

# FCC Measurement/Technical Report on LARA-R203 LTE Single Mode

FCC ID: XPY1DIQN3NN  
IC: 8595A-1DIQN3NN

**Test Report Reference:** MDE\_UBLOX\_1712\_FCCa

## Test Laboratory:

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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.

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## 1 APPLIED STANDARDS AND TEST SUMMARY

### 1.1 APPLIED STANDARDS

#### **Applicable FCC Rules**

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

#### **Part 2, Subpart J - Equipment Authorization Procedures, Certification**

#### **Part 15, Subpart B – Unintentional Radiators**

§ 15.107 Conducted limits

§ 15.109 Radiated emission limits; general requirements

Note:

ANSI C63.4-2014 is applied.

**Summary Test Results:**

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

1.2 FCC-IC CORRELATION TABLE

**Correlation of measurement requirements for  
Information Technology Equipment (ITE)  
from  
FCC and IC**

<b>Measurement</b>	<b>FCC reference</b>	<b>IC reference</b>
Conducted Emissions (AC Power Line)	§15.107	ICES-003 Issue 6: 6.1
Radiated Spurious Emissions	§15.109	ICES-003 Issue 6: 6.2

**Remarks:**

1. FCC Part 15 subpart B, ICES 003 and CISPR 22 contain different definitions of Class A and Class B limits, i.e. which class is applicable to which kind of EUT.  
ICES 003 and CISPR 22 distinguish between the location where the EUT is intended to operate whilst FCC refers to the method of commercial distribution (distributive trades).
2. The correct assignment of the appropriate class to the concrete EUT is not scope of this test report!
3. A radio apparatus that is specifically subject to an Industry Canada Radio Standard Specification (RSS) and which contains an ITE is not subject to ICES-003 provided the ITE is used only to enable operation of the radio apparatus and the ITE does not control additional functions or capabilities.
4. ISM (Industrial, Scientific or Medical) radio frequency generators, though they may contain ITE, are excluded from the definition of ITE and are not subject to ICES-003. They are instead subject to the Interference-Causing Equipment Standard ICES-001, which specifically addresses ISM radio frequency generators.

### 1.3 MEASUREMENT SUMMARY / SIGNATURES

#### **47 CFR CHAPTER I FCC PART 15 Subpart B**

#### **§ 15.107 Class B**

Conducted Emissions at AC mains

The measurement was performed according to ANSI C63.4

#### **Final Result**

#### **OP-Mode**

AC mains connection, Test setup

via connected ANC1, computer peripheral

via connected ANC2, computer peripheral

#### **Setup**

S01\_IA04

S01\_IA04

#### **FCC**

Passed

Passed

#### **IC**

Passed

Passed

#### **47 CFR CHAPTER I FCC PART 15 Subpart B**

#### **§ 15.109 Class B**

Radiated Emissions

The measurement was performed according to ANSI C63.4

#### **Final Result**

#### **OP-Mode**

AC mains connection, Measurement range, Test setup

via connected ANC1 + ANC2, 30 MHz - 1 GHz, computer peripheral

via connected ANC1 + ANC2, 1 GHz - 18 GHz, computer peripheral

#### **Setup**

S01\_IA04

S01\_IA04

#### **FCC**

Passed

Passed

#### **IC**

Passed

Passed

N/A: Not applicable

N/P: Not performed

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

---

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

## 2 ADMINISTRATIVE DATA

### 2.1 TESTING LABORATORY

Company Name: 7layers GmbH  
Address: Borsigstr. 11  
40880 Ratingen  
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-12140-01-00

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

Report Template Version: 2017-06-14

### 2.2 PROJECT DATA

Responsible for testing and report: B.Sc. Jens Dörwald

Employees who performed the tests: documented internally at 7Layers

Date of Report: 2017-07-10

Testing Period: 2017-06-21 to 2017-06-22

### 2.3 APPLICANT DATA

Company Name: u-blox AG

Address: Zürcherstrasse 68,  
CH-8800 Thalwil  
Switzerland

Contact Person: Mr. Giulio Comar

### 2.4 MANUFACTURER DATA

Company Name: please see Applicant Data

Address: -

Contact Person: -

### 3 TEST OBJECT DATA

#### 3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	LTE Data module
Product name	LARA-R203
Type	LARA-R203
<b>Declared EUT data by the supplier</b>	
Power Supply Type	DC
Comment	DC Power via AC/DC adapter
Nominal Voltage / Frequency	3.8 V DC
Test Voltage / Frequency	input: 120 V / 60 Hz AC output: 3.8 V DC
Highest internal frequency	2480 MHz
General Description	LTE Data module
Ports	USB RS232
Special software used for testing	Terminal program (e.g. Putty)

