InterLab®

FCC Measurement/Technical Report on

ECU with LF transmitter and transponder reader 013854 Part of system “37W”

FCC ID: NBG013854
IC: 2694A-013854

Report Reference: MDE_HELLA_1806_FCCa_REV1

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Deutsche Akkreditierungsstelle D-PL-12140-01-00

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

0 Summary

0.1 TECHNICAL REPORT SUMMARY

Type of Authorization

Certification for an Intentional Radiator.

0.2 APPLICABLE FCC RULES

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-18 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

§ 2.1049 Occupied bandwidth

§ 15.205 Restricted bands of operation

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

Note:
ANSI C63.10-2013 applied.

Summary Test Results:

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

0.3 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for FCC and IC for general radio equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 5: 8.8
Transmitter spurious radiated emissions	§ 15.209 (a)	RSS-Gen Issue 5: 6.13/8.9/8.10; RSS-210 Issue 9: 4.3/4.4
Restricted Bands	§ 15.205	RSS-Gen Issue 5: 8.10; RSS-210 Issue 9: 4.1;
Wanted Emission (Carrier)	§ 15.209	RSS-210 Issue 9: 4.4 RSS-Gen Issue 5: 6.12, 8.9
Other requirements, e.g. Transmitter frequency stability	–	RSS- Gen, Issue 5: 6.11/8.11
Receiver spurious emissions	–	RSS Gen Issue 5: 5/7
Occupied bandwidth	§2.1049	RSS Gen Issue 5: 6.7

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

0.4 MEASUREMENT SUMMARY / SIGNATURES

47 CFR Chapter I FCC Part 15, Subpart C	**§15.209**		
Radiated Emissions			
The measurement was performed according to ANSI C63.10			
OP-Mode	**Setup**	**Port**	**Final Result**
CM	Setup_01	Enclosure	passed
CM	Setup_02	Enclosure	passed
47 CFR Chapter I FCC Part 15, Subpart C	**§15.209**		
Peak Output Power			
The measurement was performed according to ANSI C63.10			
OP-Mode	**Setup**	**Port**	**Final Result**
CM	Setup_01	Enclosure	passed
CM	Setup_02	Enclosure	passed
47 CFR Chapter I FCC Part 15, Subpart C	**§15.207**		
Conducted Emissions AC Power line			
The measurement shall be performed according to ANSI C63.10			
OP-Mode	**Setup**	**Port**	**Final Result**
–	–	–	N/A (1)
47 CFR Chapter I FCC Part 2, Subpart J	**§2.1049**		
Occupied Bandwidth			
The measurement was performed according to ANSI C63.10			
OP-Mode	**Setup**	**Port**	**Final Result**
CM	Setup_01	Enclosure	performed
CM	Setup_02	Enclosure	performed
RSS-Gen	**6.11/8.11**		
Frequency Stability			
The measurement shall be performed according to ANSI C63.10			
OP-Mode	**Setup**	**Port**	**Final Result**
–	–	–	N/A (2)

Notes:
N/A = Not applicable
(1) The EUT is DC powered.
(2) Not required per 8.11.
performed = no limit is applicable to the test result.

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2018-11-06	---	not valid
REV1	2019-03-06	• Page 3: FCC Edition updated. • Page 6: Customer address corrected. • Page 7: Highest internal frequency added • Page 10: Measurement description for Radiated Emissions test case updated. • Page 17: EUT orientation during the measurements added.	valid

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Responsible for Accreditation Scope: M. Heller

Responsible for Test Report:

1 ADMINISTRATIVE DATA

1.1 TESTING LABORATORY

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

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

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

Laboratory accreditation no:	DAkkS D-PL-12140-01-00
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
Responsible for accreditation scope:	Dipl.-Ing. Marco Kullik
Report Template Version:	2018-01-22

1.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Dobrin Dobrinov
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2019-03-06
Testing Period:	2018-10-24 to 2018-10-25

1.3 APPLICANT DATA

Company Name:	HELLA GmbH & Co. KGaA
Address:	Rixbecker Str. 75 59557 Lippstadt Germany
Contact Person:	Mr. Christian Elbers

1.4 MANUFACTURER DATA

Company Name:	Please see applicant
Address:	
Contact Person:	

2 TEST OBJECT DATA

2.1 GENERAL EUT DESCRIPTION

Kind of Device product description	The EUT is a vehicle based 125 kHz LF transmitter, used for passive key entry / passive start and immobilizing operations
Product name	ECU with LF transmitter and transponder reader Part of system “37W”
Type	013854
Declared EUT data by the supplier	
Power Supply Type	DC
Nominal Voltage / Frequency	13.5 V
Test Voltage / Frequency	13.5 V
Highest internal frequency	24.0 MHz
General Description	125 kHz Transmitter
Ports	Combined DC antenna cables connector, Antennas
Special software used for testing	Yes, provided by the manufacturer

