

InterLab<sup>®</sup>

## FCC Measurement/Technical Report on

Instrument Cluster

Platform: VW AG MQB AO

Model: 17101043

FCC ID: 2AOUZ17101043  
IC: 2365017101043

**Report Reference:** MDE\_CONTI\_1740\_FCCe#17101043

**Test Laboratory:**

7layers GmbH  
Borsigstrasse 11  
40880 Ratingen  
Germany



**Note:**

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

**7layers GmbH**  
Borsigstraße 11  
40880 Ratingen, Germany  
T +49 (0) 2102 749 0  
F +49 (0) 2102 749 350

Geschäftsführer/  
Managing Directors:  
Frank Spiller  
Bernhard Retka  
Alexandre Norré-Oudard

Registergericht/registered:  
Düsseldorf HRB 75554  
USt-Id.-Nr./VAT-No. DE203159652  
Steuer-Nr./TAX-No. 147/5869/0385

*a Bureau Veritas  
Group Company*  
[www.7layers.com](http://www.7layers.com)

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## **0 Summary**

### **0.1 Technical Report Summary**

#### **Type of Authorization**

Certification for an intentional radiator: 125 kHz transmitter and tagging system

### **0.2 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 (10-1-16 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**

§ 2.1049 Occupied bandwidth

§ 15.205 Restricted bands of operation

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

Note:

ANSI C63.10-2013 applied.

#### **Summary Test Results:**

**The EUT complied with all performed tests as listed in sub-clause 0.4 Measurement Summary / Signatures.**

### 0.3 FCC-IC Correlation Table

#### General radio equipment

| Measurement  | FCC reference | IC reference   |
|--|---------------|--|
| Conducted emissions on AC Mains                          | § 15.207      | RSS-Gen Issue 4: 8.8   |
| Transmitter spurious radiated emissions                  | § 15.209      | RSS-Gen Issue 4:<br>6.13/8.9/8.10;<br>RSS-210 Issue 9: 4.3/4.4 |
| Restricted Bands   | §15.205       | RSS-Gen Issue 4: 8.10<br>RSS-210 Issue 9: 4.1                  |
| Wanted Emission (Carrier)                                | § 15.209      | RSS-210 Issue 9: 4.4<br>RSS-Gen Issue 4: 6.12, 8.9             |
| Other requirements, e.g. Transmitter frequency stability | -             | RSS-Gen Issue 4: 6.11/8.11                                     |
| Receiver spurious emissions                              | -             | RSS-Gen Issue 4: 5/7   |
| Occupied bandwidth                                       | §2.1049       | RSS-Gen Issue 4: 6.6   |

Note: This EUT is subject to RSS-210, 4.4.

## 0.4 Measurement Summary / Signatures

### 47 CFR Chapter I FCC Part 15, Subpart C §15.209

Radiated Emissions

The measurement was performed according to ANSI C63.10

| OP-Mode | Setup    | Port      | Final Result |
|---------|----------|-----------|--------------|
| CM      | Setup_01 | Enclosure | passed       |
| CM      | Setup_02 | Enclosure | passed       |

### 47 CFR Chapter I FCC Part 15, Subpart C §15.209

Peak Output Power

The measurement was performed according to ANSI C63.10

| OP-Mode | Setup    | Port      |
|---------|----------|-----------|
| CM      | Setup_01 | Enclosure |
| CM      | Setup_02 | Enclosure |

### 47 CFR Chapter I FCC Part 15, Subpart C §15.207

Conducted Emissions AC Power line

The measurement shall be performed according to ANSI C63.10

| OP-Mode | Setup   | Port |
|---------|---------|------|
| -       | N/A (1) |      |

### 47 CFR Chapter I FCC Part 2, Subpart J §2.1049

Occupied Bandwidth

The measurement was performed according to ANSI C63.10

| OP-Mode | Setup    | Port      |
|---------|----------|-----------|
| CM      | Setup_01 | Enclosure |
| CM      | Setup_02 | Enclosure |

### RSS-Gen 6.11/8.11

Frequency Stability

The measurement shall be performed according to ANSI C63.10

| OP-Mode | Setup   | Port |
|---------|---------|------|
| -       | N/A (2) |      |

#### Notes:

N/A = Not applicable

(1) The EUT is DC powered, a vehicular equipment.


(2) Not required per 8.11.

performed = no limit is applicable to the test result.



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

Responsible for  
Accreditation Scope:



Responsible  
for Test Report:



## 1 Administrative Data

### 1.1 Testing Laboratory

Company Name: 7layers GmbH  
Address: Borsigstr. 11  
40880 Ratingen  
Germany

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-12140-01-00  
FCC Designation Number: DE0015  
FCC Test Firm Registration: 929146  
Responsible for accreditation scope: Dipl.-Ing. Marco Kullik

Report Template Version: 2018-01-22

### 1.2 Project Data

Responsible for testing and report: Dipl.-Ing. Dobrin Dobrinov  
Employees who performed the tests: documented internally at 7Layers  
Date of Report: 2018-06-25  
Testing Period: 2018-04-26 to 2018-06-21

### 1.3 Applicant Data

Company Name: Continental Automotive GmbH  
Address: VDO-Straße 1  
64832 Babenhausen  
Germany  
Contact Person: Mr. Frank Hoppert

### 1.4 Manufacturer Data

Company Name: please see at Applicant Data  
Address:  
Contact Person:

## 2 Test object Data

### 2.1 General EUT Description

|                      |  |
|----------------------|--|
| Equipment under Test | Instrument Cluster                               |
| Product Name         | Instrument Cluster, Platform: VW AG MQB AO       |
| Type Designation:    | 17101043   |
| Kind of Device:      | 125 kHz Transmitter and Tagging System           |
| Voltage Type:        | DC   |
| Voltage level:       | 13.5 V nominal and tested voltage; 6.5 to 17.0 V |

#### 2.1.1 General product description:

The Instrument Cluster is a vehicles engine immobilizer. it is a part of a vehicles Remote Keyless System, responsible for lock/unlock and ignition of the vehicle.

The Immobilizer's counter part is a passive transponder installed in a coded key. When the Instrument cluster determines that the coded key is available and valid, the Electronic Control Unit activates the fuel-injection sequence.

A 125 kHz transceiver is implemented in, which has the following functions:

- Antenna driving with carrier frequency (125 kHz)
- 100% AM modulation (ASK) of the field for writeable transponders (write mode)
- AM/PM demodulation of the antenna signal modulation induced by the transponder (read mode)

The device is intended for professional installation only.

#### 2.1.2 Specific product description for the EUT:

For a detailed description please refer to the documentation provided by the applicant.

### 2.1.3 The EUT provides the following ports:

- Enclosure
- DC combined

Note: The port "DC combined" is a test point that combines:

- power supply wires [(plus) and (minus) cables (ports)]
- 2-wires coil antenna cable with 0.5 m length.

