# FCC Measurement/Technical Report on

# WLAN and Bluetooth module JODY-W164-03A

# FCC ID: XPYJODYW164
# IC: 8595A-JODYW164

PMN: JODY-W164-03A
HVIN: JODY-W164-03A

**Test Report Reference:** MDE_UBLOX_2104_FCC_02_rev02


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


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

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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 (10-1-19 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 DTS (e.g. WLAN 2.4 GHz, BT LE) equipment from FCC and IC**

**DTS equipment**

| Measurement | FCC reference | IC reference |
|---|---|---|
| Conducted emissions on AC Mains | § 15.207 | RSS-Gen Issue 5: 8.8 |
| Occupied bandwidth | § 15.247 (a) (2) | RSS-247 Issue 2: 5.2 (a) |
| Peak conducted output power | § 15.247 (b) (3), (4) | RSS-247 Issue 2: 5.4 (d) |
| Transmitter spurious RF conducted emissions | § 15.247 (d) | RSS-Gen Issue 5: 6.13 / 8.9/8.10;<br>RSS-247 Issue 2: 5.5 |
| Transmitter spurious radiated emissions | § 15.247 (d);<br>§ 15.209 (a) | RSS-Gen Issue 5: 6.13 / 8.9/8.10;<br>RSS-247 Issue 2: 5.5 |
| Band edge compliance | § 15.247 (d) | RSS-247 Issue 2: 5.5 |
| Power density | § 15.247 (e) | RSS-247 Issue 2: 5.2 (b) |
| 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 (a) (2)**

Occupied Bandwidth (6 dB)
The measurement was performed according to ANSI C63.10 **Final Result**

| OP-Mode<br>Radio Technology, Operating Frequency | Setup | Date | FCC | IC |
|---|---|---|---|---|
| Bluetooth BDR, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth BDR, low | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth EDR 2, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth EDR 2, low | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth EDR 3, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth EDR 3, low | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth LE 1 Mbps, high | S01_AC01 | 2021-05-10 | Passed | Passed |
| Bluetooth LE 1 Mbps, low | S01_AC01 | 2021-05-10 | Passed | Passed |
| WLAN b, high | S01_AC01 | 2021-05-10 | Passed | Passed |
| WLAN b, low | S01_AC01 | 2021-05-10 | Passed | Passed |
| WLAN g, high | S01_AC01 | 2021-05-10 | Passed | Passed |
| WLAN g, low | S01_AC01 | 2021-05-10 | Passed | Passed |
| WLAN n 20 MHz, high | S01_AC01 | 2021-05-10 | Passed | Passed |
| WLAN n 20 MHz, low | S01_AC01 | 2021-05-10 | Passed | Passed |

**47 CFR CHAPTER I FCC PART 15 Subpart C §15.247** **IC RSS-Gen & IC TRC-43; Ch. 6.7 & Ch. 8**

Occupied Bandwidth (99%)
The measurement was performed according to ANSI C63.10 **Final Result**

| OP-Mode<br>Radio Technology, Operating Frequency | Setup | Date | FCC | IC |
|---|---|---|---|---|
| Bluetooth BDR, high | S01_AC01 | 2021-05-10 | N/A | Performed |
| Bluetooth BDR, low | S01_AC01 | 2021-05-10 | N/A | Performed |
| Bluetooth EDR 2, high | S01_AC01 | 2021-05-18 | N/A | Performed |
| Bluetooth EDR 2, low | S01_AC01 | 2021-05-18 | N/A | Performed |
| Bluetooth EDR 3, high | S01_AC01 | 2021-05-18 | N/A | Performed |
| Bluetooth EDR 3, low | S01_AC01 | 2021-05-18 | N/A | Performed |
| Bluetooth LE 1 Mbps, high | S01_AC01 | 2021-05-10 | N/A | Performed |
| Bluetooth LE 1 Mbps, low | S01_AC01 | 2021-05-10 | N/A | Performed |
| WLAN b, high | S01_AC01 | 2021-05-10 | N/A | Performed |
| WLAN b, low | S01_AC01 | 2021-05-10 | N/A | Performed |
| WLAN g, high | S01_AC01 | 2021-05-10 | N/A | Performed |
| WLAN g, low | S01_AC01 | 2021-05-10 | N/A | Performed |
| WLAN n 20 MHz, high | S01_AC01 | 2021-05-10 | N/A | Performed |
| WLAN n 20 MHz, low | S01_AC01 | 2021-05-10 | N/A | Performed |

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

Band Edge Compliance Restricted Bands
The measurement was performed according to ANSI C63.10 **Final Result**

| OP-Mode<br>Radio Technology, Operating Frequency, Band Edge | Setup | Date | FCC | IC |
|---|---|---|---|---|
| Bluetooth BDR, high, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth EDR 2, high, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth EDR 3, high, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| Bluetooth LE 1 Mbps, high, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| WLAN b, high, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| WLAN g, high, high | S01_AC01 | 2021-05-12 | Passed | Passed |
| WLAN n 20 MHz, high, high | S01_AC01 | 2021-05-12 | 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 | Date | FCC | IC |
|---|---|---|---|---|
| Bluetooth BDR, high, 1 GHz - 26 GHz | S02_AC01 | 2021-06-03 | Passed | Passed |
| WLAN b, high, 1 GHz - 26 GHz | S02_AC01 | 2021-06-15 | 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 | 2021-05-19 | -- | valid |
| rev01 | 2021-06-21 | Added spot check transmitter radiated spurious emissions | valid |
| rev02 | 2021-07-02 | Added HVIN/PMN/End of report/ emission designator/ antenna list | valid |

COMMENT: This is a delta test report due to hardware change. Not all tests were performed. See test report MDE_UBLOX_1701_FCCa for results of the other test cases.

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

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

# 3 ADMINISTRATIVE DATA

## 3.1 TESTING LABORATORY

| | |
|---|---|
| Company Name: | 7layers GmbH |
| Address: | Borsigstr. 11<br>40880 Ratingen<br>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: | 2021-01-13 |

## 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: | 2021-06-21 |
| Testing Period: | 2021-05-10 to 2021-06-15 |

## 3.3 APPLICANT DATA

| | |
|---|---|
| Company Name: | u-blox AG |
| Address: | Zürcherstrasse 68<br>8800 Thalwil<br>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

<table>
<tr><td>Kind of Device product description</td><td>The EUT is a module supporting WLAN in the 2.4 GHz and 5 GHz bands as well as Bluetooth (BT) 4.2 including Bluetooth Low Energy (BT LE)</td></tr>
<tr><td>Product name</td><td>JODY-W164-03A</td></tr>
<tr><td>Type</td><td>JODY-W164-03A</td></tr>
<tr><td colspan="2">Declared EUT data by the supplier</td></tr>
<tr><td>Voltage Type</td><td>DC</td></tr>
<tr><td>Voltage Level</td><td>3.3 V</td></tr>
<tr><td>Antenna / Gain</td><td>
<table>
<tr><td>Description</td><td>Model</td><td>S/N:</td></tr>
<tr><td>Dipole Antenna</td><td>LSR 001-0012</td><td>-</td></tr>
<tr><td>Dipole Antenna</td><td>LSR 001-0009</td><td>-</td></tr>
<tr><td>PCB Antenna</td><td>TE Connectivity 2118060-1</td><td>-</td></tr>
</table>
None provided, two external 50 Ohm connectors on evaluation board. Antenna gain used for evaluation of test results: 2 dBi
</td></tr>
<tr><td>Tested Modulation Type</td><td>BT: GFSK Modulation, DHx packets (Bluetooth and Bluetooth Low Energy), 1 Mbps<br>π/4 DQPSK Modulation, 2-DHx packets, 2 Mbps<br>8-DPSK Modulation, 3-DHx packets, 3 Mbps<br>WLAN: Mode b: DSSS Modulation, 1Mbps<br>Mode g/n: OFDM Modulation, 6Mbps / MCS 0 (20 MHz only)</td></tr>
<tr><td>Specific product description for the EUT</td><td>The JODY-W1 is a compact automotive grade module that provides Wi-Fi, Bluetooth, and Bluetooth low energy communication.<br>The JODY-W164-03A module can be operated in the following modes:<br>Wi-Fi 2x2 MIMO 802.11n/ac in the 5 GHz band<br>Wi-Fi 1x1 802.11ac in 2.4 / 5 GHz real simultaneous dual band<br>Dual-mode Bluetooth v4.2, can be operated fully simultaneous with both the Wi-Fi modes<br>It is equipped with two antenna pins connected to two SMA antenna connectors on the evaluation board.<br>Maximum supported band width in 2.4 GHz WLAN mode: 20 MHz, 5 GHz WLAN mode: 80 MHz
<table>
<tr><th>Frequency Band</th><th>Modulation Method</th><th>Emission Designators</th></tr>
<tr><td>2412 - 2462</td><td>802.11[b]</td><td>11M1G1D</td></tr>
<tr><td>2412 - 2462</td><td>[g]</td><td>17M5W7D</td></tr>
<tr><td>2412 - 2462</td><td>[n]</td><td>18M5W7D</td></tr>
</table>
</td></tr>
<tr><td>EUT ports (connected cables during testing):</td><td>DC Power Supply<br>Antenna ports<br>Signal ports</td></tr>
</table>

| | |
|---|---|
| Special software used for testing | The test modes were set using scripts that were run on a board computer with linux operating system provided by the applicant. |

## 4.2 EUT MAIN COMPONENTS

| **Sample Name** | **Sample Code** | **Description** |
|---|---|---|
| EUT ac01 | DE1015139ac01 | |
| **Sample Parameter** | **Value** | |
| Serial No. | M286009C3F491541000 | |
| HW Version | 11 | |
| SW Version | PCIe CLUTCH 9.40.117.x, NVRAM jody-w164-03a (04-12-2018) | |
| 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** |
|---|---|---|
| Evaluation Board | UBLOX, JODY-W1 EVB Certivication board, REV. A, - , - | Board the EUT is mounted to, providing ports to the EUT (DC, Antennas, wired communication) |

## 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** |
|---|---|---|
| Board Computer | Toradex, Ixora, -, - , - | Computer used for setting test modes and supplying EUT |

## 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_AC01 | EUT ac01, Evaluation Board , Board Computer | Conducted measurement setup |
| S02_AC01 | EUT ac01, Evaluation Board , | Radiated measurement setup |

## 4.6 OPERATING MODES / TEST CHANNELS

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

| **WLAN** | **2.4 GHz ISM 2400 - 2483.5 MHz** | | |
|---|---|---|---|
| **20 MHz Test Channels:** | **low** | **mid** | **high** |
| **Channel:** | 1 | 6 | 11 |
| **Frequency [MHz]** | 2412 | 2437 | 2462 |

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

| | **2.4 GHz ISM 2400 - 2483.5 MHz** | | |
|---|---|---|---|
| **BT LE Test Channels:** | **low** | **mid** | **high** |
| **Channel:** | 0 | 19 | 39 |
| **Frequency [MHz]** | 2402 | 2440 | 2480 |

Output Power per Channel and Mode to be set in EUT WLAN script according to customer declaration:

| Channel No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Channel freq. [MHz] | 2412 | 2417 | 2422 | 2427 | 2432 | 2437 | 2442 | 2447 | 2452 | 2457 | 2462 |
| WLAN mode b | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| WLAN mode g | 13 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 13 |
| WLAN mode n | 13 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 13 |

## 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 OCCUPIED BANDWIDTH (6 DB)

Standard **FCC Part 15 Subpart C**

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

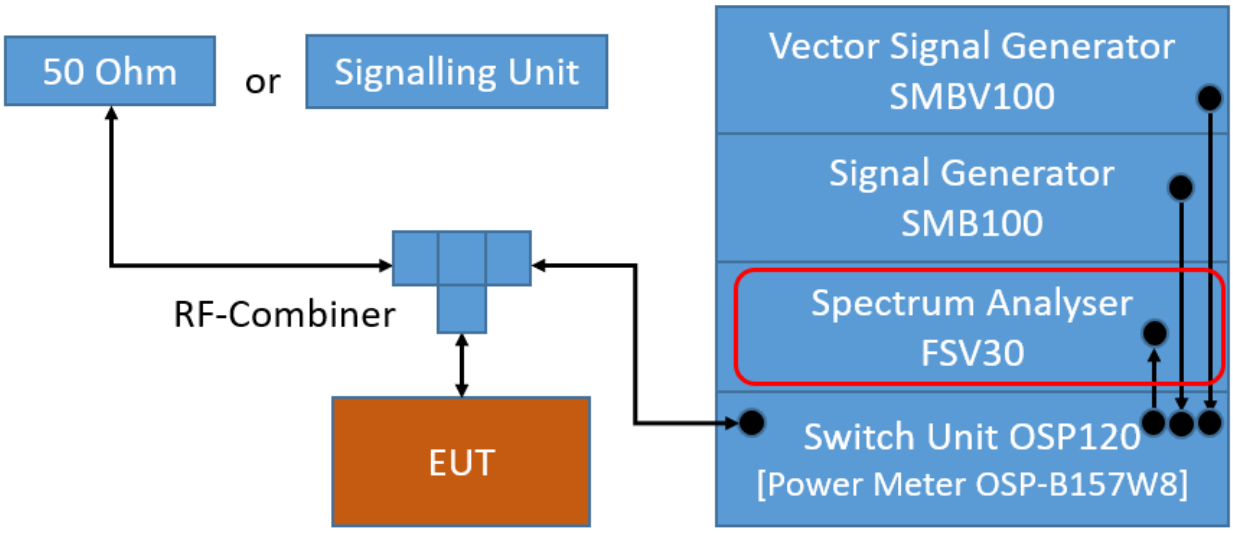
### 5.1.1 TEST DESCRIPTION

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 (smallest) emission bandwidth.

