FCC Measurement/Technical Report on

007178
VN4610

FCC ID: Contains XPYVERAP174
IC: -

Test Report Reference: MDE_VECTOR_1701_FCCb_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

Applied Standards and Test Summary

1.1 APPLIED STANDARDS

Type of Authorization
Certification for a DSRCS On-Board Unit.
Certification for a DSRCS Roadside Unit.

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 (23-10-17 Edition) and 90 (23-10-17) and 95 (23-10-17 Edition). The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 90, Subpart M – Intelligent Transportation Systems Radio Service

Part 95, Subpart L – DSRCS On-Board Units

FCC §2.1046, §95.3167, §95.3189 & ASTM E2213-03 §8.9.1

FCC §2.1049

ASTM E2213-03 §8.9.2

FCC §2.1055 & ASTM E2213-03 §8.9.4

FCC §2.1051 & ASTM E2213-03 §8.9.2 & ASTM E2213-03 §8.9.3

FCC §2.1053 & ASTM E2213-03 §8.9.2 & ASTM E2213-03 §8.9.3

The tests were performed according ANSI C63.26:2015

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.2 Measurement Summary / Signatures.

1.2 MEASUREMENT SUMMARY / SIGNATURES

FCC §2.1046, §90.377, §95.3167 & ASTM E2213-03 §8.9.1

RF Output Power

		Final Result
OP-Mode	**Setup**	**FCC**
Radio Technology, Operating Frequency		
IEEE 802.11p, low channel	Setup_02	Passed
IEEE 802.11p, mid channel	Setup_02	Passed
IEEE 802.11p, CH 180 (5900 MHz)	Setup_02	Passed
IEEE 802.11p, CH 182 (5910 MHz)	Setup_02	Passed
IEEE 802.11p, high channel	Setup_02	Passed

FCC §2.1049

Emission Bandwidth

		Final Result
OP-Mode	**Setup**	**FCC**
Radio Technology, Operating Frequency		
IEEE 802.11p, low channel	Setup_01	NP
IEEE 802.11p, mid channel	Setup_01	NP
IEEE 802.11p, high channel	Setup_01	NP

ASTM E2213-03 §8.9.2

Transmit Spectrum Mask

		Final Result
OP-Mode	**Setup**	**FCC**
Radio Technology, Operating Frequency		
IEEE 802.11p, low channel	Setup_01	NP
IEEE 802.11p, mid channel	Setup_01	NP
IEEE 802.11p, high channel	Setup_01	NP

FCC §2.1055 & ASTM E2213-03 §8.9.4

Frequency Tolerance

		Final Result
OP-Mode	**Setup**	**FCC**
Radio Technology, Operating Frequency		
IEEE 802.11p, mid channel	Setup_01	NP

FCC §2.1051 & ASTM E2213-03 §8.9.2 & ASTM E2213-03 §8.9.3

Transmit Spurious Emissions Conducted

		Final Result
OP-Mode	**Setup**	**FCC**
Radio Technology, Operating Frequency		
IEEE 802.11p, low channel	Setup_01	NP
IEEE 802.11p, mid channel	Setup_01	NP
IEEE 802.11p, high channel	Setup_01	NP

FCC §2.1053 & ASTM E2213-03 §8.9.2 & ASTM E2213-03 §8.9.3

Transmit Spurious Emissions Radiated

		Final Result
OP-Mode	**Setup**	**FCC**
Radio Technology, Operating Frequency		
IEEE 802.11p, low channel (MIMO)	Setup_01	Passed
IEEE 802.11p, CH 180 (5900 MHz) (MIMO)	Setup_01	Passed
IEEE 802.11p, high channel	Setup_01	NP

NP – not performed

Revision History

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2018-11-16	--	invalid
REV1	2019-02-08	• Page 1: IC number removed • Page 3: Part 90, Subpart M – Intelligent Transportation Systems Radio Service as applicable standard added. • Page 4: §90.377 added as reference for output power. • Page 11: Wrong column headers in SISO table corrected. • Page 11: additional comment for clarification of SISO mode added.	valid

Not all tests applicable for the device have been performed.

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(responsible for accreditation scope)
Dipl.-Ing. Daniel Gall

(responsible for testing and report)
Dipl.-Ing. Marco Kullik

2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

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

This facility has been fully described in a report submitted to the ISED 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. Daniel Gall
Report Template Version:	2018-04-11

2.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Marco Kullik
Employees who performed the tests:	documented internally at 7Layers
Date of Report:	2019-02-08
Testing Period:	2018-10-23 to 2018-10-24

2.3 APPLICANT DATA

Company Name:	Vector Informatik GmbH
Address:	Holderäckerstaße 36 70499 Stuttgart Germany
Contact Person:	Mr. Stefan Weber

2.4 MANUFACTURER DATA

Company Name:	Vector Informatik GmbH
Address:	Holderäckerstaße 36 70499 Stuttgart Germany
Contact Person:	Mr. Dominik Englert

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	IEEE 802.11p / CAN / GNSS Interface
Product name	VN4610
Type	007178
Declared EUT data by the supplier	
Voltage Type	DC (powered via ANC1)
Voltage Level	EUT:12 V, DC ANC1: 120 V / 60 Hz
Tested Modulation Type	OFDM, ½ BPSK, 10 MHz BW
Specific product description	The VN4610 is an interface with USB PC connection for accessing IEEE 802.11p and CAN FD networks for on-board units and road-side units transmitting in the 5850-5925 MHz frequency band using 10 MHz bandwidth per channel. It supports data rates from 3 Mbps up to 27 Mbps and transmission and reception on 2 antennas simultaneously (TX/RX antenna diversity). Supported channels: 172, 174, 176, 178, 180, 182, 184
Ports of the device (cables connected during testing)	- DC in (2x): ANC1 via 2m cable connected - USB: 2m USB Certified Hi-Speed cable connected - WLAN p Antenna Port (2x): 2 antennas connected - GNSS Port: ANC2 via 3m antenna cable connected - Ethernet: 1 m shielded CAT5e cable connected - CAN bus port (2x): CH3 & CH4: looped via 3m shielded CAN bus cable - CH6-IO: 3 m terminated shielded CAN bus cable connected
Antenna	External antennas, 5.9 dBi gain (value used for E.I.R.P. calculation, tested without antennas)
Tested Datarates	3 Mbps
Special software used for testing	Vector CANoe software running on Windows 7 laptop

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

3.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
EUT B	DE1327000aa02	Standard Sample
Sample Parameter	**Value**	
Serial No.	000265	
HW Version	3.0	
SW Version	10.8.22	
Comment		

