Report No. 299696-1

Test Report

Product	Boat Unit for Engine Cut-Off Device
Name and address of the applicant	Fell AS Nedre Storgate 46, 3015 Drammen Norway
Name and address of the manufacturer	Same as above
Model	BU90115
Rating	12V DC and 24V DC
Trademark	WiMEA
Serial number	/
Additional information	Low power Device
Tested according to	**FCC Part 15.247** Digital Transmission Systems **Industry Canada RSS-247, Issue 1** Low Power Licence-Exempt Radiocommunications Devices
Order number	299696
Tested in period	2015.12.09 and 2016.01.04
Issue date	2016.02.23
Name and address of the testing laboratory	Instituttveien 6 Kjeller, Norway FCC No: 994405 IC OATS: 2040D-1 TEL: +47 22 96 03 30 FAX: +47 22 96 05 50

Prepared by [Frode Sveinsen]	Approved by [G.Suhanthakumar]

Template version: B

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1 INFORMATION

1.1 Test Item

Name :	WiMEA
FCC ID :	2AFOZBU90115
Industry Canada ID :	20622-BU90115
Model/version :	BU90115
Serial number :	/
Hardware identity and/or version:	1.0
Software identity and/or version :	1.0
Frequency Range :	906.5 – 922.5 MHz
Number of Channels :	5
Channel Separation :	4 MHz
Type of Modulation :	2-GFSK
User Frequency Adjustment :	None
Rated Output Power :	0.0119
Type of Power Supply :	12-24V DC (Powered from boat battery)
Number of Antennas :	2
Antenna Connector :	Reversed SMA and Internal Antenna
Antenna Diversity Supported :	Yes

Description of Test Item

The EUT is a Boat Unit for an Engine Cut-Off device for recreational crafts. The EUT is continuously polling the Mobile Unit when the engine is operating, if the reply from the Mobile Unit is lost the Boat Unit will stop the engine.

Exposure Evaluation

The EUT is designed to be fixed to the engine and the user manual contains text that it shall be mounted with a separation distance of at least 20 cm from any humans. For the purposes of exposure evaluation this EUT is a mobile or fixed device. MPE Calculation at 20 cm satisfying FCC requirements is submitted as a separate document.

The EUT is exempted from RF Exposure Evaluation to Industry Canada requirements since the output power complies with the power levels of section 2.5.2 of RSS-102 Issue 5.

1.2 Test Environment

1.2.1 Normal test condition

Temperature:	21.1 – 21.8 °C
Relative humidity:	20 – 41 %
Normal test voltage:	13.8 V DC

The values are the limit registered during the test period.

1.3 Test Engineer(s)

Frode Sveinsen / Tore Løvlien

1.4 Test Equipment

See list of test equipment in clause 5.

2 TEST REPORT SUMMARY

2.1 General

All measurements are tracable to national standards.

The tests were conducted for the purpose of demonstrating compliance with FCC CFR 47 Part 15C and Industry Canada RSS-247 Issue 1.

Tests were performed in accordance with ANSI C63.4-2014 and and ANSI C63.10-2013.

Radiated tests were made in a semi-anechoic chamber at measuring distances of 3m and 10m.

A description of the test facility is on file with the FCC and Industry Canada.

☒ New Submission	☒ Production Unit
☐ Class II Permissive Change	☐ Pre-production Unit
DTS Equipment Code	☐ Family Listing

THIS TEST REPORT APPLIES ONLY TO THE ITEM(S) AND CONFIGURATIONS TESTED.

Deviations from, additions to, or exclusions from the test specifications are described in “Summary of Test Data”.