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): 100 kHz
- Video Bandwidth (VBW): 300 kHz
- Span: Two times nominal bandwidth
- Trace: Maxhold
- Sweeps: Till stable (min. 500, max. 15000)
- Sweeptime: Auto
- Detector: Peak




TS8997; Channel Bandwidth

## 5.1.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.247 (a) (2)
Systems using digital modulation techniques may operate in the 902-928 MHz and 2400-2483.5 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

## 5.1.3 TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1007 hPa
Humidity: 28 %

BT LE 1 Mbit/s

| Band / Mode | Channel No. | Frequency [MHz] | 6 dB Bandwidth [MHz] | Limit [MHz] | Margin to Limit [MHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 0.729 | 0.5 | 0.229 |
| | 39 | 2480 | 0.745 | 0.5 | 0.245 |

BT GFSK (1-DH5)

| Band / Mode | Channel No. | Frequency [MHz] | 6 dB Bandwidth [MHz] | Limit [MHz] | Margin to Limit [MHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 0.505 | 0.5 | 0.005 |
| | 78 | 2480 | 0.505 | 0.5 | 0.005 |

BT π/4 DQPSK (2-DH5)

| Band / Mode | Channel No. | Frequency [MHz] | 6 dB Bandwidth [MHz] | Limit [MHz] | Margin to Limit [MHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1.099 | 0.5 | 0.599 |
| | 78 | 2480 | 1.069 | 0.5 | 0.569 |

BT 8-DPSK (3-DH5)

| Band / Mode | Channel No. | Frequency [MHz] | 6 dB Bandwidth [MHz] | Limit [MHz] | Margin to Limit [MHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1.099 | 0.5 | 0.599 |
| | 78 | 2480 | 1.069 | 0.5 | 0.569 |

WLAN b-Mode; 20 MHz; 1 Mbit/s

| Band | Channel No. | Frequency [MHz] | 6 dB Bandwidth [MHz] | Limit [MHz] | Margin to Limit [MHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 1 | 2412 | 7.2 | 0.5 | 6.7 |
| | 11 | 2462 | 7.2 | 0.5 | 6.7 |

WLAN g-Mode; 20 MHz; 6 Mbit/s

| Band | Channel No. | Frequency [MHz] | 6 dB Bandwidth [MHz] | Limit [MHz] | Margin to Limit [MHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 1 | 2412 | 16.4 | 0.5 | 15.9 |
| | 11 | 2462 | 16.4 | 0.5 | 15.9 |

WLAN n-Mode; 20 MHz; MCS0

| Band | Channel No. | Frequency [MHz] | 6 dB Bandwidth [MHz] | Limit [MHz] | Margin to Limit [MHz] |
|---|---|---|---|---|---|
| 2.4 GHz ISM | 1 | 2412 | 17.7 | 0.5 | 17.2 |
| | 11 | 2462 | 17.7 | 0.5 | 17.2 |

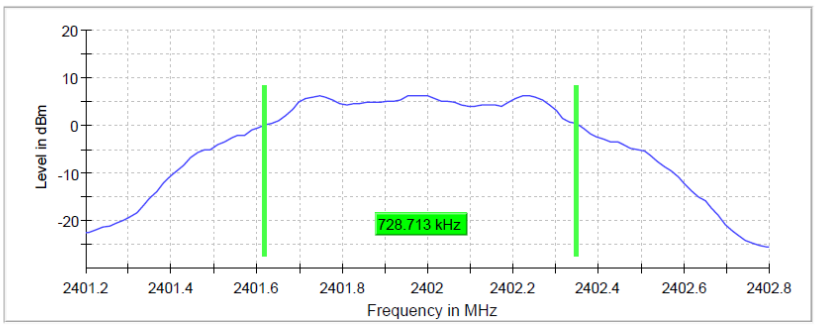
Remark: Please see next sub-clause for the measurement plot.

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

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = low (S01_AC01)

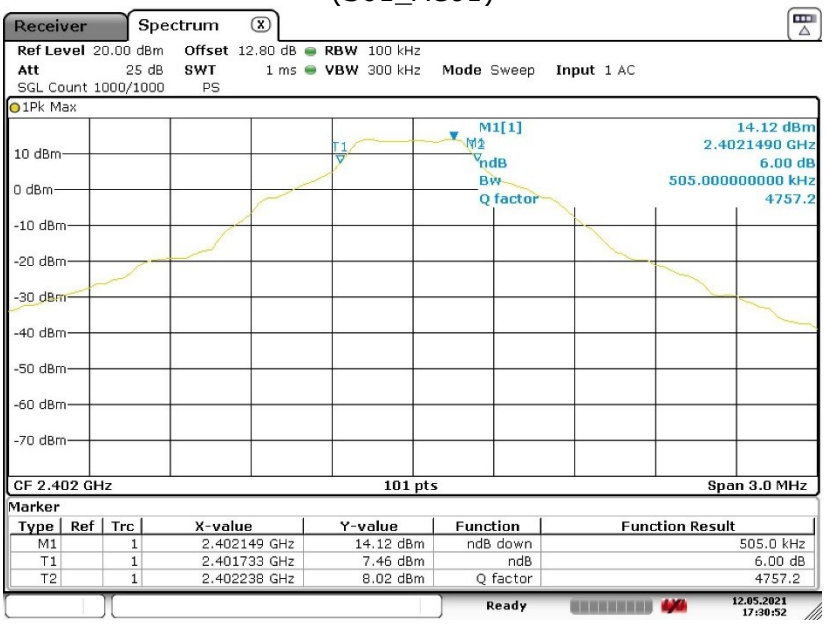
**6 dB Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Max Level (dBm) | Result |
|---|---|---|---|---|---|---|---|
| 2402.000000 | 0.728713 | 0.500000 | --- | 2401.619802 | 2402.348515 | 6.3 | PASS |



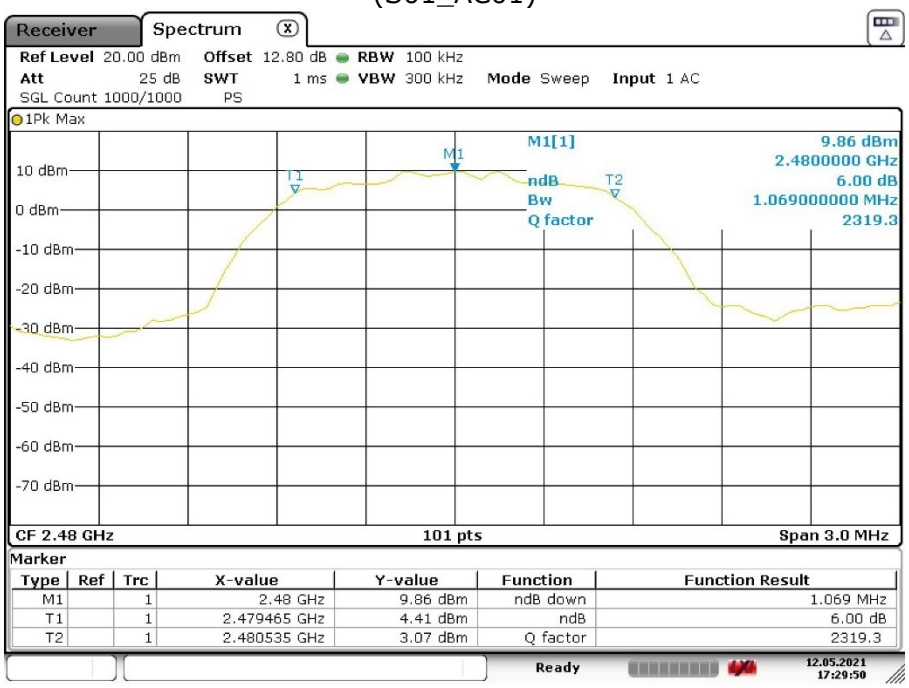

| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.40120 GHz |
| Stop Frequency | 2.40280 GHz |
| Span | 1.600 MHz |
| RBW | 100.000 kHz |
| VBW | 300.000 kHz |
| SweepPoints | 101 |
| Sweeptime | 18.987 µs |
| Reference Level | -10.000 dBm |
| Attenuation | 10.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.50 dB |
| Run | 9 / max. 150 |
| Stable | 5 / 5 |
| Max Stable Difference | 0.08 dB |

Radio Technology = Bluetooth BDR, Operating Frequency = low (S01_AC01)



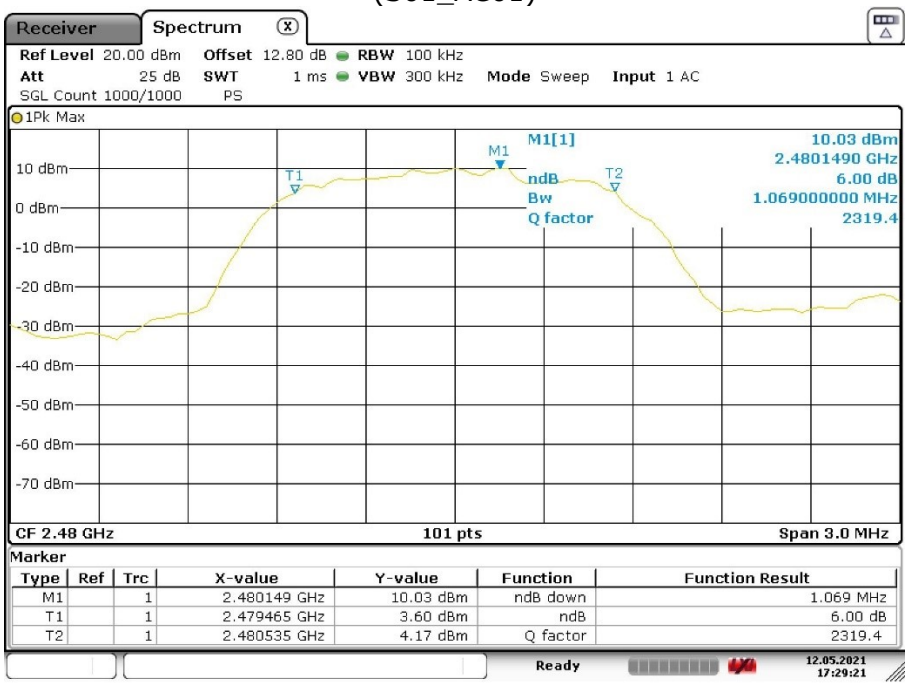

Date: 12.MAY.2021 17:30:53

Radio Technology = Bluetooth EDR2, Operating Frequency = high (S01_AC01)




Date: 12.MAY.2021 17:29:51

Radio Technology = Bluetooth EDR3, Operating Frequency = high (S01_AC01)

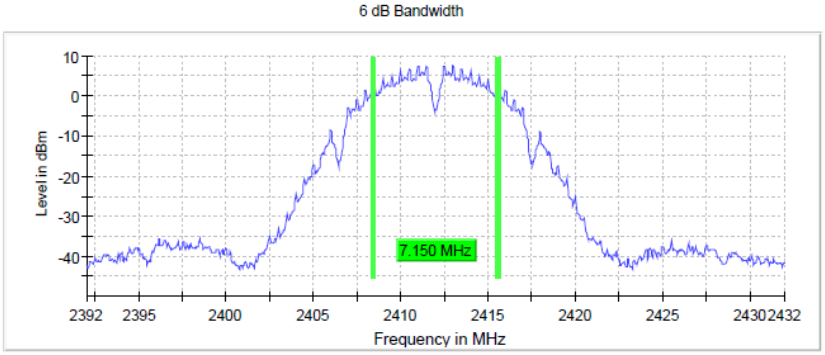



Date: 12.MAY.2021 17:29:21

Radio Technology = WLAN b, Operating Frequency = low
(S01_AC01)

