

InterLab®

FCC Measurement/Technical Report on

Instrument Cluster
Plattform: VW AG PQ26
Model: 17101072

FCC ID: 2AOUZ17101072
IC: 23650-17101072

Report Reference: MDE_CONTI_1740_FCC02#17101072

Test Laboratory:

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Note:

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

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0 Summary

0.1 Technical Report Summary

Type of Authorization

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

0.2 Applicable FCC Rules

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

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	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.



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Responsible for
Accreditation Scope:



Responsible
for Test Report:



1 Administrative Data

1.1 Testing Laboratory

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

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

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

Laboratory accreditation no: DAKKS D-PL-12140-01-00
FCC Designation Number: DE0015
FCC Test Firm Registration: 929146
Responsible for accreditation scope: Dipl.-Ing. Marco Kullik

Report Template Version: 2018-01-22

1.2 Project Data

Responsible for testing and report: M.Sc. Joel Asongwe
Employees who performed the tests: documented internally at 7Layers
Date of Report: 2019-08-31
Testing Period: 2019-08-01 to 2019-08-31

1.3 Applicant Data

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

1.4 Manufacturer Data

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

2 Test object Data

2.1 General EUT Description

Equipment under Test	Instrument Cluster
Product Name	Instrument Cluster, Platform: VW AG PQ26
Type Designation:	17101072
Kind of Device:	125 kHz Transmitter and Tagging System
Voltage Type:	DC
Voltage level:	13.5 V nominal and tested voltage; 6.5 to 17.0 V

2.1.1 General product description:

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

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

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

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

The device is intended for professional installation only.

2.1.2 Specific product description for the EUT:

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

2.1.3 The EUT provides the following ports:

- Enclosure
- DC combined

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

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

2.2 EUT Main components

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

Short Description	Equipment under Test	Type Designation	Serial No.	HW Status	SW Status
EUT A (Code: DE1304027ab02)	Instrument Cluster	17101072	VD1-04821.06.1999647769	205	2321

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

2.3 Ancillary Equipment

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

Short Description	Equipment under Test	Type Designation	Serial No.	HW Status	SW Status
ANC 1	Immobilizer coil antenna	KESY 17101072	-	-	-
ANC 2	Immobilizer coil antenna	BIT Key 17101072	-	-	-

2.4 Auxiliary Equipment

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

Short Description	Device	Type Designation	Serial No.	HW Status	SW Status
AUX 1	Key fob	BH8-ELB 05.02.18 0008 0254	-	-	-

2.5 EUT Setups

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

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

2.6 Operating Modes

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

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

2.7 Special software used for testing

The applicant provides the test software.

2.8 Product labelling

Please refer to the documentation of the applicant.

3 Test Results

3.1 Spurious radiated emissions

Standard FCC Part 15, Subpart C

The test was performed according to: ANSI C63.10

3.1.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 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 2 orthogonal EUT orientations (vertical and horizontal) to determine the worst-case EUT orientation. In combination with the turntable rotation, emissions of at least 3 orthogonal axes are detected.

1. Measurement up to 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: pre-measurement

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

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

Step 2: final measurement

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

- Detector: Quasi-Peak besides 9–90 kHz and 110–490 kHz: Average and Peak
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan

This is a preliminary test to identify the highest amplitudes relative to the limit.

Settings for step 1:

- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF-Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: -180° 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 2, the final measurement will be performed:

EMI receiver settings for step 3:

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

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

3.1.2 Test Requirements / Limits

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

Frequency in MHz	Limit ($\mu\text{V}/\text{m}$)	Measurement distance (m)	Limits ($\text{dB}\mu\text{V}/\text{m}$)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

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

Frequency in MHz	Limit ($\mu\text{V}/\text{m}$)	Measurement distance (m)	Limits ($\text{dB}\mu\text{V}/\text{m}$)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 – 26000	500@3m	3	54.0@3m
26000 – 40000	500@3m	1	54.0@3m

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

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

3.1.3 Test Protocol

Temperature: 27 °C
Air Pressure: 1005 hPa
Humidity: 44 %

3.1.3.1 Measurement up to 30 MHz

Op. Mode	Setup	Port
CM	Setup_01	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dB μ V/m			Limit dB μ V/m	Limit dB μ V/m	Limit dB μ V/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
-	-	-	-	-	-	-	-	-	-	-

Op. Mode	Setup	Port
CM	Setup_02	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dB μ V/m			Limit dB μ V/m	Limit dB μ V/m	Limit dB μ V/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
-	-	-	-	-	-	-	-	-	-	-

