# FCC Measurement/Technical Report on

# WiBEAR11n-DF2 / ELLA-W163

# FCC ID: PV7-WIBEAR11N-DF2
# IC: 7738A-WB11NDF2

**Test Report Reference:** MDE_UBLOX_1624FCCe


**Test Laboratory:**
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DAkkS Deutsche Akkreditierungsstelle D-PL-12140-01-01

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# 1 Applied Standards and Test Summary

## 1.1 Applied Standards

**Type of Authorization**
Certification for an Intentional Radiator (Digital Device / Spread Spectrum).

**Applicable FCC Rules**

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

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

Part 15, Subpart E – Unlicensed National Information Infrastructure Devices

§ 15.403 Definitions

§ 15.407 General technical requirements

Note:
The tests were selected and performed with reference to the FCC Public Notice “Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E, 789033 D02 General U-NII Test Procedures v01r02, 2016-04-08”.

ANSI C63.10-2013 is applied.

FCC ET Docket No. 13-49, FIRST REPORT AND ORDER, April 1, 2014 (“new rules”) is applied.

This test report considers FCC KDB Inquiry 586005 which deals with the reuse of test results from the product WiBear11n-DF1(ELLA-W161) with FCC ID PV7-WIBEAR11N-DF1.

As such, this test report contains a “spot check” to ensure no significant degradation against the parent product.

**Summary Test Results:**

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

## 1.2 FCC-IC Correlation Table

### Correlation of measurement requirements for UNII / LE-LAN (e.g. WLAN 5 GHz) equipment from FCC and IC

**UNII equipment**

| Measurement | FCC reference | IC reference |
|---|---|---|
| Conducted emissions on AC Mains | § 15.207 | RSS-Gen Issue 4: 8.8 |
| Occupied bandwidth | § 15.403 (i) (26 dB) / § 15.407 (e) (6 dB) | RSS-247 Issue 1: 6.2.1 (1), 6.2.2 (1), 6.2.3 (1) (99%) RSS-247 Issue 1: 6.2.4 (1) (6 dB) |
| Maximum conducted output power | § 15.407 (a) (1),(2),(3),(4) | RSS-247 Issue 1: : 6.2.1 (1), 6.2.2 (1), 6.2.3 (1), 6.2.4 (1) |
| Maximum power spectral density | § 15.407 (a) (1),(2),(3),(5) | RSS-247 Issue 1: : 6.2.1 (1), 6.2.2 (1), 6.2.3 (1), 6.2.4 (1) |
| Transmitter undesirable emissions; General Field Strength Limits, Restricted Bands | 15.407 (b) § 15.209 (a) | RSS-Gen Issue 4: 6.13/8.9/8.10; RSS-247 Issue 1: : 6.2.1 (2), 6.2.2 (2), 6.2.3 (2), 6.2.4 (2) |
| Frequency stability | § 15.407 (g) | RSS-Gen Issue 4: 6.11/8.11 |
| Transmit Power Control (TPC) and Dynamic Frequency Selection (DFS) | § 15.407 (h) | RSS-247 Issue 1: 6.2.2 (1), 6.2.3 (1), 6.3 |
| Antenna requirement | § 15.203 / 15.204 | RSS-Gen Issue 4: 8.3 |
| Receiver spurious emissions | – | - |

## 1.3 Measurement Summary / Signatures

| 47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 | FCC §15.31, §15.403 (i) | | |
|---|---|---|---|
| 26 dB Bandwidth<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology, Operating Frequency, Subband | **Setup** | **FCC** | **IC** |
| WLAN a, high, U-NII-1 | | N/P | N/P |

| 47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 | FCC §15.31, §15.403 (i) | | |
|---|---|---|---|
| 6 dB Bandwidth<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology, Operating Frequency, Subband | **Setup** | **FCC** | **IC** |
| WLAN a, high, U-NII-3 | | N/P | N/P |

| 47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 | FCC §15.31, §15.403 (i) | | |
|---|---|---|---|
| 99 % Bandwidth<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology, Operating Frequency, Subband | **Setup** | **FCC** | **IC** |
| WLAN a, high, U-NII-1 | | N/P | N/P |

| 47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 | FCC §15.31, §15.407 (a)(1) | | |
|---|---|---|---|
| Maximum Conducted Output Power<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology, Operating Frequency, Subband | **Setup** | **FCC** | **IC** |
| WLAN a, high, U-NII-1 | | N/P | N/P |

| 47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 | FCC §15.31, §15.407 (a)(1),(5) | | |
|---|---|---|---|
| Peak Power Spectral Density<br>The measurement was performed according to ANSI C63.10 | | **Final Result** | |
| **OP-Mode**<br>Radio Technology, Operating Frequency, Subband | **Setup** | **FCC** | **IC** |
| WLAN a, high, U-NII-1 | | N/P | N/P |

| 47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 | FCC §15.407 (b), (1),(2),(3),(4); FCC §15.205, §15.209, §15.407 (b) (5),(6) |
|---|---|

Undesirable Emissions; General Field Strength Limits
The measurement was performed according to ANSI C63.10