**6 dB Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Max Level (dBm) | Result |
|---|---|---|---|---|---|---|---|
| 2412.000000 | 7.150000 | 0.500000 | --- | 2408.425000 | 2415.575000 | 7.5 | PASS |

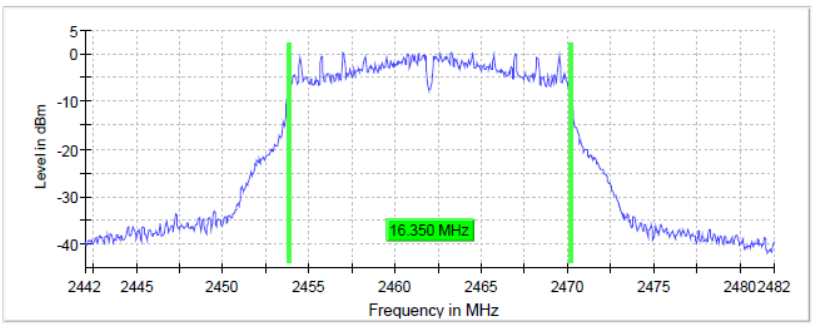



| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.39200 GHz |
| Stop Frequency | 2.43200 GHz |
| Span | 40.000 MHz |
| RBW | 100.000 kHz |
| VBW | 300.000 kHz |
| SweepPoints | 800 |
| Sweeptime | 56.836 µs |
| Reference Level | 10.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.50 dB |
| Run | 7 / max. 150 |
| Stable | 5 / 5 |
| Max Stable Difference | 0.19 dB |

Radio Technology = WLAN g, Operating Frequency = high
(S01_AC01)

**6 dB Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Max Level (dBm) | Result |
|---|---|---|---|---|---|---|---|
| 2462.000000 | 16.350000 | 0.500000 | --- | 2453.825000 | 2470.175000 | 0.2 | PASS |

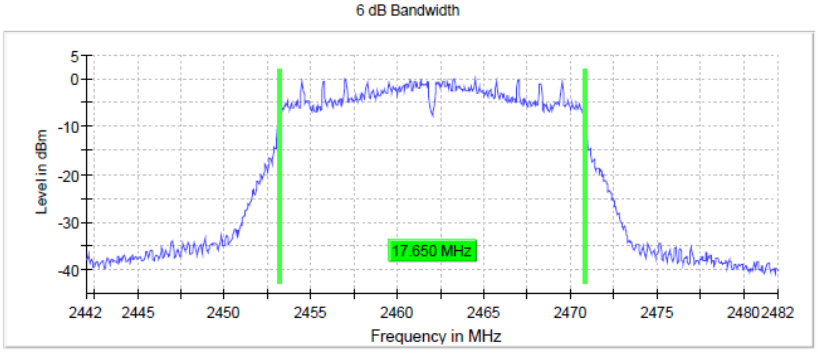



| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.44200 GHz |
| Stop Frequency | 2.48200 GHz |
| Span | 40.000 MHz |
| RBW | 100.000 kHz |
| VBW | 300.000 kHz |
| SweepPoints | 800 |
| Sweeptime | 56.836 µs |
| Reference Level | 10.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.50 dB |
| Run | 32 / max. 150 |
| Stable | 5 / 5 |
| Max Stable Difference | 0.11 dB |

Radio Technology = WLAN n 20 MHz, Operating Frequency = high
(S01_AC01)

**6 dB Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Max Level (dBm) | Result |
|---|---|---|---|---|---|---|---|
| 2462.000000 | 17.650000 | 0.500000 | --- | 2453.175000 | 2470.825000 | 0.1 | PASS |




| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.44200 GHz |
| Stop Frequency | 2.48200 GHz |
| Span | 40.000 MHz |
| RBW | 100.000 kHz |
| VBW | 300.000 kHz |
| SweepPoints | 800 |
| Sweeptime | 56.836 µs |
| Reference Level | 10.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.50 dB |
| Run | 60 / max. 150 |
| Stable | 5 / 5 |
| Max Stable Difference | 0.21 dB |

## 5.1.5 TEST EQUIPMENT USED

- R&S TS8997

## 5.2 OCCUPIED BANDWIDTH (99%)

Standard **FCC Part 15 Subpart C**

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

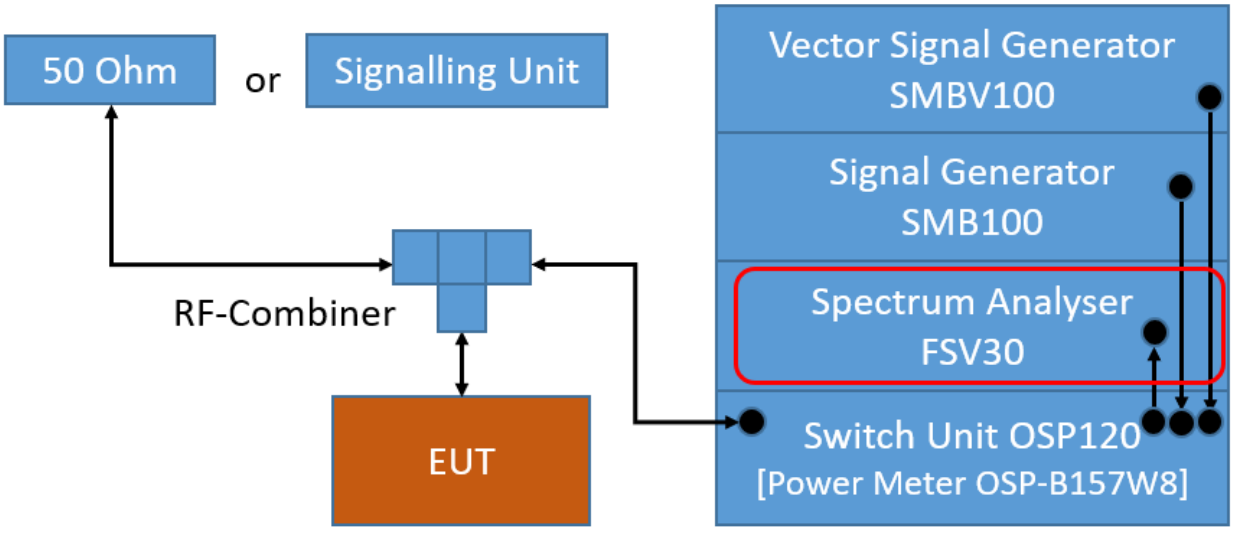
### 5.2.1 TEST DESCRIPTION

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 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): 1 to 5 % of the OBW
- Video Bandwidth (VBW): ≥ 3 times the RBW
- Span: 1.5 to 5 times the OBW
- Trace: Maxhold
- Sweeps: Till stable (min. 500, max. 75000)
- Sweeptime: Auto
- Detector: Peak




TS8997; Channel Bandwidth

## 5.2.2 TEST REQUIREMENTS / LIMITS

No applicable limit.

## 5.2.3 TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1007 hPa
Humidity: 28 %

BT GFSK (1-DH5)

| Band | Channel No. | Frequency [MHz] | 99 % Bandwidth [MHz] |
|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 0.885 |
| | 78 | 2480 | 0.885 |

BT π/4 DQPSK (2-DH5)

| Band | Channel No. | Frequency [MHz] | 99 % Bandwidth [MHz] |
|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1.205 |
| | 78 | 2480 | 1.210 |

BT 8-DPSK (3-DH5)

| Band | Channel No. | Frequency [MHz] | 99 % Bandwidth [MHz] |
|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1.215 |
| | 78 | 2480 | 1.220 |

BT LE 1 Mbit/s

| Band | Channel No. | Frequency [MHz] | 99 % Bandwidth [MHz] |
|---|---|---|---|
| 2.4 GHz ISM | 0 | 2402 | 1.050 |
| | 39 | 2480 | 1.060 |

WLAN b-Mode; 20 MHz; 1 Mbit/s

| Band | Channel No. | Frequency [MHz] | 99 % Bandwidth [MHz] |
|---|---|---|---|
| 2.4 GHz ISM | 1 | 2412 | 10.3 |
| | 11 | 2462 | 10.2 |

WLAN g-Mode; 20 MHz; 6 Mbit/s

| Band | Channel No. | Frequency [MHz] | 99 % Bandwidth [MHz] |
|---|---|---|---|
| 2.4 GHz ISM | 1 | 2412 | 16.5 |
| | 11 | 2462 | 16.5 |

WLAN n-Mode; 20 MHz; MCS0

| Band | Channel No. | Frequency [MHz] | 99 % Bandwidth [MHz] |
|---|---|---|---|
| 2.4 GHz ISM | 1 | 2412 | 17.7 |
| | 11 | 2462 | 17.7 |

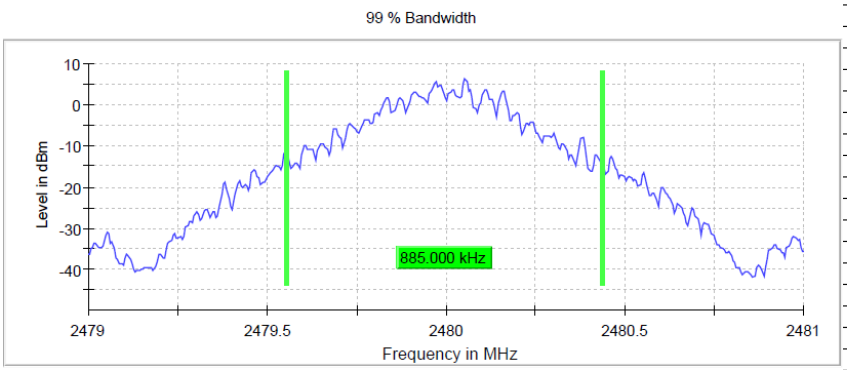
Remark: Please see next sub-clause for the measurement plot.

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

Radio Technology = Bluetooth BDR, Operating Frequency = high (S01_AC01)

**99 % Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Result |
|---|---|---|---|---|---|---|
| 2480.000000 | 0.885000 | --- | --- | 2479.552500 | 2480.437500 | PASS |

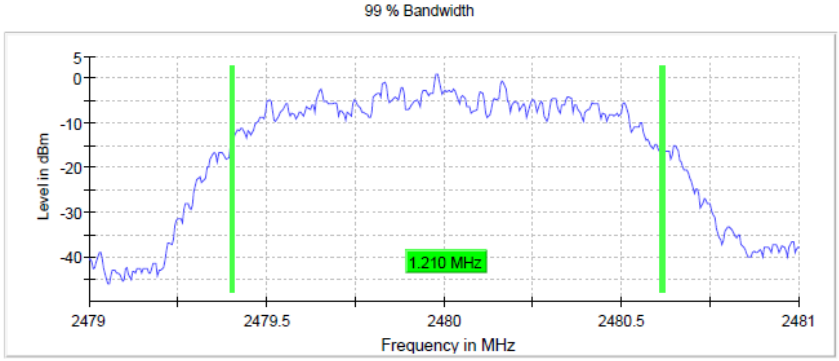



| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.47900 GHz |
| Stop Frequency | 2.48100 GHz |
| Span | 2.000 MHz |
| RBW | 10.000 kHz |
| VBW | 30.000 kHz |
| SweepPoints | 400 |
| Sweeptime | 189.648 µs |
| Reference Level | 0.000 dBm |
| Attenuation | 20.000 dB |
| Detector | MaxPeak |
| SweepCount | 500 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.30 dB |
| Run | 12 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.07 dB |

Radio Technology = Bluetooth EDR2, Operating Frequency = high (S01_AC01)

**99 % Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Result |
|---|---|---|---|---|---|---|
| 2480.000000 | 1.210000 | --- | --- | 2479.402500 | 2480.612500 | PASS |

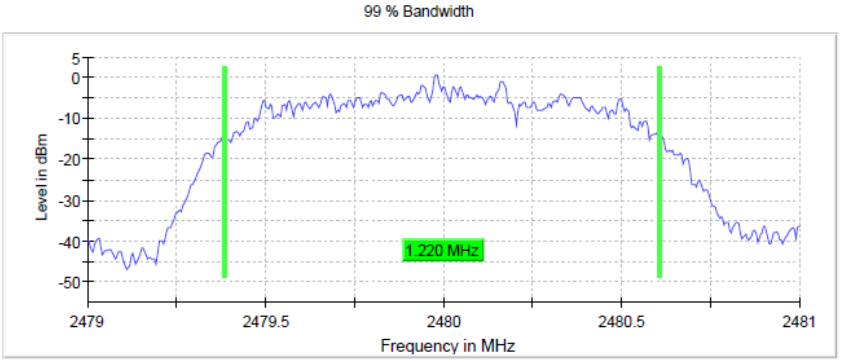



| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.47900 GHz |
| Stop Frequency | 2.48100 GHz |
| Span | 2.000 MHz |
| RBW | 10.000 kHz |
| VBW | 30.000 kHz |
| SweepPoints | 400 |
| Sweeptime | 189.648 µs |
| Reference Level | 0.000 dBm |
| Attenuation | 20.000 dB |
| Detector | MaxPeak |
| SweepCount | 500 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.30 dB |
| Run | 8 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.26 dB |

