

CETECOM™

CETECOM ICT Services
consulting - testing - certification >>>

TEST REPORT

Test report no.: 1-1207/16-01-02-B



Testing laboratory

CETECOM ICT Services GmbH
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
Fax: + 49 681 5 98 - 9075
Internet: <http://www.cetecom.com>
e-mail: ict@cetecom.com

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

CAE SpA
Via Colunga 20
40068 San Lazzaro di Savena / ITALY
Phone: +39 05 14 49 27 11
Fax: +39 05 14 99 28 79
Contact: Armando Cocchi
e-mail: armando.cocchi@cae.it
Phone: +39 05 14 99 27 11

Manufacturer

CAE SpA
Via Colunga 20
40068 San Lazzaro di Savena / ITALY

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: LPR
FCC ID: 2AIKRLPRX01
IC: 21500-LPRX01
Frequency: 24 GHz band
Antenna: horn antenna
Power Supply: 11 – 16 V DC, typ. 12 V DC
Temperature Range: -30 °C to +50 °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:

Meheza Walla
Lab Manager
Radio Communications & EMC

Test performed:

Karsten Geraldy
Lab Manager
Radio Communications & EMC

1 Table of contents

1	Table of contents	2
2	General information	3
2.1	Notes and disclaimer	3
2.2	Application details.....	3
3	Test standard/s and guideline/s.....	3
4	Test laboratories sub-contracted	4
5	Test environment.....	4
6	Test item.....	5
6.1	General Description	5
6.2	Additional information	5
7	Description of the test setup	6
7.1	Shielded semi anechoic chamber.....	7
7.2	Shielded fully anechoic chamber	8
7.3	Radiated measurements > 18 GHz.....	9
7.4	Radiated measurements > 50 GHz.....	9
7.5	AC conducted	11
8	Measurement uncertainty	11
9	Sequence of testing	12
9.1	Sequence of testing radiated spurious 9 kHz to 30 MHz.....	12
9.2	Sequence of testing radiated spurious 30 MHz to 1 GHz.....	13
9.3	Sequence of testing radiated spurious 1 GHz to 18 GHz	14
9.4	Sequence of testing radiated spurious above 18 GHz	15
9.5	Sequence of testing radiated spurious above 50 GHz with external mixers	16
10	Summary of measurement results.....	17
11	Test results.....	18
11.1	Frequency stability and fundamental bandwidth	18
11.2	Fundamental emissions	20
11.3	Unwanted emissions limit.....	23
11.4	Antenna beamwidth and antenna side lobe gain	32
11.5	Emissions from digital circuitry	33
11.6	Conducted limits	34
12	Document history	37
13	Further information.....	37
14	Accreditation Certificate	38

2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CETECOM ICT Services GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.

The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM ICT Services GmbH.

The testing service provided by CETECOM ICT Services GmbH has been rendered under the current "General Terms and Conditions for CETECOM ICT Services GmbH".

CETECOM ICT Services GmbH will not be liable for any loss or damage resulting from false, inaccurate, inappropriate or incomplete product information provided by the customer.

Under no circumstances does the CETECOM ICT Services GmbH test report include any endorsement or warranty regarding the functionality, quality or performance of any other product or service provided.

Under no circumstances does the CETECOM ICT Services GmbH test report include or imply any product or service warranties from CETECOM ICT Services GmbH, including, without limitation, any implied warranties of merchantability, fitness for purpose, or non-infringement, all of which are expressly disclaimed by CETECOM ICT Services GmbH.

All rights and remedies regarding vendor's products and services for which CETECOM ICT Services GmbH has prepared this test report shall be provided by the party offering such products or services and not by CETECOM ICT Services GmbH.

In no case this test report can be considered as a Letter of Approval.

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

This test report replaces the test report with the number 1-1207/16-01-02-A dated 2016-06-07.

2.2 Application details

Date of receipt of order:	2016-03-04
Date of receipt of test item:	2016-04-13
Start of test:	2016-04-29
End of test:	2016-05-25
Person(s) present during the test:	-/-

3 Test standard/s and guideline/s

Test standard	Date	Test standard description
47 CFR Part 15	2015-10	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 laboratories sub-contracted

None

5 Test environment

Temperature:	T_{nom}	+22 °C during room temperature tests
	T_{max}	+50 °C
	T_{min}	-30 °C
Relative humidity content:		45 %
Barometric pressure:		not relevant for this kind of testing
Power supply:	V_{nom}	12.0 V DC
	V_{max}	16.0 V DC
	V_{min}	11.0 V DC

6 Test item

6.1 General Description

Kind of test item	Level probing radar
Type identification	LPR
PMN	LPR
HVIN	01
FVIN	-/-
HMN	-/-
S/N serial number	1600140
HW hardware status	01
SW software status	2.18
Frequency band	24.05 GHz – 25.5 GHz
Type of modulation	FMCW
Number of channels	1
Antenna	horn antenna
Power supply	11 – 16 V DC, typ. 12 V DC, < 200 mA
Temperature range	-30 °C to +50 °C

Note:

Following antenna is used as LPR application:

Antenna	Maximum gain	Maximum 3 dB beam width	Maximum side lobe level > 60 deg
75 mm horn antenna	23.7	11.7	< -10 dBi

6.2 Additional information

The customer prepared a special test sample as follows:

- The test mode is programmed in "continuous mode" with a 60 s measure interval and 99 number of measures. The instrument takes a measure every 500 ms, each measure consist of a 75 ms sweep, the remaining 425 ms transmitter is off.
- The normal mode is programmed with 20 samples of 75 ms sweep every 600 s.

The difference of both modes, test mode and normal operation mode, results in approx. 17 dB more average power during the test mode because of the higher duty-cycle. Therefor 17 dB have to be subtracted for all measured average values to get the average values for normal operation mode.

See also manufacturer's declaration *LPR test and normal mode of 2016-04-27*.

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: 1-1207/16-01-01_AnnexA
 1-1207/16-01-01_AnnexD
 1-1207/16-01-01_AnnexE

7 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).

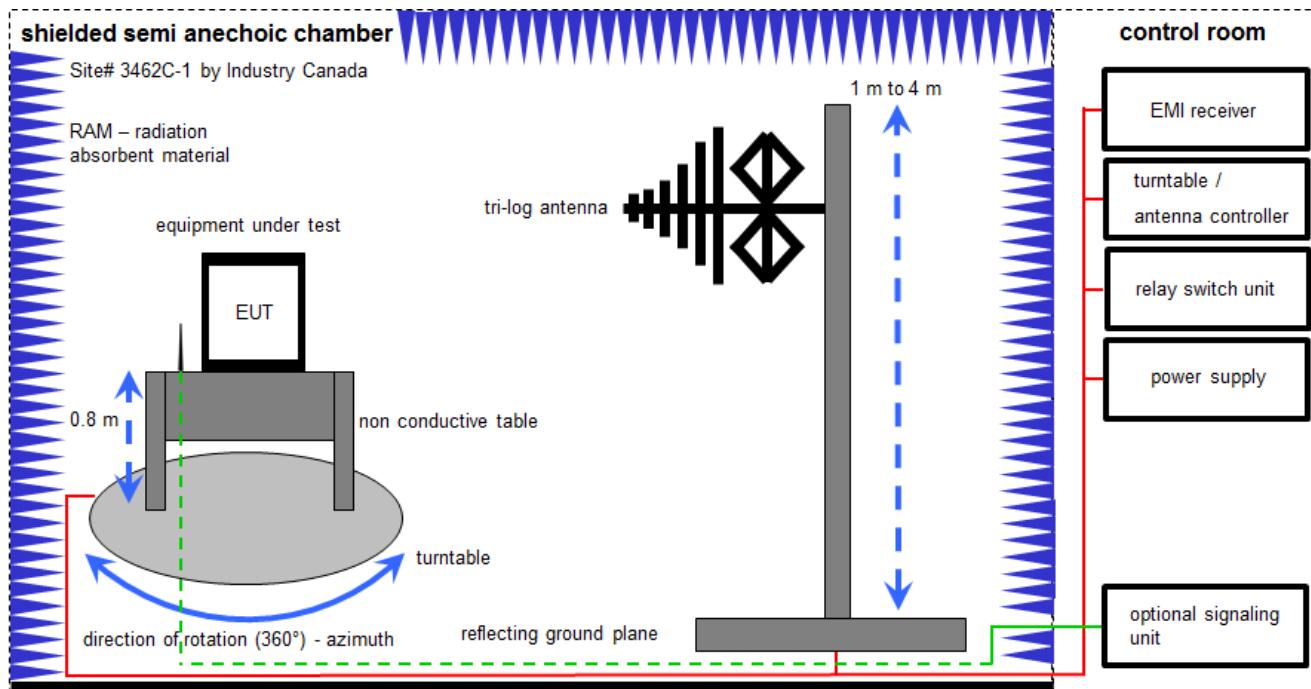
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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