**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
DE1015055	ia04	
Sample Parameter	Value	
Serial No.	356935080016147	
HW Version	2730A2	
SW Version	30.34	
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, SN)	Description
AC/DC Adapter	UNIFIVE, UUX324-1215, G05-0122279	ANC1
DC Power Supply	PeakTech, 6005D, 081062045	ANC2

### 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
Laptop	Fujitsu Lifebook E series E782, 2011.11, DSCM004672	-
AC/DC Adapt. Laptop	Fujitsu Ltd. SEB100P2-19.0, CA010007-0920	-
Monitor	LG Flatron L1730BSNHN-ANE	-
Mouse	Logitech M-BB48	-
Keyboard	CHERRY RS 6000 USB ON	-

### 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_IA04	DE1015055ia04	-

### 3.6 OPERATING MODES

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

#### 3.6.1 TEST CHANNELS

- eFDD12 traffic mode (TCH 23095, QPSK 5 MHz, RB25) for conducted emissions
- eFDD2 idle mode for radiated emissions

for all measurements USB & RS232 data traffic was established



## 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 CONDUCTED EMISSIONS AT AC MAINS

Standard **FCC Part 15 Subpart B**

**The test was performed according to:**  
ANSI C63.4

#### 4.1.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C 63.4. The Equipment Under Test (EUT) was setup in a shielded room to perform the conducted emissions measurements in a typical installation configuration. The EUT was powered from 50 $\mu$ H || 50 Ohm Line Impedance Stabilization Network (LISN). The LISN's unused connections were terminated with 50 Ohm loads.

The measurement procedure consists of two steps. It is implemented into the EMI test software EMC-32 from R&S.

##### **Step 1: Preliminary scan**

Intention of this step is, to determine the conducted EMI-profile of the EUT.

EMI receiver settings:

- Detector: Peak – Maxhold & Average
- Frequency range: 150 kHz – 30 MHz
- Frequency steps: 2.5 kHz
- IF-Bandwidth: 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)
- Measurement on phase + neutral lines of the power cords

On basis of this preliminary scan the highest amplitudes and the corresponding frequencies relative to the limit are identified. Emissions above the limit and emissions which are in the 10 dB range below the limit are considered.

##### **Step 2: Final measurement**

Intention of this step is, to determine the highest emissions with the settings defined in the test specification for the frequencies identified in step 1.

EMI receiver settings:

- Detector: Quasi-Peak
- IF Bandwidth: 9 kHz
- Measuring time: 1 s / frequency

At each frequency determined in step 1, four measurements are performed in the following combinations:

- 1) Neutral lead - reference ground (PE grounded)
- 2) Phase lead - reference ground (PE grounded)
- 3) Neutral lead - reference ground (PE floating)
- 4) Phase lead - reference ground (PE floating)

The highest value is reported.

#### 4.1.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart B, §15.107

##### Class B:

Frequency (MHz)	QP Limits (dBµV)	AV Limits (dBµV)
0.15 - 0.5	66 - 56	56 - 46
0.5 - 5	56	46
5 - 30	60	50

##### Class A:

Frequency (MHz)	QP Limits (dBµV)	AV Limits (dBµV)
0.15 - 0.5	79	66
0.5 - 30	73	60

#### 4.1.3 TEST PROTOCOL

Temperature: 28 - 30 °C  
 Air Pressure: 1002 - 1006 hPa  
 Humidity: 35 - 39 %  
 Labornetzteil Computer Peripheral

