

FCC Measurement/Technical Report on

WLAN and Bluetooth module

M2-JODY-W263

FCC ID: XPYJODYW263

IC: 8595A-JODYW263

Test Report Reference: MDE_UBLOX_2107_FCC_01

Test Laboratory:

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40880 Ratingen
Germany



Deutsche
Akkreditierungsstelle
D-PL-12140-01-01
D-PL-12140-01-02
D-PL-12140-01-03

Note:

The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the test laboratory.

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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 (10-1-21 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:

The tests were selected and performed with reference to the FCC Public Notice "Guidance for Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating under Section 15.247 of the FCC Rules, 558074 D01 15.247 Meas Guidance v05r02, 2019-04-02". ANSI C63.10-2013 is applied.

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 5: 8.8 |
| Occupied bandwidth | § 15.247 (a) (1) | RSS-247 Issue 2: 5.1 (b) |
| Peak conducted output power | § 15.247 (b) (1), (4) | RSS-247 Issue 2: 5.4 (b) |
| Transmitter spurious RF conducted emissions | § 15.247 (d) | RSS-Gen Issue 5: 6.13/8.9/8.10; RSS-247 Issue 2: 5.5 |
| Transmitter spurious radiated emissions | § 15.247 (d); § 15.209 (a) | RSS-Gen Issue 5: 6.13 / 8.9/8.10; RSS-247 Issue 2: 5.5 |
| Band edge compliance | § 15.247 (d) | RSS-247 Issue 2: 5.5 |
| Dwell time | § 15.247 (a) (1) (iii) | RSS-247 Issue 2: 5.1 (d) |
| Channel separation | § 15.247 (a) (1) | RSS-247 Issue 2: 5.1 (b) |
| No. of hopping frequencies | § 15.247 (a) (1) (iii) | RSS-247 Issue 2: 5.1 (d) |
| Hybrid systems (only) | § 15.247 (f); § 15.247 (e) | RSS-247 Issue 2: 5.3 |
| Antenna requirement | § 15.203 / 15.204 | RSS-Gen Issue 5: 8.3 |
| Receiver spurious emissions | - | - |

1.3 MEASUREMENT SUMMARY

47 CFR CHAPTER I FCC PART 15 Subpart C §15.247

§ 15.247 (b) (1) (2)

Peak Power Output

The measurement was performed according to ANSI C63.10, chapter 11.9.1.3

Final Result

| OP-Mode | Setup | Date | FCC | IC |
|---|----------|------------|--------|--------|
| Radio Technology, Operating Frequency, Measurement method | | | | |
| Bluetooth BDR, high, conducted | S01_AA01 | 2022-05-16 | Passed | Passed |
| Bluetooth BDR, low, conducted | S01_AA01 | 2022-05-16 | Passed | Passed |
| Bluetooth BDR, mid, conducted | S01_AA01 | 2022-05-16 | Passed | Passed |
| Bluetooth EDR 2, high, conducted | S01_AA01 | 2022-05-16 | Passed | Passed |
| Bluetooth EDR 2, low, conducted | S01_AA01 | 2022-05-16 | Passed | Passed |
| Bluetooth EDR 2, mid, conducted | S01_AA01 | 2022-05-16 | Passed | Passed |
| Bluetooth EDR 3, high, conducted | S01_AA01 | 2022-05-16 | Passed | Passed |
| Bluetooth EDR 3, low, conducted | S01_AA01 | 2022-05-16 | Passed | Passed |
| Bluetooth EDR 3, mid, conducted | S01_AA01 | 2022-05-16 | 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, chapter 6.4, 6.5, 6.6.5

Final Result

| OP-Mode | Setup | Date | FCC | IC |
|--|----------|------------|--------|--------|
| Radio Technology, Operating Frequency, Measurement range | | | | |
| Bluetooth BDR, low, 1 GHz - 26 GHz | S02_AA01 | 2022-05-13 | 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, chapter 6.6.5

Final Result

| OP-Mode | Setup | Date | FCC | IC |
|--|----------|------------|--------|--------|
| Radio Technology, Operating Frequency, Band Edge | | | | |
| Bluetooth EDR 3, high, high | S02_AA01 | 2022-05-13 | Passed | Passed |

N/A: Not applicable

N/P: Not performed

2 REVISION HISTORY / SIGNATURES

| Report version control | | | |
|------------------------|--------------|--------------------|------------------|
| Version | Release date | Change Description | Version validity |
| initial | 2022-11-16 | -- | valid |
| -- | -- | -- | -- |

COMMENT: A different variant has already been tested that according to the applicant is identical to this variant except for being mounted on an M.2 card. Due to this only spot checks have been performed. Reference to report of original variant: MDE_UBLOX_2008_FCC_01.



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



(responsible for testing and report)
Dipl.Ing. Daniel Gall



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3 ADMINISTRATIVE DATA

3.1 TESTING LABORATORY

Company Name: 7layers GmbH

Address: Borsigstr. 11
40880 Ratingen
Germany

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no: DAkkS D-PL-12140-01-01 | -02 | -03

FCC Designation Number: DE0015

FCC Test Firm Registration: 929146

ISED CAB Identifier DE0007; ISED#: 3699A

Responsible for accreditation scope: Dipl.-Ing. Marco Kullik

Report Template Version: 2022-05-25

3.2 PROJECT DATA

Responsible for testing and report: Dipl.Ing. Daniel Gall

Employees who performed the tests: documented internally at 7Layers

Date of Report: 2022-11-18

Testing Period: 2022-05-13 to 2022-05-16

3.3 APPLICANT DATA

Company Name: u-blox AG

Address: Zürcherstrasse 68
8800 Thalwil
Switzerland

Contact Person: Filip Kruzela



3.4 MANUFACTURER DATA

Company Name: please see Applicant Data

Address:

Contact Person:

4 TEST OBJECT DATA

4.1 GENERAL EUT DESCRIPTION

| | |
|------------------------------------|---------------------------------------|
| Kind of Device product description | WLAN and Bluetooth Module on M.2 Card |
| Product name | JODY-W263-00B |
| Type | JODY-W263-00B |

Declared EUT data by the supplier

| | |
|--|--|
| Voltage Type | DC |
| Voltage Level | 3.3 V |
| Antenna / Gain | External single band antenna with 2.2 dBi max. gain in the relevant 2.4 GHz ISM band |
| Tested Modulation Type | BT Classic: GFSK Modulation, DHx packets n/4 DQPSK Modulation, 2-DHx packets 8-DPSK Modulation, 3-DHx packets |
| Specific product description for the EUT | The EUT is a Bluetooth and WLAN module. In the 2.4 GHz band it supports SISO Mode only. Supported technologies are Bluetooth Classic, Bluetooth Low Energy and WLAN b, g, n, ac Relevant for this report is Bluetooth Classic only. |
| EUT ports (connected cables during testing): | Enclosure Data DC Power Antenna |
| Tested datarates | GFSK modulation, 1 Mbit n/4 DQPSK Modulation, 2 Mbit 8-DPSK Modulation, 3 Mbit |
| Special software used for testing | The test modes were set by the software labtool Version 1.0.0.146 provided by the applicant on an auxiliary computer board. |

4.2 EUT MAIN COMPONENTS

| Sample Name | Sample Code | Description |
|------------------|---|-------------|
| EUT_aa01 | DE1015160aa01 | |
| Sample Parameter | Value | |
| Serial No. | I52CCF957E07F400300 | |
| HW Version | M2-JODY-W263-00C-00 /HW3_01 | |
| SW Version | FW: 16.80.205.164, Mfg WIFI: 2.0.0.63, Mfg BT: 1.0.0.10 | |
| Comment | | |

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

4.3 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 |
|-----------|---|---|
| Antenna 1 | Linx, ANT-DB1-RAF-RPS, -, -, - | Dual band antenna used for WLAN |
| Antenna 2 | Linx, ANT-2.4-CW-RCT-RP, -, -, - | Single band antenna for Bluetooth in the 2.4 GHz ISM band |

4.4 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, Type Model, HW, SW, S/N) | Description |
|--------|--|-------------------|
| AUX1 | UBLOX, ADP-uSD-M2, Week 10/21, - , - | M2 to µSD adapter |
| AUX2 | Toradex, Ixora carrier board with Apalis TK1 host computer, V1.2A, -, 10694745 | Computer Board |

4.5 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 |
|----------|--------------------------------------|---------------------------|
| S01_AA01 | EUT aa01, AUX2, AUX1, | Conducted Setup |
| S02_AA01 | EUT aa01, AUX1, Antenna 1, Antenna 2 | Radiated Setup |

4.6 OPERATING MODES / TEST CHANNELS

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

BT Test Channels:
Channel:
Frequency [MHz]

| 2.4 GHz ISM 2400 - 2483.5 MHz | | |
|----------------------------------|------|------|
| low | mid | high |
| 0 | 39 | 78 |
| 2402 | 2441 | 2480 |

4.7 PRODUCT LABELLING

4.7.1 FCC ID LABEL

Please refer to the documentation of the applicant.

