FCC Measurement/Technical Report on

BRA300
in
VEGAPULS 21
VEGAPULS 31

FCC ID: O6QBRA300
IC: 3892A-BRA300

Test Report Reference: MDE_VEGA_1902_FCC_06_REV01

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

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

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.

Table of Contents

1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization
Certification for an Intentional Radiator.

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-18 Edition). The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.209 Radiated emission limits; general requirements

§ 15.256 Operation of level probing radars within the bands 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz

Note:
The tests were selected and performed with reference to the FCC Public Notice “Measurement procedure for level probing radars, 890966 D01 Meas level Probing Radars v01r01”.

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 Level-Probing-Radars equipment from FCC and IC

Measurement	FCC reference	IC reference
Fundamental bandwidth	§ 15.256 (f) (1) (2)	RSS-211: 5.1 (a)
Fundamental emission	§ 15.256 (g)	RSS-211: 5.2 (b)
Unwanted emissions	§ 15.256 (h)	RSS-211: 5.3
Antenna beamwidth	§ 15.256 (i) (B)	RSS-211: 5.2 (a)
Antenna side lobe gain	§ 15.256 (j)	RSS-211: 5.2 (c)
Frequency Stability	§ 15.215 (c)	RSS-211: 5.1 (f)

1.3 MEASUREMENT SUMMARY / SIGNATURES

47 CFR CHAPTER I FCC PART 15 Subpart C §15.256 **§ 15.256 (f)**

Fundamental bandwidth

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

OP-Mode Radio Technology, Operating Frequency, Measurement range	Setup	Date	FCC	IC
FMCW Radar, 78 – 82 GHz, 75 GHz - 85 GHz	S01_CB01	2019-09-24	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.256 **§ 15.256 (g)**

Fundamental emission

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

OP-Mode Radio Technology, Operating Frequency, Measurement range	Setup	Date	FCC	IC
FMCW Radar, 78 – 82 GHz, 75 GHz - 85 GHz	S01_CB01	2019-09-24	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.256 **§ 15.256 (h)**

Unwanted emissions

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

OP-Mode Radio Technology, Operating Frequency, Measurement range	Setup	Date	FCC	IC
FMCW Radar, 78 – 82 GHz, 30 MHz – 1 GHz	S01_CB01	2019-09-09	Passed	Passed
FMCW Radar, 78 – 82 GHz, 1 GHz – 18 GHz	S01_CB01	2019-10-09	Passed	Passed
FMCW Radar, 78 – 82 GHz, 18 GHz – 26 GHz	S01_CB01	2019-10-09	Passed	Passed
FMCW Radar, 78 – 82 GHz, 26 GHz – 40 GHz	S01_CB01	2019-10-09	Passed	Passed
FMCW Radar, 78 – 82 GHz, 40 GHz – 60 GHz	S01_CB01	2019-10-17	Passed	Passed
FMCW Radar, 78 – 82 GHz, 60 GHz – 90 GHz	S01_CB01	2019-10-17	Passed	Passed
FMCW Radar, 78 – 82 GHz, 90 GHz – 140 GHz	S01_CB01	2019-10-17	Passed	Passed
FMCW Radar, 78 – 82 GHz, 140 GHz – 200 GHz	S01_CB01	2019-10-18	Passed	Passed
FMCW Radar, 78 – 82 GHz, 30 MHz – 1 GHz	S01_FB01	2019-10-24	Passed	Passed
FMCW Radar, 78 – 82 GHz, 1 GHz – 18 GHz	S01_FB01	2019-10-24	Passed	Passed
FMCW Radar, 78 – 82 GHz, 18 GHz – 26 GHz	S01_FB01	2019-10-30	Passed	Passed
FMCW Radar, 78 – 82 GHz, 26 GHz – 40 GHz	S01_FB01	2019-10-30	Passed	Passed
FMCW Radar, 78 – 82 GHz, 40 GHz – 60 GHz	S01_FB01	2019-10-30	Passed	Passed
FMCW Radar, 78 – 82 GHz, 60 GHz – 90 GHz	S01_FB01	2019-10-30	Passed	Passed
FMCW Radar, 78 – 82 GHz, 90 GHz – 140 GHz	S01_FB01	2019-10-30	Passed	Passed
FMCW Radar, 78 – 82 GHz, 140 GHz – 200 GHz	S01_FB01	2019-10-30	Passed	Passed

RSS 211 5.3

Unwanted emissions

The measurement was performed according to ETSI EN 302 372 **Final Result**

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
FMCW Radar, 78 – 82 GHz	S01_CB01	2019-10-29	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.256 **§ 15.256 (i)**

Antenna beamwidth

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

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
FMCW Radar, 78 – 82 GHz	S01_CB01	2019-09-04	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.256 **§ 15.256 (j)**

Antenna side lobe gain

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

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
FMCW Radar, 78 – 82 GHz	S01_CB01	2019-09-04	Passed	Passed

47 CFR CHAPTER I FCC PART 15 Subpart C §15.256 **§ 15.256 (c)**

Frequency Stability

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

OP-Mode Radio Technology, Operating Frequency	Setup	Date	FCC	IC
FMCW Radar, 78 – 82 GHz	S01_CB01	2019-10-22	Passed	Passed

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

2 REVISION HISTORY

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2020-02-18	--	invalid
REV01	2020-04-20	• Page 13 Analyzer settings corrected • Page 14 comment added • Page 18 calculation parameters for Average-Factor added • Page 19 & 20 EIRP in 50 MHz added • Page 56 MU for 10 dB added	valid

COMMENT:
According to customer specification BRA300 (with VEGAPULS 11, VEGAPULS 21 and VEGAPULS 31) are identical in their radar technology, so not all tests have been performed on all devices.

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

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

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3 ADMINISTRATIVE DATA

3.1 TESTING LABORATORY

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

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-01 D-PL-12140-01-02 D-PL-12140-01-03
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
ISED CAB Identifier	DE0007; ISED#: 3699A
Responsible for accreditation scope:	Dipl.-Ing. Marco Kullik
Report Template Version:	2019-06-18

3.2 PROJECT DATA

Responsible for testing and report:	B.Sc. Jens Dörwald
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2020-04-20
Testing Period:	2019-09-30 to 2019-10-01

3.3 APPLICANT DATA

Company Name: Address:	VEGA Grieshaber KG Am Hohenstein 113 77761 Schiltach Germany
Contact Person:	Mr. Patrick Friedmann

3.4 MANUFACTURER DATA

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

4 TEST OBJECT DATA

4.1 GENERAL EUT DESCRIPTION

Kind of Device product description	BRA300 are electronic modules used in VEGAPULS devices. The electronic modules contain the main electronics of the devices and a Bluetooth module with an antenna integrated on the PCB. The Bluetooth interface is for communication with the device via smartphone, tablet pc or laptop.
Product name	VEGAPULS 11 VEGAPULS 21 VEGAPULS 31
Type	-
Declared EUT data by the supplier	
Voltage Type	DC
Voltage Level	24 V
Tested Modulation Type	FMCW
General product description	The EUT is a Level Probing Radar including Bluetooth Low Energy.
The EUT provides the following ports:	DC

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

4.2 EUT MAIN COMPONENTS

Sample Name	**Sample Code**	**Description**
EUT A	DE1373002cb01	VEGAPULS 21
Sample Parameter	**Value**	
Serial No.	15203022	
HW Version	1.1.0	
SW Version	1.1.0	
Comment	-	

Sample Name	**Sample Code**	**Description**
EUT B	DE1373002fb01	VEGAPULS 31
Sample Parameter	**Value**	
Serial No.	13303121	
HW Version	1.1.0	
SW Version	1.1.0	
Comment	-	

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

4.3 ANCILLARY EQUIPMENT

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

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

4.4 AUXILIARY EQUIPMENT

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

Device	Details (Manufacturer, Type Model, HW, SW, S/N)	Description
-	-	-

4.5 EUT SETUPS

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

Setup	Combination of EUTs	Description and Rationale
S01_CB01	DE1373002	VEGAPULS 21 (radiated setup)
S01_FB01	DE1373002	VEGAPULS 31 (radiated setup)

4.6 OPERATING MODES

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

4.6.1 TEST CHANNELS

FMCW Radar Signal with an operational frequency range from 78 GHz to 82 GHz

4.7 PRODUCT LABELLING

4.7.1 FCC ID LABEL

Please refer to the documentation of the applicant.

4.7.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

5 TEST RESULTS

5.1 FUNDAMENTAL BANDWIDTH

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

5.1.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the fundamental bandwidth measurements.
The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.
The results recorded were measured with the modulation which produce the worst-case (smallest) emission bandwidth.

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in a fully-anechoic chamber. The LPR and the test antenna were adjusted for maximum main beam coupling.

Analyzer settings:

- Resolution Bandwidth (RBW): 1000 kHz
- Video Bandwidth (VBW): 3000 kHz
- Span: 10 GHz
- Trace: Maxhold
- Sweeps: allow the trace to stabilize
- Sweeptime: $T_D = T_s / \Delta F$ (where Ts is the signal sweep frequency time in seconds; ΔF is the signal sweep frequency in MHz)
- Detector: Peak

5.1.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.256 (f)(1)(2)
(1) The minimum fundamental emission bandwidth shall be 50 MHz for LPR operation under the provisions of this section.
(2) LPR devices operating under this section must confine their fundamental emission bandwidth within the 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz bands under all conditions of operation.

RSS-211: 5.1
(a)The minimum fundamental emission bandwidth shall be 50 MHz.

5.1.3 TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1002 hPa
Humidity: 44 %

Lower -10 dB Frequency fL [MHz]	Upper -10 dB Frequency fH [MHz]	Max Frequency fM [MHz]	Center Frequency fC [MHz]	Occupied Bandwidth [MHz]	Minimum Occupied Bandwidth [MHz]	Occupied Bandwidth Margin to Limit [MHz]
77690.00	82009.70	77950.70	79849.9	4319.7	50.0	4269.7

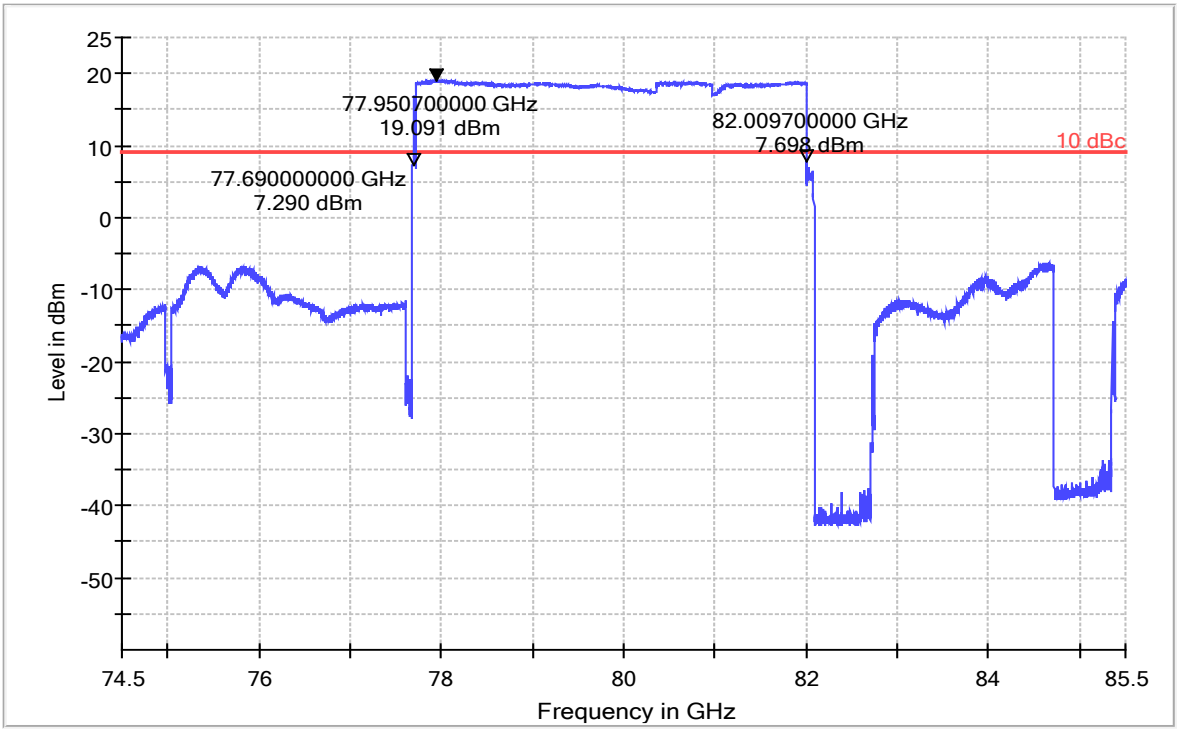
COMMENT: Measurement was performed with activated sweep function.

Lower -10 dB Frequency [MHz]	Upper -10 dB Frequency [MHz]	Lower Band Edge [MHz]	Upper Band Edge [MHz]	Margin to Lower Limit [MHz]	Margin to Upper Limit [MHz]
77690.00	82009.70	77000.00	85000.00	690.00	2990.30

COMMENT: Measurement was performed with activated sweep function.

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

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



5.1.5 TEST EQUIPMENT USED

- Radiated Emissions

5.2 FUNDAMENTAL EMISSION

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

5.2.1 TEST DESCRIPTION

According to KDB890966 D01 Meas level Probing Radars v01r01

Fundamental emission for Pulsed Transmitters
1. For radiated emission measurements, locate the receive test antenna at a far field distance boresighted on the LPR transmit antenna. Adjust the LPR and the test antenna for maximum main beam coupling.

2. For conducted measurements, connect the output of the LPR transmitter through an appropriate attenuator to the downconverter or external harmonic mixer, if necessary, to the spectrum analyzer.

3. Set the spectrum analyzer for power averaging (RMS) detector and 1 MHz RBW.

4. Record the maximum level and frequency of the signal within the fundamental emission bandwidth, which must be contained entirely within the authorized frequency band.