Radio Technology = Bluetooth EDR3, Operating Frequency = high
(S01_AC01)

**99 % Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Result |
|---|---|---|---|---|---|---|
| 2480.000000 | 1.220000 | --- | --- | 2479.387500 | 2480.607500 | PASS |

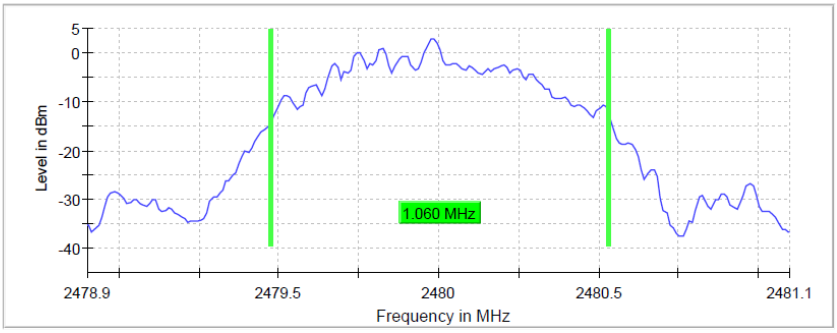



| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.47900 GHz |
| Stop Frequency | 2.48100 GHz |
| Span | 2.000 MHz |
| RBW | 10.000 kHz |
| VBW | 30.000 kHz |
| SweepPoints | 400 |
| Sweeptime | 189.648 µs |
| Reference Level | 0.000 dBm |
| Attenuation | 20.000 dB |
| Detector | MaxPeak |
| SweepCount | 500 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.30 dB |
| Run | 6 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.23 dB |

Radio Technology = Bluetooth LE 1 Mbps, Operating Frequency = high
(S01_AC01)

**99 % Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Result |
|---|---|---|---|---|---|---|
| 2480.000000 | 1.060000 | --- | --- | 2479.475000 | 2480.535000 | PASS |

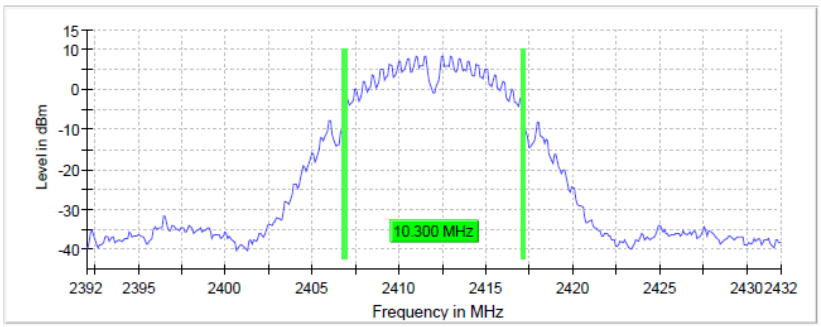



| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.47890 GHz |
| Stop Frequency | 2.48110 GHz |
| Span | 2.200 MHz |
| RBW | 20.000 kHz |
| VBW | 100.000 kHz |
| SweepPoints | 220 |
| Sweeptime | 94.727 µs |
| Reference Level | -10.000 dBm |
| Attenuation | 10.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.30 dB |
| Run | 9 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.18 dB |

Radio Technology = WLAN b, Operating Frequency = low
(S01_AC01)

**99 % Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Result |
|---|---|---|---|---|---|---|
| 2412.000000 | 10.300000 | --- | --- | 2406.850000 | 2417.150000 | PASS |

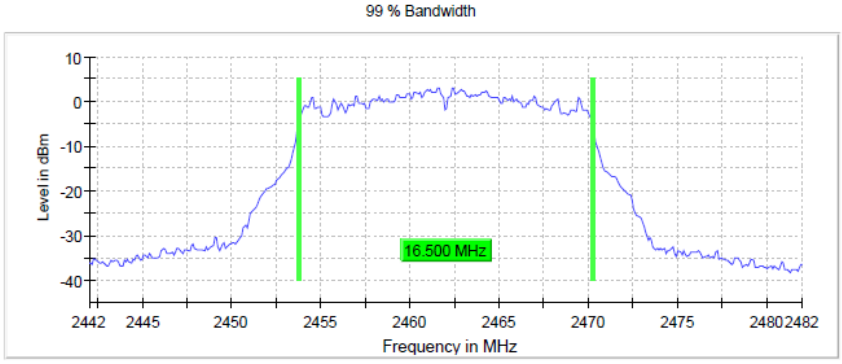



| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.39200 GHz |
| Stop Frequency | 2.43200 GHz |
| Span | 40.000 MHz |
| RBW | 200.000 kHz |
| VBW | 1.000 MHz |
| SweepPoints | 400 |
| Sweeptime | 28.477 µs |
| Reference Level | 10.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.30 dB |
| Run | 6 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.08 dB |

Radio Technology = WLAN g, Operating Frequency = high
(S01_AC01)

**99 % Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Result |
|---|---|---|---|---|---|---|
| 2462.000000 | 16.500000 | --- | --- | 2453.750000 | 2470.250000 | PASS |

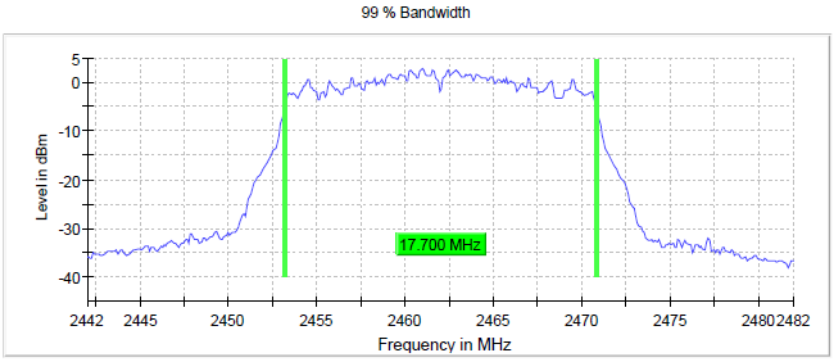



| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.44200 GHz |
| Stop Frequency | 2.48200 GHz |
| Span | 40.000 MHz |
| RBW | 200.000 kHz |
| VBW | 1.000 MHz |
| SweepPoints | 400 |
| Sweeptime | 28.477 µs |
| Reference Level | 10.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.30 dB |
| Run | 35 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.19 dB |

Radio Technology = WLAN n 20 MHz, Operating Frequency = high
(S01_AC01)

**99 % Bandwidth**

| DUT Frequency (MHz) | Bandwidth (MHz) | Limit Min (MHz) | Limit Max (MHz) | Band Edge Left (MHz) | Band Edge Right (MHz) | Result |
|---|---|---|---|---|---|---|
| 2462.000000 | 17.700000 | --- | --- | 2453.150000 | 2470.850000 | PASS |




| Setting | Instrument Value |
|---|---|
| Start Frequency | 2.44200 GHz |
| Stop Frequency | 2.48200 GHz |
| Span | 40.000 MHz |
| RBW | 200.000 kHz |
| VBW | 1.000 MHz |
| SweepPoints | 400 |
| Sweeptime | 28.477 µs |
| Reference Level | 10.000 dBm |
| Attenuation | 30.000 dB |
| Detector | MaxPeak |
| SweepCount | 100 |
| Filter | 3 dB |
| Trace Mode | Max Hold |
| Sweeptype | FFT |
| Preamp | off |
| Stablemode | Trace |
| Stablevalue | 0.30 dB |
| Run | 64 / max. 150 |
| Stable | 3 / 3 |
| Max Stable Difference | 0.19 dB |

## 5.2.5 TEST EQUIPMENT USED

- R&S TS8997

## 5.3 BAND EDGE COMPLIANCE RESTRICTED BANDS

Standard **FCC Part 15 Subpart C**

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

### 5.3.1 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:

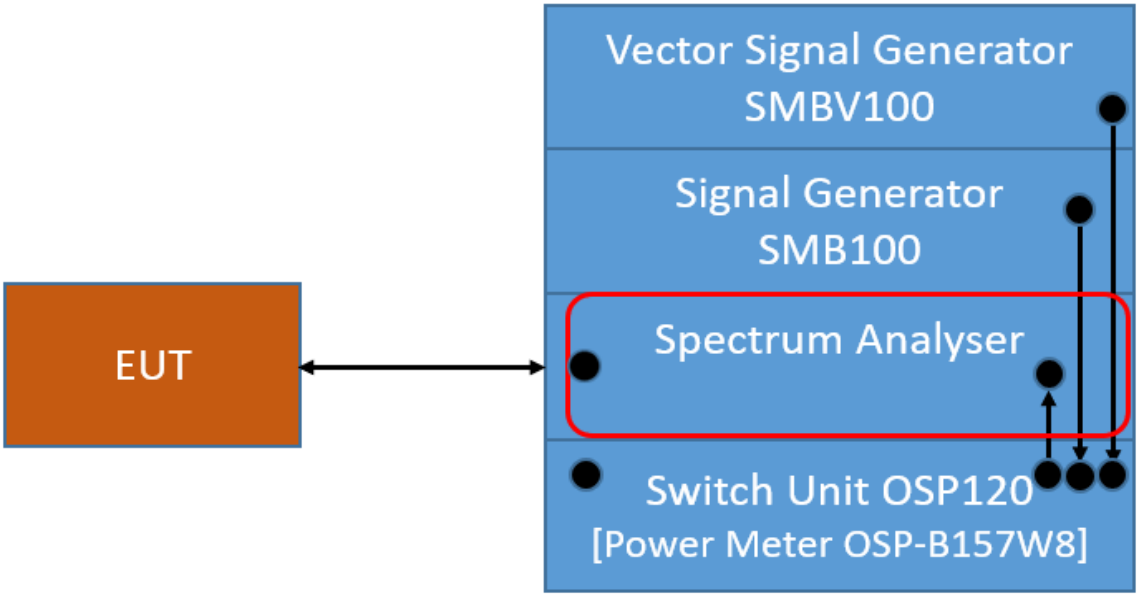
- Frequency range: 2370 – 2500 MHz
- Resolution Bandwidth (RBW): 1000 kHz
- Video Bandwidth (VBW): 3000 kHz
- Trace: Maxhold, Average Power
- Sweeps: 1000
- Sweep Time: coupled
- Detector: Peak, RMS

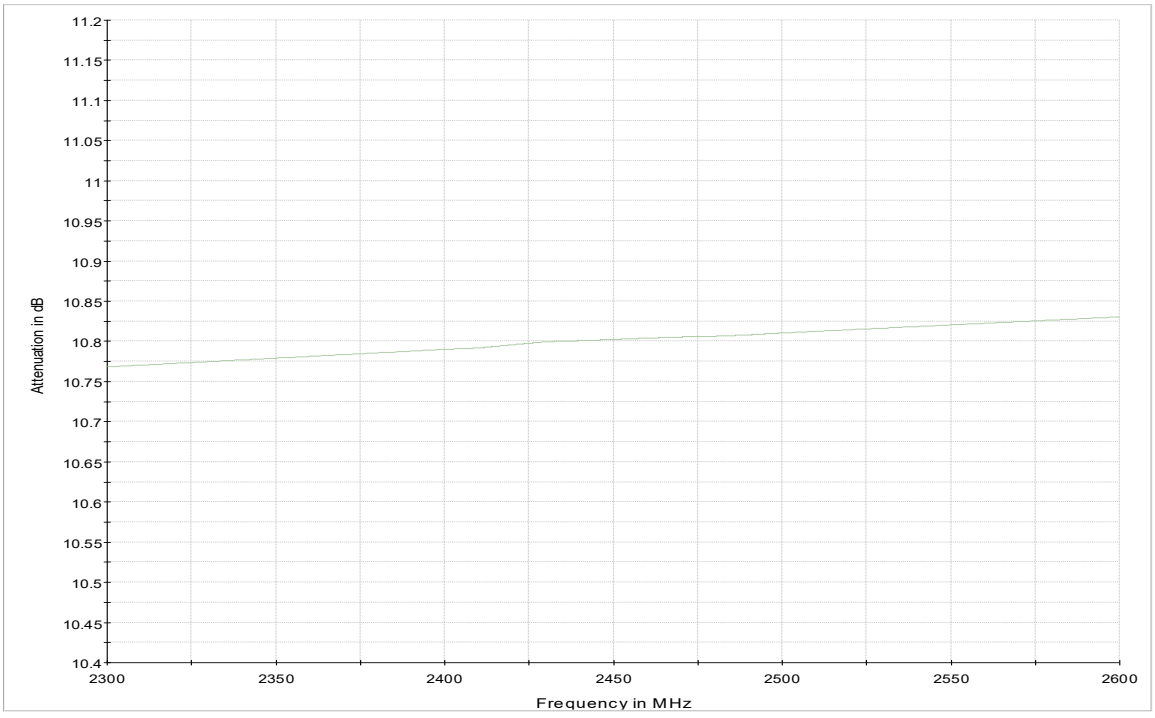
The reference value for the measurement of the spurious RF conducted emissions is determined during the test "band edge compliance conducted". This value is used to calculate the 20 dBc limit.

