# FCC Measurement/Technical Report on

# GEN3 HIGH

## Automotive Infotainment Unit w/ Bluetooth & WLAN

# FCC ID: 2AHPN-BE2820
# IC: 6434C-BE2820

**Test Report Reference:** MDE_HARMAN_1607_FCCe


**Test Laboratory:**
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany


DAkkS Deutsche Akkreditierungsstelle D-PL-12140-01-01

# Table of Contents


**1 Applied Standards and Test Summary 4**
1.1 Applied Standards 4
1.2 FCC-IC Correlation Table 5
1.3 Measurement Summary / Signatures 6

**2 Administrative Data 10**
2.1 Testing Laboratory 10
2.2 Project Data 10
2.3 Applicant Data 10
2.4 Manufacturer Data 10

**3 Test object Data 11**
3.1 General EUT Description 11
3.2 EUT Main components 11
3.3 Ancillary Equipment 12
3.4 Auxiliary Equipment 12
3.5 EUT Setups 12
3.6 Interconnecting cables 13
3.7 Operating Modes 13
3.8 Product labelling 13

**4 Test Results 14**
4.1 Occupied Bandwidth (20 dB) 14
4.2 Peak Power Output 17
4.3 Spurious RF Conducted Emissions 20
4.4 Transmitter Spurious Radiated Emissions 23
4.5 Band Edge Compliance Conducted 29
4.6 Band Edge Compliance Radiated 32
4.7 Channel Separation 35
4.8 Dwell Time 37
4.9 Number of Hopping Frequencies 40

**5 Test Equipment 42**

**6 Antenna Factors, Cable Loss and Sample Calculations 45**
6.1 LISN R&S ESH3-Z5 (150 kHz – 30 MHz) 45
6.2 Antenna R&S HFH2-Z2 (9 kHz – 30 MHz) 46
6.3 Antenna R&S HL562 (30 MHZ – 1 GHz) 47
6.4 Antenna R&S HF907 (1 GHz – 18 GHz) 48
6.5 Antenna EMCO 3160-09 (18 GHz – 26.5 GHz) 49
6.6 Antenna EMCO 3160-10 50

**7 Setup Drawings 51**

**8 Measurement Uncertainties 52**

**9 Photo Report 52**

# 1 Applied Standards and Test Summary

## 1.1 Applied Standards

**Type of Authorization**
Certification for an Intentional Radiator.

**Applicable FCC Rules**

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-15 Edition). The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

§ 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz

Note 1:
The tests were selected and performed with reference to the FCC Public Notice "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247, 558074 D01 DTS Meas Guidance v03r05, 2016-04-08". ANSI C63.10–2013 is applied.

Note 2:
The tests were selected and performed with reference to the FCC Public Notice DA 00-705, released March 30, 2000. Instead of applying ANSI C63.4-1992 which is referenced in the FCC Public Note, the newer ANSI C63.10-2013 is applied.

**Summary Test Results:**

**The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.**

## 1.2 FCC-IC Correlation Table

# Correlation of measurement requirements for FHSS (e.g. Bluetooth®) equipment from FCC and IC

**FHSS equipment**

| Measurement | FCC reference | IC reference |
|---|---|---|
| Conducted emissions on AC Mains | § 15.207 | RSS-Gen Issue 4: 8.8 |
| Occupied bandwidth | § 15.247 (a) (1) | RSS-247 Issue 1: 5.1 (2) |
| Peak conducted output power | § 15.247 (b) (1), (4) | RSS-247 Issue 1: 5.4 (2) |
| Transmitter spurious RF conducted emissions | § 15.247 (d) | RSS-Gen Issue 4: 6.13/8.9/8.10; RSS-247 Issue 1: 5.5 |
| Transmitter spurious radiated emissions | § 15.247 (d); § 15.209 (a) | RSS-Gen Issue 4: 6.13 / 8.9/8.10; RSS-247 Issue 1: 5.5 |
| Band edge compliance | § 15.247 (d) | RSS-247 Issue 1: 5.5 |
| Dwell time | § 15.247 (a) (1) (iii) | RSS-247 Issue 1: 5.1 (4) |
| Channel separation | § 15.247 (a) (1) | RSS-247 Issue 1: 5.1 (2) |
| No. of hopping frequencies | § 15.247 (a) (1) (iii) | RSS-247 Issue 1: 5.1 (4) |
| Hybrid systems (only) | § 15.247 (f); § 15.247 (e) | RSS-247 Issue 1: 5.3 |
| Antenna requirement | § 15.203 / 15.204 | RSS-Gen Issue 4: 8.3 |
| Receiver spurious emissions | – | - |

## 1.3 Measurement Summary / Signatures

| 47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 | § 15.247 (a) (1) | | |
|---|---|---|---|
| Occupied Bandwidth (20 dB)<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology, Operating Frequency | **Setup** | **FCC** | **IC** |
| Bluetooth BDR, high | Setup_AB01 | Passed | Passed |
| Bluetooth BDR, low | Setup_AB01 | Passed | Passed |
| Bluetooth BDR, mid | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, high | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, low | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, mid | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, high | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, low | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, mid | Setup_AB01 | Passed | Passed |

| 47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 | § 15.247 (b) (1) | | |
|---|---|---|---|
| Peak Power Output<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology, Operating Frequency, Measurement method | **Setup** | **FCC** | **IC** |
| Bluetooth BDR, high, conducted | Setup_AB01 | Passed | Passed |
| Bluetooth BDR, low, conducted | Setup_AB01 | Passed | Passed |
| Bluetooth BDR, mid, conducted | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, high, conducted | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, low, conducted | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, mid, conducted | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, high, conducted | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, low, conducted | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, mid, conducted | Setup_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 15 Subpart C §15.247** **§ 15.247 (d)**

Spurious RF Conducted Emissions
The measurement was performed according to ANSI C63.10 **Final Result**

| **OP-Mode**<br>Radio Technology, Operating Frequency | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| Bluetooth BDR, high | Setup_AA01 | Passed | Passed |
| Bluetooth BDR, low | Setup_AA01 | Passed | Passed |
| Bluetooth BDR, mid | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 2, high | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 2, low | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 2, mid | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 3, high | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 3, low | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 3, mid | Setup_AA01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 15 Subpart C §15.247** **§ 15.247 (d)**

Transmitter Spurious Radiated Emissions
The measurement was performed according to ANSI C63.10 **Final Result**

| **OP-Mode**<br>Radio Technology, Operating Frequency, Measurement range | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| Bluetooth BDR, high, 1 GHz - 26 GHz | Setup_AA01 | Passed | Passed |
| Bluetooth BDR, high, 30 MHz - 1 GHz | Setup_AA01 | Passed | Passed |
| Bluetooth BDR, low, 30 MHz - 1 GHz | Setup_AA01 | Passed | Passed |
| Bluetooth BDR, mid, 1 GHz - 26 GHz | Setup_AA01 | Passed | Passed |
| Bluetooth BDR, mid, 30 MHz - 1 GHz | Setup_AA01 | Passed | Passed |
| Bluetooth BDR, mid, 9 kHz - 30 MHz | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 2, high, 1 GHz - 8 GHz | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 2, low, 1 GHz - 8 GHz | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 2, mid, 1 GHz - 8 GHz | Setup_AA01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 15 Subpart C §15.247** **§ 15.247 (d)**

Band Edge Compliance Conducted

The measurement was performed according to ANSI C63.10 **Final Result**

| **OP-Mode**<br>Radio Technology, Operating Frequency, Band Edge | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| Bluetooth BDR, high, high | Setup_AB01 | Passed | Passed |
| Bluetooth BDR, hopping, high | Setup_AB01 | Passed | Passed |
| Bluetooth BDR, hopping, low | Setup_AB01 | Passed | Passed |
| Bluetooth BDR, low, low | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, high, high | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, hopping, high | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, hopping, low | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 2, low, low | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, high, high | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, hopping, high | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, hopping, low | Setup_AB01 | Passed | Passed |
| Bluetooth EDR 3, low, low | Setup_AB01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 15 Subpart C §15.247** **§ 15.247 (d)**

Band Edge Compliance Radiated

The measurement was performed according to ANSI C63.10 **Final Result**

| **OP-Mode**<br>Radio Technology, Operating Frequency, Band Edge | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| Bluetooth BDR, high, high | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 2, high, high | Setup_AA01 | Passed | Passed |
| Bluetooth EDR 3, high, high | Setup_AA01 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 15 Subpart C §15.247** **§ 15.247 (a) (1)**

Channel Separation

The measurement was performed according to ANSI C63.10 **Final Result**

| **OP-Mode**<br>Radio Technology | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| Bluetooth BDR | Setup_AB01 | Passed | Passed |

| 47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 | § 15.247 (a) (1) (iii) | | |
|---|---|---|---|
| Dwell Time<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology | **Setup** | **FCC** | **IC** |
| Bluetooth BDR | Setup_AB01 | Passed | Passed |

| 47 CFR CHAPTER I FCC PART 15 Subpart C §15.247 | § 15.247 (a) (1) (iii) | | |
|---|---|---|---|
| Number of Hopping Frequencies<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology | **Setup** | **FCC** | **IC** |
| Bluetooth BDR | Setup_AB01 | Passed | Passed |

N/A: Not applicable
N/P: Not performed

## Revision History

| Report version control | | | |
|---|---|---|---|
| **Version** | **Release date** | **Change Description** | **Version validity** |
| initial | 2016-06-02 | -- | invalid |
| rev01 | 2016-06-24 | Added comment for testcase: Spurious RF Conducted Emissions | valid |
| | | Added comment for testcase: Transmitter Spurious Radiated Emissions | |

7 layers GmbH, Borsigstr. 11
40880 Ratingen, Germany
Phone +49 (0)2102 749 0

(responsible for accreditation scope)
Dipl.-Ing. Marco Kullik

(responsible for testing and report)
B.Sc. Jens Dörwald

# 2 Administrative Data

## 2.1 Testing Laboratory

| | |
|---|---|
| Company Name: | 7layers GmbH |
| Address: | Borsigstr. 11<br>40880 Ratingen<br>Germany |

This facility has been fully described in a report submitted to the FCC and accepted under the registration number 96716.

This facility has been fully described in a report submitted to the IC and accepted under the registration number: Site# 3699A-1.

The test facility is also accredited by the following accreditation organisation:

| | |
|---|---|
| Laboratory accreditation no: | DAkkS D-PL-12140-01-01 |
| Responsible for accreditation scope: | Dipl.-Ing. Marco Kullik |
| Report Template Version: | 2016-02-29 |

## 2.2 Project Data

| | |
|---|---|
| Responsible for testing and report: | B.Sc. Jens Dörwald |
| Employees who performed the tests: | documented internally at 7Layers |
| Date of Report: | 2016-06-24 |
| Testing Period: | 2016-04-24 to 2016-04-27 |

## 2.3 Applicant Data

| | |
|---|---|
| Company Name: | Harman International Industries, Inc. |
| Address: | 30001 Cabot Drive<br>Novi, MI 48377<br>USA |
| Contact Person: | |

## 2.4 Manufacturer Data

| | |
|---|---|
| Company Name: | please see applicant data |
| Address: | |
| Contact Person: | |

# 3 Test object Data

## 3.1 General EUT Description

| | |
|---|---|
| Kind of Device<br>product description | Automotive Infotainment Unit w/ Bluetooth & WLAN |
| Type | GEN3 HIGH |
| **Declared EUT data by the supplier** | |
| Voltage Type | DC |
| Voltage Level | 13.2 V |
| Tested Modulation Type | GFSK Modulation, 1-DHx packets<br>π/4 DQPSK Modulation, 2-DHx packets<br>8-DQPSK Modulation, 3-DHx packets |
| General product description | The EUT is a car radio infotainment system. |
| Specific product description for the EUT | The EUT is a car radio infotainment system, it is using Bluetooth and WLAN radio technology in the 2.4 GHz ISM band and WLAN radio technology in the 5 GHz ISM band. |
| The EUT provides the following ports: | DC<br>USB<br>AM/FM, SDARS<br>GPS<br>rear camera<br>display |
| Tested datarates | 1 Mbps, 2 Mbps, 3 Mbps |

**The main components of the EUT are listed and described in chapter 3.2 EUT Main components.**

## 3.2 EUT Main components

| Sample Name | Sample Code | Description |
|---|---|---|
| FCC Conducted sample | DE1009012ab01 | |
| **Sample Parameter** | **Value** | |
| Integral Antenna | deactivated | |
| Serial No. | SN014 | |
| HW Version | QTPV | |
| SW Version | Trunk.16.16.01 | |
| Comment | - | |

| Sample Name | Sample Code | Description |
|---|---|---|
| FCC Radiated sample | DE1009012aa01 | |
| **Sample Parameter** | **Value** | |
| Integral Antenna | 1.18 dBi | |
| Serial No. | SN021 | |
| HW Version | QTPV | |
| SW Version | Trunk.16.16.01 | |
| Comment | - | |

NOTE:The short description is used to simplify the identification of the EUT in this test report.