7.1 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 confirmed with 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)

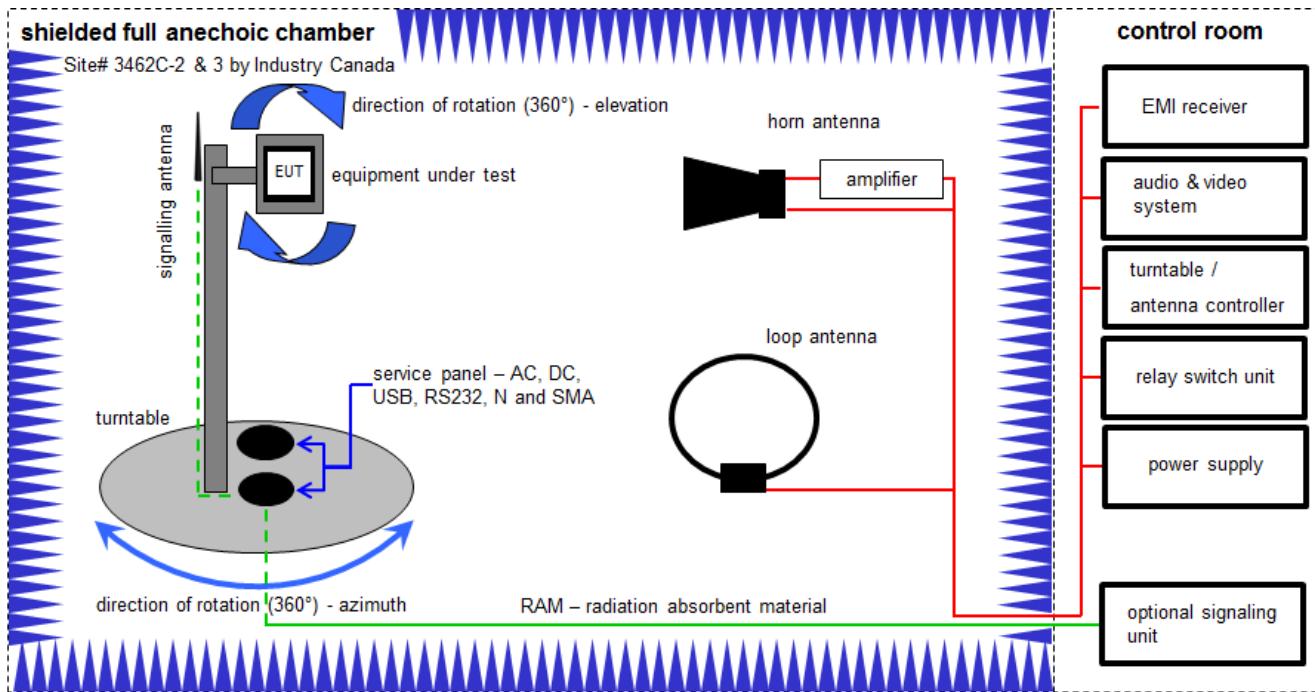
Example calculation:

$$FS [dB\mu V/m] = 12.35 [dB\mu V/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dB\mu V/m] (35.69 \mu V/m)$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufact.	Serial No.	INV. No Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	Switch / Control Unit	3488A	HP		300000929	ne		
2	n. a.	Directional Coupler	101020010	Krytar	70215	300002840	ev		
3	n. a.	DC-Blocker	8143	Inmet Corp.	none	300002842	ne		
4	n. a.	Powersplitter	6005-3	Inmet Corp.		300002841	ev		
5	n. a.	Temperature Test Chamber	VT 4002	Heraeus Voetsch	58566046820010	300003019	ev	03.09.2015	03.09.2017
6	n. a.	System DC Power Supply	N5767A	Agilent Technologies	US14J1569P	300004851	vIKI!	04.09.2014	04.09.2016
7	n. a.	Signal Analyzer 30GHz	FSV30	R&S	103170	300004855	k	25.01.2016	25.01.2017
8	n. a.	Power Sensor	NRP-Z81	R&S	100010	300003780	k	25.01.2016	25.01.2017
9	AC2-C01	RF-Cable	ST18/SMAm/SMAm/72	Huber & Suhner	Batch no. 605505	400001187	ev		
10	AC2-C02	RF-Cable	Sucoflex 104	Huber & Suhner	147636/4	400001188	ev		

7.2 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)

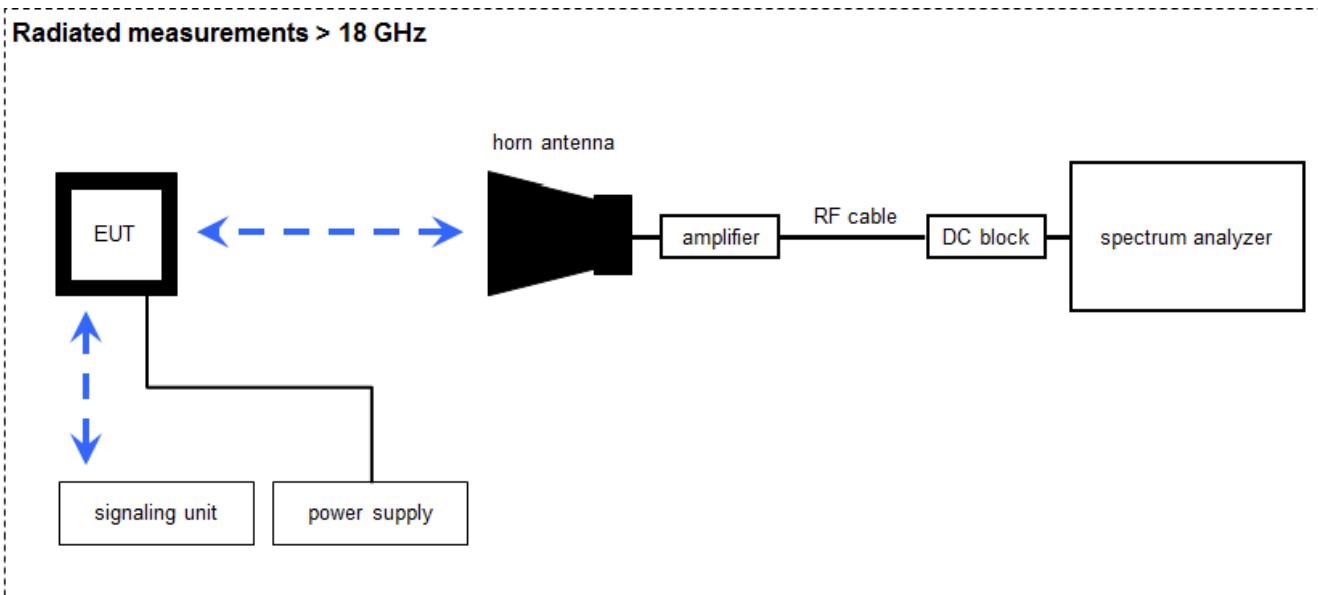
Example calculation:

$$\text{FS [dB}\mu\text{V/m]} = 40.0 \text{ [dB}\mu\text{V/m]} + (-35.8) \text{ [dB]} + 32.9 \text{ [dB/m]} = 37.1 \text{ [dB}\mu\text{V/m]} (71.61 \mu\text{V/m})$$