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

3.1.3.2 Measurement above 30 MHz

Op. Mode	Setup	Port
CM	Setup_01	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dB μ V/m			Limit dB μ V/m	Limit dB μ V/m	Limit dB μ V/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
-	-	-	-	-	-	-	-	-	-	-

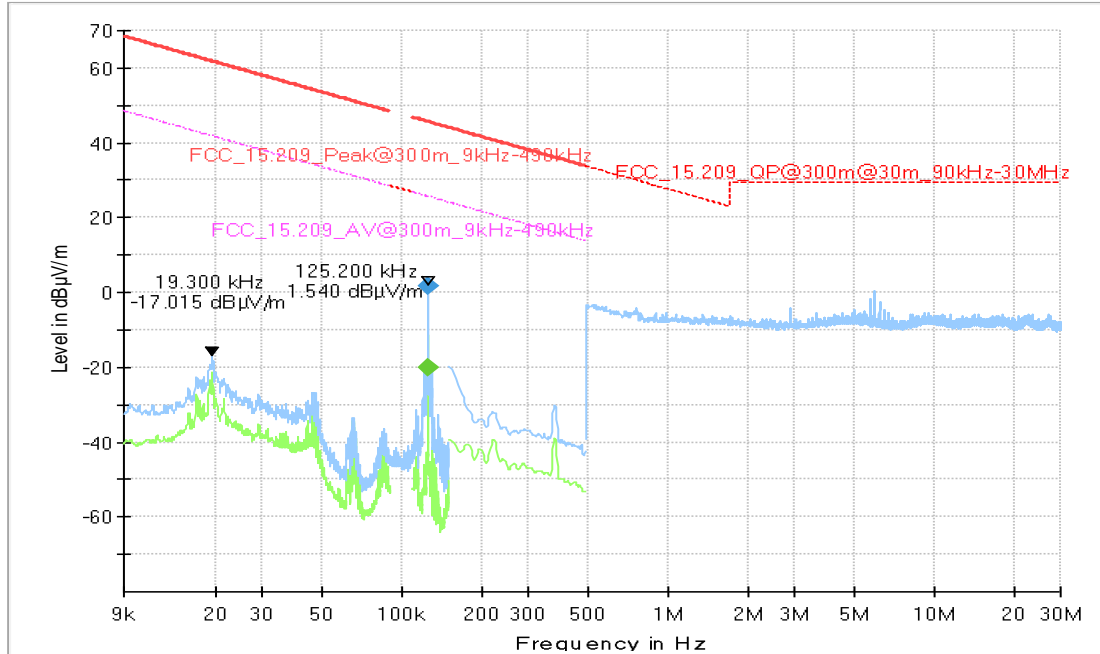
Op. Mode	Setup	Port
CM	Setup_02	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dB μ V/m			Limit dB μ V/m	Limit dB μ V/m	Limit dB μ V/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
-	-	-	-	-	-	-	-	-	-	-

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

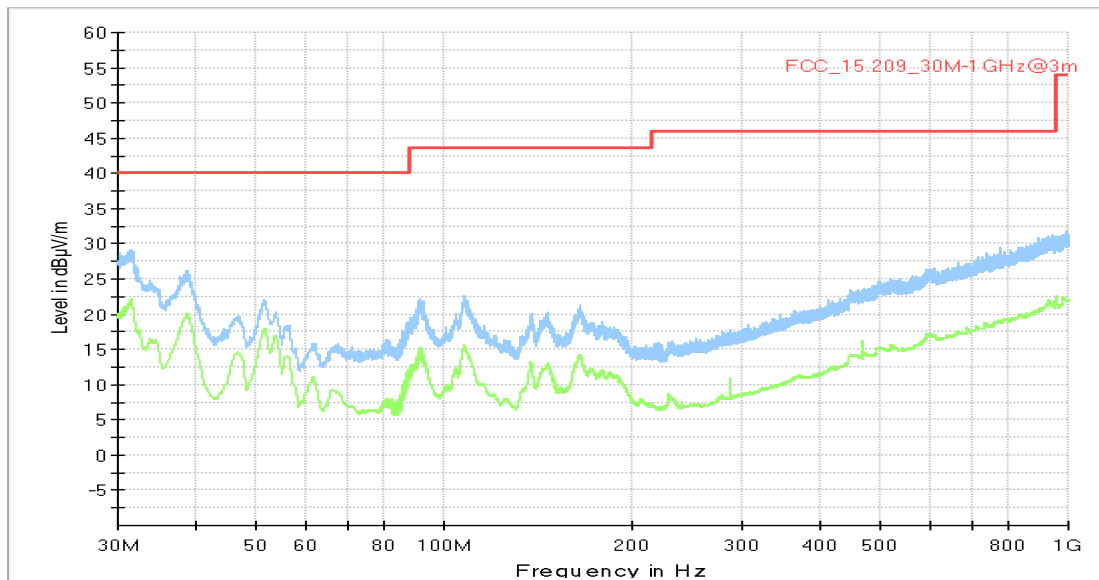
3.1.4 Measurement Plots (worst case)