## 2.2 EUT Main components

Type, S/N, Short Descriptions etc. used in this Test Report

| Short Description           | Equipment under Test | Type Designation | Serial No.              | HW Status | SW Status |
|-----------------------------|----------------------|------------------|-------------------------|-----------|-----------|
| EUT A (Code: DE1304004aa01) | Instrument Cluster   | 17101043         | V03-04119.01.1872091222 | 303       | 2300      |

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

## 2.3 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.

| Short Description | Equipment under Test     | Type Designation    | Serial No. | HW Status | SW Status |
|-------------------|--------------------------|---------------------|------------|-----------|-----------|
| ANC 1             | Immobilizer coil antenna | KESY<br>17101043    | -          | -         | -         |
| ANC 2             | Immobilizer coil antenna | BIT Key<br>17101043 | -          | -         | -         |



## 2.4 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.

| Short Description | Device  | Type Designation                     | Serial No.                       | HW Status | SW Status |
|-------------------|---------|--------------------------------------|----------------------------------|-----------|-----------|
| AUX 1             | Key fob | VW 17101043<br>KESY<br>TAB.049.165.G | BH8-ELB<br>02.02.18 0008<br>0132 | -         | -         |

## 2.5 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 No. | Combination of EUTs  | Description and Rationale   |
|-----------|----------------------|---|
| Setup_01  | EUT A + ANC 1+ AUX 1 | EUT ancillaries, auxiliary and representative cables are connected to the DC combined connector |
| Setup_02  | EUT A + ANC 2+ AUX 1 | EUT ancillaries, auxiliary and representative cables are connected to the DC combined connector |

## 2.6 Operating Modes

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

| Op. Mode | Description of Operating Modes | Remarks   |
|----------|--------------------------------|---|
| CM       | continuously modulated         | EUT is transmitting a continuously ASK modulated signal |

## 2.7 Special software used for testing

The applicant provides the test software.

## 2.8 Product labelling

Please refer to the documentation of the applicant.

## 3 Test Results

### 3.1 Spurious radiated emissions

**Standard** FCC Part 15, Subpart C

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

#### 3.1.1 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 m<sup>2</sup> 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 2 orthogonal EUT orientations (vertical and horizontal) to determine the worst-case EUT orientation. In combination with the turntable rotation, emissions of at least 3 orthogonal axes are detected.

#### 1. Measurement up to 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 will be performed with the following changed settings. Intention of this step is to find the maximum emission level.

- Detector: Quasi-Peak besides 9–90 kHz and 110–490 kHz: Average and Peak
- 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:  $-180^{\circ}$  to  $90^{\circ}$
- Turntable step size:  $90^{\circ}$
- 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  $\pm 45^{\circ}$  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  $\pm 100$  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:  $\pm 45^{\circ}$  around the determined value
- Height variation range:  $\pm 100$  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 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. It 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.

### 3.1.2 Test Requirements / Limits

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

| Frequency in MHz | Limit ( $\mu\text{V}/\text{m}$ ) | Measurement distance (m) | Limits ( $\text{dB}\mu\text{V}/\text{m}$ ) |
|------------------|----------------------------------|--------------------------|--|
| 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 ( $\mu\text{V}/\text{m}$ ) | Measurement distance (m) | Limits ( $\text{dB}\mu\text{V}/\text{m}$ ) |
|------------------|----------------------------------|--------------------------|--|
| 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                                    |

§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:  $\text{Limit (dB}\mu\text{V}/\text{m)} = 20 \log (\text{Limit } (\mu\text{V}/\text{m})/1\mu\text{V}/\text{m})$

### 3.1.3 Test Protocol

Temperature: 25-26 °C  
 Air Pressure: 1010 hPa  
 Humidity: 33-40 %

#### 3.1.3.1 Measurement up to 30 MHz

| Op. Mode | Setup    | Port      |
|----------|----------|-----------|
| CM       | Setup_01 | Enclosure |

| Antenna orientation | EUT orientation | Frequency MHz | Corrected value dB $\mu$ V/m |      |    | Limit dB $\mu$ V/m | Limit dB $\mu$ V/m | Limit dB $\mu$ V/m | Margin dB | Margin dB |
|---------------------|-----------------|---------------|------------------------------|------|----|--------------------|--------------------|--------------------|-----------|-----------|
|                     |                 |               | QP                           | Peak | AV | QP                 | Peak               | AV                 | QP/Peak   | AV        |
| -                   | -               | -             | -                            | -    | -  | -                  | -                  | -                  | -         | -         |

| Op. Mode | Setup    | Port      |
|----------|----------|-----------|
| CM       | Setup_02 | Enclosure |

| Antenna orientation | EUT orientation | Frequency MHz | Corrected value dB $\mu$ V/m |      |    | Limit dB $\mu$ V/m | Limit dB $\mu$ V/m | Limit dB $\mu$ V/m | Margin dB | Margin dB |
|---------------------|-----------------|---------------|------------------------------|------|----|--------------------|--------------------|--------------------|-----------|-----------|
|                     |                 |               | QP                           | Peak | AV | QP                 | Peak               | AV                 | QP/Peak   | AV        |
| -                   | -               | -             | -                            | -    | -  | -                  | -                  | -                  | -         | -         |

Remark: No relevant spurious emissions are found in the range 20 dB below the limit.

#### 3.1.3.2 Measurement above 30 MHz

| Op. Mode | Setup    | Port      |
|----------|----------|-----------|
| CM       | Setup_01 | Enclosure |

| Antenna orientation | EUT orientation | Frequency MHz | Corrected value dB $\mu$ V/m |      |    | Limit dB $\mu$ V/m | Limit dB $\mu$ V/m | Limit dB $\mu$ V/m | Margin dB | Margin dB |
|---------------------|-----------------|---------------|------------------------------|------|----|--------------------|--------------------|--------------------|-----------|-----------|
|                     |                 |               | QP                           | Peak | AV | QP                 | Peak               | AV                 | QP/Peak   | AV        |
| -                   | -               | -             | -                            | -    | -  | -                  | -                  | -                  | -         | -         |

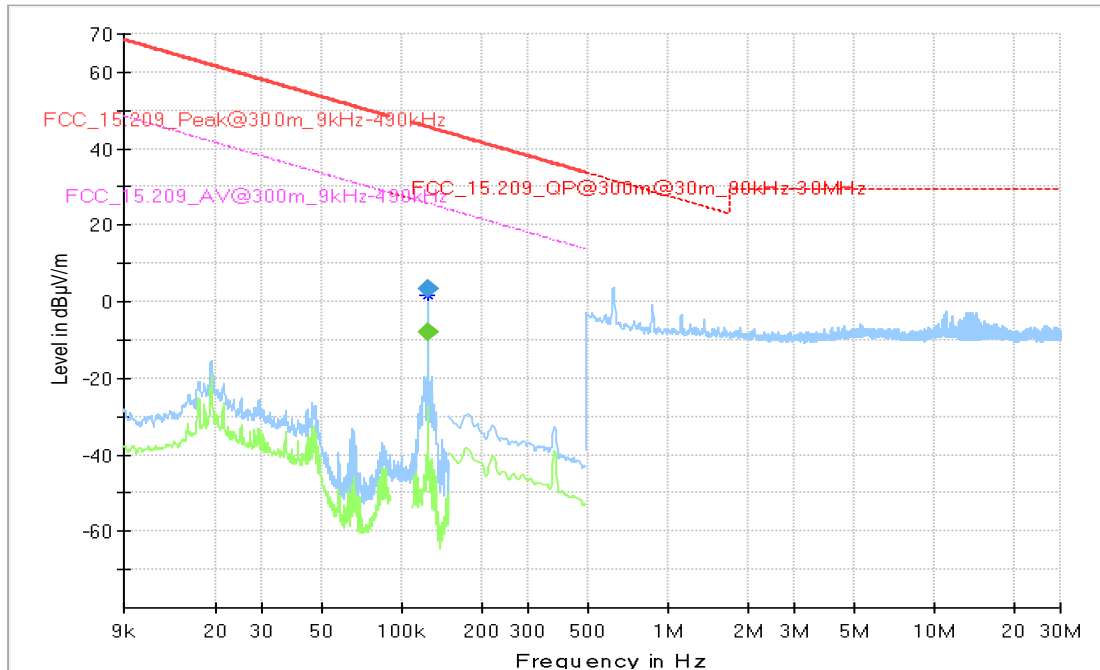
| Op. Mode | Setup    | Port      |
|----------|----------|-----------|
| CM       | Setup_02 | Enclosure |