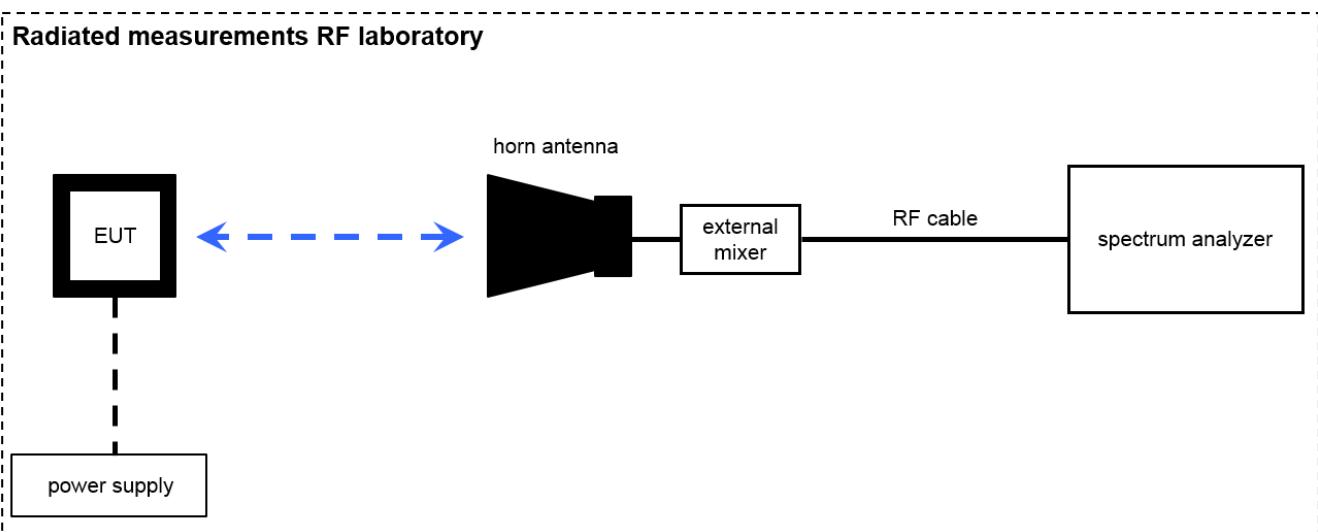
Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No Cetecom	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	vIKI!	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	Variable isolating transformer	MPL IEC625 Bus Variable isolating transformer	Erfi	91350	300001155	ne		
6	90	Active Loop Antenna 10 kHz to 30 MHz	6502	EMCO/2	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.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	371	300003854	vIKI!	29.10.2014	29.10.2017
12	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne		
13	n. a.	EMI Test Receiver 9kHz-26,5GHz	ESR26	R&S	101376	300005063	k	04.09.2015	04.09.2016

7.3 Radiated measurements > 18 GHz



7.4 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:

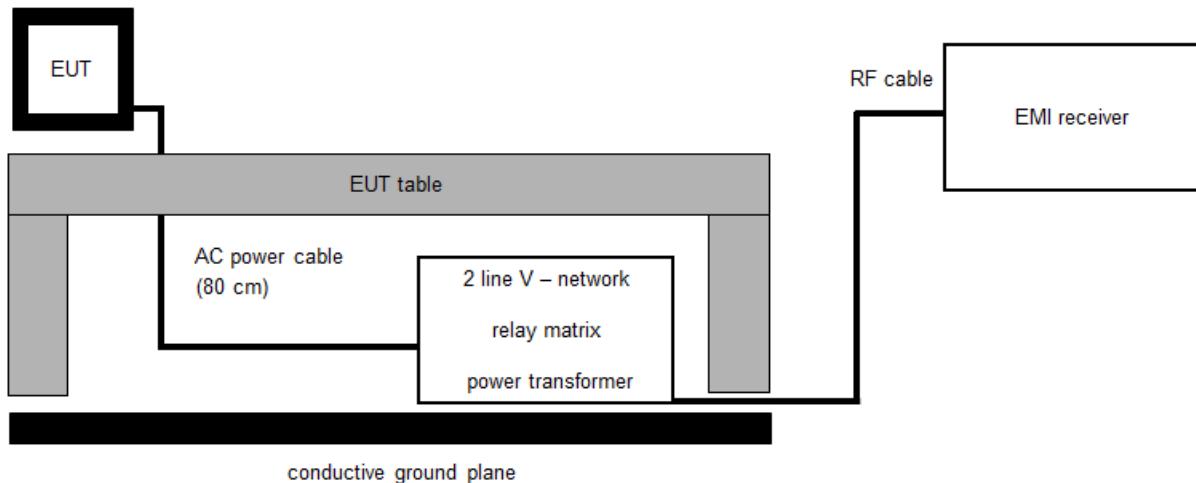
$$OP [dBm] = -54.0 [dBm] + 64.0 [dB] - 20.0 [dBi] = -10 [dBm] (100 \mu W)$$

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

No.	Lab / Item	Equipment	Type	Manufact.	Serial No.	INV. No Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	A023	Std. Gain Horn Antenna 39.3-59.7 GHz	2424-20	Flann	75	300001979	ne		
2	A025	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne		
3	A026	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001986	ne		
4	A027	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001988	ne		
5	A028	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001991	ne		
6		Std. Gain Horn Antenna 12.4 to 18.0 GHz	639	Narda	8402	300000787	k	14.08.2015	14.08.2017
7		Std. Gain Horn Antenna 18.0 to 26.5 GHz	638	Narda		300000486	k	10.09.2015	10.09.2017
8	A031	Std. Gain Horn Antenna 26.5 to 40.0 GHz	V637	Narda	82-16	300000510	k	14.08.2015	14.08.2017
9	n. a.	Spectrum Analyzer 20 Hz - 50 GHz	FSU50	R&S	200012	300003443	Ve	02.10.2014	02.10.2016
10	n. a.	Harmonic Mixer 2-Port, 50-75 GHz	FS-Z75	R&S	100099	300003949	k	09.03.2016	09.03.2017
11	n. a.	PXA Spectrum Analyzer 3Hz to 50GHz	N9030A PXA Signal Analyzer	Agilent Technologies	US51350267	300004338	k	09.02.2016	09.02.2017
12	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev		
13	n. a.	Harmonic Mixer 3-Port, 75-110 GHz	FS-Z110	R&S	101411	300004959	k	12.05.2016	12.05.2017
14	n. a.	Waveguide Harmonic Mixer, 75-110 GHz	M1970W	KEYSIGHT	MY51430848	300005115	k	25.02.2016	25.02.2018
15	n. a.	Waveguide Harmonic Mixer, 50-80 GHz	M1970V	KEYSIGHT	MY51390914	300005116	k	05.02.2016	05.02.2018
16	n. a.	Temperature Test Chamber	T-40/50	CTS GmbH	053031	300003592	ev	03.09.2015	03.09.2017

7.5 AC conducted

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:

$$FS [\text{dB}\mu\text{V/m}] = 37.62 [\text{dB}\mu\text{V/m}] + 9.90 [\text{dB}] + 0.23 [\text{dB}] = 47.75 [\text{dB}\mu\text{V/m}] (244.06 \mu\text{V/m})$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufact.	Serial No.	INV. No Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	R&S	892475/017	300002209	k	17.06.2014	17.06.2016
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	04.02.2016	04.02.2017

8 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

9 Sequence of testing

9.1 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.

9.2 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.

Premereasurement

- 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 $\pm 45^\circ$ 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.

9.3 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.

9.4 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.

Premereasurement

- 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.

9.5 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.

Premereasurement

- 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.

10 Summary of measurement results

<input checked="" type="checkbox"/>	No deviations from the technical specifications were ascertained
<input type="checkbox"/>	There were deviations from the technical specifications ascertained
<input type="checkbox"/>	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	2016-07-05	-/-

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

Note:

NA = Not Applicable; NP = Not Performed

MD = see Manufacturer's Documentation

11 Test results

11.1 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}	24.05155	25.5004	1.44885
-20 °C / V_{nom}	24.05155	25.5004	1.44885
-10 °C / V_{nom}	24.05155	25.5004	1.44885
0 °C / V_{nom}	24.05155	25.5004	1.44885
10 °C / V_{nom}	24.05155	25.5004	1.44885
20 °C / $V_{\text{min}} - V_{\text{max}}$	24.05155	25.5004	1.44885
30 °C / V_{nom}	24.05155	25.5004	1.44885
40 °C / V_{nom}	24.05155	25.5004	1.44885
50 °C / V_{nom}	24.05155	25.5004	1.44885
deviation based on 20 °C	±0.0 MHz (±0 ppm)	±0.0 MHz (±0 ppm)	

Verdict: Complies

11.2 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 test mode (dBm)	Average EIRP normal mode (dBm)
horn antenna	23.7	24.4	-15.5	-33.2

Note:

See manufacturer's documentation *LPR test and normal mode of 2016-04-27*.

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 ramp over approx. 1.45 GHz within approx. 75 ms.

Test mode:

The total DUT cycle is 500 ms. Therefore the gap (blanking period) between the emissions is approx. 425 ms (without period of inactivity after 99 transmissions).

This will lead to:

- dwell time $T_D = T_S / \Delta F = 51.7 \mu\text{s}/\text{MHz}$
- averaging factor $AF = T_D / \text{cycle time} = 1.034 \times 10^{-4} \triangleq -39.9 \text{ dB}$

Normal mode:

The manufacturer declared: the normal mode is programmed with 20 samples of 75 ms sweep from 24.054 to 25.494 GHz every 600 s.