4.7.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

5 TEST RESULTS

5.1 PEAK POWER OUTPUT

Standard **FCC Part 15 Subpart C**

The test was performed according to:

ANSI C63.10, chapter 11.9.1.3

5.1.1 TEST DESCRIPTION

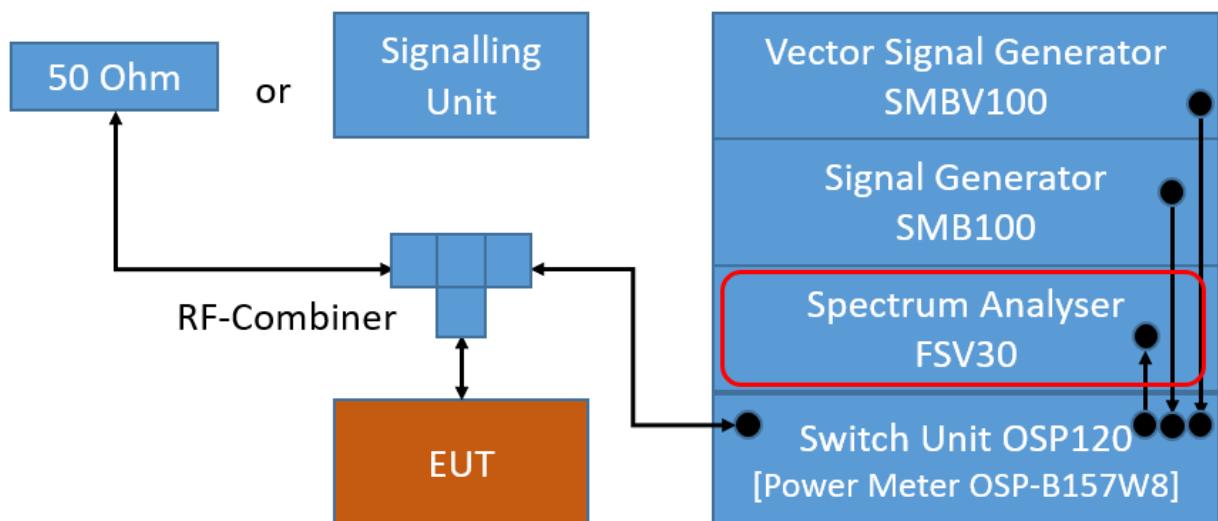
FHSS EQUIPMENT:

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 analyser was set higher than the output power of the EUT.

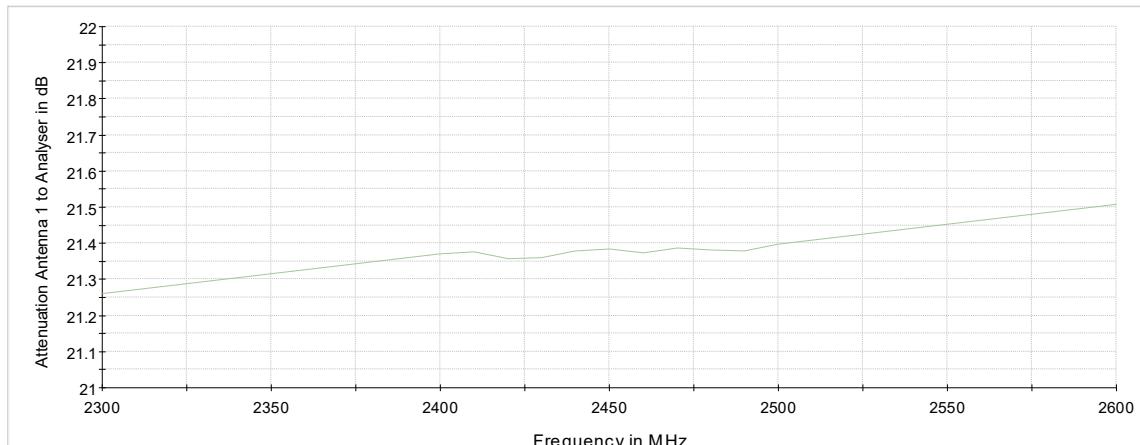
The EUT was connected to the test system as described in the block diagram below. The complete attenuation of the measurement path is known and considered.

Analyser settings:

- Resolution Bandwidth (RBW): ≥ 20 dB BW
- Video Bandwidth (VBW): ≥ 3 times RBW
- Trace: Maxhold
- Sweeps: Till stable (min. 300, max. 15000)
- Sweptime: Auto
- Detector: Peak



TS8997; Output Power



Attenuation Output power

5.1.2 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)

5.1.3 TEST PROTOCOL

Ambient temperature: 24 °C
 Air Pressure: 1006 hPa
 Humidity: 40 %
 BT GFSK (1-DH1)

| Band | Channel No. | Frequency [MHz] | Peak Power [dBm] | Limit [dBm] | Margin to Limit [dB] | E.I.R.P [dBm] |
|-------------|-------------|-----------------|------------------|-------------|----------------------|---------------|
| 2.4 GHz ISM | 0 | 2402 | 10.4 | 21.0 | 10.6 | 10.4 |
| | 39 | 2441 | 10.4 | 21.0 | 10.6 | 10.4 |
| | 78 | 2480 | 10.4 | 21.0 | 10.6 | 10.4 |

BT π/4 DQPSK (2-DH1)

| Band | Channel No. | Frequency [MHz] | Peak Power [dBm] | Limit [dBm] | Margin to Limit [dB] | E.I.R.P [dBm] |
|-------------|-------------|-----------------|------------------|-------------|----------------------|---------------|
| 2.4 GHz ISM | 0 | 2402 | 9.6 | 21.0 | 11.4 | 9.6 |
| | 39 | 2441 | 9.6 | 21.0 | 11.4 | 9.6 |
| | 78 | 2480 | 9.7 | 21.0 | 11.3 | 9.7 |

BT 8-DPSK (3-DH1)

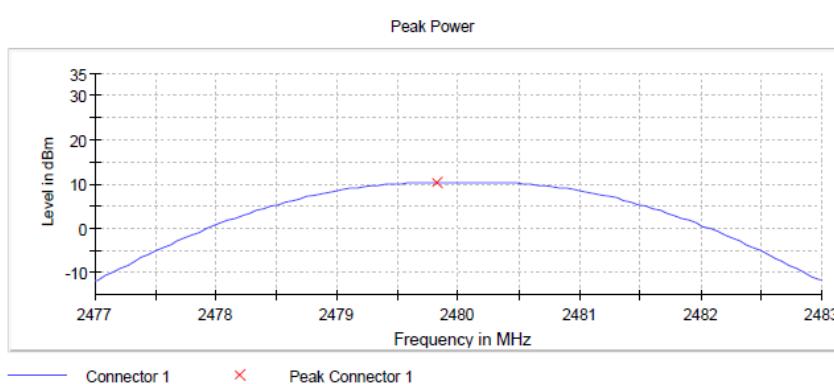
| Band | Channel No. | Frequency [MHz] | Peak Power [dBm] | Limit [dBm] | Margin to Limit [dB] | E.I.R.P [dBm] |
|-------------|-------------|-----------------|------------------|-------------|----------------------|---------------|
| 2.4 GHz ISM | 0 | 2402 | 9.9 | 21.0 | 11.1 | 9.9 |
| | 39 | 2441 | 9.9 | 21.0 | 11.1 | 9.9 |
| | 78 | 2480 | 10.0 | 21.0 | 11.0 | 10.0 |

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

5.1.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth BDR, Operating Frequency = high, Measurement method = conducted
 (S01_AA01)