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

3.3 ANCILLARY EQUIPMENT

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

Device	Details (Manufacturer, Type Model, HW, SW, S/N)	Description
ANC1	FRIWO Gerätebau GmbH, MSIG-REM-FGG-FW7520-12, -, -, -	AC/DC Adapter
ANC2	Taoglas, AA.162, -, -, 162TT18290312	Active GPS/GLONASS Antenna
ANC3	Taoglas, TD.10.5113, -, -, -	5.9GHz DSRC Antenna SMA, Article number: 07204
ANC4	Taoglas, TD.10.5113, -, -, -	5.9GHz DSRC Antenna SMA, Article number: 07204

3.4 AUXILIARY EQUIPMENT

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

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

3.5 EUT SETUPS

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

Setup	Combination of EUTs	Description and Rationale
Setup_01	EUT B + ANC1 + ANC2 + ANC3 + ANC4	Radiated Test Setup
Setup_02	EUT B + ANC1	Conducted Test Setup

3.6 OPERATING MODES

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

3.6.1 TEST CHANNELS

Channel	172 (low)	178 (mid)	180	182	184 (high)
Frequency [MHz]	5860	5890	5900	5910	5920

3.6.1 POWER SETTINGS

The power was set to the maximum possible value possible by the SW of the EUT.

The duty cycle was appr. 98 % for all tests.

3.7 PRODUCT LABELLING+

3.7.1 FCC ID LABEL

Please refer to the documentation of the applicant.

3.7.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 RF OUTPUT POWER

Standard **FCC Part 95 Subpart L and FCC Part 90 Subpart M**

The test was performed according to:
FCC §2.1046, §95.3167 & ASTM E2213-03 §8.9.1

4.1.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was set up to perform the output power measurements. The results recorded were measured with the modulation which produces the worst-case (highest) output power. The reference level of the spectrum analyzer was set higher than the output power of the EUT.

The EUT was connected to the spectrum analyzer via a short coax cable with a known loss.

Analyzer settings:
- Resolution Bandwidth (RBW): 1 MHz
- Video Bandwidth (VBW): 3 MHz
- Trace: Average (Power Averaging)
- Sweeps: 1000
- Sweeptime: coupled
- Detector: RMS
- Trigger: gated on IF Power

The channel power function of the spectrum analyser was used (Used channel bandwidth = nominal bandwidth)

4.1.2 TEST REQUIREMENTS / LIMITS

According to ASTM E2213-03 §8.9.1, Private OBU operations in Channels 172, 174, 176, 178 and 184 shall not exceed 28.8 dBm antenna input power and 33 dBm EIRP. Private OBU operations in Channel 175 shall not exceed 10 dBm antenna input power and 23 dBm EIRP. Private OBU operations in Channels 180, 181 and 182 shall not exceed 20 dBm antenna input power and 23 dBm EIRP.

4.1.3 TEST PROTOCOL

Ambient temperature: 24 °C
Air Pressure: 1017 hPa
Humidity: 37 %

SISO Operation

Channel No.	Frequency [MHz]	Power Antenna 1 [dBm]	Power Antenna 2 [dBm]	Antenna Gain [dBi]	Max. Power [dBm]	Max E.I.R.P. Power [dBm]	Limit conducted power [dBm]	E.I.R.P. Limit conducted power [dBm]	Margin to Limit cond. power [dB]	Margin to Limit E.I.R.P. power [dB]	Verdict
172	5860	**17.7**	**17.5**	5.9	17.7	23.6	28.8	33.0	11.1	9.4	Passed
178	5890	17.2	16.9	5.9	17.2	23.1	28.8	33.0	11.6	9.9	Passed
180	5900	15.3	14.5	5.9	15.3	21.2	20.0	23.0	4.7	1.8	Passed
182	5910	15.6	14.5	5.9	15.6	21.5	20.0	23.0	4.4	1.5	Passed
184	5920	17.0	16.4	5.9	17.0	22.9	28.8	33.0	11.8	10.1	Passed

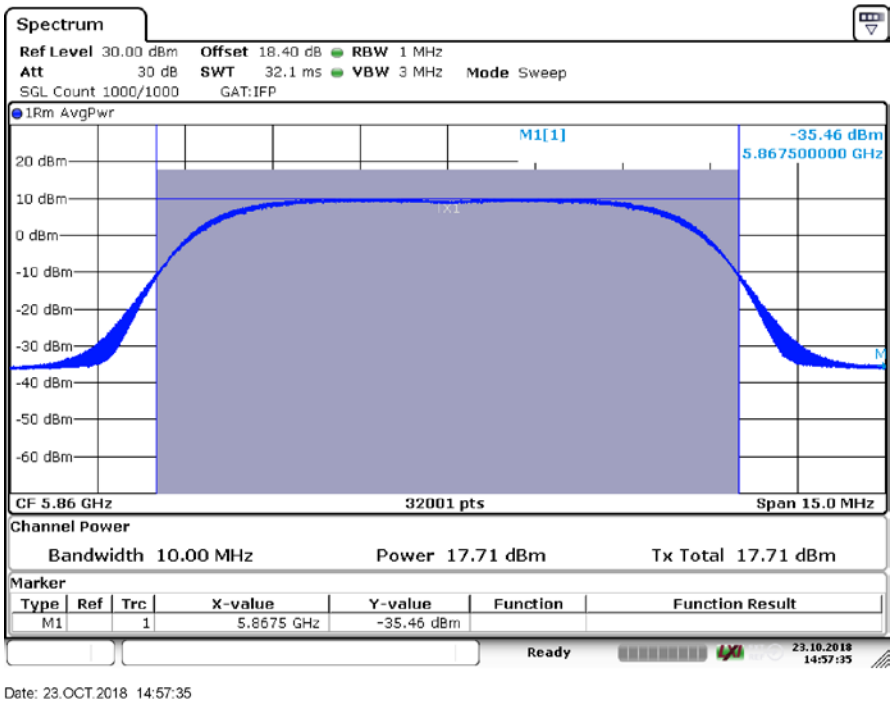
Note: Either antenna 1 **or** 2 is used. The margins are calculated for the antenna port with the highest output power for each frequency.

