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TEST REPORT

Test report no.: 1-2913/16-01-06

DAkkS Deutsche Akkreditierungsstelle D-PL-12076-01-01

Testing laboratory

CTC advanced GmbH
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Accredited Testing Laboratory:
The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2005) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)
The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number: D-PL-12076-01-01

Applicant

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47058 Duisburg / GERMANY
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Fax: +49 234 588 80-101
Contact: Ouzounis Charalambos
e-mail: c.ouzounis@krohne.com
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Manufacturer

KROHNE SAS
2 allee des Ors – BP98
26103 Romans / FRANCE

Test standard/s

47 CFR Part 15	Title 47 of the Code of Federal Regulations; Chapter I; Part 15 – Radio frequency devices
RSS-211	Level Probing Radar Equipment

For further applied test standards please refer to section 3 of this test report.

Test Item

Kind of test item:	**Level probing radar**
Model name:	**Optiwave x500 series**
FCC ID:	**Q6BFMCW80G74LA**
IC:	**1991D-FMCW80G74LA**
Frequency:	78 GHz – 82 GHz
Antenna:	dielectric lens antenna
Power Supply:	14 – 36 V DC
Temperature Range:	-40 °C to +80 °C

This test report is electronically signed and valid without handwriting signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

Test report authorized:

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Karsten Geraldy
Lab Manager
Radio Communications & EMC

1 Table of contents

2 General information

2.1 Notes and disclaimer

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2.2 Application details

Date of receipt of order:	2016-10-31
Date of receipt of test item:	2016-11-15
Start of test:	2016-11-21
End of test:	2016-11-25
Person(s) present during the test:	-/-

2.3 Test laboratories sub-contracted

None

3 Test standard/s and guideline/s

Test standard	Date	Test standard description
47 CFR Part 15		Title 47 of the Code of Federal Regulations; Chapter I; Part 15 – Radio frequency devices
RSS-211	2015-03	Level Probing Radar Equipment
890966 D01 v01r01	2014-09	Measurement Procedure for Level Probing Radars

4 Test environment

Temperature:	T_{nom}	+22 °C during room temperature tests
	T_{max}	+50 °C
	T_{min}	-20 °C
Relative humidity content:		45 %
Barometric pressure:		not relevant for this kind of testing
Power supply:	V_{nom}	24.0 V DC
	V_{max}	36.0 V DC
	V_{min}	14.0 V DC

5 Test item

5.1 General Description

Kind of test item	:	Level probing radar
Type identification	:	Optiwave x500 series
PMN	:	Optiwave x500 series
HVIN	:	80G-L-C
FVIN	:	-/-
HMN	:	-/-
S/N serial number	:	1 (radiated sample) / 2 (conducted sample)
HW hardware status	:	HW hardware status sensor: 4002581601 b-mod HW hardware status converter: 4002260701 c-mod
SW software status	:	Cetecom_RadioTesting_80GHz_Jan2015_Final_PV Rev. 11087
Frequency band	:	78 GHz – 82 GHz
Type of modulation	:	FMCW
Number of channels	:	1
Antenna	:	dielectric lens antenna
Power supply	:	14 – 36 V DC, < 30 mA
Temperature range	:	-40 °C to +85 °C

Note:
Following antennas are used as LPR application:

Antenna	Maximum gain	Maximum 3 dB beam width	Maximum side lobe level > 60 deg
40 mm convex lens	26.1 dBi	8.0°	-12.6 dBi
70 mm convex lens	29.8 dBi	4.3°	-11.8 dBi

5.2 Additional information

The content of the following annexes is defined in the QA. It may be that not all of the listed annexes are necessary for this report, thus some values in between may be missing.
Test setup- and EUT-photos are included in documents: 1-2913/16-01-06_AnnexA
1-2913/16-01-06_AnnexB
1-2913/16-01-06_AnnexC

6 Description of the test setup

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Weekly chamber inspections and range calibrations are performed. Where possible, RF generating and signaling equipment as well as measuring receivers and analyzers are connected to an external high-precision 10 MHz reference (GPS-based or rubidium frequency standard).

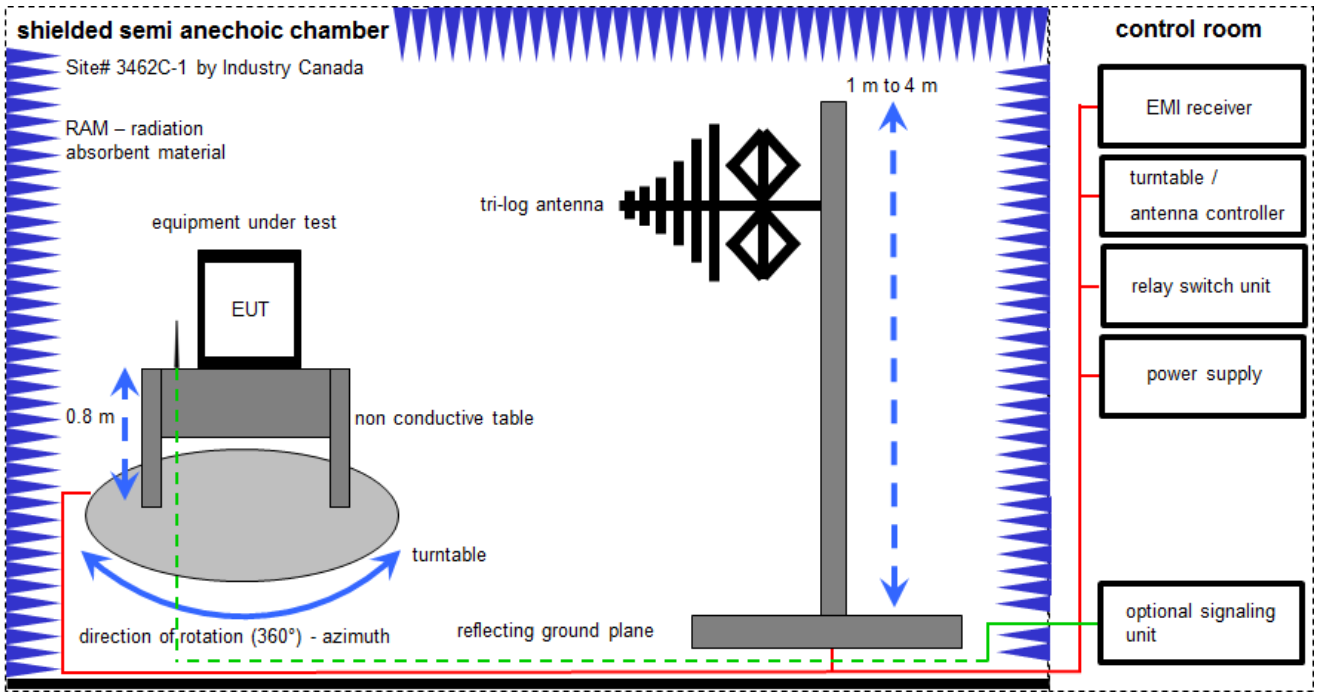
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

Agenda: Kind of Calibration

k	calibration / calibrated	EK	limited calibration
ne	not required (k, ev, izw, zw not required)	zw	cyclical maintenance (external cyclical maintenance)
ev	periodic self verification	izw	internal cyclical maintenance
Ve	long-term stability recognized	g	blocked for accredited testing
vlkl!	Attention: extended calibration interval		
NK!	Attention: not calibrated	*)	next calibration ordered / currently in progress

6.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 9 kHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are conform to specifications ANSI C63. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