5. Centered on the frequency of the maximum signal recorded in step 4, select peak detector, 50 MHz RBW and at least 50 MHz VBW. a. If 50 MHz RBW is not available on the spectrum analyzer, determine the maximum of the spectrum trace in a narrower RBW which is greater than or less than the PRF by a factor of 3, but not less than 1 MHz, and calculate the maximum signal level in 50 MHz by adding the appropriate correction factor shown below to the maximum measured signal level. For pulsed LPRs

20 Log (50/RBW) dB, if PRF < RBW/3
20 Log (50/PRF) dB, if PRF > 3*RBW
where:
RBW is the resolution bandwidth in MHz
PFR is the pulse repetition frequency in MHz

b. It may be necessary to offset the measurement frequency in order to ensure that the measurement is made within the fundamental emission bandwidth because the 3 dB bandwidth of the RBW is not entirely within the fundamental emission bandwidth. The measurement shall be made at the nearest frequency to the frequency identified in step 4 when the 3 dB point of the RBW closest to the fundamental emission band edge is at the frequency of the band edge.

c. If the measurement must be performed with a RBW greater than 3 MHz because the PRF is between 1 MHz and 3 MHz or for any other reason, the test report must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation used.
6. Determine the conducted power output of the EUT or the field strength produced by the EUT at a given distance from the measurements in steps 1 to 5 by calculation taking into account all attenuators, amplifier gains, antenna factor, measurement distance extrapolation, conversion loss, cable losses, etc. as applicable or the signal substitution method.

7. The EIRP is then calculated by applying the appropriate equation as follows: a. For conducted measurements EIRP (dBm) = conducted power (dBm) + antenna gain (dBi) where the conducted power is the conducted power output of the EUT and antenna gain is the gain of the EUT antenna.

b. For radiated emission measurements EIRP (dBm) = E (dBµV/m) – 104.8 + 20 Log D where E is the field strength at the far field distance D.

Fundamental Emissions for FMCW transmitters

When making the following measurements, it is important to recognize that there is a sweep frequency time and sweep frequency span for both the LPR signal and the spectrum analyzer which are independent of each other.

1. For radiated emission measurements, locate the receive test antenna at a far field distance boresighted on the LPR transmit antenna. Adjust the LPR and the test antenna for maximum main beam coupling.
2. For conducted measurements, connect the output of the LPR transmitter through an appropriate attenuator to the downconverter or external harmonic mixer, if necessary, to the spectrum analyzer.
3. Set the spectrum analyzer frequency span to enable viewing the entire sweep frequency span of the LPR signal.
4. Calculate the dwell time, TD, of the sweep frequency signal per MHz of the sweep frequency span

   TD = TS/ΔF
   where:
   TS is the signal sweep frequency time in seconds
   ΔF is the signal sweep frequency span in MHz
5. Set the detector to peak mode.
6. Set the RBW to 1 MHz.
7. Perform sufficient multiple scans on the spectrum analyzer in maximum hold with a sweep time suitable for displaying the variation in the signal level over the frequency span.
8. Record the maximum signal level. This is the peak value of the LPR signal.
9. Calculate the average factor
   Average factor = (TD) / cycle time
   where:
   cycle time is the total time for a complete cycle of the signal including retrace and any other latency times.
10. Determine the average by multiplying the maximum signal level obtained in Step 8 by the average factor.
11. Determine the conducted power output of the EUT or the field strength produced by the EUT at a given distance from the measurements in steps 1 to 10 by calculation taking into account all attenuators, amplifier gains, antenna factor, measurement distance extrapolation, conversion loss, cable losses, etc. as applicable or the signal substitution method.
12. The EIRP is then calculated by applying the appropriate equation as follows:

    a. For conducted measurements EIRP (dBm) = conducted power (dBm) + antenna gain (dBi) where the conducted power is the conducted power output of the EUT and antenna gain is the gain of the EUT antenna.

    b. For radiated emission measurements EIRP (dBm) = E (dBμV/m) – 104.8 + 20 Log D where E is the field strength at the far field distance D.

5.2.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.256 (g)

Fundamental emissions limits. (1) All emission limits provided in this section are expressed in terms of Equivalent Isotropic Radiated Power (EIRP).

The EIRP level is to be determined from the maximum measured power within a specified bandwidth.

(i) The EIRP in 1 MHz is computed from the maximum power level measured within any 1-MHz bandwidth using a power averaging detector;

(ii) The EIRP in 50 MHz is computed from the maximum power level measured with a peak detector in a 50-MHz bandwidth centered on the frequency at which the maximum average power level is realized and this 50 MHz bandwidth must be contained within the authorized operating bandwidth. For a RBW less than 50 MHz, the peak EIRP limit (in dBm) is reduced by 20 log(RBW/50) dB where RBW is the resolution bandwidth in megahertz. The RBW shall not be lower than 1 MHz or greater than 50 MHz. The video bandwidth of the measurement instrument shall not be less than the RBW. If the RBW is greater than 3 MHz, the application for certification filed shall contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

(3) The EIRP limits for LPR operations in the bands authorized by this rule section are provided in Table 1. The emission limits in Table 1 are based on boresight measurements (i.e., measurements performed within the main beam of an LPR antenna).

Table 1

Frequency band of operation (GHz)	Average emission limit (EIRP in dBm measured in 1 MHz)	Peak emission limit (EIRP in dBm measured in 50 MHz)
5.925 – 7.250	-33	7
24.05 – 29.00	-14	26
75 - 85	-3	34

RSS-211: 5.2
(b) For average emission limits, LPR devices shall not exceed the limits provided in Table 1 measured in a 1 MHz measurement bandwidth with an average detector. For peak emission limits, LPR devices shall not exceed the limits provided in Table 1 measured in a 50 MHz measurement bandwidth with a peak detector.

5.2.3 TEST PROTOCOL

Ambient temperature:	24 °C
Air Pressure:	1002 hPa
Humidity:	44 %

EIRP in 1 MHz

Power EIRP [dBm]	Emission Frequency [MHz]	Limit [dBm]	Margin to Power Limit EIRP [dBm]
-31.74	77950.7	-3.0	28.74

COMMENT:
Average-Factor = -50.83 dB

Calculation-Parameters:
Frequency Seep Time Ts = 5.12 ms
Signal Sweep Frequency Span ΔF = 4000 MHz
Re-trace Time = 150 ms
Total-cycle Time = 155.12 ms

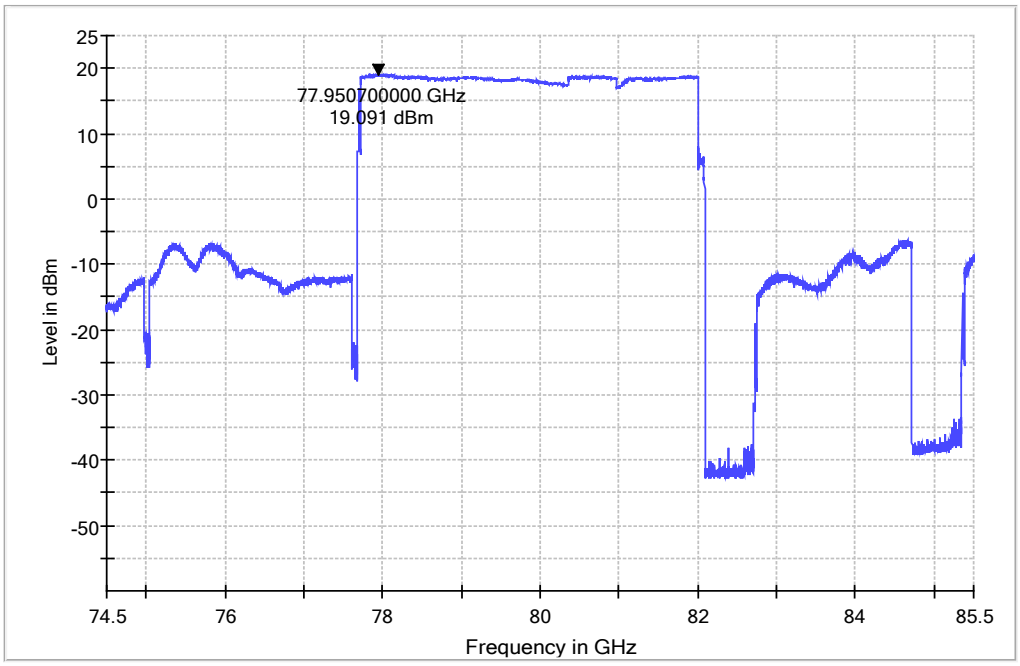
EIRP in 50 MHz

Power EIRP [dBm]	Emission Frequency [MHz]	Limit [dBm]	Margin to Power Limit EIRP [dBm]
25.4	77936.0	34.0	8.6

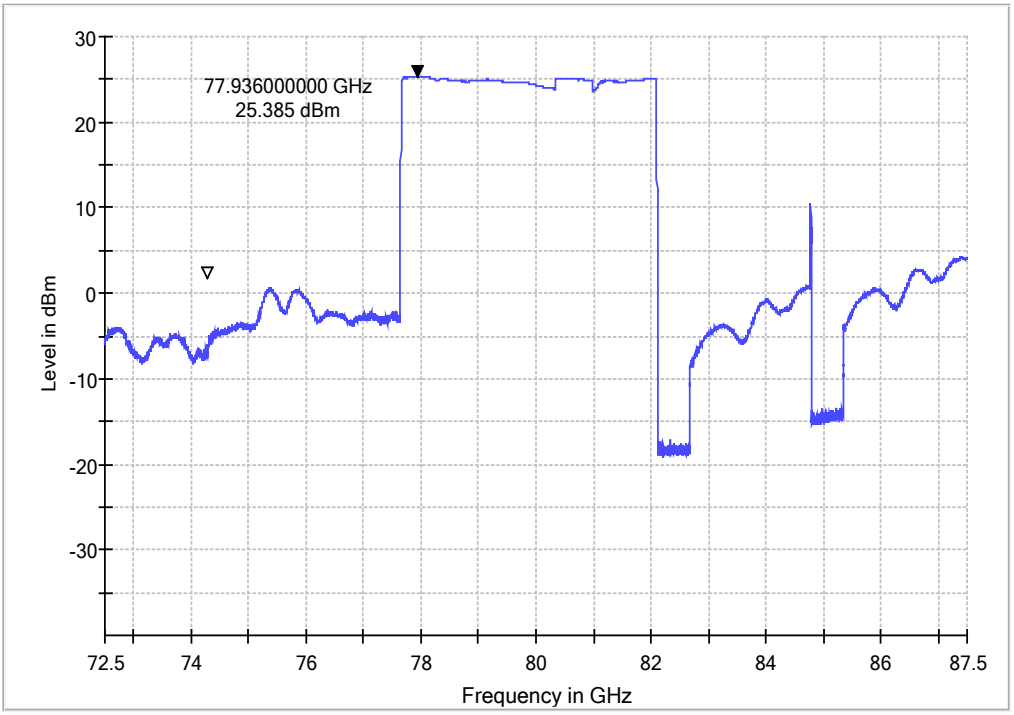
Remark: Please see next sub-clause for the measurement plot.

5.2.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

EIRP in 1 MHz



EIRP in 50 MHz



5.2.5 TEST EQUIPMENT USED

- Radiated Emissions

5.3 UNWANTED EMISSIONS

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

5.3.1 TEST DESCRIPTION

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

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

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

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

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

2. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms

- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

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

Step 2: Adjustment measurement

In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.

For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by ± 45° around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by ± 100 cm around the antenna height determined. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.

- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: ± 45 ° around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector

With the settings determined in step 3, the final measurement will be performed:

EMI receiver settings for step 4:

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

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

3. Measurement above 1 GHz

The following modifications apply to the measurement procedure for the frequency range above 1 GHz:

Step 1:

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only.

The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90 °.

The turn table step size (azimuth angle) for the preliminary measurement is 45 °.

Step 2:

Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna instep 2 is omitted. Instead of this, a maximum search with a step size ± 45° for the elevation axis is performed.

The turn table azimuth will slowly vary by ± 22.5°.

The elevation angle will slowly vary by ± 45°

EMI receiver settings (for all steps):

- Detector: Peak, Average
- IF Bandwidth = 1 MHz

Step 3:

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

5.3.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.256 (h)
.*Unwanted emissions limits.* Unwanted emissions from LPR devices shall not exceed the general emission limit in §15.209 of this chapter.

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

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according FCC 15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m
above 40000	500@3m	0.5	54.0@3m

The measured values above 26 GHz are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

RSS-211: 5.3
(a) The device shall be installed inside a closed container or in a still pipe by qualified installers.
(b) The leakage of the RF field outside the container at 3 m from the container or still pipe walls shall not exceed the values outlined in Table. The levels shall be assessed using the procedures defined in ETSI EN 302 372.

