

FCC Measurement/Technical Report on

VEGAPULS Air 23

FCC ID: 06QAIR23
IC: 3892A-AIR23

Test Report Reference: MDE_VEGA_1905_FCC_14

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.

7layers GmbH

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

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

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

a Bureau Veritas
Group Company
www.7layers.com

Table of Contents

1	Applied Standards and Test Summary	4
1.1	Applied Standards	4
1.2	FCC-IC Correlation Table	5
1.3	Measurement Summary / Signatures	6
2	Revision History	8
3	Administrative Data	9
3.1	Testing Laboratory	9
3.2	Project Data	9
3.3	Applicant Data	9
3.4	Manufacturer Data	9
4	Test object Data	10
4.1	General EUT Description	10
4.2	EUT Main components	10
4.3	Ancillary Equipment	11
4.4	Auxiliary Equipment	11
4.5	EUT Setups	11
4.6	Operating Modes	12
4.7	Product labelling	12
5	Test Results	13
5.1	Fundamental Bandwidth	13
5.2	Fundamental Emission	15
5.3	Unwanted Emissions	20
5.4	Antenna Beamwidth	28
5.5	Antenna Side Lobe Gain	34
5.6	Frequency Stability	36
6	Test Equipment	39
7	Antenna Factors, Cable Loss and Sample Calculations	42
7.1	LISN R&S ESH3-Z5 (150 kHz – 30 MHz)	42
7.2	Antenna R&S HFH2-Z2 (9 kHz – 30 MHz)	43
7.3	Antenna R&S HL562 (30 MHz – 1 GHz)	44
7.4	Antenna R&S HF907 (1 GHz – 18 GHz)	45
7.5	Antenna EMCO 3160-09 (18 GHz – 26.5 GHz)	46
7.6	Antenna EMCO 3160-10 (26.5 GHz – 40 GHz)	47
7.7	Antenna SGH-19 (40 GHz – 60 GHz)	48
7.8	Antenna SGH-12 (60 GHz – 90 GHz)	49
7.9	Antenna SGH-08 (90 GHz – 140 GHz)	50
7.10	Antenna SGH-05 (140 GHz – 200 GHz)	51

8	Setup Drawings	52
9	Measurement Uncertainties	53
10	Photo Report	54

1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization

Certification for an Intentional Radiator.

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-19 Edition). The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.209 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 § 15.256 (f)

Subpart C §15.256

Fundamental bandwidth

The measurement was performed according to ANSI C63.10

Final Result

OP-Mode	Setup	Date	FCC	IC
Radio Technology, Measurement range FMCW Radar, 75 GHz - 85 GHz	S01_AB01	2021-02-19	Passed	Passed

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

Subpart C §15.256

Fundamental emission

The measurement was performed according to ANSI C63.10

Final Result

OP-Mode	Setup	Date	FCC	IC
Radio Technology, Measurement range FMCW Radar, 75 GHz - 85 GHz	S01_AB01	2021-02-19	Passed	Passed

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

Subpart C §15.256

Unwanted emissions

The measurement was performed according to ANSI C63.10

Final Result

OP-Mode: outside tank enclosure	Setup	Date	FCC	IC
Radio Technology, Measurement range FMCW Radar, 30 MHz – 1 GHz	S01_AB01	2021-03-01	Passed	Passed
FMCW Radar, 1 GHz – 18 GHz	S01_AB01	2021-02-28	Passed	Passed
FMCW Radar, 18 GHz – 26 GHz	S01_AB01	2021-03-16	Passed	Passed
FMCW Radar, 26 GHz – 40 GHz	S01_AB01	2021-03-03	Passed	Passed
FMCW Radar, 40 GHz – 60 GHz	S01_AB01	2021-03-23	Passed	Passed
FMCW Radar, 60 GHz – 90 GHz	S01_AB01	2021-03-23	Passed	Passed
FMCW Radar, 90 GHz – 140 GHz	S01_AB01	2021-03-19	Passed	Passed
FMCW Radar, 140 GHz – 200 GHz	S01_AB01	2021-03-19	Passed	Passed

RSS 211 5.3

Unwanted emissions

The measurement was performed according to ETSI EN 302 372

Final Result

OP-Mode: inside tank enclosure	Setup	Date	FCC	IC
Radio Technology, Measurement range FMCW Radar, 60 GHz – 90 GHz	S01_AB01	2021-04-13	-	Passed

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

Antenna beamwidth The measurement was performed according to ANSI C63.10			Final Result	
OP-Mode	Setup	Date	FCC	IC
Radio Technology				
FMCW Radar	S01_AB01	2021-02-15	Passed	Passed

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

Antenna side lobe gain The measurement was performed according to ANSI C63.10			Final Result	
OP-Mode	Setup	Date	FCC	IC
Radio Technology				
FMCW Radar	S01_AB01	2021-02-15	Passed	Passed

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

Frequency Stability The measurement was performed according to ANSI C63.10			Final Result	
OP-Mode	Setup	Date	FCC	IC
Radio Technology				
FMCW Radar	S01_AB01	2021-03-17	Passed	Passed

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

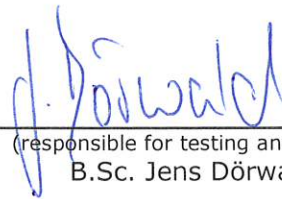
2 REVISION HISTORY

Report version control			
Version	Release date	Change Description	Version validity
initial	2021-09-16	--	valid
--	--	--	--

COMMENT: --



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



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



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

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: 2021-09-16

Testing Period: 2021-02-15 to 2021-04-13

3.3 APPLICANT DATA

Company Name: VEGA Grieshaber KG
Address: 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	The EUT is a radar sensor for continuous level measurement of plastic vessels. The device is suitable for almost all liquids.
Product name	VEGAPULS
Type	VEGAPULS Air 23
Declared EUT data by the supplier	
Voltage Type	DC (internal battery)
Voltage Level	3.6 V
Tested Modulation Type	FMCW
General product description	The EUT is a Level Probing Radar including cellular technologies and GPS.
The EUT provides the following ports:	none

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	DE1373010ab01	
Sample Parameter	Value	
Serial No.	51246347	
HW Version	1.0.0	
SW Version	1.0.0	
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_AA01	EUT A	VEGAPULS Air 23

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
- Sweep time: $T_D = T_s / \Delta F$ (where T_s 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: 25 °C
Air Pressure: 1030 hPa
Humidity: 34 %

Setup_AD01

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]
75160.0	83025.0	75193.0	79092.5	7865.0	50	7815.0

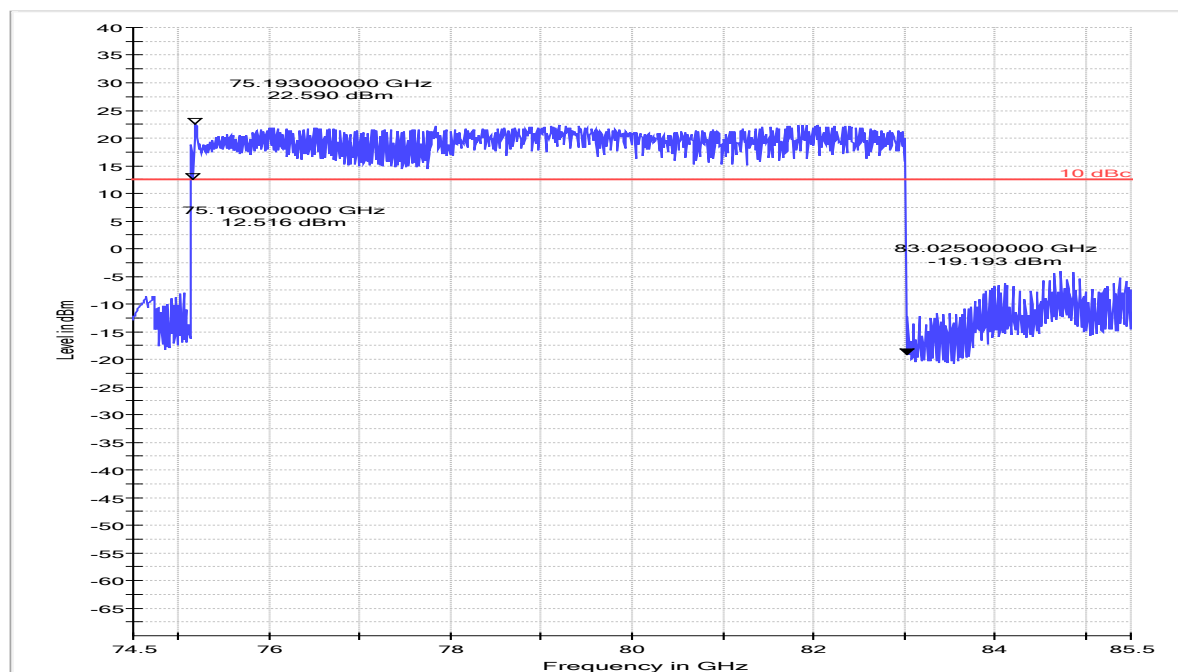
COMMENT: Measurement was performed with activated sweep function.

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]
75160.0	83025.0	75000	85000	160.0	1975.0

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

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

Setup_AB01



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 $EIRP (dBm) = \text{conducted power (dBm)} + \text{antenna gain (dBi)}$ 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 $EIRP (dBm) = E (dB\mu V/m) - 104.8 + 20 \text{ Log } D$ 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

$$TD = TS/\Delta F$$

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 $EIRP (dBm) = \text{conducted power (dBm)} + \text{antenna gain (dBi)}$ 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 $EIRP (dBm) = E (dB\mu V/m) - 104.8 + 20 \text{ Log } D$ 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 $20 \log(\text{RBW}/50)$ 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: 25 °C
Air Pressure: 1030 hPa
Humidity: 34 %

Setup_AA01
EIRP in 1 MHz

Power EIRP [dBm]	Emission Frequency [MHz]	Limit [dBm]	Margin to Power Limit EIRP [dBm]
-31.2	75193.0	-3	28.2

COMMENT:
Average-Factor = -53.7 dB

Calculation-Parameters:
Frequency Sweep Time T_s = 5.12 ms
Signal Sweep Frequency Span ΔF = 7815 MHz
Re-trace Time = 150 ms
Total-cycle Time = 155.12 ms