Using this information this will lead to an averaging factor of $AF = 1.724 \times 10^{-6} \triangleq -57.6 \text{ dB}$

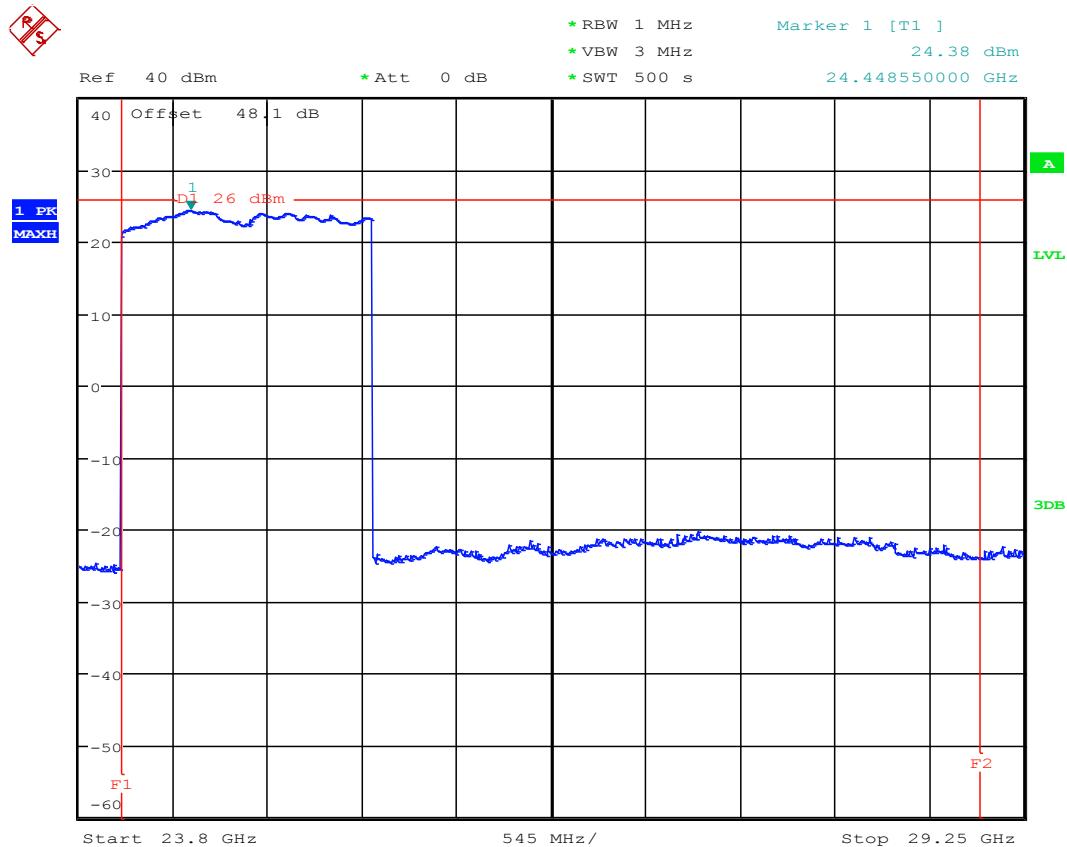
Peak output power was measured as radiated output power (EIRP) with settings shown in FCC document 890966 D01, *Measurement Procedure for Level Probing Radars*.

Measurements were performed in a 1m test distance.

Average EIRP was calculated according to FCC document 890966 D01, *Measurement Procedure for Level Probing Radars*.

Verdict: Complies

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



Date: 10.MAY.2016 08:28:37

11.3 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: \geq resolution bandwidth
 Detector: Quasi Peak / Average (RMS)
 Trace: Max hold

Limits:

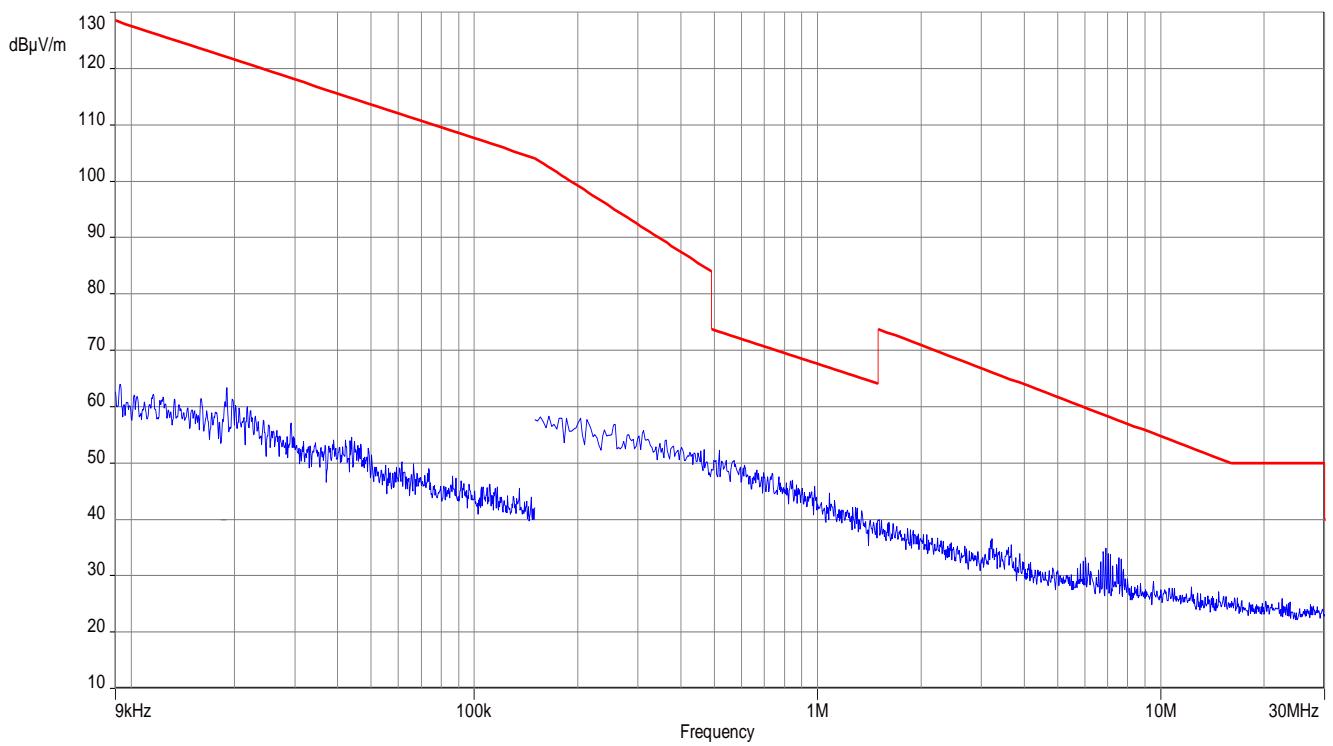
FCC §15.209 / RSS-Gen		
Field strength of the harmonics and spurious.		
Frequency (MHz)	Field strength (μ V/m)	Measurement distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30 (29.5 dB μ V/m)	30
30 – 88	100 (40 dB μ V/m)	3
88 – 216	150 (43.5 dB μ V/m)	3
216 – 960	200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