**Final Result**

| **OP-Mode**<br>Radio Technology, Operating Frequency, Measurement range, Subband | **Setup** | **FCC** | **IC** |
|---|---|---|---|
| WLAN a, high, 1GHz - 26GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN a, low, 1GHz - 26GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN a, low, 26GHz - 40GHz, U-NII-3 | S01_AB01 | Passed | Passed |
| WLAN a, mid, 1GHz - 26GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN a, mid, 30MHz - 1GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN a, mid, 9kHz - 30MHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 20 MHz, high, 1GHz - 26GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 20 MHz, high, 26GHz - 40GHz, U-NII-3 | S01_AB01 | Passed | Passed |
| WLAN n 20 MHz, low, 1GHz - 26GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 20 MHz, mid, 1GHz - 26GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 40 MHz, high, 1GHz - 26GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 40 MHz, high, 30MHz - 1GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 40 MHz, high, 9kHz - 30MHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 40 MHz, low, 1GHz - 26GHz, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 40 MHz, low, 26GHz - 40GHz, U-NII-3 | S01_AB01 | Passed | Passed |

| 47 CFR CHAPTER I FCC PART 15 Subpart E §15.407 | FCC §15.407 (b), (1),(2),(3),(4) |
|---|---|

Band Edge

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

| OP-Mode<br>Radio Technology, Operating Frequency, Subband | Setup | FCC | IC |
|---|---|---|---|
| WLAN a, high, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN a, low, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 20 MHz, high, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 20 MHz, low, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 40 MHz, high, U-NII-3 | S01_AA01 | Passed | Passed |
| WLAN n 40 MHz, low, U-NII-3 | S01_AA01 | Passed | Passed |

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

(responsible for accreditation scope)
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# 2 Administrative Data

## 2.1 Testing Laboratory

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

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

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

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

| | |
|---|---|
| Laboratory accreditation no: | DAkkS D-PL-12140-01-01 |
| Responsible for accreditation scope: | Dipl.-Ing. Bernhard Retka |
| Report Template Version: | 2016-05-12 |

## 2.2 Project Data

| | |
|---|---|
| Responsible for testing and report: | Patrick Lomax |
| Employees who performed the tests: | documented internally at 7Layers |
| Date of Report: | 2016-05-23 |
| Testing Period: | 2016-05-29 to 2016-05-30 |

## 2.3 Applicant Data

| | |
|---|---|
| Company Name: | u-blox Berlin GmbH |
| Address: | Rudower Chausse 9<br>12489 Berlin<br>Germany |
| Contact Person: | Dr. Daniel Dietterle |

## 2.4 Manufacturer Data

| | |
|---|---|
| Company Name: | PRETTL Electronics AG |
| Address: | Robert-Bosch-Str 10<br>01454 Radeberg<br>Germany |
| Contact Person: | Mrs. Kerstin Sauer |

# 3 Test object Data

## 3.1 General EUT Description

| | |
|---|---|
| Kind of Device product description | IEEE 802.11a/b/g/n WLAN transceiver |
| Product name | ELLA-W161 (DF3) |
| Type | - |
| **Declared EUT data by the supplier** | |
| Voltage Type | DC |
| Voltage Level | 1.8 V and 3.3 V |
| Tested Modulation Type | BPSK, QPSK, 16-QAM, 64-QAM |
| General product description | The EUT is industrial universal module, targeted for integration into different Original Equipment Manufacturer products. The module is designed for both - simultaneous and independent operation of the following:<br>IEEE 802.11a/b/g/n payload data rates for Wireless Local Area Network (WLAN), Bluetooth 3.0+ High Speed (HS) and Bluetooth 2.1+ EDR. It provides a complete end-to-end solution for low power applications. It includes an integrated MAC/Baseband processor and RF front-end components, and can connect to a host processor via SDIO interface. |
| Specific product description | The EUT is a dual band WLAN (802.11 a/b/g/n, 2.5 and 5 GHz) and Bluetooth module with one joint antenna connector for WLAN and Bluetooth. In IEEE 802.11n mode it supports 20 MHz and 40 MHz bandwidth channels (both with MCS7), providing 72.2 Mbit/s, and 150 Mbit/s transfer data rates respectively.<br>The object of this test report is the WLAN transceiver, consequently switched on the IEEE 802.11 a/n modes, working in the 5 GHz bands. In IEEE 802.11n mode, it was tested with 20 MHz and 40 MHz channel bandwidth. |
| Ports of the device | Enclosure<br>Antenna connector<br>DC port<br>Data port |
| Antenna 1 | Integral / Gain: 4.6 dBi (5GHz Band) |
| Antenna 2 | Integral / Gain: 1.8 dBi (2.4GHz Band) |
| Tested Modulations | DBPSK; OFDM:BPSK; OFDM:64-QAM |
| Tested Datarates | • WLAN a-Mode; Channel Bandwidth: 20 MHz ; Data rate: 6 Mbit/s<br>• WLAN n-Mode; Channel Bandwidth: 20 MHz ; Data rate: 72.2 Mbit/s<br>• WLAN n-Mode; Channel Bandwidth: 40 MHz ; Data rate: 150 Mbit/s |
| Special software used for testing | Marvell Labtool 8787 software is used to set the EUT into the different operating modes. |
| Duty Cycle | The duty cycle was for all operating modes was 100%. |