MIMO Operation

Channel No.	Frequency [MHz]	Power Antenna 1 [dBm]	Power Antenna 2 [dBm]	Antenna Gain [dBi]	Combined Power [dBm]	E.I.R.P. Combined Power [dBm]	Limit conducted power [dBm]	E.I.R.P. Limit conducted power [dBm]	Margin to Limit cond. power [dB]	Margin to Limit E.I.R.P. power [dB]	Verdict
172	5860	17.1	16.5	5.9	19.8	25.7	28.8	33.0	9.0	7.3	Passed
178	5890	16.8	15.9	5.9	19.4	25.3	28.8	33.0	9.4	7.7	Passed
180	5900	**12.8**	**11.8**	5.9	15.3	21.2	20.0	23.0	4.7	1.8	Passed
182	5910	12.5	11.7	5.9	15.1	21.0	20.0	23.0	4.9	2.0	Passed
184	5920	16.3	15.3	5.9	18.8	24.7	28.8	33.0	10.0	8.3	Passed

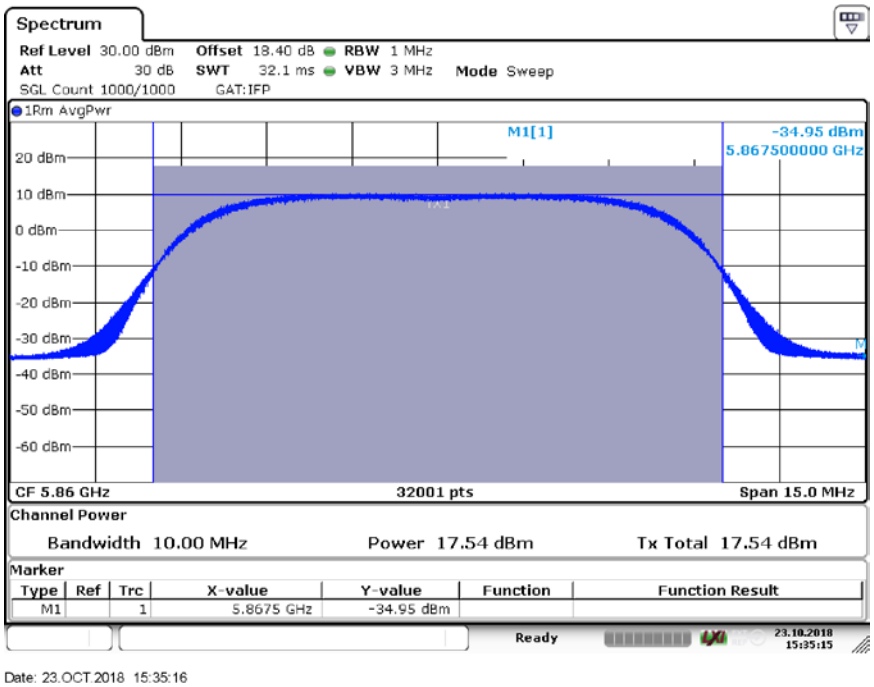
Remark: Please see next sub-clause for the measurement plot (for bold printed values).

4.1.4MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, “WORST CASE”)



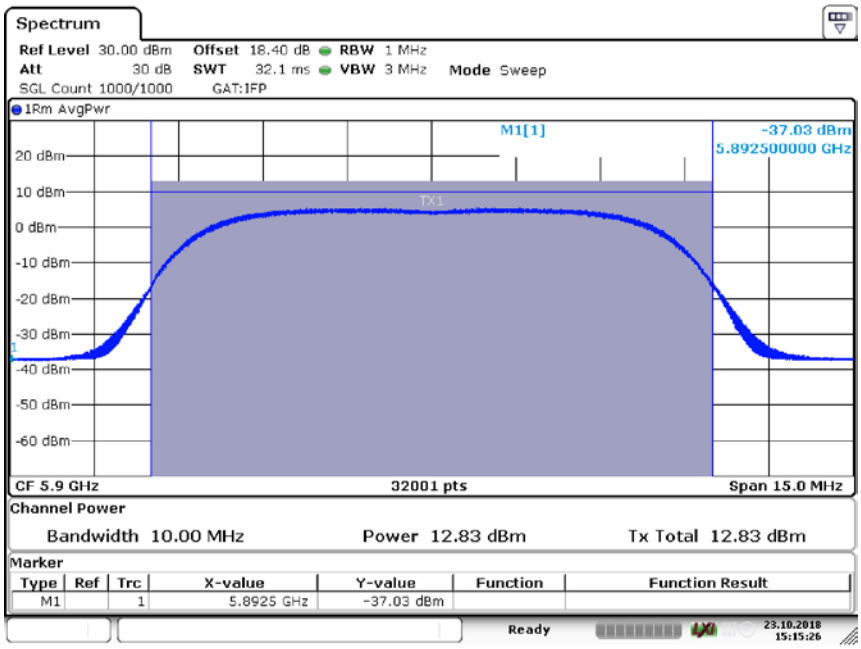
Date: 23.OCT.2018 14:57:35

Antenna 1, Ch. 172 (SISO)



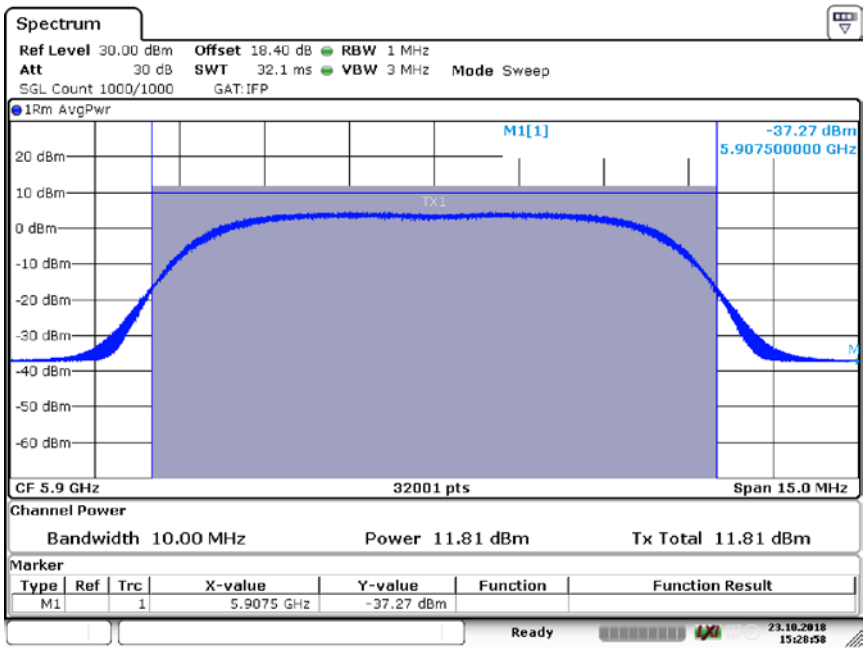
Date: 23.OCT.2018 15:35:16

Antenna 2, Ch. 172 (SISO



Date: 23.OCT.2018 15:15:26

Antenna 1, Ch. 180 (MIMO)



Date: 23.OCT.2018 15:28:59

Antenna 2, Ch. 180 (MIMO)

4.1.5TEST EQUIPMENT USED

Radio Lab

4.2 TRANSMIT SPURIOUS EMISSIONS RADIATED

Standard **FCC Part 95 Subpart L and FCC Part 90 Subpart M**

The test was performed according to:
ANSI C63.26

4.2.1TEST DESCRIPTION

The test set-up was made in accordance to the general provisions of ANSI C63.26 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 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
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 100 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: 100 kHz
- Measuring time: 100 ms
- Turntable angle range: ± 45 ° around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector
With the settings determined in step 3, the final measurement will be performed:
EMI receiver settings for step 4:
- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 100 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.