Frequency Band [GHz]	Maximum Average EIRP (in dBm/MHz) Outside Tank Enclosure Structure Inside the Operating Frequency Range
5.65 – 8.50	-41.3
8.50 - 10.55	-41.3
24.05 – 29.00	-41.3
75 - 85	-41.3

5.3.3 TEST PROTOCOL

Ambient temperature: 20 °C – 25 °C
Air Pressure: 1000 hPa – 1020 hPa
Humidity: 30 % - 40 %

S01_CB01

Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]
96.030000	27.09	QP	120	43.50	16.41
332.640000	30.33	QP	120	46.00	15.67
385.200000	35.84	QP	120	46.00	10.16
389.760000	33.42	QP	120	46.00	12.58
393.480000	34.07	QP	120	46.00	11.93
450.000000	42.26	QP	120	46.00	3.74
770.010000	40.71	QP	120	46.00	5.29

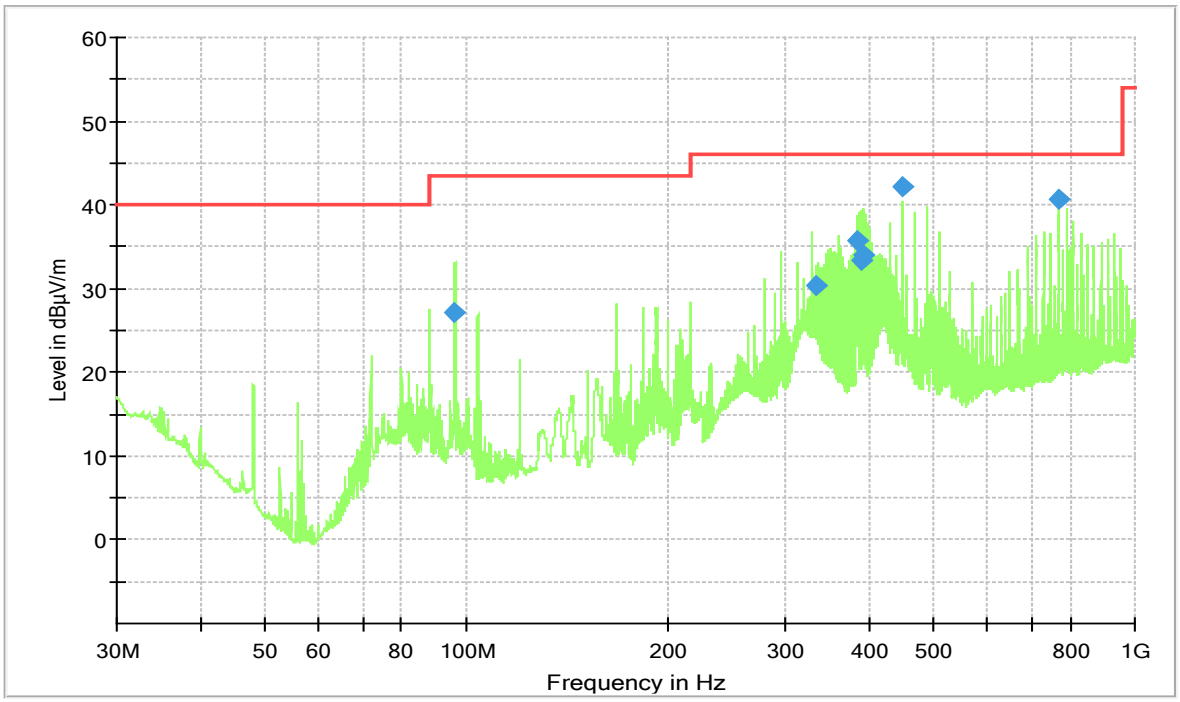
S01_FB01

Spurious Freq. [MHz]	Spurious Level [dBµV/m]	Detec-tor	RBW [kHz]	Limit [dBµV/m]	Margin to Limit [dB]
450.000000	40.44	QP	120	43.50	5.56
470.010000	40.83	QP	120	46.00	5.17
489.990000	41.87	QP	120	46.00	4.13
510.000000	41.65	QP	120	46.00	4.35
530.010000	40.50	QP	120	46.00	5.50
570.000000	32.98	QP	120	46.00	13.02
590.010000	31.37	QP	120	46.00	14.63
709.980000	38.71	QP	120	46.00	7.29
729.870000	40.39	QP	120	46.00	5.61
750.000000	42.03	QP	120	46.00	3.97
770.010000	41.21	QP	120	46.00	4.79
789.990000	40.19	QP	120	46.00	5.81
870.000000	37.29	QP	120	46.00	8.71

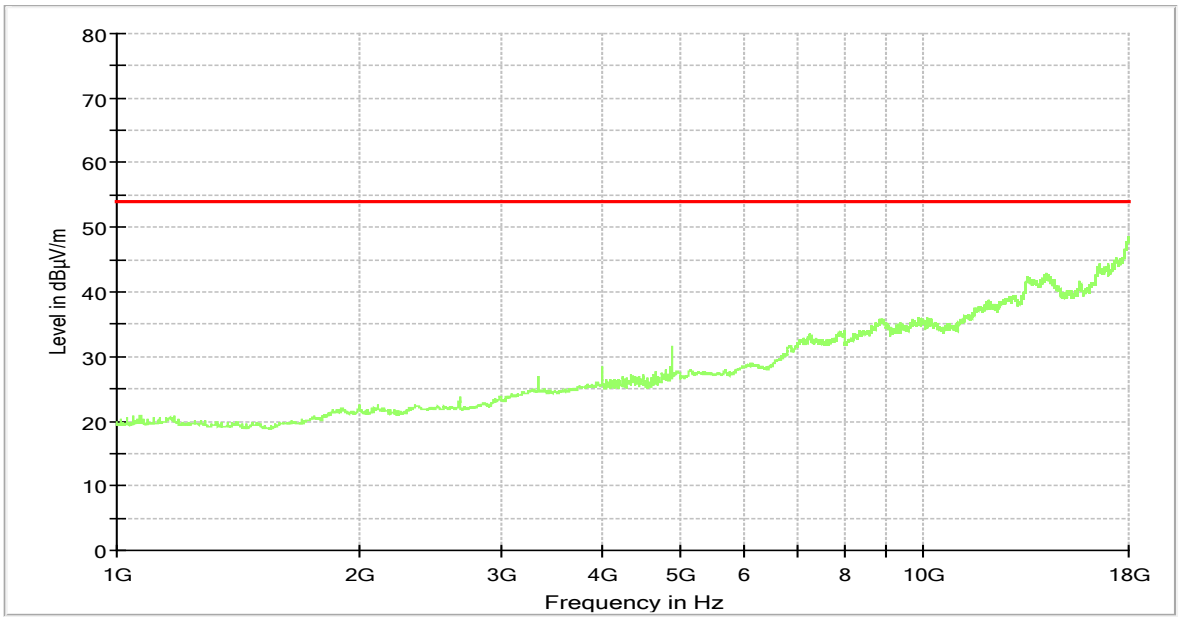
Remark: Please see next sub-clause for the measurement plot.