## 3.3 Ancillary Equipment

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

| Device | Details (Manufacturer, Type Model, OUT Code) | Description |
|---|---|---|
| - | - | - |

## 3.4 Auxiliary Equipment

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it.
But nevertheless Auxiliary Equipment can influence the test results.

| Device | Details (Manufacturer, HW, SW, S/N) | Description |
|---|---|---|
| - | - | - |

## 3.5 EUT Setups

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

| Setup | Combination of EUTs | Description and Rationale |
|---|---|---|
| Setup_AB01 | FCC Conducted sample, | FCC Setup for Conducted measurement |
| Setup_AA01 | FCC Radiated sample, | FCC Setup for Radiated measurement |

## 3.6 Interconnecting cables

This chapter describes the used cables. The rationale for selecting the ports and interconnecting cables is to test a representative configuration meeting the requirements of the referenced standards.

| Port and interconnecting cables | Cable length | shielded | Connected during test |
|---|---|---|---|
| DC cable harness | 110 cm | N/A | Yes |
| USB | 130 cm | Yes | Yes |
| AM/FM, SDARS | 150 cm | Yes | Yes |
| GPS | 100 cm | Yes | Yes |
| rear camera | 110 cm | N/A | Yes |
| display | 150 cm | N/A | Yes |

## 3.7 Operating Modes

This chapter describes the operating modes of the EUTs used for testing.

### 3.7.1 Test Channels

| | 2.4 GHz ISM 2400 - 2483.5 MHz | | |
|---|---|---|---|
| **BT Test Channels:** | **low** | **mid** | **high** |
| **Channel:** | 0 | 39 | 78 |
| **Frequency [MHz]** | 2402 | 2441 | 2480 |

## 3.8 Product labelling

### 3.8.1 FCC ID label

Please refer to the documentation of the applicant.

### 3.8.2 Location of the label on the EUT

Please refer to the documentation of the applicant.

# 4 Test Results

## 4.1 Occupied Bandwidth (20 dB)

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.1.1Test Description

The Equipment Under Test (EUT) was set up to perform the occupied bandwidth measurements.
The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.
The results recorded were measured with the modulation which produce the worst-case (widest) emission bandwidth.

The EUT was connected to spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Resolution Bandwidth (RBW): 1% to 5 % of the OBW
- Video Bandwidth (VBW): 3 x RBW
- Span: 2 to 5 times the OBW
- Trace: Maxhold
- Sweeps: 2000
- Sweeptime: 20 ms
- Detector: Peak

The technology depending measurement parameters can be found in the measurement plot.

### 4.1.2Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (a) (2)

For the band: 902 – 928 MHz
FCC Part 15, Subpart C, §15.247 (a) (1) (i)

The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz

For the band: 5725 – 5850 MHz
FCC Part 15, Subpart C, §15.247 (a) (1) (ii)

The maximum allowed 20 dB bandwidth of the hopping channel is 1 MHz

For the frequency band 2400 – 2483.5 MHz:
FCC Part 15, Subpart C, §15.247 (a) (1) (iii)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Implication by the test laboratory:
Since the Bluetooth technology defines a fixed channel separation of 1 MHz this design parameter defines the maximum allowed occupied bandwidth depending on the EUT's output power:
1. Under the provision that the system operates with an output power not greater than 125 mW (21.0 dBm):
Implicit Limit: Max. 20 dB BW = 1.0 MHz / 2/3 = 1.5 MHz

2. If the system output power exceeds 125 mW (21.0 dBm):
Implicit Limit: Max. 20 dB BW = 1.0 MHz

Used conversion factor: Output power (dBm) = 10 log (Output power (W) / 1mW)

The measured output power of the system is below 125 mW (21.0 dBm). For the results, please refer to the related chapter of this report.
Therefore the limit is determined as 1.5 MHz.

### 4.1.3Test Protocol

Ambient temperature: 23 °C
Air Pressure: 1008 hPa
Humidity: 41 %
BT GFSK (1-DH1)

| Band | Channel No. | Frequency [MHz] | 20 dB Bandwidth [kHz] | Limit [kHz] | Margin to Limit [kHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1046.4 | 1528.5 | 482.1 |
| | 39 | 2441 | 1052.4 | 1528.5 | 476.1 |
| | 78 | 2480 | 1052.4 | 1528.5 | 476.1 |

BT π/4 DQPSK (2-DH1)

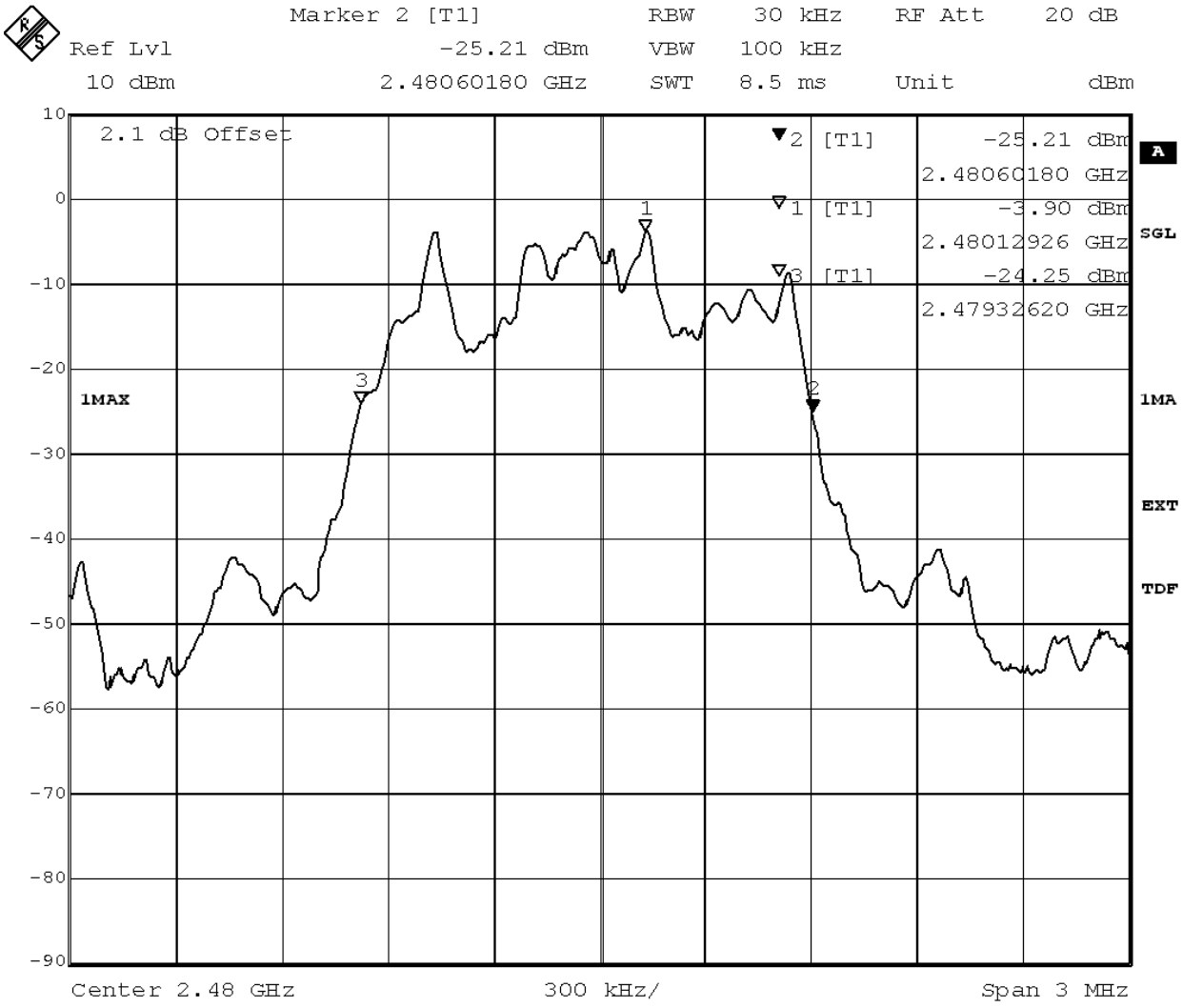
| Band | Channel No. | Frequency [MHz] | 20 dB Bandwidth [kHz] | Limit [kHz] | Margin to Limit [kHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1136.4 | 1528.5 | 392.1 |
| | 39 | 2441 | 1136.4 | 1528.5 | 392.1 |
| | 78 | 2480 | 1136.4 | 1528.5 | 392.1 |

BT 8-DPSK (3-DH1)

| Band | Channel No. | Frequency [MHz] | 20 dB Bandwidth [kHz] | Limit [kHz] | Margin to Limit [kHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1275.6 | 1528.5 | 252.9 |
| | 39 | 2441 | 1275.6 | 1528.5 | 252.9 |
| | 78 | 2480 | 1275.6 | 1528.5 | 252.9 |

Remark: Please see next sub-clause for the measurement plot.

### 4.1.4Measurement Plot (showing the highest value, "worst case")




Title: 20dB Bandwidth
Comment A: CH T: 2480 MHz; 20dB bandwidth (kHz):1275.6
Date: 26.APR.2016 12:39:51

BT 8-DPSK (3-DH1), CH78

### 4.1.5Test Equipment used

Regulatory Bluetooth RF Test Solution

## 4.2 Peak Power Output

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.2.1 Test Description

The Equipment Under Test (EUT) was set up to perform the output power measurements. The results recorded were measured with the modulation which produces the worst-case (highest) output power. The reference level of the spectrum analyzer was set higher than the output power of the EUT.

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Resolution Bandwidth (RBW): 3 MHz
- Video Bandwidth (VBW): 3 MHz
- Trace: Maxhold
- Sweeps: 2000
- Sweeptime: 5 ms
- Detector: Peak

The channel power function of the spectrum analyser was used (Used channel bandwidth = DTS bandwidth)

### 4.2.2 Test Requirements / Limits

**DTS devices:**
FCC Part 15, Subpart C, §15.247 (b) (3)
For systems using digital modulation techniques in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands: 1 watt.

==> Maximum conducted peak output power: 30 dBm (excluding antenna gain, if antennas with directional gains that do not exceed 6 dBi are used).

**Frequency Hopping Systems:**
FCC Part 15, Subpart C, §15.247 (b) (1)
For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

FCC Part 15, Subpart C, §15.247 (b) (2)
For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

Used conversion factor: Limit (dBm) = 10 log (Limit (W)/1mW)

### 4.2.3Test Protocol

Ambient temperature: 23 °C
Air Pressure: 1008 hPa
Humidity: 41 %

BT GFSK (1-DH1)

| Band | Channel No. | Frequency [MHz] | Peak Power [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 2.8 | 21.0 | 18.2 |
| | 39 | 2441 | 3.0 | 21.0 | 18.0 |
| | 78 | 2480 | 2.5 | 21.0 | 18.5 |

BT π/4 DQPSK (2-DH1)