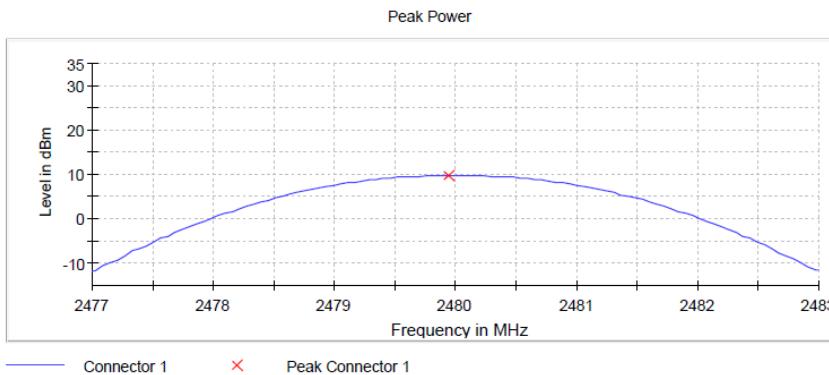
| DUT Frequency (MHz) | Peak Power (dBm) | Limit Max (dBm) | Result |
|---------------------|------------------|-----------------|--------|
| 2480.000000 | 10.4 | 21.0 | PASS |



| Setting | Instrument Value |
|-----------------------|------------------|
| Start Frequency | 2.47700 GHz |
| Stop Frequency | 2.48300 GHz |
| Span | 6.000 MHz |
| RBW | 2.000 MHz |
| VBW | 10.000 MHz |
| SweepPoints | 101 |
| Sweeptime | 1.000 ms |
| Reference Level | 20.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | Sweep |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.50 dB |
| Run | 4 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.03 dB |

Radio Technology = Bluetooth EDR 2, Operating Frequency = high, Measurement method = conducted
(S01_AA01)

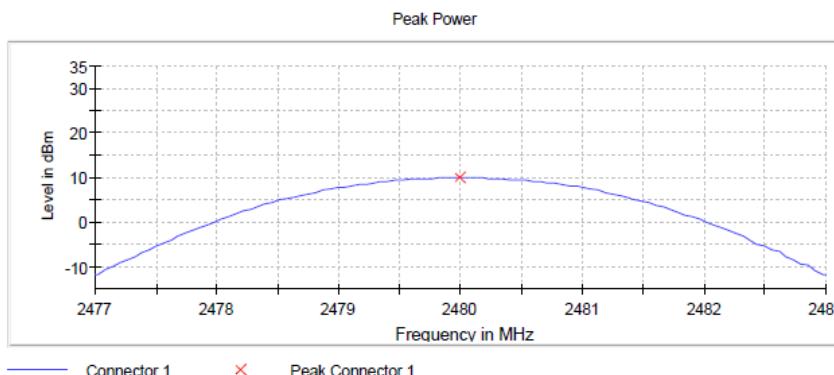
| DUT Frequency (MHz) | Peak Power (dBm) | Limit Max (dBm) | Result |
|---------------------|------------------|-----------------|--------|
| 2480.000000 | 9.7 | 21.0 | PASS |



| Setting | Instrument Value |
|-----------------------|------------------|
| Start Frequency | 2.47700 GHz |
| Stop Frequency | 2.48300 GHz |
| Span | 6.000 MHz |
| RBW | 2.000 MHz |
| VBW | 10.000 MHz |
| SweepPoints | 101 |
| Sweeptime | 1.000 ms |
| Reference Level | 20.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | Sweep |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.50 dB |
| Run | 4 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.10 dB |

Radio Technology = Bluetooth EDR 3, Operating Frequency = high, Measurement method = conducted
(S01_AA01)

| DUT Frequency (MHz) | Peak Power (dBm) | Limit Max (dBm) | Result |
|---------------------|------------------|-----------------|--------|
| 2480.000000 | 10.0 | 21.0 | PASS |



| Setting | Instrument Value |
|-----------------------|------------------|
| Start Frequency | 2.47700 GHz |
| Stop Frequency | 2.48300 GHz |
| Span | 6.000 MHz |
| RBW | 2.000 MHz |
| VBW | 10.000 MHz |
| SweepPoints | 101 |
| Sweeptime | 1.000 ms |
| Reference Level | 20.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | Sweep |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.50 dB |
| Run | 4 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.19 dB |

5.1.5 TEST EQUIPMENT USED

- R&S TS8997

5.2 TRANSMITTER SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:

ANSI C63.10, chapter 6.4, 6.5, 6.6.5

5.2.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according the following sub-chapters of ANSI C63.10:

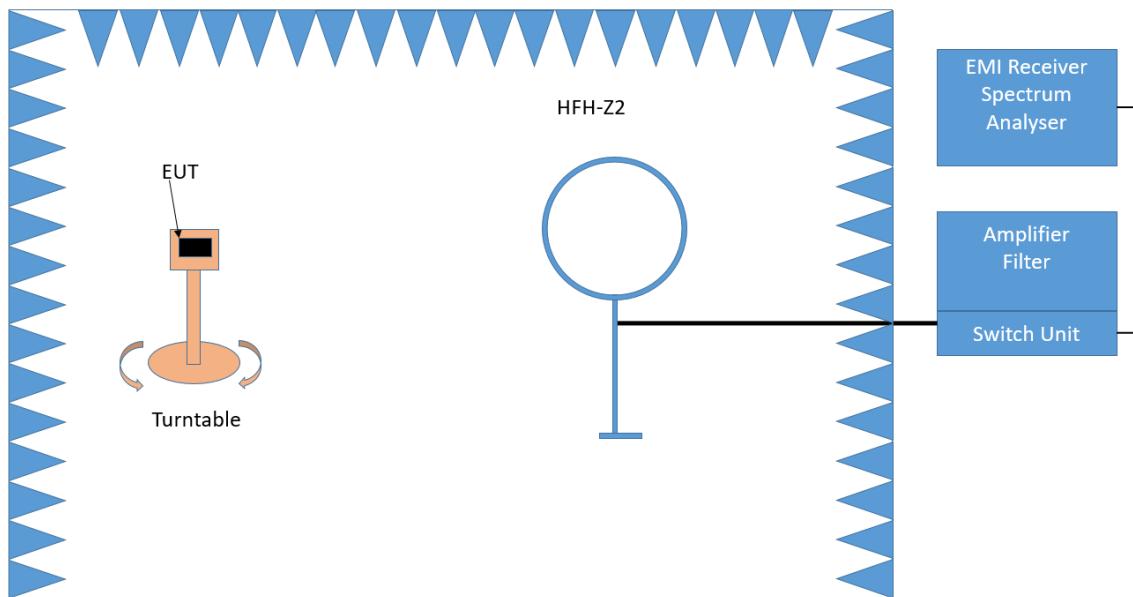
- < 30 MHz: Chapter 6.4
- 30 MHz – 1 GHz: Chapter 6.5
- > 1 GHz: Chapter 6.6 (procedure according 6.6.5 used)

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.

Below 1 GHz:

The Equipment Under Test (EUT) was set up on a non-conductive table in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.

1. Measurement up to 30 MHz



Test Setup; Spurious Emission Radiated (SAC), 9 kHz – 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre measurement

- Anechoic chamber
- Antenna distance: 3 m
- Antenna height: 1 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)

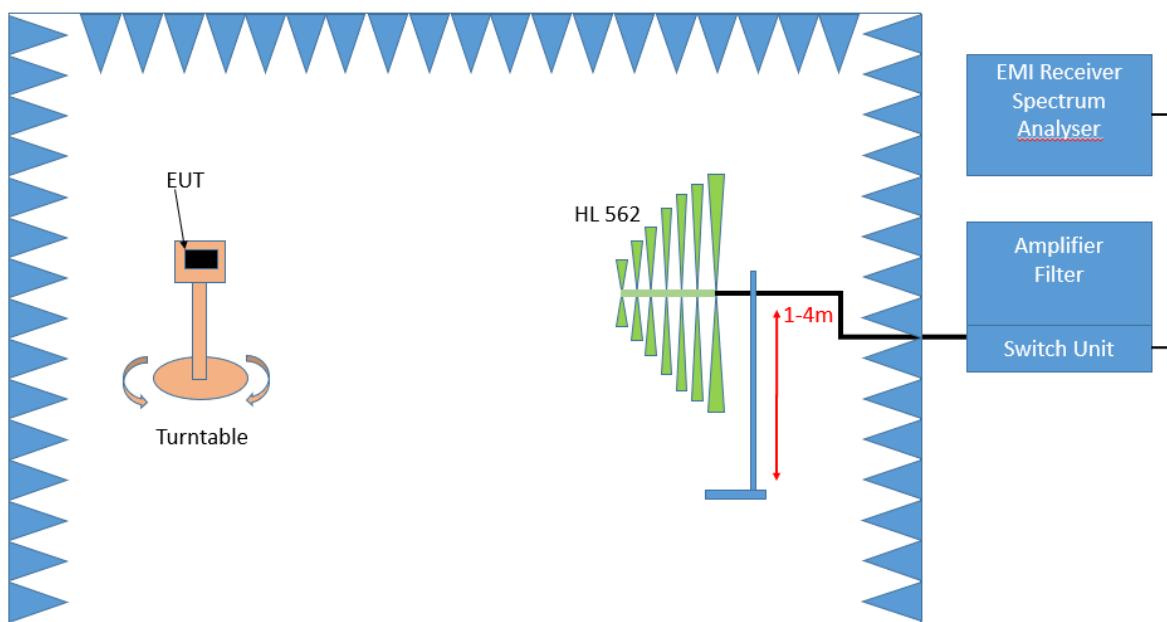
Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

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.