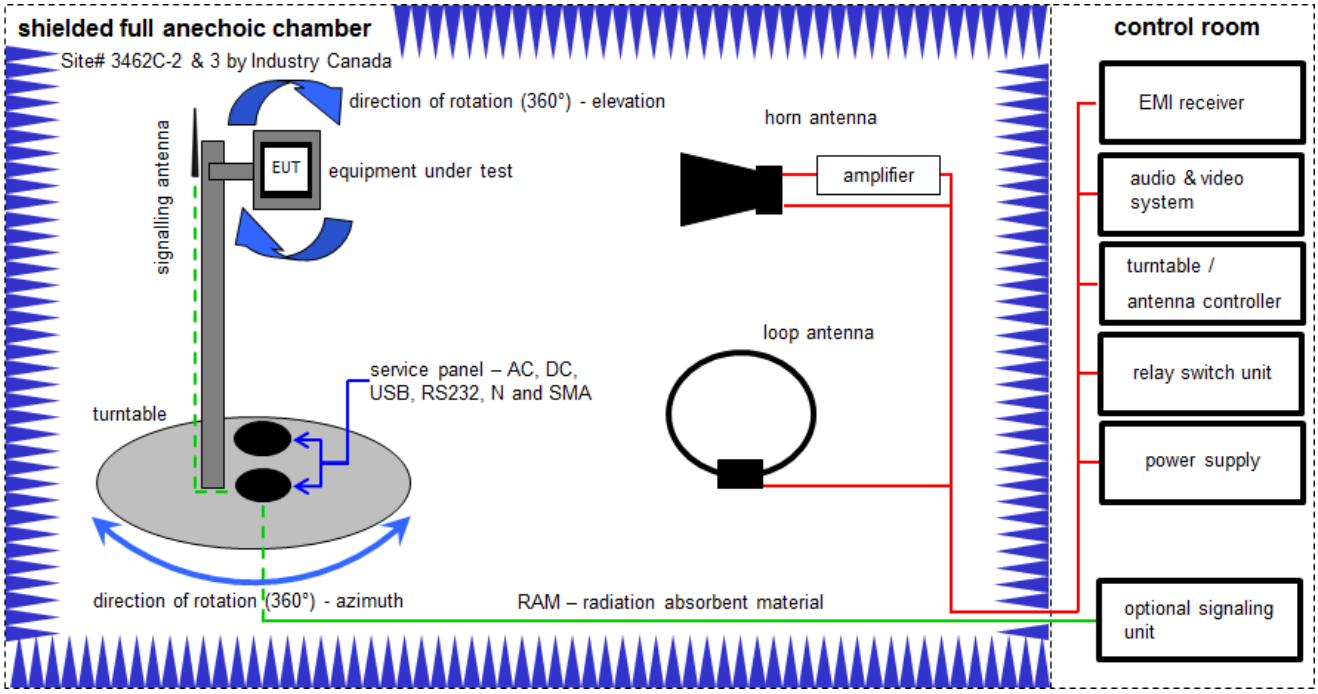
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No CTC	Kind of Calibration	Last Calibration	Next Calibration
1	45	Switch-Unit	3488A	HP	2719A14505	300000368	ev		
2	50	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne		
3	n. a.	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	08.03.2016	08.03.2017
4	n. a.	Amplifier	JS42-00502650-28-5A	MITEQ	1084532	300003379	ev		
5	n. a.	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw		
6	n. a.	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw		
7	n. a.	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw		
8	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	295	300003787	k	25.04.2016	25.04.2018
9	n. a.	Spectrum-Analyzer	FSU26	R&S	200809	300003874	k	29.01.2016	29.01.2017

6.2 Shielded fully anechoic chamber



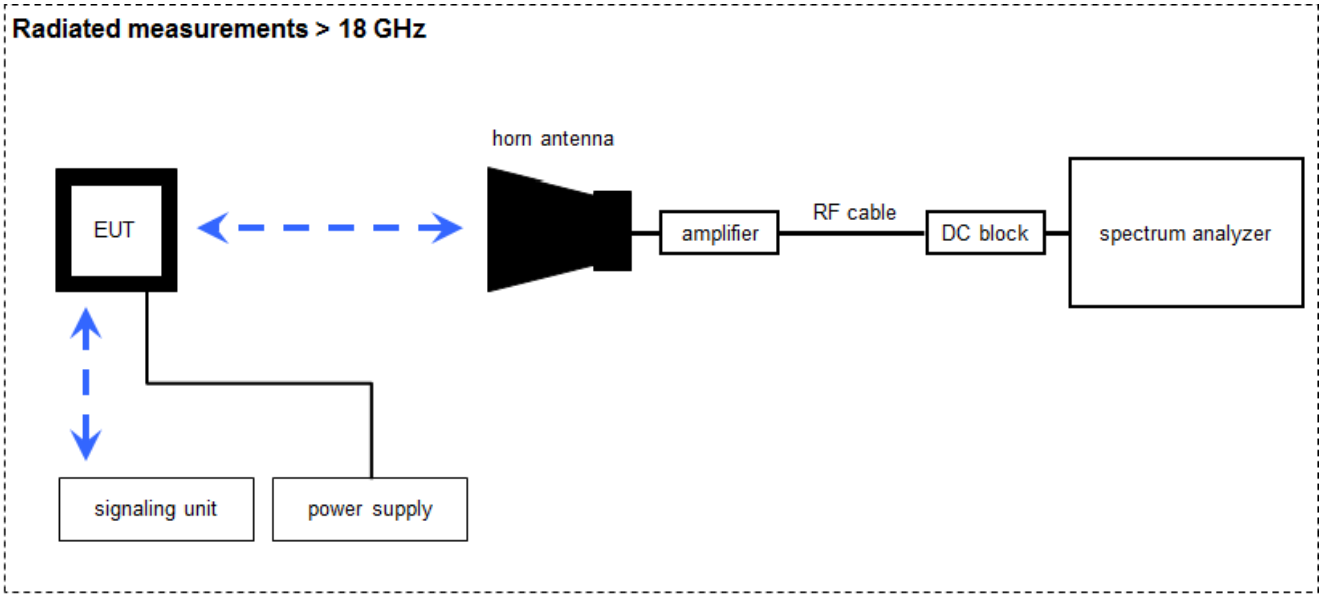
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBµV/m] (71.61 µV/m)

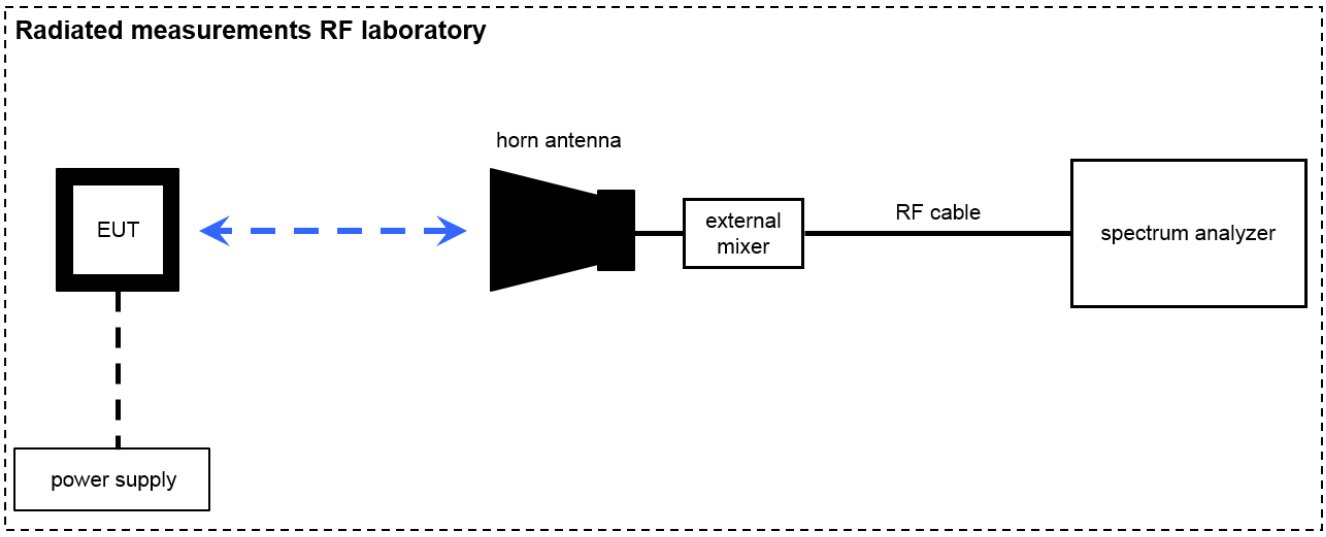
Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No CTC	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2818A03450	300001040	Ve	20.01.2015	20.01.2018
2	n. a.	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3088	300001032	vlKI!	20.05.2015	20.05.2017
3	n. a.	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev		
4	n. a.	Switch / Control Unit	3488A	HP	*	300000199	ne		
5	9	Isolating Transformer	MPL IEC625 Bus Regeltrenntravo	Erfi	91350	300001155	ne		
6	90	Active Loop Antenna 10 kHz to 30 MHz	6502	Kontron Psychotech	8905-2342	300000256	k	24.06.2015	24.06.2017
7	n. a.	Amplifier	js42-00502650-28-5a	Parzich GMBH	928979	300003143	ne		
8	n. a.	Band Reject filter	WRCG1855/1910-1835/1925-40/8SS	Wainwright	7	300003350	ev		
9	n. a.	Band Reject filter	WRCG2400/2483-2375/2505-50/10SS	Wainwright	11	300003351	ev		
10	n. a.	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	18	300003789	ne		
11	n. a.	MXE EMI Receiver 20 Hz to 26,5 GHz	N9038A	Agilent Technologies	MY51210197	300004405	k	16.08.2016	16.08.2017
12	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne		