| Antenna orientation | EUT orientation | Frequency MHz | Corrected value dB $\mu$ V/m |      |    | Limit dB $\mu$ V/m | Limit dB $\mu$ V/m | Limit dB $\mu$ V/m | Margin dB | Margin dB |
|---------------------|-----------------|---------------|------------------------------|------|----|--------------------|--------------------|--------------------|-----------|-----------|
|                     |                 |               | QP                           | Peak | AV | QP                 | Peak               | AV                 | QP/Peak   | AV        |
| -                   | -               | -             | -                            | -    | -  | -                  | -                  | -                  | -         | -         |

Remark: No relevant spurious emissions are found in the range 20 dB below the limit.

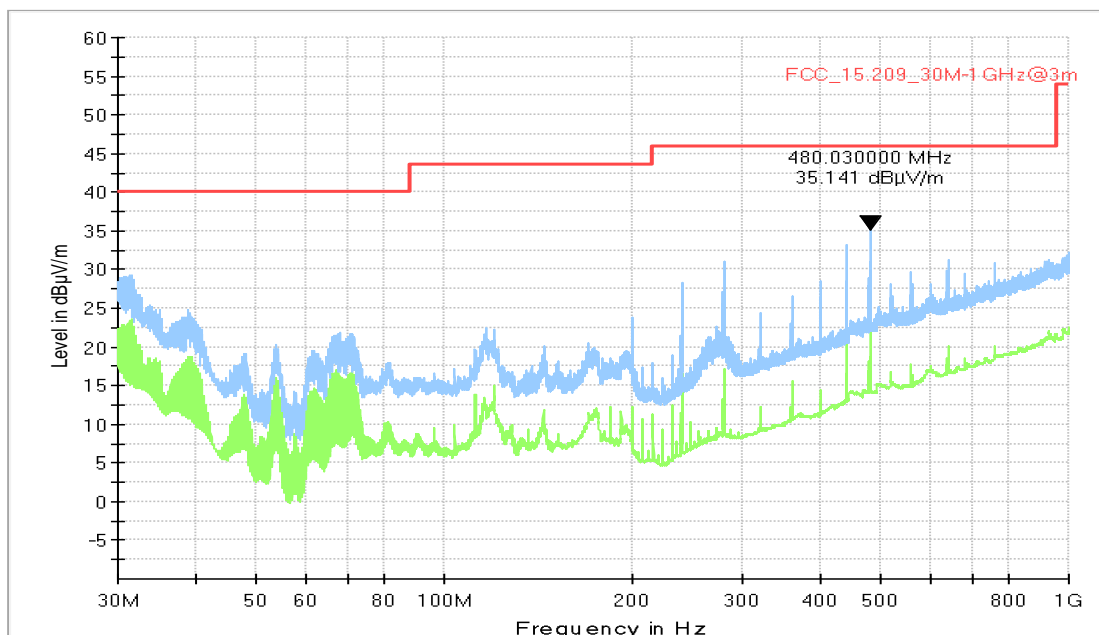
### 3.1.4 Measurement Plots (worst case)

#### 3.1.4.1 Below 30 MHz



Setup\_01

#### 3.1.4.2 Above 30 MHz



Setup\_02

### 3.1.5 Test Equipment used

- Radiated Emissions

## 3.2 Peak power output

**Standard** FCC Part 15, Subpart C

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

### 3.2.1 Test Description

Please refer to sub-clause 3.1.1.

### 3.2.2 Test Limits

Please refer to sub-clause 3.1.2.

### 3.2.3 Test Protocol

Temperature: 25-26 °C  
Air Pressure: 1010 hPa  
Humidity: 33-40 %

| Op. Mode | Setup    | Port      |
|----------|----------|-----------|
| CM       | Setup_01 | Enclosure |

| Antenna orientation | EUT orientation | Frequency kHz | Maximum radiated field strength at fundamental frequency (corrected) dB $\mu$ V/m | Limit dB $\mu$ V/m | Margin dB |
|---------------------|-----------------|---------------|---|--------------------|-----------|
|                     |                 |               | AV  | AV                 | AV        |
| 0°                  | Ver.            | 125.00        | -8.00   | 25.68              | 33.68     |

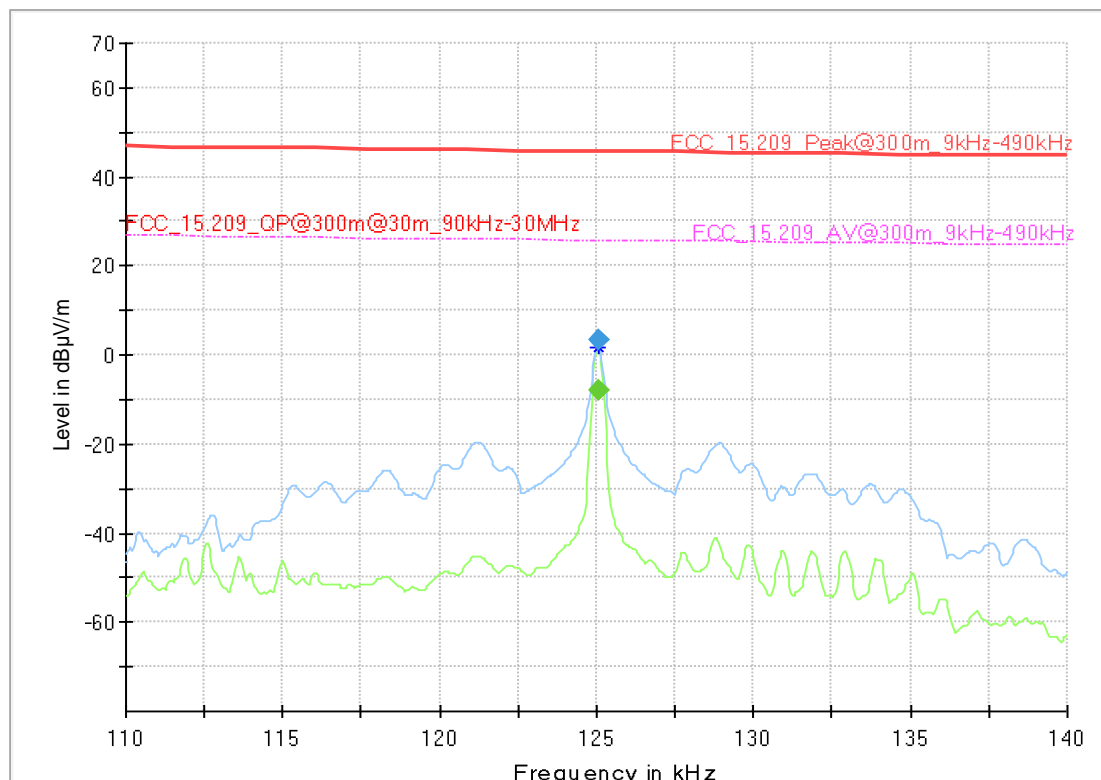
| Op. Mode | Setup    | Port      |
|----------|----------|-----------|
| CM       | Setup_02 | Enclosure |

| Antenna orientation | EUT orientation | Frequency kHz | Maximum radiated field strength at fundamental frequency (corrected) dB $\mu$ V/m | Limit dB $\mu$ V/m | Margin dB |
|---------------------|-----------------|---------------|---|--------------------|-----------|
|                     |                 |               | AV  | AV                 | AV        |
| 0°                  | Ver.            | 125.00        | -21.64  | 25.68              | 47.32     |