Power line	PE	Frequency [MHz]	Level [dBµV]	Detector	Limit [dBµV]	Margin [dB]
N	GND	0.326	40.47	QP	60	19.09
L1	FLO	0.737	23.09	AV	46	22.91
L1	FLO	0.740	28.62	QP	56	27.38
N	FLO	0.771	15.38	AV	46	30.62
L1	FLO	1.475	30.34	AV	46	15.66
L1	FLO	1.475	35.17	QP	56	20.83
N	FLO	1.540	19.70	AV	46	26.30
L1	FLO	1.635	32.25	AV	46	13.75
L1	FLO	1.716	33.00	AV	46	13.00
L1	GND	1.880	32.31	AV	46	13.69
L1	FLO	2.022	32.44	AV	46	13.56
L1	GND	2.125	32.00	AV	46	14.00
L1	FLO	2.213	22.90	AV	46	23.10
N	FLO	11.528	39.22	QP	60	20.78

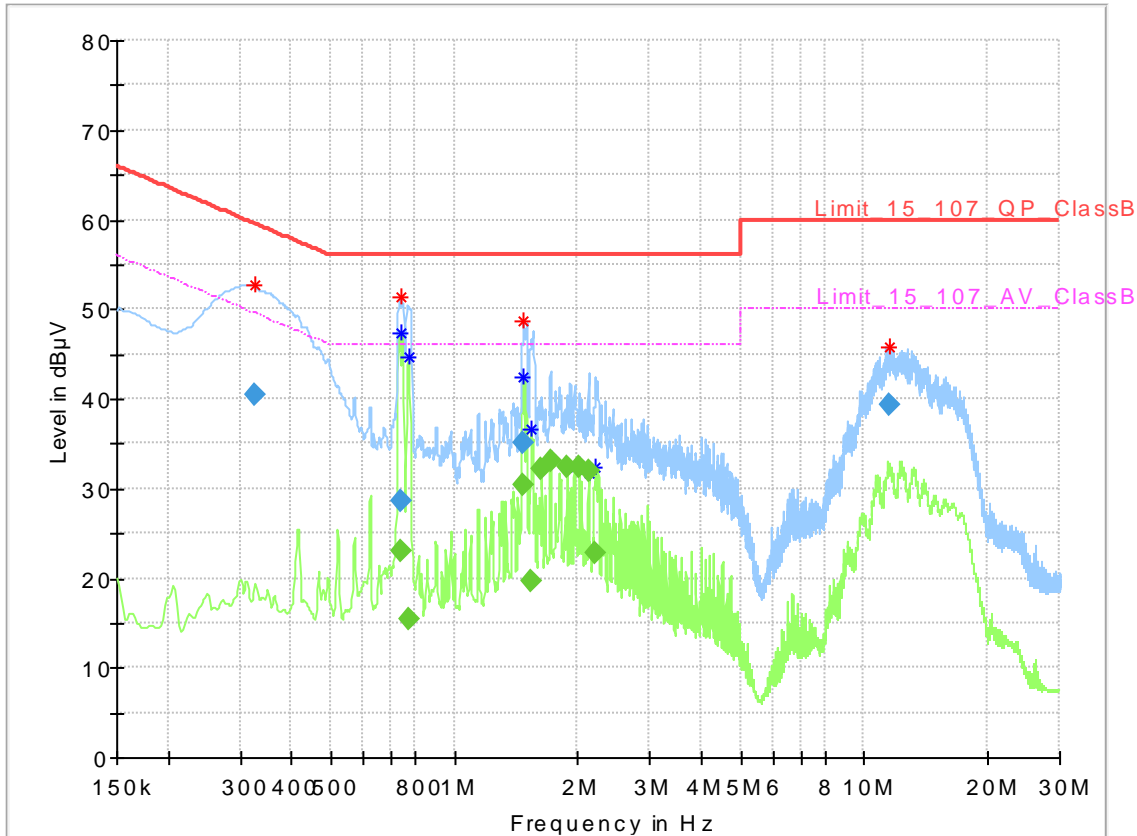
##### AC/DC Adapter

Power line	PE	Frequency [MHz]	Level [dBµV]	Detector	Limit [dBµV]	Margin [dB]
N	GND	0.427	31.15	AV	47.32	16.16
N	FLO	0.427	41.45	QP	57.32	15.86
N	FLO	24.263	27.81	AV	50.00	22.19