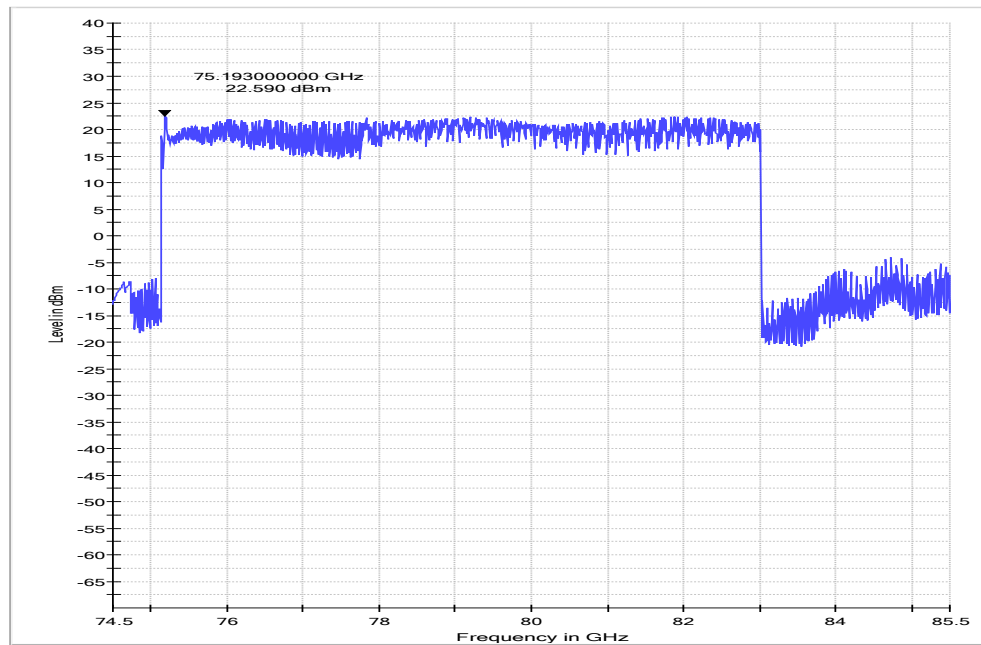
EIRP in 50 MHz

Power EIRP [dBm]	Emission Frequency [MHz]	Limit [dBm]	Margin to Power Limit EIRP [dBm]
23.84	75524.0	34	10.16

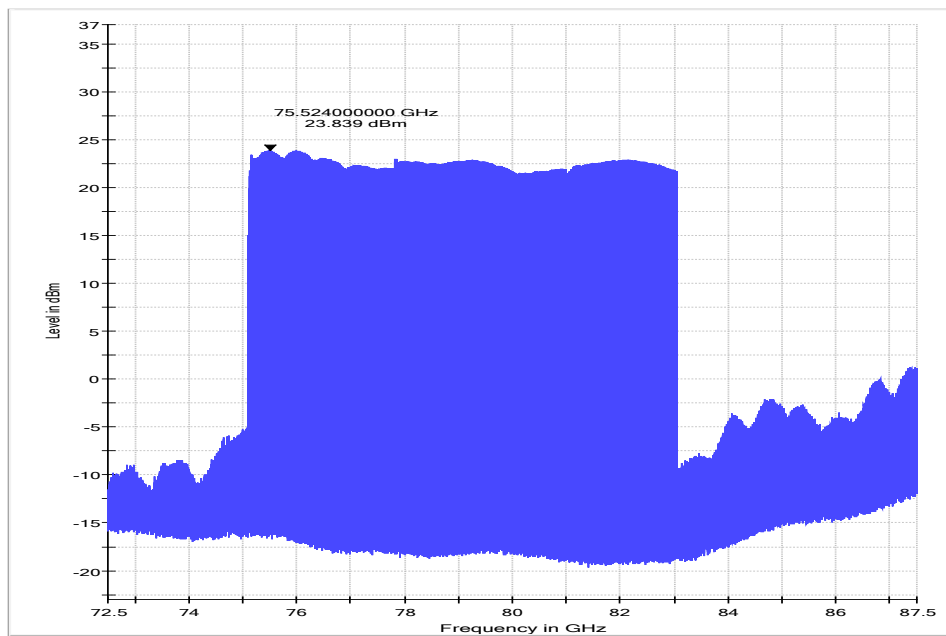
Remark: Please see next sub-clause for the measurement plot.

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

Setup_AC01
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 $\pm 45^{\circ}$ 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 ± 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: ± 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 $\pm 45^{\circ}$ for the elevation axis is performed.

The turn table azimuth will slowly vary by $\pm 22.5^{\circ}$.

The elevation angle will slowly vary by $\pm 45^{\circ}$

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

- The device shall be installed inside a closed container or in a still pipe by qualified installers.
- 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 – 1030 hPa
Humidity: 28 % - 40 %

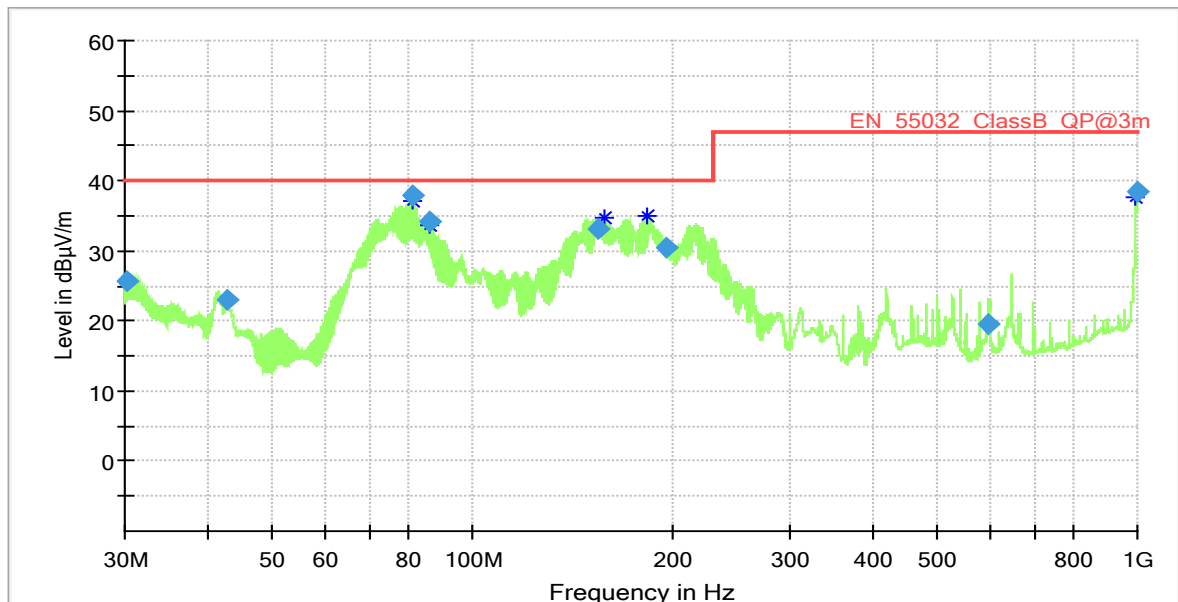
S01_AD01

Spurious Freq. [MHz]	Spurious Level [dBμV/m]	Detector	RBW [kHz]	Limit [dBμV/m]	Margin to Limit [dB]
30.12	25.63	QP	120	40.00	14.37
42.63	23.03	QP	120	40.00	16.97
81.03	37.84	QP	120	40.00	2.16
86.16	34.22	QP	120	40.00	5.78
154.35	33.08	QP	120	40.00	6.92
195.99	30.45	QP	120	40.00	9.55
597.21	19.63	QP	120	47.00	27.37
997.83	38.38	QP	120	47.00	8.62
14015.25	41.39	AV	1000	54.00	12.61
14100.00	42.94	AV	1000	54	11.06

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

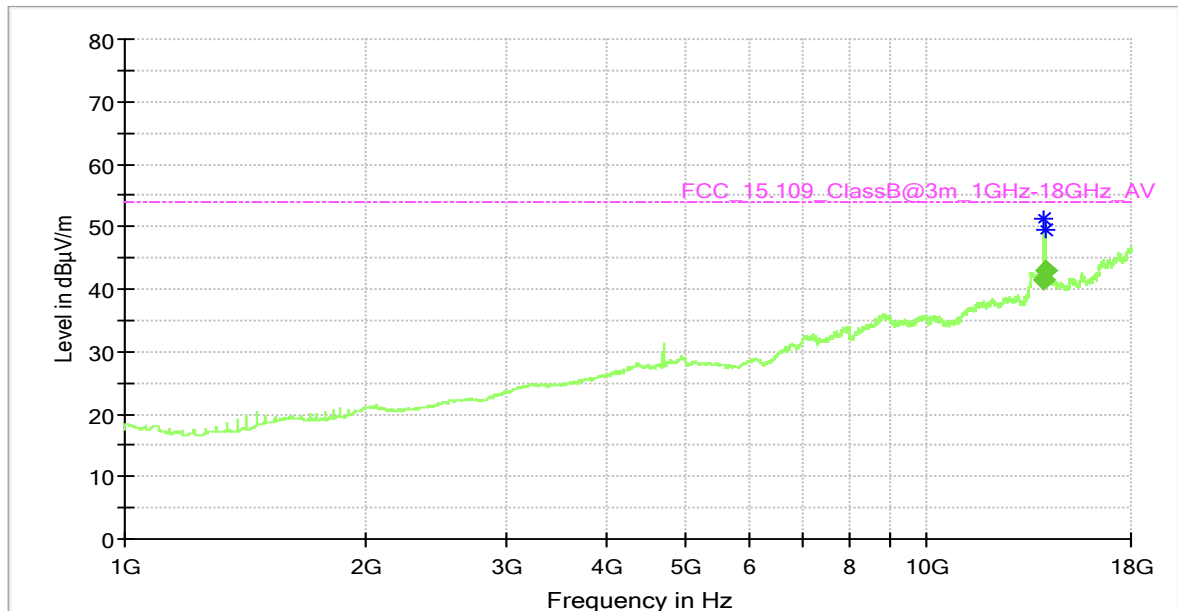
5.3.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