- Detector: Quasi-Peak (9 kHz - 150 kHz, Peak / Average 150 kHz- 30 MHz)
- 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



Test Setup; Spurious Emission Radiated (SAC), 30 MHz- 1GHz

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 – 4 m
- Height variation step size: 1.5 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 360°. 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 between 1 – 4 meter. 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: 360 °
- Height variation range: 1 – 4 m
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector

With the settings determined in step 2, the final measurement will be performed:

EMI receiver settings for step 3:

- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

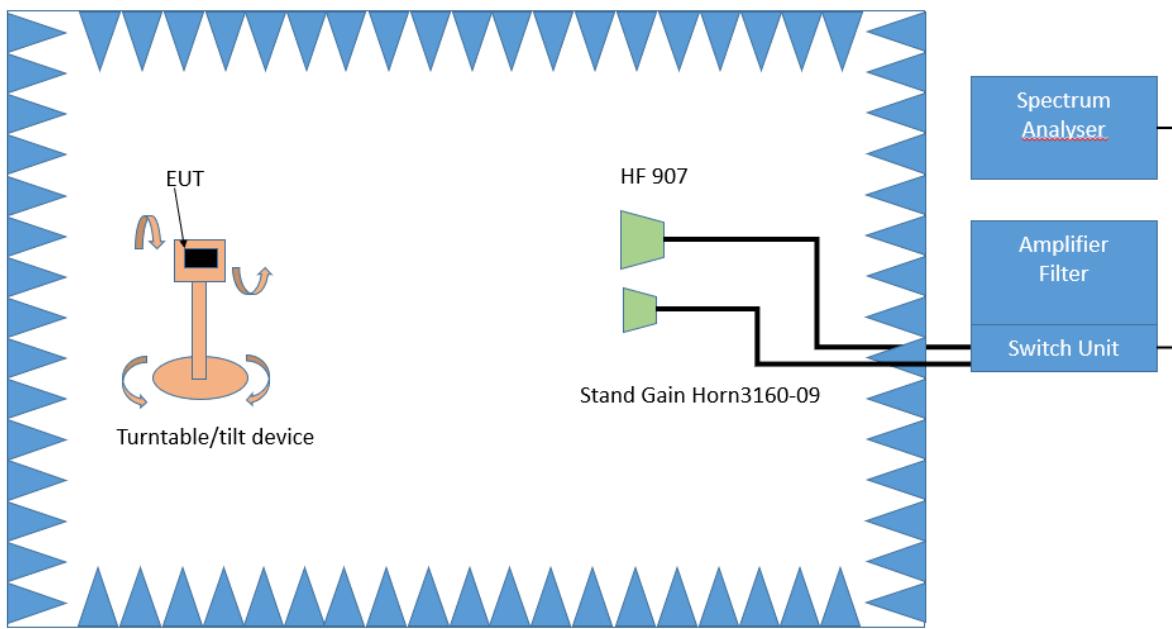
After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

Above 1 GHz:

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.

3. Measurement above 1 GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

Step 1:

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 °.

Spectrum analyser settings:

- Detector: Peak, Average
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:

The turn table azimuth will slowly vary by $\pm 22.5^\circ$.

The elevation angle will slowly vary by $\pm 45^\circ$

Spectrum analyser settings:

- Detector: Peak

Step 3:

Spectrum analyser settings for step 3:

- Detector: Peak / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s

5.2.2 TEST 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 (μ V/m) | Measurement distance (m) | Limits ($\text{dB}\mu$ V/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 (μ V/m) | Measurement distance (m) | Limits ($\text{dB}\mu$ V/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 ($\text{dB}\mu$ V/m) = 20 log (Limit (μ V/m)/1 μ V/m)

5.2.3 TEST PROTOCOL

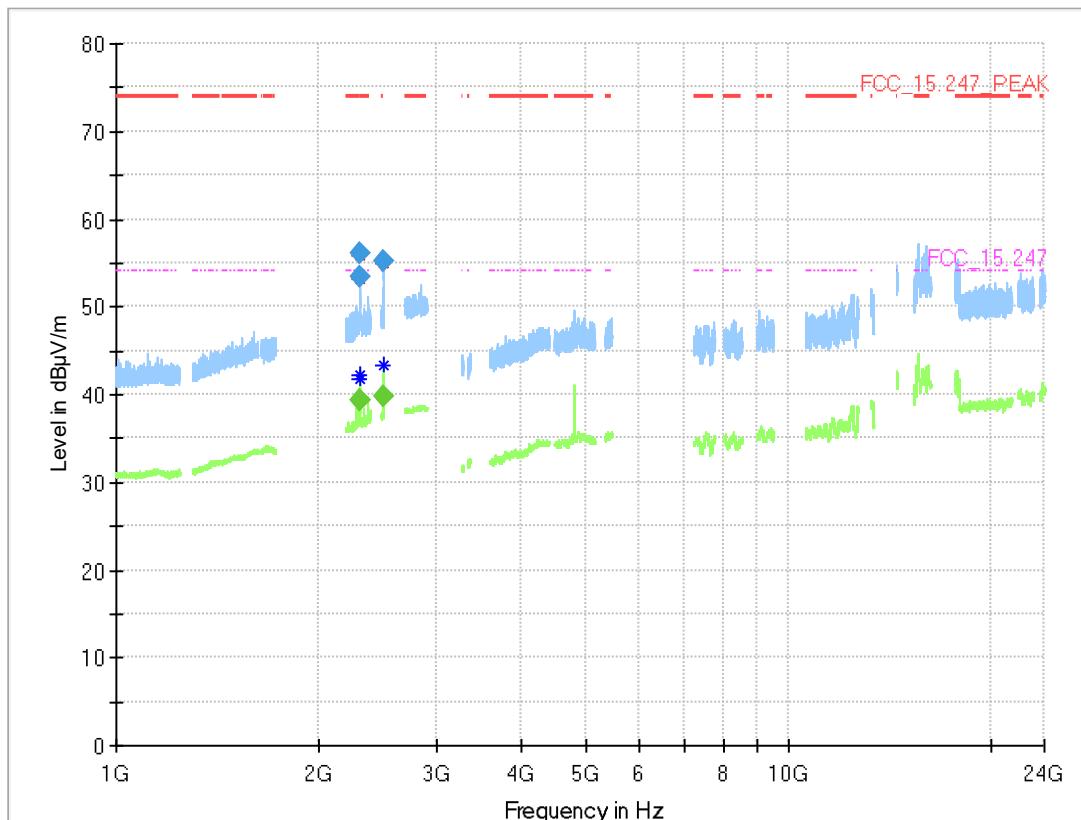
Ambient temperature: 32 °C
 Air Pressure: 1015 hPa
 Humidity: 26 %
 BT GFSK (1-DH1)
 Applied duty cycle correction (AV): 0 dB

| Ch. No. | Ch. Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [$\text{dB}\mu$ V/m] | Detector | RBW [kHz] | Limit [$\text{dB}\mu$ V/m] | Margin to Limit [dB] | Limit Type |
|---------|------------------------|----------------------|--------------------------------------|----------|-----------|-----------------------------|----------------------|------------|
| 0 | 2402 | 2298.8 | 53.3 | PEAK | 1000 | 74.0 | 20.7 | RB |
| 0 | 2402 | 2298.8 | 39.4 | AV | 1000 | 54.0 | 14.6 | RB |
| 0 | 2402 | 2310.0 | 56.0 | PEAK | 1000 | 74.0 | 18.0 | RB |
| 0 | 2402 | 2310.0 | 39.9 | AV | 1000 | 54.0 | 14.1 | RB |
| 0 | 2402 | 2494.2 | 55.2 | PEAK | 1000 | 74.0 | 18.8 | RB |
| 0 | 2402 | 2494.2 | 39.8 | AV | 1000 | 54.0 | 14.2 | RB |