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

#### 4.1.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Labornetzteil



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.325500	40.47	---	59.57	19.09	1000.0	9.000	N	GND	10.1
0.737250	---	23.09	46.00	22.91	1000.0	9.000	L1	FLO	10.1
0.739500	28.62	---	56.00	27.38	1000.0	9.000	L1	FLO	10.1
0.771000	---	15.38	46.00	30.62	1000.0	9.000	N	FLO	10.1
1.475250	---	30.34	46.00	15.66	1000.0	9.000	L1	FLO	10.1
1.475250	35.17	---	56.00	20.83	1000.0	9.000	L1	FLO	10.1
1.540500	---	19.70	46.00	26.30	1000.0	9.000	N	FLO	10.1
1.635000	---	32.25	46.00	13.75	1000.0	9.000	L1	FLO	10.1
1.716000	---	33.00	46.00	13.00	1000.0	9.000	L1	FLO	10.1
1.880250	---	32.31	46.00	13.69	1000.0	9.000	L1	GND	10.1
2.022000	---	32.44	46.00	13.56	1000.0	9.000	L1	FLO	10.2
2.125500	---	32.00	46.00	14.00	1000.0	9.000	L1	GND	10.2
2.213250	---	22.90	46.00	23.10	1000.0	9.000	L1	FLO	10.2
11.528250	39.22	---	60.00	20.78	1000.0	9.000	N	FLO	10.6

#### 4.1.5 TEST EQUIPMENT USED

- Conducted Emissions FCC

## 4.2 RADIATED EMISSIONS

Standard **FCC Part 15 Subpart B**

**The test was performed according to:**  
ANSI C63.4

### 4.2.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.4 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 was evaluated. For the measurement above 1 GHz an absorber field with 30 cm pyramidal absorber is placed between EUT table and antenna (required to fulfil the CISPR 16.1.4 S-VSWR criteria).

The measurement procedure is implemented into the EMI test software EMC32 from R&S.

#### **1. 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  $\pm 45^\circ$  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 3, the final measurement will be performed:

EMI receiver settings for step 4:

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

## 2. Measurement above 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 / Average (up to 7 GHz FFT-based)
- Frequency range: 1 GHz – 18 GHz
- Frequency steps: 250 kHz
- IF-Bandwidth: 1 MHz
- Measuring time / Frequency step: 100 ms (up to 7 GHz) / 500µs (above 7 GHz)
- Turntable angle range: -180° to 135°
- Turntable step size: 45°
- Height variation range: 1 – 3.7 m (due to the small antenna lobe, a tilt-mast is used)
- Height variation step size: 0.9 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  $\pm 22.5^\circ$  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  $\pm 45$  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: 1 MHz
- Measuring time: 100 ms
- Turntable angle range:  $\pm 22.5^\circ$  around the determined value
- Height variation range:  $\pm 45$  cm around the determined value
- Antenna Polarisation: max. value determined in step 1

**Step 3:** Final measurement with Max-Peak / CISPR-Average detector

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

EMI receiver settings for step 3:

- Detector: Max-Peak / CISPR-Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 200 ms

After each measurement, a report will be generated which contains a diagram with the results of the preliminary scan and a table with the frequencies, values and polarisation of the results of the final measurement.

#### 4.2.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart B, §15.109, Radiated Emission Limits

##### Class B:

Frequency (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

##### Class A:

Frequency (MHz)	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	90@10m	3	39.1@10m
88 – 216	150@10m	3	43.5@10m
216 – 960	210@10m	3	46.4@10m
960 - 26000	300@10m	3	49.5@10m
26000 - 40000	300@10m	1	49.5@10m

The measured values for Class A and for Class B (> 26 GHz) measurements 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:  $\text{Limit (dB}\mu\text{V/m)} = 20 \log (\text{Limit } (\mu\text{V/m})/1\mu\text{V/m})$