For the conducted emissions in restricted bands the Value is measured in dBm and then converted to dBµV/m as given in KDB 558074:

1. Measure the conducted output power in dBm.
2. Add the maximum antenna gain in dBi
3. Add the appropriate ground reflection factor
   6 dB for frequencies ≤ 30 MHz;
   4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive; and
   0 dB for frequencies > 1000 MHz).
4. Convert the resulting EIRP level to an equivalent electric field strength level using the following relationship:
   E = EIRP – 20 log D + 104.8
   Where E is the electric field strength in dBµV/m,
   EIRP is the equivalent isotropically radiated power in dBm
   D is the specified measurement distance in m

Value [dBµV/m] = Measured value [dBm] + Maximum Antenna Gain [dBi] + Ground reflection factor – 20 log D + 104.8




Path attenuation

### 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 (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)

### 5.3.3 TEST PROTOCOL

Ambient temperature: 27 °C
Air Pressure: 993 hPa
Humidity: 28 %
BT GFSK (1-DH5)
Applied duty cycle correction (AV): 0 dB

| 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] |
|---|---|---|---|---|---|---|---|
| 0 | 2402 | 2390 | 46.1 | PEAK | 1000 | 74.0 | 28.0 |
| 0 | 2402 | 2390 | 37.6 | AV | 1000 | 54.0 | 16.4 |
| 78 | 2480 | 2483.5 | 51.7 | PEAK | 1000 | 74.0 | 22.3 |
| 78 | 2480 | 2483.5 | 42.6 | AV | 1000 | 54.0 | 11.4 |

BT π/4 DQPSK (2-DH5)
Applied duty cycle correction (AV): 0 dB

| 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] |
|---|---|---|---|---|---|---|---|
| 0 | 2402 | 2390 | 46.3 | PEAK | 1000 | 74.0 | 27.7 |
| 0 | 2402 | 2390 | 37.4 | AV | 1000 | 54.0 | 16.6 |
| 78 | 2480 | 2483.5 | 51.0 | PEAK | 1000 | 74.0 | 23.0 |
| 78 | 2480 | 2483.5 | 41.1 | AV | 1000 | 54.0 | 12.9 |

BT 8-DPSK (3-DH5)
Applied duty cycle correction (AV): 0 dB

| 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] |
|---|---|---|---|---|---|---|---|
| 0 | 2402 | 2390 | 46.8 | PEAK | 1000 | 74.0 | 27.2 |
| 0 | 2402 | 2390 | 37.4 | AV | 1000 | 54.0 | 16.6 |
| 78 | 2480 | 2483.5 | 51.0 | PEAK | 1000 | 74.0 | 23.0 |
| 78 | 2480 | 2483.5 | 41.5 | AV | 1000 | 54.0 | 12.5 |

BT LE 1 Mbit/s
Applied duty cycle correction (AV): 0 dB

| 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] |
|---|---|---|---|---|---|---|---|
| 0 | 2402 | 2390 | 45.7 | PEAK | 1000 | 74.0 | 28.3 |
| 0 | 2402 | 2390 | 37.2 | AV | 1000 | 54.0 | 16.8 |
| 39 | 2480 | 2483.5 | 52.8 | PEAK | 1000 | 74.0 | 21.2 |
| 39 | 2480 | 2483.5 | 39.6 | AV | 1000 | 54.0 | 14.4 |

WLAN b-Mode; 20 MHz; 1 Mbit/s
Applied duty cycle correction (AV): 0 dB

| 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] |
|---|---|---|---|---|---|---|---|
| 1 | 2412 | 2390 | 55.4 | PEAK | 1000 | 74.0 | 18.6 |
| 1 | 2412 | 2390 | 47.2 | AV | 1000 | 54.0 | 6.8 |
| 11 | 2462 | 2483.5 | 53.8 | PEAK | 1000 | 74.0 | 20.2 |
| 11 | 2462 | 2483.5 | 46.5 | AV | 1000 | 54.0 | 7.5 |

WLAN g-Mode; 20 MHz; 6 Mbit/s
Applied duty cycle correction (AV): 0 dB

| 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] |
|---|---|---|---|---|---|---|---|
| 1 | 2412 | 2390 | 62.9 | PEAK | 1000 | 74.0 | 11.1 |
| 1 | 2412 | 2390 | 51.6 | AV | 1000 | 54.0 | 2.4 |
| 11 | 2462 | 2483.5 | 60.7 | PEAK | 1000 | 74.0 | 13.3 |
| 11 | 2462 | 2483.5 | 49.5 | AV | 1000 | 54.0 | 4.5 |
| 2 | 2417 | 2390 | 60.3 | PEAK | 1000 | 74.0 | 13.7 |
| 2 | 2417 | 2390 | 50.3 | AV | 1000 | 54.0 | 3.8 |
| 10 | 2457 | 2483.5 | 59.5 | PEAK | 1000 | 74.0 | 14.5 |
| 10 | 2457 | 2483.5 | 48.6 | AV | 1000 | 54.0 | 5.4 |

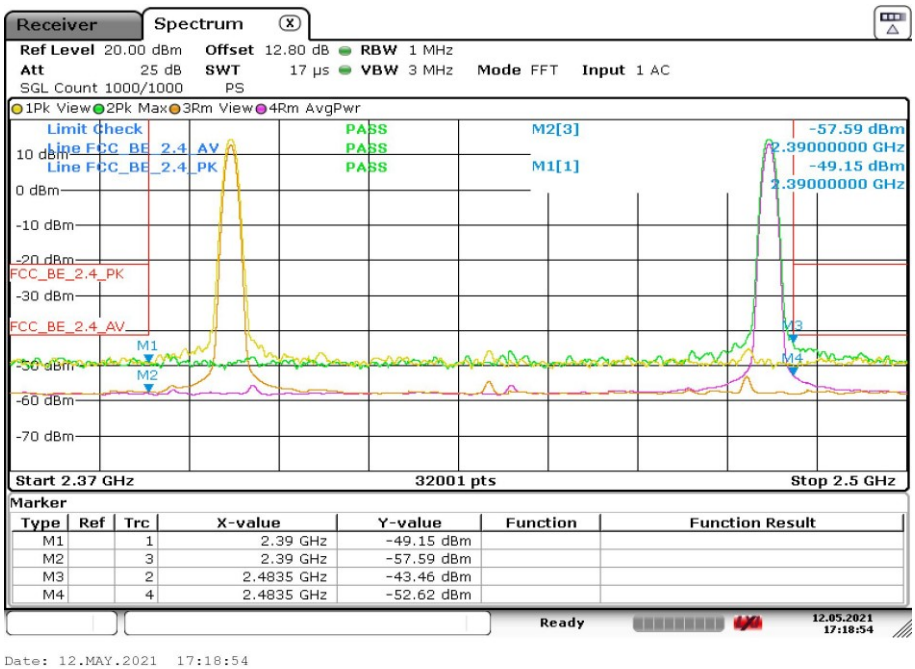
WLAN n-Mode; 20 MHz; MCS0
Applied duty cycle correction (AV): 0 dB

| 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] |
|---|---|---|---|---|---|---|---|
| 1 | 2412 | 2390 | 64.0 | PEAK | 1000 | 74.0 | 10.0 |
| 1 | 2412 | 2390 | 53.2 | AV | 1000 | 54.0 | 0.8 |
| 11 | 2462 | 2483.5 | 60.0 | PEAK | 1000 | 74.0 | 14.0 |
| 11 | 2462 | 2483.5 | 50.6 | AV | 1000 | 54.0 | 3.5 |
| 2 | 2417 | 2390 | 62.7 | PEAK | 1000 | 74.0 | 11.3 |
| 2 | 2417 | 2390 | 51.3 | AV | 1000 | 54.0 | 2.7 |
| 10 | 2457 | 2483.5 | 58.5 | PEAK | 1000 | 74.0 | 15.5 |
| 10 | 2457 | 2483.5 | 48.9 | AV | 1000 | 54.0 | 5.1 |

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

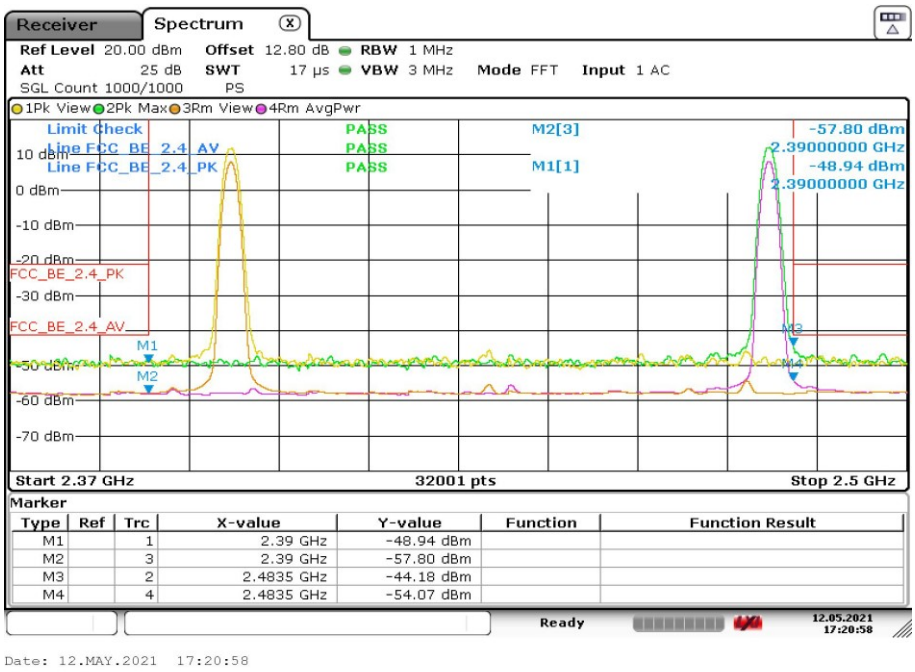
## 5.3.4 MEASUREMENT PLOTS

Radio Technology = Bluetooth BDR
(S01_AC01)




Result plot includes 2 dBi antenna gain

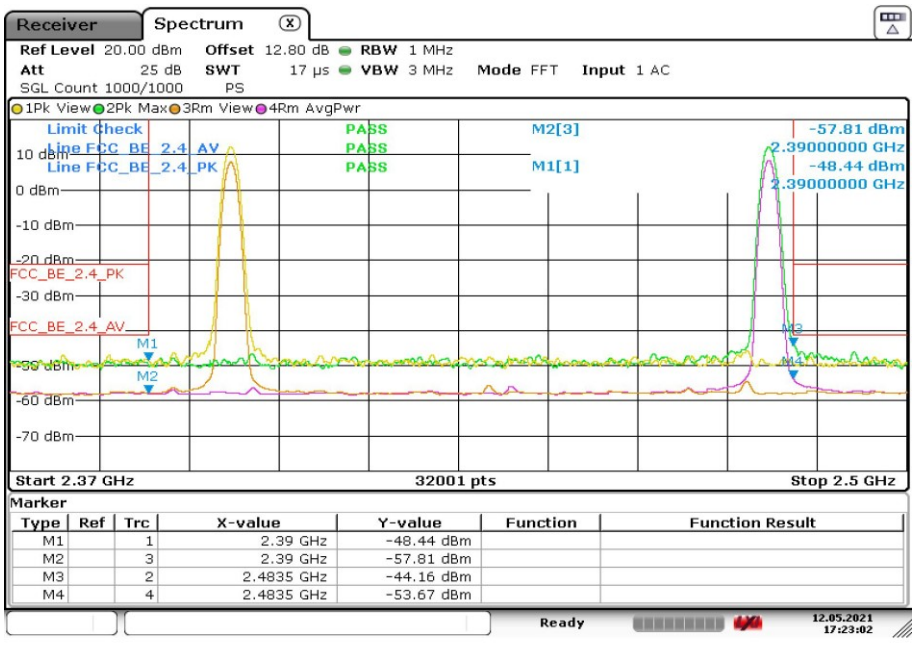
Radio Technology = Bluetooth EDR 2
(S01_AC01)