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

5.2.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth BDR, Operating Frequency = low, Measurement range = 1 GHz - 26 GHz
(S02_AA01)



Final Result

| Frequency (MHz) | MaxPeak (dBµV/m) | CAverage (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Elevation (deg) | Corr. (dB/m) |
|-----------------|------------------|-------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|-----------------|--------------|
| 2298.800 | --- | 39.4 | 54.00 | 14.65 | 1000.0 | 1000.000 | 150.0 | V | -92.0 | 86.0 | 4.4 |
| 2298.800 | 53.3 | --- | 74.00 | 20.70 | 1000.0 | 1000.000 | 150.0 | V | -92.0 | 86.0 | 4.4 |
| 2310.000 | --- | 39.3 | 54.00 | 14.68 | 1000.0 | 1000.000 | 150.0 | H | -63.0 | -15.0 | 4.4 |
| 2310.000 | 56.0 | --- | 74.00 | 17.97 | 1000.0 | 1000.000 | 150.0 | H | -63.0 | -15.0 | 4.4 |
| 2494.225 | --- | 39.8 | 54.00 | 14.25 | 1000.0 | 1000.000 | 150.0 | V | 30.0 | 89.0 | 5.4 |
| 2494.225 | 55.2 | --- | 74.00 | 18.84 | 1000.0 | 1000.000 | 150.0 | V | 30.0 | 89.0 | 5.4 |

5.2.5 TEST EQUIPMENT USED

- Radiated Emissions FAR 2.4 GHz FCC

5.3 BAND EDGE COMPLIANCE RADIATED

Standard **FCC Part 15 Subpart C**

The test was performed according to:

ANSI C63.10, chapter 6.6.5

5.3.1 TEST DESCRIPTION

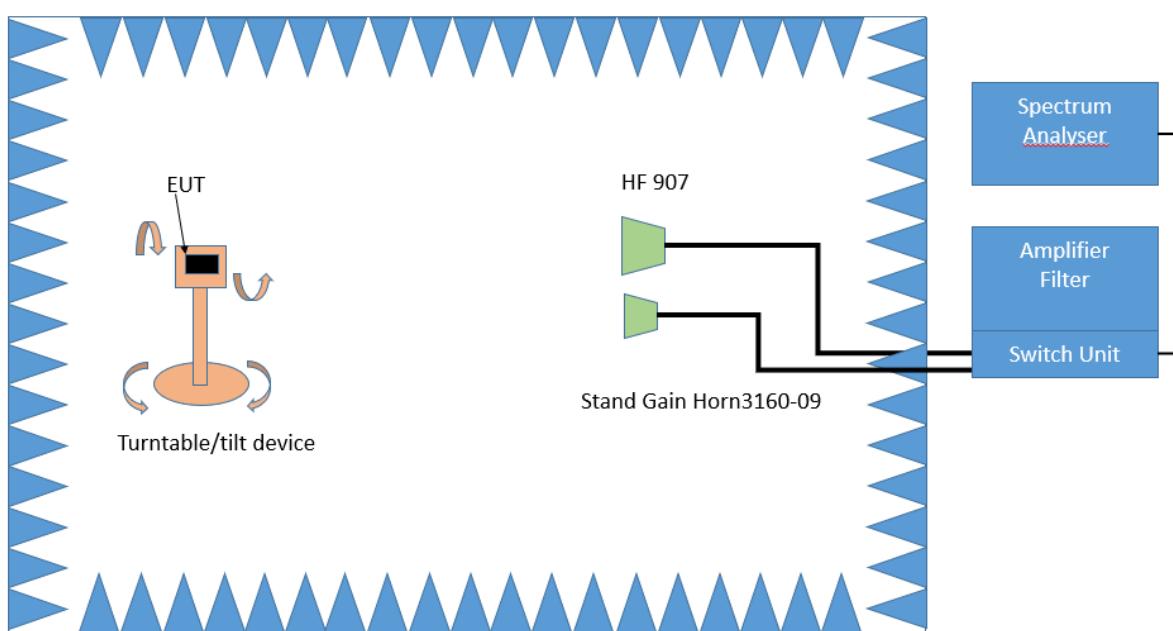
The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The measurements were performed according the following sub-chapter of ANSI C63.10:

- Chapter 6.10.5

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 (procedure according ANSI C63.10, chapter 6.6.5).

3. Measurement above 1 GHz



Test Setup; Spurious Emission Radiated (FAC), 1 GHz-26.5 GHz

Step 1:

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 °.

Spectrum analyser settings:

- Detector: Peak, Average
- RBW = 1 MHz
- VBW = 3 MHz

Step 2:

The turn table azimuth will slowly vary by $\pm 22.5^\circ$.

The elevation angle will slowly vary by $\pm 45^\circ$

Spectrum analyser settings:

- Detector: Peak

Step 3:

Spectrum analyser settings for step 3:

- Detector: Peak / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- RBW = 1 MHz
- VBW = 3 MHz
- Measuring time: 1 s

5.3.2 TEST REQUIREMENTS / LIMITS

For band edges connected to a restricted band, the limits are specified in Section 15.209(a)

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

| Frequency in MHz | Limit (μ V/m) | Measurement distance (m) | Limits (dB μ V/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 (μ V/m) | Measurement distance (m) | Limits (dB μ V/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 (dB μ V/m) = 20 log (Limit (μ V/m)/1 μ V/m)

5.3.3 TEST PROTOCOL

Ambient temperature: 32 °C
 Air Pressure: 1015 hPa
 Humidity: 26 %

BT 8-DPSK (3-DH1)

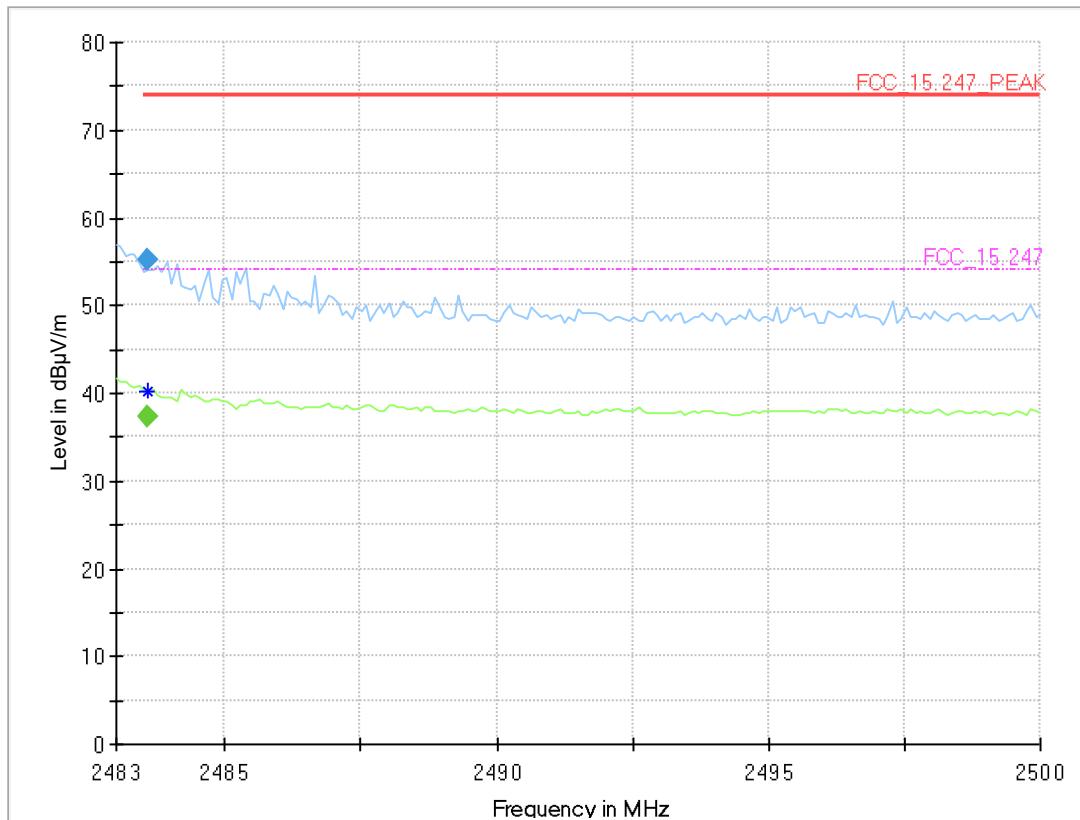
Applied duty cycle correction (AV): 0 dB

| Ch. No. | Ch. Center Freq. [MHz] | Band Edge Freq. [MHz] | Spurious Level [dB μ V/m] | Detector | RBW [kHz] | Limit [dB μ V/m] | Margin to Limit [dB] |
|---------|------------------------|-----------------------|-------------------------------|----------|-----------|----------------------|----------------------|
| 78 | 2480 | 2483.5 | 55.2 | PEAK | 1000 | 74.0 | 18.8 |
| 78 | 2480 | 2483.5 | 37.4 | AV | 1000 | 54.0 | 16.6 |

