portion of the packets is:
- -60dBm for the interfering signal on the co-channel or at ± 1 MHz or ± 2 MHz adjacent channel
 - -67dBm for the interfering signal on all other frequencies
- d) The interfering signal shall be continuously modulated using PRBS15 data. For co-channel measurements, the interferer shall use the same modulation as the wanted signal and its properties shall be as defined in Section 6.1, "Reference Signal Definition". For adjacent channel measurements, the interferer shall use GFSK modulation as defined in Section 6.1. For interferer power levels see Table 4.10.
- e) The returned packets are received and the BER is measured by the tester according to Section 6.6. The minimum number of samples shall be 1 600 000 returned payload bits.
- f) Repeat steps c) to e) with the interferer at all regular Bluetooth frequencies.
- g) Repeat steps c) to f) while the IUT receives (fRX) at:
- the mid operating frequency
 - the highest operating frequency – 3 MHz
- h) If 8DPSK is supported by the IUT then repeat steps b) to g) while the tester continuously sends 8DPSK packets, according to Annex 6.1 Reference Signal Definition, with the longest supported packet type (3-DHx or 3-EVx) and with maximum length payload containing PRBS9.

The IUT transmit frequency is on the same channel as its receive frequency.

Frequency of Interference	2Mbps ($\pi/4$ -DQPSK) C/I ratio	3Mbps (8dpsk) C/I ratio
Co-Channel interference, C/I co-channel	13 dB	21 dB
Adjacent (1 MHz) interference ¹⁾ , C/I 1MHz	0 dB	5 dB
Adjacent (2 MHz) interference ¹⁾ , C/I 2MHz	-30 dB	-25 dB
Adjacent (≥ 3 MHz) interference ¹⁾ , C/I ≥ 3 MHz	-40 dB	-33 dB

¹⁾If two adjacent channel specifications from Table 4.10 are applicable to the same channel, the more relaxed specification applies.

Frequency of Interference	2Mbps ($\pi/4$ -DQPSK) C/I ratio	3Mbps (8dpsk) C/I ratio
Image frequency Interference ¹⁾ ²⁾ ³⁾ , C/I Image	-7 dB	0 dB
Adjacent (1 MHz) interference to in-band image frequency ¹⁾ ²⁾ ³⁾ , C/I Image ± 1 MHz	-20 dB	-13 dB

Table 4.10: Interference Performance

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions.

- BER 0.1 %

Frequencies where the BER is greater than 10^{-3} are called spurious response frequencies. For each RX frequency, five spurious response frequencies are allowed. On these spurious response frequencies a relaxed interference requirement $C/I = -15$ dB for $\pi/4$ -DQPSK and $C/I = -10$ dB for 8DPSK shall be met.

- This relaxation does not apply to the following measurements:
- Co-Channel interference, $C/I_{\text{co-channel}}$
- Adjacent (1 MHz) interference, $C/I_{1\text{MHz}}$
- Image frequency Interference, C/I_{image}

4.7.10 RF/RCV/CA/BV-10-C [EDR Maximum Input Level]

- Test Purpose

Verification of the receiver performance at the maximum specified input signal level.

²If the image frequency is not equal to $n \cdot 1$ MHz, then the image reference frequency is defined as the closest $n \cdot 1$ MHz frequency.

³In-band image frequency.

- Reference

[1] 4.2.4

- Initial Condition

- IUT in test mode loop back, whitening on.
- Hopping off (transmit and receive frequencies are defined in Section 6.3.2.).
- IUT transmits at maximum output power back to the tester.

- Test Procedure

When multiple power classes are declared in the ICS, the test shall be performed using the power class representing the highest power supported.

- The tester continuously sends $\pi/4$ -DQPSK packets with the longest supported packet type (2-DHx or 2-EVx) and with maximum length payload containing PRBS9.
- The tester transmit power is chosen such that the input power to the IUT receiver is -20dBm, measured over the DPSK modulated portion of the packets.
- The IUT receives (fRX) at:
 - the lowest operation frequency
- The returned packets are received and the BER is measured by the tester according to Section 6.6 "Bit error rate (BER) measurements". The minimum number of samples shall be 1 600 000 returned payload bits.
- Repeat step d) while the IUT receives (fRX) at:
 - the mid operating frequency
 - the highest operating frequency
- If 8DPSK is supported by the IUT then repeat steps b) to e) while the tester continuously sends 8DPSK packets with the longest supported packet type (3-DHx or 3-EVx) and with maximum length payload containing PRBS9.

- Test Condition

Common Test Case Conditions defined in Section 4.3 apply.