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

## 3.2 EUT Main components

| Sample Name | Sample Code | Description |
|---|---|---|
| Radiated Sample | DE1015035aa01 | |
| **Sample Parameter** | **Value** | |
| HW Version | G8 | |
| Integral Antenna | Gain: 4.6 dB | |
| Serial No. | None | |
| SW Version | MFG Firmware | |
| Comment | | |

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

## 3.3 Ancillary Equipment

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

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

## 3.4 Auxiliary Equipment

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

| Device | Details (Manufacturer, HW, SW, S/N) | Description |
|---|---|---|
| HyCell HCPS1500 | , -, - , - | Power Supply |

## 3.5 EUT Setups

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

| Setup | Combination of EUTs | Description and Rationale |
|---|---|---|
| S01_AA01 | Radiated Sample, HyCell HCPS1500, | Setup for radiated measurements |

## 3.6 Operating Modes

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

### 3.6.1 Test Channels

| | U-NII-Subband 1 5150 - 5250 MHz | | | U-NII-Subband 2A 5250 - 5350 MHz | | | U-NII-Subband 2C 5470 - 5725 MHz | | | U-NII-Subband 3 5725 - 5850 MHz | | | Nom. BW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 MHz Test Channels: | low | mid | high | low | mid | high | low | mid | high | low | mid | high | 20 MHz |
| Channel: | | | | | | | | | | 149 | 157 | 165 | Ch.-No. |
| Frequency [MHz] | | | | | | | | | | 5745 | 5785 | 5825 | MHz |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 MHz Test Channels: | low | mid | high | low | mid | high | low | mid | high | low | mid | high | 40 MHz |
| Channel: | | | | | | | | | | 151 | - | 159 | Ch.-No. |
| Frequency [MHz] | | | | | | | | | | 5755 | - | 5795 | MHz |

## 3.7 Product labelling

### 3.7.1 FCC ID label

Please refer to the documentation of the applicant.

### 3.7.2 Location of the label on the EUT

Please refer to the documentation of the applicant.

# 4 Test Results

## 4.1 Undesirable Emissions; General Field Strength Limits

Standard: FCC Part 15, Subpart E

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

### 4.1.1 Test Description

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

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

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

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

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

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

**Step 1:** Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:

- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

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

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

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

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

**3. Measurement above 1 GHz**
The following modifications apply to the measurement procedure for the frequency range above 1 GHz:
**Step 1:**
The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.
All steps were performed with one height (1.5 m) of the receiving antenna only.
The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.
The turn table step size (azimuth angle) for the preliminary measurement is 45 °.
Above 26 GHz the measurement distance is reduced to 1 m.
**Step 2:**

Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size ± 45° for the elevation axis is performed.
The turn table azimuth will slowly vary by ± 22.5°.
The elevation angle will slowly vary by ± 45°
EMI receiver settings (for all steps):
- Detector: Peak, Average
- IF Bandwidth = 1 MHz

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

### 4.1.2 Test Requirements / Limits

**A) FCC**

FCC Part 15 Subpart E, §15.407 (b)(1)
For transmitters operating in the 5150–5250 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5350 MHz.

FCC Part 15 Subpart E, §15.407 (b)(2)
For transmitters operating in the 5250–5350 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5350 MHz.

FCC Part 15 Subpart E, §15.407 (b)(3)
For transmitters operating in the 5470–5725 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5470–5725 MHz.

FCC Part 15 Subpart E, §15.407 (b)(4)
For transmitters operating in the 5725–5850 MHz band:
Limit: –27 dBm/MHz EIRP outside of the band 5715–5860 MHz and additionally
Limit: –17 dBm/MHz EIRP within the frequency ranges 5715–5725 and 5850–5860 MHz.

**B) IC**
Different frequency bands and limits apply, as compared to the FCC requirements.

RSS-247, 6.2.1 (2), Emissions outside the band 5150-5250 MHz, indoor operation only:
Limit: –27 dBm/MHz EIRP outside of the band 5150–5250 MHz.

RSS-247, 6.2.2 (2), Emissions outside the band 5250-5350 MHz:
Limit: –27 dBm/MHz EIRP outside of the band 5250–5350 MHz.

RSS-247, 6.2.3 (2), Emissions outside the bands 5470-5600 MHz and 5650-5725 MHz:
Limit: –27 dBm/MHz EIRP outside of the band 5470–5725 MHz.
Note: No operation is permitted for the frequency range 5600–5650 MHz.

RSS-247, 6.2.4 (2), Emissions outside the band 5725-5825 MHz:
Limit: –27 dBm/MHz EIRP outside of the band 5715–5835 MHz and additionally
Limit: –17 dBm/MHz EIRP within the frequency ranges 5715–5725 and 5825–5835 MHz.

**C) FCC & IC**

FCC Part 15 Subpart E, §15.405
The provisions of §§ 15.203 and 15.205 are included.