2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 1, RSS-GEN Issue 4 reference	Result
Supply Voltage Variations	15.31(e)	6.11 (RSS-GEN)	Complies
Antenna Requirement	15.203	8.3 (RSS-GEN)	Complies
Power Line Conducted Emission	15.107(a) 15.207(a)	8.8 (RSS-GEN)	Complies
Occupied Bandwidth	N/A	6.6 (RSS-GEN)	Complies
Minimum 6 dB Bandwidth	15.247(a)(2)	5.2 (1) (RSS-247)	Complies
Peak Power Output	15.247(b)	5.4 (RSS-247)	Complies
Power Spectral Density	15.247(d)	5.2 (2) (RSS-247)	Complies
Spurious Emissions (Antenna Conducted)	15.247(c)	5.5 (RSS-247)	Complies
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	5.5 (RSS-247) 6.13 (RSS-GEN) 8.9 (RSS-GEN)	Complies

2.3 Description of modification for Modification Filing

Not applicable.

2.4 Comments

The measurements were done with the EUT powered by 13.8 V DC. It was checked that power variations between 85% and 115% of the nominal voltages (12 - 24 V DC) did not have any influence on the measurements.

All ports were populated during spurious emission measurements.

2.5 Family List Rational

Not Applicable.

3 TEST RESULTS

3.1 Power Line Conducted Emissions

Para. No.: 15.207 (a)

Test Performed By: Tore Løvlien	**Date of Test: 9-Dec-2015**

Measurement procedure:	**ANSI C63.4-2014 using 50 µH/50 ohms LISN.**
Test Results:	**Complies.**
Measurement Data:	**See attached graph, (Peak detector).**

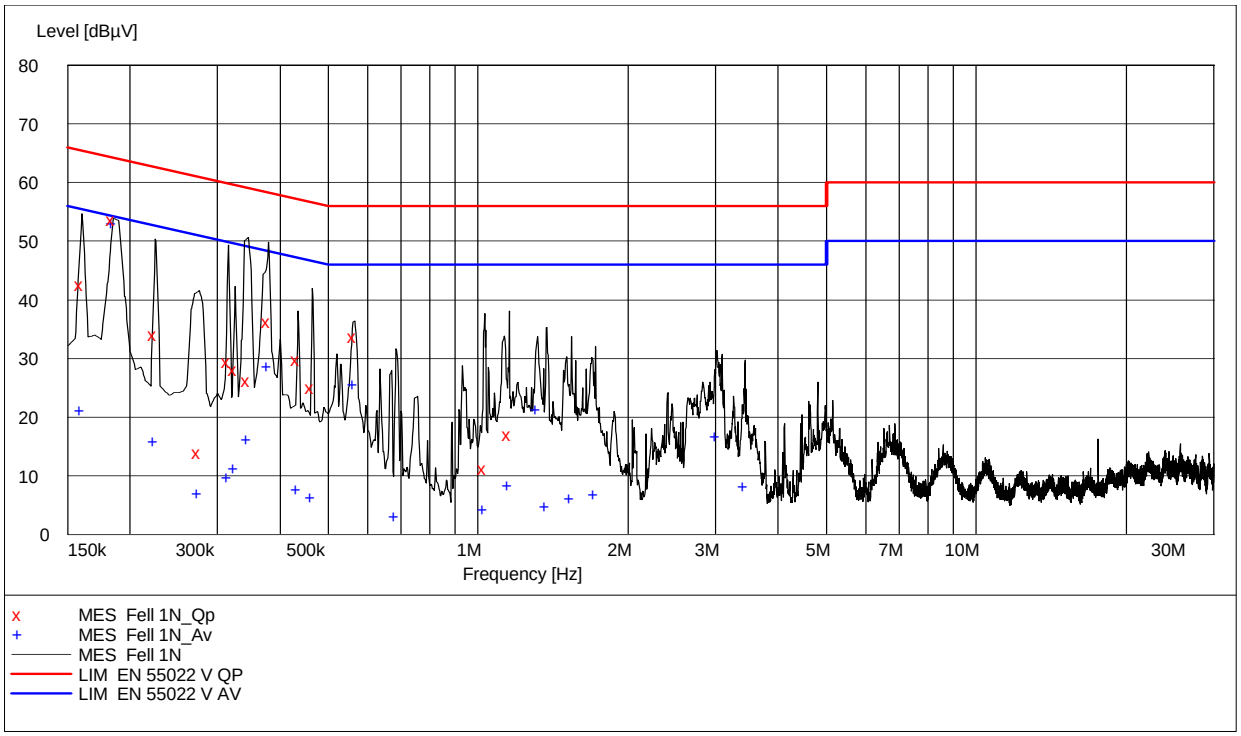
Highest measured value (L1 and N):