3.1.4.1 Below 30 MHz



Setup_01

3.1.4.2 Above 30 MHz



Setup_01

3.1.5 Test Equipment used

- Radiated Emissions

3.2 Peak power output

Standard FCC Part 15, Subpart C

The test was performed according to: ANSI C63.10

3.2.1 Test Description

Please refer to sub-clause 3.1.1.

3.2.2 Test Limits

Please refer to sub-clause 3.1.2.

3.2.3 Test Protocol

Temperature: 27 °C
 Air Pressure: 1005 hPa
 Humidity: 44 %

Op. Mode	Setup	Port
CM	Setup_01	Enclosure

Antenna orientation	EUT orientation	Frequency kHz	Maximum radiated field strength at fundamental frequency (corrected) dB μ V/m	Limit dB μ V/m	Margin dB
			AV	AV	AV
0°	Ver.	125.2	-18.68	25.67	44.35

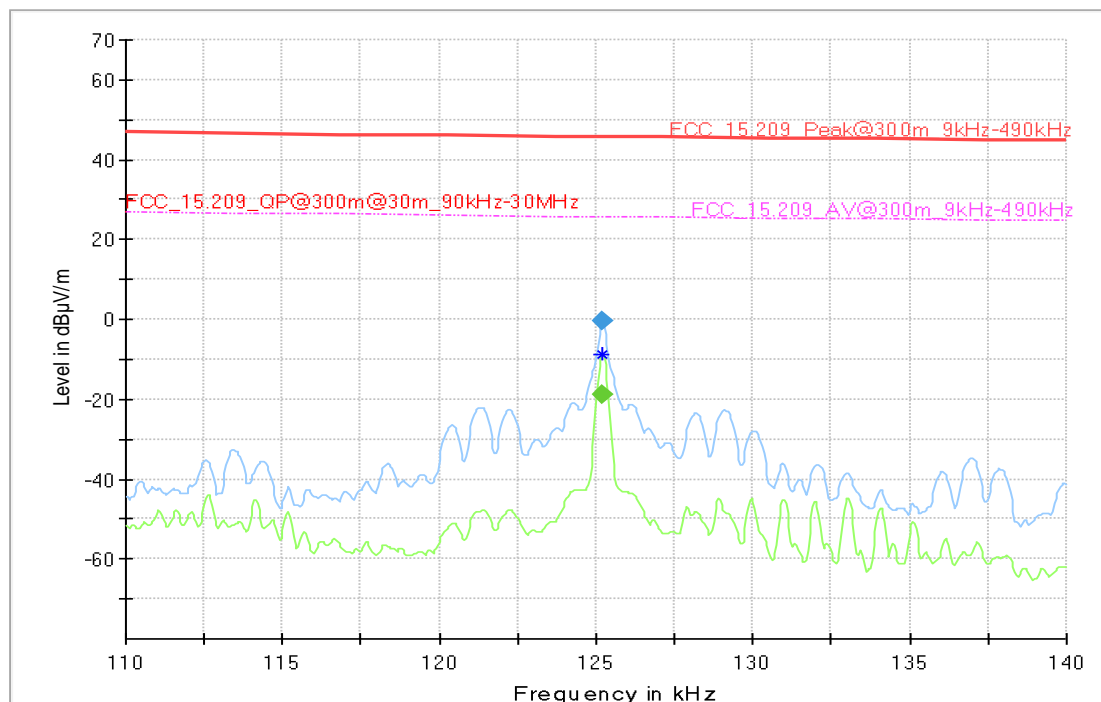
Op. Mode	Setup	Port
CM	Setup_02	Enclosure

Antenna orientation	EUT orientation	Frequency kHz	Maximum radiated field strength at fundamental frequency (corrected) dB μ V/m	Limit dB μ V/m	Margin dB
			AV	AV	AV
0°	Ver.	125.2	-27.46	25.67	53.13

3.2.4 Measurement Plot (worst case)

Common Information

Test Description:	Peak Power Output
Test Standard:	FCC 15c209
EUT Code:	DE1304027ab02
Operating Conditions:	NTNV, EUT Antenna Vertical
Antenna Type:	KESY
Operator Name:	Wes
Comment:	The vertical and horizontal position of the EUT antenna were tested and it was found, that a maximal field strength is radiated when antenna is installed vertically.



Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
0.125200	---	-18.68	25.67	44.36	1000.0	0.200	100.0	H	-107.0	---
0.125200	-0.50	---	45.67	46.18	1000.0	0.200	100.0	H	-107.0	---

3.2.5 Test Equipment used

- Radiated Emissions

3.3 Occupied bandwidth

Standard FCC Part 2, Subpart J, §2.1049

The test was performed according to: ANSI C63.10

3.3.1 Test Description

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

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

3.3.2 Test Requirements / Limits

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

3.3.3 Test Protocol

Temperature: 27 °C
Air Pressure: 1009 hPa
Humidity: 42 %

Op. Mode	Setup	Port
CM	Setup_01	Enclosure

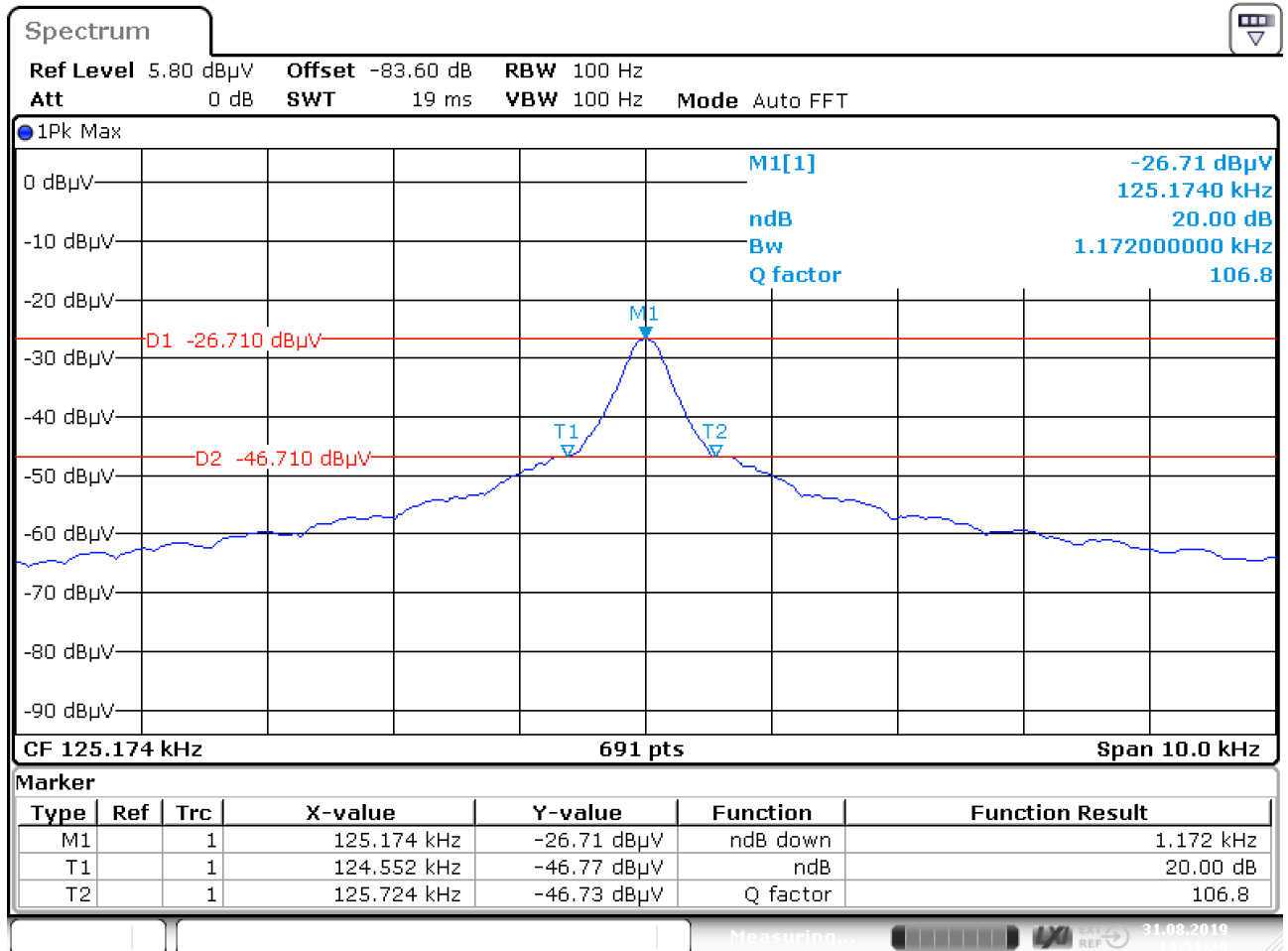
20 dBc bandwidth	99% occupied bandwidth
0.97 kHz	4.226 kHz