6.3 Radiated measurements > 18 GHz



6.4 Radiated measurements > 50 GHz

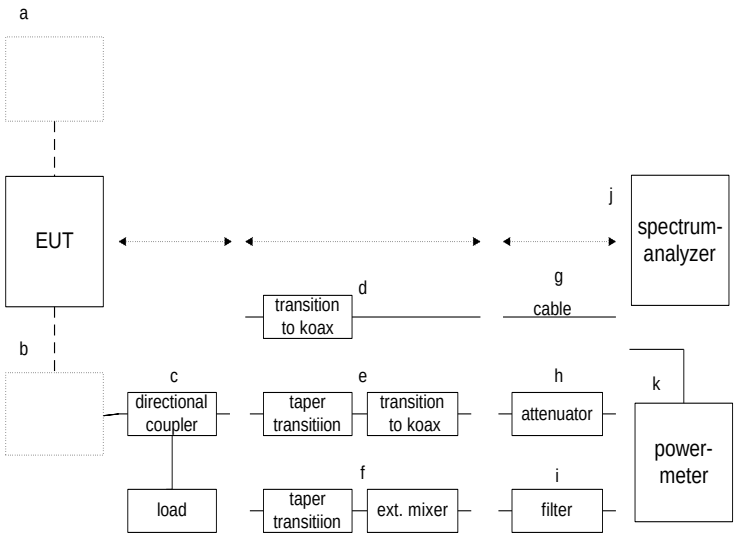


OP = AV + D - G
(OP-rad. output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain)

Example calculation:
OP [dBm] = -54.0 [dBm] + 64.0 [dB] - 20.0 [dBi] = -10 [dBm] (100 µW)

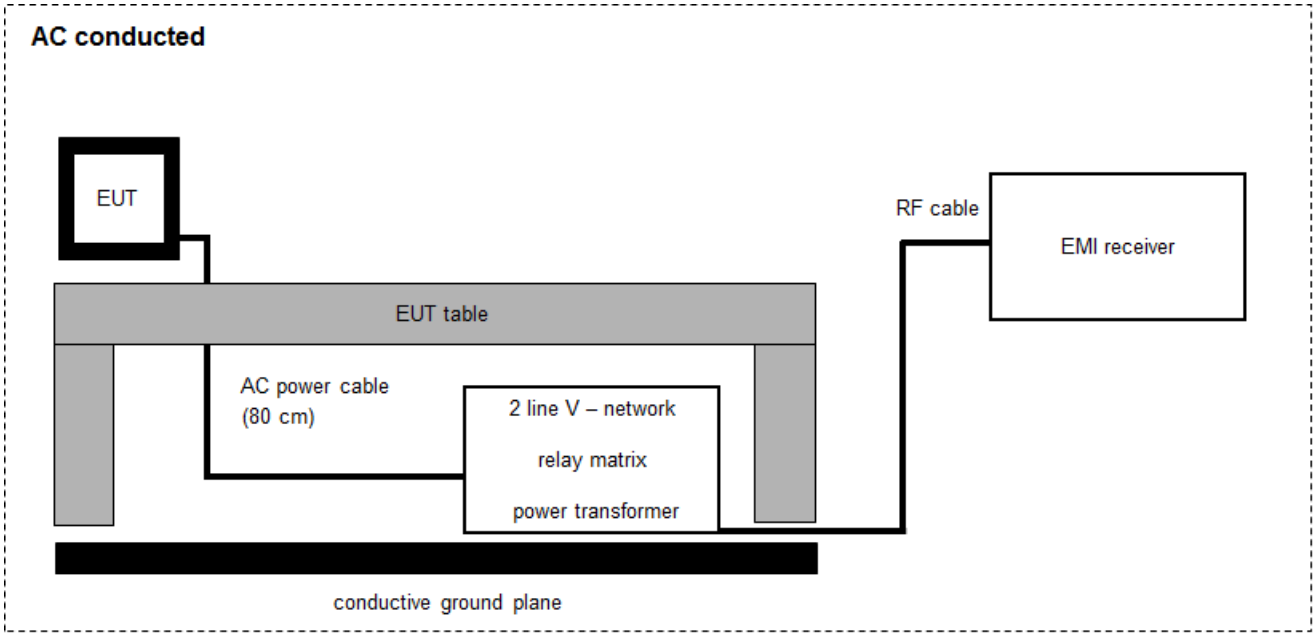
Note: conversion loss of mixer is already included in analyzer value.

6.5 Conducted measurements in test lab



No.	Equipment	Type	Manufact.	Serial No.	INV. No CTC	Kind of Calibration	Last Calibration	Next Calibration
1	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	7911	300001751	ne		
2	Microwave System Amplifier, 0.5-26.5 GHz	83017A	HP	00419	300002268	ev		
3	Std. Gain Horn Antenna 39.3-59.7 GHz	2424-20	Flann	75	300001979	ne		
4	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne		
5	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001991	ne		
6	Std. Gain Horn Antenna 114-173 GHz	2924-20	Flann	*	300001999	ne		
7	Std. Gain Horn Antenna 145-220 GHz	3024-20	Flann	*	300002000	ne		
8	Std. Gain Horn Antenna 12.4 to 18.0 GHz	639	Narda	8402	300000787	k	14.08.2015	14.08.2017
9	Std. Gain Horn Antenna 18.0 to 26.5 GHz	638	Narda	8205	300002442	k	19.07.2015	19.07.2017
10	Power Supply	LA30/5GA	Zentro	2046	300000711	NK!		
11	Spectrum Analyzer 20 Hz - 50 GHz	FSU50	R&S	200012	300003443	Ve	28.10.2016	28.10.2018
12	Harmonic mixer 50 - 75 GHz for spectrum analyzers	FS-Z75	R&S	100099	300003949	k	09.03.2016	09.03.2017
13	Harmonic Mixer 3-Port, 75-110 GHz	FS-Z110	R&S	101411	300004959	k	24.10.2016	24.10.2017
14	Spectrum Analyzer Mixer 3-Port, 110-170 GHz	SAM-170	Radiometer Physics GmbH	100014	300004156	k	23.05.2016	23.05.2018
15	Spectrum Analyzer Mixer 3-Port, 170-220 GHz	SAM-220	Radiometer Physics GmbH	200001	300004157	k	09.06.2016	09.06.2018
16	Broadband Low Noise Amplifier 18-50 GHz	CBL18503070-XX	CERNEX	19338	300004273	ne		
17	Harmonic mixer 60 - 90 GHz	FS-Z90	R&S	101555	300004691	k	12.05.2016	12.05.2017

6.6 AC conducted



FS = UR + CF + VC
(FS-field strength; UR-voltage at the receiver; CR-loss of the cable and filter; VC-correction factor of the ISN)

Example calculation:
FS [dBµV/m] = 37.62 [dBµV/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dBµV/m] (244.06 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufact.	Serial No.	INV. No CTC	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	AC-Spannungsquelle variabel	MV2616-V	EM-Test	0397-12	300003259	k	11.12.2015	11.12.2017
2	n. a.	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	Ve	02.02.2016	02.02.2018
3	n. a.	MXE EMI Receiver 20 Hz to 26,5 GHz	N9038A	Agilent Technologies	MY51210197	300004405	k	16.08.2016	16.08.2017
4	n. a.	Power Supply	NGSM 32/10	R&S	3939	400000192	vlKI!	22.01.2015	22.01.2017
5	101	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	R&S	893045/004	300000584	k	02.02.2016	02.02.2017

7 Measurement uncertainty

Measurement uncertainty	
Test case	**Uncertainty**
Spectrum bandwidth	span/1000
Conducted output power	± 3 dB
Spurious emissions radiated below 30 MHz	± 3 dB
Spurious emissions radiated 30 MHz to 1 GHz	± 3 dB
Spurious emissions radiated 1 GHz to 12.75 GHz	± 3.7 dB
Spurious emissions radiated above 12.75 GHz	± 4.5 dB
Spurious emissions conducted below 30 MHz (AC conducted)	± 2.6 dB

8 Sequence of testing

8.1 Sequence of testing radiated spurious 9 kHz to 30 MHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a 2-axis positioner with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna height is 1.5 m.
- At each turntable position the analyzer sweeps with positive-peak detector to find the maximum of all emissions.

Final measurement

- Identified emissions during the premeasurement are maximized by the software by rotating the turntable from 0° to 360°. In case of the 2-axis positioner is used the elevation axis is also rotated from 0° to 360°.
- The final measurement is done in the position (turntable and elevation) causing the highest emissions with quasi-peak (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. A plot with the graph of the premeasurement and the limit is stored.

8.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 10 m or 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 m to 3 m.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable position ± 45° and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

8.3 Sequence of testing radiated spurious 1 GHz to 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a 2-axis positioner with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height is 1.5 m.
- At each turntable position and antenna polarization the analyzer sweeps with positive peak detector to find the maximum of all emissions.

Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximizes the peaks by rotating the turntable from 0° to 360°. This measurement is repeated for different EUT-table positions (0° to 150° in 30°-steps) and for both antenna polarizations.
- The final measurement is done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

8.4 Sequence of testing radiated spurious above 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet.
- The measurement distance is as appropriate (e.g. 0.5 m).
- The EUT is set into operation.