- Expected Outcome

Pass Verdict

All values as measured shall fulfil the following conditions:

$$\text{BER} \leq 10^{-3}$$

5 Test Case Mapping

The Test Case Mapping Table (TCMT) maps test cases to specific capabilities in the ICS. Profiles, protocols and services may define multiple roles, and it is possible that a product may implement more than one role. The product shall be tested in all roles for which support is declared in the ICS document. For products which support more than one role, a separate TCMT shall be filled out for each role, and separate tests shall be conducted for each role.

The columns for the TCMT are defined as follows:

Item: contains an y/x reference, where y corresponds to the table number and x corresponds to the feature number as defined in the ICS Proforma for RF [3]. If the item is defined with Protocol, Profile or Service abbreviation before y/x, the table and feature number referenced are defined in the abbreviated ICS proforma document.

Feature: recommended to be the primary feature defined in the ICS being tested or may be the test case name.

Test Case(s): the applicable test case identifiers required for Bluetooth Qualification if the corresponding y/x references defined in the Item column are supported.

For purpose and structure of the ICS/IXIT proforma and instructions for completing the ICS/IXIT proforma refer to the Bluetooth ICS and IXIT proforma document.

Item	Feature	Test Case(s)
RF 1/9	Default GFSK RF Test	RF/TRM/CA/BV-01-C
RF 1/9	Default GFSK RF Test	RF/TRM/CA/BV-02-C
RF 1/4 AND RF 1/9	Power Control	RF/TRM/CA/BV-03-C
RF 1/9	Default GFSK RF Test	RF/TRM/CA/BV-04-C
RF 1/9	Default GFSK RF Test	RF/TRM/CA/BV-05-C
RF 1/9	Default GFSK RF Test	RF/TRM/CA/BV-06-C
RF 1/9	Default GFSK RF Test	RF/TRM/CA/BV-07-C
RF 1/9	Default GFSK RF Test	RF/TRM/CA/BV-08-C
RF 1/9	Default GFSK RF Test	RF/TRM/CA/BV-09-C
RF 1/9	Default GFSK RF Test	RF/RCV/CA/BV-01-C
RF 1/9 AND (RF 1/6 OR RF 1/7)	Multi Slot	RF/RCV/CA/BV-02-C
RF 1/9	Default GFSK RF Test	RF/RCV/CA/BV-03-C
RF 1/9	Default GFSK RF Test	RF/RCV/CA/BV-04-C
RF 1/9	Default GFSK RF Test	RF/RCV/CA/BV-05-C
RF 1/9	Default GFSK RF Test	RF/RCV/CA/BV-06-C



Item	Feature	Test Case(s)
RF 1/10 OR RF 1/11	Default EDR RF Test	RF/TRM/CA/BV-10-C
RF 1/10 OR RF 1/11	Default EDR RF Test	RF/TRM/CA/BV-11-C
RF 1/10 OR RF 1/11	Default EDR RF Test	RF/TRM/CA/BV-12-C
RF 1/10 OR RF 1/11	Default EDR RF Test	RF/TRM/CA/BV-13-C
RF 1/10 OR RF 1/11	Default EDR RF Test	RF/RCV/CA/BV-07-C
RF 1/10 OR RF 1/11	Default EDR RF Test	RF/RCV/CA/BV-08-C
RF 1/10 OR RF 1/11	Default EDR RF Test	RF/RCV/CA/BV-09-C
RF 1/10 OR RF 1/11	Default EDR RF Test	RF/RCV/CA/BV-10-C
RF 1/12	Enhanced Power Control	RF/TRM/CA/BV-14-C
RF 1/10 OR RF 1/11	Enhanced Data Rate guard time	RF/TRM/CA/BV-15-C
RF 1/10 OR RF 1/11	Enhanced Data Rate synchronization sequence and trailer	RF/TRM/CA/BV-16-C

Table 5.1: Test Case Mapping

6 Annex

6.1 Reference Signal Definition

If not stated differently in the corresponding test cases, the IUT shall always transmit at the maximum output power and the tester shall transmit with a power between -60dBm and -40dBm at the IUT receiver input.

The modulated interfering signal shall be continuous modulated.

A Bluetooth modulated signal used as “wanted signal” and “interfering signal” is defined as:

- Modulation = GFSK
- Modulation index = $0.32 \pm 1\%$
- BT = $0.5 \pm 1\%$
- Bit Rate = 1 Mbps ± 1 ppm
- Frequency accuracy better than ± 1 ppm
- Free selectable Access Code
- Modulating Data for wanted signal = PRBS9
- Modulating Data for interfering signal = PRBS15

Additionally the signal shall follow the ramp up as shown in [Figure 6.1](#).