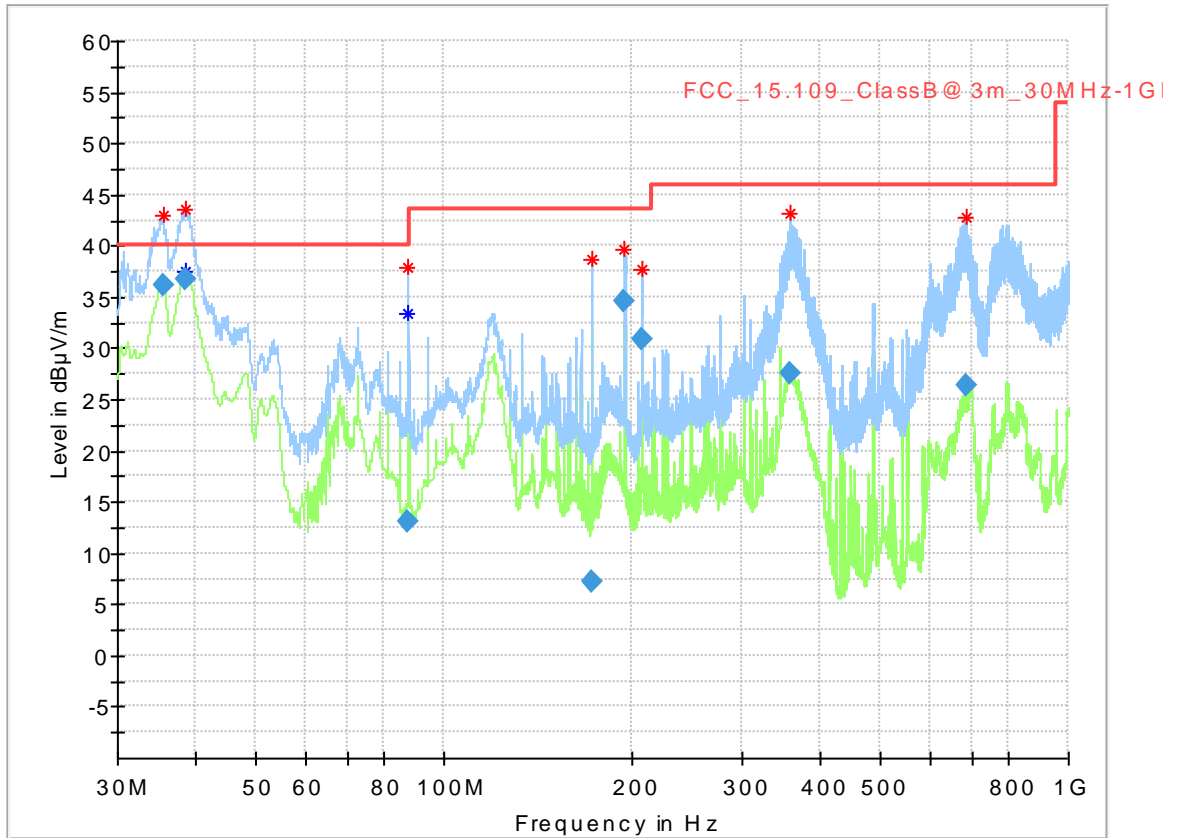
#### 4.2.3 TEST PROTOCOL

Ambient temperature: 29 - 30 °C  
 Air Pressure: 1002 - 1003 hPa  
 Humidity: 42 - 46 %  
 Computer Peripheral Setup

Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detector	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]
35.5	36.2	QP	120	40.0	3.9
38.6	36.8	QP	120	40.0	3.2
87.8	13.1	QP	120	40.0	26.9
172.3	7.1	QP	120	43.5	36.4
194.8	34.5	QP	120	43.5	9.0
207.8	30.9	QP	120	43.5	12.6
359.0	27.6	QP	120	46.0	18.5
684.8	26.4	QP	120	46.0	19.6