§15.407 (b)(6)
Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in § 15.209.

§15.407 (b)(7)
The provisions of §15.205 apply to intentional radiators operating under this section

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)
- Limit (dBµV/m) = EIRP [dBm] – 20 log (d [m]) + 104.8

Limit types (in result tables on next page):
RB – Emissions falls into a "Restricted Band" according FCC §§15.205 and 15.209 *)
UE – "Undesirable Emission Limit" according FCC §15.407
BE-RB – Band Edge Limit basing on "Restricted Band Limits"
BE-UE – Band Edge Limit basing on "Undesirable Emission Limit"
*) Below 1 GHz the limits of §15.209 are applied for all frequencies.

### 4.1.3 Test Protocol

Ambient temperature: 24–29 °C
Air Pressure: 1000–1009 hPa
Humidity: 33–49 %

**WLAN a-Mode; 20 MHz; 6 Mbit/ s** **Applied duty cycle correction (AV) [dB]: 0.0 dB**

| Ch. No. | Ch. Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [dBµV/ m] | Detector | RBW [kHz] | Limit [dBµV/ m] | Margin [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|
| 149 | 5745 | 5715.00 | 57.3 | PEAK | 1000 | 68.2 | 10.9 | RE |
| 157 | 5785 | 37.83 | 31.4 | QP | 120 | 40.0 | 8.6 | RB |
| 157 | 5785 | 84.45 | 32.7 | QP | 120 | 40.0 | 7.3 | RB |
| 157 | 5785 | 87.45 | 34.2 | QP | 120 | 40.0 | 5.8 | RB |
| 157 | 5785 | 148.14 | 39.1 | QP | 120 | 43.5 | 4.4 | RB |
| 157 | 5785 | 225.00 | 40.0 | QP | 120 | 46.0 | 6 | RB |
| 157 | 5785 | 247.50 | 38.4 | QP | 120 | 46.0 | 7.6 | RB |
| 157 | 5785 | 408.00 | 32.1 | QP | 120 | 46.0 | 13.9 | RB |

**WLAN n-Mode; 20 MHz; 72.2 Mbit/ s MCS7 Applied duty cycle correction (AV) [dB]: 0.0 dB**

| Ch. No. | Ch. Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [dBµV/ m] | Detector | RBW [kHz] | Limit [dBµV/ m] | Margin [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|
| 149 | 5745 | 5725 | 63.4 | PEAK | 1000 | 78.2 | 14.8 | RE |
| 165 | 5825 | 5850.1 | 68.3 | PEAK | 1000 | 78.2 | 9.9 | RE |

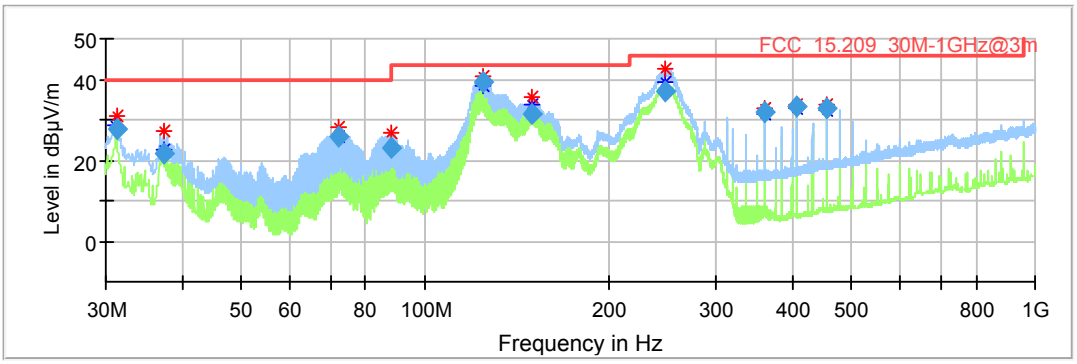
**WLAN n-Mode; 40 MHz; 150 Mbit/ s MCS7 Applied duty cycle correction (AV) [dB]: 0.0 dB**

| Ch. No. | Ch. Center Freq. [MHz] | Spurious Freq. [MHz] | Spurious Level [dBµV/ m] | Detector | RBW [kHz] | Limit [dBµV/ m] | Margin [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|
| 151 | 5755 | 5711.57 | 67.9 | PEAK | 1000 | 68.2 | 0.3 | BE |
| 151 | 5755 | 5725 | 73.6 | PEAK | 1000 | 78.2 | 4.6 | BE |
| 159 | 5795 | 31.2 | 27.7 | QP | 120 | 40 | 12.3 | RB |
| 159 | 5795 | 37.32 | 21.8 | QP | 120 | 40 | 18.2 | RB |
| 159 | 5795 | 72 | 25.9 | QP | 120 | 40 | 14.1 | RB |
| 159 | 5795 | 87.93 | 23.1 | QP | 120 | 40 | 16.9 | RB |
| 159 | 5795 | 124.29 | 39.2 | QP | 120 | 43.5 | 4.3 | RB |
| 159 | 5795 | 149.64 | 31.3 | QP | 120 | 43.5 | 12.2 | RB |
| 159 | 5795 | 247.5 | 37.1 | QP | 120 | 46 | 8.9 | RB |
| 159 | 5795 | 360 | 31.7 | QP | 120 | 46 | 14.3 | RB |
| 159 | 5795 | 408 | 33 | QP | 120 | 46 | 13 | RB |
| 159 | 5795 | 456 | 32.6 | PEAK | 1000 | 46 | 13.4 | RB |