### 3.2.4 Measurement Plot (worst case)

#### Common Information

|                       |   |
|-----------------------|---|
| Test Description:     | Peak Power Output   |
| Test Standard:        | FCC 15c209  |
| EUT Code:             | DE1304004aa01   |
| Operating Conditions: | NTNV, EUT Antenna Vertical  |
| <b>Antenna Type:</b>  | <b>KESY</b>   |
| Operator Name:        | Kat   |
| Comment:              | The vertical and horizontal position of the EUT antenna were tested and it was found, that a maximal field strength is radiated when antenna is installed vertically. |



#### Final Result

| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|--------------|
| 0.125050        | ---              | -8.00            | 25.68          | 33.68       | 1000.0          | 0.200           | 100.0       | V   | 71.0          | -59.6        |
| 0.125050        | 3.23             | ---              | 45.68          | 42.46       | 1000.0          | 0.200           | 100.0       | V   | 71.0          | -59.6        |

### 3.2.5 Test Equipment used

- Radiated Emissions



### 3.3 Occupied bandwidth

**Standard** FCC Part 2, Subpart J, §2.1049

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

#### 3.3.1 Test Description

The Equipment Under Test (EUT) was setup in a shielded room to perform the occupied bandwidth measurements.

The results recorded were measured with the modulation which produces the worst-case (widest) occupied bandwidth.

#### 3.3.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.209 does not contain any requirement related to the bandwidth.

#### 3.3.3 Test Protocol

Temperature: 26-27 °C  
Air Pressure: 1008-1013 hPa  
Humidity: 41-47 %

| <b>Op. Mode</b> | <b>Setup</b> | <b>Port</b> |
|-----------------|--------------|-------------|
| CM              | Setup_01     | Enclosure   |

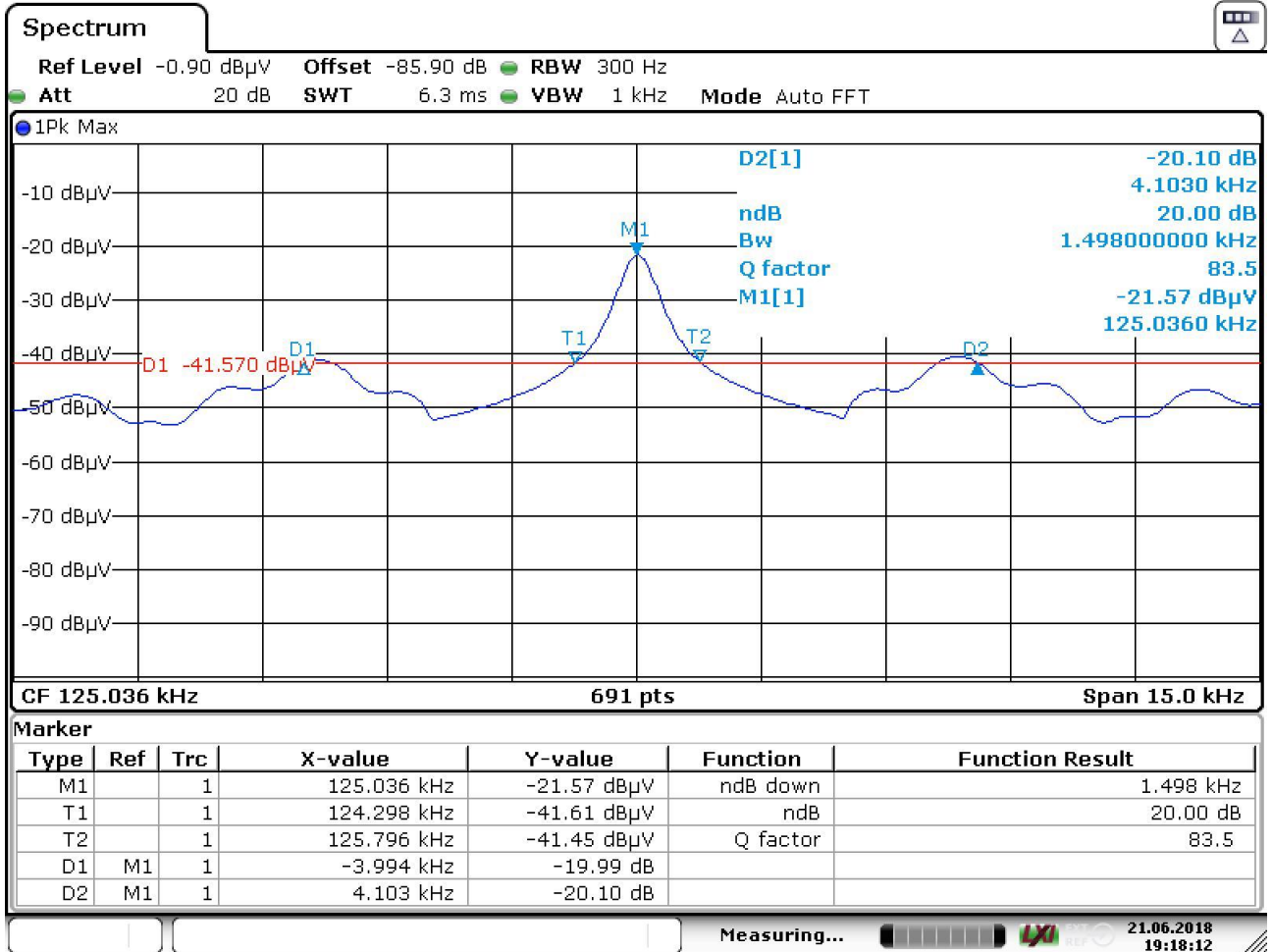
| <b>20 dBc bandwidth</b> | <b>99% occupied bandwidth</b> |
|-------------------------|-------------------------------|
| 7.967 kHz               | 16.733 kHz                    |

| <b>Op. Mode</b> | <b>Setup</b> | <b>Port</b> |
|-----------------|--------------|-------------|
| CM              | Setup_02     | Enclosure   |

| <b>20 dBc bandwidth</b> | <b>99% occupied bandwidth</b> |
|-------------------------|-------------------------------|
| 8.097 kHz               | 13.068 kHz                    |