Date: 12.MAY.2021 17:20:58

Result plot includes 2 dBi antenna gain

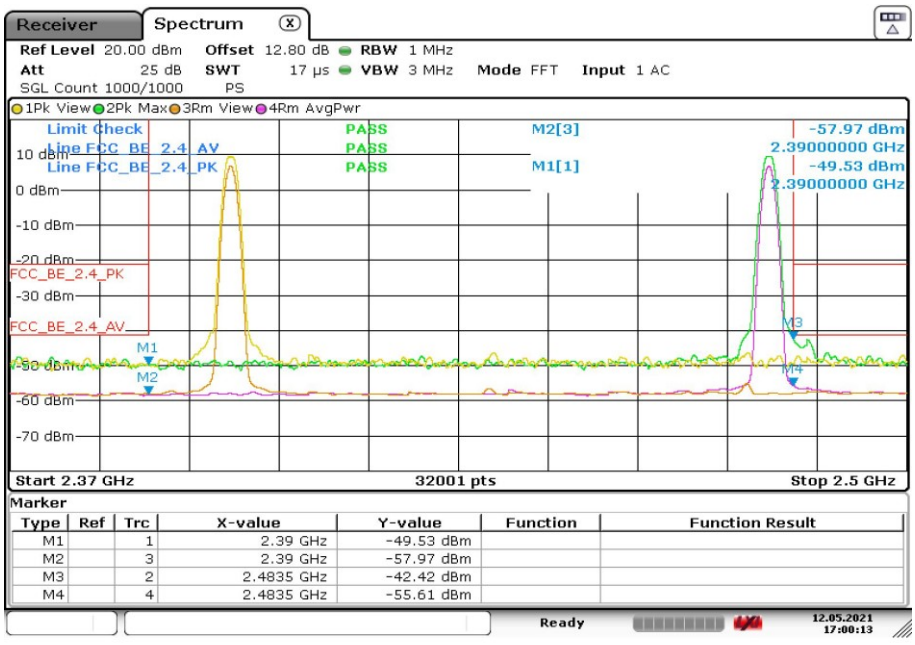
Radio Technology = Bluetooth EDR 3
(S01_AC01)




Date: 12.MAY.2021 17:23:01

Result plot includes 2 dBi antenna gain

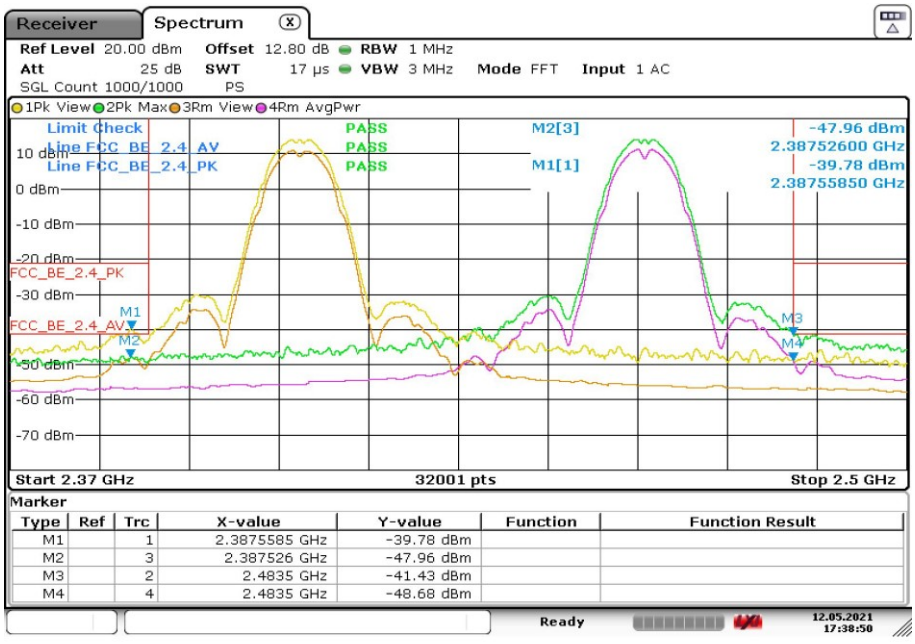
Radio Technology = Bluetooth LE 1 Mbps
(S01_AC01)




Date: 12.MAY.2021 17:00:13

Result plot includes 2 dBi antenna gain

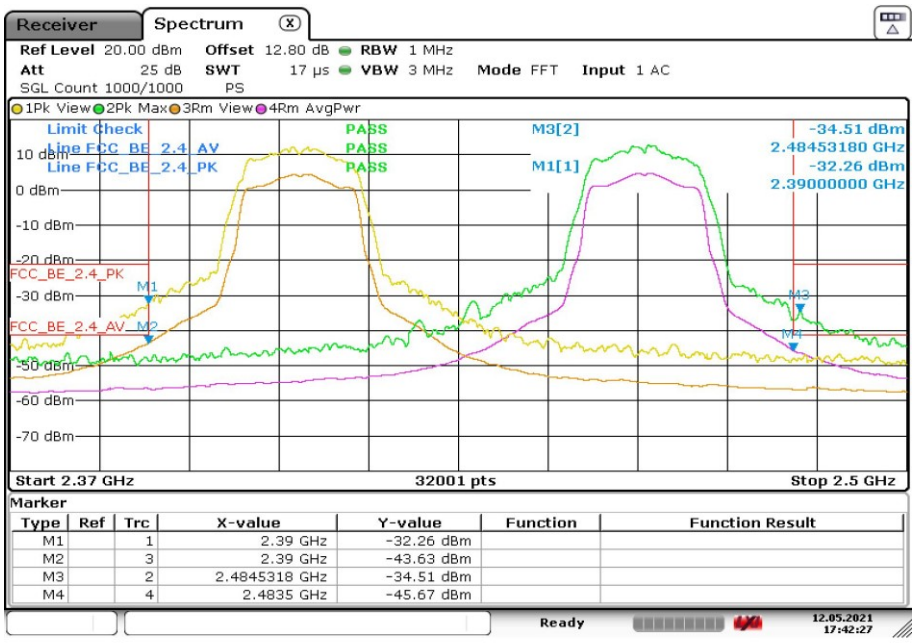
Radio Technology = WLAN b
(S01_AC01)



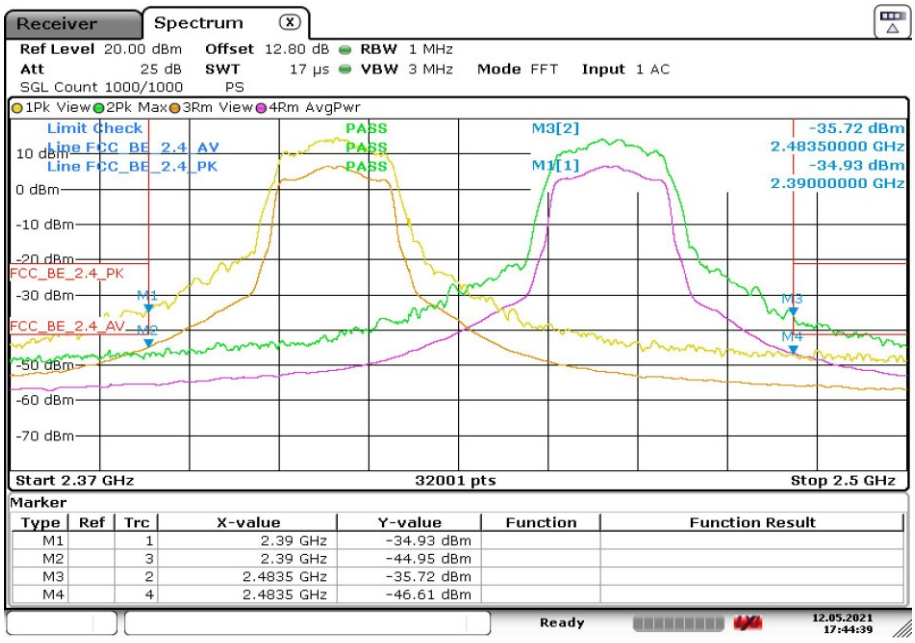

Date: 12.MAY.2021 17:38:49

Result plot includes 2 dBi antenna gain

Radio Technology = WLAN g
(S01_AC01)



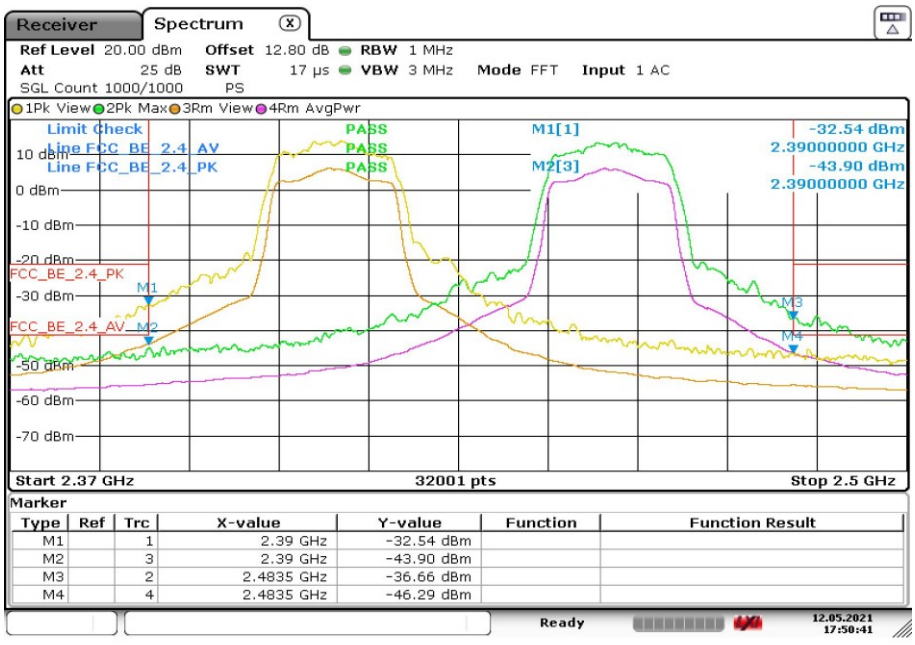

Date: 12.MAY.2021 17:42:27



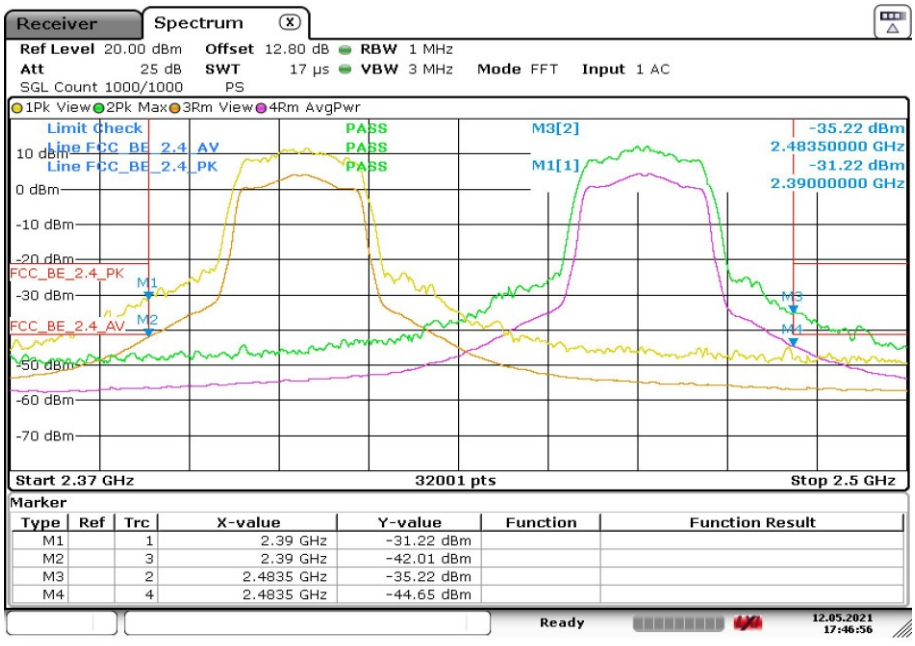

Date: 12.MAY.2021 17:44:40

Result plots includes 2 dBi antenna gain

Radio Technology = WLAN n 20 MHz
(S01_AC01)