Premeasurement

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and different polarizations of the antenna.

Final measurement

- The final measurement is performed at the position and antenna orientation causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement and the limit is stored.

8.5 Sequence of testing radiated spurious above 50 GHz with external mixers

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet.
- The measurement distance is as appropriate for far field (e.g. 0.25 m).
- The EUT is set into operation.

Premeasurement

- The test antenna with external mixer is handheld and moved carefully over the EUT to cover the EUT's whole sphere and different polarizations of the antenna.
- Caution is taken to reduce the possible overloading of the external mixer.

Final measurement

- The final measurement is performed at the position and antenna orientation causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- As external mixers may generate false images care is taken to ensure that any emission measured by the spectrum analyzer does indeed originate in the EUT. Signal identification feature of spectrum analyzer is used to eliminate false mixer images (i.e., it is not the fundamental emission or a harmonic falling precisely at the measured frequency).
- Final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement and the limit is stored.

9 Summary of measurement results

☒	No deviations from the technical specifications were ascertained
☐	There were deviations from the technical specifications ascertained
☐	This test report is only a partial test report. The content and verdict of the performed test cases are listed below.

TC identifier	Description	verdict	date	Remark
RF-Testing	47 CFR Part 15 / RSS-211	see below	2017-01-18	-/-

Test Specification Clause	Test Case	Temperature Conditions	Power Source Voltages	Pass	Fail	NA	NP	Results
§15.215(c)	Frequency stability	Nominal Extreme	Nominal Extreme	☒	☐	☐	☐	complies
§15.256(f) RSS-211, 2.4	Fundamental bandwidth	Nominal	Nominal	☒	☐	☐	☐	complies
§15.256(g) RSS-211,5.2b	Fundamental emissions limits	Nominal	Nominal	☒	☐	☐	☐	complies
§15.256(h) RSS-211,5.1d	Unwanted emissions limit	Nominal	Nominal	☒	☐	☐	☐	complies
§15.256(i) RSS-211,5.2a	Antenna beamwidth	Nominal	Nominal	☒	☐	☐	☐	complies
§15.256(j) RSS-211,5.2c	Antenna side lobe gain	Nominal	Nominal	☒	☐	☐	☐	complies
§15.256(k) RSS-Gen, 7.1	Emissions from digital circuitry	Nominal	Nominal	☒	☐	☐	☐	complies
§15.107/207 RSS-Gen, 8.8	Conducted limits	Nominal	Nominal	☒	☐	☐	☐	complies

Note:
NA = Not applicable; NP = Not performed

10 Test results

10.1 Frequency stability and fundamental bandwidth

Description:

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

§15.256(f) The fundamental bandwidth of an LPR emission is defined as the width of the signal between two points, one below and one above the center frequency, outside of which all emissions are attenuated by at least 10 dB relative to the maximum transmitter output power when measured in an equivalent resolution bandwidth.

Measurement:

f_C is the point in the radiation where the power is at maximum. The frequency points where the power falls 10 dB below the f_C level and above f_C level are designated as f_L and f_H respectively.
The operating frequency range (i.e. the frequency band of operation) is defined as f_H - f_L.

Measurement parameters:

Resolution bandwidth:	1 MHz
Video bandwidth:	≥1 MHz
Detector:	Pos-Peak
Trace:	Max hold

Limits:

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

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

Same requirements for fundamental emission bandwidth are given in RSS-211, 2.4 and 5.1.a)

Results:

Test Conditions	Transmitter Frequency Range (GHz)		10 dB bandwidth (GHz)
	f_L	f_H	
-30 °C / V_{nom}	78.012821	81.995192	3.982371
-20 °C / V_{nom}	78.020833	81.987179	3.966346
-10 °C / V_{nom}	78.028846	81.995192	3.966346
0 °C / V_{nom}	78.028846	81.979167	3.950321
10 °C / V_{nom}	78.012821	81.979167	3.966346
20 °C / V_{min} - V_{max}	78.012821	81.987179	3.974358
30 °C / V_{nom}	78.004808	81.987179	3.982371
40 °C / V_{nom}	78.004808	81.979167	3.974359
50 °C / V_{nom}	77.996795	81.979167	3.982372
deviation based on 20 °C	±16.0 MHz (±205 ppm)	±8.0 MHz (±98 ppm)	

Verdict: **Complies**

10.2 Fundamental emissions

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

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

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

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

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

Limits:

Frequency range (GHz)	Average emission limit (EIRP in dBm / 1 MHz)	Peak emission limit (EIRP in dBm / 50 MHz)
5.925 to 7.250	-33	+7 dBm
24.05 to 29.00	-14	+26 dBm
75.00 to 85.00	-3	+34 dBm

Same requirements are given in RSS-211, 5.2.b)

Measurement parameters:

Resolution bandwidth: 1 MHz
Video bandwidth: ≥1 MHz
Span: depends on DUT
Detector: Pos-Peak
Trace: Max hold

Results:

Antenna type	Antenna gain (dBi)	Peak EIRP (dBm)	Average EIRP (dBm)
40 mm convex lens	26.1	17.7	-41.3
70 mm convex lens	29.8	21.4	-37.6

Note:
See manufacturer's documentation *Operating Description, Level Probing Radar OPTIWAVE 7400-80 C*.

There are two different aspects which will affect the peak-to-average ratio resp. RMS value at all:
- Duty cycle of the device
- Frequency domain mitigation due to FMCW-modulation

The EUT uses FMCW with a negative ramp over approx. 3.975 GHz within approx. 5 ms.
The total DUT cycle is 1000 ms. Therefore the gap (blanking period) between the emissions is approx. 995 ms.

This will lead to:
- dwell time $T_D = T_S / \Delta F$ = 1.258 µs/MHz
- averaging factor AF = T_D / cycle time = $1.258*10^{-6} \triangleq$ -59.0 dB

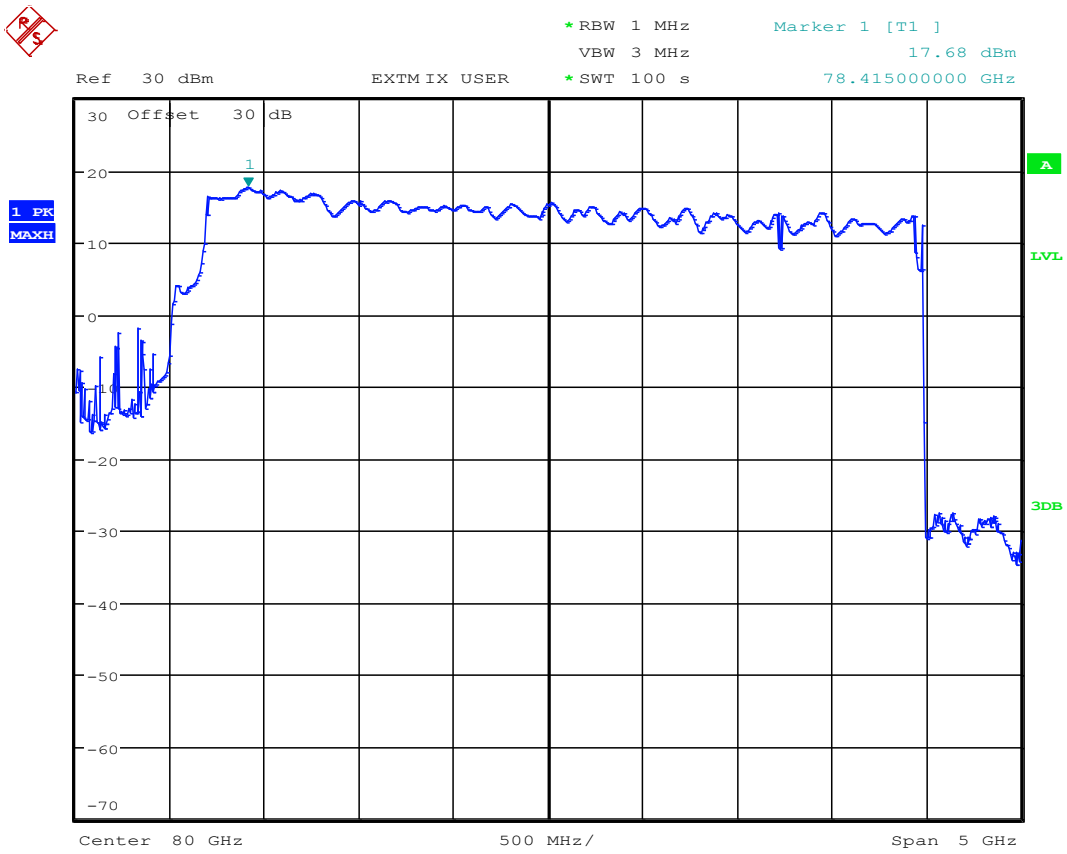
Peak output power was measured as conducted output power with settings shown in FCC document *890966 D01, Measurement Procedure for Level Probing Radars*. Measurements were performed using a special test adapter supplied by the manufacturer.
Peak EIRP was calculated based on the peak output power and the antenna gain given in above mentioned antenna test report of the manufacturer.
Plots show measurement results for 40 mm convex lens. Antenna gain is considered in reference level offset.
Average EIRP was calculated according to FCC document *890966 D01, Measurement Procedure for Level Probing Radars*.