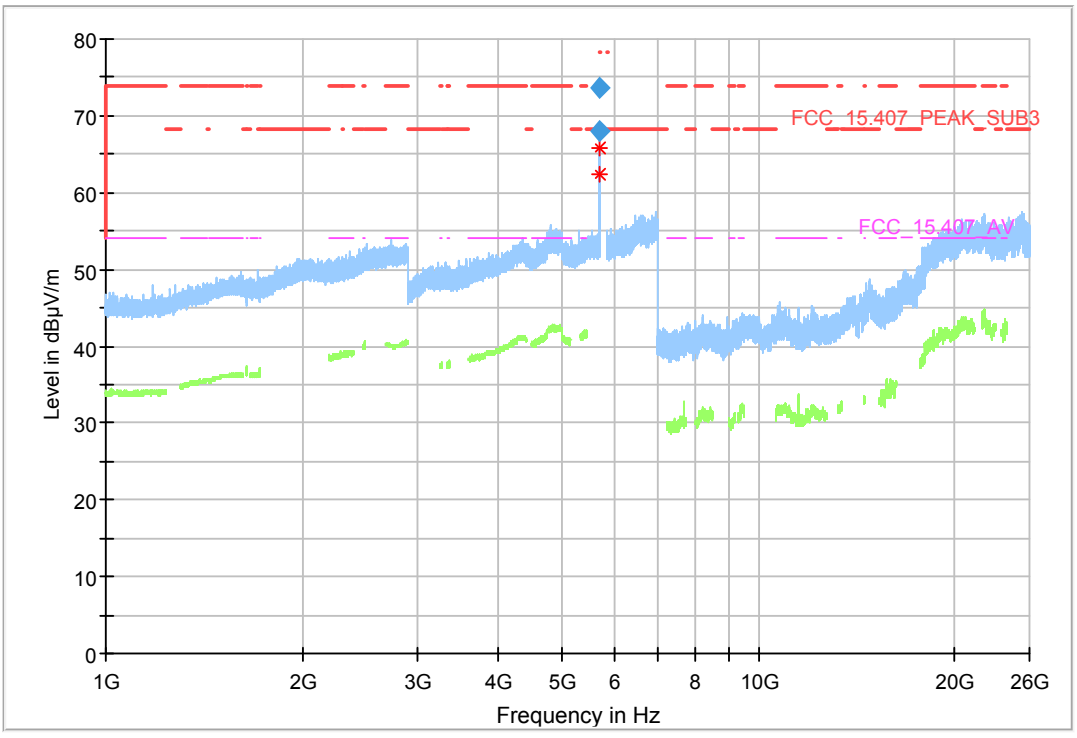
Remark 1: All values marked with a * are the typical noise values of the test system
Remark 2: Please see next sub-clause for the measurement plot.

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

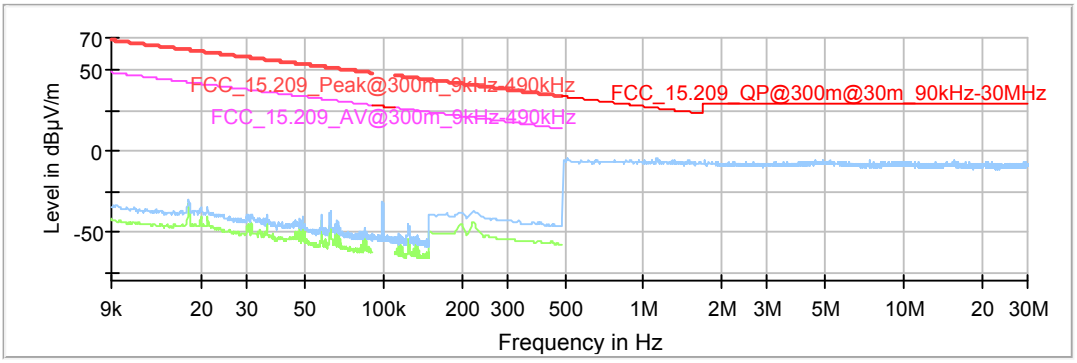
Radio Technology = WLAN n 40 MHz, Operating Frequency = high, Measurement range = 30MHz - 1GHz, Subband = U-NII-3