2.2 EUT MAIN COMPONENTS

Sample Name	**Sample Code**	**Description**
EUT A	DE1332007aa02	radiated sample
Sample Parameter	**Value**	
Serial No.	N/A	
HW Version	7	
SW Version	special SOFTWARE TYPE based on serial SW 4	
Comment	used for radiated measurements, mode LF Scan	
Comment	Model: 013854, Testsetup 1 ECU “LF Scan”	

Sample Name	**Sample Code**	**Description**
EUT B	DE1332007aa03	radiated sample
Sample Parameter	**Value**	
Serial No.	N/A	
HW Version	7	
SW Version	special SOFTWARE TYPE based on serial SW 4	
Comment	used for radiated measurements, mode IMMO	
Comment	Model: 013854, Testsetup 1 ECU “IMMO”	

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

2.3 ANCILLARY EQUIPMENT

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

Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
ANC1	LF antenna 5WA 962 132, 5FA 224.075-00 1803001, Hella Muster Nr. 0812	C1 sample, A2 12/18 02K, MD 4.0 KW 13/18, HW 3.0 KW 10/18
Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
ANC2	LF antenna 5WA 962 132, 5FA 224.075-00 1803001, Hella Muster Nr. 0826	C1 sample, A2 12/18 02K, MD 4.0 KW 13/18, HW 3.0 KW 10/18
Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
ANC3	LF antenna Volkswagen Hella, Exterior 2-polig 5WA 962. 131, 5FA 224.076-00 Hella Muster Nr. 3011	C0 Muster, HW 5.0 KW29/18 MD 5.0 KW30/18,
Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
ANC4	LF antenna Volkswagen Hella, Exterior 2-polig 5WA 962. 131, 5FA 224.076-00 Hella Muster Nr. 3075	C0 Muster, HW 5.0 KW29/18 MD 5.0 KW30/18,
Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
ANC5	LF antenna Volkswagen Hella, Exterior 2-polig 5WA 962. 131, 5FA 224.076-00 Hella Muster Nr. 3008	C0 Muster, HW 5.0 KW29/18 MD 5.0 KW30/18,
Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
ANC6	LF antenna Volkswagen Hella, Exterior 2-polig 5WA 962. 131, 5FA 224.076-00 Hella Muster Nr. 3078	C0 Muster, HW 5.0 KW29/18 MD 5.0 KW30/18,

2.4 AUXILIARY EQUIPMENT

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

Short Description	**Device**	**Type Designation**	**Serial No.**	**HW Status**	**SW Status**
---	---	---	-	–	–

2.5 EUT SETUPS

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

Setup No.	Combination of EUTs	Description and Rationale
Setup_01	EUT A + ANC 1 to ANC 6	EUT ancillaries, auxiliary and representative cables are connected to the DC combined connector
Setup_02	EUT B + ANC 1 to ANC 6	EUT ancillaries, auxiliary and representative cables are connected to the DC combined connector

2.6 OPERATING MODES

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

Op. Mode	Description of Operating Modes	Remarks
LF Scan	continuously modulated	EUT is transmitting continuously modulated signal
IMMO	continuously modulated	EUT is transmitting continuously modulated signal

2.6.1 TEST CHANNELS

Single: 125 kHz modulated carrier

2.7 PRODUCT LABELLING

2.7.1 FCC ID LABEL

NBG013854

2.7.2 IC LABEL

2694A-013854

2.7.3 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

3 TEST RESULTS

3.1 SPURIOUS RADIATED EMISSIONS

Standard **FCC Part 15, Subpart C**

The test was performed according to: ANSI C63.10

3.1.1 TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 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. 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
- Antenna height: 1 m
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

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

Step 2: final measurement
For the relevant emissions determined in step 1, an additional measurement with the following settings will be performed. Intention of this step is to find the maximum emission level.

- Detector: Quasi-Peak (9 kHz – 150 kHz, Peak / Average 150 kHz- 30 MHz)
- 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 2, the final measurement will be performed:
EMI receiver settings for step 3:
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated 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 / CISPR Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

3.1.2 TEST REQUIREMENTS / LIMITS

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

Class B:

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

Class A:

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

The measured values for Class A and for Class B (> 26 GHz) measurements are corrected with an inverse linear distance extrapolation factor (20 dB/decade).