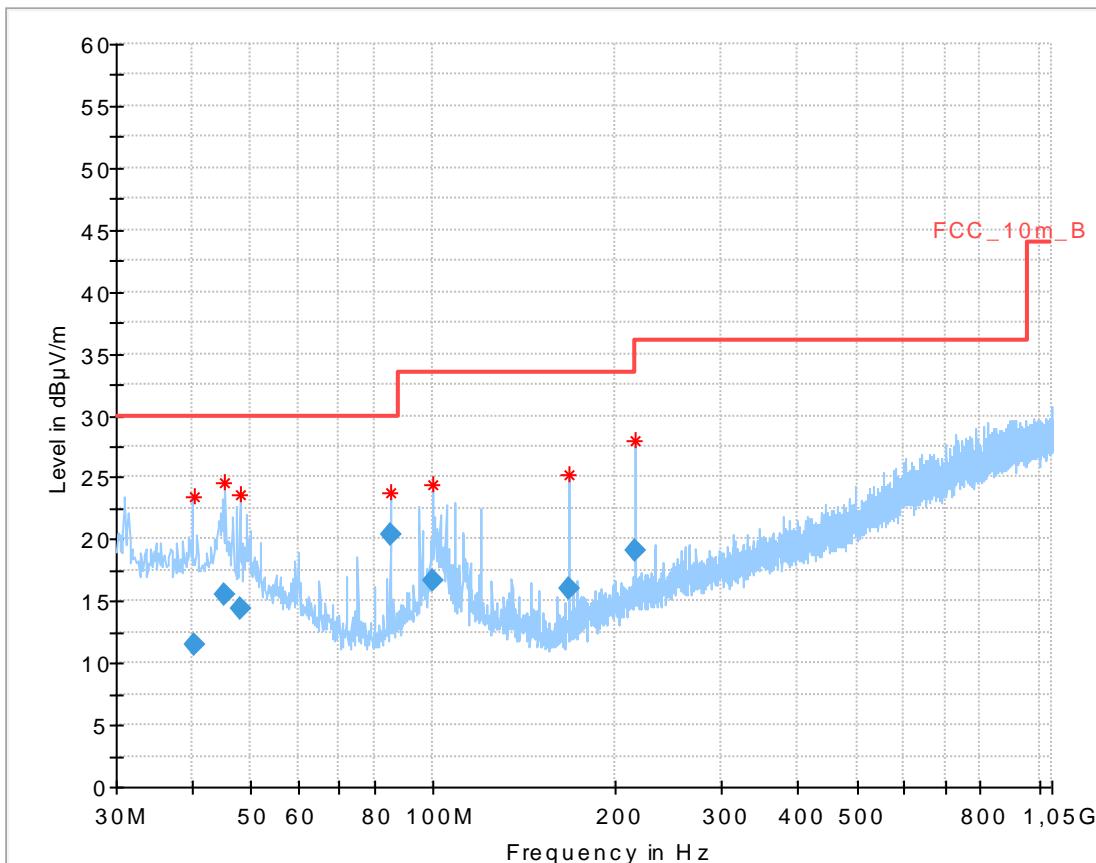
Verdict: Complies

Plot 2: 9 kHz – 30 MHz, test mode



Plot 3: 30 MHz – 1000 MHz, test mode

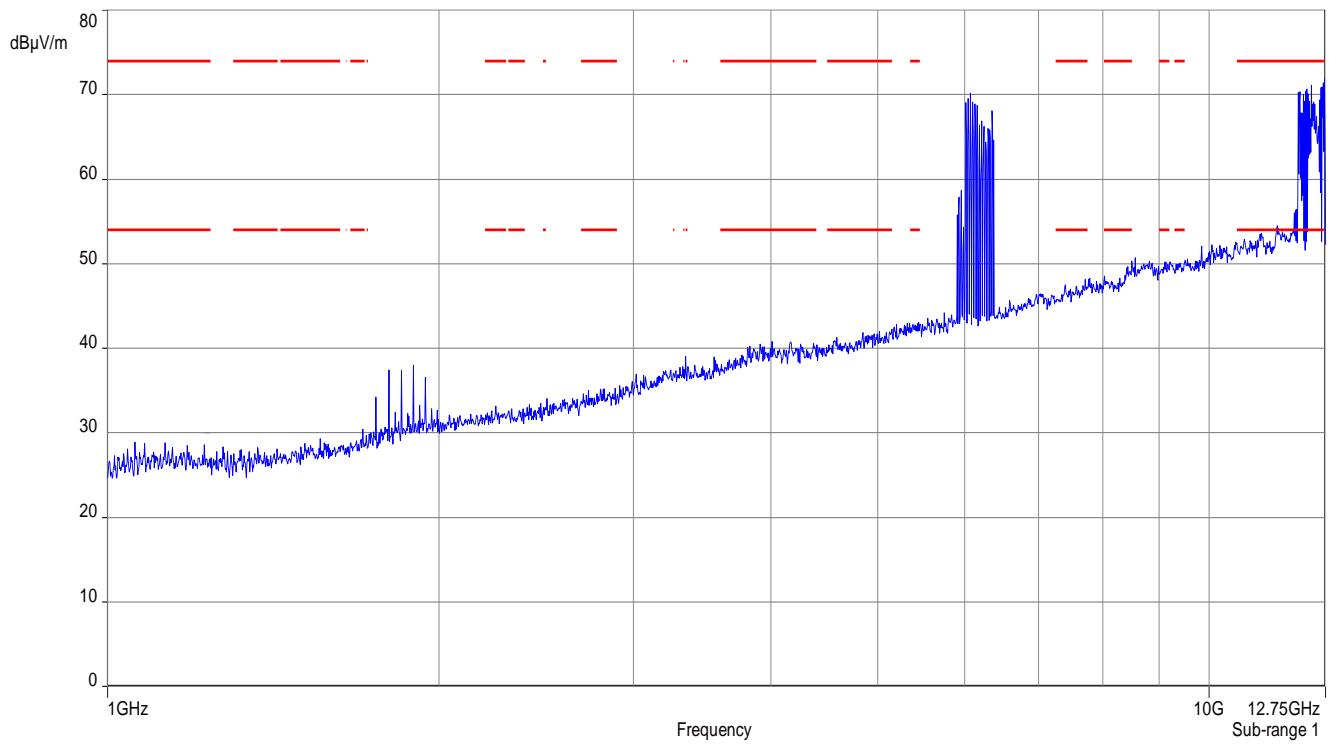
EUT: Level probing radar
 Test description: FCC part 15 class B @ 10 m
 Operating condition: cont. communication via serial port
 Operator name: Hennemann
 Comment: DC powered



Final Result

Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.503150	11.41	30.00	18.59	1000.0	120.000	173.0	V	232.0	14.0
45.109950	15.49	30.00	14.51	1000.0	120.000	103.0	V	213.0	13.8
48.179700	14.32	30.00	15.68	1000.0	120.000	98.0	V	175.0	13.1
84.993300	20.33	30.00	9.67	1000.0	120.000	101.0	V	320.0	9.3
99.955200	16.73	33.50	16.77	1000.0	120.000	101.0	V	7.0	12.2
167.993700	15.97	33.50	17.53	1000.0	120.000	101.0	V	28.0	9.6
215.994900	19.08	33.50	14.42	1000.0	120.000	101.0	V	28.0	12.3

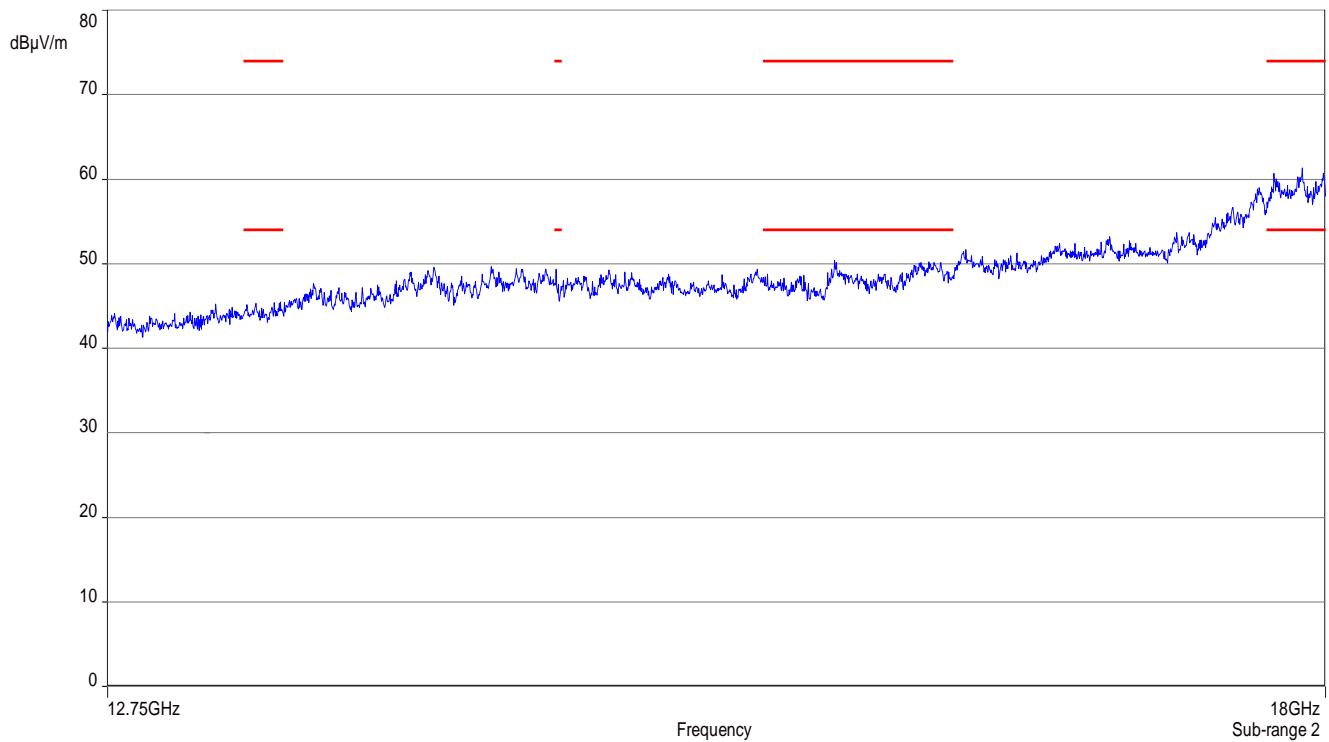
Plot 4: 1 GHz – 12.75 GHz, test mode


Final measurement:

Frequency	Detector	Level	Limit	Remark
5.908 GHz	RMS	66.2 dB μ V	54 dB μ V	test mode
5.908 GHz	RMS	49.2 dBμV	54 dB μ V	normal mode
12.40 GHz	RMS	53.8 dB μ V	54 dB μ V	test mode
12.40 GHz	RMS	36.8 dBμV	54 dB μ V	normal mode