2. 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 °.
Above 26 GHz the measurement distance is reduced to 1 m.
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 = 100 kHz
Step 3:
Spectrum analyser settings for step 3:
- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 100 kHz
- Measuring time: 1 s

4.2.2TEST REQUIREMENTS / LIMITS

According to ASTM E2213-03 §8.9.2.2 the transmitted spectral mask for Class A, B, C and D devices are shown in Figs. 12-15. In addition, all DSRC site installations shall limit the EIRP in the transmitted spectrum to -25 dBm or less in the 100 kHz at the channel edges and the band edges. Additional filtering that supplements the filtering provided by the transmitter may be needed for some antenna/transmitter combinations.

The DSRC transmitted spectrum mask is relative to the device class of operation. The power in the transmitted spectrum for all DSRC devices shall be -25 dBm or less within 100 kHz outside all channel and band edges. This will be accomplished by attenuation the transmitted signal 100 kHz outside the channel and band edges by 55 + 10log(p) dB, where P is the total transmitted power in watts. The transmitted spectral density of the transmitted signal for all

devices shall fall within the spectral mask, as detailed in Table 10. The measurements shall be made using a 100 kHz resolution bandwidth and 30 kHz video bandwidth.

ASTM E2213-03 §8.9.3 Spurious transmissions from compliant devices shall comply with national regulations.

4.2.3TEST PROTOCOL

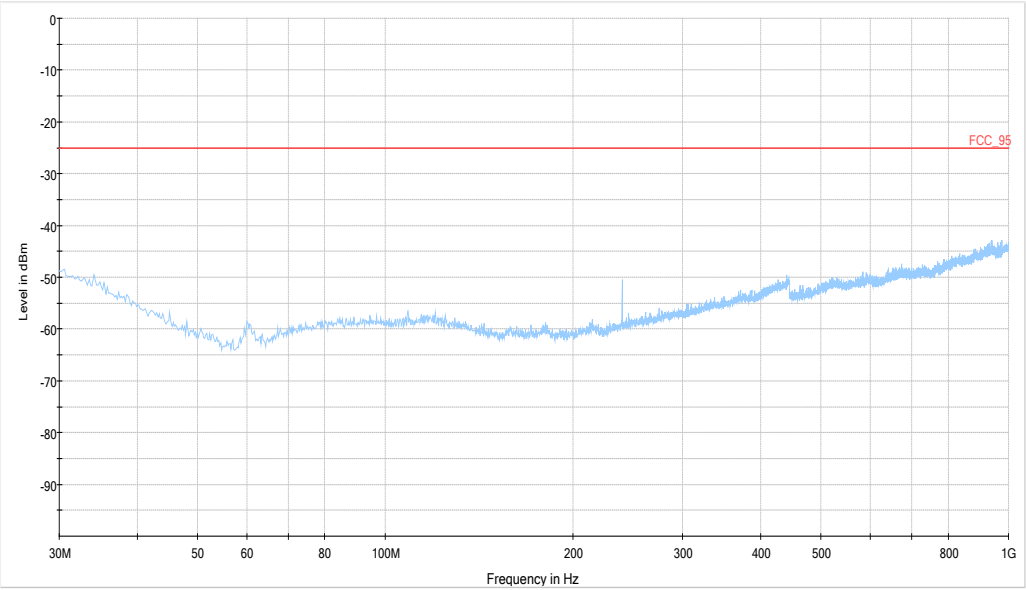
Ambient temperature: 23 °C
Air Pressure: 1016 - 1021 hPa
Humidity: 35 - 39 %
MIMO Mode

Transmitter Frequency [MHz]	Antenna	Spurious Frequency [MHz]	Spurious Level Peak Detector [dBm]	RBW [kHz]	Limit [dBm]	Margin to Limit [dB]	Verdict
5860	ANC3 ANC4	-	-	-	-	-	Passed
5900	ANC3 ANC4	-	-	-	-	-	Passed

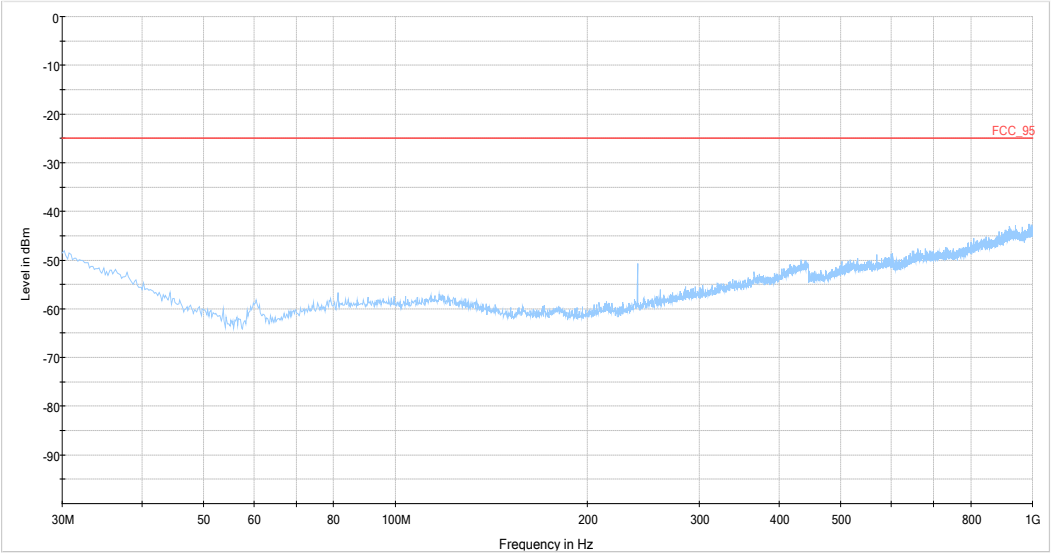
Remark: Please see next sub-clause for the measurement plot.