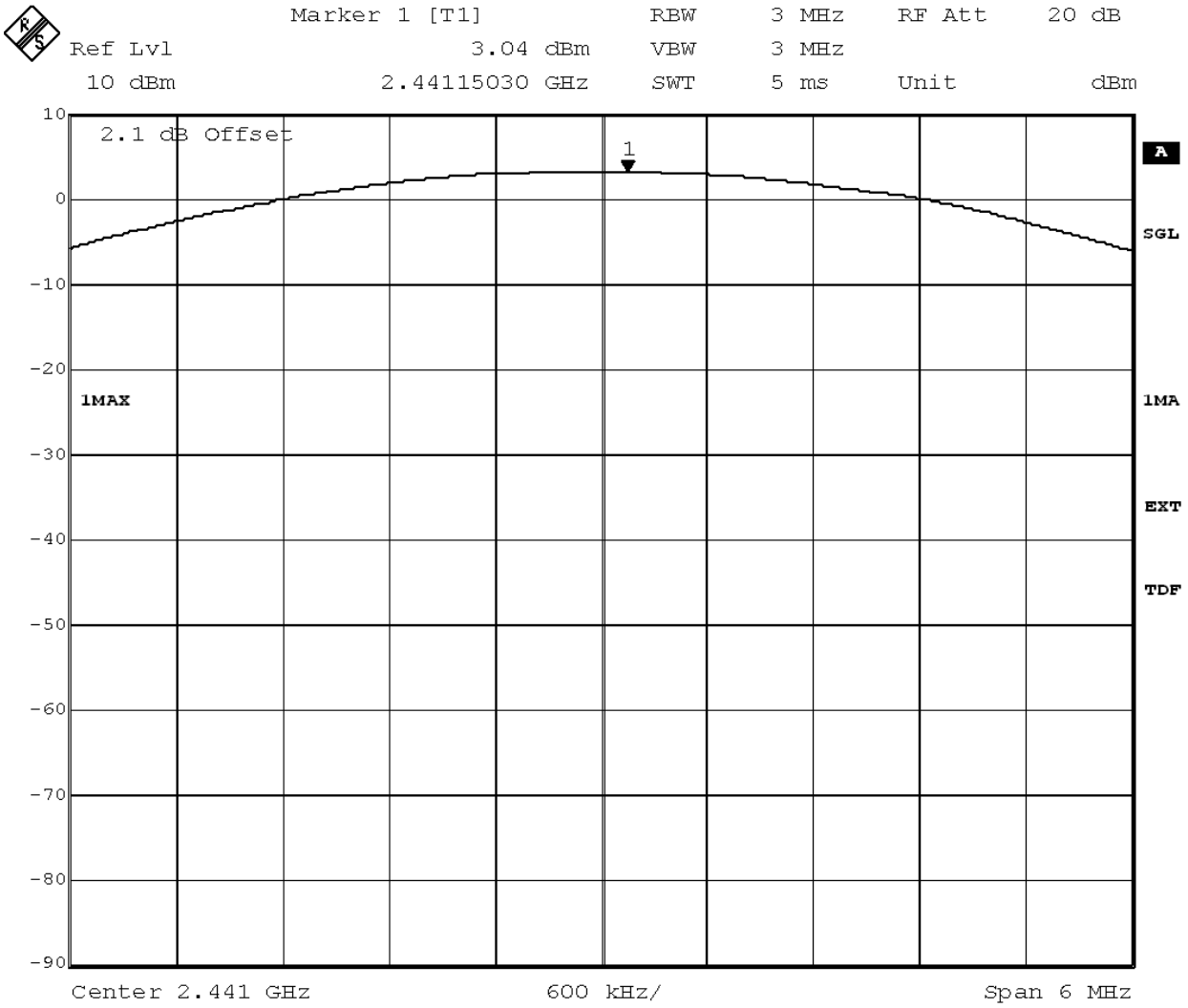
| Band | Channel No. | Frequency [MHz] | Peak Power [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1.3 | 21.0 | 19.7 |
| | 39 | 2441 | 1.8 | 21.0 | 19.2 |
| | 78 | 2480 | 1.1 | 21.0 | 20.0 |

BT 8-DPSK (3-DH1)

| Band | Channel No. | Frequency [MHz] | Peak Power [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1.2 | 21.0 | 19.8 |
| | 39 | 2441 | 1.8 | 21.0 | 19.2 |
| | 78 | 2480 | 1.1 | 21.0 | 19.9 |

Remark: Please see next sub-clause for the measurement plot.

### 4.2.4Measurement Plot (showing the highest value, "worst case")




Title: Peak outputpower Power
Comment A: CH M: 2441 MHz
Date: 26.APR.2016 10:37:41

BT GFSK (1-DH1), CH39

### 4.2.5Test Equipment used

Regulatory Bluetooth RF Test Solution

## 4.3 Spurious RF Conducted Emissions

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.3.1 Test Description

The Equipment Under Test (EUT) was set up to perform the spurious emissions measurements.
The EUT was connected to spectrum analyzer via a short coax cable with a known loss.
Analyzer settings:

- Frequency range: 30 – 25000 MHz
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Trace: Maxhold
- Sweeps: 2
- Sweep Time: 330 s
- Detector: Peak

The reference value for the measurement of the spurious RF conducted emissions is determined during the test "band edge compliance conducted". This value is used to calculate the 20 dBc limit.

### 4.3.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (c)
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

### 4.3.3Test Protocol

Ambient temperature: 23 °C
Air Pressure: 1008 hPa
Humidity: 41 %

BT GFSK (1-DH1)

| Channel No | Channel Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Ref. Level [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | - | - | - | - | - | - | - |
| 39 | 2441 | - | - | - | - | - | - | - |
| 78 | 2480 | - | - | - | - | - | - | - |

BT π/4 DQPSK (2-DH1)

| Channel No | Channel Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Ref. Level [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | - | - | - | - | - | - | - |
| 39 | 2441 | - | - | - | - | - | - | - |
| 78 | 2480 | - | - | - | - | - | - | - |

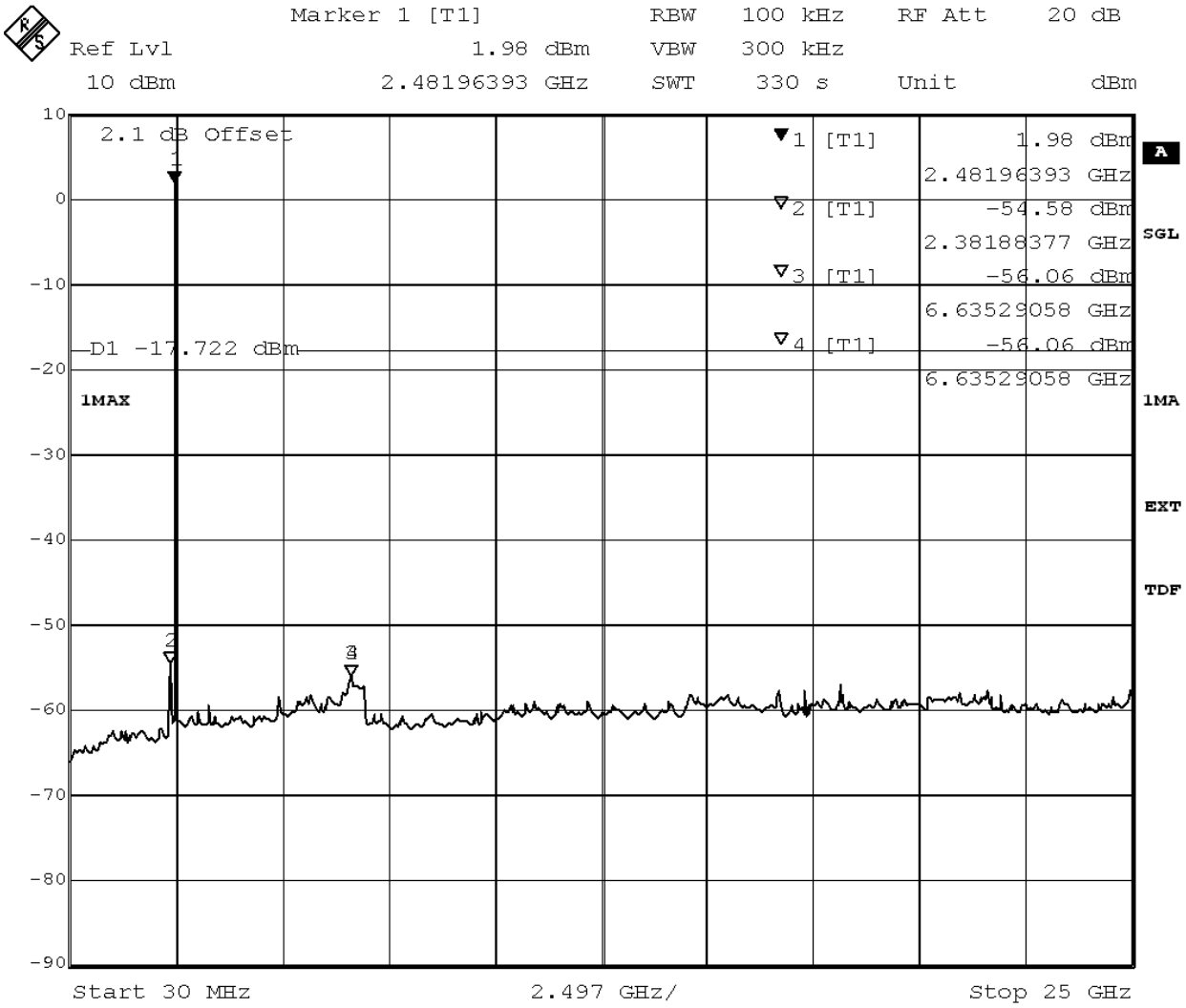
BT 8-DPSK (3-DH1)

| Channel No | Channel Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Ref. Level [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | - | - | - | - | - | - | - |
| 39 | 2441 | - | - | - | - | - | - | - |
| 78 | 2480 | - | - | - | - | - | - | - |

Remark: Please see next sub-clause for the measurement plot.

COMMENT:
No (further) Spurious emissions in the range 20dB below the limit found, therefore no measurement values are reported in the tables.

### 4.3.4Measurement Plot (showing the highest value, "worst case")




Title: spurious emissions
Comment A: CH T: 2480 MHz
Date: 26.APR.2016 11:31:08

BT GFSK (1-DH1), CH78

### 4.3.5Test Equipment used

Regulatory Bluetooth RF Test Solution

## 4.4 Transmitter Spurious Radiated Emissions

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.4.1Test Description

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.
The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered from a DC power source.

**1. Measurement up to 30 MHz**
The Loop antenna HFH2-Z2 is used.

**Step 1:** pre measurement
- Anechoic chamber
- Antenna distance: 3 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

**Step 2:** final measurement
For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.
- Open area test side
- Antenna distance: according to the Standard
- Detector: Quasi-Peak
- Frequency range: 0.009 – 30 MHz
- Frequency steps: measurement at frequencies detected in step 1
- IF–Bandwidth: 0.2 - 10 kHz
- Measuring time / Frequency step: 1 s

**2. Measurement above 30 MHz and up to 1 GHz**

**Step 1:** Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz

- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

**Step 2:** Adjustment measurement
In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.
For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by ± 45° around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by ± 100 cm around the antenna height determined. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.
- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: ± 45 ° around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

**Step 3:** Final measurement with QP detector
With the settings determined in step 3, the final measurement will be performed:
EMI receiver settings for step 4:
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

**3. Measurement above 1 GHz**
The following modifications apply to the measurement procedure for the frequency range above 1 GHz:
**Step 1:**
The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.
All steps were performed with one height (1.5 m) of the receiving antenna only.
The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.
The turn table step size (azimuth angle) for the preliminary measurement is 45 °.
**Step 2:**
Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size ± 45° for the elevation axis is performed.
The turn table azimuth will slowly vary by ± 22.5°.

The elevation angle will slowly vary by ± 45°
EMI receiver settings (for all steps):
- Detector: Peak, Average
- IF Bandwidth = 1 MHz

**Step 3:**
Spectrum analyser settings for step 3:
- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

### 4.4.2Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (d)
... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

| Frequency in MHz | Limit (µV/m) | Measurement distance (m) | Limits (dBµV/m) |
|---|---|---|---|
| 0.009 – 0.49 | 2400/F(kHz)@300m | 3 | (48.5 – 13.8)@300m |
| 0.49 – 1.705 | 24000/F(kHz)@30m | 3 | (33.8 – 23.0)@30m |
| 1.705 – 30 | 30@30m | 3 | 29.5@30m |

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

| Frequency in MHz | Limit (µV/m) | Measurement distance (m) | Limits (dBµV/m) |
|---|---|---|---|
| 30 – 88 | 100@3m | 3 | 40.0@3m |
| 88 – 216 | 150@3m | 3 | 43.5@3m |
| 216 – 960 | 200@3m | 3 | 46.0@3m |
| 960 - 26000 | 500@3m | 3 | 54.0@3m |
| 26000 - 40000 | 500@3m | 1 | 54.0@3m |

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

### 4.4.3Test Protocol

Ambient temperature: 22–23 °C
Air Pressure: 1002–1011 hPa
Humidity: 32–39 %
BT GFSK (1-DH1)

| Ch. No. | Ch. Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [dBµV/m] | Detec-tor | RBW [kHz] | Limit [dBµV/m] | Margin to Limit [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | 324.0 | 34.8 | QP | 120.0 | 46.0 | 11.2 | RB |
| 39 | 2441 | 324.0 | 35.1 | QP | 120.0 | 46.0 | 10.9 | RB |
| 78 | 2480 | 324.0 | 34.5 | QP | 120.0 | 46.0 | 11.5 | RB |