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

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

3.1.3 Test Protocol

Temperature: 27 °C
Air Pressure: 1005 hPa
Humidity: 37 %

3.1.3.1 Measurement up to 30 MHz

Op. Mode	Setup	Port
LF Scan	Setup_01	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
–	–	–	–	–	–	–	–	–	–	–

Op. Mode	Setup	Port
IMMO	Setup_02	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
–	–	–	–	–	–	–	–	–	–	–

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

3.1.3.2 Measurement above 30 MHz

Op. Mode	Setup	Port
LF Scan	Setup_01	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
–	–	–	–	–	–	–	–	–	–	–

Op. Mode	Setup	Port
IMMO	Setup_02	Enclosure

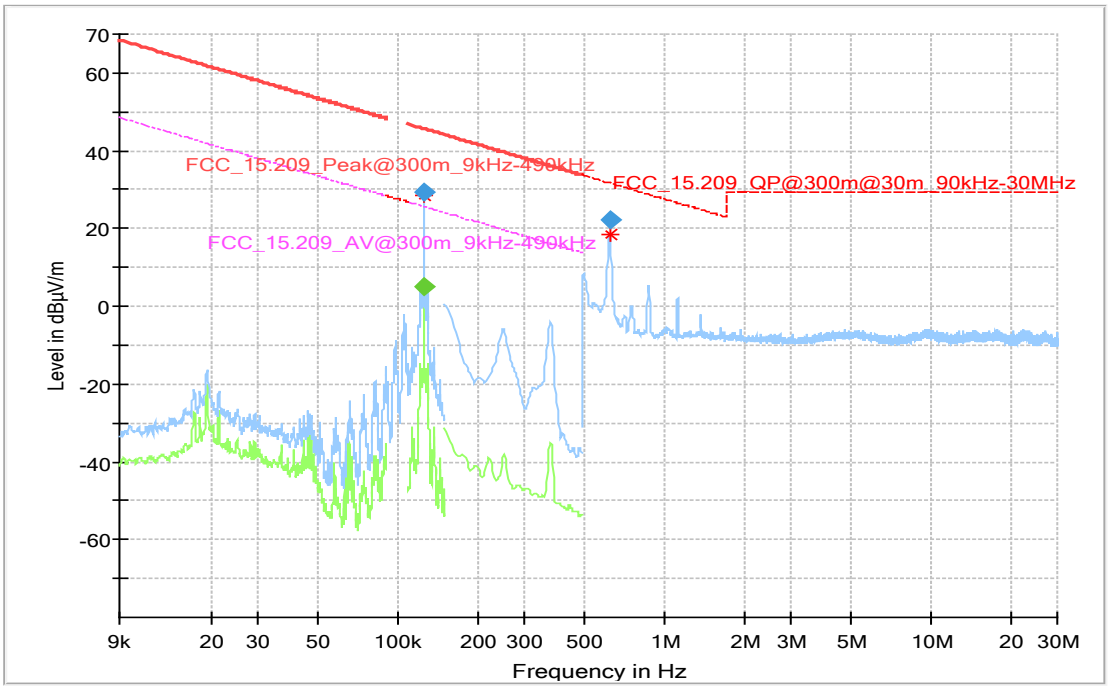
Antenna orientation	EUT orientation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
–	–	–	–	–	–	–	–	–	–	–

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

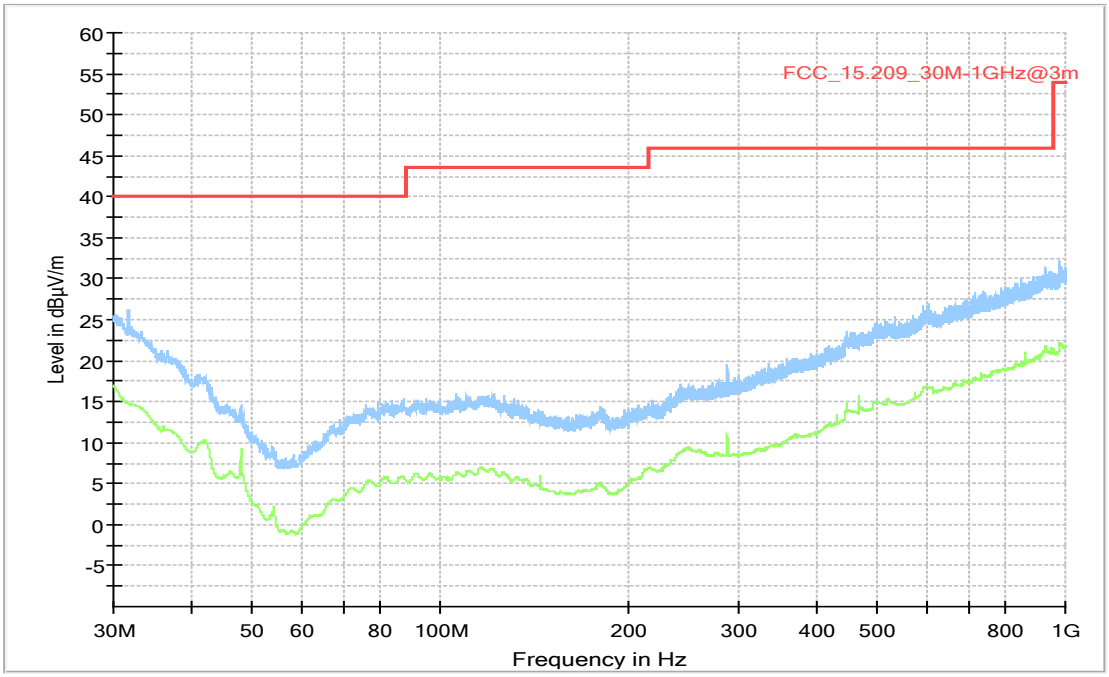
MEASUREMENT PLOTS (SHOWING THE HIGHEST VALUE, “WORST CASE”)