Op. Mode	Setup	Port
CM	Setup_02	Enclosure

20 dBc bandwidth	99% occupied bandwidth
1.172 kHz	4.486 kHz

3.3.4 Measurement Plots (worst case)

Mode: CM Setup 02, BITKey, 20 dBc BW



Date: 31.AUG.2019 14:51:29

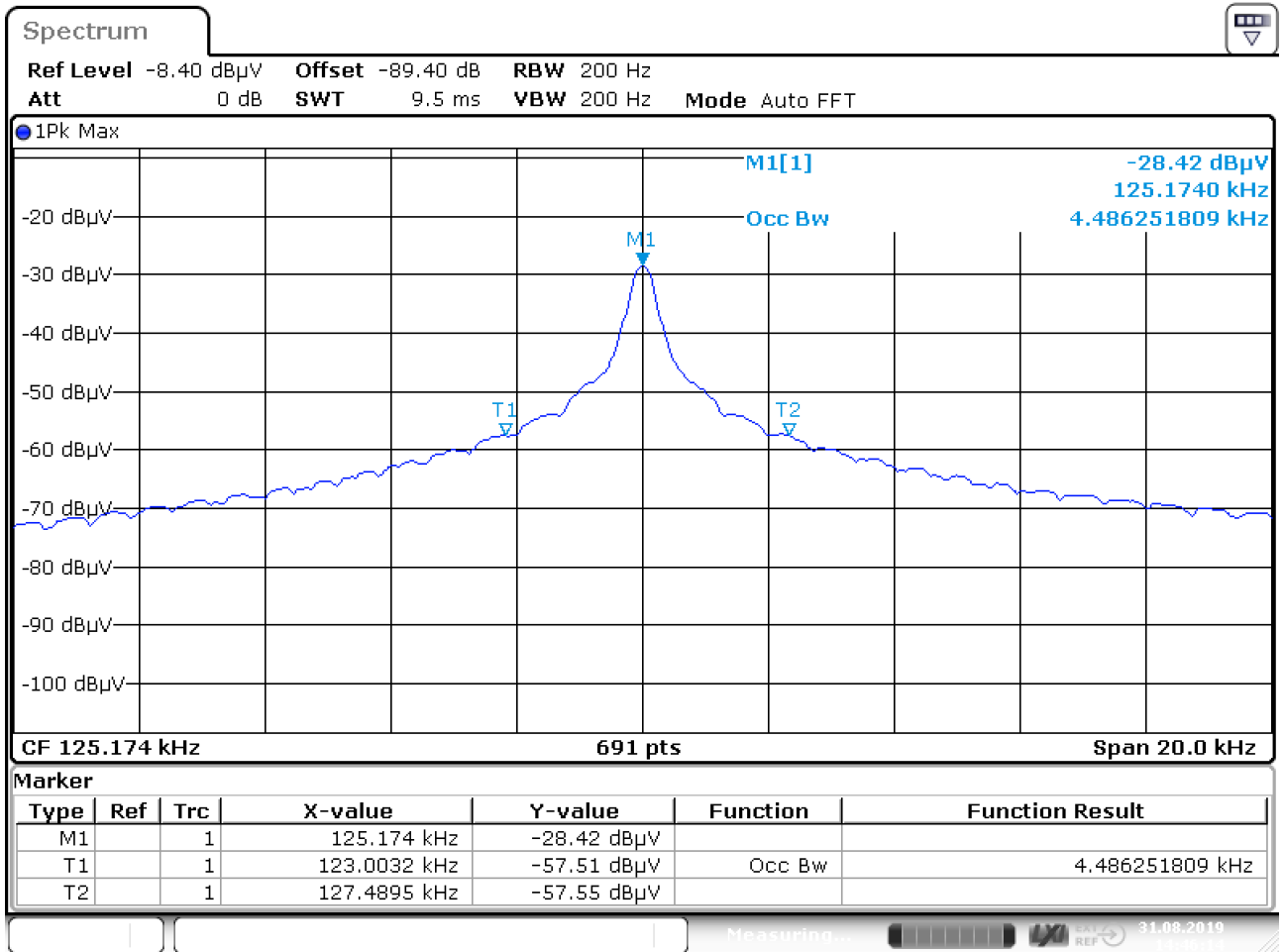
Note:

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 T1 and T2.