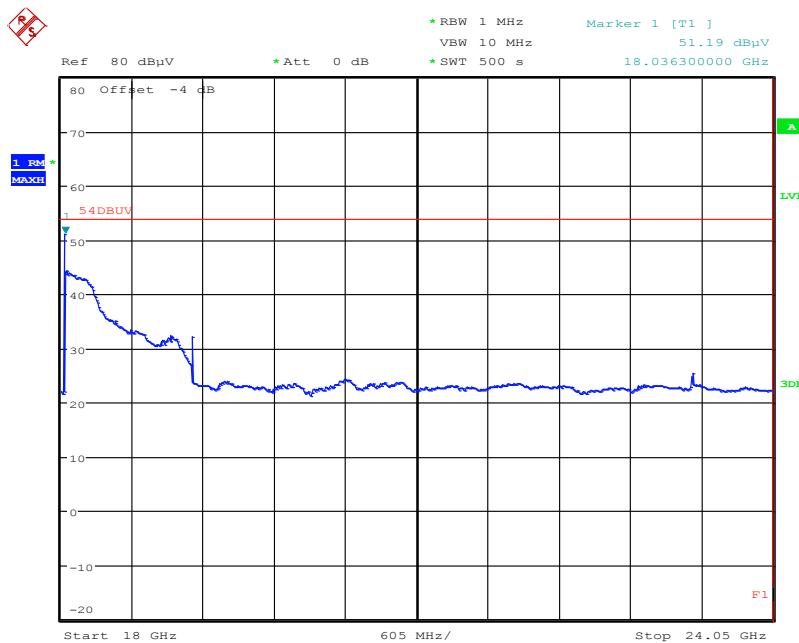
For more information concerning test mode and normal mode see 6.2 Additional information and manufacturer's declaration.

Plot 5: 12.75 GHz – 18 GHz, test mode



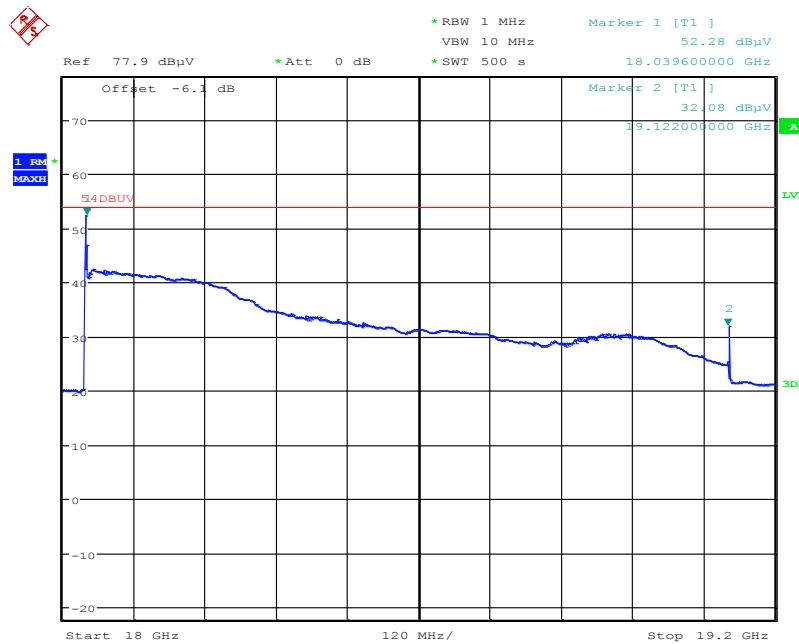
Note: Plot shows problems with dynamic range in the higher frequency range.
Manual re-test in a shorter test distance showed no emissions coming from DUT.