3.1.4 Measurement Plots (worst case)

3.1.4.1 Below 30 MHz, Operating Mode = LF Scan, Measurement range = 9 kHz - 30 MHz



3.1.4.2 Above 30 MHz, Operating Mode = IMMO, Measurement range = 30 MHz - 1 GHz



3.1.5 Test Equipment used

- Radiated Emissions

3.2 WANTED EMISSIONS (CARRIER)

Standard **FCC Part 15, Subpart C**

The test was performed according to: ANSI C63.10

3.2.1 TEST DESCRIPTION

Please refer to sub-clause 3.1.1.

3.2.2 TEST LIMITS

Please refer to sub-clause 3.1.2.

3.2.3 TEST PROTOCOL

Temperature: 27 °C
Air Pressure: 1005 hPa
Humidity: 37 %

RF ID 125 kHz

Band	Operating Mode	Frequency [kHz]	Output Power [dBµV/m]	Limit [dBµV/m]	Margin to Limit [dB]
125 kHz	LF Scan	125.05	6.63	25.68	19.05

RF ID 125 kHz

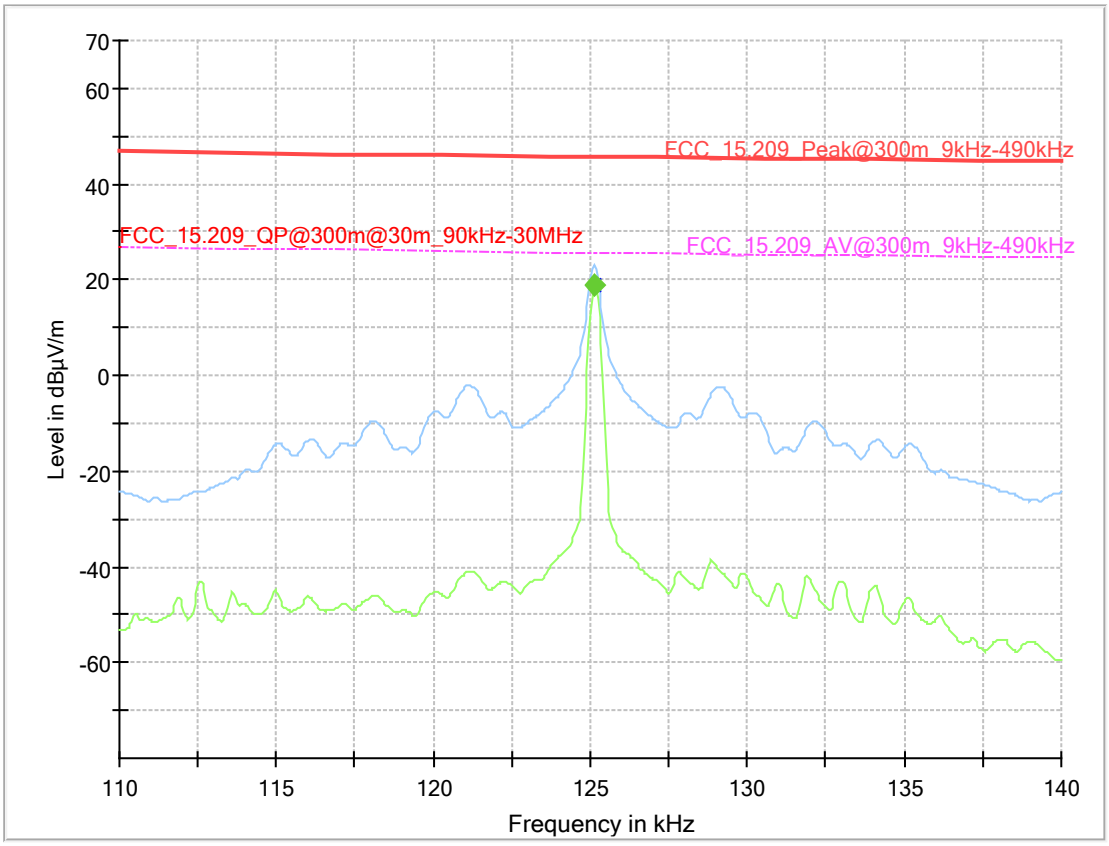
Band	Operating Mode	Frequency [kHz]	Output Power [dBµV/m]	Limit [dBµV/m]	Margin to Limit [dB]
125 kHz	IMMO	125.15	18.78	25.68	6.9