5.3.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

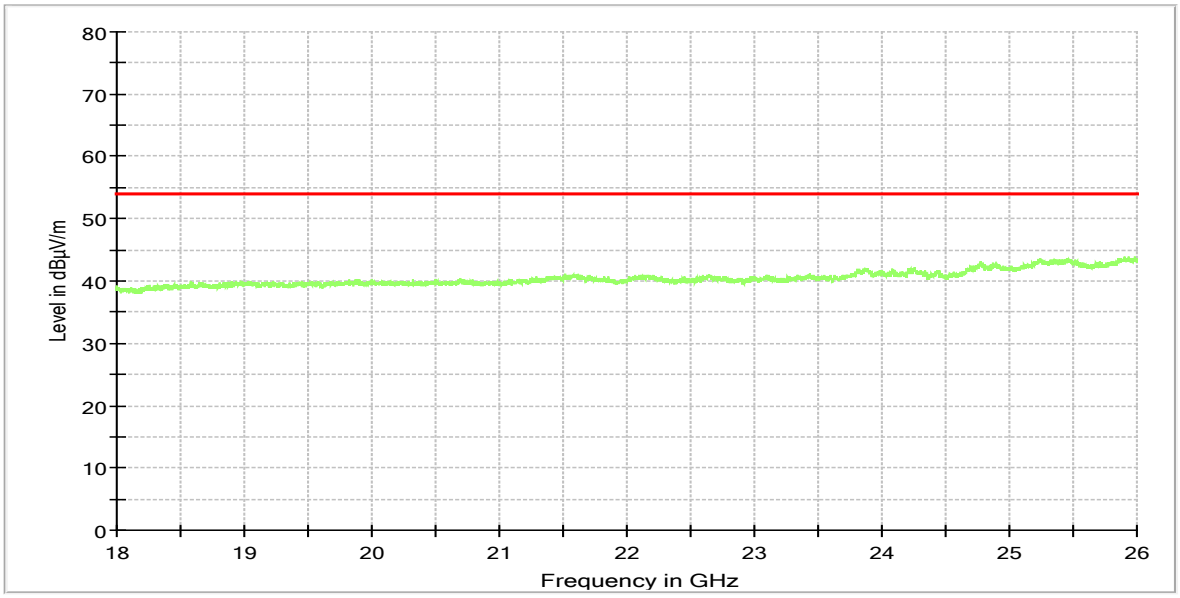
S01_CB01
30 MHz – 1 GHz



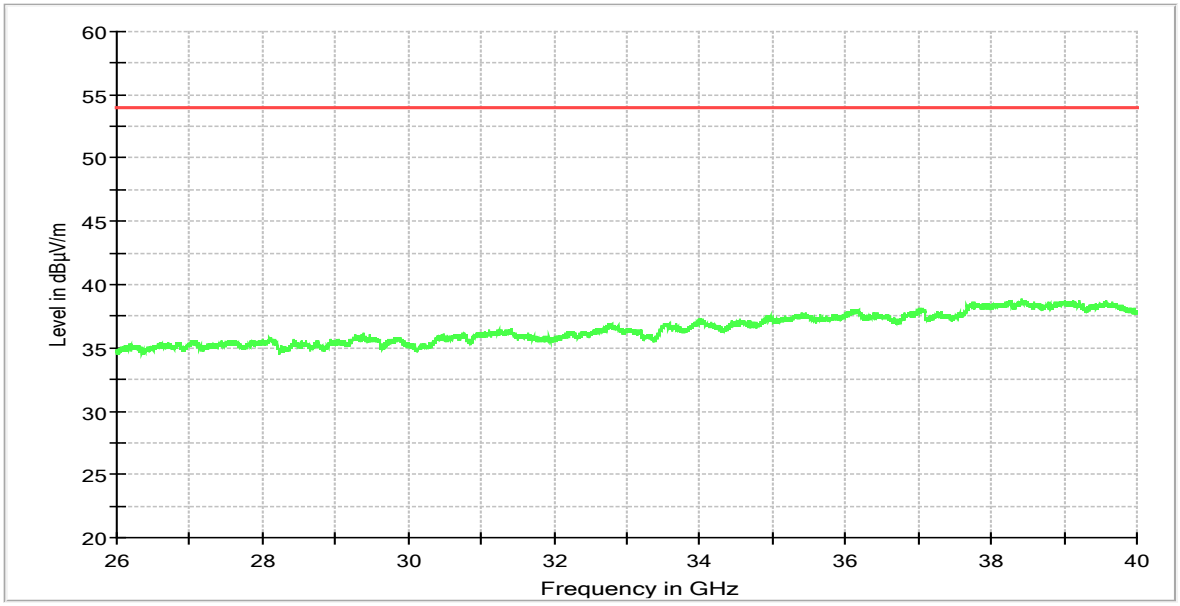
S01_CB01
1 GHz – 18 GHz



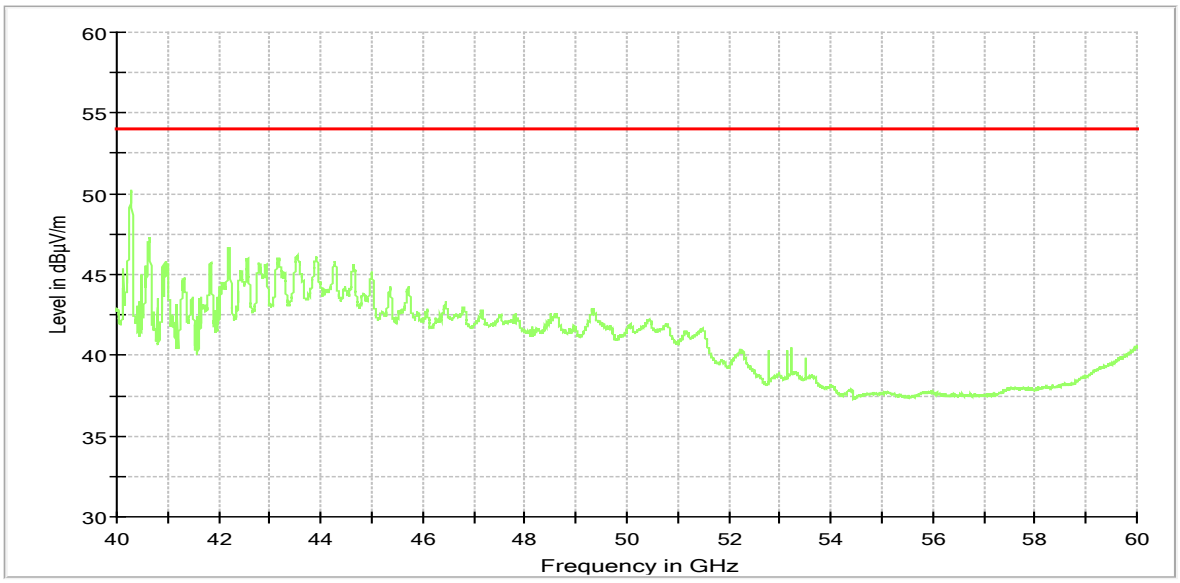
S01_CB01
18 GHz – 26 GHz



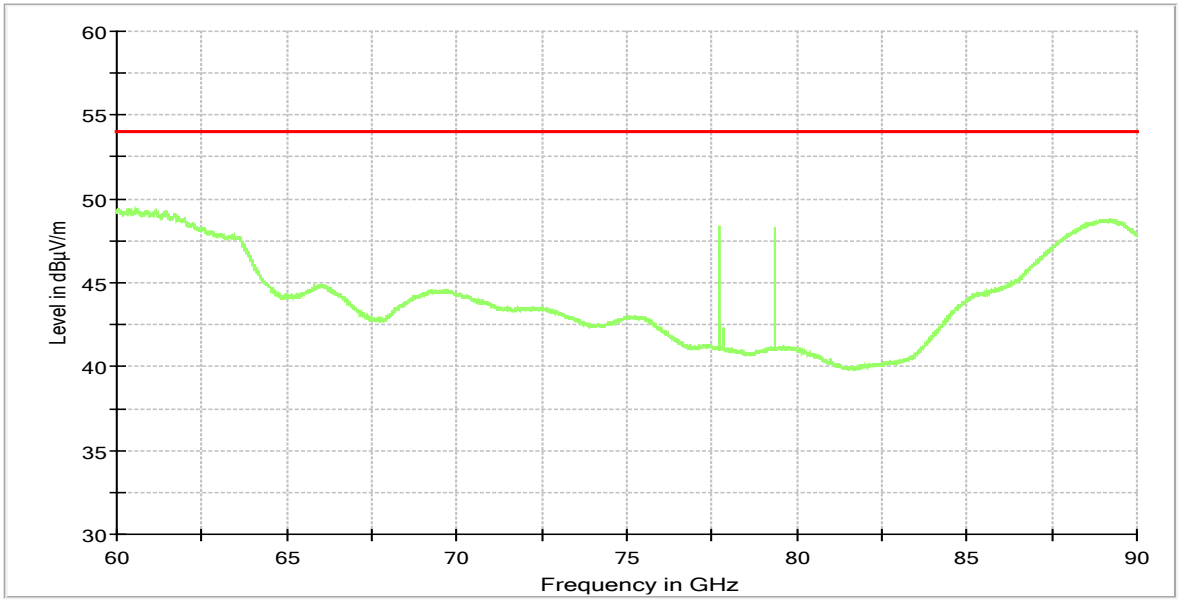
S01_CB01
26 GHz – 40 GHz



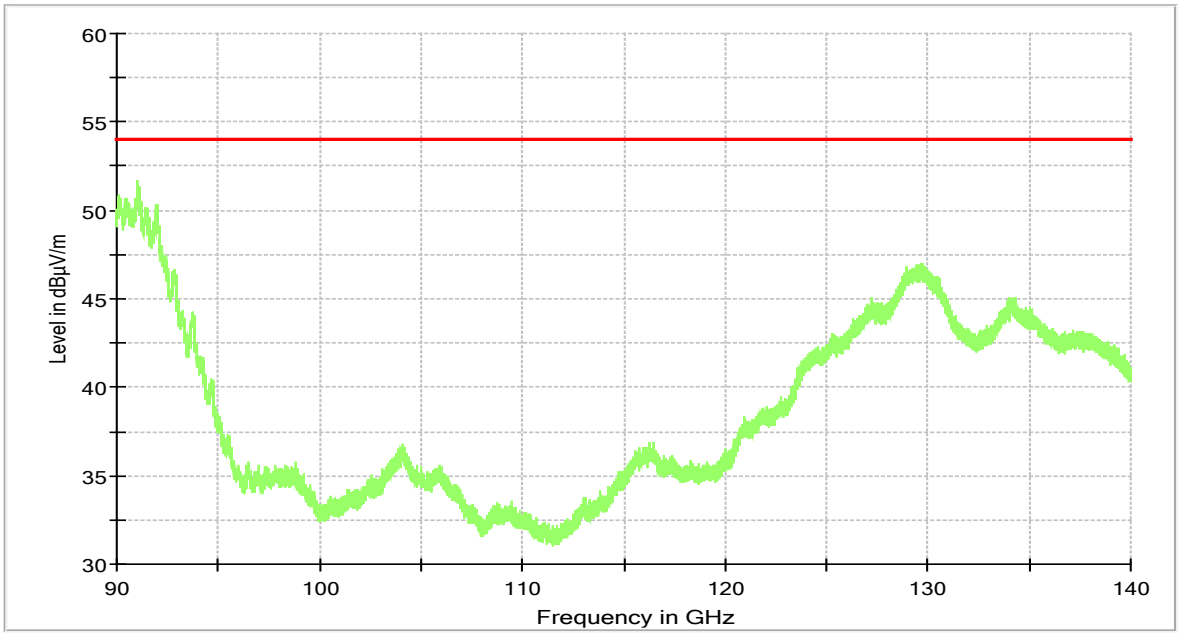
S01_CB01
40 GHz – 60 GHz



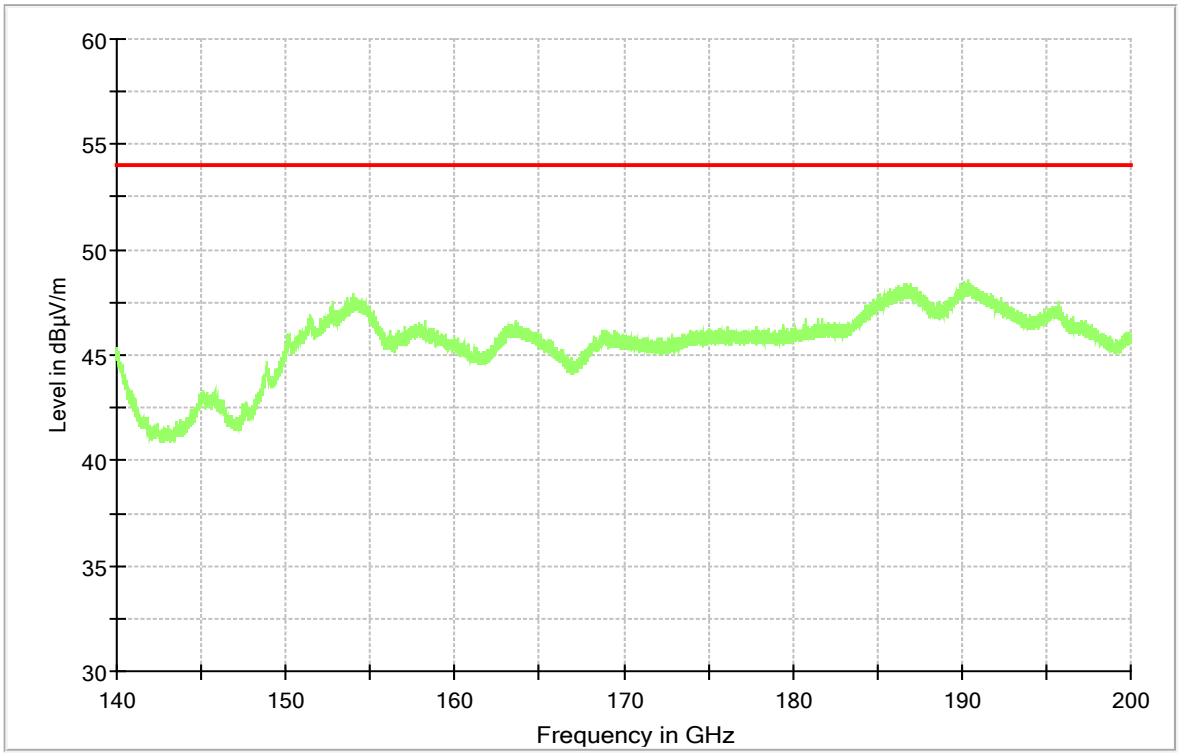
S01_CB01
60 GHz – 90 GHz



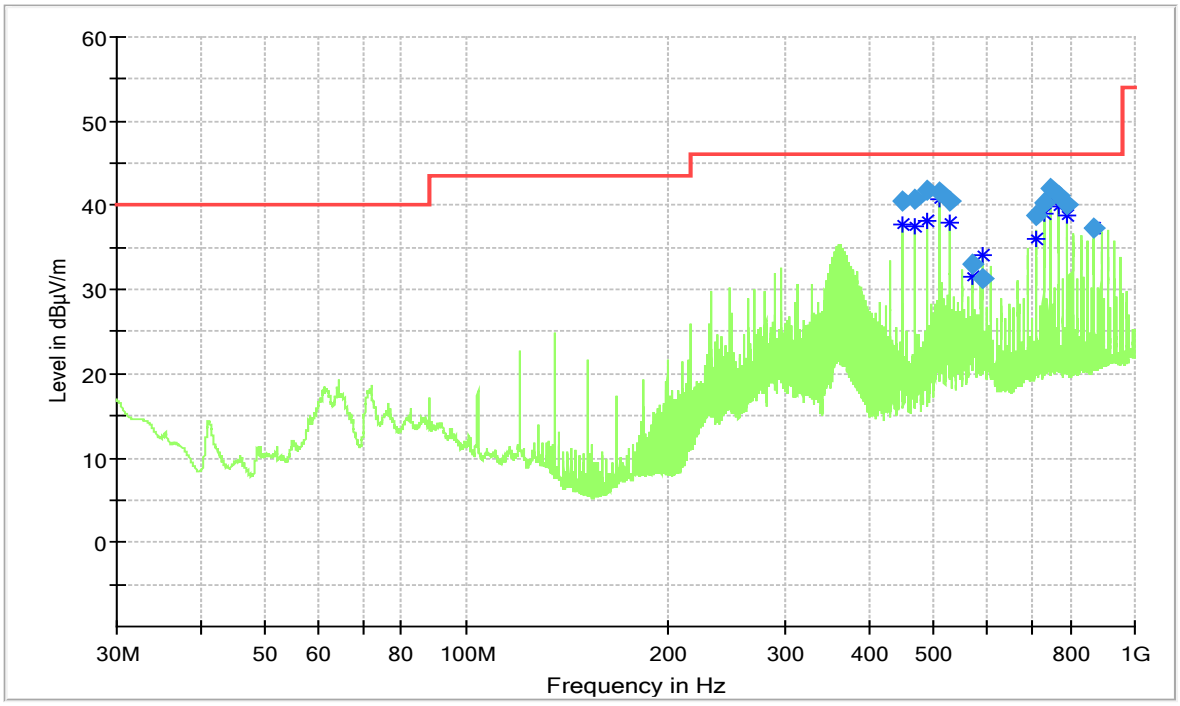
S01_CB01
90 GHz – 140 GHz



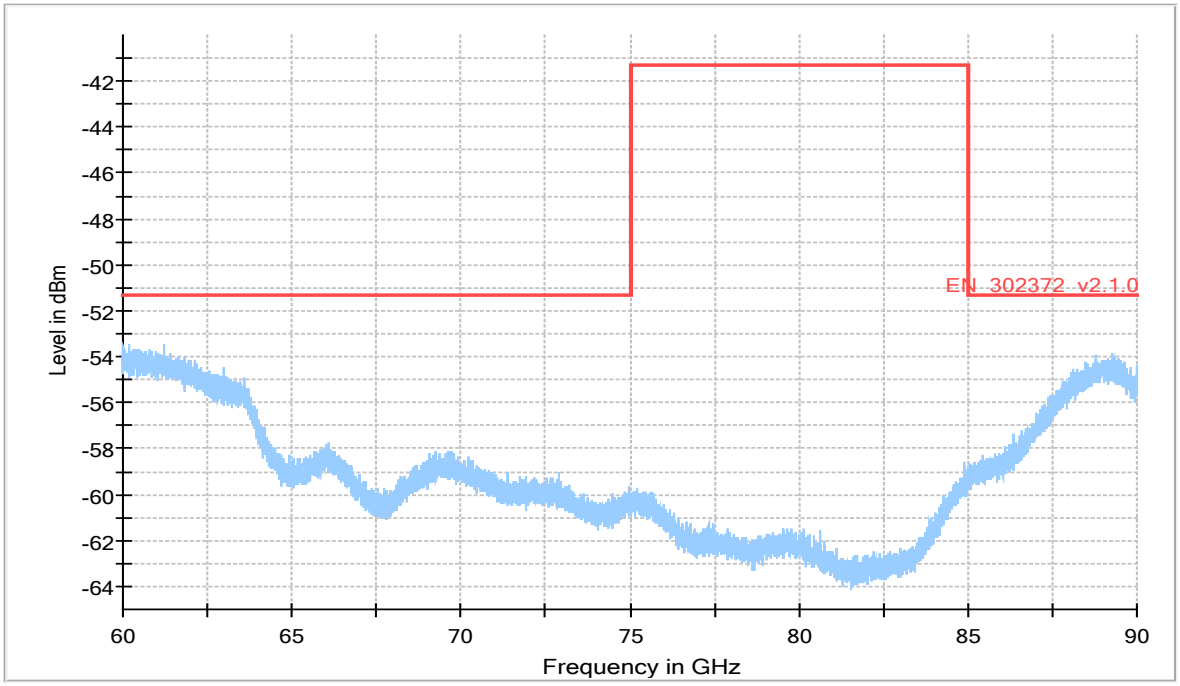
S01_CB01
140 GHz – 200 GHz



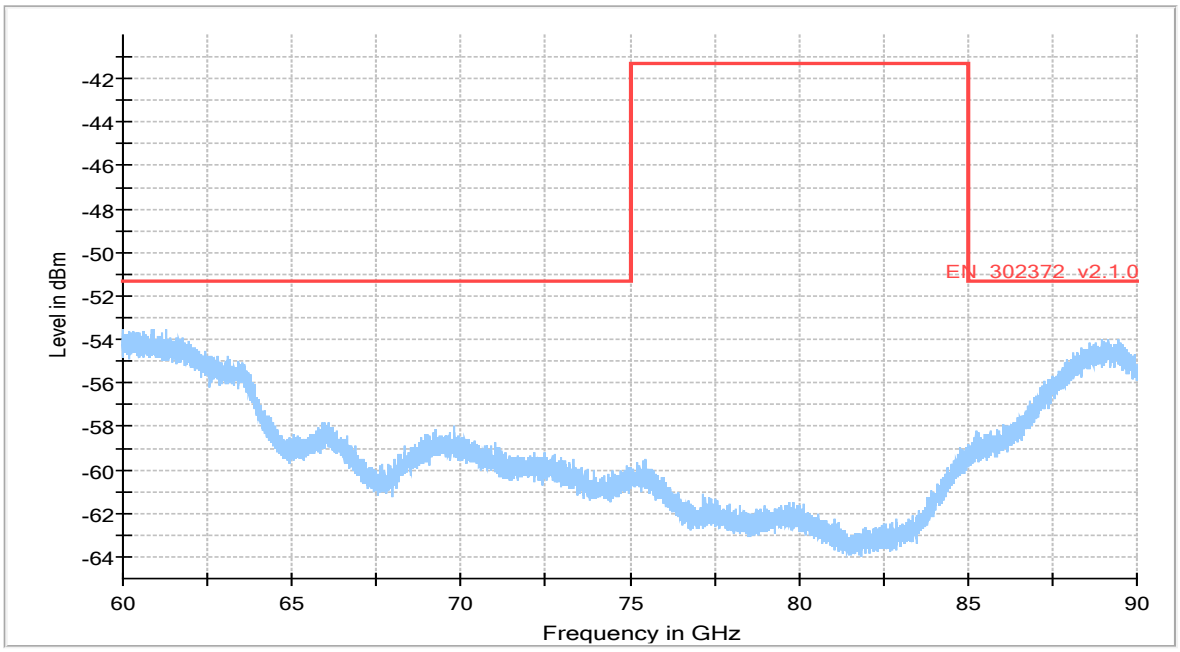
S01_FB01
30 MHz – 1 GHz



S01_CB01
60 GHz – 90 GHz



S01_FB01
60 GHz – 90 GHz



5.3.5 TEST EQUIPMENT USED

- Radiated Emissions

5.4 ANTENNA BEAMWIDTH

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

5.4.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.
All steps were performed with one height (1.5 m) of the receiving antenna only.
The EUT is turned during the measurement the turn table step size (azimuth angle) for the measurement is 1 °, the Turntable angle range: –180° to +180°.