4.2.4 MEASUREMENT PLOTS

30 MHz – 1 GHz

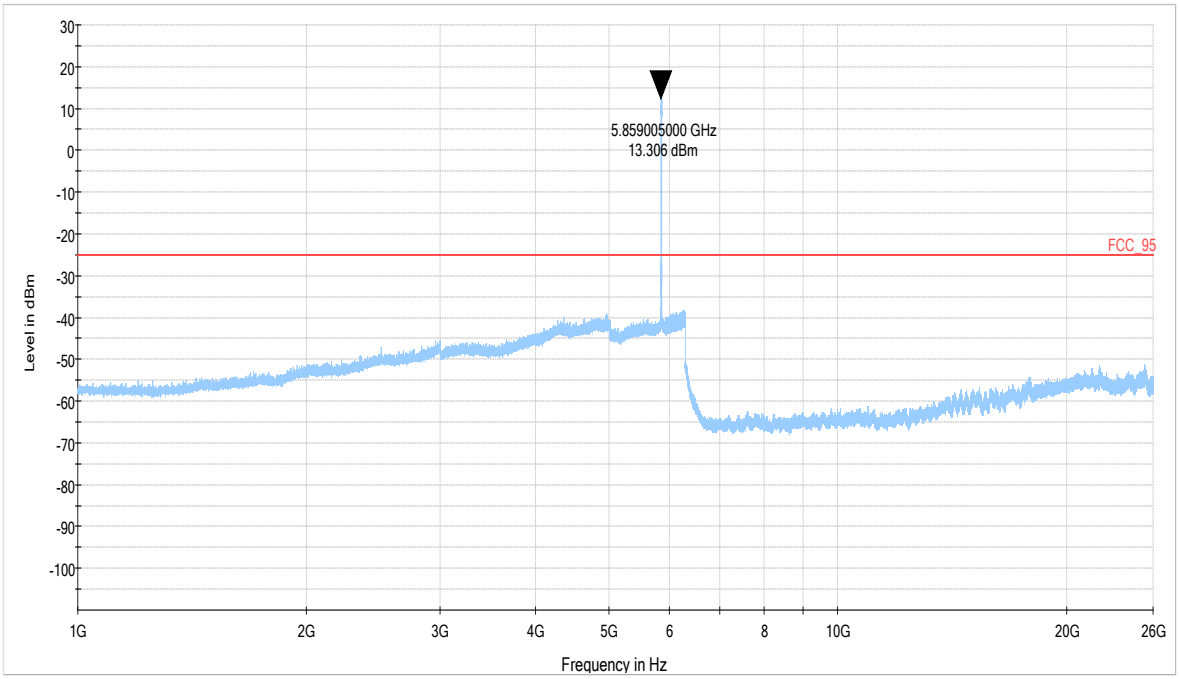


TX frequency 5860 MHz



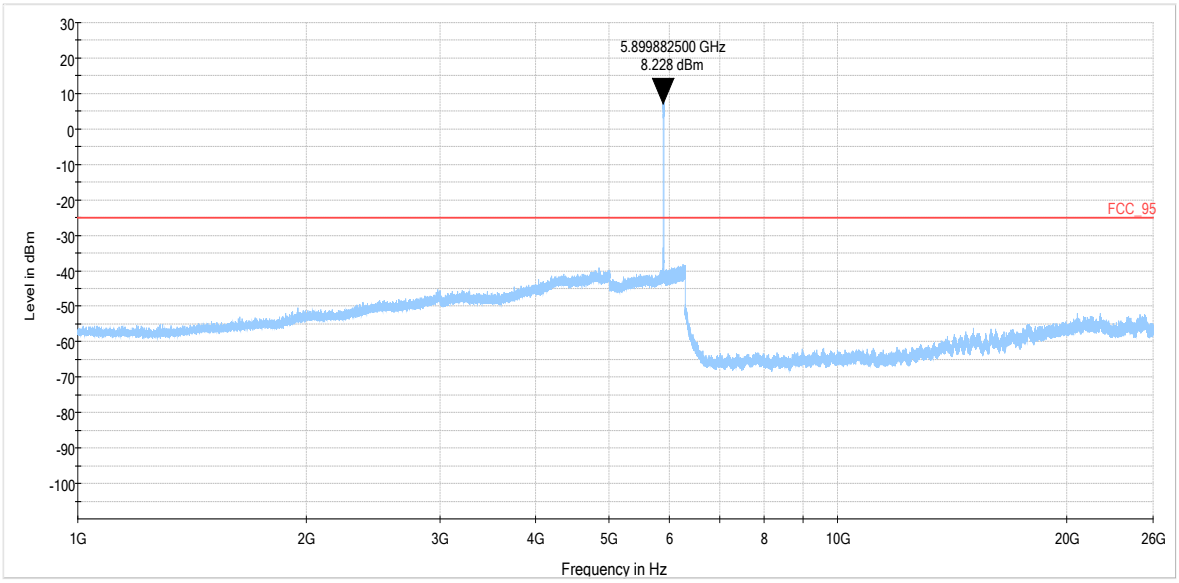
TX frequency 5900 MHz

1 GHz – 26 GHz



TX frequency 5860 MHz

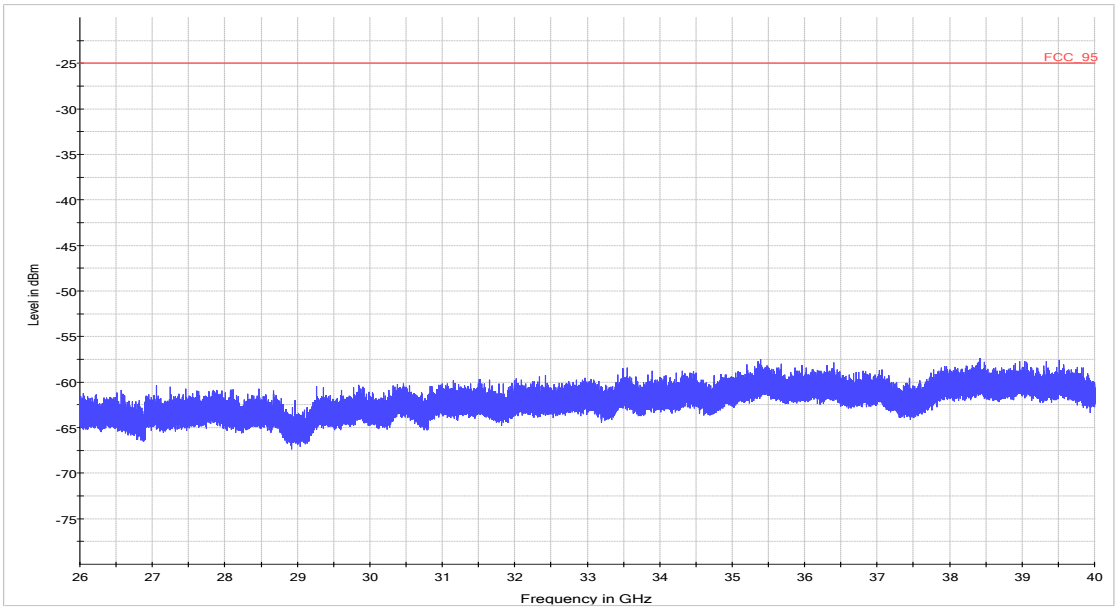
TX frequency 5860 MHz, the peak above the limit is not to be compared against the limit since it is the intentional transmitter



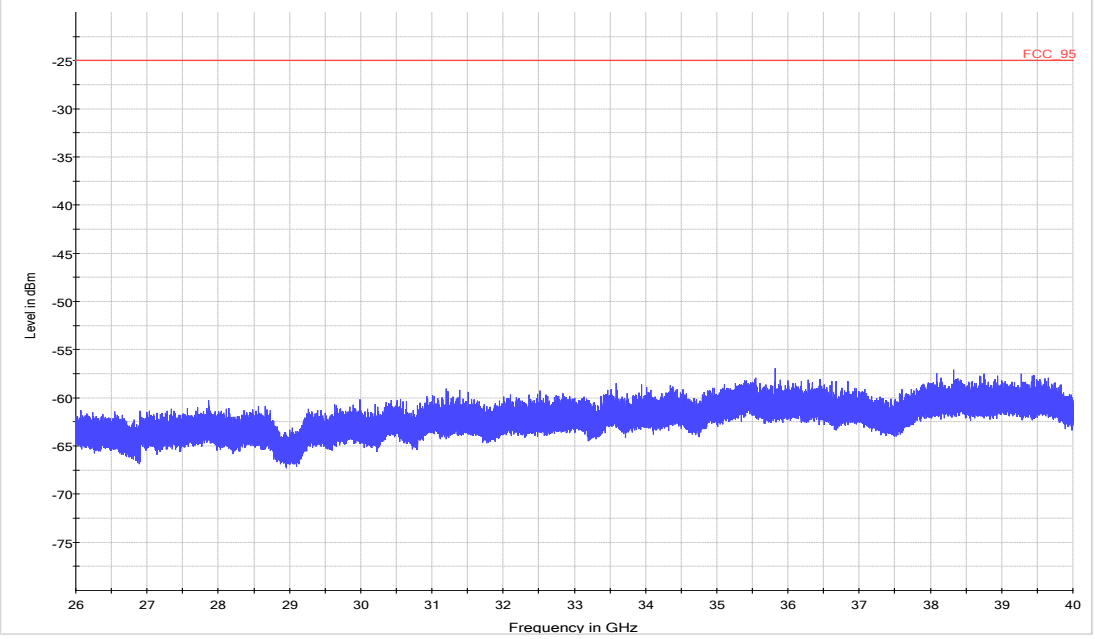
TX frequency 5900 MHz

TX frequency 5900 MHz, the peak above the limit is not to be compared against the limit since it is the intentional transmitter