S01_AB01
30 MHz – 1 GHz



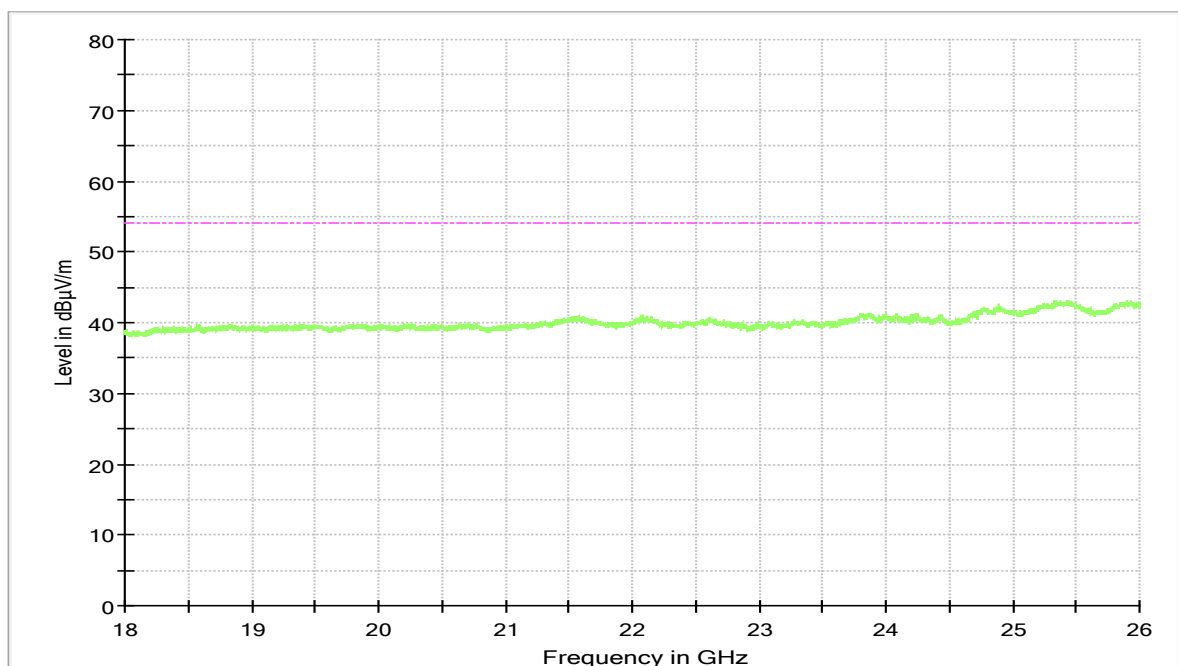
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.120000	25.63	40.00	14.37	1000.0	120.000	105.0	V	-109.0	19.1
42.630000	23.03	40.00	16.97	1000.0	120.000	103.0	V	-177.0	11.9
81.030000	37.84	40.00	2.16	1000.0	120.000	115.0	V	69.0	10.2
86.160000	34.22	40.00	5.78	1000.0	120.000	117.0	V	46.0	10.3
154.350000	33.08	40.00	6.92	1000.0	120.000	115.0	V	72.0	8.9
195.990000	30.45	40.00	9.55	1000.0	120.000	108.0	V	89.0	9.0
597.210000	19.63	47.00	27.37	1000.0	120.000	152.0	V	-180.0	20.1
997.830000	38.38	47.00	8.62	1000.0	120.000	105.0	V	3.0	25.4

S01_AB01
1 GHz – 18 GHz

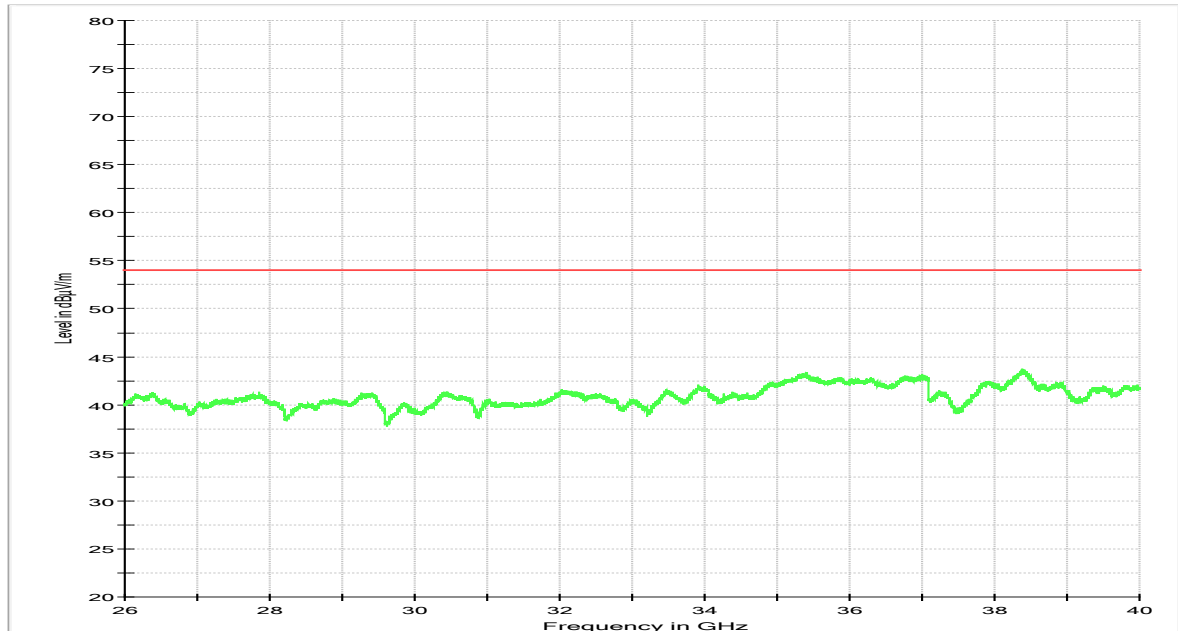


Frequency (MHz)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
14015.250000	41.39	54.00	12.61	200.0	1000.000	291.0	V	61.0	25.8
14100.000000	42.94	54.00	11.06	200.0	1000.000	291.0	V	61.0	25.8