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

Radio Technology = RF ID 125 kHz, Operating Mode = Operating Mode 2 (Setup_02)

Common Information

Test Description:	Peak Power Output
Test Standard:	FCC 15c209
EUT Code:	DE1232007aa03
Operating Conditions:	NTNV
Operator Name:	Dob
Comment:	none



Note: The measurements are done with the EUT in horizontal and vertical orientation on the turn table.
It is determined that a maximal field strength is reached when the EUT has a horizontal orientation
For details, please see the Photo report.

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
0.125150	---	18.78	25.68	6.90	5000.0	0.200	100.0	V	-106.0	---

3.2.5 Test Equipment used

- Radiated Emissions

3.3 OCCUPIED BANDWIDTH

Standard **FCC Part 15 Subpart C**

The test was performed according to: ANSI C63.10

3.3.1 Test Description

The Equipment Under Test (EUT) was setup in a shielded room to perform the occupied bandwidth measurements.
The results recorded were measured with the modulation which produces the worst-case (widest) occupied bandwidth.

3.3.2 Test Requirements / Limits

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

3.3.3 Test Protocol

Temperature: 27 °C
Air Pressure: 1005 hPa
Humidity: 37 %

Op. Mode	Setup	Port
LF Scan	Setup_01	Enclosure

20 dBc bandwidth	99% occupied bandwidth
1.049 kHz	10.275 kHz

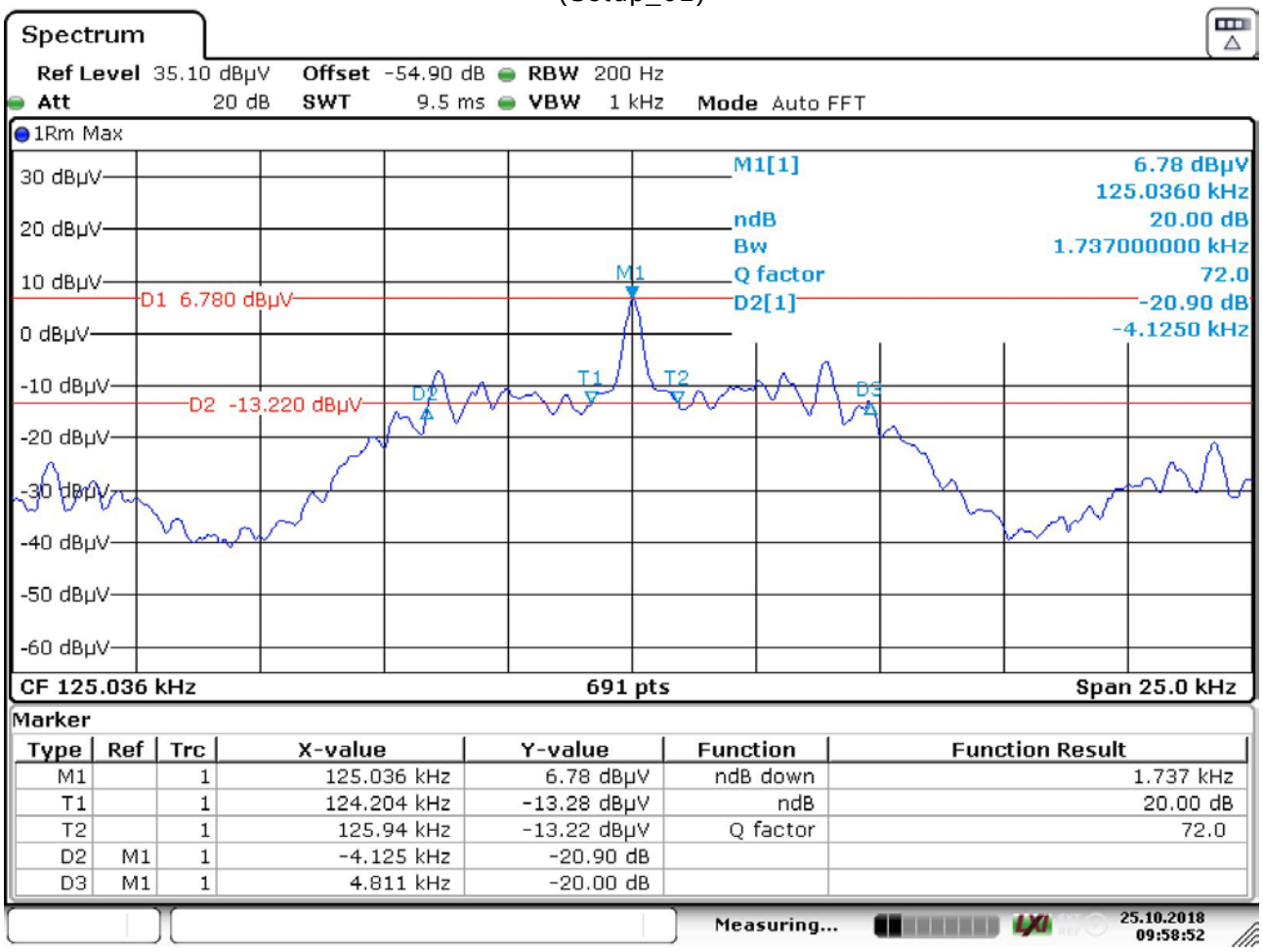
Op. Mode	Setup	Port
MIMO	Setup_02	Enclosure