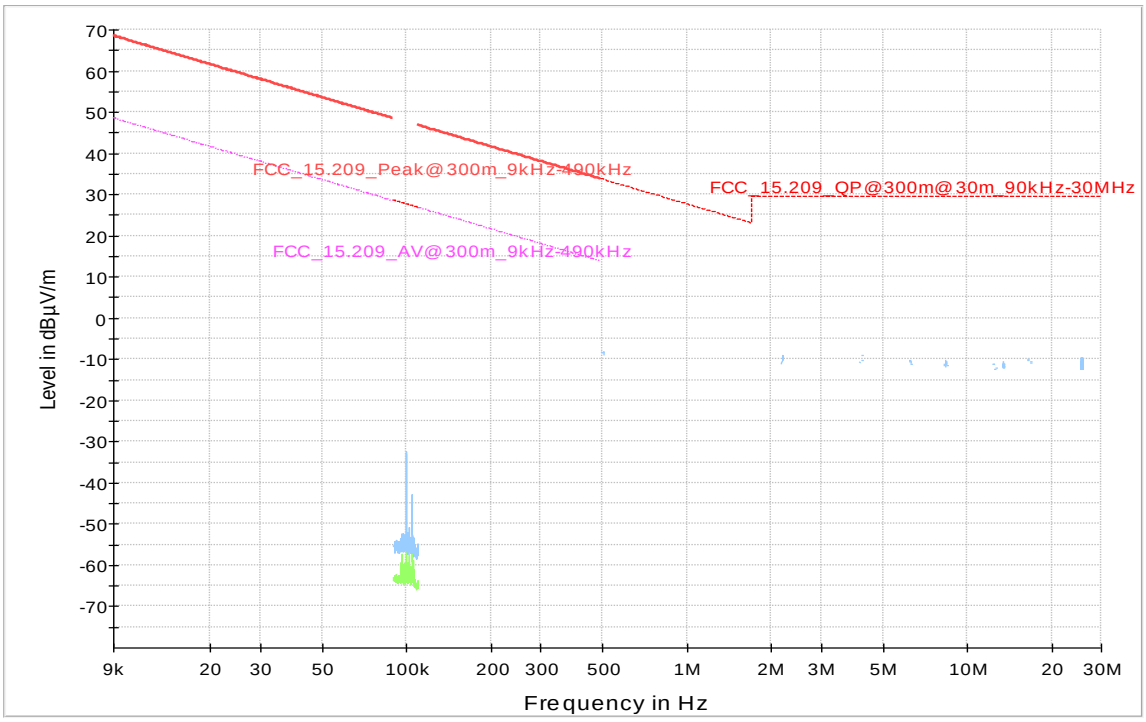
BT π/4 DQPSK (2-DH1)

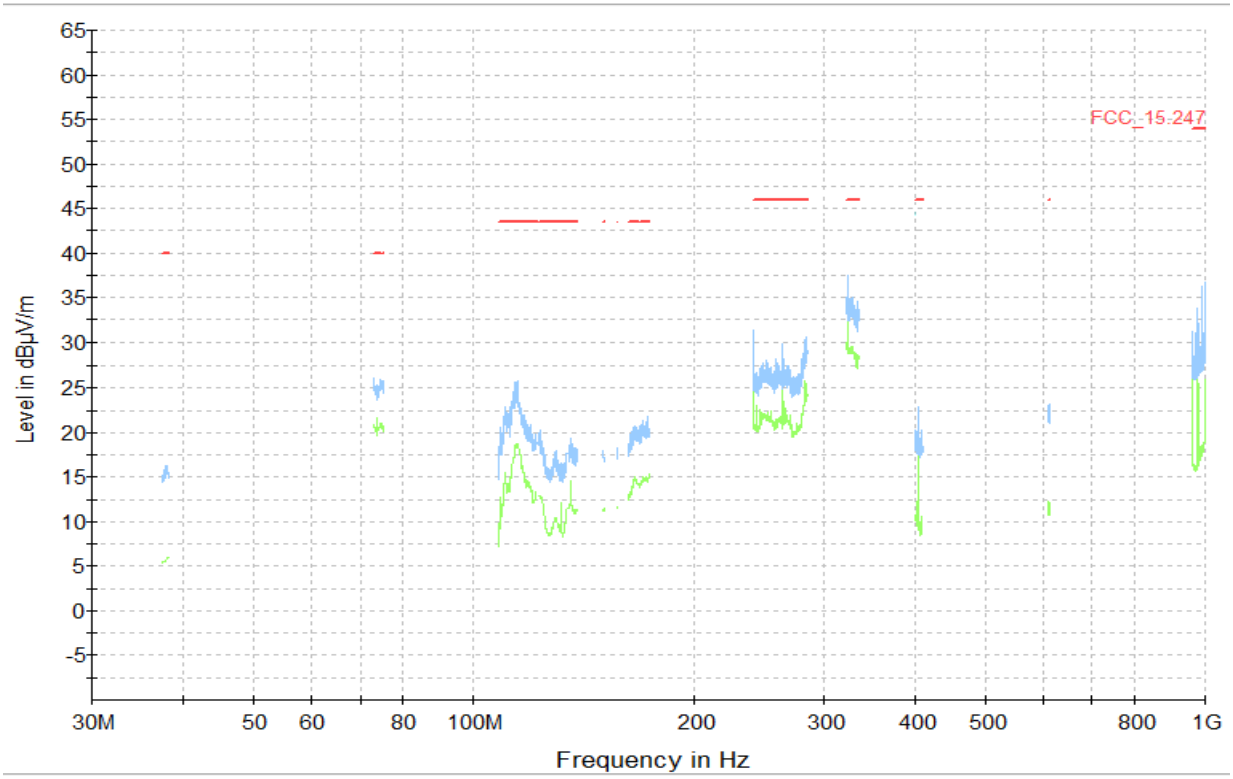
| Ch. No. | Ch. Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [dBµV/m] | Detec-tor | RBW [kHz] | Limit [dBµV/m] | Margin to Limit [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | - | - | - - - | - | - | - | - |
| 39 | 2441 | - | - | - - - | - | - | - | - |
| 78 | 2480 | - | - | - - - | - | - | - | - |

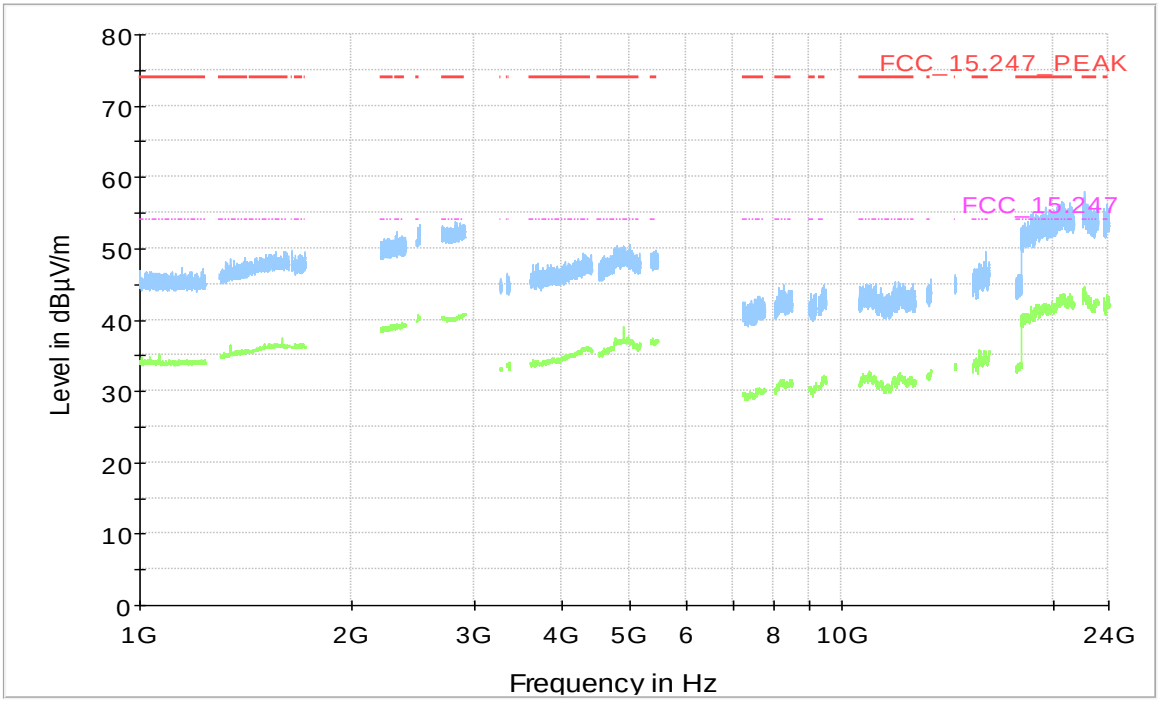
Remark: Please see next sub-clause for the measurement plot.

COMMENT:
No (further) spurious emissions in the range 20dB below the limit found. Because no significant spurious emissions have been found, the measurement range for BT π/4 DQPSK (2-DH1) was reduced up to 8GHz and the measurements for BT 8-DPSK (3-DH1) were not repeated.

### 4.4.4Measurement Plot (showing the highest value, "worst case")






### 4.4.5Test Equipment used

Radiated Emissions

## 4.5 Band Edge Compliance Conducted

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.5.1Test Description

For the conducted measurement, the Equipment Under Test (EUT) is placed in a shielded room. The reference power was measured in the test case "Spurious RF Conducted Emissions".
The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Frequency Range 30 MHz – 25 GHz
- Detector: Peak
- Resolution Bandwidth (RBW): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Sweeptime: 330 s
- Sweeps: 2
- Trace: Maxhold

### 4.5.2Test Requirements / Limits

FCC Part 15.247 (d)
"In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. ...
If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c))."

For the conducted measurement the RF power at the band edge shall be "at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power..."

### 4.5.3Test Protocol

Ambient temperature: 23 °C
Air Pressure: 1008 hPa
Humidity: 41 %

BT GFSK (1-DH1)

| Channel No. | Channel Center Frequency [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Ref. Level [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | 2400.0 | -58.4 | PEAK | 100 | 2.6 | -17.4 | 41.1 |
| 78 | 2480 | 2483.5 | -61.4 | PEAK | 100 | 2.3 | -17.7 | 43.7 |
| hopping | hopping | 2400.0 | -54.5 | PEAK | 100 | 1.5 | -18.5 | 36.0 |
| hopping | hopping | 2483.5 | -54.4 | PEAK | 100 | 1.1 | -18.9 | 35.5 |

BT π/4 DQPSK (2-DH1)

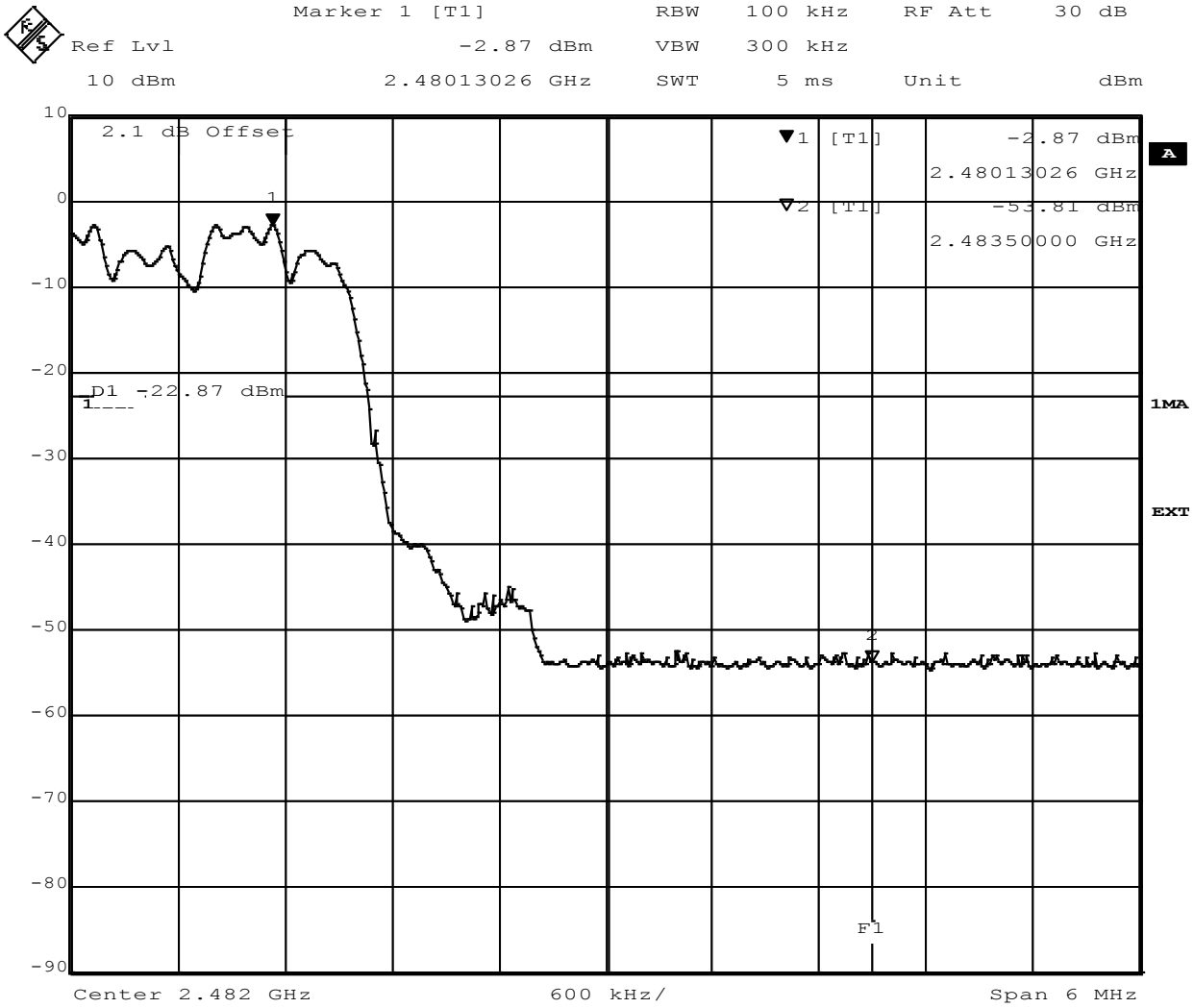
| Channel No. | Channel Center Frequency [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Ref. Level [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | 2400.0 | -62.2 | PEAK | 100 | -1.0 | -21.0 | 41.3 |
| 78 | 2480 | 2483.5 | -63.6 | PEAK | 100 | -1.2 | -21.2 | 42.3 |
| hopping | hopping | 2400.0 | -53.8 | PEAK | 100 | -1.9 | -21.9 | 32.0 |
| hopping | hopping | 2483.5 | -53.4 | PEAK | 100 | -2.4 | -22.4 | 31.0 |

BT 8-DPSK (3-DH1)

| Channel No. | Channel Center Frequency [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBm] | Detector | RBW [kHz] | Ref. Level [dBm] | Limit [dBm] | Margin to Limit [dB] |
|---|---|---|---|---|---|---|---|---|
| 0 | 2402 | 2400.0 | -60.6 | PEAK | 100 | -1.4 | -21.4 | 39.2 |
| 78 | 2480 | 2483.5 | -63.2 | PEAK | 100 | -1.5 | -21.5 | 41.7 |
| hopping | hopping | 2400.0 | -53.3 | PEAK | 100 | -2.3 | -22.3 | 31.0 |
| hopping | hopping | 2483.5 | -53.8 | PEAK | 100 | -2.9 | -22.9 | 30.9 |

Remark: Please see next sub-clause for the measurement plot.