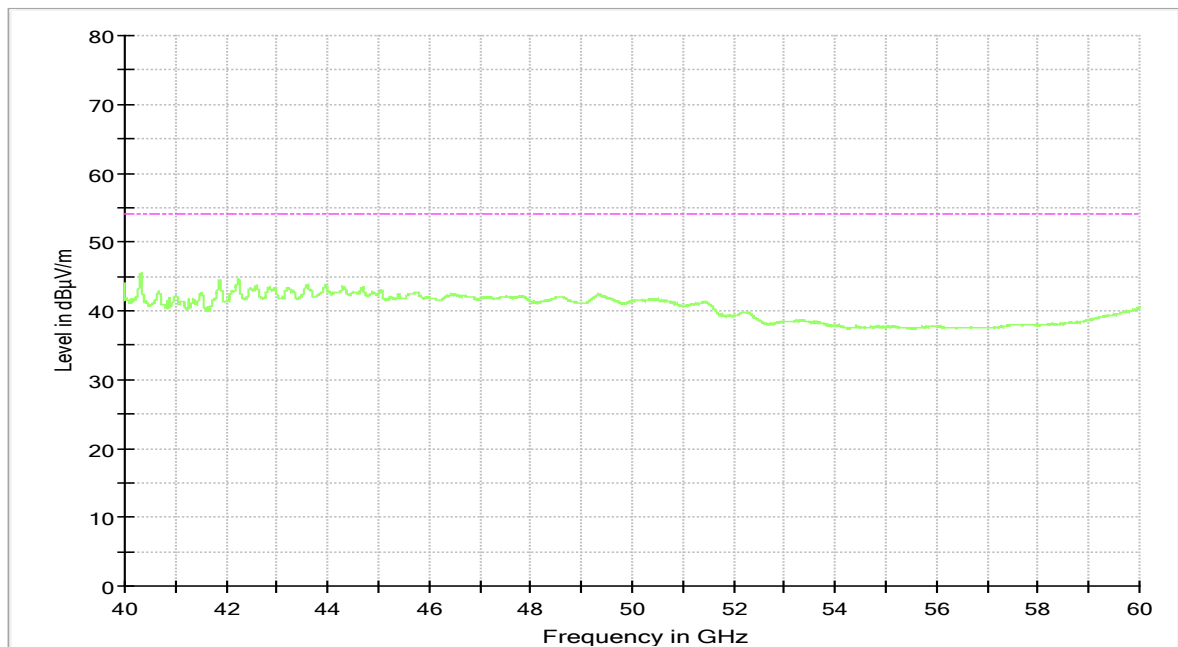
S01_AB01
18 GHz – 26 GHz



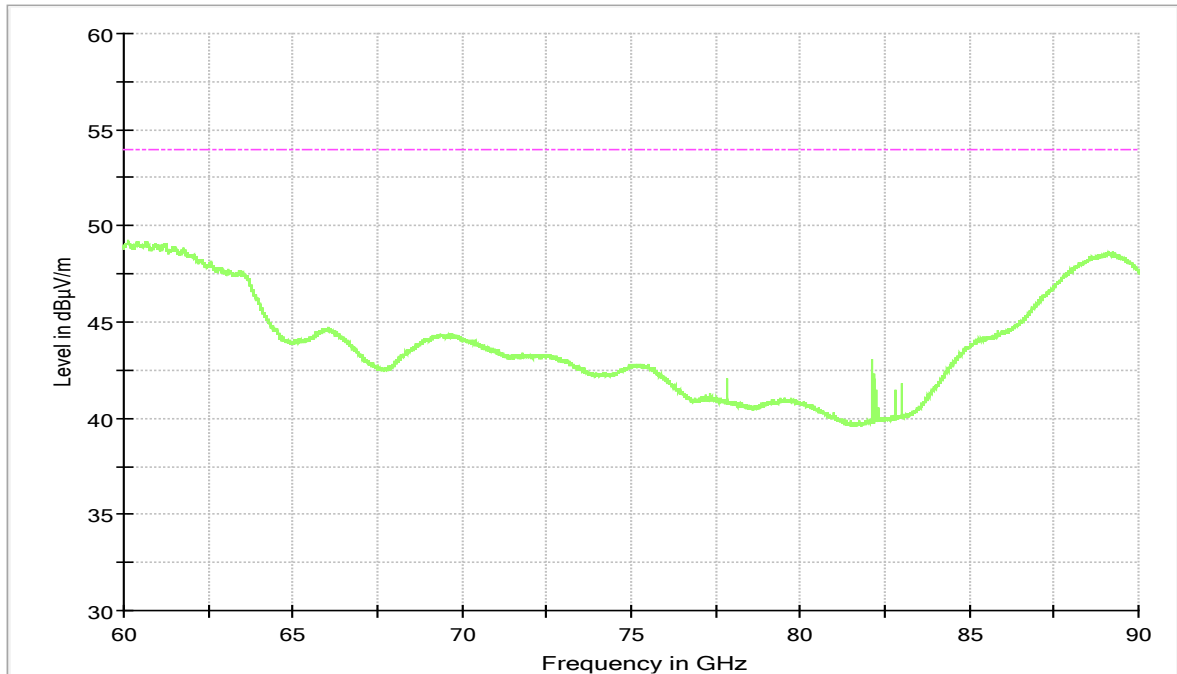
S01_AB01
26 GHz – 40 GHz



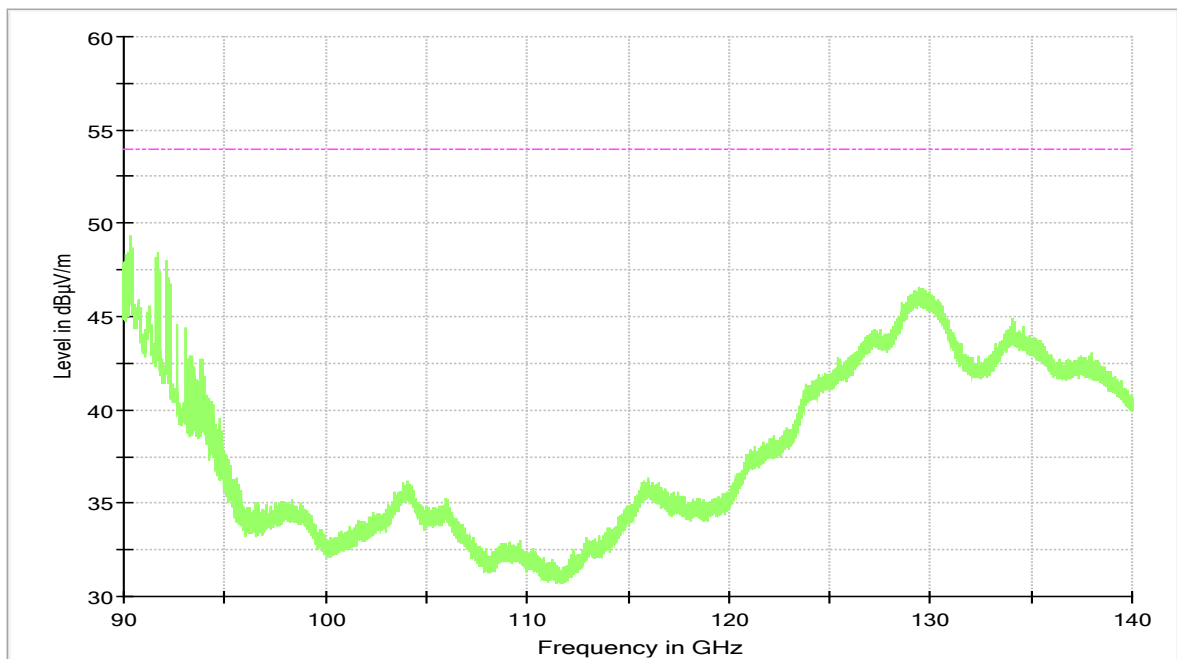
S01_AB01
40 GHz – 60 GHz



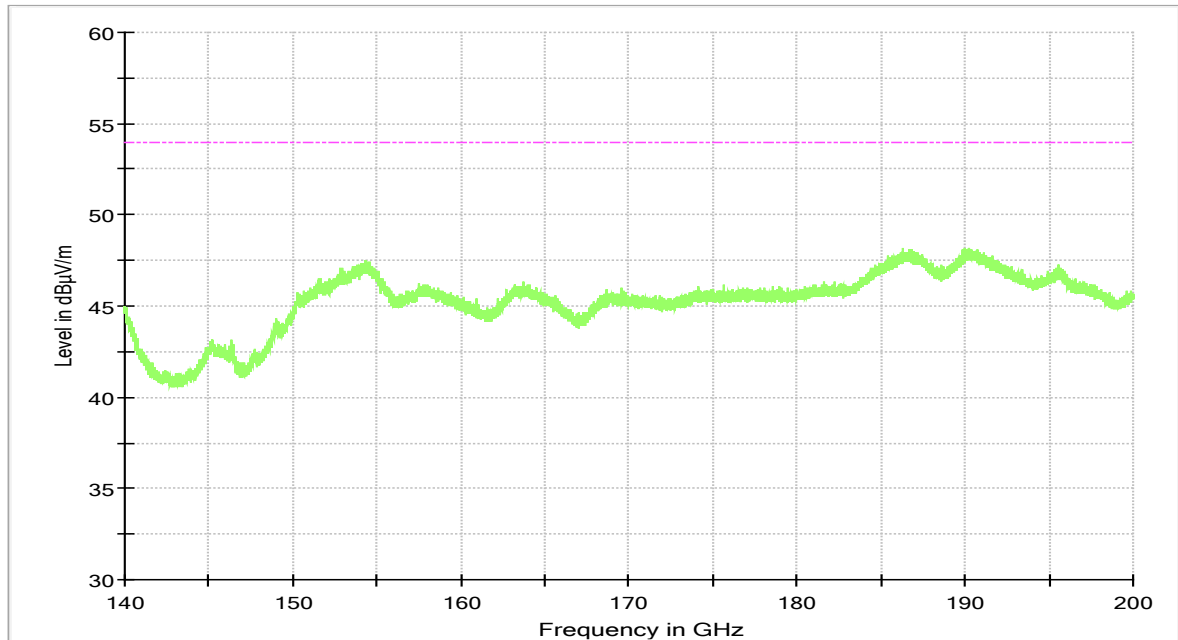
S01_AB01
60 GHz – 90 GHz



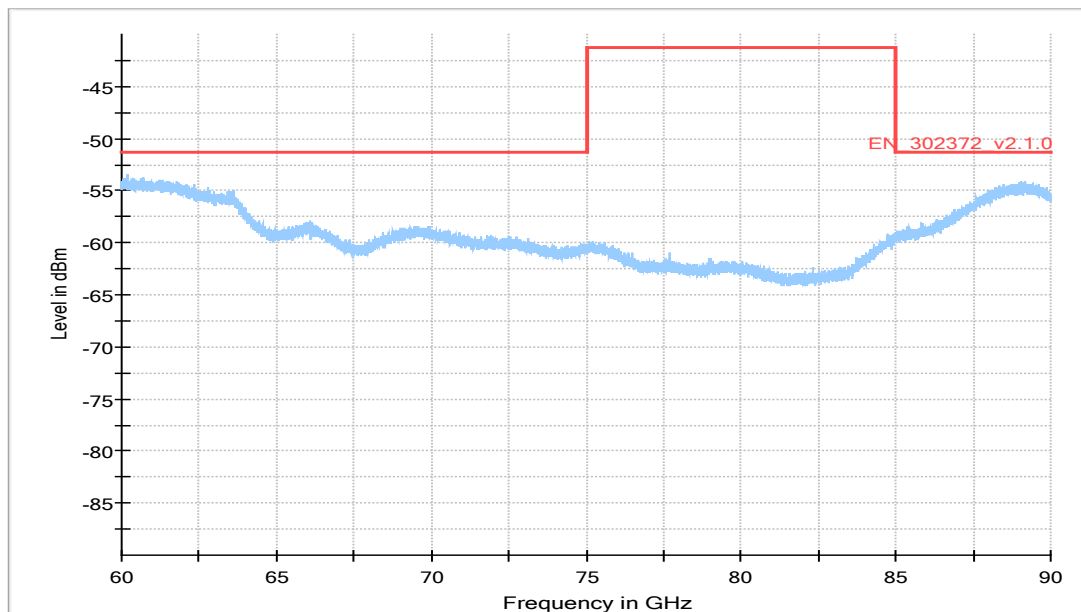
S01_AB01
90 GHz – 140 GHz



S01_AC01
140 GHz – 200 GHz



S01_AB01
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: 23 °C
Air Pressure: 997 hPa
Humidity: 18 %

S01_AA01

Mea- sured Azimut h [deg]	Mea- sured Level [dBm]	Normal- ized Azimut h [deg]	Normal - ized Level [dB]	Half- Power Beam- width Limit [dbc]	Side -Lobe Gain Limit [dbc]
0.0	-29.1	183.0	-44.6	-3	-38
1.0	-29.1	184.0	-44.6	-3	-38
2.0	-27.6	185.0	-43.0	-3	-38
3.0	-27.3	186.0	-42.8	-3	-38
4.0	-31.4	187.0	-46.9	-3	-38
5.0	-31.3	188.0	-46.7	-3	-38
6.0	-31.3	189.0	-46.8	-3	-38
7.0	-31.1	190.0	-46.5	-3	-38
8.0	-34.3	191.0	-49.8	-3	-38
9.0	-34.5	192.0	-50.0	-3	-38
10.0	-33.7	193.0	-49.1	-3	-38
11.0	-36.7	194.0	-52.2	-3	-38
12.0	-36.8	195.0	-52.3	-3	-38
13.0	-30.1	196.0	-45.6	-3	-38
14.0	-30.2	197.0	-45.6	-3	-38
15.0	-31.9	198.0	-47.4	-3	-38
16.0	-31.8	199.0	-47.3	-3	-38
17.0	-33.1	200.0	-48.5	-3	-38
18.0	-33.8	201.0	-49.2	-3	-38
19.0	-38.9	202.0	-54.4	-3	-38
20.0	-37.6	203.0	-53.0	-3	-38
21.0	-34.6	204.0	-50.0	-3	-38
22.0	-32.9	205.0	-48.4	-3	-38
23.0	-30.7	206.0	-46.1	-3	-38
24.0	-34.5	207.0	-50.0	-3	-38
25.0	-39.4	208.0	-54.9	-3	-38
26.0	-39.4	209.0	-54.9	-3	-38
27.0	-40.0	210.0	-55.4	-3	-38
28.0	-39.7	211.0	-55.2	-3	-38
29.0	-30.9	212.0	-46.3	-3	-38
30.0	-30.8	213.0	-46.3	-3	-38
31.0	-40.1	214.0	-55.5	-3	-38
32.0	-40.0	215.0	-55.5	-3	-38
33.0	-30.7	216.0	-46.1	-3	-38
34.0	-30.0	217.0	-45.5	-3	-38

Mea- sured Azimut h [deg]	Mea- sured Level [dBm]	Normal- ized Azimut h [deg]	Normal - ized Level [dB]	Half- Power Beam- width Limit [dbc]	Side -Lobe Gain Limit [dbc]
180.0	13.3	3.0	-2.1	#N/A	#N/A
181.0	13.4	4.0	-2.1	#N/A	#N/A
182.0	10.5	5.0	-5.0	-3	#N/A
183.0	8.8	6.0	-6.7	-3	#N/A
184.0	7.2	7.0	-8.3	-3	#N/A
185.0	6.3	8.0	-9.2	-3	#N/A
186.0	6.3	9.0	-9.2	-3	#N/A
187.0	4.7	10.0	-10.7	-3	#N/A
188.0	4.0	11.0	-11.5	-3	#N/A
189.0	2.4	12.0	-13.0	-3	#N/A
190.0	0.5	13.0	-14.9	-3	#N/A
191.0	-1.9	14.0	-17.3	-3	#N/A
192.0	-1.9	15.0	-17.3	-3	#N/A
193.0	-6.7	16.0	-22.2	-3	#N/A
194.0	-8.8	17.0	-24.3	-3	#N/A
195.0	-10.4	18.0	-25.8	-3	#N/A
196.0	-11.7	19.0	-27.2	-3	#N/A
197.0	-13.6	20.0	-29.1	-3	#N/A
198.0	-15.9	21.0	-31.3	-3	#N/A
199.0	-14.9	22.0	-30.3	-3	#N/A
200.0	-14.5	23.0	-30.0	-3	#N/A
201.0	-15.3	24.0	-30.8	-3	#N/A
202.0	-16.8	25.0	-32.3	-3	#N/A
203.0	-18.1	26.0	-33.6	-3	#N/A
204.0	-17.6	27.0	-33.1	-3	#N/A
205.0	-15.9	28.0	-31.4	-3	#N/A
206.0	-15.6	29.0	-31.0	-3	#N/A
207.0	-15.8	30.0	-31.2	-3	#N/A
208.0	-16.7	31.0	-32.1	-3	#N/A
209.0	-18.6	32.0	-34.1	-3	#N/A
210.0	-17.5	33.0	-33.0	-3	#N/A
211.0	-16.7	34.0	-32.2	-3	#N/A
212.0	-17.1	35.0	-32.6	-3	#N/A
213.0	-17.1	36.0	-32.6	-3	#N/A
214.0	-20.8	37.0	-36.3	-3	#N/A