20 dBc bandwidth	99% occupied bandwidth
8.936 kHz	10.492 kHz

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

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

Radio Technology = RF ID 125 kHz, Operating Mode = LF Scan (Setup_01)



Date: 25.OCT.2018 09:58:52

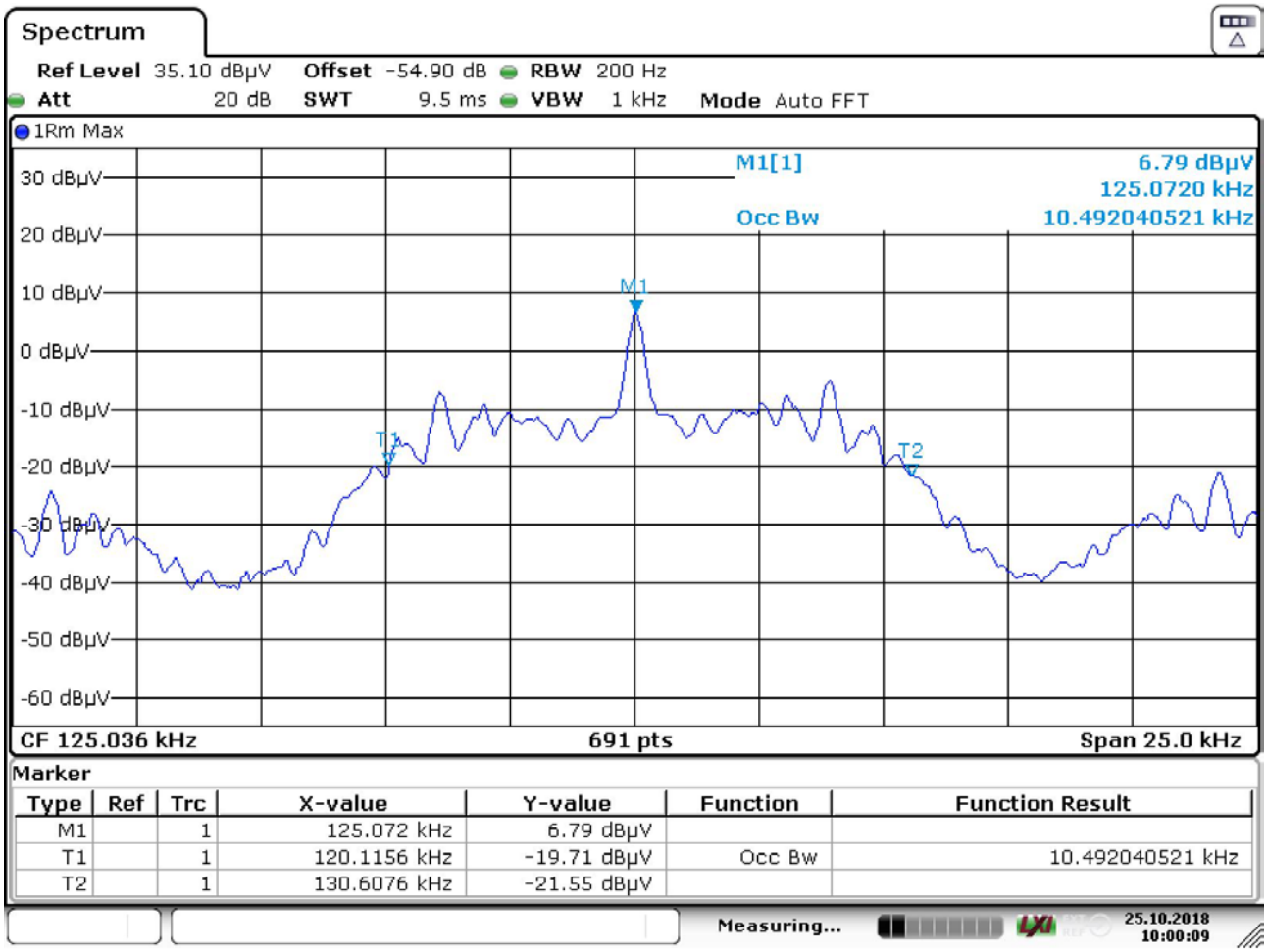
Mode: LF Scan Setup 01, 20 dBc BW

Note:
To determine the D2-line, which is 20 dB under the peak value (marker M1), the “20 dB down” function of the spectrum analyser is used. The D2-line crosses the signal curve at points marked D2 and D3.

The 20 dBc bandwidth is between markers D2 and D3:

4.811 kHz - (-4.125) kHz = **8.936 kHz** in LF Scan mode of operation

Mode: CM Setup 02, BITKey, 99% BW



Date: 25.OCT.2018 10:00:09

Note:
The OccBW is between Markers T1 and T2. The “OccBW measurement” function of the spectrum analyser is used.

3.3.5 Test Equipment used

- Radio Lab

4 TEST EQUIPMENT

1 Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	NRV-Z1	Sensor Head A	Rohde & Schwarz GmbH & Co. KG	827753/005		
1.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2018-10	2020-10
1.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-04	2019-04
1.4	ESW44	EMI Test Receiver	Rohde & Schwarz GmbH & Co. KG	101603	2018-05	2019-05
1.5	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	none		
1.6	FS-Z60	Harmonic Mixer 40 - 60 GHz	Rohde & Schwarz Messgerätebau GmbH	100178	2016-12	2019-12
1.7	FS-Z220	Harmonic Mixer 140 - 220 GHz	Rohde & Schwarz Messgerätebau GmbH	101005	2017-03	2020-03
1.8	SGH-05	Standard Gain / Pyramidal Horn Antenna (140 - 220 GHz)		075		
1.9	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2018-07	2021-07
1.10	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
1.11	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
1.12	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	2018-06	2020-06
1.13	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
1.14	NRVD	Power Meter	Rohde & Schwarz GmbH & Co. KG	828110/016		
1.15	HF 906	Double-ridged horn	Rohde & Schwarz	357357/002	2018-06	2021-06