### 4.5.4Measurement Plot (showing the highest value, "worst case")




BT 8-DPSK (3-DH1), hopping

### 4.5.5Test Equipment used

Regulatory Bluetooth RF Test Solution

## 4.6 Band Edge Compliance Radiated

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.6.1 Test Description

Please see test description for the test case "Spurious Radiated Emissions"

### 4.6.2 Test Requirements / Limits

FCC Part 15.247 (d)
"In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. ...
If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c))."

### 4.6.3Test Protocol

Ambient temperature: 22–23 °C
Air Pressure: 1002–1011 hPa
Humidity: 32–39 %

BT GFSK (1-DH1)

| Ch. No. | Ch. Center Freq. [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBµV/m] | Detec-tor | RBW [kHz] | Limit [dBµV/m] | Margin to Limit [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|
| 78 | 2480 | 2483.5 | 51.5 | PEAK | 1000 | 74 | 22.5 | BE |
| 78 | 2480 | 2483.5 | 40.3 | AV | 1000 | 54 | 13.7 | BE |

BT π/4 DQPSK (2-DH1)

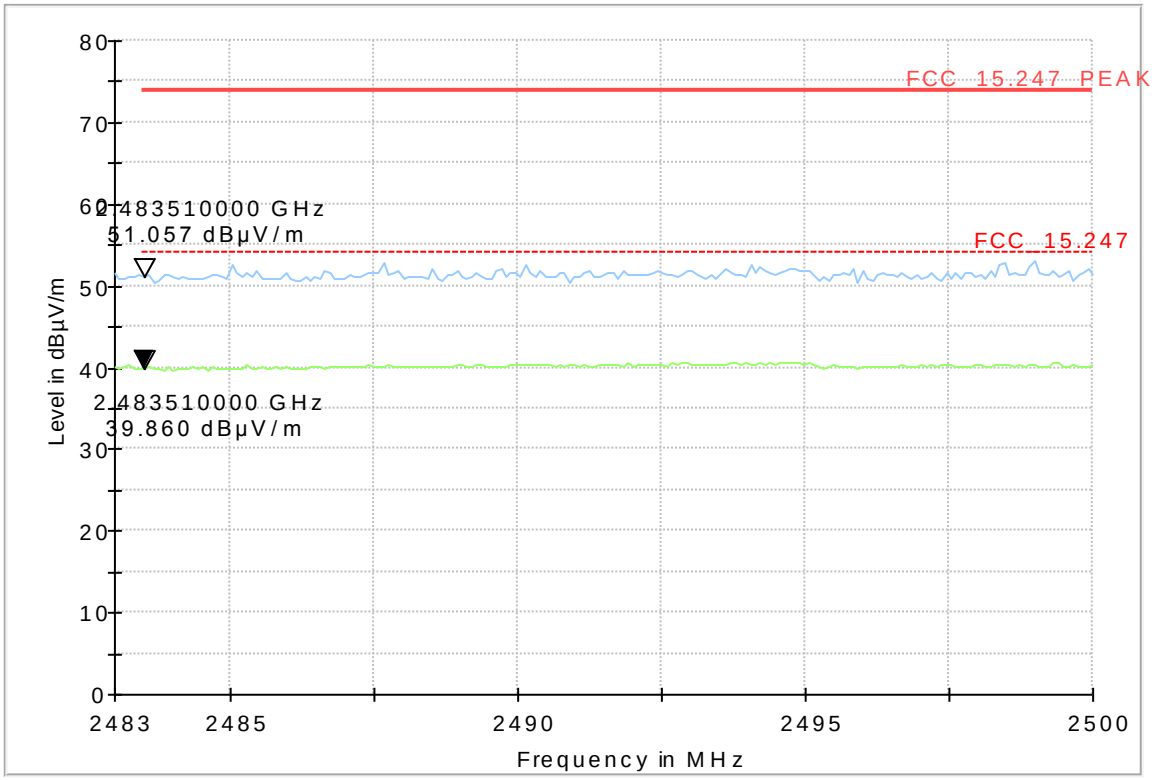
| Ch. No. | Ch. Center Freq. [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBµV/m] | Detec-tor | RBW [kHz] | Limit [dBµV/m] | Margin to Limit [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|
| 78 | 2480 | 2483.5 | 51.0 | PEAK | 1000 | 74 | 23.0 | BE |
| 78 | 2480 | 2483.5 | 40.4 | AV | 1000 | 54 | 13.6 | BE |

BT 8-DPSK (3-DH1)

| Ch. No. | Ch. Center Freq. [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBµV/m] | Detec-tor | RBW [kHz] | Limit [dBµV/m] | Margin to Limit [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|
| 78 | 2480 | 2483.5 | 51.1 | PEAK | 1000 | 74 | 22.9 | BE |
| 78 | 2480 | 2483.5 | 40.5 | AV | 1000 | 54 | 13.5 | BE |

Remark: Please see next sub-clause for the measurement plot.

### 4.6.4Measurement Plot (showing the highest value, "worst case")




BT 8-DPSK (3-DH1), CH78

### 4.6.5Test Equipment used

Radiated Emissions

## 4.7 Channel Separation

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.7.1 Test Description

The Equipment Under Test (EUT) was set up to perform the channel separation measurements. The channel separation is independent from the modulation pattern.

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Detector: Peak
- Trace: Maxhold
- Span: appr. 3 x OBW
- Centre Frequency: a mid frequency of the used band
- Resolution Bandwidth (RBW): appr. 3 % of channel spacing
- Video Bandwidth (VBW): 3 x RBW
- Sweep Time: 5 ms
- Sweeps: 2000

The technology depending measurement parameters can be found in the measurement plot.

### 4.7.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.247 (a) (1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

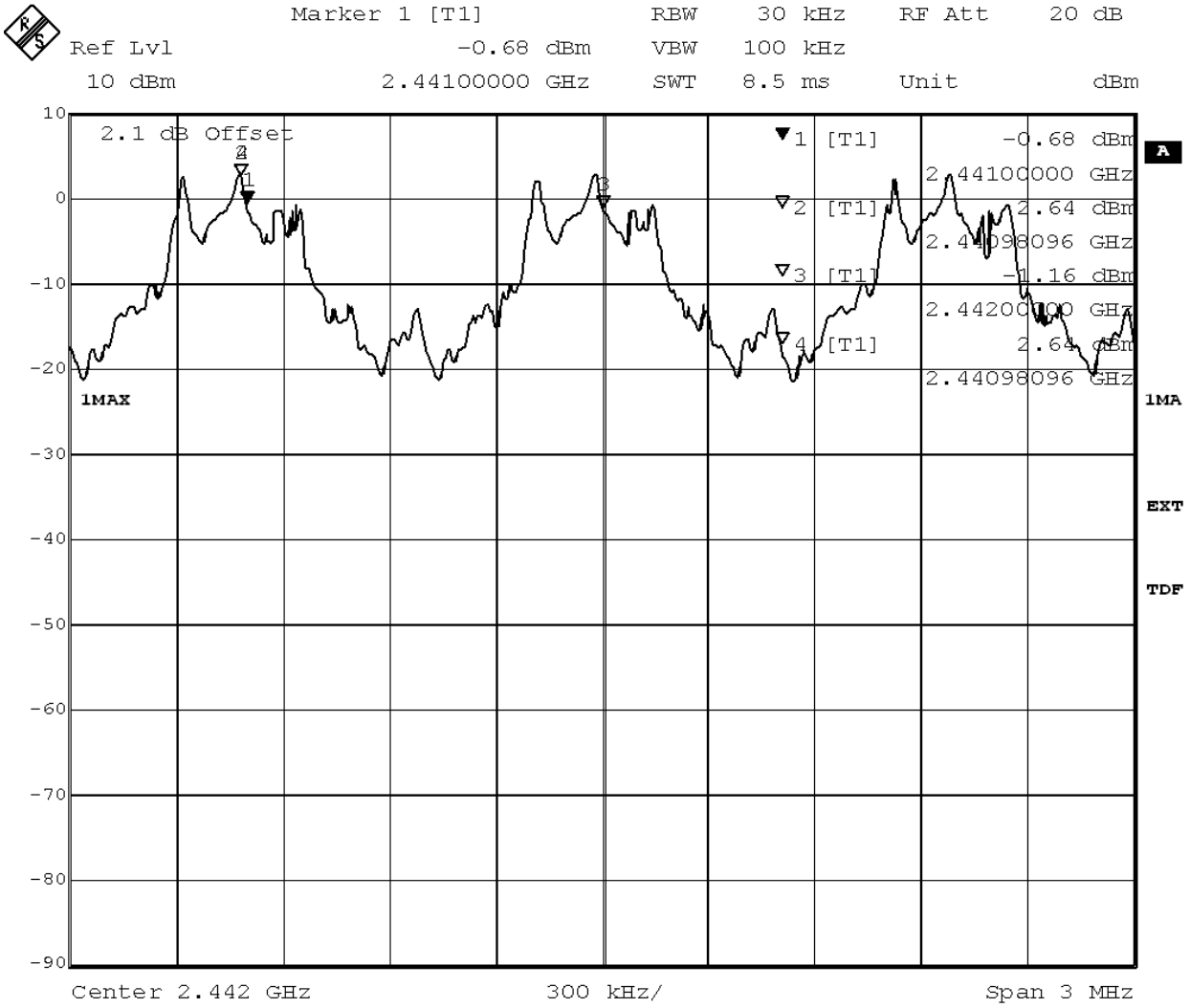
### 4.7.3Test Protocol

| | |
|---|---|
| Ambient temperature: | 23 °C |
| Air Pressure: | 1008 hPa |
| Humidity: | 41 % |

| Radio Technology | Channel Separation [kHz] | Limit [kHz] | Margin to Limit [kHz] |
|---|---|---|---|
| BT GFSK (1-DH1) | 1019.0 | 701.6 | 317.4 |

Remark: Please see next sub-clause for the measurement plot.

### 4.7.4Measurement Plot (showing the highest value, "worst case")




Title: Channel separation
Comment A: CH H: Hopping
Date: 26.APR.2016 12:57:37

### 4.7.5Test Equipment used

Regulatory Bluetooth RF Test Solution

## 4.8 Dwell Time

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.8.1 Test Description

The Equipment Under Test (EUT) was set up to perform the dwell time measurements. The dwell time is independent from the modulation pattern. The dwell time is calculated by:

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Dwell time = time slot length * hop rate / number of hopping channels * 31.6 s

with:

- hop rate = 1600 * 1/s for DH1 packets = 1600 s-1
- hop rate = 1600/3 * 1/s for DH3 packets= 533.33 s-1
- hop rate = 1600/5 * 1/s for DH5 packets= 320 s-1
- number of hopping channels = 79
- 31.6 s = 0.4 seconds multiplied by the number of hopping channels = 0.4 s * 79

The highest value of the dwell time is reported.

Analyzer settings:

- Center Frequency: mid channel frequency
- Span: Zero span
- Detector: Peak
- Trace: Maxhold
- Resolution Bandwidth (RBW): ≤ channel separation
- Trigger: Video

### 4.8.2 Test Requirements / Limits

For the band: 902 – 928 MHz
FCC Part 15, Subpart C, §15.247 (a) (1) (i)

If the 20 dB bandwidth of the hopping channel is less than 250 kHz the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.
If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period.