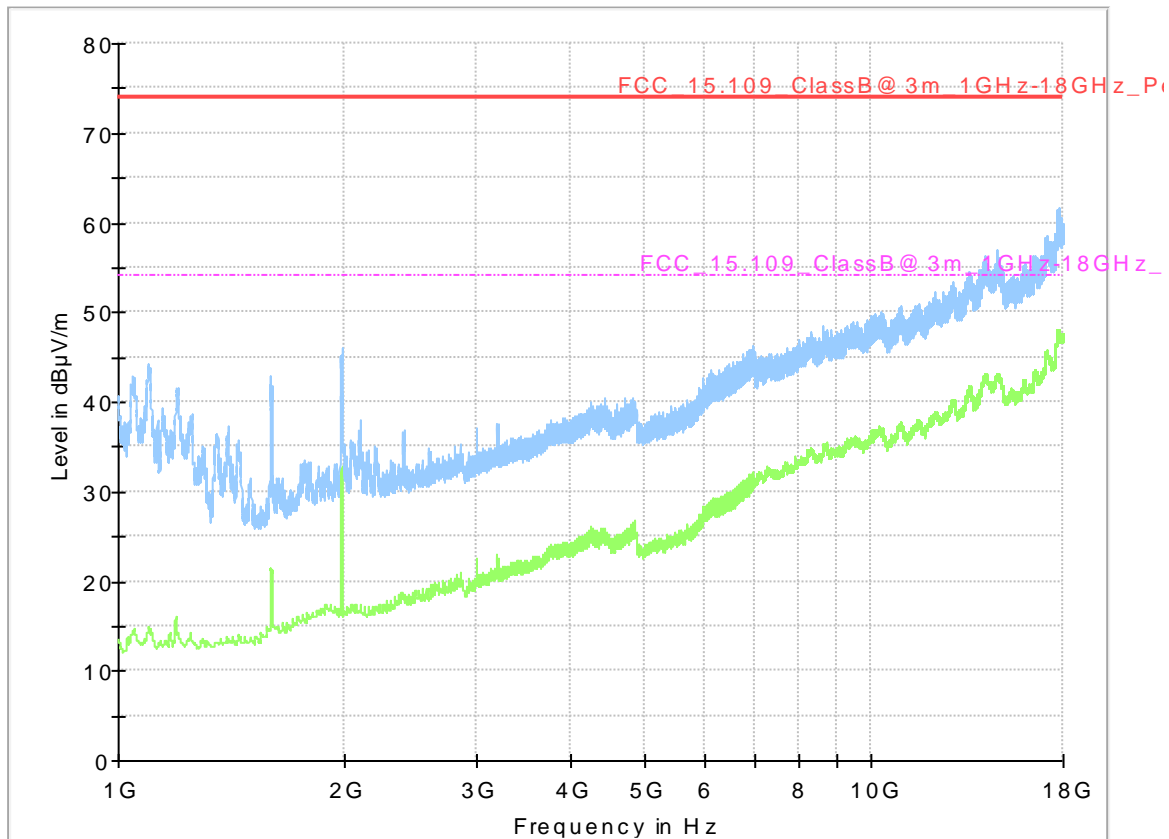
Remark: Please see next sub-clause for the measurement plot.

#### 4.2.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.460000	36.15	40.00	3.85	1000.0	120.000	100.0	V	-146.0	16.2
38.580000	36.78	40.00	3.22	1000.0	120.000	107.0	V	-170.0	14.6
87.750000	13.11	40.00	26.89	1000.0	120.000	282.0	V	-180.0	10.6
172.260000	7.13	43.50	36.37	1000.0	120.000	325.0	H	-102.0	9.2
194.760000	34.49	43.50	9.01	1000.0	120.000	106.0	V	-28.0	9.2
207.750000	30.94	43.50	12.56	1000.0	120.000	257.0	V	16.0	9.9
358.980000	27.55	46.00	18.45	1000.0	120.000	106.0	H	-183.0	15.3
684.780000	26.42	46.00	19.58	1000.0	120.000	106.0	V	-157.0	22.3