Following antenna gain is included in above value as worst case:
- 40mm convex lens antenna: max. 26.1 dBi
- 70mm convex lens antenna: max. 29.8 dBi

Furthermore, 3.9 dB test adapter loss is considered for conducted measurements.

Verdict: **Complies**

Plot 1: Pos-Peak-measurement (1 MHz RBW)



10.3 Unwanted emissions limit

Description:

§15.256(h)
Unwanted emissions from LPR devices shall not exceed the general emission limit in §15.209 of this chapter.

Measurement parameters:

Resolution bandwidth: 100 kHz / 1 MHz
Video bandwidth: ≥ resolution bandwidth
Detector: Quasi Peak / Average (RMS)
Trace: Max hold

Limits:

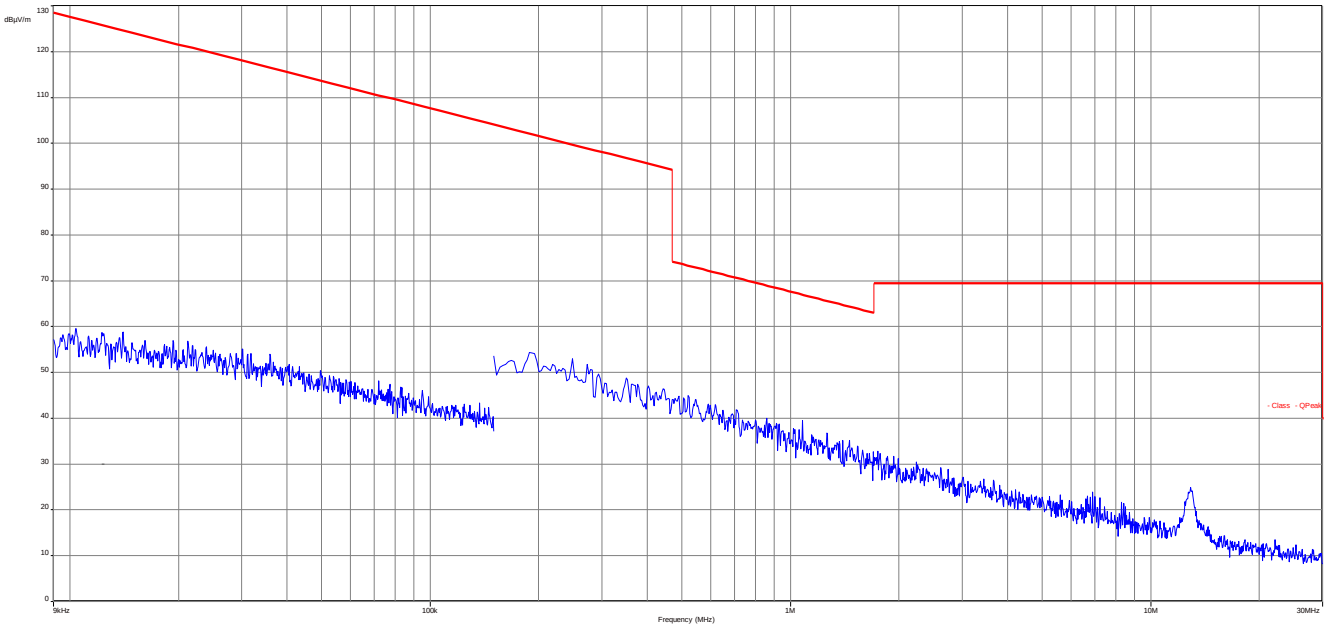
FCC §15.209 / RSS-Gen		
Field strength of the harmonics and spurious.		
Frequency (MHz)	**Field strength (µV/m)**	**Measurement distance (m)**
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30 (29.5 dBµV/m)	30
30 – 88	100 (40 dBµV/m)	3
88 – 216	150 (43.5 dBµV/m)	3
216 – 960	200 (46 dBµV/m)	3
>960	500 (54 dBµV/m)	3

Results:

Spurious emission level (dBm)								
-/-			-/-			-/-		
Frequency [GHz]	BW [kHz]	Level [dBm]	Frequency [GHz]	BW [kHz]	Level [dBm]	Frequency [GHz]	BW [kHz]	Level [dBm]
see plots								

Verdict: **Complies**

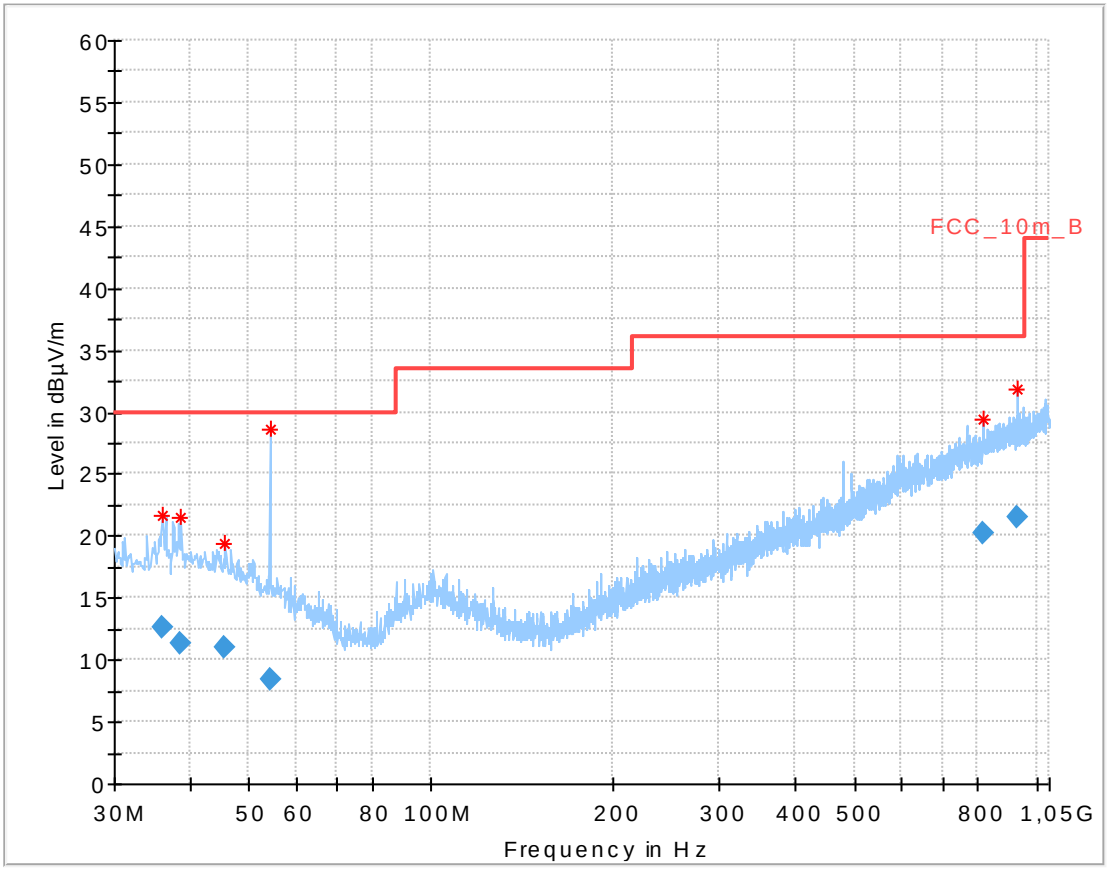
Plot 2: 9 kHz – 30 MHz, special test mode, frequency sweep stopped at $f_{low}/f_{mid}/f_{high}$



Plot 3: 30 MHz – 1000 MHz, special test mode, frequency sweep stopped at $f_{low}/f_{mid}/f_{high}$