- t_{rampup} is the time taken for the output power from the signal generator to increase from below -40 dB to with ± 3 dB of the final output power x dBm.
- t_{settling} is the time taken for the output power from the signal generator to reach to within better than ± 1 dB of the final output power x dBm.
- t_{PO} is the time at which the first bit of the preamble begins.

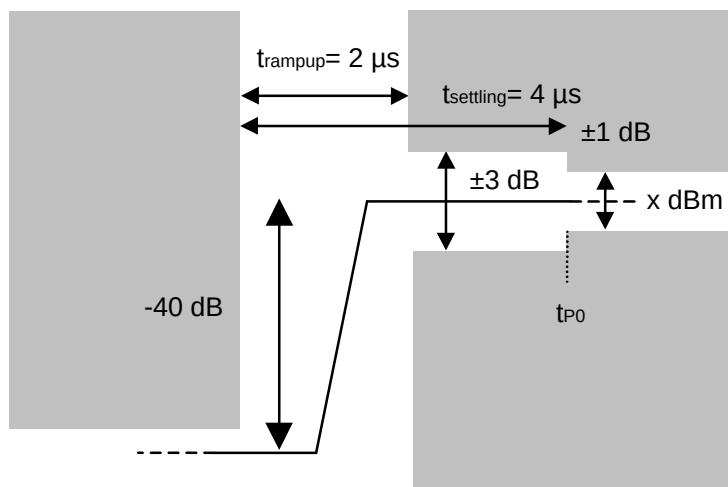


Figure 6.1: Ramp-up profile of signal generator used in Bluetooth RF testing

The lower limit of below -40 dB is very important since above this level, the signal would be of sufficient power to be detected by the receiver.

6.1.1 2 Mbps Reference Signal (EDR)

A 2 Mbps Bluetooth signal used as "wanted" or "interfering signal" is defined as:

- Modulation: $\pi/4$ -DQPSK
- Symbol Rate = 1 Msym/s ± 1 ppm
- Frequency accuracy better than ± 1 ppm
- Modulating Data for wanted signal = PRBS9
- Modulating Data for interfering signal = PRBS15
- RMS Differential Error Vector Magnitude < 5%
- Average power over the GFSK and DPSK portions of the packet shall be equal to within ± 1 dB

6.1.2 3 Mbps Reference Signal (EDR)

A 3 Mbps Bluetooth signal used as "wanted" or "interfering signal" is defined as:

- Modulation: 8DPSK
- Symbol Rate = 1 Msym/s ± 1 ppm
- Frequency accuracy better than ± 1 ppm
- Modulating Data for wanted signal = PRBS9
- Modulating Data for interfering signal = PRBS15
- RMS Differential Error Vector Magnitude < 5%
- Average power over the GFSK and DPSK portions of the packet shall be equal to within ± 1 dB

6.2 Provisional RF Testing

Measurement of RF performance in accordance with the RF test cases may not be possible until appropriate test equipment, with loop back capability, is available. Therefore, certain deviations from the specified test procedures shall be permitted for an interim period. These deviations cease to be permitted for a particular test case when this test case is made active in Category A as indicated in a released Test Case Reference List (TCRL).

The permitted test procedure deviations are as follows:

- Non loop back testing may be used.
- The IUT may be configured for a test case by any suitable means.
- Whitening may be disabled.
- Frequency hopping may be disabled.
- For receiver bit error measurements, the bit error rate may be calculated and reported by any suitable means.



For each test case, all deviations from the specified test procedure shall be documented by the manufacturer.

6.3 Frequencies for testing

6.3.1 Operating frequency bands

The Bluetooth system is operating in the 2.4 GHz ISM band. .

Regulatory Range	RF Channels used by Bluetooth
2.400-2.4835 GHz	$f = 2402 + k$ MHz, $k = 0, \dots, 78$

Table 6.1: Operating frequency bands

6.3.2 Frequencies for testing, loopback, hopping off

Several test cases of this RF Test Suite make use of the Bluetooth testmode, loopback with hopping turned off. These test cases reference to this section and the IUT's receive and transmit frequencies are set according to [Table 6.2](#) and [Table 6.3](#):

For transmit test cases:

Low operating frequency		Mid operating frequency		High operating frequency	
IUT fTX	IUT fRX	IUT fTX ¹	IUT fRX ¹	IUT fTX	IUT fRX
2402 MHz	2480 MHz	2441 MHz	2402 MHz	2480 MHz	2402 MHz

Table 6.2: Frequencies for transmit test cases

For receive test cases:

Low operating frequency		Mid operating frequency		High operating frequency	
IUT fTX	IUT fRX	IUT fTX	IUT fRX	IUT fTX	IUT fRX
2480 MHz	2402 MHz	2402 MHz	2441 MHz	2402 MHz	2480 MHz

Table 6.3: Frequencies for receive test cases

6.3.3 Frequencies for testing, TX-Test, hopping off

Some test cases of this RF Test Suite make use of the Bluetooth testmode, TX-test, with hopping turned off. These test cases reference to this section and the IUT's transmit frequencies are set according to [Table 6.4](#):



Low operating frequency	Mid operating frequency	High operating frequency
IUT fTX	IUT fTX	IUT fTX
2402 MHz	2441 MHz	2480 MHz

Table 6.4: Frequencies TX-test, hopping off

6.4 Normal test conditions

All test cases shall be performed under the following normal test conditions.