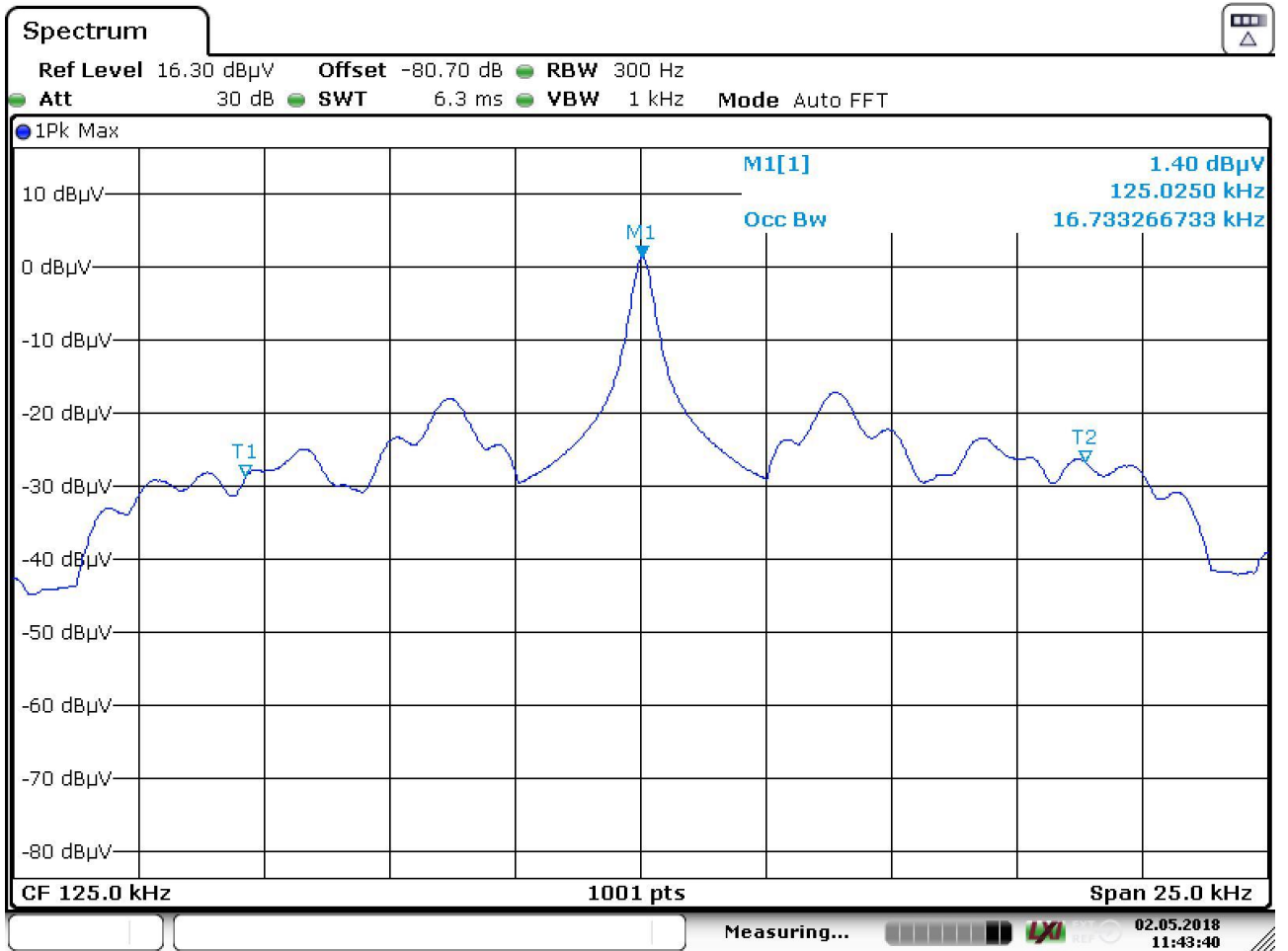
### 3.3.4 Measurement Plots (worst case)

Mode: CM Setup 02, BIT Key, 20 dbc BW



Date: 21.JUN.2018 19:18:12

Mode: CM Setup 01, KESSY, 99% BW



Date: 2.MAY.2018 11:43:40

### 3.3.5 Test Equipment used

- Radio Lab

## 4 Test equipment

- 1 Radiated Emissions  
Lab to perform radiated emission tests

| Ref. No. | Device Name          | Description                                     | Manufacturer                      | Serial Number      | Last Calibration | Calibration Due |
|----------|----------------------|---|-----------------------------------|--------------------|------------------|-----------------|
| 1.1      | MFS                  | Rubidium Frequency Normal MFS                   | Datum GmbH                        | 002                | 2017-10          | 2018-10         |
| 1.2      | Opus10 TPR (8253.00) | ThermoAirpressure Datalogger 13 (Environ)       | Lufft Mess- und Regeltechnik GmbH | 13936              | 2017-04          | 2019-04         |
| 1.3      | Anechoic Chamber     | 10.58 x 6.38 x 6.00 m <sup>3</sup>              | Frankonia                         | none               | 2016-05          | 2019-05         |
| 1.4      | HL 562               | Ultralog new biconicals                         | Rohde & Schwarz                   | 830547/003         | 2015-06          | 2018-06         |
| 1.5      | 5HC2700/12750-1.5-KK | High Pass Filter                                | Trilithic                         | 9942012            |                  |                 |
| 1.6      | ASP 1.2/1.8-10 kg    | Antenna Mast                                    | Maturo GmbH                       | -                  |                  |                 |
| 1.7      | Fully Anechoic Room  | 8.80m x 4.60m x 4.05m (l x w x h)               | Albatross Projects                | P26971-647-001-PRB | 2015-06          | 2018-06         |
| 1.8      | JS4-18002600-32-5P   | Broadband Amplifier 18 GHz - 26 GHz             | Miteq                             | 849785             |                  |                 |
| 1.9      | FSW 43               | Spectrum Analyzer                               | Rohde & Schwarz                   | 103779             | 2016-12          | 2018-12         |
| 1.10     | 3160-09              | Standard Gain / Pyramidal Horn Antenna 26.5 GHz | EMCO Elektronik GmbH              | 00083069           |                  |                 |
| 1.11     | WHKX 7.0/18G-8SS     | High Pass Filter                                | Wainwright                        | 09                 |                  |                 |
| 1.12     | 4HC1600/12750-1.5-KK | High Pass Filter                                | Trilithic                         | 9942011            |                  |                 |
| 1.13     | Chroma 6404          | AC Power Source                                 | Chroma ATE INC.                   | 64040001304        |                  |                 |
| 1.14     | JS4-00102600-42-5A   | Broadband Amplifier 30 MHz - 26 GHz             | Miteq                             | 619368             |                  |                 |
| 1.15     | TT 1.5 WI            | Turn Table                                      | Maturo GmbH                       | -                  |                  |                 |
| 1.16     | HL 562 Ultralog      | Log.-per. Antenna                               | Rohde & Schwarz                   | 100609             | 2016-04          | 2019-04         |
| 1.17     | 3160-10              | Standard Gain / Pyramidal Horn Antenna 40 GHz   | EMCO Elektronik GmbH              | 00086675           |                  |                 |
| 1.18     | 5HC3500/18000-1.2-KK | High Pass Filter                                | Trilithic                         | 200035008          |                  |                 |
| 1.19     | HFH2-Z2              | Loop Antenna                                    | Rohde & Schwarz                   | 829324/006         | 2018-01          | 2021-01         |
| 1.20     | Opus10 THI (8152.00) | ThermoHygro Datalogger 12 (Environ)             | Lufft Mess- und Regeltechnik GmbH | 12482              | 2017-03          | 2019-03         |