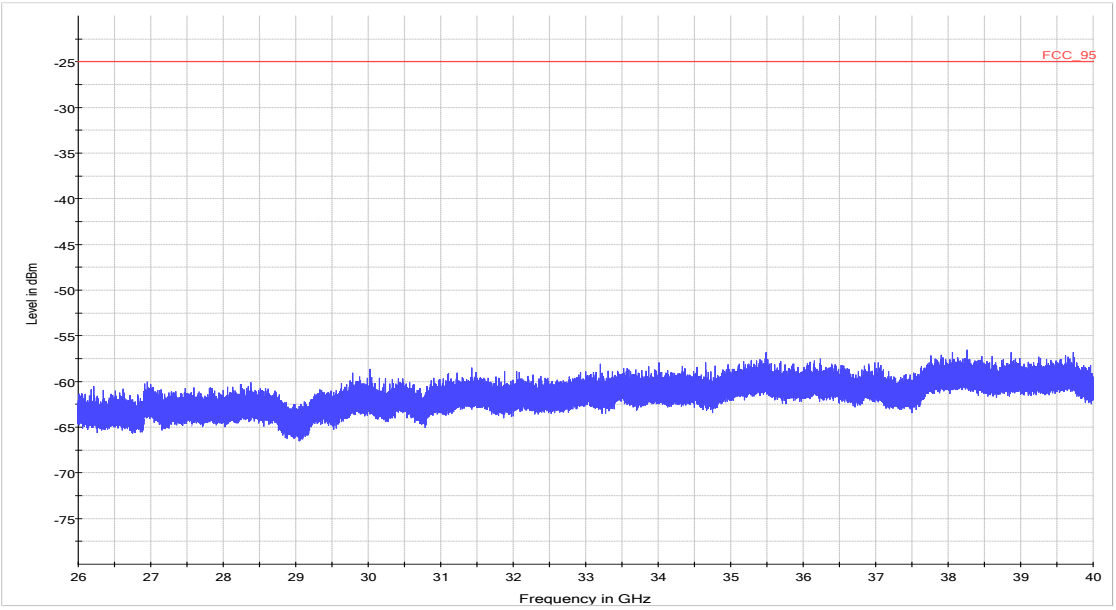
26 GHz – 40 GHz



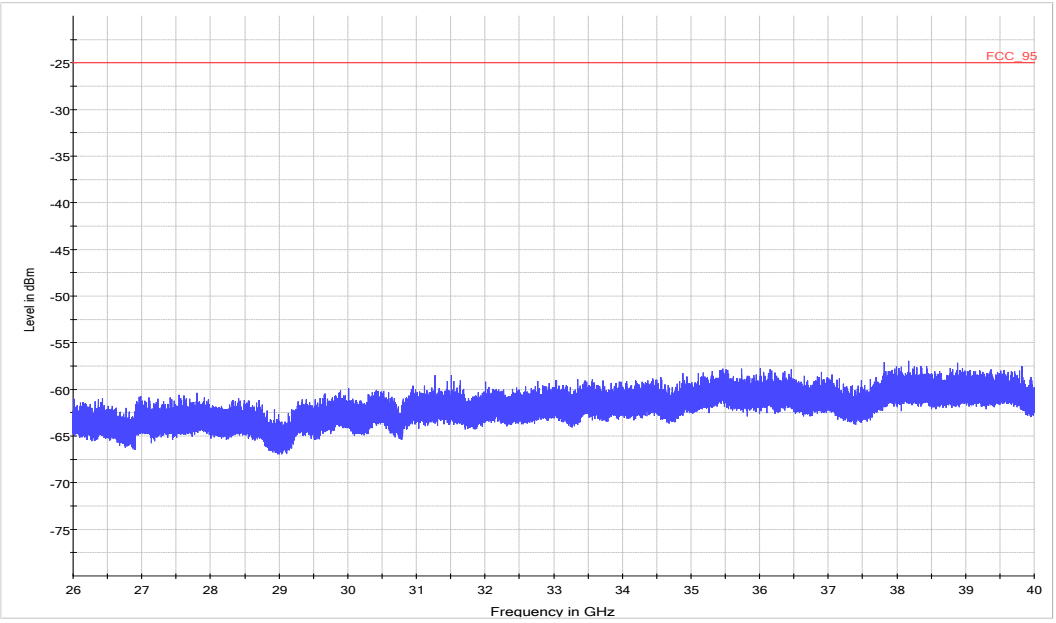
Horizontal antenna polarisation TX on CH 172 (5860 MHz)



Vertical antenna polarisation TX on 5860



Horizontal antenna polarisation TX on CH 180 (5900 MHz)



Vertical antenna polarisation TX on CH 180 (5900 MHz)

4.2.5TEST EQUIPMENT USED

Radiated Emissions

5 TEST EQUIPMENT

1 Radio Lab

Conducted Radio Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
1.2	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2017-03	2019-03
1.3	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2017-07	2020-07
1.4	VT 4002	Climatic Chamber	Vötsch	58566002150010	2018-04	2020-04
1.5	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-04	2020-04
1.6	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2016-10	2019-10
1.7	MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2018-07	2019-07

2 Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2018-10	2019-10
2.2	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-04	2019-04
2.3	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	none	2018-06	2021-06
2.4	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2018-07	2021-07
2.5	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
2.6	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
2.7	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
2.8	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.9	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
2.10	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2016-12	2018-12
2.11	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronic GmbH	00083069		
2.12	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
2.13	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
2.14	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
2.15	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
2.16	TT 1.5 WI	Turn Table	Maturo GmbH	-		
2.17	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz	100609	2016-04	2019-04
2.18	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronic GmbH	00086675		
2.19	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
2.20	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2018-01	2021-01
2.21	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-03	2019-03
2.22	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2016-11	2018-11
2.23	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
2.24	AS 620 P	Antenna mast	HD GmbH	620/37		
2.25	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
2.26	ESIB 26	Spectrum Analyzer	Rohde & Schwarz	830482/004	2018-01	2020-01
2.27	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