35.0	-33.4	218.0	-48.9	-3	-38
36.0	-36.1	219.0	-51.5	-3	-38
37.0	-36.8	220.0	-52.3	-3	-38
38.0	-37.9	221.0	-53.3	-3	-38
39.0	-37.0	222.0	-52.5	-3	-38
40.0	-36.5	223.0	-52.0	-3	-38
41.0	-34.2	224.0	-49.7	-3	-38
42.0	-31.2	225.0	-46.7	-3	-38
43.0	-31.0	226.0	-46.5	-3	-38
44.0	-31.5	227.0	-47.0	-3	-38
45.0	-33.0	228.0	-48.4	-3	-38
46.0	-32.5	229.0	-47.9	-3	-38
47.0	-30.7	230.0	-46.2	-3	-38
48.0	-34.9	231.0	-50.4	-3	-38
49.0	-35.5	232.0	-50.9	-3	-38
50.0	-34.0	233.0	-49.5	-3	-38
51.0	-36.7	234.0	-52.2	-3	-38
52.0	-39.8	235.0	-55.3	-3	-38
53.0	-34.7	236.0	-50.2	-3	-38
54.0	-35.7	237.0	-51.2	-3	-38
55.0	-34.8	238.0	-50.2	-3	-38
56.0	-32.7	239.0	-48.2	-3	-38
57.0	-33.3	240.0	-48.7	-3	-38
58.0	-36.0	241.0	-51.5	-3	-38
59.0	-36.6	242.0	-52.0	-3	-38
60.0	-36.4	243.0	-51.8	-3	-38
61.0	-34.7	244.0	-50.2	-3	-38
62.0	-36.4	245.0	-51.9	-3	-38
63.0	-38.3	246.0	-53.7	-3	-38
64.0	-38.9	247.0	-54.4	-3	-38
65.0	-40.4	248.0	-55.9	-3	-38
66.0	-40.5	249.0	-56.0	-3	-38
67.0	-39.7	250.0	-55.2	-3	-38
68.0	-39.6	251.0	-55.1	-3	-38
69.0	-40.5	252.0	-55.9	-3	-38
70.0	-38.6	253.0	-54.1	-3	-38
71.0	-37.7	254.0	-53.1	-3	-38
72.0	-39.6	255.0	-55.0	-3	-38
73.0	-38.4	256.0	-53.8	-3	-38
74.0	-35.7	257.0	-51.1	-3	-38
75.0	-32.8	258.0	-48.3	-3	-38
76.0	-34.4	259.0	-49.8	-3	-38
77.0	-31.7	260.0	-47.1	-3	-38
78.0	-30.8	261.0	-46.3	-3	-38
79.0	-33.6	262.0	-49.0	-3	-38
80.0	-36.0	263.0	-51.4	-3	-38
81.0	-37.3	264.0	-52.7	-3	-38

215.0	-23.0	38.0	-38.4	-3	#N/A
216.0	-23.0	39.0	-38.5	-3	#N/A
217.0	-22.6	40.0	-38.1	-3	#N/A
218.0	-22.5	41.0	-38.0	-3	#N/A
219.0	-25.2	42.0	-40.7	-3	#N/A
220.0	-24.9	43.0	-40.3	-3	#N/A
221.0	-26.8	44.0	-42.3	-3	#N/A
222.0	-26.6	45.0	-42.1	-3	#N/A
223.0	-26.7	46.0	-42.2	-3	#N/A
224.0	-26.8	47.0	-42.3	-3	#N/A
225.0	-22.7	48.0	-38.2	-3	#N/A
226.0	-22.6	49.0	-38.1	-3	#N/A
227.0	-22.1	50.0	-37.6	-3	#N/A
228.0	-22.2	51.0	-37.7	-3	#N/A
229.0	-24.1	52.0	-39.5	-3	#N/A
230.0	-23.5	53.0	-39.0	-3	#N/A
231.0	-22.2	54.0	-37.7	-3	#N/A
232.0	-21.9	55.0	-37.4	-3	#N/A
233.0	-20.9	56.0	-36.4	-3	#N/A
234.0	-21.7	57.0	-37.1	-3	#N/A
235.0	-21.8	58.0	-37.2	-3	#N/A
236.0	-22.5	59.0	-38.0	-3	#N/A
237.0	-22.5	60.0	-38.0	-3	#N/A
238.0	-24.6	61.0	-40.1	-3	-38
239.0	-27.5	62.0	-43.0	-3	-38
240.0	-30.1	63.0	-45.5	-3	-38
241.0	-30.3	64.0	-45.8	-3	-38
242.0	-29.2	65.0	-44.7	-3	-38
243.0	-25.4	66.0	-40.9	-3	-38
244.0	-25.4	67.0	-40.9	-3	-38
245.0	-25.7	68.0	-41.1	-3	-38
246.0	-25.8	69.0	-41.3	-3	-38
247.0	-26.6	70.0	-42.0	-3	-38
248.0	-27.4	71.0	-42.8	-3	-38
249.0	-27.6	72.0	-43.1	-3	-38
250.0	-31.1	73.0	-46.5	-3	-38
251.0	-31.5	74.0	-47.0	-3	-38
252.0	-32.1	75.0	-47.5	-3	-38
253.0	-31.4	76.0	-46.9	-3	-38
254.0	-29.4	77.0	-44.9	-3	-38
255.0	-29.8	78.0	-45.3	-3	-38
256.0	-30.1	79.0	-45.6	-3	-38
257.0	-30.9	80.0	-46.4	-3	-38
258.0	-36.1	81.0	-51.6	-3	-38
259.0	-36.1	82.0	-51.6	-3	-38
260.0	-35.3	83.0	-50.7	-3	-38
261.0	-34.2	84.0	-49.6	-3	-38

82.0	-36.7	265.0	-52.1	-3	-38
83.0	-33.7	266.0	-49.1	-3	-38
84.0	-33.3	267.0	-48.8	-3	-38
85.0	-32.3	268.0	-47.7	-3	-38
86.0	-33.3	269.0	-48.8	-3	-38
87.0	-37.7	270.0	-53.2	-3	-38
88.0	-39.6	271.0	-55.1	-3	-38
89.0	-34.8	272.0	-50.2	-3	-38
90.0	-35.1	273.0	-50.5	-3	-38
91.0	-33.6	274.0	-49.0	-3	-38
92.0	-33.6	275.0	-49.1	-3	-38
93.0	-33.4	276.0	-48.8	-3	-38
94.0	-33.5	277.0	-49.0	-3	-38
95.0	-36.9	278.0	-52.4	-3	-38
96.0	-38.0	279.0	-53.5	-3	-38
97.0	-38.3	280.0	-53.7	-3	-38
98.0	-38.6	281.0	-54.0	-3	-38
99.0	-34.6	282.0	-50.1	-3	-38
100.0	-33.9	283.0	-49.4	-3	-38
101.0	-35.8	284.0	-51.3	-3	-38
102.0	-34.9	285.0	-50.3	-3	-38
103.0	-31.8	286.0	-47.2	-3	-38
104.0	-31.8	287.0	-47.3	-3	-38
105.0	-25.5	288.0	-41.0	-3	-38
106.0	-27.3	289.0	-42.8	-3	-38
107.0	-32.0	290.0	-47.5	-3	-38
108.0	-30.6	291.0	-46.1	-3	-38
109.0	-30.1	292.0	-45.6	-3	-38
110.0	-31.2	293.0	-46.6	-3	-38
111.0	-33.2	294.0	-48.6	-3	-38
112.0	-31.6	295.0	-47.1	-3	-38
113.0	-32.4	296.0	-47.9	-3	-38
114.0	-31.0	297.0	-46.4	-3	-38
115.0	-24.6	298.0	-40.1	-3	-38
116.0	-23.1	299.0	-38.5	-3	-38
117.0	-23.2	300.0	-38.7	-3	#N/A
118.0	-22.1	301.0	-37.6	-3	#N/A
119.0	-22.3	302.0	-37.8	-3	#N/A
120.0	-20.3	303.0	-35.8	-3	#N/A
121.0	-20.2	304.0	-35.7	-3	#N/A
122.0	-21.3	305.0	-36.8	-3	#N/A
123.0	-21.4	306.0	-36.9	-3	#N/A
124.0	-21.4	307.0	-36.8	-3	#N/A
125.0	-21.2	308.0	-36.7	-3	#N/A
126.0	-17.4	309.0	-32.9	-3	#N/A
127.0	-17.4	310.0	-32.8	-3	#N/A
128.0	-17.2	311.0	-32.7	-3	#N/A

262.0	-35.4	85.0	-50.9	-3	-38
263.0	-35.6	86.0	-51.1	-3	-38
264.0	-40.3	87.0	-55.8	-3	-38
265.0	-40.3	88.0	-55.7	-3	-38
266.0	-39.0	89.0	-54.5	-3	-38
267.0	-39.0	90.0	-54.5	-3	-38
268.0	-40.2	91.0	-55.7	-3	-38
269.0	-39.9	92.0	-55.4	-3	-38
270.0	-40.0	93.0	-55.4	-3	-38
271.0	-40.1	94.0	-55.6	-3	-38
272.0	-38.5	95.0	-53.9	-3	-38
273.0	-38.8	96.0	-54.3	-3	-38
274.0	-35.7	97.0	-51.1	-3	-38
275.0	-39.5	98.0	-55.0	-3	-38
276.0	-39.6	99.0	-55.1	-3	-38
277.0	-36.9	100.0	-52.3	-3	-38
278.0	-34.9	101.0	-50.4	-3	-38
279.0	-34.8	102.0	-50.2	-3	-38
280.0	-38.2	103.0	-53.7	-3	-38
281.0	-37.9	104.0	-53.3	-3	-38
282.0	-40.7	105.0	-56.2	-3	-38
283.0	-40.3	106.0	-55.8	-3	-38
284.0	-31.6	107.0	-47.1	-3	-38
285.0	-34.1	108.0	-49.5	-3	-38
286.0	-34.2	109.0	-49.7	-3	-38
287.0	-37.5	110.0	-53.0	-3	-38
288.0	-37.0	111.0	-52.5	-3	-38
289.0	-40.1	112.0	-55.5	-3	-38
290.0	-40.4	113.0	-55.8	-3	-38
291.0	-37.5	114.0	-53.0	-3	-38
292.0	-37.6	115.0	-53.1	-3	-38
293.0	-38.0	116.0	-53.4	-3	-38
294.0	-39.2	117.0	-54.7	-3	-38
295.0	-39.1	118.0	-54.6	-3	-38
296.0	-39.3	119.0	-54.8	-3	-38
297.0	-40.2	120.0	-55.7	-3	-38
298.0	-40.5	121.0	-56.0	-3	-38
299.0	-37.7	122.0	-53.1	-3	-38
300.0	-36.5	123.0	-52.0	-3	-38
301.0	-38.2	124.0	-53.7	-3	-38
302.0	-37.5	125.0	-52.9	-3	-38
303.0	-38.5	126.0	-54.0	-3	-38
304.0	-37.7	127.0	-53.2	-3	-38
305.0	-36.3	128.0	-51.7	-3	-38
306.0	-36.3	129.0	-51.7	-3	-38
307.0	-35.5	130.0	-51.0	-3	-38
308.0	-36.4	131.0	-51.8	-3	-38