Plot 6: 18 GHz – 24.05 GHz, test mode



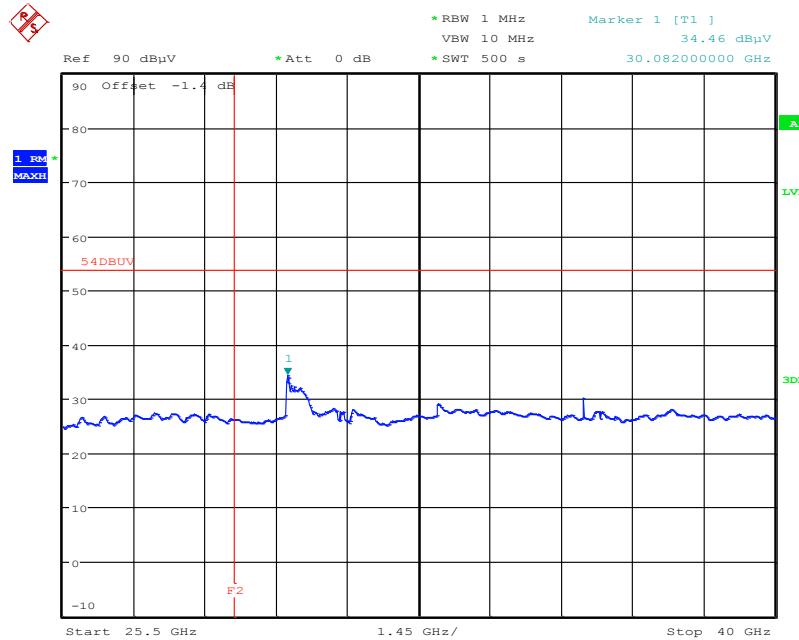
Date: 12.MAY.2016 14:44:15

Plot 7: 18 GHz band, test mode



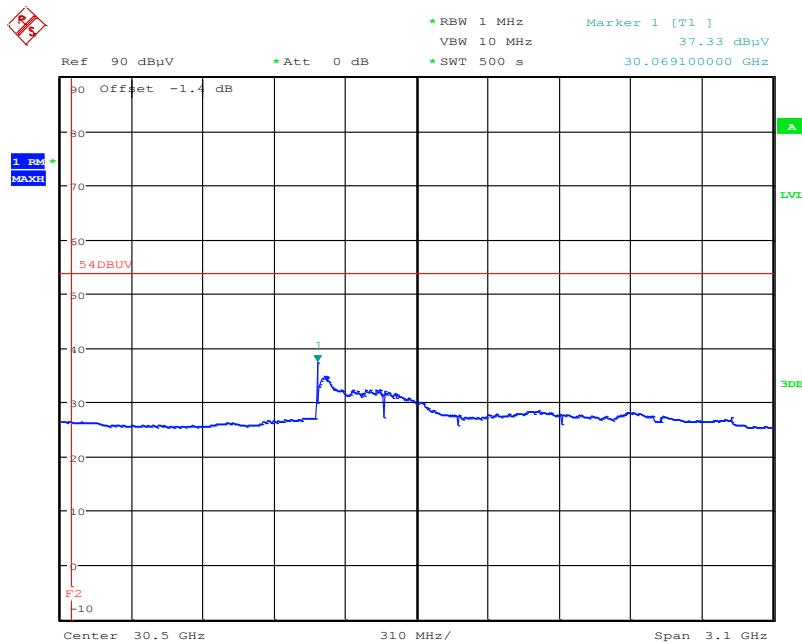
Date: 12.MAY.2016 15:43:59

Plot 8: 25.5 GHz – 40 GHz, test mode

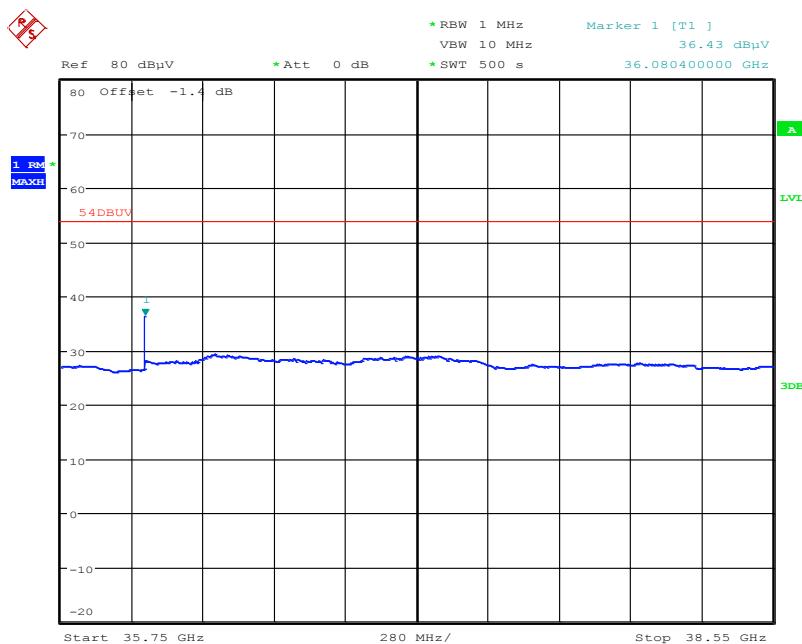


Date: 12.MAY.2016 16:21:27

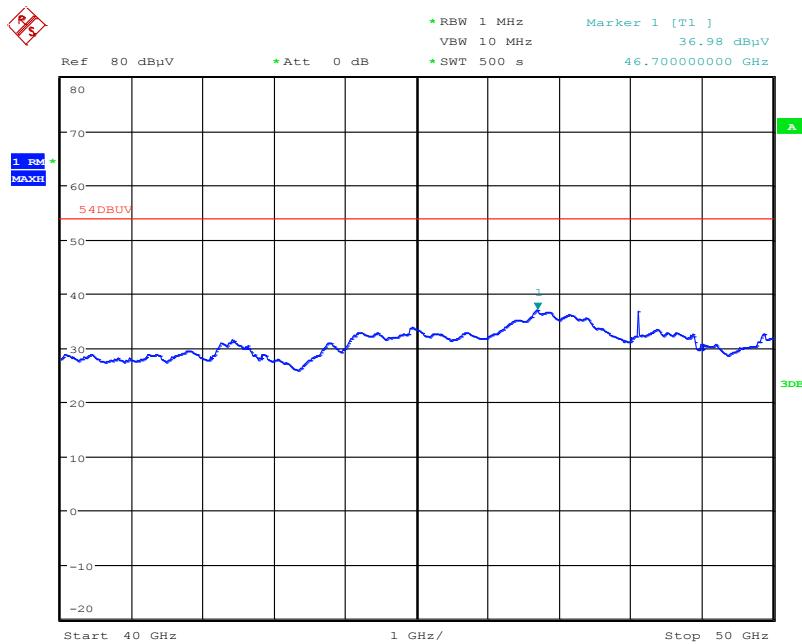
Plot 9: 30 GHz band, test mode



Plot 10: 36 GHz band, test mode

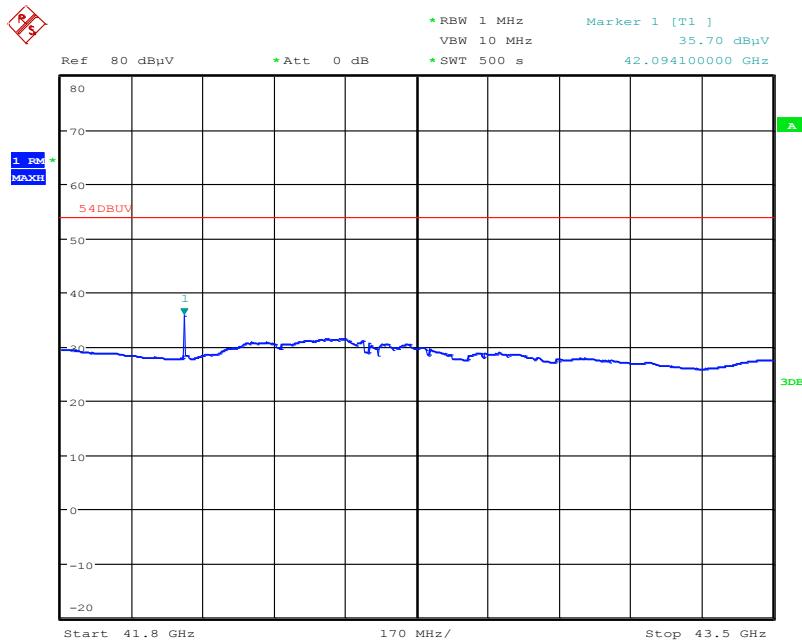


Plot 11: 40 GHz – 50 GHz, test mode



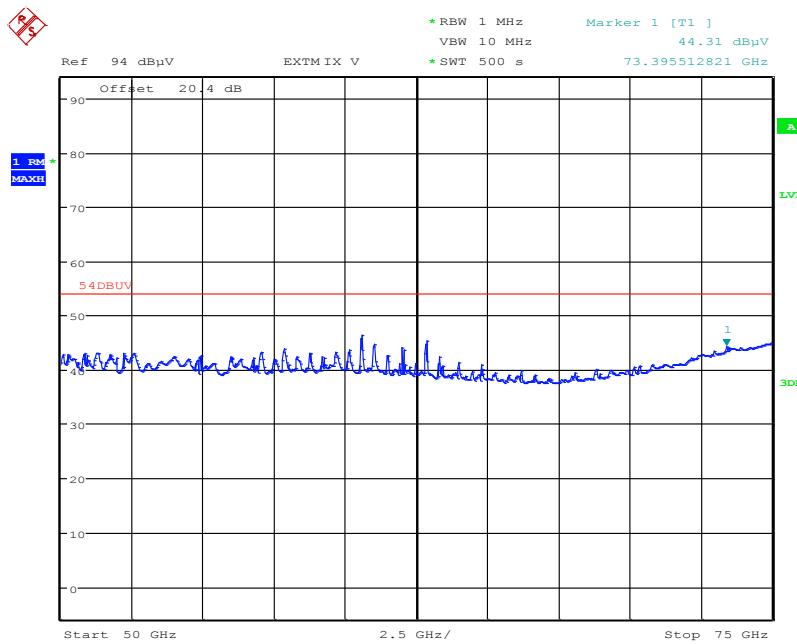
Date: 12.MAY.2016 18:04:07

Plot 12: 42 GHz band, test mode



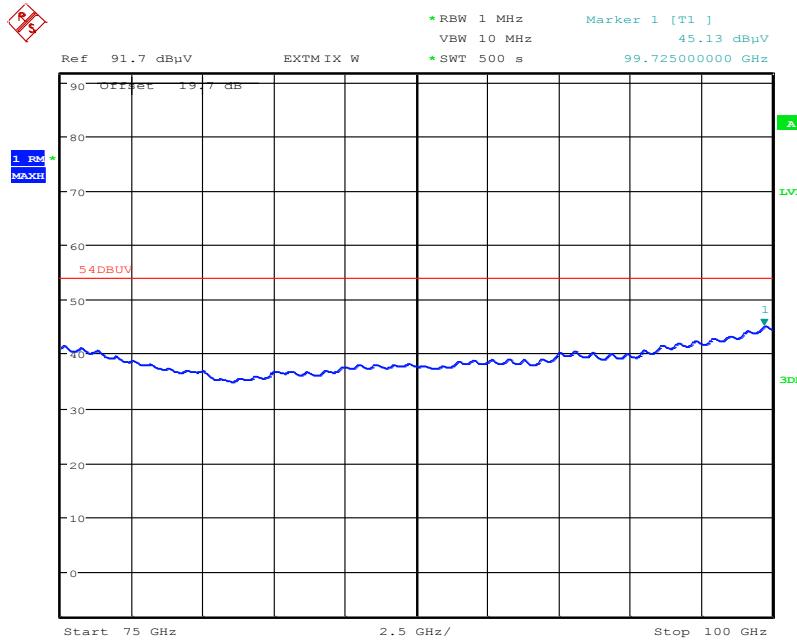
Date: 12.MAY.2016 18:18:56

Plot 13: 50 GHz – 75 GHz, test mode



Date: 25.MAY.2016 13:49:09

Plot 14: 75 GHz – 100 GHz, test mode



Date: 25.MAY.2016 14:21:47

11.4 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
horn antenna	23.7	11.7	< -10 dBi

Note:

See manufacturer's documentation:

RAPPORTO TECNICO, Caratterizzazione di un'antenna di tipo "horn conico ad aperture circolare" in banda Ka
N°doc.:RT/2014/124, Config.: RTW/ANT_MIS14-PRCS-OUT-RT, Rev. 1.0, Pisa, 01/10/2014

Verdict: Complies

11.5 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 (μ V/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 dB μ V/m)	30
30 – 88	100 (40 dB μ V/m)	3
88 – 216	150 (43.5 dB μ V/m)	3
216 – 960	200 (46 dB μ V/m)	3
>960	500 (54 dB μ V/m)	3

Results:

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

Verdict: Complies

11.6 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

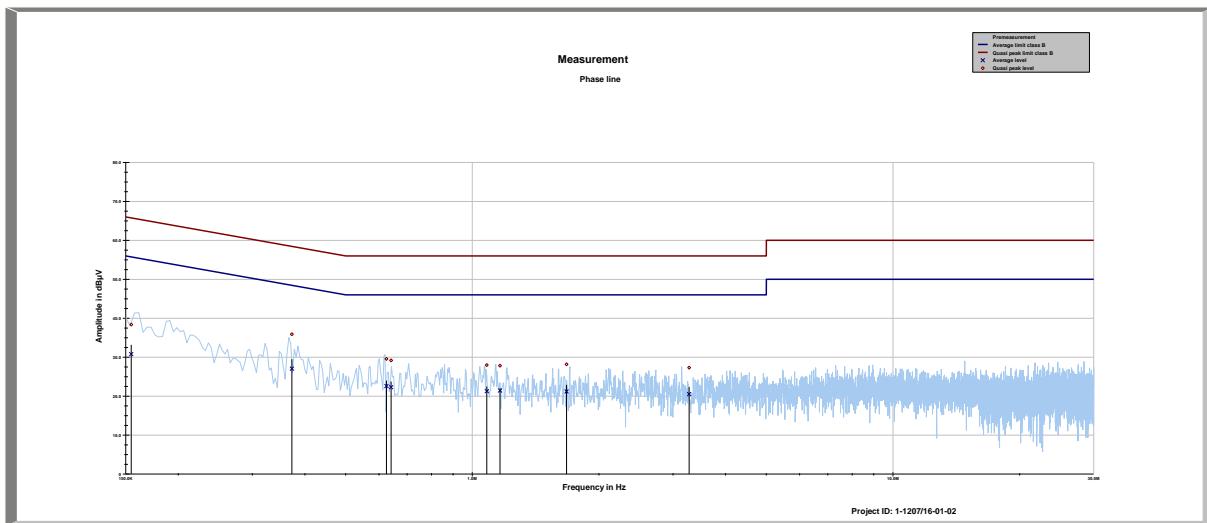
Limits:

FCC §15.107 / §15.207 / RSS-Gen, 8.8		
Conducted limits		
Frequency of Emission (MHz)	Conducted Limit (dB μ V)	
	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 15: Phase line



Phase line tbl

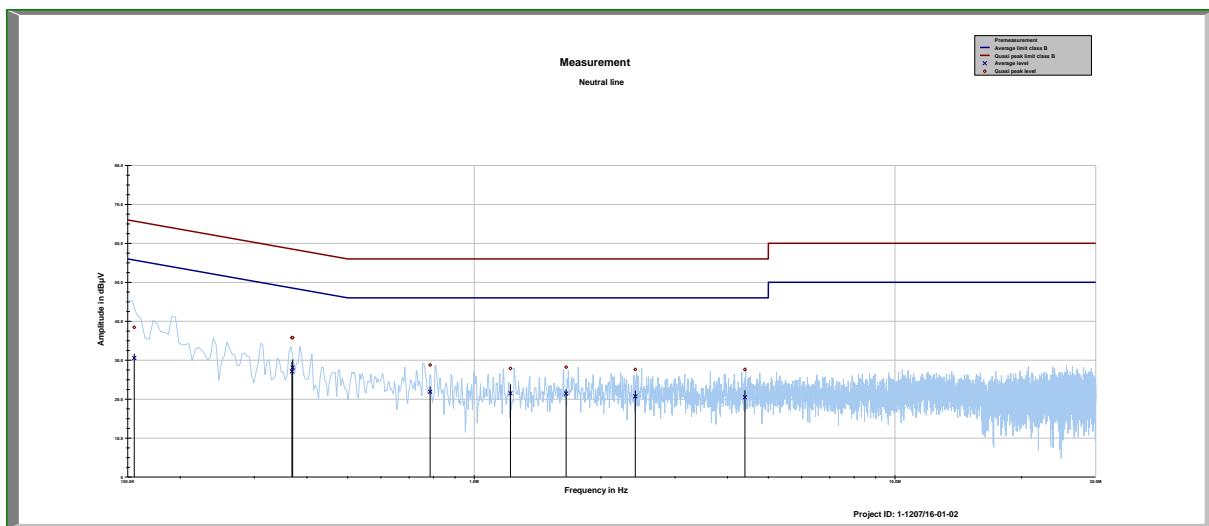
Frequency MHz	Quasi peak level dB μ V	Margin quasi peak dB	Limit QP dB μ V	Average level dB μ V	Margin average dB	Limit AV dB μ V
0.154603	38.37	27.38	65.749	30.78	25.09	55.868
0.372526	35.89	22.56	58.444	27.05	22.59	49.642
0.625107	29.55	26.45	56.000	22.58	23.42	46.000
0.641185	29.16	26.84	56.000	22.29	23.71	46.000
1.082394	27.98	28.02	56.000	21.27	24.73	46.000
1.163966	27.81	28.19	56.000	21.42	24.58	46.000
1.675189	28.18	27.82	56.000	21.19	24.81	46.000
3.276129	27.31	28.69	56.000	20.51	25.49	46.000

Project ID - 1-1207/16-01-02

EUT - Level probing radar

Operating mode – active

Plot 16: Neutral line



Neutral line tbl

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.155464	38.42	27.28	65.703	30.56	25.28	55.844
0.368630	35.77	22.76	58.532	27.11	22.64	49.753
0.369986	35.79	22.71	58.501	28.11	21.60	49.715
0.785437	28.77	27.23	56.000	21.88	24.12	46.000
1.218867	27.88	28.12	56.000	21.50	24.50	46.000
1.653453	28.23	27.77	56.000	21.42	24.58	46.000
2.413505	27.61	28.39	56.000	20.71	25.29	46.000
4.399513	27.60	28.40	56.000	20.50	25.50	46.000

Project ID - 1-1207/16-01-02

EUT - Level probing radar

Operating mode - active

12 Document history

Version	Applied changes	Date of release
DRAFT	Initial release – DRAFT	2016-06-03
	minor editorial changes based on applicant's comments	2026-06-06
-A	applicant's/manufacturer's address corrected	2016-06-07
-B	test setup and sequence of testing corrected	2016-07-05

13 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

14 Accreditation Certificate

Front side of certificate

Back side of certificate



Deutsche Akkreditierungsstelle GmbH

Beelebene gemäß § 8 Absatz 1 AkkStelleG i.V.m. § 1 Absatz 1 AkkStelleGBV
Unterzeichnerin der Multilateralen Abkommen
von EA, ILAC und IAF zur gegenseitigen Anerkennung

Akkreditierung 

Die Deutsche Akkreditierungsstelle GmbH bestätigt hiermit, dass das Prüflaboratorium
CETECOM ICT Services GmbH
Untertürkheimer Straße 6-10, 66117 Saarbrücken

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

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

Die Akkreditierungsurkunde gilt nur in Verbindung mit dem Bescheid vom 04.05.2016 mit der
Akkreditierungsnummer D-PL-12076-01 und ist gültig bis 17.01.2018. Sie besteht aus diesem Deckblatt,
der Rückseite des Deckblatts und der folgenden Anlage mit insgesamt 63 Seiten.

Registrierungsnummer der Urkunde: D-PL-12076-01-01

Frankfurt, 04.05.2016

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

Abteilungsleiter

Deutsche Akkreditierungsstelle GmbH

Standort Berlin
Spittelmarkt 10
10117 Berlin

Standort Frankfurt am Main
Europa-Allee 52
60327 Frankfurt am Main

Standort Braunschweig
Bundesallee 100
38116 Braunschweig

Die auszugsweise Veröffentlichung der Akkreditierungsurkunde bedarf der vorherigen schriftlichen
Zustimmung der Deutsche Akkreditierungsstelle GmbH (DAkkS). Ausgenommen davon ist die separate
Weiterverbreitung des Deckblattes durch die umseitig genannte Konformitätsbewertungsstelle in
unveränderter Form.

Es darf nicht der Anschein erweckt werden, dass sich die Akkreditierung auch auf Bereiche erstreckt,
die über den durch die DAkkS bestätigten Akkreditierungsbereich hinausgehen.

Die Akkreditierung erfolgte gemäß des Gesetzes über die Akkreditierungsstellen (AkkStelleG) vom
31. Juli 2000 (BGBl. I S. 2029) sowie die Verordnung (EG) Nr. 765/2008 des Europäischen Parlaments
und des Rates vom 9. Juli 2008 über die Anforderungen für die Akkreditierung und Marktüberwachung
im Zusammenhang mit der Vermarktung von Produkten (Abl. L 221 vom 9. Juli 2008, S. 30).
Die DAkkS ist Unterzeichnerin der Multilateralen Abkommen zur gegenseitigen Anerkennung der
European co-operation for Accreditation (EA), des International Accreditation Forum (IAF) und
der International Laboratory Accreditation Cooperation (ILAC). Die Unterzeichner dieser Abkommen
erkennen ihre Akkreditierungen gegenseitig an.

Der aktuelle Stand der Mitgliedschaft kann folgenden Webseiten entnommen werden:
EA: www.european-accreditation.org
ILAC: www.ilac.org
IAF: www.iaf.nu

Note:

The current certificate including annex may be received from CETECOM ICT Services on request.