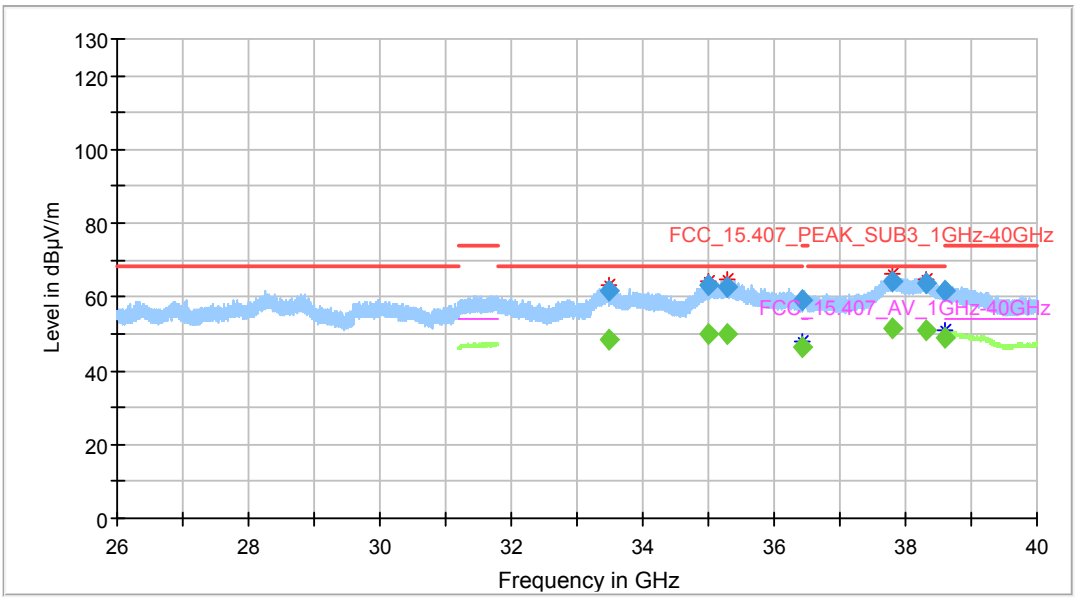

Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Measurement range = 1GHz - 26GHz, Subband = U-NII-3



Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Measurement range = -9KHz – 30MHz, Subband = U-NII-3




Radio Technology = WLAN n 40 MHz, Operating Frequency = low, Measurement range = -26GHz – 40GHz, Subband = U-NII-3




### 4.1.5 Test Equipment used

Radiated Emissions

## 4.2 Band Edge

Standard: FCC Part 15, Subpart E

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

### 4.2.1 Test Description

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

### 4.2.2 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)

### 4.2.3 Test Protocol

**WLAN a-Mode; 20 MHz; 6 Mbit/ s  Applied duty cycle correction (AV) [dB]: 0.0 dB**

| U-NII-Subband | Ch. No. | Ch. Center Freq. [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBµV/ m] | Detec -tor | RBW [kHz] | Limit [dBµV/ m] | Margin [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 149 | 5745.0 | 5715.0 | 57.3 | PEAK | 1000 | 68.2 | 10.9 | BE-UE |
| | 165 | 5825.0 | 5850.0 | 55.0 | PEAK | 1000 | 78.0 | 23.0 | BE-UE |

**WLAN n-Mode; 20 MHz; 72.2 Mbit/ s MCS7 Applied duty cycle correction (AV) [dB]: 0.0 dB**

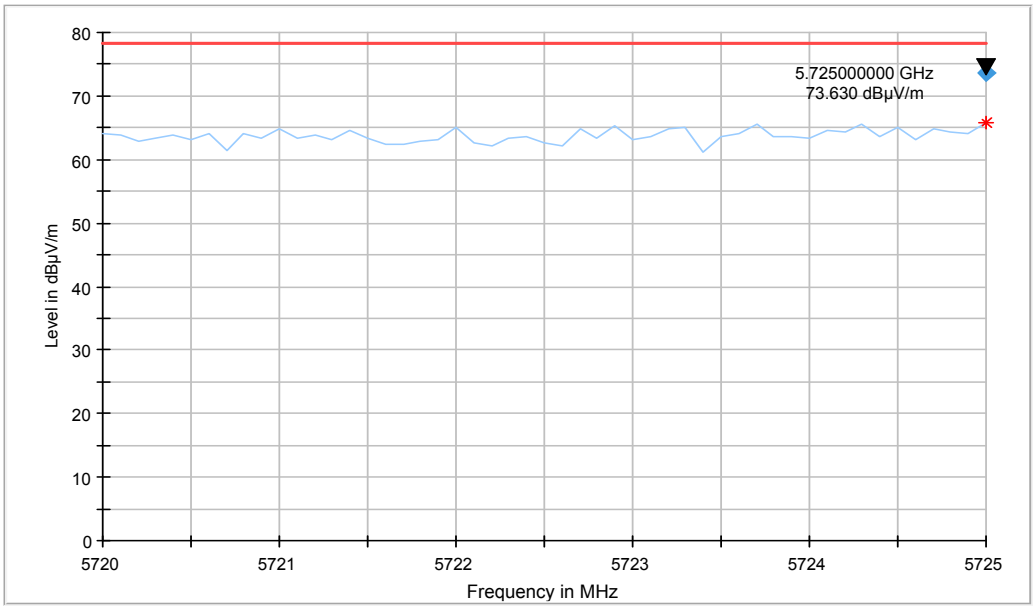
| U-NII-Subband | Ch. No. | Ch. Center Freq. [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBµV/ m] | Detec -tor | RBW [kHz] | Limit [dBµV/ m] | Margin [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 149 | 5745.0 | 5725.0 | 70.5 | PEAK | 1000 | 78.2 | 7.6 | BE-UE |
| | 165 | 5825.1 | 5850.0 | 68.3 | PEAK | 1000 | 78.2 | 9.8 | BE-UE |