For the band: 5725 – 5850 MHz
FCC Part 15, Subpart C, §15.247 (a) (1) (ii)

The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

For the frequency band 2400 – 2483.5 MHz:
FCC Part 15, Subpart C, §15.247 (a) (1) (iii)

…The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Since the Bluetooth technology uses 79 channels this period is calculated to be 31.6 seconds.

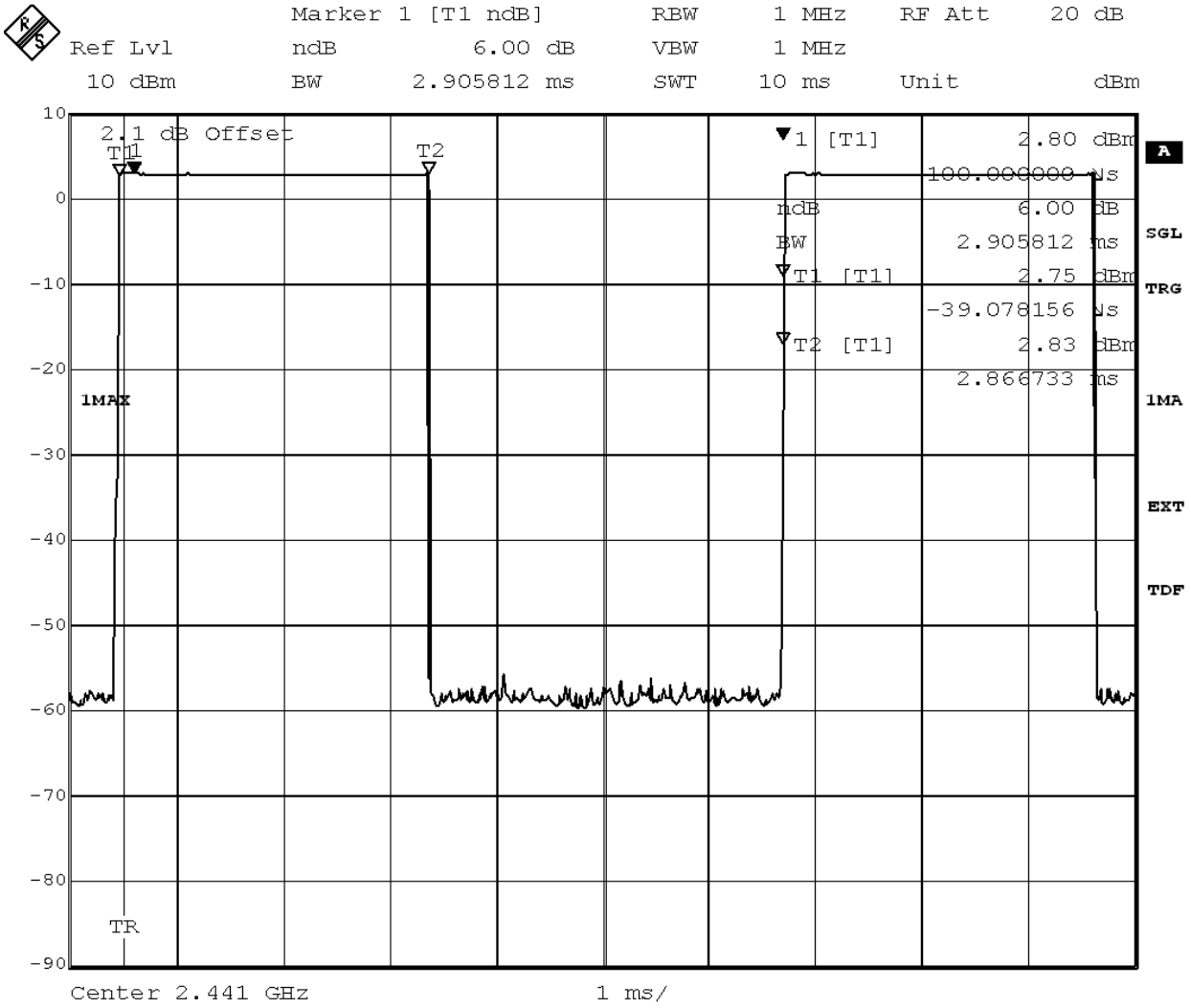
### 4.8.3Test Protocol

Ambient temperature: 23 °C
Air Pressure: 1008 hPa
Humidity: 41 %

| Radio Technology | Time Slot Length [ms] | Dwell Time [ms] | Limit [s] | Margin to Limit [ms] |
|---|---|---|---|---|
| BT GFSK (1-DH5) | 2.9 | 372.5 | 0.4 | 27.5 |

Remark: Please see next sub-clause for the measurement plot.

### 4.8.4Measurement Plot (showing the highest value, "worst case")




Title: Dwell time
Comment A: CH M: 2441 MHz
Date: 26.APR.2016 10:24:17

### 4.8.5Test Equipment used

Regulatory Bluetooth RF Test Solution

## 4.9 Number of Hopping Frequencies

Standard **47 CFR CHAPTER I FCC PART 15 Subpart C §15.247**

**The test was performed according to:** ANSI C63.10

### 4.9.1Test Description

The Equipment Under Test (EUT) was set up to perform the number of hopping frequencies measurement. The number of hopping frequencies is independent from the modulation pattern.

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:

- Detector: Peak
- Trace: Maxhold
- Centre frequency: 2442 MHz
- Frequency span: Frequency band of operation
- Resolution Bandwidth (RBW): < 30 % of channel spacing or 20 dB bandwidth (whichever is maller)
- Video Bandwidth (VBW): 3 x RBW
- Sweep Time: 5 ms
- Sweeps: 2000

The technology depending measurement parameters can be found in the measurement plot.

### 4.9.2Test Requirements / Limits

For the band: 902 – 928 MHz
FCC Part 15, Subpart C, §15.247 (a) (1) (i)

If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies.
If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies

For the band: 5725 – 5850 MHz
FCC Part 15, Subpart C, §15.247 (a) (1) (ii)

Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies.

For the band: 2400 – 2483.5 MHz
FCC Part 15, Subpart C, §15.247 (a) (1) (iii)

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

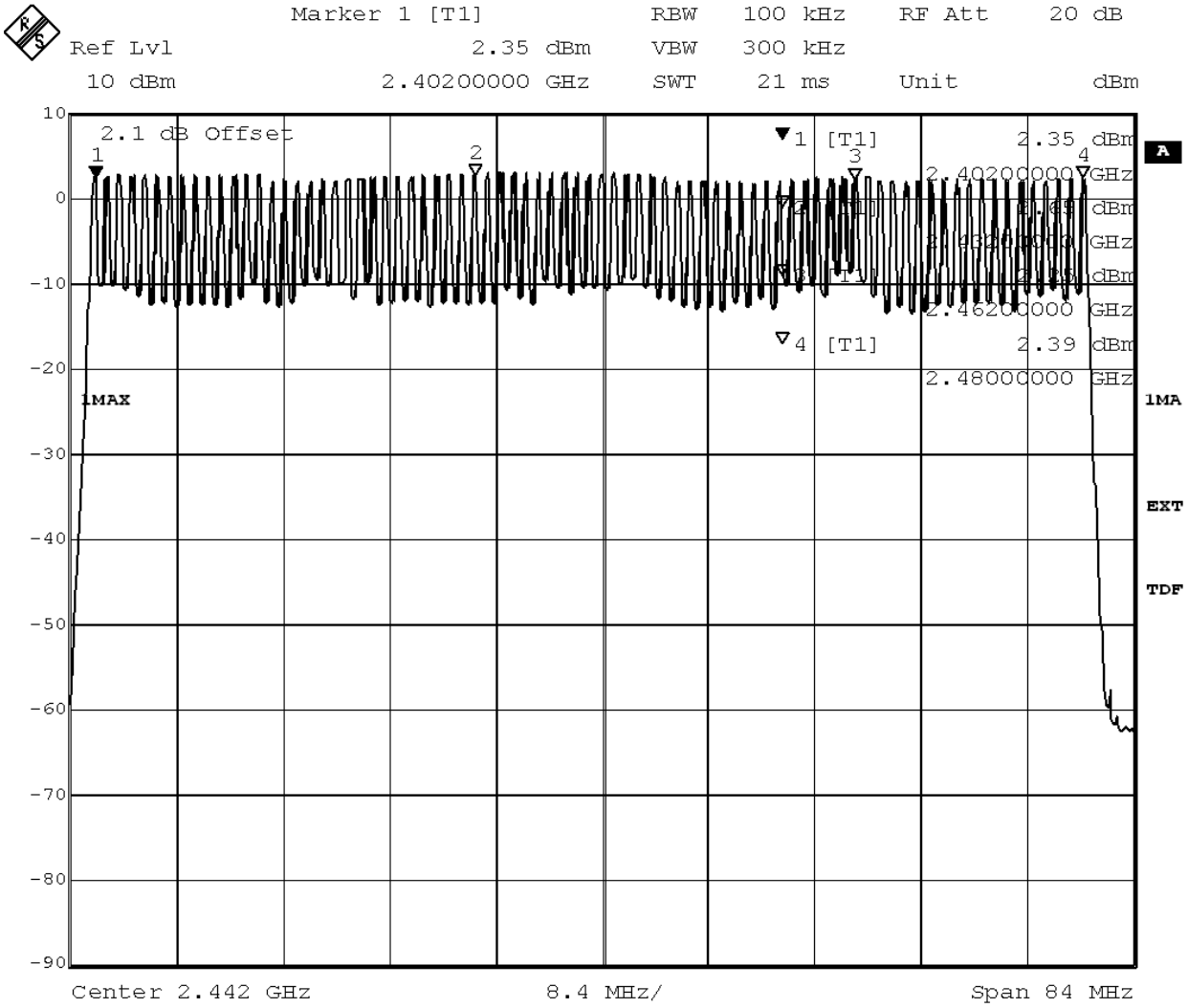
### 4.9.3Test Protocol

| | |
|---|---|
| Ambient temperature: | 23 °C |
| Air Pressure: | 1008 hPa |
| Humidity: | 41 % |

| Radio Technology | Number of Hopping Frequencies | Limit | Margin to Limit |
|---|---|---|---|
| BT GFSK (1-DH1) | 79.0 | 15.0 | 64.0 |

Remark: Please see next sub-clause for the measurement plot.

### 4.9.4Measurement Plot (showing the highest value, "worst case")




Title: Number of hopping frequencies
Comment A: CH H: Hopping
Date: 26.APR.2016 13:02:41

### 4.9.5Test Equipment used

Regulatory Bluetooth RF Test Solution

# 5 Test Equipment

## 1 Radiated Emissions

Lab to perform radiated emission tests

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Calibration Due |
|---|---|---|---|---|---|
| 1.1 | 3160-09 | Standard Gain / Pyramidal Horn Antenna 26.5 GHz | EMCO Elektronic GmbH | 00083069 | |
| 1.2 | WHKX 7.0/18G-8SS | High Pass Filter | Wainwright | 09 | |
| 1.3 | 5HC3500/18000-1.2-KK | High Pass Filter | Trilithic | 200035008 | |
| 1.4 | Fully Anechoic Room | 8.80m x 4.60m x 4.05m (l x w x h) | Albatross Projects | P26971-647-001-PRB | |
| 1.5 | AM 4.0 | Antenna mast | Maturo GmbH | AM4.0/180/11920513 | |
| 1.6 | ESR 7 | EMI Receiver / Spectrum Analyzer | Rohde & Schwarz | 101424 | 2016-11-12 |
| 1.7 | TT 1.5 WI | Turn Table | Maturo GmbH | - | |
| 1.8 | Anechoic Chamber | 10.58 x 6.38 x 6.00 m³ | Frankonia | none | 2017-01-09 |
| 1.9 | ESIB 26 | Spectrum Analyzer | Rohde & Schwarz | 830482/004 | 2017-12-08 |
| 1.10 | Tilt device Maturo (Rohacell) | Antrieb TD1.5-10kg | Maturo GmbH | TD1.5-10kg/024/3790709 | |
| 1.11 | 5HC2700/12750-1.5-KK | High Pass Filter | Trilithic | 9942012 | |
| 1.12 | AS 620 P | Antenna mast | HD GmbH | 620/37 | |
| 1.13 | NRV-Z1 | Sensor Head A | Rohde & Schwarz | 827753/005 | 2016-05-10 |
| 1.14 | 4HC1600/12750-1.5-KK | High Pass Filter | Trilithic | 9942011 | |
| 1.15 | ASP 1.2/1.8-10 kg | Antenna Mast | Maturo GmbH | - | |
| 1.16 | JS4-18002600-32-5P | Broadband Amplifier 18 GHz - 26 GHz | Miteq | 849785 | |
| 1.17 | JS4-00101800-35-5P | Broadband Amplifier 30 MHz - 18 GHz | Miteq | 896037 | |
| 1.18 | HL 562 | Ultralog new biconicals | Rohde & Schwarz GmbH & Co. KG | 830547/003 | 2018-06-29 |
| 1.19 | Opus10 THI (8152.00) | ThermoHygro Datalogger 12 (Environ) | Lufft Mess- und Regeltechnik GmbH | 12482 | 2017-03-09 |
| 1.20 | JS4-00102600-42-5A | Broadband Amplifier 30 MHz - 26 GHz | Miteq | 619368 | |