| Ref. No. | Device Name                   | Description                         | Manufacturer    | Serial Number          | Last Calibration | Calibration Due |
|----------|-------------------------------|-------------------------------------|-----------------|------------------------|------------------|-----------------|
| 1.21     | ESR 7                         | EMI Receiver / Spectrum Analyzer    | Rohde & Schwarz | 101424                 | 2016-11          | 2018-11         |
| 1.22     | JS4-00101800-35-5P            | Broadband Amplifier 30 MHz - 18 GHz | Miteq           | 896037                 |                  |                 |
| 1.23     | AS 620 P                      | Antenna mast                        | HD GmbH         | 620/37                 |                  |                 |
| 1.24     | Tilt device Maturo (Rohacell) | Antrieb TD1.5-10kg                  | Maturo GmbH     | TD1.5-10kg/024/3790709 |                  |                 |
| 1.25     | ESIB 26                       | Spectrum Analyzer                   | Rohde & Schwarz | 830482/004             | 2018-01          | 2020-01         |
| 1.26     | PAS 2.5 - 10 kg               | Antenna Mast                        | Maturo GmbH     | -                      |                  |                 |
| 1.27     | AM 4.0                        | Antenna mast                        | Maturo GmbH     | AM4.0/180/11920513     |                  |                 |

- 2 Radio Lab  
Lab to perform bandwidth test

| Ref. No. | Device Name          | Description               | Manufacturer                      | Serial Number | Last Calibration | Calibration Due |
|----------|----------------------|---------------------------|-----------------------------------|---------------|------------------|-----------------|
| 2.1      | FSIQ26               | Spectrum Analyzer         | Rohde & Schwarz                   | 840061/005    | 2017-05          | 2019-05         |
| 2.2      | Opus10 THI (8152.00) | ThermoHygro Datalogger 03 | Lufft Mess- und Regeltechnik GmbH | 7482          | 2017-03          | 2019-03         |

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

## 5 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.

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

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

#### Sample calculation

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

U = Receiver reading

LISN Insertion loss = Voltage Division Factor of LISN

Corr. = sum of single correction factors of used LISN, cables, switch units (if used)

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

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

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

### Sample calculation

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

### 5.3 Antenna R&S HL562 (30 MHz – 1 GHz)

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

| Frequency<br>MHz | AF<br>R&S<br>HL562<br>dB (1/m) | Corr.<br>dB |
|------------------|--------------------------------|-------------|
| 30               | 18,6                           | 0,6         |
| 50               | 6,0                            | 0,9         |
| 100              | 9,7                            | 1,2         |
| 150              | 7,9                            | 1,6         |
| 200              | 7,6                            | 1,9         |
| 250              | 9,5                            | 2,1         |
| 300              | 11,0                           | 2,3         |
| 350              | 12,4                           | 2,6         |
| 400              | 13,6                           | 2,9         |
| 450              | 14,7                           | 3,1         |
| 500              | 15,6                           | 3,2         |
| 550              | 16,3                           | 3,5         |
| 600              | 17,2                           | 3,5         |
| 650              | 18,1                           | 3,6         |
| 700              | 18,5                           | 3,6         |
| 750              | 19,1                           | 4,1         |
| 800              | 19,6                           | 4,1         |
| 850              | 20,1                           | 4,4         |
| 900              | 20,8                           | 4,7         |
| 950              | 21,1                           | 4,8         |
| 1000             | 21,6                           | 4,9         |

| cable<br>loss 1<br>(inside<br>chamber)<br>dB | cable<br>loss 2<br>(outside<br>chamber)<br>dB | cable<br>loss 3<br>(switch<br>unit)<br>dB | cable<br>loss 4<br>(to<br>receiver)<br>dB | distance<br>corr.<br>(-20 dB/<br>decade)<br>dB | $d_{\text{Limit}}$<br>(meas.<br>distance<br>(limit))<br>m | $d_{\text{used}}$<br>(meas.<br>distance<br>(used))<br>m |
|--|---|---|---|--|---|---|
| 0,29   | 0,04  | 0,23                                      | 0,02                                      | 0,0  | 3   | 3   |
| 0,39   | 0,09  | 0,32                                      | 0,08                                      | 0,0  | 3   | 3   |
| 0,56   | 0,14  | 0,47                                      | 0,08                                      | 0,0  | 3   | 3   |
| 0,73   | 0,20  | 0,59                                      | 0,12                                      | 0,0  | 3   | 3   |
| 0,84   | 0,21  | 0,70                                      | 0,11                                      | 0,0  | 3   | 3   |
| 0,98   | 0,24  | 0,80                                      | 0,13                                      | 0,0  | 3   | 3   |
| 1,04   | 0,26  | 0,89                                      | 0,15                                      | 0,0  | 3   | 3   |
| 1,18   | 0,31  | 0,96                                      | 0,13                                      | 0,0  | 3   | 3   |
| 1,28   | 0,35  | 1,03                                      | 0,19                                      | 0,0  | 3   | 3   |
| 1,39   | 0,38  | 1,11                                      | 0,22                                      | 0,0  | 3   | 3   |
| 1,44   | 0,39  | 1,20                                      | 0,19                                      | 0,0  | 3   | 3   |
| 1,55   | 0,46  | 1,24                                      | 0,23                                      | 0,0  | 3   | 3   |
| 1,59   | 0,43  | 1,29                                      | 0,23                                      | 0,0  | 3   | 3   |
| 1,67   | 0,34  | 1,35                                      | 0,22                                      | 0,0  | 3   | 3   |
| 1,67   | 0,42  | 1,41                                      | 0,15                                      | 0,0  | 3   | 3   |
| 1,87   | 0,54  | 1,46                                      | 0,25                                      | 0,0  | 3   | 3   |
| 1,90   | 0,46  | 1,51                                      | 0,25                                      | 0,0  | 3   | 3   |
| 1,99   | 0,60  | 1,56                                      | 0,27                                      | 0,0  | 3   | 3   |
| 2,14   | 0,60  | 1,63                                      | 0,29                                      | 0,0  | 3   | 3   |
| 2,22   | 0,60  | 1,66                                      | 0,33                                      | 0,0  | 3   | 3   |
| 2,23   | 0,61  | 1,71                                      | 0,30                                      | 0,0  | 3   | 3   |