Common Information

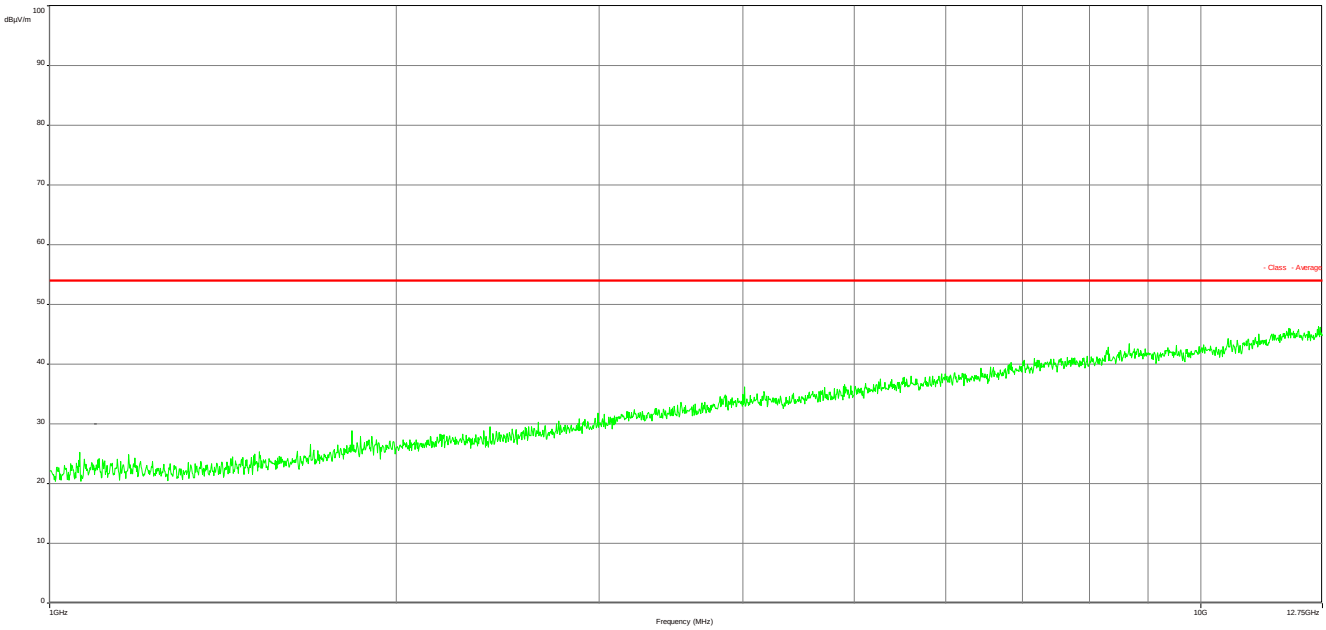
EUT:	Optiwave
Serial number:	no 3
Test description:	FCC part 15 class B @ 10 m
Operating condition:	TX low/mid/high
Operator name:	Hennemann
Comment:	DC 24 V



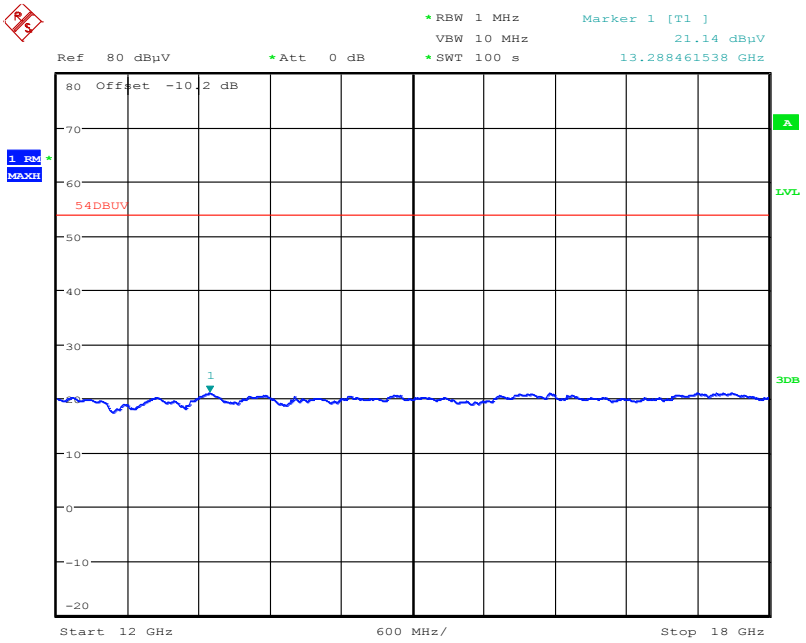
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
36.014100	12.59	30.00	17.41	1000.0	120.000	272.0	V	8	13.8
38.665050	11.26	30.00	18.74	1000.0	120.000	273.0	V	7	14.0
45.466650	10.93	30.00	19.07	1000.0	120.000	271.0	H	266	13.7
54.520950	8.47	30.00	21.53	1000.0	120.000	274.0	V	282	11.9
816.635550	20.18	36.00	15.82	1000.0	120.000	100.0	V	53	23.0
927.661650	21.45	36.00	14.55	1000.0	120.000	100.0	V	5	24.2

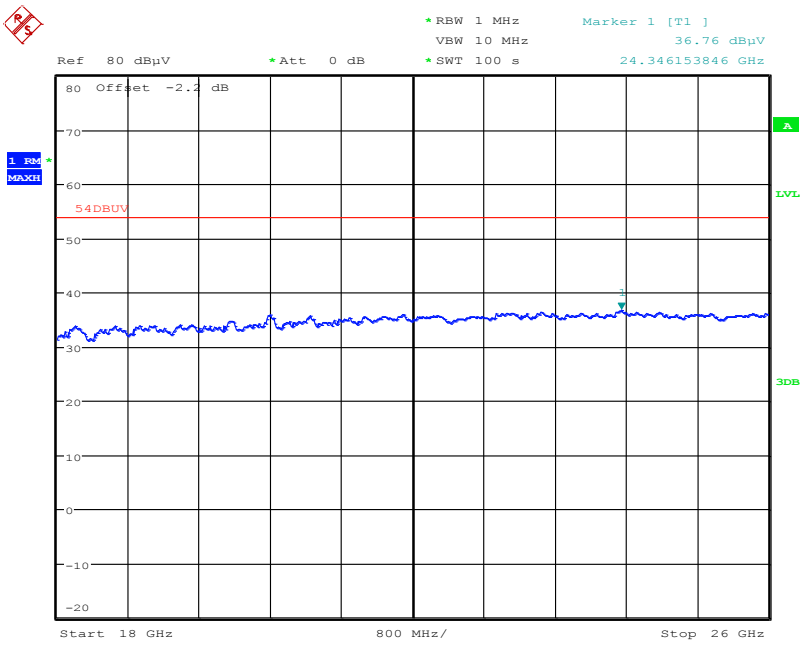
Plot 4: 1 GHz – 12.75 GHz, special test mode, frequency sweep stopped at $f_{low}/f_{mid}/f_{high}$



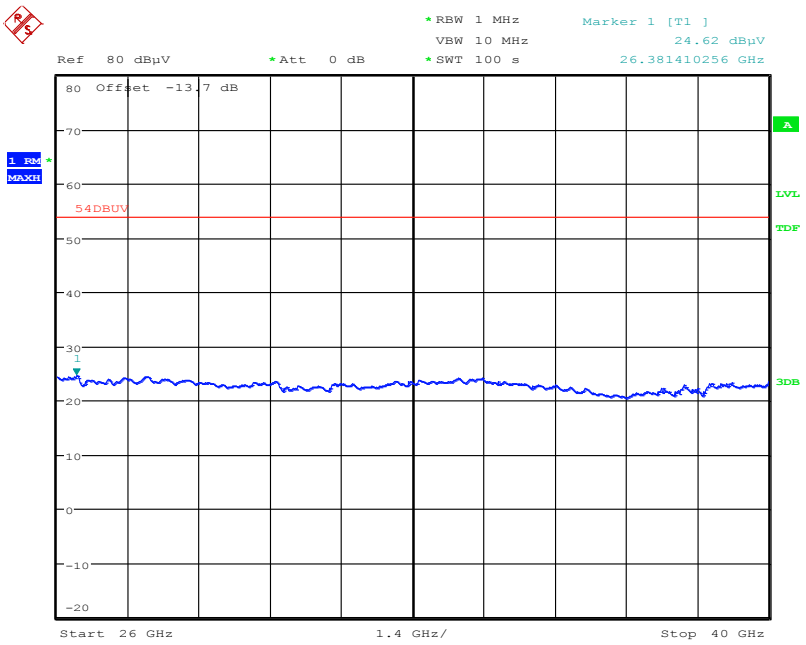
Plot 5: 12 GHz – 18 GHz, special test mode, $f_{low}/f_{mid}/f_{high}$