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

5.3.4 MEASUREMENT PLOT (EXAMPLE PLOT, SHOWING WORST CASE, IF APPLICABLE)

Radio Technology = Bluetooth EDR 3, Operating Frequency = high, Band Edge = high (S02_AA01)



Final Result

| Frequency (MHz) | MaxPeak (dB μ V/m) | CAverage (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Elevation (deg) | Corr. (dB/m) |
|-----------------|------------------------|-------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|-----------------|--------------|
| 2483.595 | -- | 37.4 | 54.00 | 16.59 | 1000.0 | 1000.000 | 150.0 | V | -191.0 | 105.0 | 5.3 |
| 2483.595 | 55.2 | --- | 74.00 | 18.77 | 1000.0 | 1000.000 | 150.0 | V | -191.0 | 105.0 | 5.3 |



5.3.5 TEST EQUIPMENT USED

- Radiated Emissions FAR 2.4 GHz FCC

6 TEST EQUIPMENT

6.1 TEST EQUIPMENT HARDWARE

1 R&S TS8997
2.4 and 5 GHz Bands Conducted Test Lab

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---------|--------------------------------|---|-----------------------------------|----------------|------------------|-----------------|
| 1.1 | MFS | Rubidium Frequency Normal | Datum GmbH | 002 | 2021-11 | 2022-11 |
| 1.2 | Opus10 TPR (8253.00) | T/P Logger 13 | Lufft Mess- und Regeltechnik GmbH | 13936 | 2021-10 | 2023-10 |
| 1.3 | SMB100A | Signal Generator 9 kHz - 6 GHz | Rohde & Schwarz | 107695 | 2021-06 | 2024-06 |
| 1.4 | EX520 | Digital Multimeter 12 | Extech Instruments Corp | 05157876 | 2020-04 | 2022-06 |
| 1.5 | NGSM 32/10 | Power Supply | Rohde & Schwarz GmbH & Co. KG | 3456 | 2022-01 | 2024-01 |
| 1.6 | Temperature Chamber KWP 120/70 | Temperature Chamber Weiss 01 | Weiss | 59226012190010 | 2020-05 | 2022-05 |
| 1.7 | Temperature Chamber VT 4002 | Temperature Chamber Vötsch 03 | Vötsch | 58566002150010 | 2020-05 | 2022-05 |
| 1.8 | FSW43 | Signal analyser | Rohde & Schwarz GmbH & Co. KG | 102013 | 2021-06 | 2023-06 |
| 1.9 | Opus10 THI (8152.00) | T/H Logger 14 | Lufft Mess- und Regeltechnik GmbH | 13993 | 2021-08 | 2023-08 |
| 1.10 | SMBV100A | Vector Signal Generator 9 kHz - 6 GHz | Rohde & Schwarz | 259291 | 2019-11 | 2022-11 |
| 1.11 | OSP120 | Contains Power Meter and Switching Unit OSP-B157W8 PLUS | Rohde & Schwarz | 101158 | 2021-08 | 2024-08 |

2 Radiated Emissions FAR 2.4 GHz FCC
Radiated emission tests for 2.4 GHz ISM devices in a fully anechoic room

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---------|-------------------------|--|-----------------------------------|--------------------|------------------|-----------------|
| 2.1 | Opus10 TPR (8253.00) | T/P Logger 13 | Lufft Mess- und Regeltechnik GmbH | 13936 | 2021-10 | 2023-10 |
| 2.2 | AMF-7D00101800-30-10P-R | Broadband Amplifier 100 MHz - 18 GHz | Miteq | | | |
| 2.3 | Anechoic Chamber 03 | FAR, 8.80m x 4.60m x 4.05m (l x w x h) | Albatross Projects | P26971-647-001-PRB | 2021-04 | 2023-04 |
| 2.4 | Fluke 177 | Digital Multimeter 03 (Multimeter) | Fluke Europe B.V. | 86670383 | 2020-04 | 2022-06 |

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---------|------------------------|--|-------------------------------------|------------------------|------------------|-----------------|
| 2.5 | JS4-18002600-32-5P | Broadband Amplifier 18 GHz - 26 GHz | Miteq | 849785 | | |
| 2.6 | FSW 43 | Spectrum Analyzer | Rohde & Schwarz GmbH & Co. KG | 103779 | 2021-06 | 2023-06 |
| 2.7 | EP 1200/B, NA/B1 | AC Source, Amplifier with integrated variable Oscillator | Spitzenberger & Spies GmbH & Co. KG | B6278 | | |
| 2.8 | 3160-09 | Standard Gain / Pyramidal Horn Antenna 26.5 GHz | EMCO Elektronic GmbH | 00083069 | | |
| 2.9 | WHKX 7.0/18G-8SS | High Pass Filter | Wainwright Instruments GmbH | 09 | | |
| 2.10 | TT 1.5 WI | Turn Table | Maturo GmbH | - | | |
| 2.11 | 5HC3500/18000 -1.2-KK | High Pass Filter | Trilithic | 200035008 | | |
| 2.12 | Opus 20 THI (8120.00) | ThermoHygro Datalogger | Lufft Mess- und Regeltechnik GmbH | 115.0318.0802.033 | 2020-10 | 2022-10 |
| 2.13 | TD1.5-10kg | EUT Tilt Device (Rohacell) | Maturo GmbH | TD1.5-10kg/024/3790709 | | |
| 2.14 | PAS 2.5 - 10 kg | Antenna Mast | Maturo GmbH | - | | |
| 2.15 | AFS42-00101800-25-S-42 | Broadband Amplifier 25 MHz - 18 GHz | Miteq | 2035324 | | |
| 2.16 | HF 907 | Double-ridged horn | Rohde & Schwarz | 102444 | 2021-09 | 2024-09 |

The calibration interval is the time interval between "Last Calibration" and "Calibration Due"

6.2 TEST EQUIPMENT SOFTWARE

| Semi-Anechoic Chamber: | |
|--------------------------------|----------|
| Software | Version |
| EMC32 Measurement Software | 10.60.10 |
| INNCO Mast Controller | 1.02.62 |
| MATURO Mast Controller | 12.19 |
| MATURO Turn-Table Controller | 30.10 |
| Fully-Anechoic Chamber: | |
| Software | Version |
| EMC32 Measurement Software | 10.60.10 |
| MATURO Turn-Unit Cotroller | 11.10 |
| MATURO Mast Controller | 12.10 |
| MATURO Turntable Controller | 12.11 |
| Conducted AC Emissions: | |
| Software | Version |
| EMC32 Measurement Software | 10.60.20 |

7 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.

7.1 LISN R&S ESH3-Z5 (150 KHZ – 30 MHZ)

| Frequency | Corr. | LISN insertion loss ESH3-Z5 | cable loss (incl. 10 dB attenuator) |
|-----------|-------|-----------------------------|-------------------------------------|
| 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

$$U_{\text{LISN}} (\text{dB } \mu\text{V}) = U (\text{dB } \mu\text{V}) + \text{Corr. (dB)}$$

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.