Analyzer settings:

- Resolution Bandwidth (RBW): 1000 kHz
- Video Bandwidth (VBW): 3000 kHz
- Span: zero-span
- Trace: Maxhold
- Sweeps: single
- Sweeptime: 1 s
- Detector: Peak

5.4.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.256 (i) (B)

(i) Antenna beamwidth.

(A) LPR devices operating under the provisions of this section within the 5.925-7.250 GHz and 24.05-29.00 GHz bands must use an antenna with a −3 dB beamwidth no greater than 12 degrees.

(B) LPR devices operating under the provisions of this section within the 75-85 GHz band must use an antenna with a −3 dB beamwidth no greater than 8 degrees.

RSS-211: 5.2

(a) For devices operating in open-air environments, the antenna shall have a maximum half-power beamwidth of 12° for the bands 5.65-8.5 GHz and 24.05-29 GHz, and a maximum half-power beamwidth of 8° for the band 75-85 GHz.

5.4.3 TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1002 hPa
Humidity: 44 %

S01_CB01
COMMENT: only an extract of the table is represented

Normalized Azimuth [deg]	Normalized Level [dB]	Half-Power Beamwidth Limit [dbc]	Side-Lobe Gain Limit [dbc]	Margin to 3 dB Limit [dB]	Margin to side-lobe Limit [dB]
294.0	-49.4	-3	-38	-46.4	-11.4
295.0	-49.2	-3	-38	-46.2	-11.2
296.0	-52.8	-3	-38	-49.8	-14.8
297.0	-50.0	-3	-38	-47.0	-12.0
298.0	-47.7	-3	-38	-44.7	-9.7
299.0	-51.2	-3	-38	-48.2	-13.2
300.0	-57.4	-3	N/A	-54.4	N/A
301.0	-54.6	-3	N/A	-51.6	N/A
302.0	-51.3	-3	N/A	-48.3	N/A
303.0	-52.4	-3	N/A	-49.4	N/A
304.0	-53.6	-3	N/A	-50.6	N/A
305.0	-52.5	-3	N/A	-49.5	N/A
306.0	-48.9	-3	N/A	-45.9	N/A
307.0	-45.7	-3	N/A	-42.7	N/A
308.0	-45.5	-3	N/A	-42.5	N/A
309.0	-44.4	-3	N/A	-41.4	N/A
310.0	-42.0	-3	N/A	-39.0	N/A
311.0	-42.1	-3	N/A	-39.1	N/A
312.0	-42.4	-3	N/A	-39.4	N/A
313.0	-39.7	-3	N/A	-36.7	N/A
314.0	-39.6	-3	N/A	-36.6	N/A
315.0	-45.2	-3	N/A	-42.2	N/A
316.0	-44.5	-3	N/A	-41.5	N/A
317.0	-46.6	-3	N/A	-43.6	N/A
318.0	-46.8	-3	N/A	-43.8	N/A
319.0	-51.8	-3	N/A	-48.8	N/A
320.0	-52.3	-3	N/A	-49.3	N/A
321.0	-41.1	-3	N/A	-38.1	N/A
322.0	-40.9	-3	N/A	-37.9	N/A
323.0	-39.1	-3	N/A	-36.1	N/A
324.0	-38.5	-3	N/A	-35.5	N/A
325.0	-38.4	-3	N/A	-35.4	N/A
326.0	-36.9	-3	N/A	-33.9	N/A
327.0	-36.7	-3	N/A	-33.7	N/A
328.0	-36.8	-3	N/A	-33.8	N/A
329.0	-36.8	-3	N/A	-33.8	N/A
330.0	-36.2	-3	N/A	-33.2	N/A
331.0	-35.9	-3	N/A	-32.9	N/A
332.0	-35.3	-3	N/A	-32.3	N/A
333.0	-34.8	-3	N/A	-31.8	N/A
334.0	-35.0	-3	N/A	-32.0	N/A
335.0	-35.4	-3	N/A	-32.4	N/A
336.0	-35.5	-3	N/A	-32.5	N/A
337.0	-35.6	-3	N/A	-32.6	N/A
338.0	-35.4	-3	N/A	-32.4	N/A
339.0	-32.6	-3	N/A	-29.6	N/A
340.0	-32.7	-3	N/A	-29.7	N/A
341.0	-29.4	-3	N/A	-26.4	N/A
342.0	-28.7	-3	N/A	-25.7	N/A
343.0	-27.6	-3	N/A	-24.6	N/A

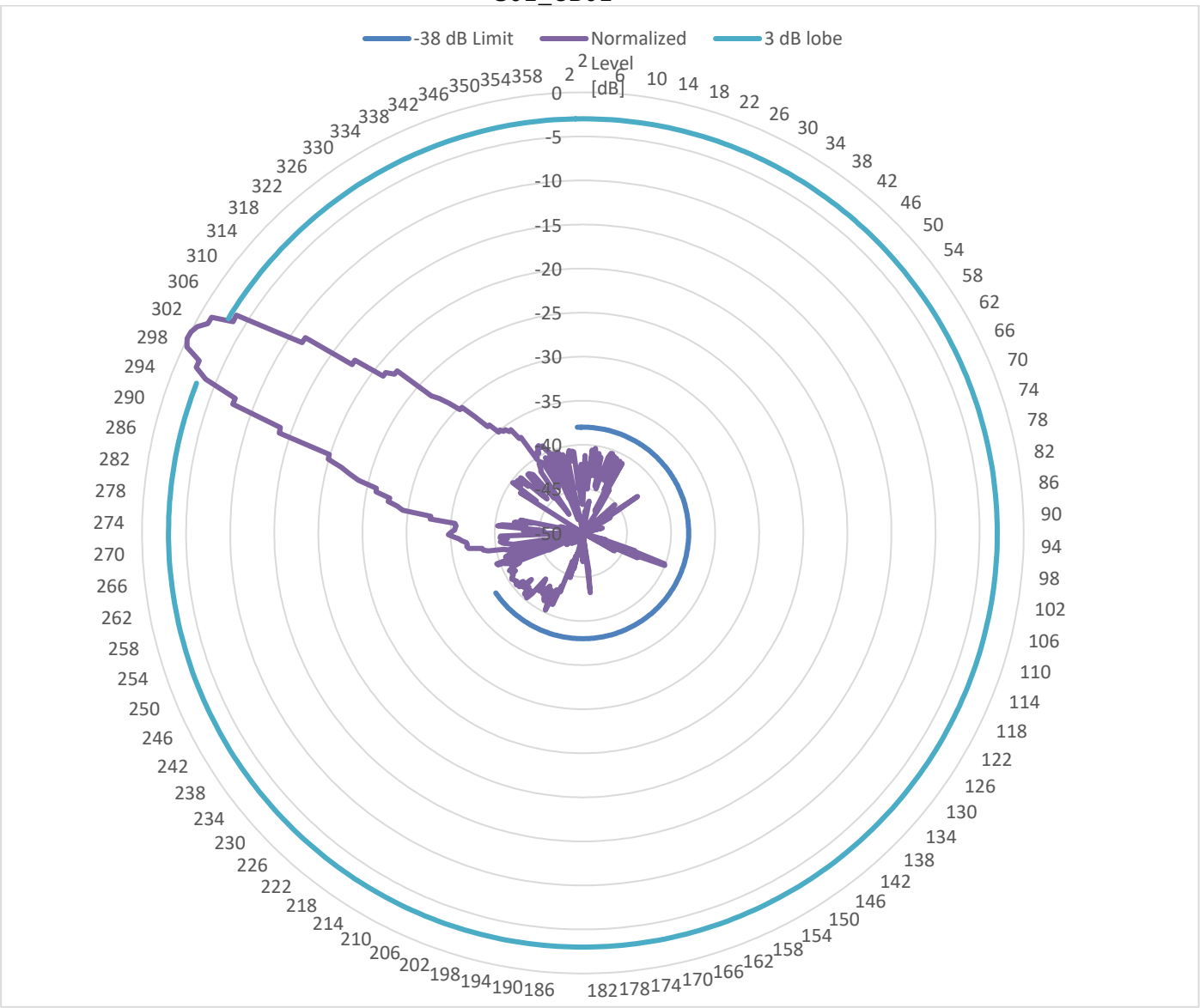
344.0	-27.8	-3	N/A	-24.8	N/A
345.0	-26.1	-3	N/A	-23.1	N/A
346.0	-26.0	-3	N/A	-23.0	N/A
347.0	-23.8	-3	N/A	-20.8	N/A
348.0	-22.7	-3	N/A	-19.7	N/A
349.0	-21.6	-3	N/A	-18.6	N/A
350.0	-19.9	-3	N/A	-16.9	N/A
351.0	-19.9	-3	N/A	-16.9	N/A
352.0	-13.7	-3	N/A	-10.7	N/A
353.0	-13.7	-3	N/A	-10.7	N/A
354.0	-7.7	-3	N/A	-4.7	N/A
355.0	-7.7	-3	N/A	-4.7	N/A
356.0	-3.8	N/A	N/A	N/A	N/A
357.0	-2.3	N/A	N/A	N/A	N/A
358.0	-2.3	N/A	N/A	N/A	N/A
359.0	-0.4	N/A	N/A	N/A	N/A
0.0	0.0	N/A	N/A	N/A	N/A
1.0	0.0	N/A	N/A	N/A	N/A
2.0	-0.4	N/A	N/A	N/A	N/A
3.0	-1.3	N/A	N/A	N/A	N/A
4.0	-1.3	N/A	N/A	N/A	N/A
5.0	-3.6	-3	N/A	-0.6	N/A
6.0	-3.6	-3	N/A	-0.6	N/A
7.0	-8.1	-3	N/A	-5.1	N/A
8.0	-11.5	-3	N/A	-8.5	N/A
9.0	-11.5	-3	N/A	-8.5	N/A
10.0	-17.6	-3	N/A	-14.6	N/A
11.0	-17.5	-3	N/A	-14.5	N/A
12.0	-21.2	-3	N/A	-18.2	N/A
13.0	-21.1	-3	N/A	-18.1	N/A
14.0	-22.0	-3	N/A	-19.0	N/A
15.0	-22.0	-3	N/A	-19.0	N/A
16.0	-26.8	-3	N/A	-23.8	N/A
17.0	-27.6	-3	N/A	-24.6	N/A
18.0	-28.9	-3	N/A	-25.9	N/A
19.0	-30.2	-3	N/A	-27.2	N/A
20.0	-30.3	-3	N/A	-27.3	N/A
21.0	-32.0	-3	N/A	-29.0	N/A
22.0	-33.8	-3	N/A	-30.8	N/A
23.0	-33.8	-3	N/A	-30.8	N/A
24.0	-35.1	-3	N/A	-32.1	N/A
25.0	-35.0	-3	N/A	-32.0	N/A
26.0	-35.4	-3	N/A	-32.4	N/A
27.0	-35.4	-3	N/A	-32.4	N/A
28.0	-35.8	-3	N/A	-32.8	N/A
29.0	-35.7	-3	N/A	-32.7	N/A
30.0	-37.1	-3	N/A	-34.1	N/A
31.0	-37.1	-3	N/A	-34.1	N/A
32.0	-40.2	-3	N/A	-37.2	N/A
33.0	-39.9	-3	N/A	-36.9	N/A
34.0	-39.5	-3	N/A	-36.5	N/A
35.0	-39.7	-3	N/A	-36.7	N/A
36.0	-39.0	-3	N/A	-36.0	N/A
37.0	-38.9	-3	N/A	-35.9	N/A
38.0	-39.2	-3	N/A	-36.2	N/A
39.0	-39.1	-3	N/A	-36.1	N/A
40.0	-39.8	-3	N/A	-36.8	N/A
41.0	-40.0	-3	N/A	-37.0	N/A
42.0	-45.8	-3	N/A	-42.8	N/A
43.0	-45.6	-3	N/A	-42.6	N/A
44.0	-48.0	-3	N/A	-45.0	N/A
45.0	-48.4	-3	N/A	-45.4	N/A
46.0	-42.7	-3	N/A	-39.7	N/A
47.0	-42.8	-3	N/A	-39.8	N/A
48.0	-41.4	-3	N/A	-38.4	N/A

49.0	-40.9	-3	N/A	-37.9	N/A
50.0	-42.7	-3	N/A	-39.7	N/A
51.0	-44.8	-3	N/A	-41.8	N/A
52.0	-46.7	-3	N/A	-43.7	N/A
53.0	-48.1	-3	N/A	-45.1	N/A
54.0	-48.6	-3	N/A	-45.6	N/A
55.0	-54.4	-3	N/A	-51.4	N/A
56.0	-54.8	-3	N/A	-51.8	N/A
57.0	-56.8	-3	N/A	-53.8	N/A
58.0	-49.8	-3	N/A	-46.8	N/A
59.0	-51.6	-3	N/A	-48.6	N/A
60.0	-49.6	-3	N/A	-46.6	N/A
61.0	-50.0	-3	-38	-47.0	-12.0
62.0	-49.4	-3	-38	-46.4	-11.4
63.0	-50.0	-3	-38	-47.0	-12.0

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

5.4.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

S01_CB01



5.4.5 TEST EQUIPMENT USED

- Radiated Emissions

5.5 ANTENNA SIDE LOBE GAIN

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

5.5.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.
All steps were performed with one height (1.5 m) of the receiving antenna only.
The EUT is turned during the measurement the turn table step size (azimuth angle) for the measurement is 1 °, the Turntable angle range: –180° to +180°.