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Calibration Due |
|---|---|---|---|---|---|
| 1.21 | HFH2-Z2 | Loop Antenna | Rohde & Schwarz GmbH & Co. KG | 829324/006 | 2017-11-26 |
| 1.22 | FSW 43 | Spectrum Analyzer | Rohde & Schwarz | 103779 | 2016-11-16 |
| 1.23 | Opus10 TPR (8253.00) | ThermoAirpressure Datalogger 13 (Environ) | Lufft Mess- und Regeltechnik GmbH | 13936 | 2017-02-26 |
| 1.24 | Chroma 6404 | AC Power Source | Chroma ATE INC. | 64040001304 | |
| 1.25 | 3160-10 | Standard Gain / Pyramidal Horn Antenna 40 GHz | EMCO Elektronik GmbH | 00086675 | |
| 1.26 | HL 562 Ultralog | Log.-per. Antenna | Rohde & Schwarz GmbH & Co. KG | 100609 | 2019-04-10 |
| 1.27 | PAS 2.5 - 10 kg | Antenna Mast | Maturo GmbH | - | |
| 1.28 | HF 907 | Double-ridged horn | Rohde & Schwarz GmbH & Co. KG | 102444 | 2018-05-10 |

## 2 Regulatory Bluetooth RF Test Solution

Regulatory Bluetooth RF Tests

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Calibration Due |
|---|---|---|---|---|---|
| 2.1 | CBT | IL BT RF Test Solution | Rohde & Schwarz GmbH & Co. KG | 100302 | 2016-08-20 |
| 2.2 | EX520 | Digital Multimeter 12 (Multimeter) | Extech Instruments Corp | 05157876 | 2018-02-03 |
| 2.3 | SMIQ03B | Options:<br>B5<br>B11<br>B19<br>B20<br>B50<br>Battery Pack | Rohde & Schwarz GmbH & Co. KG | 832870/017 | 2016-06-21 |
| 2.4 | Datum MFS | Rubidium Frequency Normal MFS | Datum GmbH | 002 | 2016-08-25 |
| 2.5 | FSIQ26 | IL BT RF Test Solution Ratingen 1119.6001.26 | Rohde & Schwarz GmbH & Co. KG | 832695/007 | 2016-08-28 |
| 2.6 | NRVD | Powermeter | Rohde & Schwarz GmbH & Co. KG | 832025/059 | 2016-08-19 |
| 2.7 | TOCT Switching Unit | | 7 layers, Inc | 040107 | |

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Calibration Due |
|---|---|---|---|---|---|
| 2.8 | Opus10 THI (8152.00) | T/H Logger 15 | Lufft Mess- und Regeltechnik GmbH | 13985 | 2017-03-10 |
| 2.9 | NRV Z1 A | Power Sensor | Rohde & Schwarz GmbH & Co. KG | 832279/013 | 2016-08-18 |
| 2.10 | ADU 200 Relay Box 7 | used for automated testing (EMMI) only | Ontrak Control Systems Inc | A04380 | |
| 2.11 | R&S CBT | Bluetooth Signalling Unit | Rohde & Schwarz | 100589 | 2018-01-21 |
| 2.12 | KWP 120/70 | Temperature Chamber Weiss 01 | Weiss | 59226012190010 | 2018-03-09 |
| 2.13 | NGSM 32/10 | Power Supply | Rohde & Schwarz GmbH & Co. KG | 2725 | 2017-06-22 |
| 2.14 | SMP02 | Signal Generator | Rohde & Schwarz GmbH & Co. KG | 829076/017 | 2016-04-18 |

# 6 Antenna Factors, Cable Loss and Sample Calculations

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

## 6.1 LISN R&S ESH3-Z5 (150 kHz – 30 MHz)

| Frequency | | Corr. | LISN insertion loss ESH3-Z5 | cable loss (incl. 10 dB atten-uator) |
|---|---|---|---|---|
| MHz | | dB | dB | dB |
| 0,15 | | 10,1 | 0,1 | 10,0 |
| 5 | | 10,3 | 0,1 | 10,2 |
| 7 | | 10,5 | 0,2 | 10,3 |
| 10 | | 10,5 | 0,2 | 10,3 |
| 12 | | 10,7 | 0,3 | 10,4 |
| 14 | | 10,7 | 0,3 | 10,4 |
| 16 | | 10,8 | 0,4 | 10,4 |
| 18 | | 10,9 | 0,4 | 10,5 |
| 20 | | 10,9 | 0,4 | 10,5 |
| 22 | | 11,1 | 0,5 | 10,6 |
| 24 | | 11,1 | 0,5 | 10,6 |
| 26 | | 11,2 | 0,5 | 10,7 |
| 28 | | 11,2 | 0,5 | 10,7 |
| 30 | | 11,3 | 0,5 | 10,8 |

**Sample calculation**

$U_{LISN}$ (dB µV) = U (dB µV) + Corr. (dB)
U = Receiver reading
LISN Insertion loss = Voltage Division Factor of LISN
Corr. = sum of single correction factors of used LISN, cables, switch units (if used)
Linear interpolation will be used for frequencies in between the values in the table.

## 6.2 Antenna R&S HFH2-Z2 (9 kHz – 30 MHz)

| Frequency | AF HFH-Z2) | Corr. | cable loss 1 (inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit) | cable loss 4 (to receiver) | distance corr. (-40 dB/ decade) | $d_{Limit}$ (meas. distance (limit) | $d_{used}$ (meas. distance (used) |
|---|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | dB | m | m |
| 0,009 | 20,50 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,01 | 20,45 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,015 | 20,37 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,02 | 20,36 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,025 | 20,38 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,03 | 20,32 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,05 | 20,35 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,08 | 20,30 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,1 | 20,20 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,2 | 20,17 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,3 | 20,14 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,49 | 20,12 | -79,6 | 0,1 | 0,1 | 0,1 | 0,1 | -80 | 300 | 3 |
| 0,490001 | 20,12 | -39,6 | 0,1 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 0,5 | 20,11 | -39,6 | 0,1 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 0,8 | 20,10 | -39,6 | 0,1 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 1 | 20,09 | -39,6 | 0,1 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 2 | 20,08 | -39,6 | 0,1 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 3 | 20,06 | -39,6 | 0,1 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 4 | 20,05 | -39,5 | 0,2 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 5 | 20,05 | -39,5 | 0,2 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 6 | 20,02 | -39,5 | 0,2 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 8 | 19,95 | -39,5 | 0,2 | 0,1 | 0,1 | 0,1 | -40 | 30 | 3 |
| 10 | 19,83 | -39,4 | 0,2 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 12 | 19,71 | -39,4 | 0,2 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 14 | 19,54 | -39,4 | 0,2 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 16 | 19,53 | -39,3 | 0,3 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 18 | 19,50 | -39,3 | 0,3 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 20 | 19,57 | -39,3 | 0,3 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 22 | 19,61 | -39,3 | 0,3 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 24 | 19,61 | -39,3 | 0,3 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 26 | 19,54 | -39,3 | 0,3 | 0,1 | 0,2 | 0,1 | -40 | 30 | 3 |
| 28 | 19,46 | -39,2 | 0,3 | 0,1 | 0,3 | 0,1 | -40 | 30 | 3 |
| 30 | 19,73 | -39,1 | 0,4 | 0,1 | 0,3 | 0,1 | -40 | 30 | 3 |

**Sample calculation**

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -40 * LOG ($d_{Limit}$/ $d_{used}$)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values

## 6.3 Antenna R&S HL562 (30 MHZ – 1 GHz)

**($d_{Limit}$ = 3 m)**

| Frequency | AF R&S HL562 | Corr. | cable loss 1 (inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit) | cable loss 4 (to receiver) | distance corr. (-20 dB/ decade) | $d_{Limit}$ (meas. distance (limit) | $d_{used}$ (meas. distance (used) |
|---|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | dB | m | m |
| 30 | 18,6 | 0,6 | 0,29 | 0,04 | 0,23 | 0,02 | 0,0 | 3 | 3 |
| 50 | 6,0 | 0,9 | 0,39 | 0,09 | 0,32 | 0,08 | 0,0 | 3 | 3 |
| 100 | 9,7 | 1,2 | 0,56 | 0,14 | 0,47 | 0,08 | 0,0 | 3 | 3 |
| 150 | 7,9 | 1,6 | 0,73 | 0,20 | 0,59 | 0,12 | 0,0 | 3 | 3 |
| 200 | 7,6 | 1,9 | 0,84 | 0,21 | 0,70 | 0,11 | 0,0 | 3 | 3 |
| 250 | 9,5 | 2,1 | 0,98 | 0,24 | 0,80 | 0,13 | 0,0 | 3 | 3 |
| 300 | 11,0 | 2,3 | 1,04 | 0,26 | 0,89 | 0,15 | 0,0 | 3 | 3 |
| 350 | 12,4 | 2,6 | 1,18 | 0,31 | 0,96 | 0,13 | 0,0 | 3 | 3 |
| 400 | 13,6 | 2,9 | 1,28 | 0,35 | 1,03 | 0,19 | 0,0 | 3 | 3 |
| 450 | 14,7 | 3,1 | 1,39 | 0,38 | 1,11 | 0,22 | 0,0 | 3 | 3 |
| 500 | 15,6 | 3,2 | 1,44 | 0,39 | 1,20 | 0,19 | 0,0 | 3 | 3 |
| 550 | 16,3 | 3,5 | 1,55 | 0,46 | 1,24 | 0,23 | 0,0 | 3 | 3 |
| 600 | 17,2 | 3,5 | 1,59 | 0,43 | 1,29 | 0,23 | 0,0 | 3 | 3 |
| 650 | 18,1 | 3,6 | 1,67 | 0,34 | 1,35 | 0,22 | 0,0 | 3 | 3 |
| 700 | 18,5 | 3,6 | 1,67 | 0,42 | 1,41 | 0,15 | 0,0 | 3 | 3 |
| 750 | 19,1 | 4,1 | 1,87 | 0,54 | 1,46 | 0,25 | 0,0 | 3 | 3 |
| 800 | 19,6 | 4,1 | 1,90 | 0,46 | 1,51 | 0,25 | 0,0 | 3 | 3 |
| 850 | 20,1 | 4,4 | 1,99 | 0,60 | 1,56 | 0,27 | 0,0 | 3 | 3 |
| 900 | 20,8 | 4,7 | 2,14 | 0,60 | 1,63 | 0,29 | 0,0 | 3 | 3 |
| 950 | 21,1 | 4,8 | 2,22 | 0,60 | 1,66 | 0,33 | 0,0 | 3 | 3 |
| 1000 | 21,6 | 4,9 | 2,23 | 0,61 | 1,71 | 0,30 | 0,0 | 3 | 3 |

**($d_{Limit}$ = 10 m)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 18,6 | -9,9 | 0,29 | 0,04 | 0,23 | 0,02 | -10,5 | 10 | 3 |
| 50 | 6,0 | -9,6 | 0,39 | 0,09 | 0,32 | 0,08 | -10,5 | 10 | 3 |
| 100 | 9,7 | -9,2 | 0,56 | 0,14 | 0,47 | 0,08 | -10,5 | 10 | 3 |
| 150 | 7,9 | -8,8 | 0,73 | 0,20 | 0,59 | 0,12 | -10,5 | 10 | 3 |
| 200 | 7,6 | -8,6 | 0,84 | 0,21 | 0,70 | 0,11 | -10,5 | 10 | 3 |
| 250 | 9,5 | -8,3 | 0,98 | 0,24 | 0,80 | 0,13 | -10,5 | 10 | 3 |
| 300 | 11,0 | -8,1 | 1,04 | 0,26 | 0,89 | 0,15 | -10,5 | 10 | 3 |
| 350 | 12,4 | -7,9 | 1,18 | 0,31 | 0,96 | 0,13 | -10,5 | 10 | 3 |
| 400 | 13,6 | -7,6 | 1,28 | 0,35 | 1,03 | 0,19 | -10,5 | 10 | 3 |
| 450 | 14,7 | -7,4 | 1,39 | 0,38 | 1,11 | 0,22 | -10,5 | 10 | 3 |
| 500 | 15,6 | -7,2 | 1,44 | 0,39 | 1,20 | 0,19 | -10,5 | 10 | 3 |
| 550 | 16,3 | -7,0 | 1,55 | 0,46 | 1,24 | 0,23 | -10,5 | 10 | 3 |
| 600 | 17,2 | -6,9 | 1,59 | 0,43 | 1,29 | 0,23 | -10,5 | 10 | 3 |
| 650 | 18,1 | -6,9 | 1,67 | 0,34 | 1,35 | 0,22 | -10,5 | 10 | 3 |
| 700 | 18,5 | -6,8 | 1,67 | 0,42 | 1,41 | 0,15 | -10,5 | 10 | 3 |
| 750 | 19,1 | -6,3 | 1,87 | 0,54 | 1,46 | 0,25 | -10,5 | 10 | 3 |
| 800 | 19,6 | -6,3 | 1,90 | 0,46 | 1,51 | 0,25 | -10,5 | 10 | 3 |
| 850 | 20,1 | -6,0 | 1,99 | 0,60 | 1,56 | 0,27 | -10,5 | 10 | 3 |
| 900 | 20,8 | -5,8 | 2,14 | 0,60 | 1,63 | 0,29 | -10,5 | 10 | 3 |
| 950 | 21,1 | -5,6 | 2,22 | 0,60 | 1,66 | 0,33 | -10,5 | 10 | 3 |
| 1000 | 21,6 | -5,6 | 2,23 | 0,61 | 1,71 | 0,30 | -10,5 | 10 | 3 |