13.8 V DC:

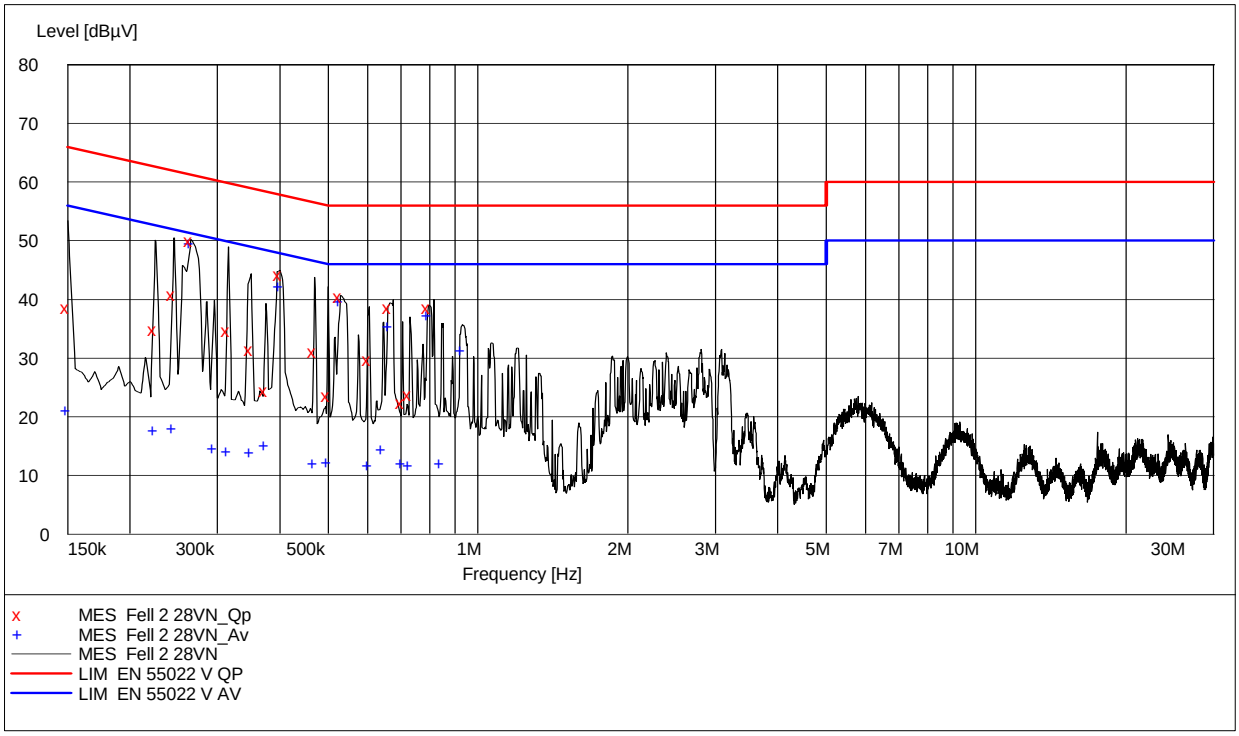
Frequency [MHz]	Level [dBuV]	Af [dB]	Limit [dBuV]	Margin [dB]	Det	Position	Verdict [Pass/Fail]
0.160000	42.60	10.70	65.50	22.90	QP	L1	Pass
0.185000	53.80	10.70	64.30	10.50	QP	L1	Pass
0.225000	34.10	10.70	62.60	28.50	QP	L1	Pass
0.275000	14.10	10.60	61.00	46.90	QP	N	Pass
0.315000	29.60	10.50	59.80	30.20	QP	N	Pass
0.325000	28.20	10.50	59.60	31.40	QP	L1	Pass
0.345000	26.20	10.40	59.10	32.90	QP	N	Pass
0.380000	36.40	10.40	58.30	21.90	QP	N	Pass
0.435000	29.90	10.30	57.20	27.30	QP	L1	Pass
0.465000	25.10	10.30	56.60	31.50	QP	L1	Pass
0.565000	33.80	10.20	56.00	22.20	QP	L1	Pass
1.030000	11.20	10.40	56.00	44.80	QP	N	Pass
1.155000	17.20	10.40	56.00	38.80	QP	N	Pass
0.160000	21.20	10.70	55.50	34.30	AV	L1	Pass
0.185000	53.10	10.70	54.30	1.20	AV	L1	Pass
0.225000	15.90	10.70	52.60	36.70	AV	L1	Pass
0.275000	7.00	10.60	51.00	44.00	AV	N	Pass
0.315000	9.70	10.50	49.80	40.10	AV	N	Pass
0.325000	11.30	10.50	49.60	38.30	AV	L1	Pass
0.345000	16.20	10.40	49.10	32.90	AV	N	Pass
0.380000	28.70	10.40	48.30	19.60	AV	N	Pass
0.435000	7.80	10.30	47.20	39.40	AV	L1	Pass
0.465000	6.30	10.30	46.60	40.30	AV	L1	Pass
0.565000	25.60	10.20	46.00	20.40	AV	L1	Pass
0.685000	3.00	10.20	46.00	43.00	AV	N	Pass
1.030000	4.30	10.40	46.00	41.70	AV	N	Pass
1.155000	8.30	10.40	46.00	37.70	AV	N	Pass
1.315000	21.30	10.40	46.00	24.70	AV	L1	Pass
1.375000	4.80	10.40	46.00	41.20	AV	N	Pass
1.540000	6.20	10.40	46.00	39.80	AV	N	Pass
1.720000	6.80	10.40	46.00	39.20	AV	N	Pass
3.015000	16.80	10.40	46.00	29.20	AV	L1	Pass
3.435000	8.20	10.40	46.00	37.80	AV	N	Pass