Analyzer settings:

- Resolution Bandwidth (RBW): 1000 kHz
- Video Bandwidth (VBW): 3000 kHz
- Span: zero-span
- Trace: Maxhold
- Sweeps: single
- Sweeptime: 1 s
- Detector: Peak

5.5.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.256 (j)

Antenna side lobe gain. LPR devices operating under the provisions of this section must limit the side lobe antenna gain relative to the main beam gain for off-axis angles from the main beam of greater than 60 degrees to the levels provided in Table.

Antenna Side Lobe Gain Limits

Frequency range (GHz)	Antenna side lobe gain limit relative to main beam gain (dB)
5.925 – 7.250	-22
24.05 – 29.00	-27
75 - 85	-38

RSS-211: 5.2

(c)LPR devices must limit the antenna side lobe gain relative to the main beam gain for off-axis angles from the main beam of greater than 60° for the levels provided in Table.

Frequency range (GHz)	Antenna side lobe gain limit relative to main beam gain (dB)
5.925 – 7.250	-22
24.05 – 29.00	-27
75 - 85	-38

5.5.3 TEST PROTOCOL

For test results please refer to Chapter 5.4 Antenna Beamwidth

5.5.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

For test results please refer to Chapter 5.4 Antenna Beamwidth

5.5.5 TEST EQUIPMENT USED

- Radiated Emissions

5.6 FREQUENCY STABILITY

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

5.6.1 TEST DESCRIPTION

As specified in Section 15.215(c), the bandwidth of the fundamental emission must be contained within the frequency band over the temperature range -20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage. Frequency stability is to be measured according to Section 2.1055 at the highest and lowest frequency of operation and with the modulation that produces the widest emission bandwidth.

5.6.2 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.215 (c)

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

RSS-211: 5.1

(b) The fundamental emission bandwidth shall be confined within the designated device operating bands under all conditions.

5.6.3 TEST PROTOCOL

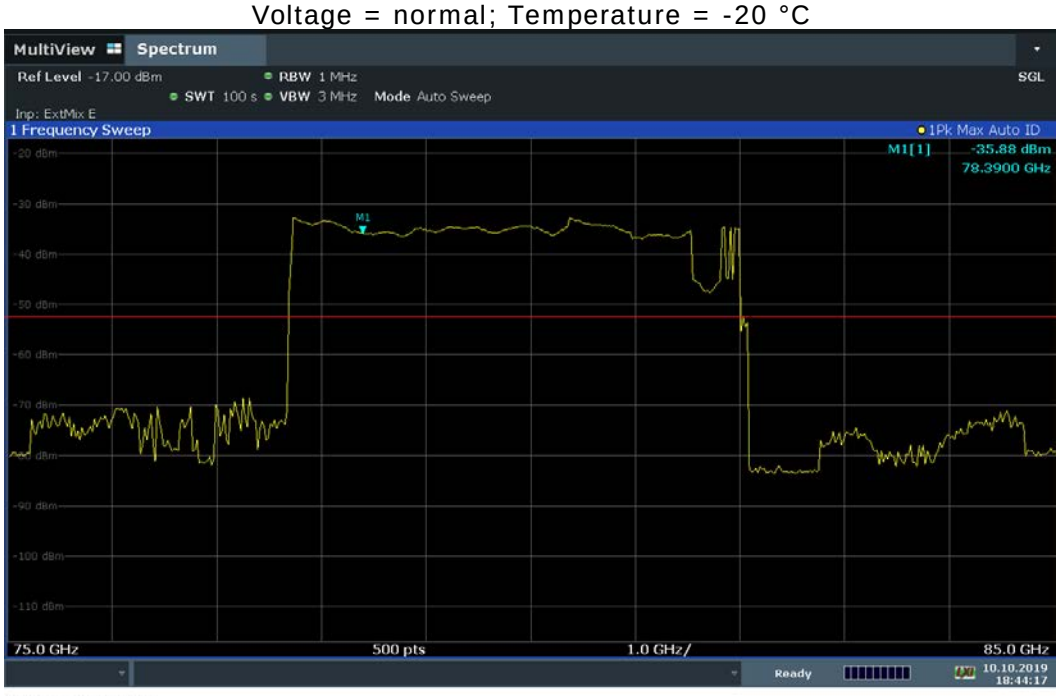
Ambient temperature: 24 °C
Air Pressure: 1002 hPa
Humidity: 44 %

Ch. Center Freq. [MHz]	Temperature	Voltage	Limit	Verdict
80000	-20 °C	normal	20 dBc	Passed
80000	-10 °C	normal	20 dBc	Passed
80000	0 °C	normal	20 dBc	Passed
80000	10 °C	normal	20 dBc	Passed
80000	20 °C	low	20 dBc	Passed
80000	20 °C	normal	20 dBc	Passed
80000	20 °C	high	20 dBc	Passed
80000	30 °C	normal	20 dBc	Passed
80000	40 °C	normal	20 dBc	Passed
80000	50 °C	normal	20 dBc	Passed

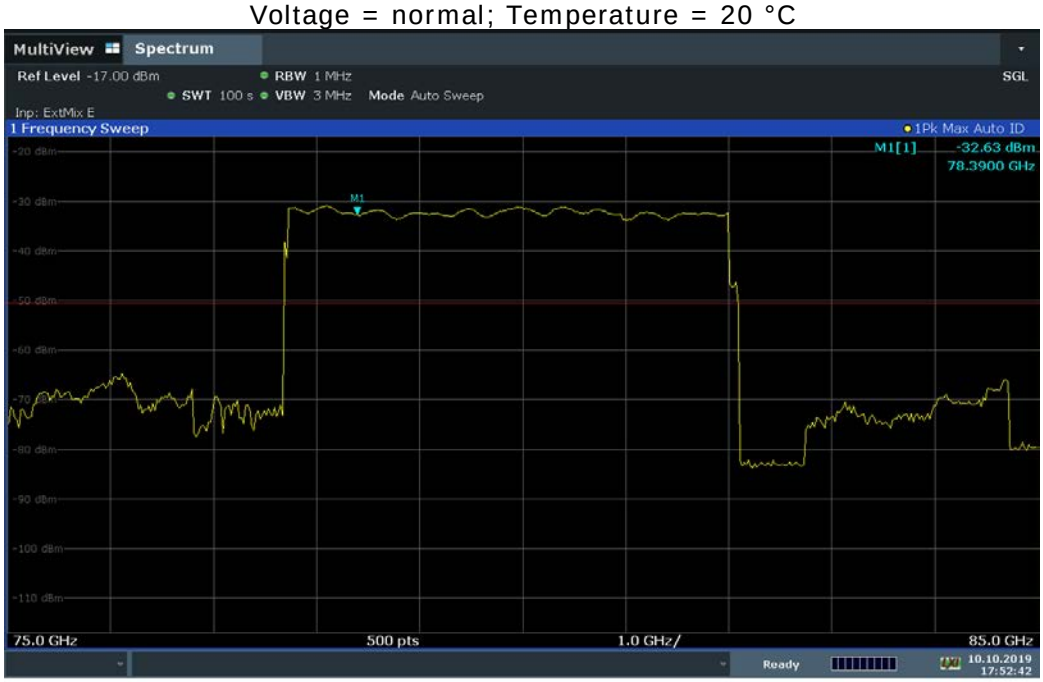
Remark: Please see next sub-clause for the measurement plot.

5.6.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)

S01_CB01
Voltage = normal; Temperature = -20 °C

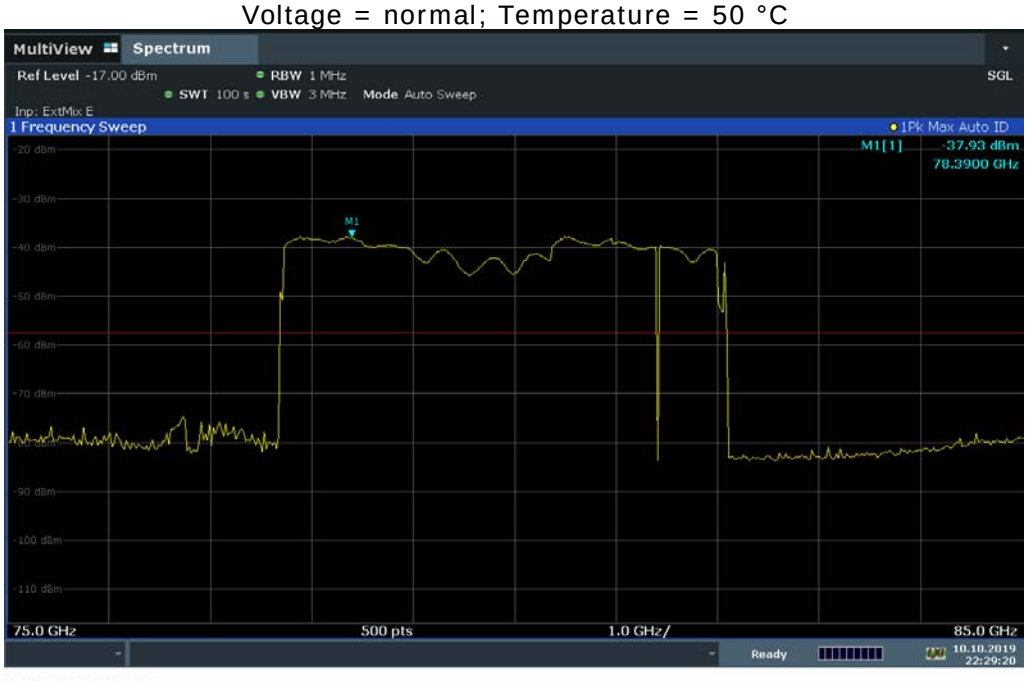


S01_CB01
Voltage = normal; Temperature = 20 °C



17:52:42 10.10.2019

S01_CB01
Voltage = normal; Temperature = 50 °C



22:29:21 10.10.2019

5.6.5 TEST EQUIPMENT USED

- Radiated Emissions

6 TEST EQUIPMENT

1 R&S TS8997
EN300328/301893 Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2017-07	2020-07
1.2	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-04	2020-04
1.3	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
1.4	Temperature Chamber VT 4002	Temperature Chamber Vötsch 03	Vötsch	58566002150010	2018-04	2020-04
1.5	A8455-4	4 Way Power Divider (SMA)		-		
1.6	Opus10 THI (8152.00)	ThermoHygro Datalogger 03	Lufft Mess- und Regeltechnik GmbH	ID 7482	2019-06	2021-06
1.7	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2016-10	2019-10
1.8	OSP120	Switching Unit with integrated power meter	Rohde & Schwarz	101158	2018-05	2021-05

2 Radiated Emissions
Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2018-10	2020-10
2.2	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515		
2.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13	Lufft Mess- und Regeltechnik GmbH	ID 13936	2019-05	2021-05
2.4	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2018-05	2019-11
2.5	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia	none	2018-06	2020-06
2.6	FS-Z60	Harmonic Mixer 40 - 60 GHz	Rohde & Schwarz Messgerätebau GmbH	100178	2016-12	2019-12
2.7	FS-Z220	Harmonic Mixer 140 - 220 GHz	Rohde & Schwarz Messgerätebau GmbH	101005	2017-03	2020-03