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

| Frequency<br>MHz | AF<br>R&S<br>HL562<br>dB (1/m) | Corr.<br>dB |
|------------------|--------------------------------|-------------|
| 30               | 18,6                           | -9,9        |
| 50               | 6,0                            | -9,6        |
| 100              | 9,7                            | -9,2        |
| 150              | 7,9                            | -8,8        |
| 200              | 7,6                            | -8,6        |
| 250              | 9,5                            | -8,3        |
| 300              | 11,0                           | -8,1        |
| 350              | 12,4                           | -7,9        |
| 400              | 13,6                           | -7,6        |
| 450              | 14,7                           | -7,4        |
| 500              | 15,6                           | -7,2        |
| 550              | 16,3                           | -7,0        |
| 600              | 17,2                           | -6,9        |
| 650              | 18,1                           | -6,9        |
| 700              | 18,5                           | -6,8        |
| 750              | 19,1                           | -6,3        |
| 800              | 19,6                           | -6,3        |
| 850              | 20,1                           | -6,0        |
| 900              | 20,8                           | -5,8        |
| 950              | 21,1                           | -5,6        |
| 1000             | 21,6                           | -5,6        |

| cable<br>loss 1<br>(inside<br>chamber)<br>dB | cable<br>loss 2<br>(outside<br>chamber)<br>dB | cable<br>loss 3<br>(switch<br>unit)<br>dB | cable<br>loss 4<br>(to<br>receiver)<br>dB | distance<br>corr.<br>(-20 dB/<br>decade)<br>dB | $d_{\text{Limit}}$<br>(meas.<br>distance<br>(limit))<br>m | $d_{\text{used}}$<br>(meas.<br>distance<br>(used))<br>m |
|--|---|---|---|--|---|---|
| 0,29   | 0,04  | 0,23                                      | 0,02                                      | -10,5  | 10  | 3   |
| 0,39   | 0,09  | 0,32                                      | 0,08                                      | -10,5  | 10  | 3   |
| 0,56   | 0,14  | 0,47                                      | 0,08                                      | -10,5  | 10  | 3   |
| 0,73   | 0,20  | 0,59                                      | 0,12                                      | -10,5  | 10  | 3   |
| 0,84   | 0,21  | 0,70                                      | 0,11                                      | -10,5  | 10  | 3   |
| 0,98   | 0,24  | 0,80                                      | 0,13                                      | -10,5  | 10  | 3   |
| 1,04   | 0,26  | 0,89                                      | 0,15                                      | -10,5  | 10  | 3   |
| 1,18   | 0,31  | 0,96                                      | 0,13                                      | -10,5  | 10  | 3   |
| 1,28   | 0,35  | 1,03                                      | 0,19                                      | -10,5  | 10  | 3   |
| 1,39   | 0,38  | 1,11                                      | 0,22                                      | -10,5  | 10  | 3   |
| 1,44   | 0,39  | 1,20                                      | 0,19                                      | -10,5  | 10  | 3   |
| 1,55   | 0,46  | 1,24                                      | 0,23                                      | -10,5  | 10  | 3   |
| 1,59   | 0,43  | 1,29                                      | 0,23                                      | -10,5  | 10  | 3   |
| 1,67   | 0,34  | 1,35                                      | 0,22                                      | -10,5  | 10  | 3   |
| 1,67   | 0,42  | 1,41                                      | 0,15                                      | -10,5  | 10  | 3   |
| 1,87   | 0,54  | 1,46                                      | 0,25                                      | -10,5  | 10  | 3   |
| 1,90   | 0,46  | 1,51                                      | 0,25                                      | -10,5  | 10  | 3   |
| 1,99   | 0,60  | 1,56                                      | 0,27                                      | -10,5  | 10  | 3   |
| 2,14   | 0,60  | 1,63                                      | 0,29                                      | -10,5  | 10  | 3   |
| 2,22   | 0,60  | 1,66                                      | 0,33                                      | -10,5  | 10  | 3   |
| 2,23   | 0,61  | 1,71                                      | 0,30                                      | -10,5  | 10  | 3   |

#### Sample calculation

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

U = Receiver reading

AF = Antenna factor

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

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

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

Tables show an extract of values.



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

| Frequency | AF R&S HF907 | Corr. |
|-----------|--------------|-------|
| MHz       | dB (1/m)     | dB    |
| 1000      | 24,4         | -19,4 |
| 2000      | 28,5         | -17,4 |
| 3000      | 31,0         | -16,1 |
| 4000      | 33,1         | -14,7 |
| 5000      | 34,4         | -13,7 |
| 6000      | 34,7         | -12,7 |
| 7000      | 35,6         | -11,0 |

| cable loss 1 (relay + cable inside chamber) | cable loss 2 (outside chamber) | cable loss 3 (switch unit, attenuator & pre-amp) | cable loss 4 (to receiver) |
|---|--------------------------------|--|----------------------------|
| dB  | dB                             | dB   | dB                         |
| 0,99  | 0,31                           | -21,51   | 0,79                       |
| 1,44  | 0,44                           | -20,63   | 1,38                       |
| 1,87  | 0,53                           | -19,85   | 1,33                       |
| 2,41  | 0,67                           | -19,13   | 1,31                       |
| 2,78  | 0,86                           | -18,71   | 1,40                       |
| 2,74  | 0,90                           | -17,83   | 1,47                       |
| 2,82  | 0,86                           | -16,19   | 1,46                       |

| Frequency | AF R&S HF907 | Corr. |
|-----------|--------------|-------|
| MHz       | dB (1/m)     | dB    |
| 3000      | 31,0         | -23,4 |
| 4000      | 33,1         | -23,3 |
| 5000      | 34,4         | -21,7 |
| 6000      | 34,7         | -21,2 |
| 7000      | 35,6         | -19,8 |

| cable loss 1 (relay inside chamber) | cable loss 2 (inside chamber) | cable loss 3 (outside chamber) | cable loss 4 (switch unit, attenuator & pre-amp) | cable loss 5 (to receiver) | used for FCC 15.247 |
|-------------------------------------|-------------------------------|--------------------------------|--|----------------------------|---------------------|
| dB                                  | dB                            | dB                             | dB   | dB                         |                     |
| 0,47                                | 1,87                          | 0,53                           | -27,58   | 1,33                       |                     |
| 0,56                                | 2,41                          | 0,67                           | -28,23   | 1,31                       |                     |
| 0,61                                | 2,78                          | 0,86                           | -27,35   | 1,40                       |                     |
| 0,58                                | 2,74                          | 0,90                           | -26,89   | 1,47                       |                     |
| 0,66                                | 2,82                          | 0,86                           | -25,58   | 1,46                       |                     |

| Frequency | AF R&S HF907 | Corr. |
|-----------|--------------|-------|
| MHz       | dB (1/m)     | dB    |
| 7000      | 35,6         | -57,3 |
| 8000      | 36,3         | -56,3 |
| 9000      | 37,1         | -55,3 |
| 10000     | 37,5         | -56,2 |
| 11000     | 37,5         | -55,3 |
| 12000     | 37,6         | -53,7 |
| 13000     | 38,2         | -53,5 |
| 14000     | 39,9         | -56,3 |
| 15000     | 40,9         | -54,1 |
| 16000     | 41,3         | -54,1 |
| 17000     | 42,8         | -54,4 |
| 18000     | 44,2         | -54,7 |

| cable loss 1 (relay inside chamber) | cable loss 2 (High Pass) | cable loss 3 (pre-amp) | cable loss 4 (inside chamber) | cable loss 5 (outside chamber) | cable loss 6 (to receiver) |
|-------------------------------------|--------------------------|------------------------|-------------------------------|--------------------------------|----------------------------|
| dB                                  | dB                       | dB                     | dB                            | dB                             | dB                         |
| 0,56                                | 1,28                     | -62,72                 | 2,66                          | 0,94                           | 1,46                       |
| 0,69                                | 0,71                     | -61,49                 | 2,84                          | 1,00                           | 1,53                       |
| 0,68                                | 0,65                     | -60,80                 | 3,06                          | 1,09                           | 1,60                       |
| 0,70                                | 0,54                     | -61,91                 | 3,28                          | 1,20                           | 1,67                       |
| 0,80                                | 0,61                     | -61,40                 | 3,43                          | 1,27                           | 1,70                       |
| 0,84                                | 0,42                     | -59,70                 | 3,53                          | 1,26                           | 1,73                       |
| 0,83                                | 0,44                     | -59,81                 | 3,75                          | 1,32                           | 1,83                       |
| 0,91                                | 0,53                     | -63,03                 | 3,91                          | 1,40                           | 1,77                       |
| 0,98                                | 0,54                     | -61,05                 | 4,02                          | 1,44                           | 1,83                       |
| 1,23                                | 0,49                     | -61,51                 | 4,17                          | 1,51                           | 1,85                       |
| 1,36                                | 0,76                     | -62,36                 | 4,34                          | 1,53                           | 2,00                       |
| 1,70                                | 0,53                     | -62,88                 | 4,41                          | 1,55                           | 1,91                       |