The 20 dBc bandwidth is between markers T1 and T2:

125.724 kHz - 124.552 kHz = **1.172 kHz** for BITKey antenna

Mode: CM Setup 02, BITKey, 99% BW



Date: 31.AUG.2019 14:46:14

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	2019-07	2020-07
1.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2018-10	2020-10
1.3	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2018-05	2019-11
1.4	Anechoic Chamber	10.58 x 6.38 x 6.00 m ³	Frankonia	none	2018-06	2020-06
1.5	FS-Z60	Harmonic Mixer 40 - 60 GHz	Rohde & Schwarz Messgerätebau GmbH	100178	2016-12	2019-12
1.6	FS-Z220	Harmonic Mixer 140 - 220 GHz	Rohde & Schwarz Messgerätebau GmbH	101005	2017-03	2020-03
1.7	SGH-05	Standard Gain / Pyramidal Horn Antenna (140 - 220 GHz)	RPG-Radiometer Physics GmbH	075		
1.8	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2018-07	2021-07
1.9	5HC2700/12750 -1.5-KK	High Pass Filter	Trilithic	9942012		
1.10	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
1.11	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
1.12	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
1.13	PONTIS Con4101	PONTIS Camera Controller		6061510370		
1.14	HF 906	Double-ridged horn	Rohde & Schwarz	357357/002	2018-09	2021-09
1.15	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
1.16	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2019-02	2021-02
1.17	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronik GmbH	00083069		

Ref. No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.18	SGH-19	Standard Gain / Pyramidal Horn Antenna (40 - 60 GHz)	RPG-Radiometer Physics GmbH	093		
1.19	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
1.20	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
1.21	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
1.22	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
1.23	TT 1.5 WI	Turn Table	Maturo GmbH	-		
1.24	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz	100609	2019-05	2022-05
1.25	HF 906	Double-ridged horn	Rohde & Schwarz	357357/001	2018-03	2021-03
1.26	FS-Z325	Harmonic Mixer 220 - 325 GHz	Rohde & Schwarz Messgerätebau GmbH	101006	2017-03	2020-03
1.27	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronik GmbH	00086675		
1.28	SGH-08	Standard Gain / Pyramidal Horn Antenna (90 - 140 GHz)	RPG-Radiometer Physics GmbH	064		
1.29	SGH-12	Standard Gain / Pyramidal HornAntenna (60 - 90 GHz)	RPG-Radiometer Physics GmbH	326		
1.30	Air compressor	Anechoic Chamber; 8.8m x 4.6 m x 4.05 m	JUN-AIR Deutschland GmbH	612582		
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	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2019-01	2020-01
1.35	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
1.36	AS 620 P	Antenna mast	HD GmbH	620/37		
1.37	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
1.38	SGH-03	Standard Gain / Pyramidal Horn Antenna (220 - 325 GHz)	RPG-Radiometer Physics GmbH	060		

Ref. No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.39	FS-Z90	Harmonic Mixer 60 - 90 GHz	Rohde & Schwarz Messgerätebau GmbH	101686	2017-03	2020-03
1.40	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2018-01	2020-01
1.41	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
1.42	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
1.43	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
1.44	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07

- 1 Radio Lab
Lab to perform bandwidth test

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	SFE100	Test Transmitter	Rohde & Schwarz	132520	2019-05	2021-05
1.2	1515 / 93459	Broadband Power Divider SMA (Aux)	Weinschel Associates	LN673	-	-
1.3	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-04	2020-04
1.4	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
1.5	SMBV100A	Vector Signal Generator 9 kHz - 3 GHz	Rohde & Schwarz	260001	2018/01	2021/01
1.6	24315	DC-Block	MTS Systemtechnik	025613-0024	-	-
1.7	PSC-4 1W-DCS-S1	4 Way Power Divider (BNC)	MTS Systemtechnik	000000-0001	-	-
1.8	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2016-10	2019-10
1.9	OSP120	Switching Unit with integrated power meter	Rohde & Schwarz	101158	2018-05	2021-05
1.10	UPL	Audio Analyser	Rohde & Schwarz	830768/015	2018-04	2021-04