129.0	-17.1	312.0	-32.5	-3	#N/A
130.0	-21.9	313.0	-37.4	-3	#N/A
131.0	-21.8	314.0	-37.3	-3	#N/A
132.0	-24.6	315.0	-40.0	-3	#N/A
133.0	-24.6	316.0	-40.1	-3	#N/A
134.0	-24.3	317.0	-39.7	-3	#N/A
135.0	-25.8	318.0	-41.3	-3	#N/A
136.0	-30.8	319.0	-46.3	-3	#N/A
137.0	-31.7	320.0	-47.1	-3	#N/A
138.0	-25.7	321.0	-41.2	-3	#N/A
139.0	-26.3	322.0	-41.7	-3	#N/A
140.0	-17.2	323.0	-32.6	-3	#N/A
141.0	-17.0	324.0	-32.5	-3	#N/A
142.0	-14.6	325.0	-30.1	-3	#N/A
143.0	-14.5	326.0	-29.9	-3	#N/A
144.0	-14.6	327.0	-30.0	-3	#N/A
145.0	-15.8	328.0	-31.3	-3	#N/A
146.0	-15.9	329.0	-31.4	-3	#N/A
147.0	-16.4	330.0	-31.9	-3	#N/A
148.0	-16.3	331.0	-31.8	-3	#N/A
149.0	-19.5	332.0	-34.9	-3	#N/A
150.0	-20.6	333.0	-36.1	-3	#N/A
151.0	-19.0	334.0	-34.5	-3	#N/A
152.0	-16.3	335.0	-31.8	-3	#N/A
153.0	-16.3	336.0	-31.8	-3	#N/A
154.0	-12.1	337.0	-27.5	-3	#N/A
155.0	-10.7	338.0	-26.2	-3	#N/A
156.0	-10.4	339.0	-25.9	-3	#N/A
157.0	-11.2	340.0	-26.7	-3	#N/A
158.0	-13.2	341.0	-28.7	-3	#N/A
159.0	-13.2	342.0	-28.7	-3	#N/A
160.0	-14.8	343.0	-30.3	-3	#N/A
161.0	-10.5	344.0	-25.9	-3	#N/A
162.0	-6.9	345.0	-22.4	-3	#N/A
163.0	-3.8	346.0	-19.2	-3	#N/A
164.0	-3.8	347.0	-19.2	-3	#N/A
165.0	0.6	348.0	-14.9	-3	#N/A
166.0	0.7	349.0	-14.8	-3	#N/A
167.0	2.9	350.0	-12.5	-3	#N/A
168.0	3.8	351.0	-11.6	-3	#N/A
169.0	5.2	352.0	-10.2	-3	#N/A
170.0	5.2	353.0	-10.3	-3	#N/A
171.0	9.3	354.0	-6.2	-3	#N/A
172.0	9.3	355.0	-6.2	-3	#N/A
173.0	12.6	356.0	-2.9	#N/A	#N/A
174.0	12.6	357.0	-2.8	#N/A	#N/A
175.0	14.8	358.0	-0.6	#N/A	#N/A

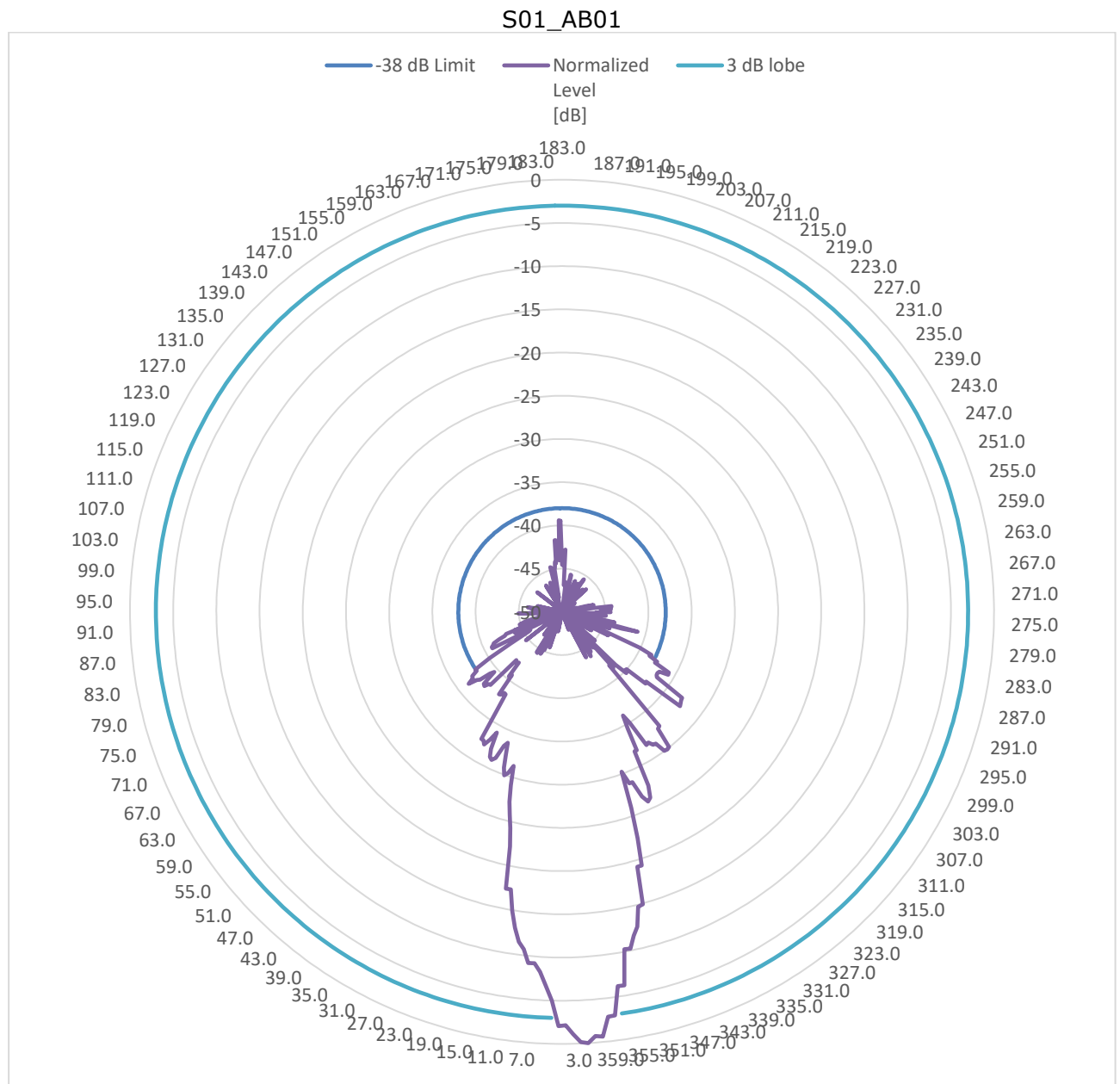
309.0	-30.9	132.0	-46.4	-3	-38
310.0	-32.5	133.0	-47.9	-3	-38
311.0	-33.1	134.0	-48.5	-3	-38
312.0	-39.6	135.0	-55.0	-3	-38
313.0	-39.1	136.0	-54.6	-3	-38
314.0	-38.1	137.0	-53.6	-3	-38
315.0	-38.1	138.0	-53.6	-3	-38
316.0	-37.1	139.0	-52.5	-3	-38
317.0	-37.3	140.0	-52.8	-3	-38
318.0	-39.7	141.0	-55.1	-3	-38
319.0	-40.1	142.0	-55.6	-3	-38
320.0	-40.0	143.0	-55.5	-3	-38
321.0	-36.3	144.0	-51.7	-3	-38
322.0	-36.9	145.0	-52.3	-3	-38
323.0	-38.5	146.0	-54.0	-3	-38
324.0	-39.2	147.0	-54.6	-3	-38
325.0	-40.2	148.0	-55.7	-3	-38
326.0	-40.0	149.0	-55.5	-3	-38
327.0	-40.0	150.0	-55.5	-3	-38
328.0	-40.7	151.0	-56.1	-3	-38
329.0	-31.2	152.0	-46.6	-3	-38
330.0	-31.0	153.0	-46.4	-3	-38
331.0	-35.6	154.0	-51.1	-3	-38
332.0	-35.2	155.0	-50.6	-3	-38
333.0	-40.5	156.0	-56.0	-3	-38
334.0	-34.2	157.0	-49.7	-3	-38
335.0	-31.4	158.0	-46.9	-3	-38
336.0	-31.4	159.0	-46.8	-3	-38
337.0	-33.2	160.0	-48.6	-3	-38
338.0	-31.7	161.0	-47.2	-3	-38
339.0	-30.9	162.0	-46.4	-3	-38
340.0	-36.0	163.0	-51.4	-3	-38
341.0	-36.8	164.0	-52.2	-3	-38
342.0	-34.3	165.0	-49.8	-3	-38
343.0	-33.7	166.0	-49.2	-3	-38
344.0	-33.4	167.0	-48.9	-3	-38
345.0	-33.1	168.0	-48.6	-3	-38
346.0	-29.2	169.0	-44.7	-3	-38
347.0	-29.3	170.0	-44.7	-3	-38
348.0	-32.9	171.0	-48.4	-3	-38
349.0	-32.8	172.0	-48.2	-3	-38
350.0	-31.7	173.0	-47.2	-3	-38
351.0	-29.6	174.0	-45.1	-3	-38
352.0	-29.3	175.0	-44.8	-3	-38
353.0	-28.7	176.0	-44.2	-3	-38
354.0	-28.9	177.0	-44.4	-3	-38
355.0	-26.2	178.0	-41.7	-3	-38

176.0	14.7	359.0	-0.8	#N/A	#N/A
177.0	15.5	0.0	0.0	#N/A	#N/A
178.0	15.3	1.0	-0.2	#N/A	#N/A
179.0	14.4	2.0	-1.1	#N/A	#N/A

356.0	-26.2	179.0	-41.7	-3	-38
357.0	-28.2	180.0	-43.6	-3	-38
358.0	-28.6	181.0	-44.0	-3	-38
359.0	-23.9	182.0	-39.4	-3	-38
360.0	-24.0	183.0	-39.5	-3	-38