**WLAN n-Mode; 40 MHz; 150 Mbit/ s MCS7  Applied duty cycle correction (AV) [dB]: 0.0 dB**

| U-NII-Subband | Ch. No. | Ch. Center Freq. [MHz] | Band Edge Freq. [MHz] | Spurious Level [dBµV/ m] | Detec -tor | RBW [kHz] | Limit [dBµV/ m] | Margin [dB] | Limit Type |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 151 | 5755.0 | 5725.0 | 73.6 | PEAK | 1000 | 78.2 | 4.4 | BE-UE |
| | 159 | 5795.0 | 5850.0 | 52.5 | PEAK | 1000 | 78.0 | 25.5 | BE-UE |

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

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




### 4.2.5 Test Equipment used

Radiated Emissions

# 5 Test Equipment

## 1 Radiated Emissions

Lab to perform radiated emission tests

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| | 3160-09 | Standard Gain / Pyramidal Horn Antenna 26.5 GHz | EMCO Elektronic GmbH | 00083069 | | |
| | WHKX 7.0/18G-8SS | High Pass Filter | Wainwright | 09 | | |
| | 5HC3500/18000-1.2-KK | High Pass Filter | Trilithic | 200035008 | | |
| | Fully Anechoic Room | 8.80m x 4.60m x 4.05m (l x w x h) | Albatross Projects | P26971-647-001-PRB | | |
| | AM 4.0 | Antenna mast | Maturo GmbH | AM4.0/180/11920513 | | |
| | ESR 7 | EMI Receiver / Spectrum Analyzer | Rohde & Schwarz | 101424 | 2014-11 | 2016-11 |
| | TT 1.5 WI | Turn Table | Maturo GmbH | - | | |
| | Anechoic Chamber | 10.58 x 6.38 x 6.00 m³ | Frankonia | none | 2014-01 | 2017-01 |
| | ESIB 26 | Spectrum Analyzer | Rohde & Schwarz | 830482/004 | 2015-12 | 2017-12 |
| | Tilt device Maturo (Rohacell) | Antrieb TD1.5-10kg | Maturo GmbH | TD1.5-10kg/024/3790709 | | |
| | 5HC2700/12750-1.5-KK | High Pass Filter | Trilithic | 9942012 | | |
| | AS 620 P | Antenna mast | HD GmbH | 620/37 | | |
| | NRV-Z1 | Sensor Head A | Rohde & Schwarz | 827753/005 | 2015-05 | 2016-05 |
| | 4HC1600/12750-1.5-KK | High Pass Filter | Trilithic | 9942011 | | |
| | ASP 1.2/1.8-10 kg | Antenna Mast | Maturo GmbH | - | | |
| | JS4-18002600-32-5P | Broadband Amplifier 18 GHz - 26 GHz | Miteq | 849785 | | |
| | JS4-00101800-35-5P | Broadband Amplifier 30 MHz - 18 GHz | Miteq | 896037 | | |
| | HL 562 | Ultralog new biconicals | Rohde & Schwarz GmbH & Co. KG | 830547/003 | 2015-06 | 2018-06 |
| | Opus10 THI (8152.00) | ThermoHygro Datalogger 12 (Environ) | Lufft Mess- und Regeltechnik GmbH | 12482 | 2015-03 | 2017-03 |

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| | JS4-00102600-42-5A | Broadband Amplifier 30 MHz - 26 GHz | Miteq | 619368 | | |
| | HFH2-Z2 | Loop Antenna | Rohde & Schwarz GmbH & Co. KG | 829324/006 | 2014-11 | 2017-11 |
| | FSW 43 | Spectrum Analyzer | Rohde & Schwarz | 103779 | 2014-11 | 2016-11 |
| | Opus10 TPR (8253.00) | ThermoAirpressure Datalogger 13 (Environ) | Lufft Mess- und Regeltechnik GmbH | 13936 | 2015-02 | 2017-02 |
| | Chroma 6404 | AC Power Source | Chroma ATE INC. | 64040001304 | | |
| | 3160-10 | Standard Gain / Pyramidal Horn Antenna 40 GHz | EMCO Elektronik GmbH | 00086675 | | |
| | HL 562 Ultralog | Log.-per. Antenna | Rohde & Schwarz GmbH & Co. KG | 100609 | 2016-04 | 2019-04 |
| | PAS 2.5 - 10 kg | Antenna Mast | Maturo GmbH | - | | |
| | HF 907 | Double-ridged horn | Rohde & Schwarz GmbH & Co. KG | 102444 | 2015-05 | 2018-05 |