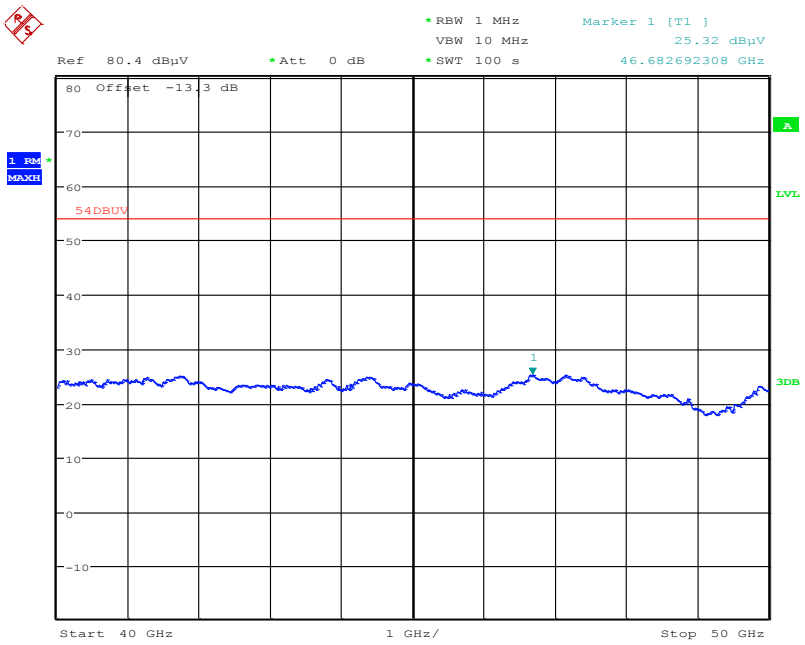
Plot 6: 18 GHz – 26 GHz, special test mode, $f_{low}/f_{mid}/f_{high}$



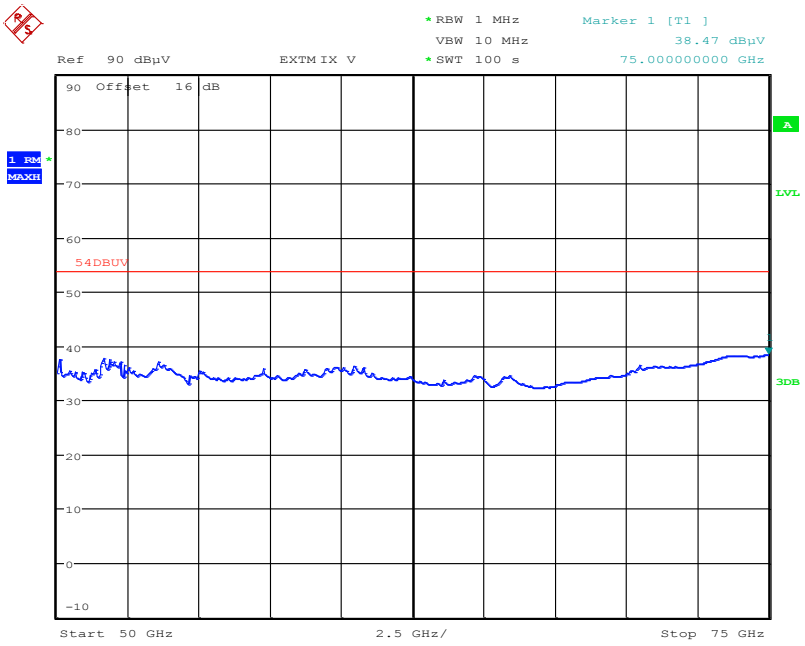
Plot 7: 26 GHz – 40 GHz, special test mode, $f_{low}/f_{mid}/f_{high}$



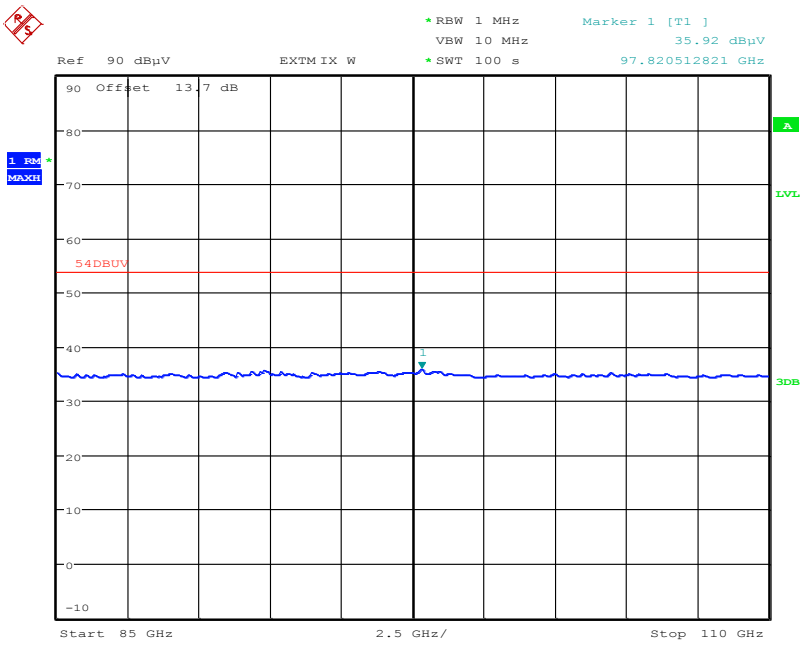
Plot 8: 40 GHz – 50 GHz, special test mode, $f_{low}/f_{mid}/f_{high}$



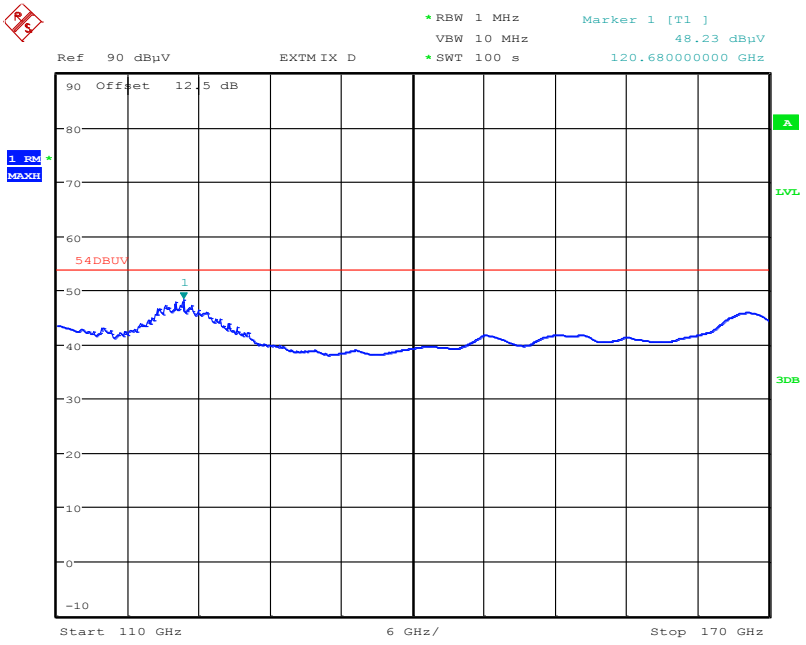
Plot 9: 50 GHz – 75 GHz, special test mode, $f_{low}/f_{mid}/f_{high}$



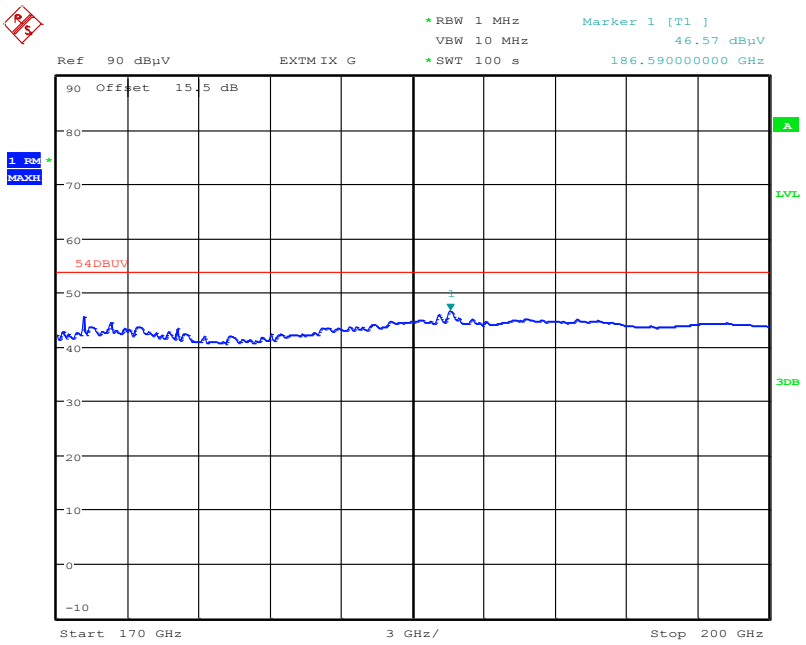
Plot 10: 85 GHz – 110 GHz, special test mode, $f_{low}/f_{mid}/f_{high}$



Plot 11: 110 GHz – 170 GHz, special test mode, $f_{low}/f_{mid}/f_{high}$



Plot 12: 170 GHz – 200 GHz, special test mode, $f_{low}/f_{mid}/f_{high}$



10.4 Antenna beamwidth and antenna side lobe gain

Description:

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

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

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

Limits:

FCC §15.256 / RSS-211 5.2a) c)		
Frequency range (GHz)	**Antenna beamwidth in degree (°)**	**Antenna side lobe gain limit relative to main beam gain (dB)**
5.925 to 7.250	12	-22
24.05 to 29.00	12	-27
75.00 to 85.00	8	-38

Antenna data:

Antenna type	Antenna gain	3 dB beam width	Side lobe gain
40 mm convex lens	26.1 dBi	8.0°	-12.6 dBi
70 mm convex lens	29.8 dBi	4.3°	-11.8 dBi

Note:
See manufacturer's documentation *Operating Description, Level Probing Radar OPTIWAVE 7400-80 C*.