#### 4.2.5 TEST EQUIPMENT USED

- Radiated Emissions

## 5 TEST EQUIPMENT

- 1 Conducted Emissions FCC  
Conducted Emissions power line for FCC standards

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-04	2019-04
1.2	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2016-02	2018-02
1.3	ESH 3-Z5	Two-Line V-Network	Rohde & Schwarz	828304/029		
1.4	EP 1200/B, NA/B1	Amplifier with integrated variable Oscillator	Spitzenberger & Spieß	B6278	2015-07	2018-07
1.5	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
1.6	Shielded Room 02	Shielded Room for conducted testing, 12qm	Frankonia	-		
1.7	ESH 3-Z5	Two-Line V-Network	Rohde & Schwarz	829996/002		
1.8	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11	2018-11
1.9	Opus10 THI (8152.00)	ThermoHygro Datalogger 02 (Environ)	Lufft Mess- und Regeltechnik GmbH	7489		
1.10	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2015-12	2017-12

- 2 Radiated Emissions  
Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	NRV-Z1	Sensor Head A	Rohde & Schwarz	827753/005	2017-05	2018-05
2.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2016-09	2017-09
2.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-04	2019-04
2.4	Anechoic Chamber	10.58 x 6.38 x 6.00 m <sup>3</sup>	Frankonia	none		
2.5	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2015-06	2018-06
2.6	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
2.7	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.8	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB		
2.9	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2016-02	2018-02
2.10	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
2.11	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2016-12	2018-12
2.12	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronik GmbH	00083069		
2.13	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
2.14	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
2.15	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
2.16	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
2.17	TT 1.5 WI	Turn Table	Maturo GmbH	-		
2.18	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz	100609	2016-04	2019-04
2.19	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronik GmbH	00086675		
2.20	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
2.21	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2014-11	2017-11
2.22	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-03	2019-03
2.23	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11	2018-11
2.24	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
2.25	AS 620 P	Antenna mast	HD GmbH	620/37		
2.26	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
2.27	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2015-12	2017-12
2.28	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
2.29	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
2.30	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2015-05	2018-05

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 MHz	Corr. dB	LISN insertion loss ESH3- Z5 dB	cable loss (incl. 10 dB atten- uator) 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.

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

Frequency MHz	AF HFH-Z2) dB (1/m)	Corr. dB	cable loss 1 (inside chamber) dB	cable loss 2 (outside chamber) dB	cable loss 3 (switch unit) dB	cable loss 4 (to receiver) dB	distance corr. (-40 dB/ decade) dB	d <sub>Limit</sub> (meas. distance (limit) m	d <sub>used</sub> (meas. distance (used) 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

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

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

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

cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	$d_{Limit}$ (meas. distance (limit))	$d_{used}$ (meas. distance (used))
dB	dB	dB	dB	dB	m	m
0.29	0.04	0.23	0.02	0.0	3	3
0.39	0.09	0.32	0.08	0.0	3	3
0.56	0.14	0.47	0.08	0.0	3	3
0.73	0.20	0.59	0.12	0.0	3	3
0.84	0.21	0.70	0.11	0.0	3	3
0.98	0.24	0.80	0.13	0.0	3	3
1.04	0.26	0.89	0.15	0.0	3	3
1.18	0.31	0.96	0.13	0.0	3	3
1.28	0.35	1.03	0.19	0.0	3	3
1.39	0.38	1.11	0.22	0.0	3	3
1.44	0.39	1.20	0.19	0.0	3	3
1.55	0.46	1.24	0.23	0.0	3	3
1.59	0.43	1.29	0.23	0.0	3	3
1.67	0.34	1.35	0.22	0.0	3	3
1.67	0.42	1.41	0.15	0.0	3	3
1.87	0.54	1.46	0.25	0.0	3	3
1.90	0.46	1.51	0.25	0.0	3	3
1.99	0.60	1.56	0.27	0.0	3	3
2.14	0.60	1.63	0.29	0.0	3	3
2.22	0.60	1.66	0.33	0.0	3	3
2.23	0.61	1.71	0.30	0.0	3	3

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

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

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

#### Sample calculation

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

U = Receiver reading

AF = Antenna factor

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

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

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 MHz	AF R&S HF907 dB (1/m)	Corr. 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) dB	cable loss 2 (outside chamber) dB	cable loss 3 (switch unit, atten- uator & pre-amp) dB	cable loss 4 (to receiver) 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 MHz	AF R&S HF907 dB (1/m)	Corr. 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) dB	cable loss 2 (inside chamber) dB	cable loss 3 (outside chamber) dB	cable loss 4 (switch unit, atten- uator & pre-amp) dB	cable loss 5 (to receiver) dB	used for FCC 15.247
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 MHz	AF R&S HF907 dB (1/m)	Corr. 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) dB	cable loss 2 (High Pass) dB	cable loss 3 (pre- amp) dB	cable loss 4 (inside chamber) dB	cable loss 5 (outside chamber) dB	cable loss 6 (to receiver) 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.