**Sample calculation**

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -20 * LOG ($d_{Limit}$/ $d_{used}$)
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

## 6.4 Antenna R&S HF907 (1 GHz – 18 GHz)

| Frequency | AF R&S HF907 | Corr. | cable loss 1 (relay + cable inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit, atten-uator & pre-amp) | cable loss 4 (to receiver) | | |
|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | | |
| 1000 | 24,4 | -19,4 | 0,99 | 0,31 | -21,51 | 0,79 | | |
| 2000 | 28,5 | -17,4 | 1,44 | 0,44 | -20,63 | 1,38 | | |
| 3000 | 31,0 | -16,1 | 1,87 | 0,53 | -19,85 | 1,33 | | |
| 4000 | 33,1 | -14,7 | 2,41 | 0,67 | -19,13 | 1,31 | | |
| 5000 | 34,4 | -13,7 | 2,78 | 0,86 | -18,71 | 1,40 | | |
| 6000 | 34,7 | -12,7 | 2,74 | 0,90 | -17,83 | 1,47 | | |
| 7000 | 35,6 | -11,0 | 2,82 | 0,86 | -16,19 | 1,46 | | |

| Frequency | AF R&S HF907 | Corr. | cable loss 1 (relay inside chamber) | cable loss 2 (inside chamber) | cable loss 3 (outside chamber) | cable loss 4 (switch unit, atten-uator & pre-amp) | cable loss 5 (to receiver) | used for FCC 15.247 |
|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | dB | |
| 3000 | 31,0 | -23,4 | 0,47 | 1,87 | 0,53 | -27,58 | 1,33 | |
| 4000 | 33,1 | -23,3 | 0,56 | 2,41 | 0,67 | -28,23 | 1,31 | |
| 5000 | 34,4 | -21,7 | 0,61 | 2,78 | 0,86 | -27,35 | 1,40 | |
| 6000 | 34,7 | -21,2 | 0,58 | 2,74 | 0,90 | -26,89 | 1,47 | |
| 7000 | 35,6 | -19,8 | 0,66 | 2,82 | 0,86 | -25,58 | 1,46 | |

| Frequency | AF R&S HF907 | Corr. | cable loss 1 (relay inside chamber) | cable loss 2 (High Pass) | cable loss 3 (pre-amp) | cable loss 4 (inside chamber) | cable loss 5 (outside chamber) | cable loss 6 (to receiver) |
|---|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | dB | dB |
| 7000 | 35,6 | -57,3 | 0,56 | 1,28 | -62,72 | 2,66 | 0,94 | 1,46 |
| 8000 | 36,3 | -56,3 | 0,69 | 0,71 | -61,49 | 2,84 | 1,00 | 1,53 |
| 9000 | 37,1 | -55,3 | 0,68 | 0,65 | -60,80 | 3,06 | 1,09 | 1,60 |
| 10000 | 37,5 | -56,2 | 0,70 | 0,54 | -61,91 | 3,28 | 1,20 | 1,67 |
| 11000 | 37,5 | -55,3 | 0,80 | 0,61 | -61,40 | 3,43 | 1,27 | 1,70 |
| 12000 | 37,6 | -53,7 | 0,84 | 0,42 | -59,70 | 3,53 | 1,26 | 1,73 |
| 13000 | 38,2 | -53,5 | 0,83 | 0,44 | -59,81 | 3,75 | 1,32 | 1,83 |
| 14000 | 39,9 | -56,3 | 0,91 | 0,53 | -63,03 | 3,91 | 1,40 | 1,77 |
| 15000 | 40,9 | -54,1 | 0,98 | 0,54 | -61,05 | 4,02 | 1,44 | 1,83 |
| 16000 | 41,3 | -54,1 | 1,23 | 0,49 | -61,51 | 4,17 | 1,51 | 1,85 |
| 17000 | 42,8 | -54,4 | 1,36 | 0,76 | -62,36 | 4,34 | 1,53 | 2,00 |
| 18000 | 44,2 | -54,7 | 1,70 | 0,53 | -62,88 | 4,41 | 1,55 | 1,91 |

**Sample calculation**

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

## 6.5 Antenna EMCO 3160-09 (18 GHz – 26.5 GHz)

| Frequency | AF EMCO 3160-09 | Corr. | cable loss 1 (inside chamber) | cable loss 2 (pre-amp) | cable loss 3 (inside chamber) | cable loss 4 (switch unit) | cable loss 5 (to receiver) |
|---|---|---|---|---|---|---|---|
| MHz | dB (1/m) | dB | dB | dB | dB | dB | dB |
| 18000 | 40,2 | -23,5 | 0,72 | -35,85 | 6,20 | 2,81 | 2,65 |
| 18500 | 40,2 | -23,2 | 0,69 | -35,71 | 6,46 | 2,76 | 2,59 |
| 19000 | 40,2 | -22,0 | 0,76 | -35,44 | 6,69 | 3,15 | 2,79 |
| 19500 | 40,3 | -21,3 | 0,74 | -35,07 | 7,04 | 3,11 | 2,91 |
| 20000 | 40,3 | -20,3 | 0,72 | -34,49 | 7,30 | 3,07 | 3,05 |
| 20500 | 40,3 | -19,9 | 0,78 | -34,46 | 7,48 | 3,12 | 3,15 |
| 21000 | 40,3 | -19,1 | 0,87 | -34,07 | 7,61 | 3,20 | 3,33 |
| 21500 | 40,3 | -19,1 | 0,90 | -33,96 | 7,47 | 3,28 | 3,19 |
| 22000 | 40,3 | -18,7 | 0,89 | -33,57 | 7,34 | 3,35 | 3,28 |
| 22500 | 40,4 | -19,0 | 0,87 | -33,66 | 7,06 | 3,75 | 2,94 |
| 23000 | 40,4 | -19,5 | 0,88 | -33,75 | 6,92 | 3,77 | 2,70 |
| 23500 | 40,4 | -19,3 | 0,90 | -33,35 | 6,99 | 3,52 | 2,66 |
| 24000 | 40,4 | -19,8 | 0,88 | -33,99 | 6,88 | 3,88 | 2,58 |
| 24500 | 40,4 | -19,5 | 0,91 | -33,89 | 7,01 | 3,93 | 2,51 |
| 25000 | 40,4 | -19,3 | 0,88 | -33,00 | 6,72 | 3,96 | 2,14 |
| 25500 | 40,5 | -20,4 | 0,89 | -34,07 | 6,90 | 3,66 | 2,22 |
| 26000 | 40,5 | -21,3 | 0,86 | -35,11 | 7,02 | 3,69 | 2,28 |
| 26500 | 40,5 | -21,1 | 0,90 | -35,20 | 7,15 | 3,91 | 2,36 |

**Sample calculation**

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

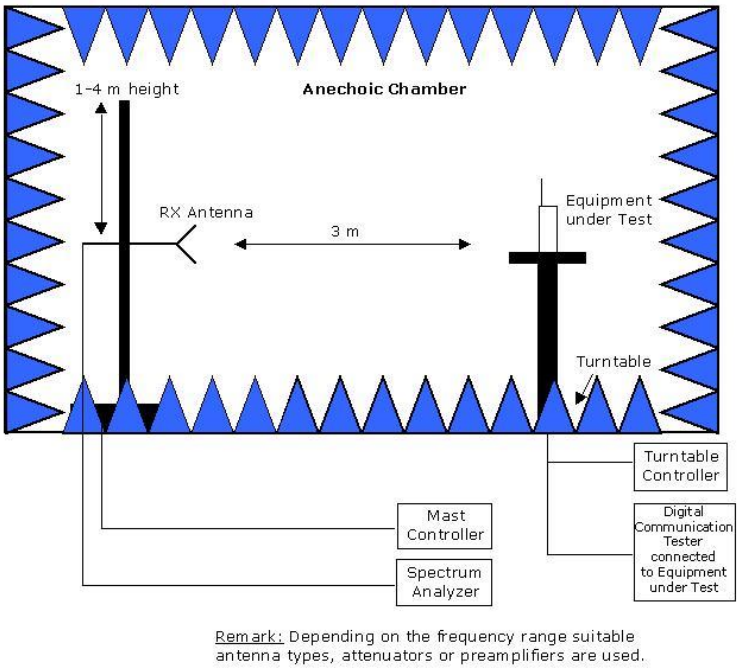
## 6.6 Antenna EMCO 3160-10

| Frequency | AF EMCO 3160-10 | Corr. | cable loss 1 (inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit) | cable loss 4 (to receiver) | distance corr. (-20 dB/ decade) | $d_{Limit}$ (meas. distance (limit) | $d_{used}$ (meas. distance (used) |
|---|---|---|---|---|---|---|---|---|---|
| GHz | dB (1/m) | dB | dB | dB | dB | dB | dB | m | m |
| 26,5 | 43,4 | -11,2 | 4,4 | | | | -15,6 | 3 | 0,5 |
| 27,0 | 43,4 | -11,2 | 4,4 | | | | -15,6 | 3 | 0,5 |
| 28,0 | 43,4 | -11,1 | 4,5 | | | | -15,6 | 3 | 0,5 |
| 29,0 | 43,5 | -11,0 | 4,6 | | | | -15,6 | 3 | 0,5 |
| 30,0 | 43,5 | -10,9 | 4,7 | | | | -15,6 | 3 | 0,5 |
| 31,0 | 43,5 | -10,8 | 4,7 | | | | -15,6 | 3 | 0,5 |
| 32,0 | 43,5 | -10,7 | 4,8 | | | | -15,6 | 3 | 0,5 |
| 33,0 | 43,6 | -10,7 | 4,9 | | | | -15,6 | 3 | 0,5 |
| 34,0 | 43,6 | -10,6 | 5,0 | | | | -15,6 | 3 | 0,5 |
| 35,0 | 43,6 | -10,5 | 5,1 | | | | -15,6 | 3 | 0,5 |
| 36,0 | 43,6 | -10,4 | 5,1 | | | | -15,6 | 3 | 0,5 |
| 37,0 | 43,7 | -10,3 | 5,2 | | | | -15,6 | 3 | 0,5 |
| 38,0 | 43,7 | -10,2 | 5,3 | | | | -15,6 | 3 | 0,5 |
| 39,0 | 43,7 | -10,2 | 5,4 | | | | -15,6 | 3 | 0,5 |
| 40,0 | 43,8 | -10,1 | 5,5 | | | | -15,6 | 3 | 0,5 |

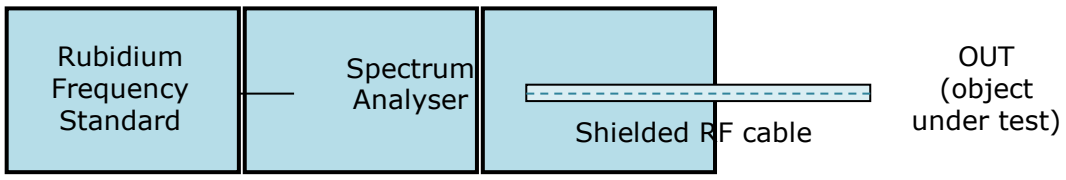
**Sample calculation**

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolarisation will be used for frequencies in between the values in the table.
distance correction = -20 * LOG ($d_{Limit}$/ $d_{used}$)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

# 7 Setup Drawings




**Drawing 1:** Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting groundplane.




**Drawing 2:** Setup for conducted radio tests.

## 8 Measurement Uncertainties

| Test Case | Parameter | Uncertainty |
|---|---|---|
| AC Power Line | Power | ± 3.4 dB |
| Field Strength of spurious radiation | Power | ± 5.5 dB |
| 6 dB / 26 dB / 99% Bandwidth | Power<br>Frequency | ± 2.9 dB<br>± 11.2 kHz |
| Conducted Output Power | Power | ± 2.2 dB |
| Band Edge Compliance | Power<br>Frequency | ± 2.2 dB<br>± 11.2 kHz |
| Frequency Stability | Frequency | ± 25 Hz |
| Power Spectral Density | Power | ± 2.2 dB |

## 9 Photo Report

Please see separate photo report.