Date: 12.MAY.2021 17:50:40




Date: 12.MAY.2021 17:46:56

Result plots includes 2 dBi antenna gain

## 5.3.5 TEST EQUIPMENT USED

- R&S TS8997

## 5.4 TRANSMITTER SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15 Subpart C**

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

### 5.4.1 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:

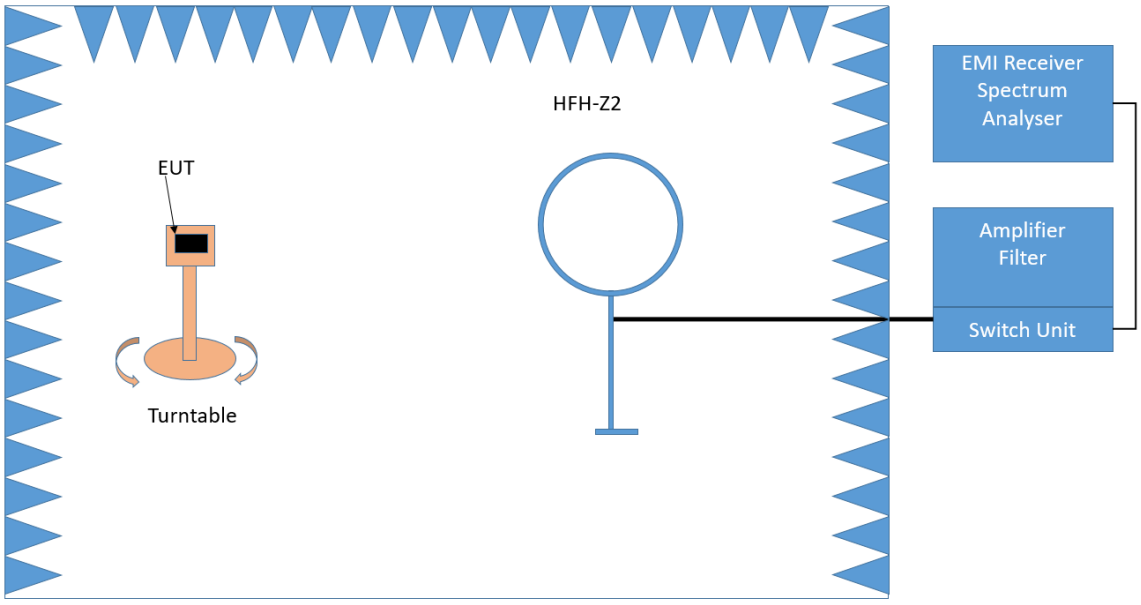
- < 30 MHz: Chapter 6.4
- 30 MHz – 1 GHz: Chapter 6.5
- > 1 GHZ: Chapter 6.6 (procedure according 6.6.5 used)

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

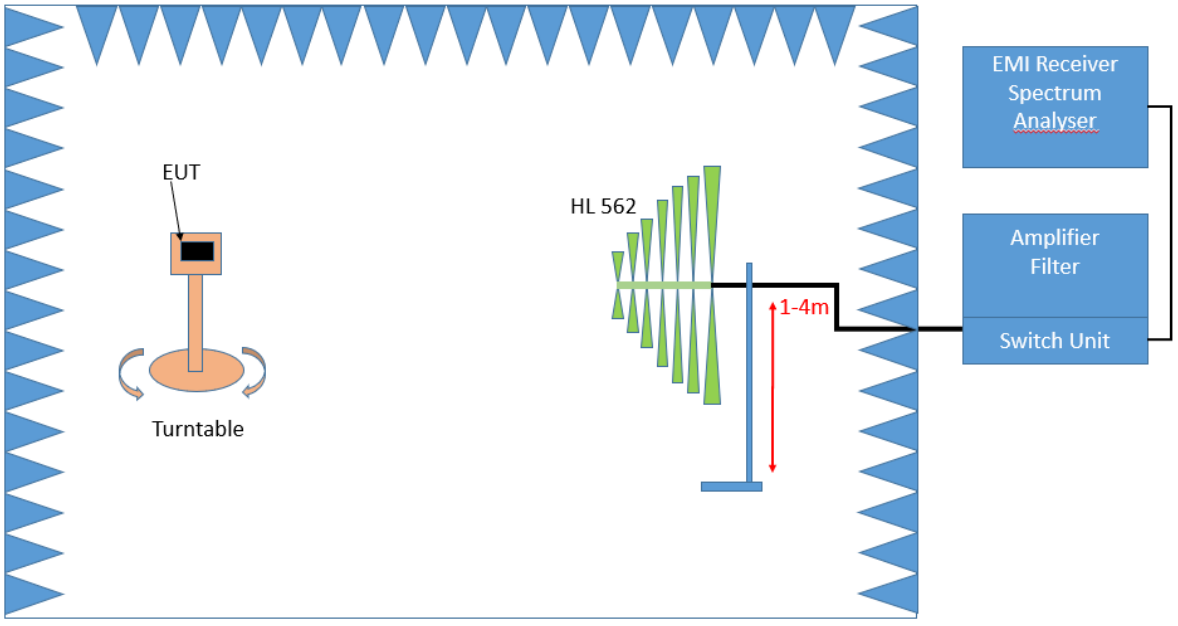
- Anechoic chamber
- Antenna distance: 3 m
- Antenna height: 1 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

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 and 4m. 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:

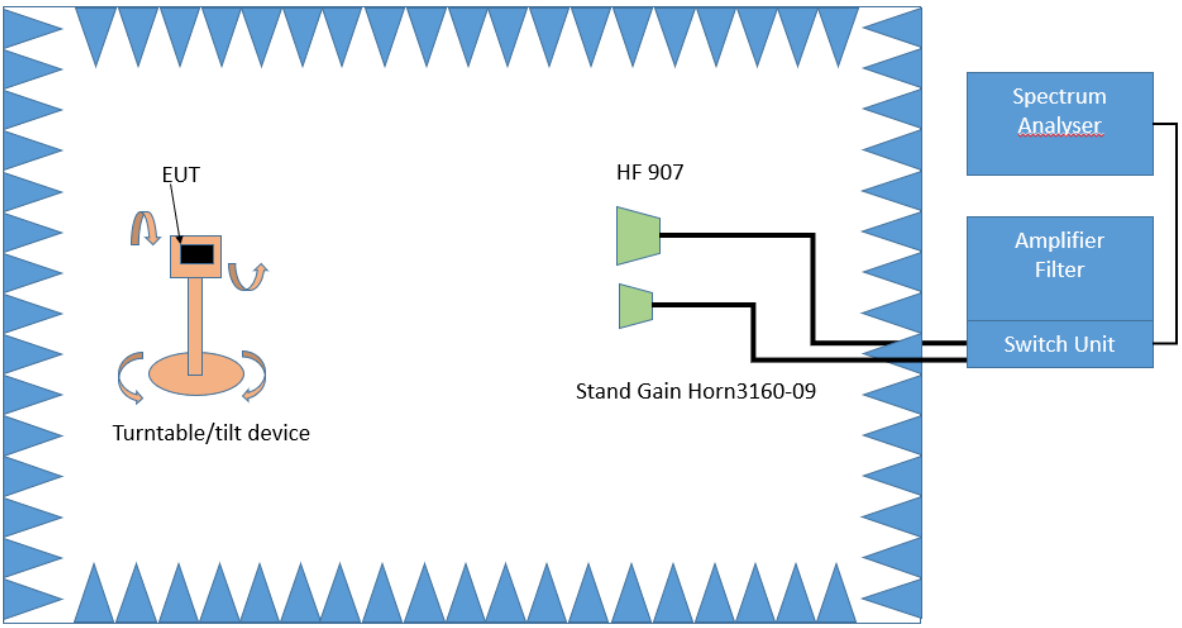
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

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 ± 22.5°.
The elevation angle will slowly vary by ± 45°
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

## 5.4.2 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 (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)

## 5.4.3 TEST PROTOCOL

**Ambient temperature:** **27 - 28 °C**
**Air Pressure:** **1006 - 1013 hPa**
**Humidity:** **34 - 43%**

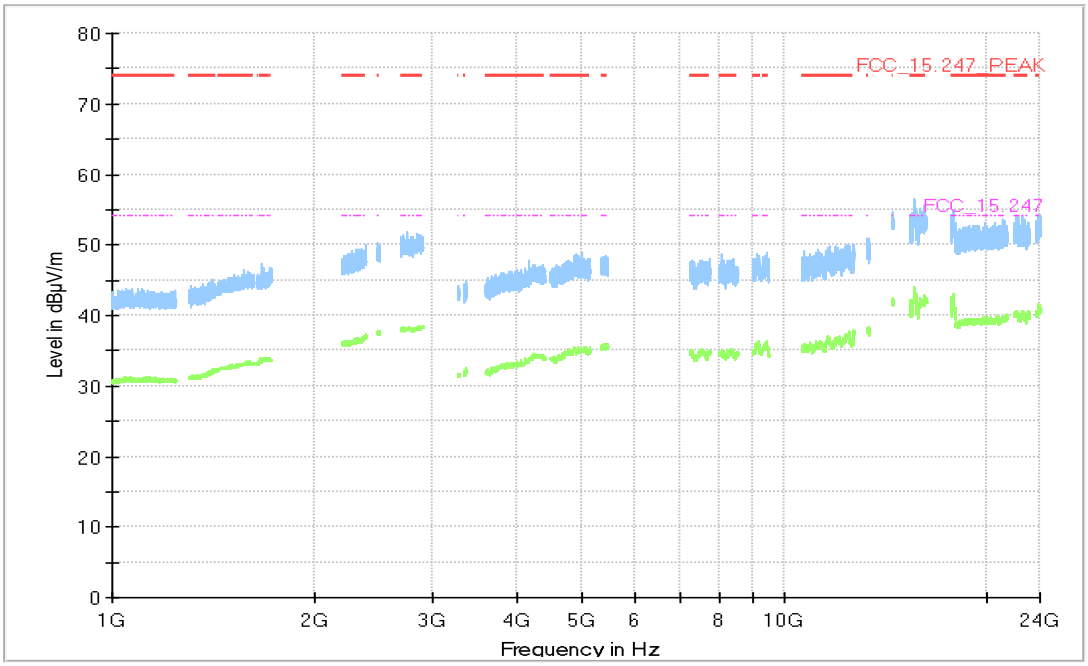
| **BT GFSK (1-DH1)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applied duty cycle correction (AV): 0 dB** | | | | | | | | |
| **Ch. No.** | **Ch. Center Freq. [MHz]** | **Spurious Freq. [MHz]** | **Spurious Level [dBµV/m]** | **Detec-tor** | **RBW [kHz]** | **Limit [dBµV/m]** | **Margin to Limit [dB]** | **Limit Type** |
| 78 | 2480 | - - - | - - - | - - - | - - - | - - - | - - - | RB |

| **WLAN b-Mode; 20 MHz; 1 Mbit/s** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applied duty cycle correction (AV): 0 dB** | | | | | | | | |
| **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** |
| 11 | 2462 | - - - | - - - | - - - | - - - | - - - | - - - | RB |

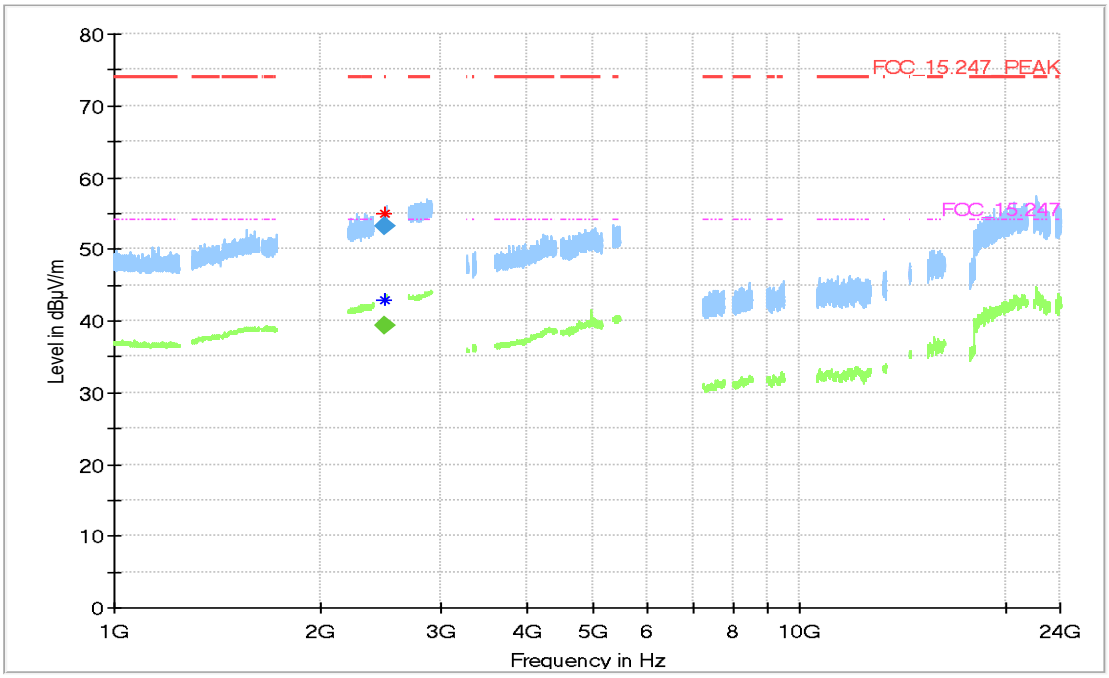
Remark: Please see next sub-clause for the measurement plot.