## 2 Radio Lab

Conducted Radio Test Lab

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| | A8455-4 | 4 Way Power Divider (SMA) | | - | | |
| | SMB100A | Signal Generator 9 kHz - 6 GHz | Rohde & Schwarz GmbH & Co. KG | 107695 | 2014-06 | 2017-06 |
| | VT 4002 | Climatic Chamber | Vötsch | 58566002150010 | 2016-03 | 2018-03 |
| | SMP03 | Signal Generator 2 GHz - 27 GHz 1035.5005.03 | Rohde & Schwarz GmbH & Co. KG | 833680/003 | 2013-10 | 2016-10 |
| | FSV30 | Signal Analyzer 10 Hz - 30 GHz | Rohde & Schwarz | 103005 | 2016-02 | 2018-02 |
| | SMBV100A | Vector Signal Generator 9 kHz - 6 GHz | Rohde & Schwarz GmbH & Co. KG | 259291 | 2013-08 | 2016-08 |
| | Voltcraft M-3860M | Digital Multimeter 01 (Multimeter) | Voltcraft | IJ096055 | | |
| | Chroma 6404 | AC Power Source | Chroma ATE INC. | 64040001304 | | |

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| | Datum, Model: MFS | Rubidium Frequency Standard | Datum-Beverly | 5489/001 | 2015-06 | 2016-06 |
| | WA1515 | Broadband Power Divider SMA | Weinschel Associates | A855 | | |
| | FSIQ26 | Spectrum Analyzer 7layers, Ratingen OIL_RE | Rohde & Schwarz GmbH & Co. KG | 840061/005 | 2015-04 | 2017-04 |

## 3 R&S TS8997

EN300328/301893 Test Lab

| Ref.No. | Device Name | Description | Manufacturer | Serial Number | Last Calibration | Calibration Due |
|---|---|---|---|---|---|---|
| | OSP120 | Switching Unit with integrated power meter | Rohde & Schwarz GmbH & Co. KG | 101158 | 2015-08 | 2016-08 |
| | A8455-4 | 4 Way Power Divider (SMA) | | - | | |
| | Opus10 THI (8152.00) | ThermoHygro Datalogger 03 (Environ) | Lufft Mess- und Regeltechnik GmbH | 7482 | 2015-02 | 2017-02 |
| | SMB100A | Signal Generator 9 kHz - 6 GHz | Rohde & Schwarz GmbH & Co. KG | 107695 | 2014-06 | 2017-06 |
| | VT 4002 | Climatic Chamber | Vötsch | 58566002150010 | 2016-03 | 2018-03 |
| | FSV30 | Signal Analyzer 10 Hz - 30 GHz | Rohde & Schwarz | 103005 | 2016-02 | 2018-02 |
| | SMBV100A | Vector Signal Generator 9 kHz - 6 GHz | Rohde & Schwarz GmbH & Co. KG | 259291 | 2013-08 | 2016-08 |
| | Voltcraft M-3860M | Digital Multimeter 01 (Multimeter) | Voltcraft | IJ096055 | | |
| | 1515 / 93459 | Broadband Power Divider SMA (Aux) | Weinschel Associates | LN673 | | |
| | Datum, Model: MFS | Rubidium Frequency Standard | Datum-Beverly | 5489/001 | 2015-06 | 2016-06 |

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

# 6 Antenna Factors, Cable Loss and Sample Calculations

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

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

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

**Sample calculation**

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

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

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

**Sample calculation**

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

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

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

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

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

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

**Sample calculation**

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

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

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

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

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

**Sample calculation**

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

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

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

**Sample calculation**

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

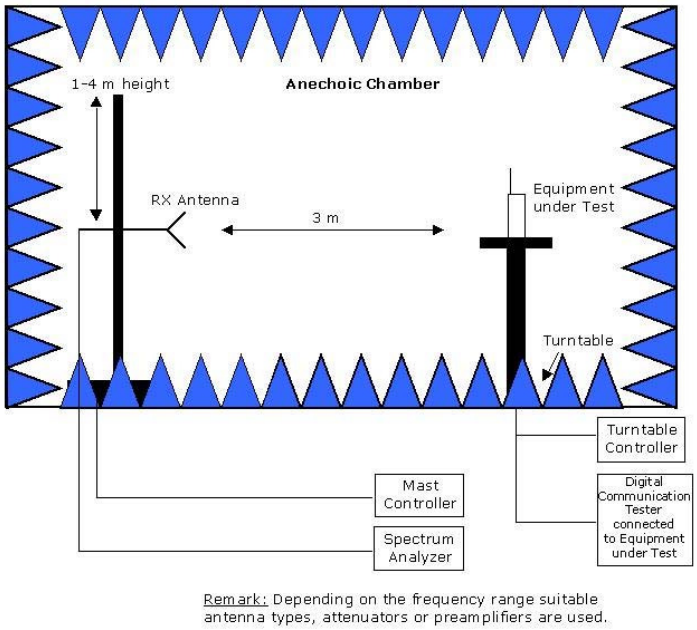
## 6.6 Antenna EMCO 3160-10

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

**Sample calculation**

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

# 7 Setup Drawings




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

## 8 Measurement Uncertainties

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

## 9 Photo Report

Please see separate photo report.