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.8	SGH-05	Standard Gain / Pyramidal Horn Antenna (140 - 220 GHz)	RPG-Radiometer Physics GmbH	075		
2.9	HL 562 ULTRALOG	Biconical-log-per antenna (30 MHz - 3 GHz) with HL 562E biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2018-07	2021-07
2.10	AMF-7D00101800-30-10P-R	Broadband Amplifier 100 MHz - 18 GHz	Miteq			
2.11	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
2.12	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
2.13	Anechoic Chamber 03	FAR, 8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	2018-06	2020-06
2.14	SMBV100A	Vector Signal Generator 9 kHz - 3.2 GHz (GNSS / Broadcast Signalling Unit)	Rohde & Schwarz GmbH & Co. KG	260001	2018-01	2021-01
2.15	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
2.16	WRD1920/1980-5/22-5EESD	Tunable Band Reject Filter	Wainwright Instruments GmbH	11		
2.17	TDS 784C	Digital Oscilloscope [SA2] (Aux)	Tektronix	B021311		
2.18	foRS232 Unit 2	Fibre optic link RS232	PONTIS Messtechnik GmbH	4031516037		
2.19	PONTIS Con4101	PONTIS Camera Controller		6061510370		
2.20	NRVD	Power Meter	Rohde & Schwarz GmbH & Co. KG	828110/016	2019-08	2020-08
2.21	OLS-1 R	Fibre optic link USB 1.1	Ingenieurbüro Scheiba	018		
2.22	HF 906	Double-ridged horn	Rohde & Schwarz	357357/002	2018-09	2021-09
2.23	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
2.24	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2019-02	2021-02
2.25	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.26	foRS232 Unit 1	Fibre optic link RS232	PONTIS Messtechnik GmbH	4021516036		
2.27	FSP3	Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	836722/011		
2.28	SGH-19	Standard Gain / Pyramidal Horn Antenna (40 - 60 GHz)	RPG-Radiometer Physics GmbH	093		
2.29	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright Instruments GmbH	09		
2.30	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99		
2.31	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
2.32	foUSB-M Converter 2	Fibre optic link USB 2.0	PONTIS Messtechnik GmbH	4471520061		
2.33	WRCD1879.8-0.2/40-10EE	Notch Filter Ultra Stable	Wainwright Instruments GmbH	16		
2.34	Chroma 6404	AC Source	Chroma ATE INC.	64040001304		
2.35	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
2.36	TT 1.5 WI	Turn Table	Maturo GmbH	-		
2.37	HL 562 ULTRALOG	Biconical-log-per Antenna (30 MHz - 3 GHz)	Rohde & Schwarz GmbH & Co. KG	100609	2019-05	2022-05
2.38	HF 906	Double-ridged horn	Rohde & Schwarz	357357/001	2018-03	2021-03
2.39	foCAN (v 4.0)	Fibre optic link CAN	Audivo GmbH (PONTIS EMC)	492 1607 014		
2.40	FS-Z325	Harmonic Mixer 220 - 325 GHz	Rohde & Schwarz Messgerätebau GmbH	101006	2017-03	2020-03
2.41	CMW 500	CMW 500 Flex 2	Rohde & Schwarz GmbH & Co. KG	155999-Ei	2019-09	2022-09
2.42	CMU 200	"CMU1" Universal Radio Communicatio n Tester	Rohde & Schwarz GmbH & Co. KG	102366	2016-12	2019-12
2.43	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronic GmbH	00086675		
2.44	MA4985-XP-ET	Bore Sight Antenna Mast	innco systems GmbH	none		
2.45	SGH-08	Standard Gain / Pyramidal Horn Antenna (90 - 140 GHz)	RPG-Radiometer Physics GmbH	064		
2.46	CBT	Bluetooth Tester "CBT-02" incl. BLE-Option	Rohde & Schwarz	100302	2018-03	2021-03

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.47	CMW 500	callbox with SUA, BT, 2G, 3G, LTE, AUDIO, UL/DL fading	Rohde & Schwarz GmbH & Co. KG	163529-bw	2017-07	2020-07
2.48	A8455-4	4 Way Power Divider (SMA)		-		
2.49	SGH-12	Standard Gain / Pyramidal HornAntenna (60 - 90 GHz)	RPG-Radiometer Physics GmbH	326		
2.50	JUN-AIR Mod. 6-15	Air Compressor	JUN-AIR Deutschland GmbH	612582		
2.51	foEthernet_M	Fibre optic link Ethernet / Gb-LAN	PONTIS Messtechnik GmbH	4841516023		
2.52	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
2.53	FS-Z140	Harmonic Mixer 90 -140 GHz	Rohde & Schwarz Messgerätebau GmbH	101007	2017-02	2020-02
2.54	OLS-1 M	Fibre optic link USB 1.1	Ingenieurbüro Scheiba	018		
2.55	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2018-01	2021-01
2.56	Voltcraft M-3860M	Digital Multimeter 01 (Multimeter)	Conrad	IJ096055		
2.57	CMW 500	callbox, 2G, 3G, LTE, WLAN, BT, Audio	Rohde & Schwarz GmbH & Co. KG	149268-Qf	2018-04	2021-04
2.58	Opus10 THI (8152.00)	ThermoHygro Datalogger 12	Lufft Mess- und Regeltechnik GmbH	ID 12482	2019-06	2021-06
2.59	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2019-01	2020-01
2.60	foEthernet_M	Fibre optic link Ethernet / Gb-LAN	PONTIS Messtechnik GmbH	4841516022		
2.61	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
2.62	AS 620 P	Antenna Mast (pneumatic polarisation)	HD GmbH	620/37		
2.63	6005D (30 V / 5 A)	Laboratory Power Supply 120 V 60 Hz	Peaktech	81062045		
2.64	TD1.5-10kg	EUT Tilt Device (Rohacell)	Maturo GmbH	TD1.5-10kg/024/3790709		
2.65	SGH-03	Standard Gain / Pyramidal Horn Antenna (220 - 325 GHz)	RPG-Radiometer Physics GmbH	060		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.66	FS-Z90	Harmonic Mixer 60 - 90 GHz	Rohde & Schwarz Messgerätebau GmbH	101686	2017-03	2020-03
2.67	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2018-01	2020-01
2.68	Innco Systems CO3000	Controller for bore sight mast SAC	innco systems GmbH	CO3000/967/393 71016/L		
2.69	NRV-Z1	Sensor Head B	Rohde & Schwarz GmbH & Co. KG	827753/006	2019-08	2020-08
2.70	foCAN (v 4.0)	Fibre optic link CAN	Audivo GmbH (PONTIS EMC)	492 1607 013		
2.71	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
2.72	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
2.73	WRCA800/960-0.2/40-6EEK	Tunable Notch Filter	Wainwright Instruments GmbH	20		
2.74	AM 4.0	Antenna Mast 4 m	Maturo GmbH	AM4.0/180/1192 0513		
2.75	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07
2.76	E4408B	Spectrum Analyser (9 kHz to 26.5 GHz)	Agilent Technologies Deutschland GmbH	MY45103714		

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

7 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

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

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

Frequency		Corr.	LISN insertion loss ESH3-Z5	cable loss (incl. 10 dB atten-uator)
MHz		dB	dB	dB
0.15		10.1	0.1	10.0
5		10.3	0.1	10.2
7		10.5	0.2	10.3
10		10.5	0.2	10.3
12		10.7	0.3	10.4
14		10.7	0.3	10.4
16		10.8	0.4	10.4
18		10.9	0.4	10.5
20		10.9	0.4	10.5
22		11.1	0.5	10.6
24		11.1	0.5	10.6
26		11.2	0.5	10.7
28		11.2	0.5	10.7
30		11.3	0.5	10.8

Sample calculation

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

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

Frequency	AF HFH-Z2)	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-40 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
0.009	20.50	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.01	20.45	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.015	20.37	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.02	20.36	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.025	20.38	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.03	20.32	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.05	20.35	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.08	20.30	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.1	20.20	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.2	20.17	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.3	20.14	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.49	20.12	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.490001	20.12	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.5	20.11	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.8	20.10	-39.6	0.1	0.1	0.1	0.1	-40	30	3
1	20.09	-39.6	0.1	0.1	0.1	0.1	-40	30	3
2	20.08	-39.6	0.1	0.1	0.1	0.1	-40	30	3
3	20.06	-39.6	0.1	0.1	0.1	0.1	-40	30	3
4	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
5	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
6	20.02	-39.5	0.2	0.1	0.1	0.1	-40	30	3
8	19.95	-39.5	0.2	0.1	0.1	0.1	-40	30	3
10	19.83	-39.4	0.2	0.1	0.2	0.1	-40	30	3
12	19.71	-39.4	0.2	0.1	0.2	0.1	-40	30	3
14	19.54	-39.4	0.2	0.1	0.2	0.1	-40	30	3
16	19.53	-39.3	0.3	0.1	0.2	0.1	-40	30	3
18	19.50	-39.3	0.3	0.1	0.2	0.1	-40	30	3
20	19.57	-39.3	0.3	0.1	0.2	0.1	-40	30	3
22	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
24	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
26	19.54	-39.3	0.3	0.1	0.2	0.1	-40	30	3
28	19.46	-39.2	0.3	0.1	0.3	0.1	-40	30	3
30	19.73	-39.1	0.4	0.1	0.3	0.1	-40	30	3

Sample calculation

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

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

(d_{Limit} = 3 m)

Frequency	AF R&S HL562	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
30	18.6	0.6	0.29	0.04	0.23	0.02	0.0	3	3
50	6.0	0.9	0.39	0.09	0.32	0.08	0.0	3	3
100	9.7	1.2	0.56	0.14	0.47	0.08	0.0	3	3
150	7.9	1.6	0.73	0.20	0.59	0.12	0.0	3	3
200	7.6	1.9	0.84	0.21	0.70	0.11	0.0	3	3
250	9.5	2.1	0.98	0.24	0.80	0.13	0.0	3	3
300	11.0	2.3	1.04	0.26	0.89	0.15	0.0	3	3
350	12.4	2.6	1.18	0.31	0.96	0.13	0.0	3	3
400	13.6	2.9	1.28	0.35	1.03	0.19	0.0	3	3
450	14.7	3.1	1.39	0.38	1.11	0.22	0.0	3	3
500	15.6	3.2	1.44	0.39	1.20	0.19	0.0	3	3
550	16.3	3.5	1.55	0.46	1.24	0.23	0.0	3	3
600	17.2	3.5	1.59	0.43	1.29	0.23	0.0	3	3
650	18.1	3.6	1.67	0.34	1.35	0.22	0.0	3	3
700	18.5	3.6	1.67	0.42	1.41	0.15	0.0	3	3
750	19.1	4.1	1.87	0.54	1.46	0.25	0.0	3	3
800	19.6	4.1	1.90	0.46	1.51	0.25	0.0	3	3
850	20.1	4.4	1.99	0.60	1.56	0.27	0.0	3	3
900	20.8	4.7	2.14	0.60	1.63	0.29	0.0	3	3
950	21.1	4.8	2.22	0.60	1.66	0.33	0.0	3	3
1000	21.6	4.9	2.23	0.61	1.71	0.30	0.0	3	3

(d_{Limit} = 10 m)

30	18.6	-9.9	0.29	0.04	0.23	0.02	-10.5	10	3
50	6.0	-9.6	0.39	0.09	0.32	0.08	-10.5	10	3
100	9.7	-9.2	0.56	0.14	0.47	0.08	-10.5	10	3
150	7.9	-8.8	0.73	0.20	0.59	0.12	-10.5	10	3
200	7.6	-8.6	0.84	0.21	0.70	0.11	-10.5	10	3
250	9.5	-8.3	0.98	0.24	0.80	0.13	-10.5	10	3
300	11.0	-8.1	1.04	0.26	0.89	0.15	-10.5	10	3
350	12.4	-7.9	1.18	0.31	0.96	0.13	-10.5	10	3
400	13.6	-7.6	1.28	0.35	1.03	0.19	-10.5	10	3
450	14.7	-7.4	1.39	0.38	1.11	0.22	-10.5	10	3
500	15.6	-7.2	1.44	0.39	1.20	0.19	-10.5	10	3
550	16.3	-7.0	1.55	0.46	1.24	0.23	-10.5	10	3
600	17.2	-6.9	1.59	0.43	1.29	0.23	-10.5	10	3
650	18.1	-6.9	1.67	0.34	1.35	0.22	-10.5	10	3
700	18.5	-6.8	1.67	0.42	1.41	0.15	-10.5	10	3
750	19.1	-6.3	1.87	0.54	1.46	0.25	-10.5	10	3
800	19.6	-6.3	1.90	0.46	1.51	0.25	-10.5	10	3
850	20.1	-6.0	1.99	0.60	1.56	0.27	-10.5	10	3
900	20.8	-5.8	2.14	0.60	1.63	0.29	-10.5	10	3
950	21.1	-5.6	2.22	0.60	1.66	0.33	-10.5	10	3
1000	21.6	-5.6	2.23	0.61	1.71	0.30	-10.5	10	3

Sample calculation

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

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

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten-uator & pre-amp)	cable loss 4 (to receiver)		
MHz	dB (1/m)	dB	dB	dB	dB	dB		
1000	24.4	-19.4	0.99	0.31	-21.51	0.79		
2000	28.5	-17.4	1.44	0.44	-20.63	1.38		
3000	31.0	-16.1	1.87	0.53	-19.85	1.33		
4000	33.1	-14.7	2.41	0.67	-19.13	1.31		
5000	34.4	-13.7	2.78	0.86	-18.71	1.40		
6000	34.7	-12.7	2.74	0.90	-17.83	1.47		
7000	35.6	-11.0	2.82	0.86	-16.19	1.46		

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten-uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	
3000	31.0	-23.4	0.47	1.87	0.53	-27.58	1.33	
4000	33.1	-23.3	0.56	2.41	0.67	-28.23	1.31	
5000	34.4	-21.7	0.61	2.78	0.86	-27.35	1.40	
6000	34.7	-21.2	0.58	2.74	0.90	-26.89	1.47	
7000	35.6	-19.8	0.66	2.82	0.86	-25.58	1.46	

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre-amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	dB
7000	35.6	-57.3	0.56	1.28	-62.72	2.66	0.94	1.46
8000	36.3	-56.3	0.69	0.71	-61.49	2.84	1.00	1.53
9000	37.1	-55.3	0.68	0.65	-60.80	3.06	1.09	1.60
10000	37.5	-56.2	0.70	0.54	-61.91	3.28	1.20	1.67
11000	37.5	-55.3	0.80	0.61	-61.40	3.43	1.27	1.70
12000	37.6	-53.7	0.84	0.42	-59.70	3.53	1.26	1.73
13000	38.2	-53.5	0.83	0.44	-59.81	3.75	1.32	1.83
14000	39.9	-56.3	0.91	0.53	-63.03	3.91	1.40	1.77
15000	40.9	-54.1	0.98	0.54	-61.05	4.02	1.44	1.83
16000	41.3	-54.1	1.23	0.49	-61.51	4.17	1.51	1.85
17000	42.8	-54.4	1.36	0.76	-62.36	4.34	1.53	2.00
18000	44.2	-54.7	1.70	0.53	-62.88	4.41	1.55	1.91