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

5 Antenna Factors, Cable Loss and Sample Calculations

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

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

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

Sample calculation

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

U = Receiver reading

LISN Insertion loss = Voltage Division Factor of LISN

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

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

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

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

Sample calculation

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

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

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

Frequency MHz	AF R&S HL562 dB (1/m)	Corr. 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) dB	cable loss 2 (outside chamber) dB	cable loss 3 (switch unit) dB	cable loss 4 (to receiver) dB	distance corr. (-20 dB/ decade) dB	d_{Limit} (meas. distance (limit)) m	d_{used} (meas. distance (used)) m
0,29	0,04	0,23	0,02	0,0	3	3
0,39	0,09	0,32	0,08	0,0	3	3
0,56	0,14	0,47	0,08	0,0	3	3
0,73	0,20	0,59	0,12	0,0	3	3
0,84	0,21	0,70	0,11	0,0	3	3
0,98	0,24	0,80	0,13	0,0	3	3
1,04	0,26	0,89	0,15	0,0	3	3
1,18	0,31	0,96	0,13	0,0	3	3
1,28	0,35	1,03	0,19	0,0	3	3
1,39	0,38	1,11	0,22	0,0	3	3
1,44	0,39	1,20	0,19	0,0	3	3
1,55	0,46	1,24	0,23	0,0	3	3
1,59	0,43	1,29	0,23	0,0	3	3
1,67	0,34	1,35	0,22	0,0	3	3
1,67	0,42	1,41	0,15	0,0	3	3
1,87	0,54	1,46	0,25	0,0	3	3
1,90	0,46	1,51	0,25	0,0	3	3
1,99	0,60	1,56	0,27	0,0	3	3
2,14	0,60	1,63	0,29	0,0	3	3
2,22	0,60	1,66	0,33	0,0	3	3
2,23	0,61	1,71	0,30	0,0	3	3

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

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

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

Sample calculation

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

U = Receiver reading

AF = Antenna factor

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

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

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

Tables show an extract of values.

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

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

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

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

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

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

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

Sample calculation

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

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

Frequency MHz	AF EMCO 3160-09 dB (1/m)	Corr. dB	cable loss 1 (inside chamber) dB	cable loss 2 (pre- amp) dB	cable loss 3 (inside chamber) dB	cable loss 4 (switch unit) dB	cable loss 5 (to receiver) 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

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

U = Receiver reading

AF = Antenna factor

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

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

Table shows an extract of values.

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

Frequency GHz	AF EMCO 3160-10 dB (1/m)	Corr. dB	cable loss 1 (inside chamber) dB	cable loss 2 (outside chamber) dB	cable loss 3 (switch unit) dB	cable loss 4 (to receiver) dB	distance corr. (-20 dB/ decade) dB	d _{Limit} (meas. distance (limit) m	d _{used} (meas. distance (used) m
26,5	43,4	-11,2	4,4				-15,6	3	0,5
27,0	43,4	-11,2	4,4				-15,6	3	0,5
28,0	43,4	-11,1	4,5				-15,6	3	0,5
29,0	43,5	-11,0	4,6				-15,6	3	0,5
30,0	43,5	-10,9	4,7				-15,6	3	0,5
31,0	43,5	-10,8	4,7				-15,6	3	0,5
32,0	43,5	-10,7	4,8				-15,6	3	0,5
33,0	43,6	-10,7	4,9				-15,6	3	0,5
34,0	43,6	-10,6	5,0				-15,6	3	0,5
35,0	43,6	-10,5	5,1				-15,6	3	0,5
36,0	43,6	-10,4	5,1				-15,6	3	0,5
37,0	43,7	-10,3	5,2				-15,6	3	0,5
38,0	43,7	-10,2	5,3				-15,6	3	0,5
39,0	43,7	-10,2	5,4				-15,6	3	0,5
40,0	43,8	-10,1	5,5				-15,6	3	0,5