1.16	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
1.17	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2016-12	2018-12
1.18	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
1.19	SGH-19	Standard Gain / Pyramidal Horn Antenna (40 - 60 GHz)		093		
1.20	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
1.21	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
1.22	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		

1.23	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
1.24	TT 1.5 WI	Turn Table	Maturo GmbH	-		
1.25	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz	100609	2016-04	2019-04
1.26	HF 906	Double-ridged horn	Rohde & Schwarz	357357/001	2018-03	2021-03
1.27	FS-Z325	Harmonic Mixer 220 - 325 GHz	Rohde & Schwarz Messgerätebau GmbH	101006	2017-03	2020-03
1.28	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronic GmbH	00086675		
1.29	SGH-08	Standard Gain / Pyramidal Horn Antenna (90 - 140 GHz)		064		
1.30	SGH-12	Standard Gain / Pyramidal HornAntenna (60 - 90 GHz)		326		
1.31	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
1.32	FS-Z140	Harmonic Mixer 90 -140 GHz	Rohde & Schwarz Messgerätebau GmbH	101007	2017-02	2020-02
1.33	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2018-01	2021-01
1.34	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-03	2019-03
1.35	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11	2018-11
1.36	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
1.37	AS 620 P	Antenna mast	HD GmbH	620/37		
1.38	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
1.39	SGH-03	Standard Gain / Pyramidal Horn Antenna (220 - 325 GHz)		060		
1.40	FS-Z90	Harmonic Mixer 60 - 90 GHz	Rohde & Schwarz Messgerätebau GmbH	101686	2017-03	2020-03
1.41	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2018-01	2020-01
1.42	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
1.43	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
1.44	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
1.45	HF 907	Double-ridged horn	Rohde & Schwarz	102444		