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

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



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
- Sweep time: 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 %

S01_AA01

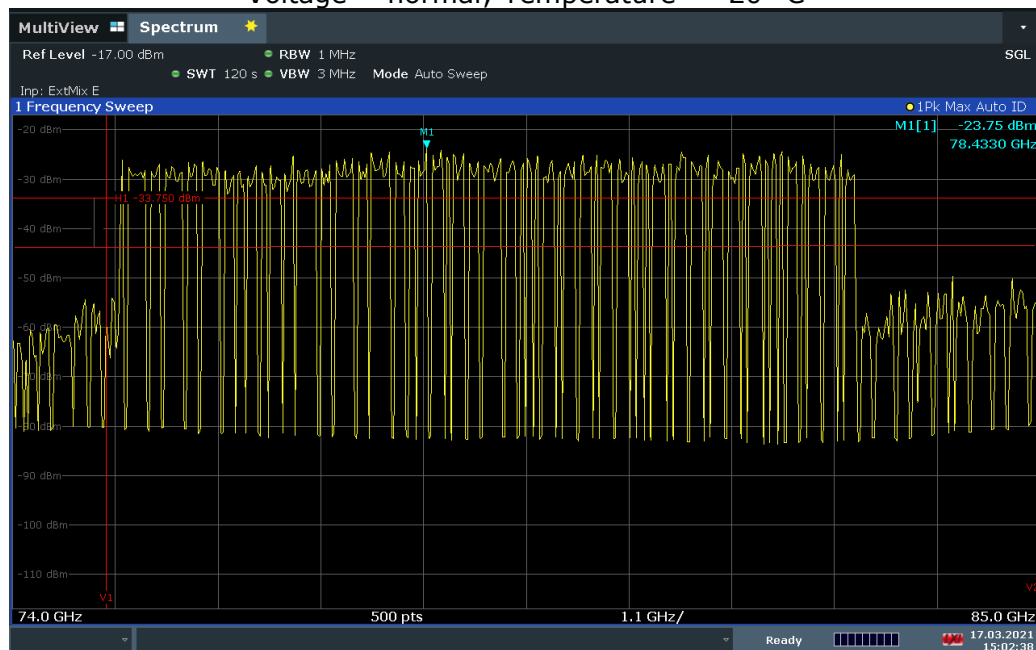
Ch.	Center Freq. [MHz]	Temperature	Voltage	Limit	Verdict
80000		-20 °C	normal	20 dBc	Passed
80000		-10 °C	normal	20 dBc	Passed
80000		0 °C	normal	20 dBc	Passed
80000		10 °C	normal	20 dBc	Passed
80000		20 °C	low	20 dBc	Passed
80000		20 °C	normal	20 dBc	Passed
80000		20 °C	high	20 dBc	Passed
80000		30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

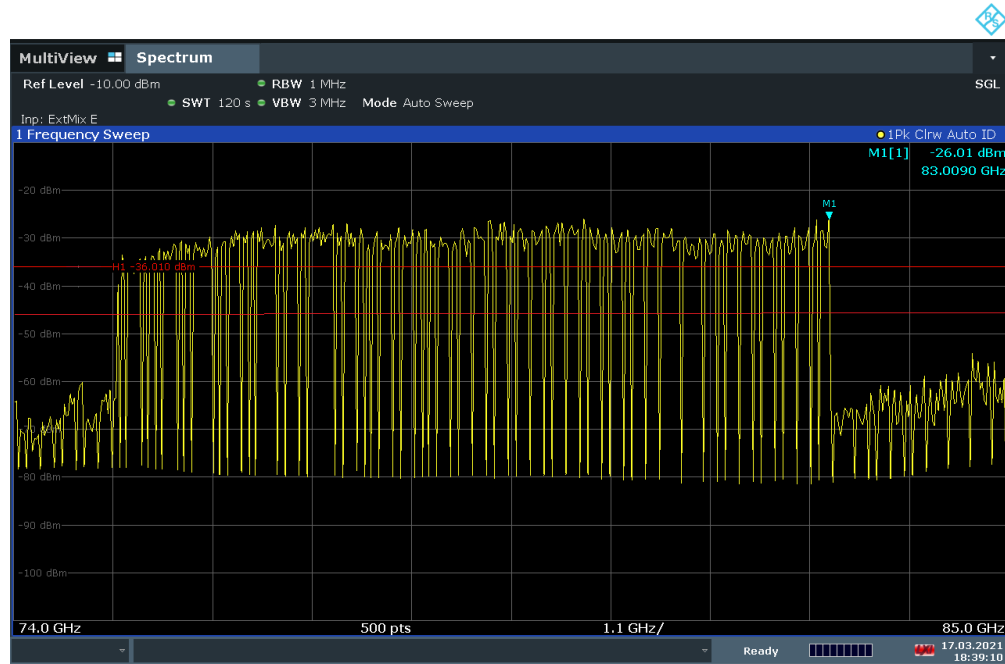
S01_AB01

Voltage = normal; Temperature = -20 °C



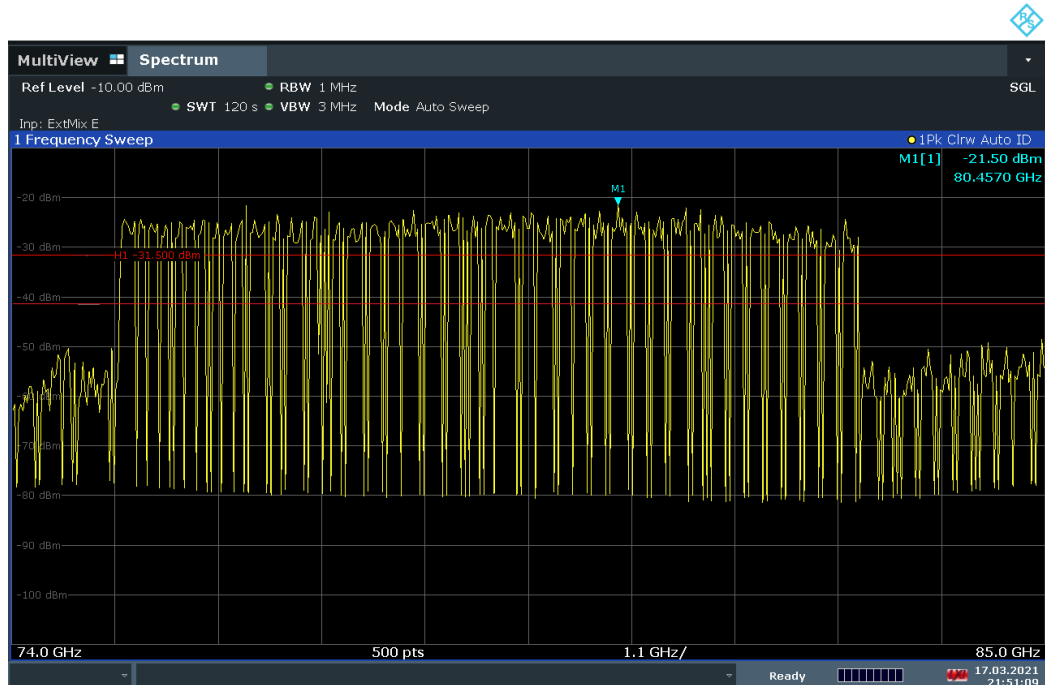
15:02:39 17.03.2021

S01_AB01
Voltage = normal; Temperature = 20 °C



18:39:11 17.03.2021

S01_AB01
Voltage = normal; Temperature = 50 °C



21:51:10 17.03.2021

5.6.5 TEST EQUIPMENT USED

- Radiated Emissions

6 TEST EQUIPMENT

- 1 Radiated Emissions
Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2020-11	2021-11
1.2	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515		
1.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13	Lufft Mess- und Regeltechnik GmbH	ID 13936	2019-05	2021-05
1.4	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2019-12	2021-12
1.5	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia	none		
1.6	FS-Z60	Harmonic Mixer 40 - 60 GHz	Rohde & Schwarz Messgerätebau GmbH	100178	2020-03	2023-03
1.7	FS-Z220	Harmonic Mixer 140 - 220 GHz	Rohde & Schwarz Messgerätebau GmbH	101005	2020-03	2023-03
1.8	SGH-05	Standard Gain / Pyramidal Horn Antenna (140 - 220 GHz)	RPG-Radiometer Physics GmbH	075		
1.9	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
1.10	AMF-7D00101800-30-10P-R	Broadband Amplifier 100 MHz - 18 GHz	Miteq			
1.11	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
1.12	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
1.13	Anechoic Chamber 03	FAR, 8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB		
1.14	WRD1920/1980-5/22-5EESD	Tunable Band Reject Filter	Wainwright Instruments GmbH	11		
1.15	TDS 784C	Digital Oscilloscope [SA2] (Aux)	Tektronix	B021311		
1.16	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.17	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2019-02	2021-08
1.18	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronik GmbH	00083069		
1.19	SGH-19	Standard Gain / Pyramidal Horn Antenna (40 - 60 GHz)	RPG-Radiometer Physics GmbH	093		
1.20	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright Instruments GmbH	09		
1.21	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99		
1.22	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
1.23	WRCD1879.8-0.2/40-10EE	Notch Filter Ultra Stable	Wainwright Instruments GmbH	16		
1.24	Chroma 6404	AC Source	Chroma ATE INC.	64040001304		
1.25	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
1.26	TT 1.5 WI	Turn Table	Maturo GmbH	-		
1.27	HL 562 ULTRALOG	Biconical-log-per Antenna (30 MHz - 3 GHz)	Rohde & Schwarz GmbH & Co. KG	100609	2019-05	2022-05
1.28	FS-Z325	Harmonic Mixer 220 - 325 GHz	Rohde & Schwarz Messgerätebau GmbH	101006	2020-03	2023-03
1.29	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronik GmbH	00086675		
1.30	MA4985-XP-ET	Bore Sight Antenna Mast	innco systems GmbH	none		
1.31	SGH-08	Standard Gain / Pyramidal Horn Antenna (90 - 140 GHz)	RPG-Radiometer Physics GmbH	064		
1.32	SGH-12	Standard Gain / Pyramidal HornAntenna (60 - 90 GHz)	RPG-Radiometer Physics GmbH	326		
1.33	JUN-AIR Mod. 6-15	Air Compressor	JUN-AIR Deutschland GmbH	612582		
1.34	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
1.35	FS-Z140	Harmonic Mixer 90 -140 GHz	Rohde & Schwarz Messgerätebau GmbH	101007	2020-03	2023-03
1.36	OLS-1 M	Fibre optic link USB 1.1	Ingenieurbüro Scheiba	018		
1.37	Opus10 THI (8152.00)	ThermoHygro Datalogger 12	Luft Mess- und Regeltechnik GmbH	ID 12482	2019-06	2021-06

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.38	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
1.39	AS 620 P	Antenna Mast (pneumatic polarisation)	HD GmbH	620/37		
1.40	TD1.5-10kg	EUT Tilt Device (Rohacell)	Maturo GmbH	TD1.5-10kg/024/3790709		
1.41	SGH-03	Standard Gain / Pyramidal Horn Antenna (220 - 325 GHz)	RPG-Radiometer Physics GmbH	060		
1.42	FS-Z90	Harmonic Mixer 60 - 90 GHz	Rohde & Schwarz Messgerätebau GmbH	101686	2020-03	2023-03
1.43	Innco Systems CO3000	Controller for bore sight mast SAC	innco systems GmbH	CO3000/967/39371016/L		
1.44	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
1.45	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
1.46	WRCA800/960-0.2/40-6EEK	Tunable Notch Filter	Wainwright Instruments GmbH	20		
1.47	AM 4.0	Antenna Mast 4 m	Maturo GmbH	AM4.0/180/11920513		
1.48	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07
1.49	E4408B	Spectrum Analyser (9 kHz to 26.5 GHz)	Agilent Technologies Deutschland GmbH	MY45103714		
1.50	Temperature Chamber VT 4002	Temperature Chamber Vötsch 03	Vötsch	58566002150010	2020-05	2022-05

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

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

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.