7.2 ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

| Frequency MHz | 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)) |
|------------------|---------------|-------|--|---|-------------------------------------|-------------------------------------|--|--|--|
| | | | 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

$$E (\text{dB } \mu\text{V/m}) = U (\text{dB } \mu\text{V}) + AF (\text{dB } 1/\text{m}) + \text{Corr. (dB)}$$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

distance correction = $-40 * \text{LOG} (d_{\text{Limit}}/ d_{\text{used}})$

Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values

7.3 ANTENNA R&S HL562 (30 MHZ – 1 GHZ)

($d_{\text{Limit}} = 3 \text{ m}$)

| Frequency | AF R&S HL562 | Corr. |
|-----------|--------------------|-------|
| MHz | dB (1/m) | dB |
| 30 | 18.6 | 0.6 |
| 50 | 6.0 | 0.9 |
| 100 | 9.7 | 1.2 |
| 150 | 7.9 | 1.6 |
| 200 | 7.6 | 1.9 |
| 250 | 9.5 | 2.1 |
| 300 | 11.0 | 2.3 |
| 350 | 12.4 | 2.6 |
| 400 | 13.6 | 2.9 |
| 450 | 14.7 | 3.1 |
| 500 | 15.6 | 3.2 |
| 550 | 16.3 | 3.5 |
| 600 | 17.2 | 3.5 |
| 650 | 18.1 | 3.6 |
| 700 | 18.5 | 3.6 |
| 750 | 19.1 | 4.1 |
| 800 | 19.6 | 4.1 |
| 850 | 20.1 | 4.4 |
| 900 | 20.8 | 4.7 |
| 950 | 21.1 | 4.8 |
| 1000 | 21.6 | 4.9 |

| 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)) |
|--|---|-------------------------------------|-------------------------------------|--|--|--|
| dB | dB | dB | dB | dB | m | m |
| 0.29 | 0.04 | 0.23 | 0.02 | 0.0 | 3 | 3 |
| 0.39 | 0.09 | 0.32 | 0.08 | 0.0 | 3 | 3 |
| 0.56 | 0.14 | 0.47 | 0.08 | 0.0 | 3 | 3 |
| 0.73 | 0.20 | 0.59 | 0.12 | 0.0 | 3 | 3 |
| 0.84 | 0.21 | 0.70 | 0.11 | 0.0 | 3 | 3 |
| 0.98 | 0.24 | 0.80 | 0.13 | 0.0 | 3 | 3 |
| 1.04 | 0.26 | 0.89 | 0.15 | 0.0 | 3 | 3 |
| 1.18 | 0.31 | 0.96 | 0.13 | 0.0 | 3 | 3 |
| 1.28 | 0.35 | 1.03 | 0.19 | 0.0 | 3 | 3 |
| 1.39 | 0.38 | 1.11 | 0.22 | 0.0 | 3 | 3 |
| 1.44 | 0.39 | 1.20 | 0.19 | 0.0 | 3 | 3 |
| 1.55 | 0.46 | 1.24 | 0.23 | 0.0 | 3 | 3 |
| 1.59 | 0.43 | 1.29 | 0.23 | 0.0 | 3 | 3 |
| 1.67 | 0.34 | 1.35 | 0.22 | 0.0 | 3 | 3 |
| 1.67 | 0.42 | 1.41 | 0.15 | 0.0 | 3 | 3 |
| 1.87 | 0.54 | 1.46 | 0.25 | 0.0 | 3 | 3 |
| 1.90 | 0.46 | 1.51 | 0.25 | 0.0 | 3 | 3 |
| 1.99 | 0.60 | 1.56 | 0.27 | 0.0 | 3 | 3 |
| 2.14 | 0.60 | 1.63 | 0.29 | 0.0 | 3 | 3 |
| 2.22 | 0.60 | 1.66 | 0.33 | 0.0 | 3 | 3 |
| 2.23 | 0.61 | 1.71 | 0.30 | 0.0 | 3 | 3 |

($d_{\text{Limit}} = 10 \text{ m}$)

| | | |
|------|------|------|
| 30 | 18.6 | -9.9 |
| 50 | 6.0 | -9.6 |
| 100 | 9.7 | -9.2 |
| 150 | 7.9 | -8.8 |
| 200 | 7.6 | -8.6 |
| 250 | 9.5 | -8.3 |
| 300 | 11.0 | -8.1 |
| 350 | 12.4 | -7.9 |
| 400 | 13.6 | -7.6 |
| 450 | 14.7 | -7.4 |
| 500 | 15.6 | -7.2 |
| 550 | 16.3 | -7.0 |
| 600 | 17.2 | -6.9 |
| 650 | 18.1 | -6.9 |
| 700 | 18.5 | -6.8 |
| 750 | 19.1 | -6.3 |
| 800 | 19.6 | -6.3 |
| 850 | 20.1 | -6.0 |
| 900 | 20.8 | -5.8 |
| 950 | 21.1 | -5.6 |
| 1000 | 21.6 | -5.6 |

| | | | | | | |
|------|------|------|------|-------|----|---|
| 0.29 | 0.04 | 0.23 | 0.02 | -10.5 | 10 | 3 |
| 0.39 | 0.09 | 0.32 | 0.08 | -10.5 | 10 | 3 |
| 0.56 | 0.14 | 0.47 | 0.08 | -10.5 | 10 | 3 |
| 0.73 | 0.20 | 0.59 | 0.12 | -10.5 | 10 | 3 |
| 0.84 | 0.21 | 0.70 | 0.11 | -10.5 | 10 | 3 |
| 0.98 | 0.24 | 0.80 | 0.13 | -10.5 | 10 | 3 |
| 1.04 | 0.26 | 0.89 | 0.15 | -10.5 | 10 | 3 |
| 1.18 | 0.31 | 0.96 | 0.13 | -10.5 | 10 | 3 |
| 1.28 | 0.35 | 1.03 | 0.19 | -10.5 | 10 | 3 |
| 1.39 | 0.38 | 1.11 | 0.22 | -10.5 | 10 | 3 |
| 1.44 | 0.39 | 1.20 | 0.19 | -10.5 | 10 | 3 |
| 1.55 | 0.46 | 1.24 | 0.23 | -10.5 | 10 | 3 |
| 1.59 | 0.43 | 1.29 | 0.23 | -10.5 | 10 | 3 |
| 1.67 | 0.34 | 1.35 | 0.22 | -10.5 | 10 | 3 |
| 1.67 | 0.42 | 1.41 | 0.15 | -10.5 | 10 | 3 |
| 1.87 | 0.54 | 1.46 | 0.25 | -10.5 | 10 | 3 |
| 1.90 | 0.46 | 1.51 | 0.25 | -10.5 | 10 | 3 |
| 1.99 | 0.60 | 1.56 | 0.27 | -10.5 | 10 | 3 |
| 2.14 | 0.60 | 1.63 | 0.29 | -10.5 | 10 | 3 |
| 2.22 | 0.60 | 1.66 | 0.33 | -10.5 | 10 | 3 |
| 2.23 | 0.61 | 1.71 | 0.30 | -10.5 | 10 | 3 |

Sample calculation

$$E (\text{dB } \mu\text{V/m}) = U (\text{dB } \mu\text{V}) + AF (\text{dB } 1/\text{m}) + \text{Corr. (dB)}$$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
 distance correction = $-20 * \text{LOG} (d_{\text{Limit}}/ d_{\text{used}})$

Linear interpolation will be used for frequencies in between the values in the table.

Tables show an extract of values.

7.4 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

| Frequency | AF R&S HF907 | Corr. |
|-----------|--------------------|-------|
| MHz | dB (1/m) | dB |
| 1000 | 24.4 | -19.4 |
| 2000 | 28.5 | -17.4 |
| 3000 | 31.0 | -16.1 |
| 4000 | 33.1 | -14.7 |
| 5000 | 34.4 | -13.7 |
| 6000 | 34.7 | -12.7 |
| 7000 | 35.6 | -11.0 |

| 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) | | |
|--|---|--|----------------------------------|--|--|
| dB | dB | dB | dB | | |
| 0.99 | 0.31 | -21.51 | 0.79 | | |
| 1.44 | 0.44 | -20.63 | 1.38 | | |
| 1.87 | 0.53 | -19.85 | 1.33 | | |
| 2.41 | 0.67 | -19.13 | 1.31 | | |
| 2.78 | 0.86 | -18.71 | 1.40 | | |
| 2.74 | 0.90 | -17.83 | 1.47 | | |
| 2.82 | 0.86 | -16.19 | 1.46 | | |

| Frequency | AF R&S HF907 | Corr. |
|-----------|--------------------|-------|
| MHz | dB (1/m) | dB |
| 3000 | 31.0 | -23.4 |
| 4000 | 33.1 | -23.3 |
| 5000 | 34.4 | -21.7 |
| 6000 | 34.7 | -21.2 |
| 7000 | 35.6 | -19.8 |

| 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 |
|---|--|---|--|----------------------------------|------------------------------|
| dB | dB | dB | dB | dB | |
| 0.47 | 1.87 | 0.53 | -27.58 | 1.33 | |
| 0.56 | 2.41 | 0.67 | -28.23 | 1.31 | |
| 0.61 | 2.78 | 0.86 | -27.35 | 1.40 | |
| 0.58 | 2.74 | 0.90 | -26.89 | 1.47 | |
| 0.66 | 2.82 | 0.86 | -25.58 | 1.46 | |