Sample calculation

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

U = Receiver reading

AF = Antenna factor

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

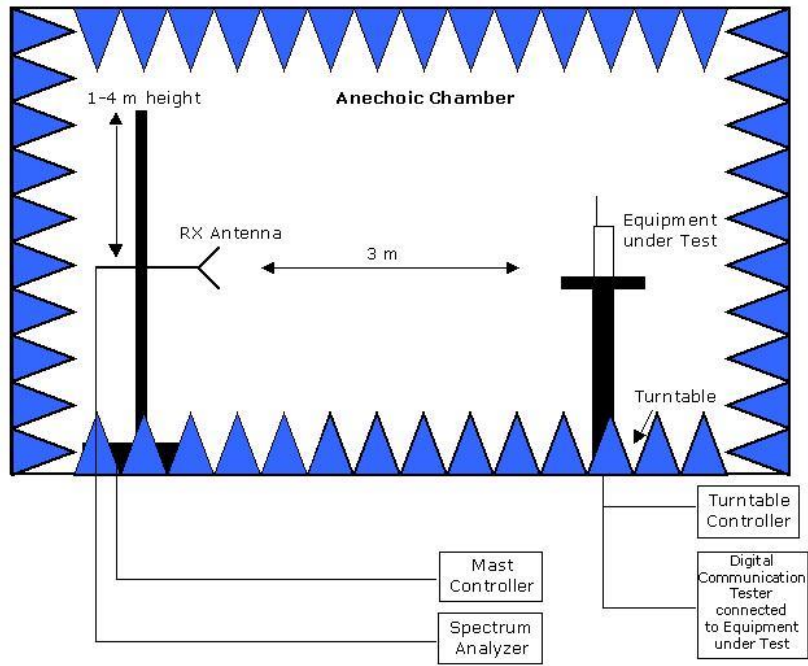
Linear interpolation will be used for frequencies in between the values in the table.

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

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

Table shows an extract of values.

6 Setup Drawings



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

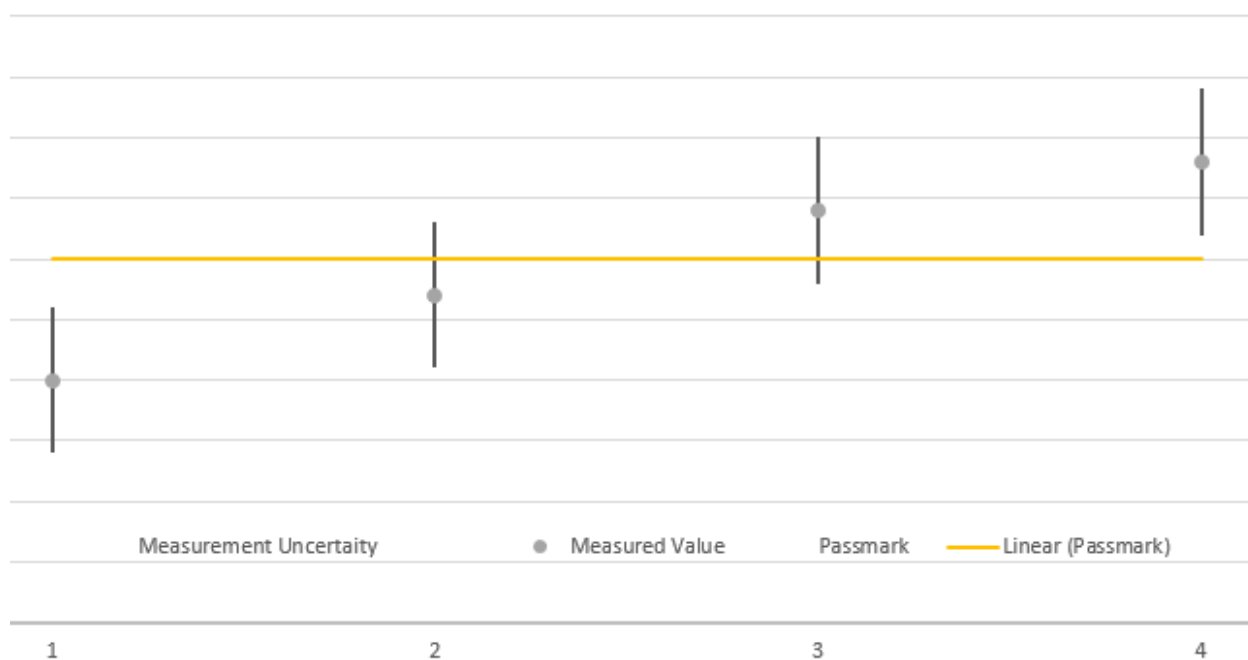
Drawing 1: Setup in the Anechoic chamber. For measurements below 1 GHz the ground was replaced by a conducting ground plane.

7 Measurement uncertainty

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

Standard specific table with the measurement uncertainties of the used parameters

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.

8 Photo Report

Photos are included in an external report.