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

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

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

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

7.3 ANTENNA R&S HL562 (30 MHz – 1 GHz)

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

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

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

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)
 $\text{distance correction} = -20 * \text{LOG} (d_{\text{Limit}} / d_{\text{used}})$
 Linear interpolation will be used for frequencies in between the values in the table.
 Tables show an extract of values.

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

Frequency	AF R&S HF907	Corr.
MHz	dB (1/m)	dB
1000	24.4	-19.4
2000	28.5	-17.4
3000	31.0	-16.1
4000	33.1	-14.7
5000	34.4	-13.7
6000	34.7	-12.7
7000	35.6	-11.0

cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten- uator & pre-amp)	cable loss 4 (to receiver)		
dB	dB	dB	dB		
0.99	0.31	-21.51	0.79		
1.44	0.44	-20.63	1.38		
1.87	0.53	-19.85	1.33		
2.41	0.67	-19.13	1.31		
2.78	0.86	-18.71	1.40		
2.74	0.90	-17.83	1.47		
2.82	0.86	-16.19	1.46		

Frequency	AF R&S HF907	Corr.
MHz	dB (1/m)	dB
3000	31.0	-23.4
4000	33.1	-23.3
5000	34.4	-21.7
6000	34.7	-21.2
7000	35.6	-19.8

cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten- uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
dB	dB	dB	dB	dB	
0.47	1.87	0.53	-27.58	1.33	
0.56	2.41	0.67	-28.23	1.31	
0.61	2.78	0.86	-27.35	1.40	
0.58	2.74	0.90	-26.89	1.47	
0.66	2.82	0.86	-25.58	1.46	

Frequency	AF R&S HF907	Corr.
MHz	dB (1/m)	dB
7000	35.6	-57.3
8000	36.3	-56.3
9000	37.1	-55.3
10000	37.5	-56.2
11000	37.5	-55.3
12000	37.6	-53.7
13000	38.2	-53.5
14000	39.9	-56.3
15000	40.9	-54.1
16000	41.3	-54.1
17000	42.8	-54.4
18000	44.2	-54.7

cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre- amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
dB	dB	dB	dB	dB	dB
0.56	1.28	-62.72	2.66	0.94	1.46
0.69	0.71	-61.49	2.84	1.00	1.53
0.68	0.65	-60.80	3.06	1.09	1.60
0.70	0.54	-61.91	3.28	1.20	1.67
0.80	0.61	-61.40	3.43	1.27	1.70
0.84	0.42	-59.70	3.53	1.26	1.73
0.83	0.44	-59.81	3.75	1.32	1.83
0.91	0.53	-63.03	3.91	1.40	1.77
0.98	0.54	-61.05	4.02	1.44	1.83
1.23	0.49	-61.51	4.17	1.51	1.85
1.36	0.76	-62.36	4.34	1.53	2.00
1.70	0.53	-62.88	4.41	1.55	1.91

Sample calculation

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

U = Receiver reading

AF = Antenna factor

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

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

Tables show an extract of values.

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

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

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.

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

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

U = Receiver reading

AF = Antenna factor

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

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

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

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

Table shows an extract of values.

7.7 ANTENNA SGH-19 (40 GHZ – 60 GHZ)

Frequency GHz	AF SGH-19 dB (1/m)	Corr. dB	cable loss 1 (inside chamber) dB	cable loss 2 (outside chamber) dB	cable loss 3 (switch unit) dB	Harmonic Mixer FS-Z60 dB	distance corr. (-20 dB/ decade) dB	d _{Limit} (meas. distance (limit) m	d _{used} (meas. distance (used) 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

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

U = Receiver reading

AF = Antenna factor

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

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

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

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

Table shows an extract of values.

7.8 ANTENNA SGH-12 (60 GHZ – 90 GHZ)

Frequency GHz	AF SGH-12 dB (1/m)	Corr. dB	cable loss 1 (inside chamber) dB	cable loss 2 (outside chamber) dB	cable loss 3 (switch unit) dB	Harmonic Mixer FS-Z90 dB	distance corr. (-20 dB/ decade) dB	d _{Limit} (meas. distance (limit) m	d _{used} (meas. distance (used) 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

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

U = Receiver reading

AF = Antenna factor

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

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

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

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

Table shows an extract of values.

7.9 ANTENNA SGH-08 (90 GHZ – 140 GHZ)

Frequency GHz	AF SGH-19 dB (1/m)	Corr. dB	cable loss 1 (inside chamber) dB	cable loss 2 (outside chamber) dB	cable loss 3 (switch unit) dB	Harmonic Mixer FS-Z140 dB	distance corr. (-20 dB/ decade) dB	d _{Limit} (meas. distance (limit) m	d _{used} (meas. distance (used) 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

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

U = Receiver reading

AF = Antenna factor

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

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

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

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

Table shows an extract of values.

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

Frequency GHz	AF SGH-19 dB (1/m)	Corr. dB	cable loss 1 (inside chamber) dB	cable loss 2 (outside chamber) dB	cable loss 3 (switch unit) dB	Harmonic Mixer FS-Z140 dB	distance corr. (-20 dB/ decade) dB	d _{Limit} (meas. distance (limit) m	d _{used} (meas. distance (used) 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

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

U = Receiver reading

AF = Antenna factor

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

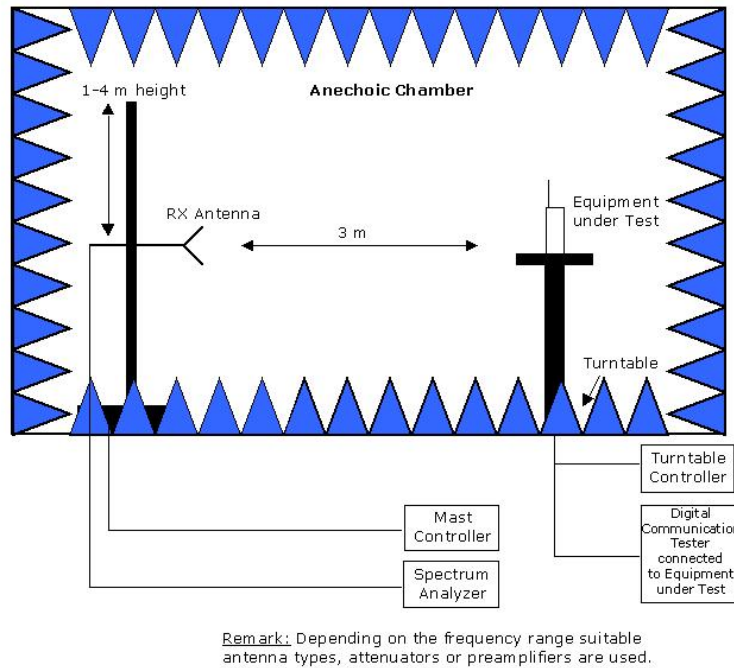
Linear interpolation will be used for frequencies in between the values in the table.

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

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

Table shows an extract of values.

8 SETUP DRAWINGS

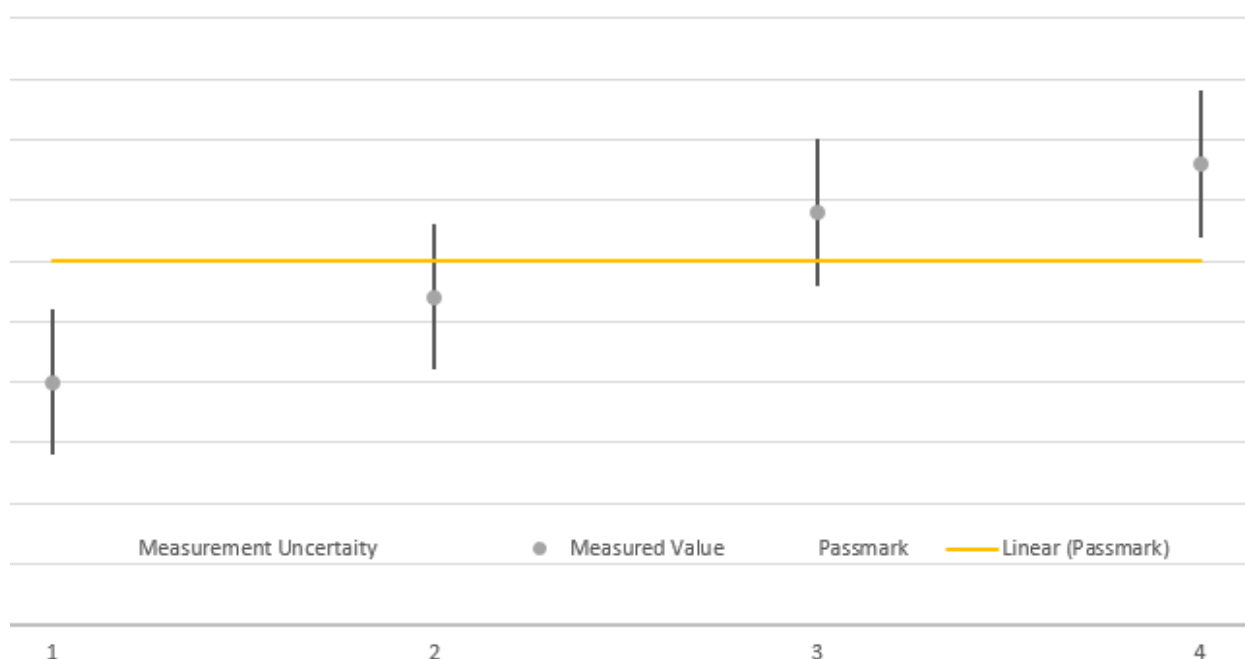


Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting groundplane.

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.