2 Radio Lab

Conducted Radio Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2017-07	2020-07
2.2	MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2018-10	2020-10
2.3	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-04	2020-04
2.4	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
2.5	SMP03	Signal Generator 2 GHz - 27 GHz	Rohde & Schwarz	833680/003	2017-09	2020-09
2.6	FSIQ26	Signal Analyser	Rohde & Schwarz	840061/005	2017-05	2019-05
2.7	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
2.8	VT 4002	Temperature Chamber	Vötsch	58566002150010	2018-04	2020-04
2.9	WA1515	Broadband Power Divider SMA	Weinschel Associates	A855		
2.10	A8455-4	4 Way Power Divider (SMA)		-		
2.11	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2017-03	2019-03
2.12	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2016-10	2019-10

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

- 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.

- 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.

- 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

- 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.

- 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.

- 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.

- ANTENNA EMCO 3160-10 (26.5 GHz – 40 GHz)

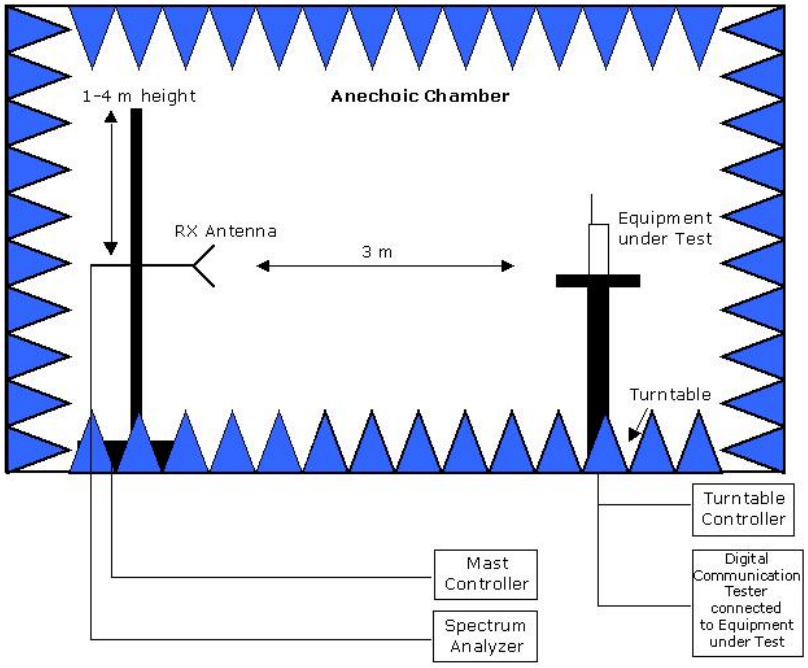
Frequency	AF EMCO 3160-10	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
26.5	43.4	-11.2	4.4				-15.6	3	0.5
27.0	43.4	-11.2	4.4				-15.6	3	0.5
28.0	43.4	-11.1	4.5				-15.6	3	0.5
29.0	43.5	-11.0	4.6				-15.6	3	0.5
30.0	43.5	-10.9	4.7				-15.6	3	0.5
31.0	43.5	-10.8	4.7				-15.6	3	0.5
32.0	43.5	-10.7	4.8				-15.6	3	0.5
33.0	43.6	-10.7	4.9				-15.6	3	0.5
34.0	43.6	-10.6	5.0				-15.6	3	0.5
35.0	43.6	-10.5	5.1				-15.6	3	0.5
36.0	43.6	-10.4	5.1				-15.6	3	0.5
37.0	43.7	-10.3	5.2				-15.6	3	0.5
38.0	43.7	-10.2	5.3				-15.6	3	0.5
39.0	43.7	-10.2	5.4				-15.6	3	0.5
40.0	43.8	-10.1	5.5				-15.6	3	0.5

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear 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.

Test Case	Parameter	Uncertainty
AC Power Line	Voltage	± 3.4 dB
Field Strength of spurious radiation	Voltage	± 5.5 dB

5 SETUP DRAWINGS



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

6 MEASUREMENT UNCERTAINTIES

Test Case	Parameter	Uncertainty
Peak power output	Field strength	± 5.5 dB
Occupied bandwidth	Power Frequency:	± 2.9 dB ± 0.125 kHz
Spurious radiated emissions	Field strength Frequency:	± 5.5 dB ± 11.2 kHz
AC Power Line	Power	± 3.4 dB

7 PHOTO REPORT

Please see separate photo report.