### Sample calculation

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

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

| Frequency | AF<br>EMCO<br>3160-09 | Corr. |
|-----------|-----------------------|-------|
| MHz       | dB (1/m)              | dB    |
| 18000     | 40,2                  | -23,5 |
| 18500     | 40,2                  | -23,2 |
| 19000     | 40,2                  | -22,0 |
| 19500     | 40,3                  | -21,3 |
| 20000     | 40,3                  | -20,3 |
| 20500     | 40,3                  | -19,9 |
| 21000     | 40,3                  | -19,1 |
| 21500     | 40,3                  | -19,1 |
| 22000     | 40,3                  | -18,7 |
| 22500     | 40,4                  | -19,0 |
| 23000     | 40,4                  | -19,5 |
| 23500     | 40,4                  | -19,3 |
| 24000     | 40,4                  | -19,8 |
| 24500     | 40,4                  | -19,5 |
| 25000     | 40,4                  | -19,3 |
| 25500     | 40,5                  | -20,4 |
| 26000     | 40,5                  | -21,3 |
| 26500     | 40,5                  | -21,1 |

| cable<br>loss 1<br>(inside<br>chamber) | cable<br>loss 2<br>(pre-<br>amp) | cable<br>loss 3<br>(inside<br>chamber) | cable<br>loss 4<br>(switch<br>unit) | cable<br>loss 5<br>(to<br>receiver) |
|--|----------------------------------|--|-------------------------------------|-------------------------------------|
| dB                                     | dB                               | dB                                     | dB                                  | dB                                  |
| 0,72                                   | -35,85                           | 6,20                                   | 2,81                                | 2,65                                |
| 0,69                                   | -35,71                           | 6,46                                   | 2,76                                | 2,59                                |
| 0,76                                   | -35,44                           | 6,69                                   | 3,15                                | 2,79                                |
| 0,74                                   | -35,07                           | 7,04                                   | 3,11                                | 2,91                                |
| 0,72                                   | -34,49                           | 7,30                                   | 3,07                                | 3,05                                |
| 0,78                                   | -34,46                           | 7,48                                   | 3,12                                | 3,15                                |
| 0,87                                   | -34,07                           | 7,61                                   | 3,20                                | 3,33                                |
| 0,90                                   | -33,96                           | 7,47                                   | 3,28                                | 3,19                                |
| 0,89                                   | -33,57                           | 7,34                                   | 3,35                                | 3,28                                |
| 0,87                                   | -33,66                           | 7,06                                   | 3,75                                | 2,94                                |
| 0,88                                   | -33,75                           | 6,92                                   | 3,77                                | 2,70                                |
| 0,90                                   | -33,35                           | 6,99                                   | 3,52                                | 2,66                                |
| 0,88                                   | -33,99                           | 6,88                                   | 3,88                                | 2,58                                |
| 0,91                                   | -33,89                           | 7,01                                   | 3,93                                | 2,51                                |
| 0,88                                   | -33,00                           | 6,72                                   | 3,96                                | 2,14                                |
| 0,89                                   | -34,07                           | 6,90                                   | 3,66                                | 2,22                                |
| 0,86                                   | -35,11                           | 7,02                                   | 3,69                                | 2,28                                |
| 0,90                                   | -35,20                           | 7,15                                   | 3,91                                | 2,36                                |

#### Sample calculation

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

U = Receiver reading

AF = Antenna factor

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

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

Table shows an extract of values.

## 5.6 Antenna EMCO 3160-10 (26.5 GHz – 40 GHz)

| Frequency<br>GHz | AF<br>EMCO<br>3160-10<br>dB (1/m) | Corr.<br>dB | cable<br>loss 1<br>(inside<br>chamber)<br>dB | cable<br>loss 2<br>(outside<br>chamber)<br>dB | cable<br>loss 3<br>(switch<br>unit)<br>dB | cable<br>loss 4<br>(to<br>receiver)<br>dB | distance<br>corr.<br>(-20 dB/<br>decade)<br>dB | d <sub>Limit</sub><br>(meas.<br>distance<br>(limit))<br>m | d <sub>used</sub><br>(meas.<br>distance<br>(used))<br>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

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

U = Receiver reading

AF = Antenna factor

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

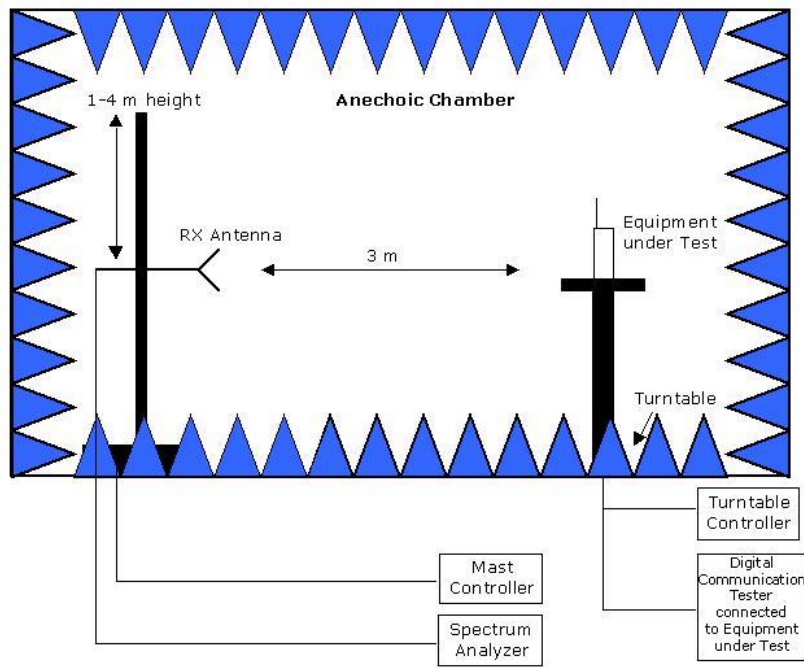
Linear interpolation will be used for frequencies in between the values in the table.

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

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

Table shows an extract of values.

## 6 Setup Drawings



*Remark:* Depending on the frequency range suitable antenna types, attenuators or preamplifiers are used.

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

## 7 Measurement uncertainty

| Test Case                   | Parameter                   | Uncertainty             |
|-----------------------------|-----------------------------|-------------------------|
| Peak power output           | Fieldstrength               | ± 5.5 dB                |
| Occupied bandwidth          | Power<br>Frequency:         | ± 2.9 dB<br>± 0.125 kHz |
| Spurious radiated emissions | Fieldstrength<br>Frequency: | ± 5.5 dB<br>± 11.2 kHz  |
| AC Power Line               | Power                       | ± 3.4 dB                |

## 8 Photo Report

Photos are included in an external report.