6.4.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

- temperature: +15°C to +35°C
- relative humidity: 20 % to 75 %

The actual values during the tests shall be recorded in the test report.

When it is impracticable to carry out the tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be recorded in the test report.

6.4.2 Nominal Power source

See section A.1.2 in [1]

6.5 Extreme test conditions

6.5.1 Extreme temperatures

Where tests at extreme temperatures are required, measurements shall be made over the extremes of the operating temperature range as declared by the manufacturer.

6.6 Bit error rate (BER) measurements

BER measurements are carried out by comparing data in the payload fields transmitted by the tester with data in the payload fields received from the IUT. If the tester does not support the loop back method of measuring BER for 2 Mbps or 3 Mbps, it is allowed to use an alternative measurement method as specified in Section 6.2.

Payload as used in this Test Suite will mean the IUT transmitted data. Only Payload data is counted for the BER measurement. The Payload header and Payload CRC are ignored.

If the IUT is unable to loop back a packet (e.g. sync not found or header check fails), this packet shall be disregarded from the BER measurement. The IUT shall regenerate the payload CRC based on the actual received payload bits.

Let the number of payload bits counted in error be γ , let the number of payload bits received (via loop back) from the IUT be ξ , then:

$$BER = \frac{\gamma}{\xi}$$

For BER sensitivity testing and floor testing an Early Exit option applies. If the early exit option is exercised the required number of bits (ξ) and BER Limit are given in Table 6.5 and Table 6.6.

BER Limit	ξ
$7 \cdot 10^{-5}$	1 600 000
$7 \cdot 10^{-6}$	8 000 000

Table 6.5: Number of Bits for BER Limit with Early Exit

For the following BER limits the following values of ξ shall apply:

BER Limit	ξ
10^{-3}	1 600 000
10^{-4}	16 000 000
10^{-5}	160 000 000

Table 6.6: Number of Bits for BER Limit without Early Exit

6.7 Definition of the position of Bit p0

The start of bit p0, which is the first preamble bit, is defined to occur at the point in time 68 bit periods before the instant at which the modulated carrier passes through the nominal channel frequency immediately prior to the deviation corresponding to the first bit of the Access Code trailer for the IUT as defined in the Baseband Specification 4.2.

The position of the start of bit p0 is calculated using an averaging based on the position of all the zero crossings in the packet:

For the m zero crossings in the packet, the i 'th zero crossing time is $t(i)$ in μs ; this is the start of bit $p(i)$.

($1 \leq i \leq m$).

The start of bit p0 is then:

$$t_0 = \frac{1}{m} \sum_{i=1}^m (t(i) - p(i)) \cdot \text{bit time}$$

with bit time is $1 \mu s$.

6.8 Definition of the reference sensitivity level

The reference sensitivity level is defined as -70 dBm.

6.9 Antenna gain

If it is necessary for Regulatory test purposes the TX peak antenna gain shall be used and declared by the manufacturer.

6.10 Measurement Uncertainty

The following values of measurement uncertainty associated with each measurement parameter apply to all of the test cases described in this RF Test Suite.

The measurement uncertainties of the used measurement equipment shall be equal or better than what is described below. The verdicts of the TCs consider already these measurement uncertainties.”

6.10.1 Conducted measurements:

- Absolute RF power (wanted channel) ¹: ± 1.2 dB
- Absolute RF power (for unwanted emissions in the BT band) ¹: ± 3 dB
- Absolute RF power (for unwanted emissions outside the BT band) ¹: ± 3 dB, ± 4 dB for frequencies above 4 GHz ²

6.10.2 Relative RF power

- Relative RF power¹: ± 1 dB

6.10.3 Radiated measurements

- Absolute RF power (wanted channel) ¹: ± 6 dB
- Radiated emissions (for unwanted emissions)¹: ± 6 dB

6.10.4 Absolute radio frequency

- Absolute radio frequency: ± 5 kHz

6.10.5 Relative drift radio frequency

- Relative drift radio frequency: ± 1 kHz

6.10.6 Peak frequency deviation

- Peak frequency deviation: ± 4 kHz