### 5.4.4 MEASUREMENT PLOT

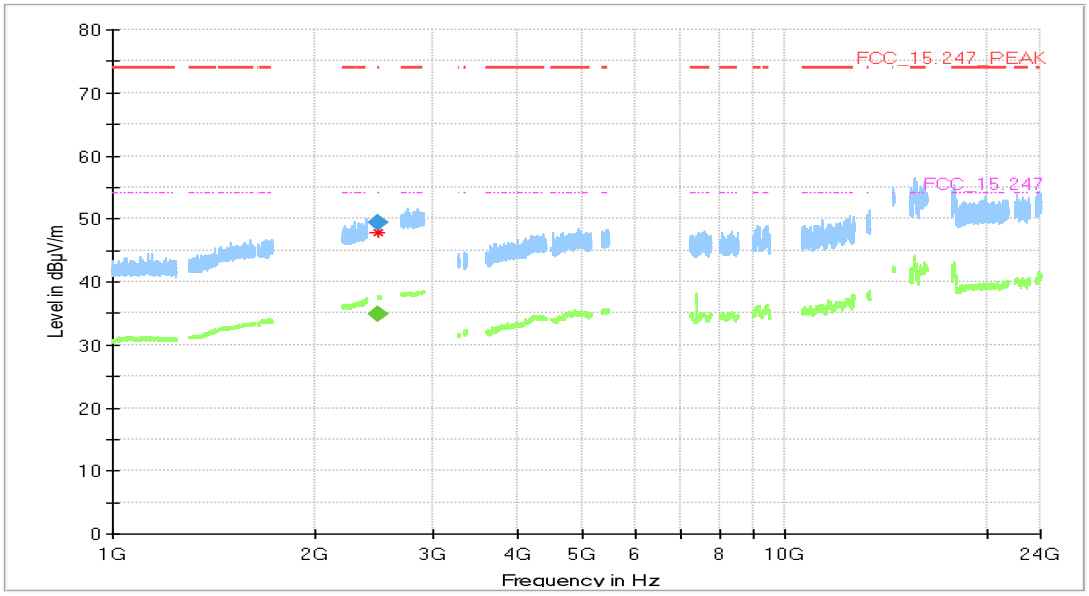
Radio Technology = Bluetooth BDR, Operating Frequency = high, Measurement range = 1 GHz - 26 GHz
(S02_AC01)




Plot original certification:



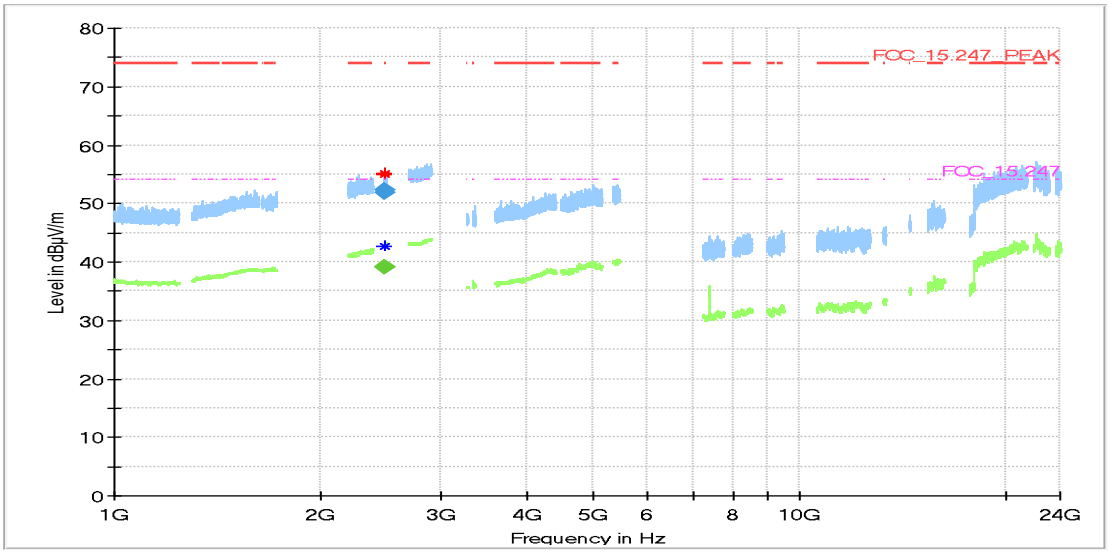
Radio Technology = WLAN b, Operating Frequency = high, Measurement range = 1 GHz - 26 GHz
(S02_AC01)




## 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) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2483.583 | --- | 34.9 | 54.00 | 19.05 | 1000.0 | 1000.000 | 150.0 | H | 112.0 | 78.0 | 5.4 |
| 2483.583 | 49.4 | --- | 74.00 | 24.55 | 1000.0 | 1000.000 | 150.0 | V | -79.0 | 15.0 | 5.4 |

Plot original certification:




## 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) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2483.500000 | --- | 39.11 | 54.00 | 14.89 | 1000.0 | 1000.000 | 150.0 | V | -29.0 | 102.1 |
| 2483.747500 | 52.33 | --- | 74.00 | 21.67 | 1000.0 | 1000.000 | 150.0 | V | -189.0 | 77.8 |

### 5.4.5 TEST EQUIPMENT USED

- Radiated Emissions

# 6 TEST EQUIPMENT

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 | FSV30 | Signal Analyzer 10 Hz - 30 GHz | Rohde & Schwarz | 103005 | 2020-05 | 2022-05 |
| 1.2 | ESR7 | EMI Receiver / Spectrum Analyzer | Rohde & Schwarz | 101424 | 2021-01 | 2023-01 |
| 1.3 | Opus10 THI (8152.00) | T/H Logger 15 | Lufft Mess- und Regeltechnik GmbH | 13985 | 2019-06 | 2021-06 |
| 1.4 | Opus10 THI (8152.00) | T/H Logger 14 | Lufft Mess- und Regeltechnik GmbH | 13993 | 2019-06 | 2021-06 |
| 1.5 | OSP120 | Contains Power Meter and Switching Unit OSP-B157W8 | Rohde & Schwarz | 101158 | 2018-05 | 2021-05 |

2 Radiated Emissions
Lab to perform radiated emission tests

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| 2.1 | MFS | Rubidium Frequency Normal MFS | Datum GmbH | 002 | 2020-11 | 2021-11 |
| 2.2 | Opus10 TPR (8253.00) | T/P Logger 13 | Lufft Mess- und Regeltechnik GmbH | 13936 | 2019-05 | 2021-05 |
| 2.3 | AMF-7D00101800-30-10P-R | Broadband Amplifier 100 MHz - 18 GHz | Miteq | | | |
| 2.4 | ASP 1.2/1.8-10 kg | Antenna Mast | Maturo GmbH | - | | |
| 2.5 | 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 |
| 2.6 | Opus10 THI (8152.00) | T/H Logger 10 | Lufft Mess- und Regeltechnik GmbH | 12488 | 2019-06 | 2021-06 |
| 2.7 | JS4-18002600-32-5P | Broadband Amplifier 18 GHz - 26 GHz | Miteq | 849785 | | |
| 2.8 | FSW 43 | Spectrum Analyzer | Rohde & Schwarz | 103779 | 2019-02 | 2021-08 |
| 2.9 | 3160-09 | Standard Gain / Pyramidal Horn Antenna 26.5 GHz | EMCO Elektronic GmbH | 00083069 | | |
| 2.10 | WHKX 7.0/18G-8SS | High Pass Filter | Wainwright Instruments GmbH | 09 | | |
| 2.11 | JS4-00102600-42-5A | Broadband Amplifier 30 MHz - 26 GHz | Miteq | 619368 | | |
| 2.12 | TT 1.5 WI | Turn Table | Maturo GmbH | - | | |

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| 2.13 | HL 562 ULTRALOG | Biconical-log-per Antenna (30 MHz - 3 GHz) | Rohde & Schwarz GmbH & Co. KG | 100609 | 2019-05 | 2022-05 |
| 2.14 | JUN-AIR Mod. 6-15 | Air Compressor | JUN-AIR Deutschland GmbH | 612582 | | |
| 2.15 | 5HC3500/18000-1.2-KK | High Pass Filter | Trilithic | 200035008 | | |
| 2.16 | JS4-00101800-35-5P | Broadband Amplifier 30 MHz - 18 GHz | Miteq | 896037 | | |
| 2.17 | AS 620 P | Antenna Mast (pneumatic polarisation) | HD GmbH | 620/37 | | |
| 2.18 | TD1.5-10kg | EUT Tilt Device (Rohacell) | Maturo GmbH | TD1.5-10kg/024/3790709 | | |
| 2.19 | HF 907-2 | Double-ridged horn | Rohde & Schwarz | 102817 | 2019-04 | 2022-04 |
| 2.20 | PAS 2.5 - 10 kg | Antenna Mast | Maturo GmbH | - | | |
| 2.21 | AFS42-00101800-25-S-42 | Broadband Amplifier 25 MHz - 18 GHz | Miteq | 2035324 | | |
| 2.22 | HF 907 | Double-ridged horn | Rohde & Schwarz | 102444 | 2018-07 | 2021-07 |

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”

# 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 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.

## 7.2 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

## 7.3 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.

## 7.4 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.

## 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 (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.

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

| 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 | | | | -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 |

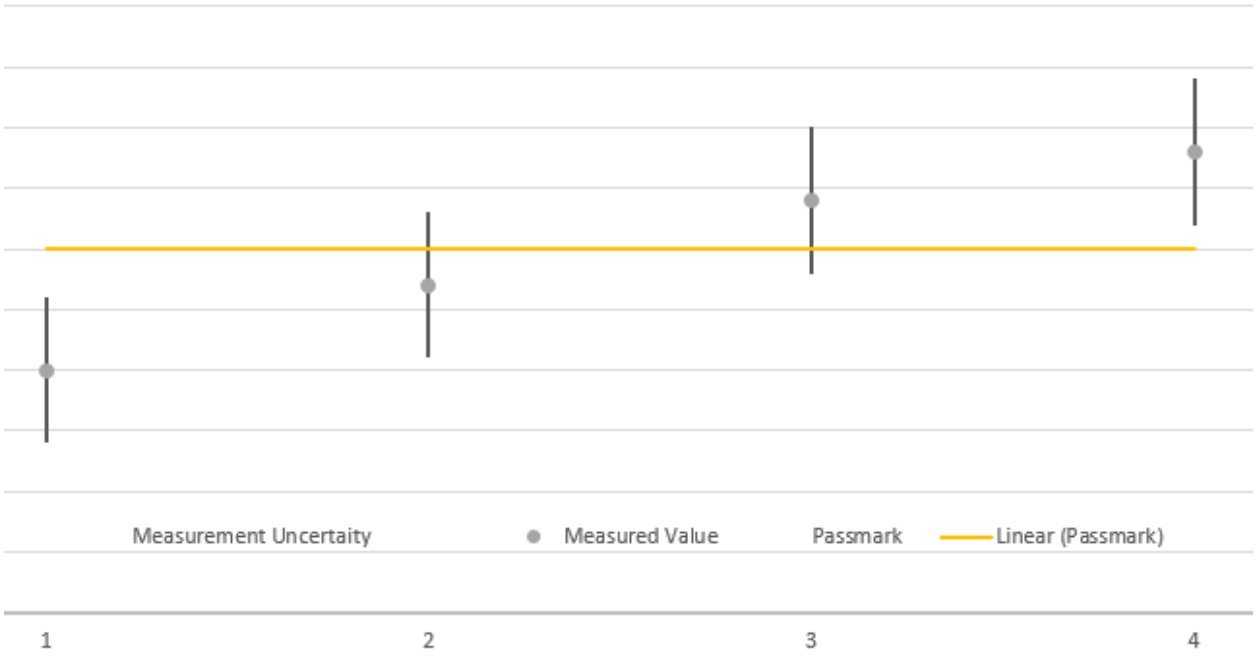
**Sample calculation**

E (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.
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.

# 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 |

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.

**End of report**