2.28	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
2.29	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07
2.30	HF 906	Double-ridged horn	Rohde & Schwarz	357357/001	2018-03	2021-03

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

6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

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

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

Frequency		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.

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

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

Sample calculation

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

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

(d_{Limit} = 3 m)

Frequency	AF R&S HL562	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
30	18,6	0,6	0,29	0,04	0,23	0,02	0,0	3	3
50	6,0	0,9	0,39	0,09	0,32	0,08	0,0	3	3
100	9,7	1,2	0,56	0,14	0,47	0,08	0,0	3	3
150	7,9	1,6	0,73	0,20	0,59	0,12	0,0	3	3
200	7,6	1,9	0,84	0,21	0,70	0,11	0,0	3	3
250	9,5	2,1	0,98	0,24	0,80	0,13	0,0	3	3
300	11,0	2,3	1,04	0,26	0,89	0,15	0,0	3	3
350	12,4	2,6	1,18	0,31	0,96	0,13	0,0	3	3
400	13,6	2,9	1,28	0,35	1,03	0,19	0,0	3	3
450	14,7	3,1	1,39	0,38	1,11	0,22	0,0	3	3
500	15,6	3,2	1,44	0,39	1,20	0,19	0,0	3	3
550	16,3	3,5	1,55	0,46	1,24	0,23	0,0	3	3
600	17,2	3,5	1,59	0,43	1,29	0,23	0,0	3	3
650	18,1	3,6	1,67	0,34	1,35	0,22	0,0	3	3
700	18,5	3,6	1,67	0,42	1,41	0,15	0,0	3	3
750	19,1	4,1	1,87	0,54	1,46	0,25	0,0	3	3
800	19,6	4,1	1,90	0,46	1,51	0,25	0,0	3	3
850	20,1	4,4	1,99	0,60	1,56	0,27	0,0	3	3
900	20,8	4,7	2,14	0,60	1,63	0,29	0,0	3	3
950	21,1	4,8	2,22	0,60	1,66	0,33	0,0	3	3
1000	21,6	4,9	2,23	0,61	1,71	0,30	0,0	3	3

(d_{Limit} = 10 m)

30	18,6	-9,9	0,29	0,04	0,23	0,02	-10,5	10	3
50	6,0	-9,6	0,39	0,09	0,32	0,08	-10,5	10	3
100	9,7	-9,2	0,56	0,14	0,47	0,08	-10,5	10	3
150	7,9	-8,8	0,73	0,20	0,59	0,12	-10,5	10	3
200	7,6	-8,6	0,84	0,21	0,70	0,11	-10,5	10	3
250	9,5	-8,3	0,98	0,24	0,80	0,13	-10,5	10	3
300	11,0	-8,1	1,04	0,26	0,89	0,15	-10,5	10	3
350	12,4	-7,9	1,18	0,31	0,96	0,13	-10,5	10	3
400	13,6	-7,6	1,28	0,35	1,03	0,19	-10,5	10	3
450	14,7	-7,4	1,39	0,38	1,11	0,22	-10,5	10	3
500	15,6	-7,2	1,44	0,39	1,20	0,19	-10,5	10	3
550	16,3	-7,0	1,55	0,46	1,24	0,23	-10,5	10	3
600	17,2	-6,9	1,59	0,43	1,29	0,23	-10,5	10	3
650	18,1	-6,9	1,67	0,34	1,35	0,22	-10,5	10	3
700	18,5	-6,8	1,67	0,42	1,41	0,15	-10,5	10	3
750	19,1	-6,3	1,87	0,54	1,46	0,25	-10,5	10	3
800	19,6	-6,3	1,90	0,46	1,51	0,25	-10,5	10	3
850	20,1	-6,0	1,99	0,60	1,56	0,27	-10,5	10	3
900	20,8	-5,8	2,14	0,60	1,63	0,29	-10,5	10	3
950	21,1	-5,6	2,22	0,60	1,66	0,33	-10,5	10	3
1000	21,6	-5,6	2,23	0,61	1,71	0,30	-10,5	10	3