| Frequency | AF R&S HF907 | Corr. |
|-----------|--------------------|-------|
| MHz | dB (1/m) | dB |
| 7000 | 35.6 | -57.3 |
| 8000 | 36.3 | -56.3 |
| 9000 | 37.1 | -55.3 |
| 10000 | 37.5 | -56.2 |
| 11000 | 37.5 | -55.3 |
| 12000 | 37.6 | -53.7 |
| 13000 | 38.2 | -53.5 |
| 14000 | 39.9 | -56.3 |
| 15000 | 40.9 | -54.1 |
| 16000 | 41.3 | -54.1 |
| 17000 | 42.8 | -54.4 |
| 18000 | 44.2 | -54.7 |

| 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) |
|---|-----------------------------------|----------------------------------|--|---|-------------------------------------|
| dB | dB | dB | dB | dB | dB |
| 0.56 | 1.28 | -62.72 | 2.66 | 0.94 | 1.46 |
| 0.69 | 0.71 | -61.49 | 2.84 | 1.00 | 1.53 |
| 0.68 | 0.65 | -60.80 | 3.06 | 1.09 | 1.60 |
| 0.70 | 0.54 | -61.91 | 3.28 | 1.20 | 1.67 |
| 0.80 | 0.61 | -61.40 | 3.43 | 1.27 | 1.70 |
| 0.84 | 0.42 | -59.70 | 3.53 | 1.26 | 1.73 |
| 0.83 | 0.44 | -59.81 | 3.75 | 1.32 | 1.83 |
| 0.91 | 0.53 | -63.03 | 3.91 | 1.40 | 1.77 |
| 0.98 | 0.54 | -61.05 | 4.02 | 1.44 | 1.83 |
| 1.23 | 0.49 | -61.51 | 4.17 | 1.51 | 1.85 |
| 1.36 | 0.76 | -62.36 | 4.34 | 1.53 | 2.00 |
| 1.70 | 0.53 | -62.88 | 4.41 | 1.55 | 1.91 |

Sample calculation

$$E (\text{dB } \mu\text{V/m}) = U (\text{dB } \mu\text{V}) + AF (\text{dB } 1/\text{m}) + \text{Corr. (dB)}$$

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.

7.5 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

$$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB } 1/\text{m)} + \text{Corr. (dB)}$$

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.

7.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

| Frequency | AF EMCO 3160-10 | Corr. | cable | cable | cable | cable | distance | d_{Limit} | d_{used} |
|-----------|-----------------------|-------|-------------------------------|--------------------------------|----------------------------|----------------------------|------------------------------|--------------------------------|-------------------------------|
| | | | loss 1 (inside chamber) | loss 2 (outside chamber) | loss 3 (switch unit) | loss 4 (to receiver) | corr. (-20 dB/ decade) | (meas. distance (limit)) | (meas. distance (used)) |
| GHz | dB (1/m) | dB | dB | dB | dB | dB | m | m | |
| 26.5 | 43.4 | -11.2 | 4.4 | | | | -9.5 | 3 | 1.0 |
| 27.0 | 43.4 | -11.2 | 4.4 | | | | -9.5 | 3 | 1.0 |
| 28.0 | 43.4 | -11.1 | 4.5 | | | | -9.5 | 3 | 1.0 |
| 29.0 | 43.5 | -11.0 | 4.6 | | | | -9.5 | 3 | 1.0 |
| 30.0 | 43.5 | -10.9 | 4.7 | | | | -9.5 | 3 | 1.0 |
| 31.0 | 43.5 | -10.8 | 4.7 | | | | -9.5 | 3 | 1.0 |
| 32.0 | 43.5 | -10.7 | 4.8 | | | | -9.5 | 3 | 1.0 |
| 33.0 | 43.6 | -10.7 | 4.9 | | | | -9.5 | 3 | 1.0 |
| 34.0 | 43.6 | -10.6 | 5.0 | | | | -9.5 | 3 | 1.0 |
| 35.0 | 43.6 | -10.5 | 5.1 | | | | -9.5 | 3 | 1.0 |
| 36.0 | 43.6 | -10.4 | 5.1 | | | | -9.5 | 3 | 1.0 |
| 37.0 | 43.7 | -10.3 | 5.2 | | | | -9.5 | 3 | 1.0 |
| 38.0 | 43.7 | -10.2 | 5.3 | | | | -9.5 | 3 | 1.0 |
| 39.0 | 43.7 | -10.2 | 5.4 | | | | -9.5 | 3 | 1.0 |
| 40.0 | 43.8 | -10.1 | 5.5 | | | | -9.5 | 3 | 1.0 |

Sample calculation

$$E (\text{dB } \mu\text{V/m}) = U (\text{dB } \mu\text{V}) + AF (\text{dB } 1/\text{m}) + \text{Corr. (dB)}$$

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.

distance correction = $-20 * \log (d_{\text{Limit}} / d_{\text{used}})$

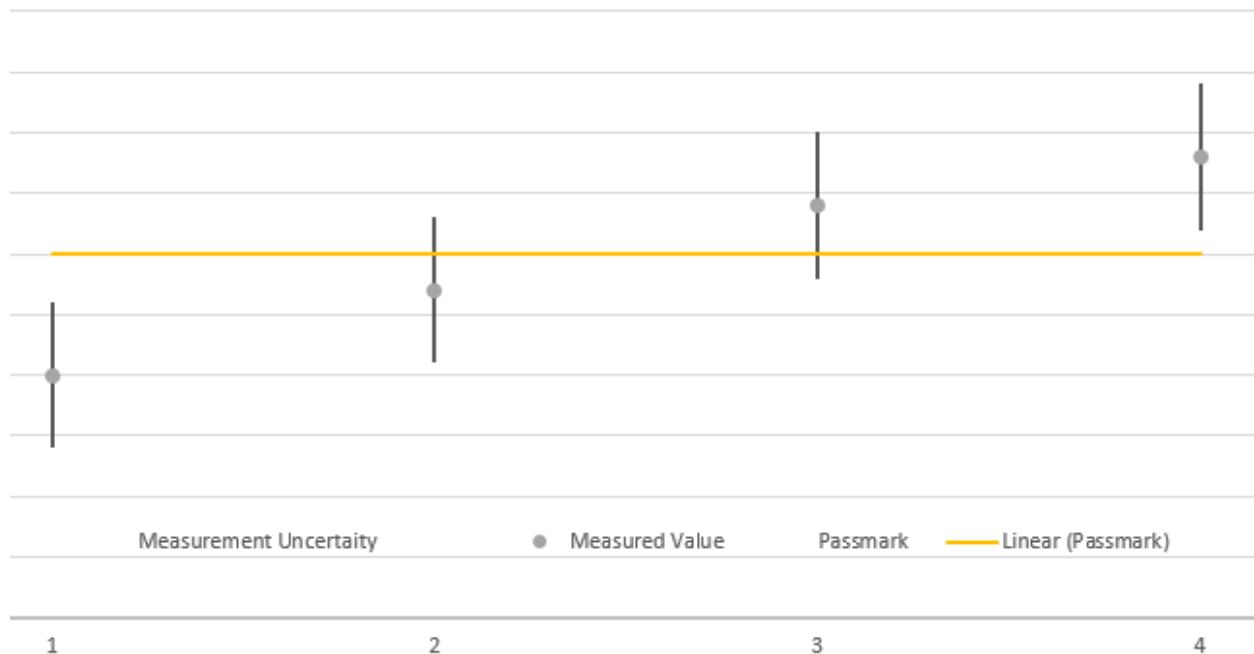
Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values.

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 Frequency | ± 2.9 dB ± 11.2 kHz |
| Conducted Output Power | Power | ± 2.2 dB |
| Band Edge Compliance | Power Frequency | ± 2.2 dB ± 11.2 kHz |
| Frequency Stability | Frequency | ± 25 Hz |
| Power Spectral Density | Power | ± 2.2 dB |

The measurement uncertainties for all parameters are calculated with an expansion factor (coverage factor) $k = 1.96$. This means, that the true value is in the corresponding interval with a probability of 95 %.



The verdicts in this test report are given according the above diagram:

| Case | Measured Value | Uncertainty Range | Verdict |
|------|-----------------|-------------------|---------|
| 1 | below pass mark | below pass mark | Passed |
| 2 | below pass mark | within pass mark | Passed |
| 3 | above pass mark | within pass mark | Failed |
| 4 | above pass mark | above pass mark | Failed |

That means, the laboratory applies, as decision rule (see ISO/IEC 17025:2017), the so called shared risk principle.



9 PHOTO REPORT

Please see separate photo report.