## 6.5 ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

Frequency	AF EMCO 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 loss 1 (inside chamber)	cable loss 2 (pre- amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to 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

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

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.

Table shows an extract of values.



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

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

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

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.

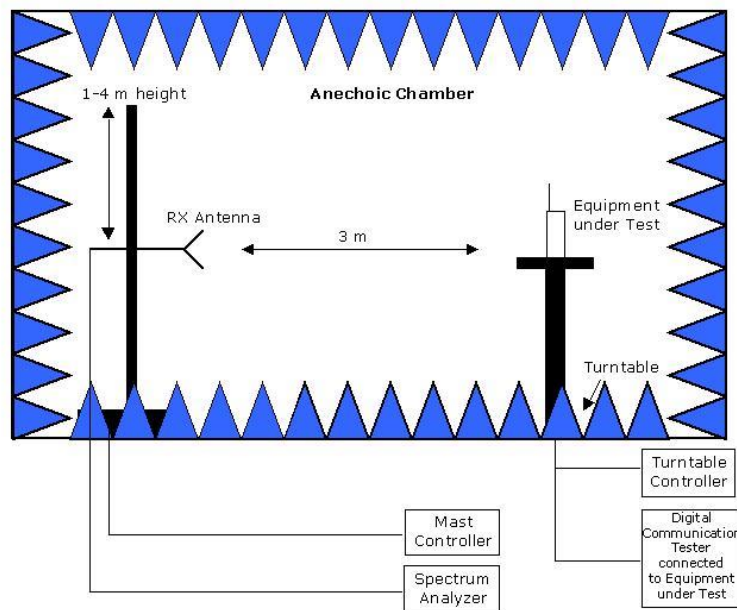
distance correction =  $-20 * \text{LOG} (d_{\text{Limit}} / d_{\text{used}})$

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

Table shows an extract of values.

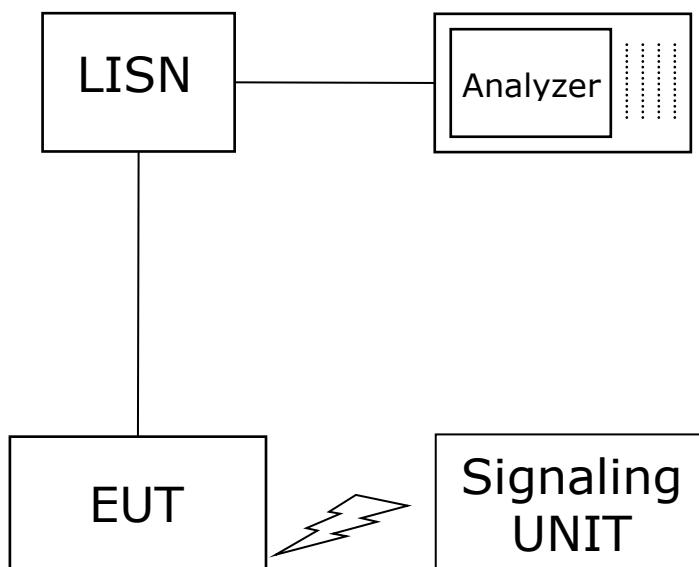
## 7 SETUP DRAWINGS

### Setup Drawings



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

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



Setup in the shielded room for conducted measurements at AC mains port

## 8 MEASUREMENT UNCERTAINTIES

<b>Test Case</b>	<b>Parameter</b>	<b>Uncertainty</b>
Conducted Emissions at AC mains	Voltage	$\pm 3.4$ dB
Radiated Emissions	Field Strength	$\pm 5.5$ dB

## 9 PHOTO REPORT

Please see separate photo report.