Sample calculation

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

7.5 ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

Frequency	AF EMCO 3160-09	Corr.	cable loss 1 (inside chamber)	cable loss 2 (pre-amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB
18000	40.2	-23.5	0.72	-35.85	6.20	2.81	2.65
18500	40.2	-23.2	0.69	-35.71	6.46	2.76	2.59
19000	40.2	-22.0	0.76	-35.44	6.69	3.15	2.79
19500	40.3	-21.3	0.74	-35.07	7.04	3.11	2.91
20000	40.3	-20.3	0.72	-34.49	7.30	3.07	3.05
20500	40.3	-19.9	0.78	-34.46	7.48	3.12	3.15
21000	40.3	-19.1	0.87	-34.07	7.61	3.20	3.33
21500	40.3	-19.1	0.90	-33.96	7.47	3.28	3.19
22000	40.3	-18.7	0.89	-33.57	7.34	3.35	3.28
22500	40.4	-19.0	0.87	-33.66	7.06	3.75	2.94
23000	40.4	-19.5	0.88	-33.75	6.92	3.77	2.70
23500	40.4	-19.3	0.90	-33.35	6.99	3.52	2.66
24000	40.4	-19.8	0.88	-33.99	6.88	3.88	2.58
24500	40.4	-19.5	0.91	-33.89	7.01	3.93	2.51
25000	40.4	-19.3	0.88	-33.00	6.72	3.96	2.14
25500	40.5	-20.4	0.89	-34.07	6.90	3.66	2.22
26000	40.5	-21.3	0.86	-35.11	7.02	3.69	2.28
26500	40.5	-21.1	0.90	-35.20	7.15	3.91	2.36

Sample calculation

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

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

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

Sample calculation

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

7.7 ANTENNA SGH-19 (40 GHZ – 60 GHZ)

Frequency	AF SGH-19	Corr.		cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	Harmonic Mixer FS-Z60	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB		dB	dB	dB	dB	dB	m	m
40.0	39.6	3.8					19.4	-15.6	3	0.5
41.0	39.7	2.7					18.3	-15.6	3	0.5
42.0	39.8	3.3					18.9	-15.6	3	0.5
43.0	39.9	2.7					18.3	-15.6	3	0.5
44.0	40.1	4.0					19.6	-15.6	3	0.5
45.0	40.2	3.8					19.4	-15.6	3	0.5
46.0	40.3	4.0					19.6	-15.6	3	0.5
47.0	40.4	4.3					19.9	-15.6	3	0.5
48.0	40.5	3.5					19.1	-15.6	3	0.5
49.0	40.6	3.2					18.8	-15.6	3	0.5
50.0	40.8	3.6					19.2	-15.6	3	0.5
51.0	40.9	2.6					18.2	-15.6	3	0.5
52.0	41.1	1.5					17.1	-15.6	3	0.5
53.0	41.1	0.1					15.7	-15.6	3	0.5
54.0	41.3	-1.0					14.6	-15.6	3	0.5
55.0	41.4	-0.8					14.8	-15.6	3	0.5
56.0	41.5	-1.2					14.4	-15.6	3	0.5
57.0	41.6	-0.8					14.8	-15.6	3	0.5
58.0	41.8	-0.9					14.7	-15.6	3	0.5
59.0	41.9	0.0					15.6	-15.6	3	0.5
60.0	42.1	1.3					16.9	-15.6	3	0.5

Sample calculation

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

7.8 ANTENNA SGH-12 (60 GHZ – 90 GHZ)

Frequency	AF SGH-12	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	Harmonic Mixer FS-Z90	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
60.0	43.3	8.2				24.4	-15.6	3	0.5
61.5	43.4	7.3				23.8	-15.6	3	0.5
63.0	43.5	4.2				22.9	-15.6	3	0.5
64.5	43.6	4.2				19.8	-15.6	3	0.5
66.0	43.7	2.0				19.8	-15.6	3	0.5
67.5	43.8	3.4				17.6	-15.6	3	0.5
69.0	43.9	3.2				19.0	-15.6	3	0.5
70.5	44.0	2.4				18.8	-15.6	3	0.5
72.0	44.1	1.6				18.0	-15.6	3	0.5
73.5	44.2	1.7				17.2	-15.6	3	0.5
75.0	44.4	0.1				17.3	-15.6	3	0.5
76.5	44.5	-0.5				15.7	-15.6	3	0.5
78.0	44.6	-0.5				15.1	-15.6	3	0.5
79.5	44.7	-1.6				15.1	-15.6	3	0.5
81.0	44.8	-1.7				14.0	-15.6	3	0.5
82.5	45.0	-0.3				13.9	-15.6	3	0.5
84.0	45.1	2.2				15.3	-15.6	3	0.5
85.5	45.2	3.7				17.8	-15.6	3	0.5
87.0	45.4	5.9				19.3	-15.6	3	0.5
88.5	45.5	5.2				21.5	-15.6	3	0.5
90.0	45.6	8.2				20.8	-15.6	3	0.5

Sample calculation

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

7.9 ANTENNA SGH-08 (90 GHZ – 140 GHZ)

Frequency	AF SGH-19	Corr.		cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	Harmonic Mixer FS-Z140	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB		dB	dB	dB	dB	dB	m	m
90.0	46.9	12.2					27.8	-15.6	3	0.5
92.5	47.0	10.8					26.4	-15.6	3	0.5
95.0	47.1	9.2					24.8	-15.6	3	0.5
97.5	47.2	7.5					23.1	-15.6	3	0.5
100.0	47.3	5.8					21.4	-15.6	3	0.5
102.5	47.4	6.0					21.6	-15.6	3	0.5
105.0	47.6	7.0					22.6	-15.6	3	0.5
107.5	47.7	5.8					21.4	-15.6	3	0.5
110.0	47.8	4.7					20.3	-15.6	3	0.5
112.5	47.9	4.1					19.7	-15.6	3	0.5
115.0	48.0	6.8					22.4	-15.6	3	0.5
117.5	48.2	7.3					22.9	-15.6	3	0.5
120.0	48.3	7.5					23.1	-15.6	3	0.5
122.5	48.4	10.4					26.0	-15.6	3	0.5
125.0	48.6	13.6					29.2	-15.6	3	0.5
127.5	48.7	15.5					31.1	-15.6	3	0.5
130.0	48.9	18.1					33.7	-15.6	3	0.5
132.5	49.0	13.5					29.1	-15.6	3	0.5
135.0	49.2	14.6					30.2	-15.6	3	0.5
137.5	49.3	14.1					29.7	-15.6	3	0.5
140.0	49.4	11.5					27.1	-15.6	3	0.5

Sample calculation

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

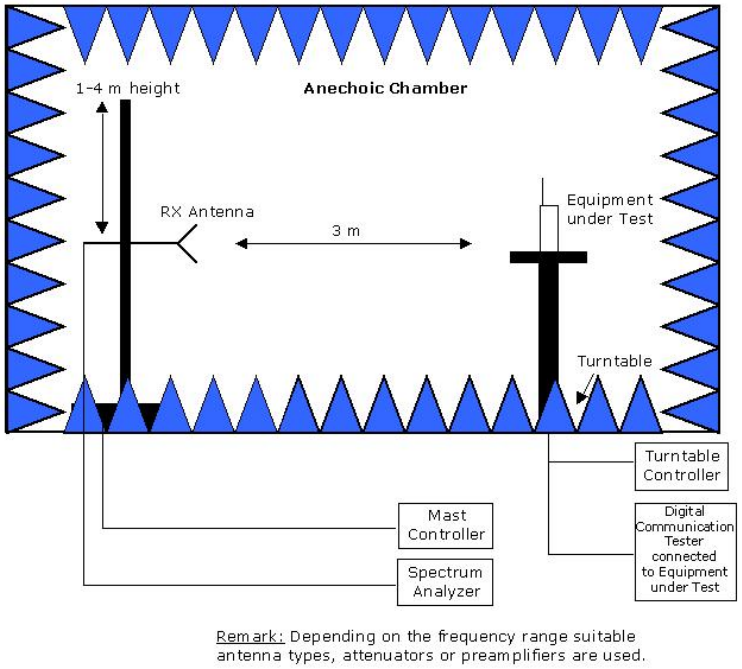
7.10 ANTENNA SGH-05 (140 GHZ – 200 GHZ)

Frequency	AF SGH-19	Corr.		cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	Harmonic Mixer FS-Z140	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB		dB	dB	dB	dB	dB	m	m
140.0	50.8	15.1					30.7	-15.6	3	0.5
142.0	50.8	11.0					26.6	-15.6	3	0.5
144.0	50.9	11.1					26.7	-15.6	3	0.5
146.0	50.9	12.1					27.7	-15.6	3	0.5
148.0	51.0	13.1					28.7	-15.6	3	0.5
150.0	51.0	15.4					31.0	-15.6	3	0.5
152.0	51.1	15.0					30.6	-15.6	3	0.5
154.0	51.1	16.9					32.5	-15.6	3	0.5
156.0	51.2	15.1					30.7	-15.6	3	0.5
158.0	51.3	15.3					30.9	-15.6	3	0.5
160.0	51.3	14.5					30.1	-15.6	3	0.5
162.0	51.4	14.2					29.8	-15.6	3	0.5
164.0	51.4	15.4					31.0	-15.6	3	0.5
166.0	51.5	13.5					29.1	-15.6	3	0.5
168.0	51.6	14.0					29.6	-15.6	3	0.5
170.0	51.6	15.1					30.7	-15.6	3	0.5
172.0	51.7	14.3					29.9	-15.6	3	0.5
174.0	51.8	14.7					30.3	-15.6	3	0.5
176.0	51.8	14.8					30.4	-15.6	3	0.5
178.0	51.9	14.6					30.2	-15.6	3	0.5
180.0	51.9	14.9					30.5	-15.6	3	0.5
182.0	52.0	14.7					30.3	-15.6	3	0.5
184.0	52.1	15.6					31.2	-15.6	3	0.5
186.0	52.1	16.8					32.4	-15.6	3	0.5
188.0	52.2	15.2					30.8	-15.6	3	0.5
190.0	52.3	16.8					32.4	-15.6	3	0.5
192.0	52.3	16.1					31.7	-15.6	3	0.5
194.0	52.4	14.8					30.4	-15.6	3	0.5
196.0	52.5	15.1					30.7	-15.6	3	0.5
198.0	52.6	13.8					29.4	-15.6	3	0.5
200.0	52.6	13.7					29.3	-15.6	3	0.5
202.0	52.7	14.0					29.6	-15.6	3	0.5
204.0	52.8	13.7					29.3	-15.6	3	0.5
206.0	52.8	13.4					29.0	-15.6	3	0.5
208.0	52.9	13.4					29.0	-15.6	3	0.5
210.0	53.0	13.9					29.5	-15.6	3	0.5
212.0	53.1	12.9					28.5	-15.6	3	0.5
214.0	53.2	13.1					28.7	-15.6	3	0.5
216.0	53.2	13.5					29.1	-15.6	3	0.5
218.0	53.3	14.5					30.1	-15.6	3	0.5
220.0	53.4	14.0					29.6	-15.6	3	0.5

Sample calculation

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

8 SETUP DRAWINGS

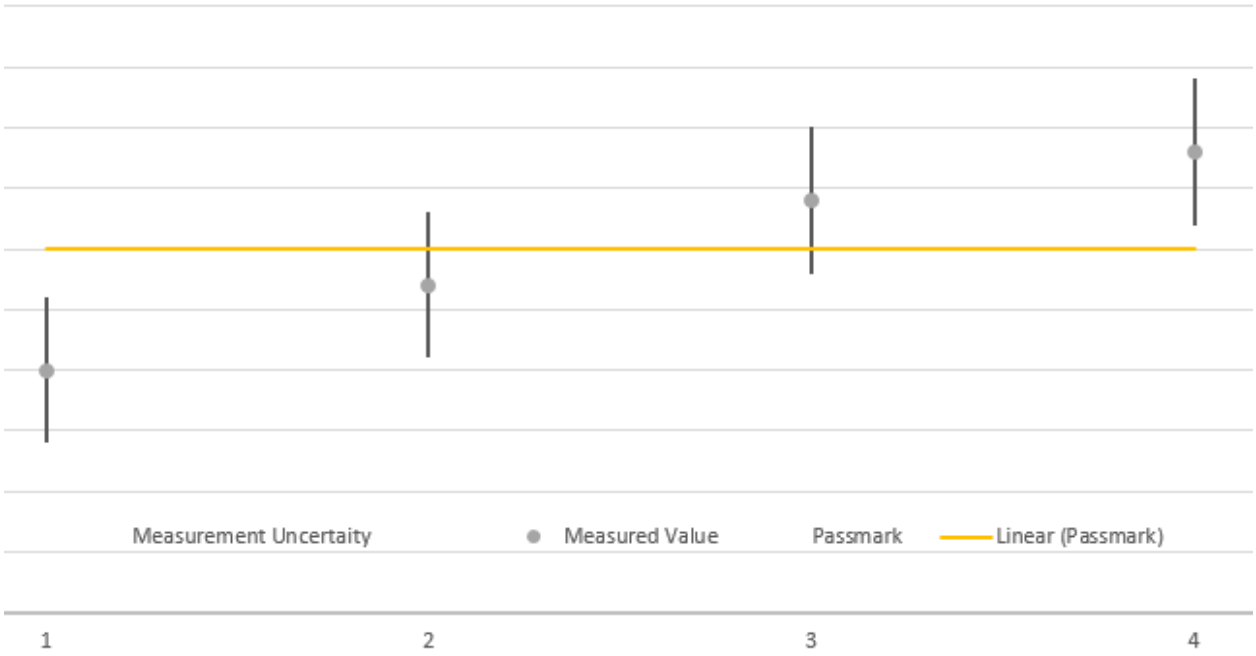


Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting groundplane.

9 MEASUREMENT UNCERTAINTIES

Test Case	Parameter	Uncertainty
AC Power Line	Power	± 3.4 dB
Field Strength of spurious radiation	Power	± 5.5 dB
10 dB Bandwidth	Power Frequency	± 5.5 dB ± 100.0 kHz
Conducted Output Power	Power	± 2.2 dB
Band Edge Compliance	Power Frequency	± 2.2 dB ± 11.2 kHz
Frequency Stability	Frequency	± 25 Hz
Power Spectral Density	Power	± 2.2 dB

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



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

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

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

10 PHOTO REPORT

Please see separate photo report.