Sample calculation

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

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

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten-uator & pre-amp)	cable loss 4 (to receiver)		
MHz	dB (1/m)	dB	dB	dB	dB	dB		
1000	24,4	-19,4	0,99	0,31	-21,51	0,79		
2000	28,5	-17,4	1,44	0,44	-20,63	1,38		
3000	31,0	-16,1	1,87	0,53	-19,85	1,33		
4000	33,1	-14,7	2,41	0,67	-19,13	1,31		
5000	34,4	-13,7	2,78	0,86	-18,71	1,40		
6000	34,7	-12,7	2,74	0,90	-17,83	1,47		
7000	35,6	-11,0	2,82	0,86	-16,19	1,46		

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten-uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	
3000	31,0	-23,4	0,47	1,87	0,53	-27,58	1,33	
4000	33,1	-23,3	0,56	2,41	0,67	-28,23	1,31	
5000	34,4	-21,7	0,61	2,78	0,86	-27,35	1,40	
6000	34,7	-21,2	0,58	2,74	0,90	-26,89	1,47	
7000	35,6	-19,8	0,66	2,82	0,86	-25,58	1,46	

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre-amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	dB
7000	35,6	-57,3	0,56	1,28	-62,72	2,66	0,94	1,46
8000	36,3	-56,3	0,69	0,71	-61,49	2,84	1,00	1,53
9000	37,1	-55,3	0,68	0,65	-60,80	3,06	1,09	1,60
10000	37,5	-56,2	0,70	0,54	-61,91	3,28	1,20	1,67
11000	37,5	-55,3	0,80	0,61	-61,40	3,43	1,27	1,70
12000	37,6	-53,7	0,84	0,42	-59,70	3,53	1,26	1,73
13000	38,2	-53,5	0,83	0,44	-59,81	3,75	1,32	1,83
14000	39,9	-56,3	0,91	0,53	-63,03	3,91	1,40	1,77
15000	40,9	-54,1	0,98	0,54	-61,05	4,02	1,44	1,83
16000	41,3	-54,1	1,23	0,49	-61,51	4,17	1,51	1,85
17000	42,8	-54,4	1,36	0,76	-62,36	4,34	1,53	2,00
18000	44,2	-54,7	1,70	0,53	-62,88	4,41	1,55	1,91

Sample calculation

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

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

Frequency	AF EMCO 3160-09	Corr.	cable loss 1 (inside chamber)	cable loss 2 (pre-amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB
18000	40,2	-23,5	0,72	-35,85	6,20	2,81	2,65
18500	40,2	-23,2	0,69	-35,71	6,46	2,76	2,59
19000	40,2	-22,0	0,76	-35,44	6,69	3,15	2,79
19500	40,3	-21,3	0,74	-35,07	7,04	3,11	2,91
20000	40,3	-20,3	0,72	-34,49	7,30	3,07	3,05
20500	40,3	-19,9	0,78	-34,46	7,48	3,12	3,15
21000	40,3	-19,1	0,87	-34,07	7,61	3,20	3,33
21500	40,3	-19,1	0,90	-33,96	7,47	3,28	3,19
22000	40,3	-18,7	0,89	-33,57	7,34	3,35	3,28
22500	40,4	-19,0	0,87	-33,66	7,06	3,75	2,94
23000	40,4	-19,5	0,88	-33,75	6,92	3,77	2,70
23500	40,4	-19,3	0,90	-33,35	6,99	3,52	2,66
24000	40,4	-19,8	0,88	-33,99	6,88	3,88	2,58
24500	40,4	-19,5	0,91	-33,89	7,01	3,93	2,51
25000	40,4	-19,3	0,88	-33,00	6,72	3,96	2,14
25500	40,5	-20,4	0,89	-34,07	6,90	3,66	2,22
26000	40,5	-21,3	0,86	-35,11	7,02	3,69	2,28
26500	40,5	-21,1	0,90	-35,20	7,15	3,91	2,36

Sample calculation

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

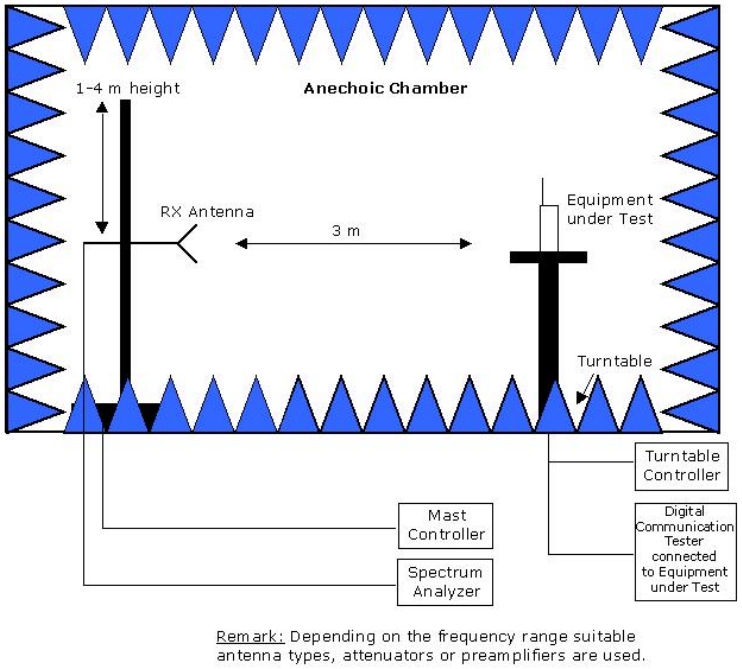
6.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

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				-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.

7 SETUP DRAWINGS



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

8 MEASUREMENT UNCERTAINTIES

Test Case	Parameter	Uncertainty
AC Power Line	Power	± 3.4 dB
Field Strength of spurious radiation	Power	± 5.5 dB
6 dB / 26 dB / 99% Bandwidth	Power Frequency	± 2.9 dB ± 11.2 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

9 PHOTO REPORT

Please see separate photo report.