Verdict: **Complies**

10.5 Emissions from digital circuitry

Description:

§15.256(k) Emissions from digital circuitry used to enable the operation of the transmitter may comply with the limits in §15.209 of this chapter provided it can be clearly demonstrated that those emissions are due solely to emissions from digital circuitry contained within the transmitter and the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in §15.3(k) of this part, e.g., emissions from digital circuitry used to control additional functions or capabilities other than the operation of the transmitter, are subject to the limits contained in subpart B, part 15 of this chapter. Emissions from these digital circuits shall not be employed in determining the -10 dB bandwidth of the fundamental emission or the frequency at which the highest emission level occurs.

Measurement:

Measurement parameter	
Detector:	Quasi Peak / Average (RMS)
Sweep time:	Auto
Resolution bandwidth:	100 kHz / 1 MHz
Video bandwidth:	> resbw
Trace-Mode:	Max-Hold

Limits:

FCC §15.109 / RSS-Gen, 7.1		
Field strength of the harmonics and spurious.		
Frequency (MHz)	**Field strength (µV/m)**	**Measurement distance (m)**
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30 (29.5 dBµV/m)	30
30 – 88	100 (40 dBµV/m)	3
88 – 216	150 (43.5 dBµV/m)	3
216 – 960	200 (46 dBµV/m)	3
>960	500 (54 dBµV/m)	3

Results:

See §15.256(h) / RSS-211,5.1d Unwanted emissions limit.

Verdict: **Complies**

10.6 Conducted limits

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. Both power lines, phase and neutral line, are measured. Found peaks are re-measured with average and quasi peak detection to show compliance to the limits.

Measurement:

Measurement parameter	
Detector:	Peak - Quasi Peak / Average
Sweep time:	Auto
Resolution bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Video bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span:	9 kHz to 30 MHz
Trace-Mode:	Max Hold

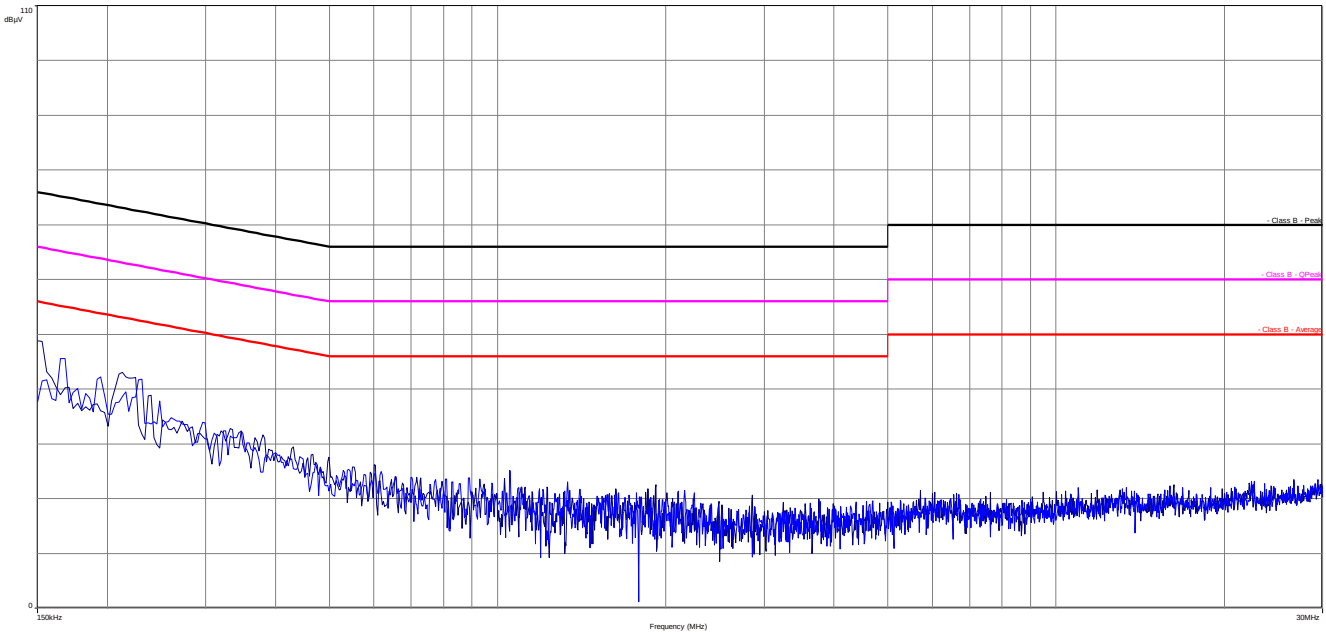
Limits:

FCC §15.107 / §15.207 / RSS-Gen, 8.8		
Conducted limits		
Frequency of Emission (MHz)	**Conducted Limit (dBµV)**	
	Quasi-peak	Average
0.15 – 0.5	66 to 56 *	56 to 46 *
0.5 – 5	56	46
5 - 30	60	50

*Decreases with the logarithm of the frequency

Verdict: **Complies**

Plot 13: Phase & Neutral



11 Document history

Version	Applied changes	Date of release
	Initial release	2017-01-18

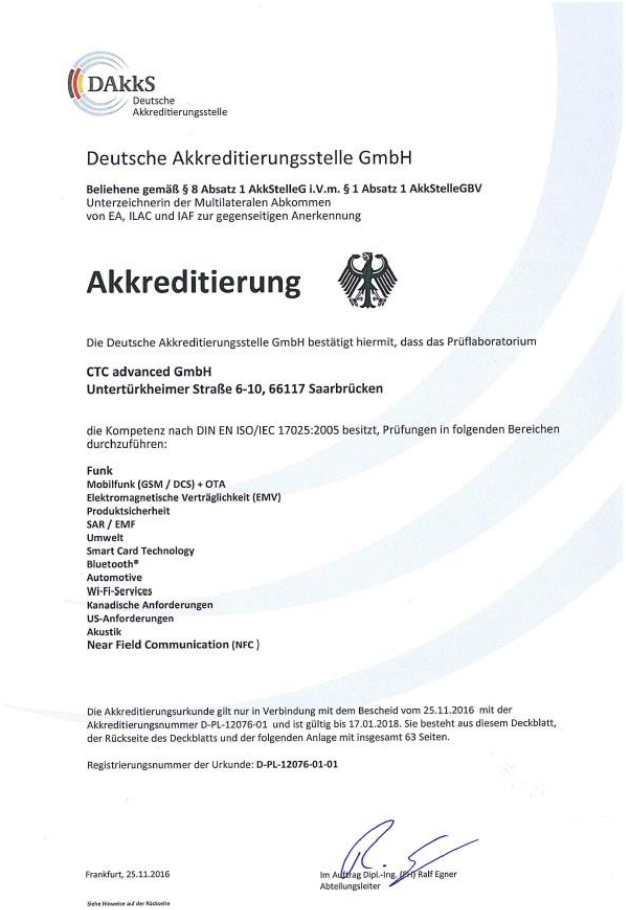
12 Further information

Glossary

AVG - Average
DUT - Device under test
EMC - Electromagnetic Compatibility
EN - European Standard
EUT - Equipment under test
ETSI - European Telecommunications Standard Institute
FCC - Federal Communication Commission
FCC ID - Company Identifier at FCC
HW - Hardware
IC - Industry Canada
Inv. No. - Inventory number
N/A - Not applicable
PP - Positive peak
QP - Quasi peak
S/N - Serial number
SW - Software

13 Accreditation Certificate

Front side of certificate



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Akkreditierung

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CTC advanced GmbH
Untertürkheimer Straße 6-10, 66117 Saarbrücken

die Kompetenz nach DIN EN ISO/IEC 17025:2005 besitzt, Prüfungen in folgenden Bereichen durchzuführen:

Funk
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Elektromagnetische Verträglichkeit (EMV)
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SAR / EMF
Umwelt
Smart Card Technology
Bluetooth®
Automotive
Wi-Fi-Services
Kanadische Anforderungen
US-Anforderungen
Akustik
Near Field Communication (NFC)

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Frankfurt, 25.11.2016

Im Auftrag Dipl.-Ing. (FH) Ralf Egner
Abteilungsleiter

Siehe Hinweise auf der Rückseite

Back side of certificate

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ILAC: www.ilac.org
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Note:
The current certificate including annex may be received on request.