28.0 V DC:

Frequency [MHz]	Level [dBuV]	Af [dB]	Limit [dBuV]	Margin [dB]	Det	Position	Verdict [Pass/Fail]
0.150000	38.70	10.70	66.00	27.30	QP	L1	Pass
0.225000	34.90	10.70	62.60	27.70	QP	L1	Pass
0.245000	40.90	10.60	61.90	21.00	QP	N	Pass
0.265000	50.10	10.60	61.30	11.20	QP	N	Pass
0.315000	34.70	10.50	59.80	25.10	QP	N	Pass
0.350000	31.50	10.40	59.00	27.50	QP	L1	Pass
0.375000	24.50	10.40	58.40	33.90	QP	L1	Pass
0.400000	44.20	10.40	57.90	13.70	QP	N	Pass
0.470000	31.20	10.30	56.50	25.30	QP	L1	Pass
0.500000	23.70	10.20	56.00	32.30	QP	N	Pass
0.530000	40.50	10.20	56.00	15.50	QP	L1	Pass
0.605000	29.80	10.20	56.00	26.20	QP	L1	Pass
0.665000	38.60	10.20	56.00	17.40	QP	N	Pass
0.705000	22.40	10.20	56.00	33.60	QP	L1	Pass
0.730000	23.80	10.20	56.00	32.20	QP	N	Pass
0.795000	38.60	10.20	56.00	17.40	QP	L1	Pass
0.150000	21.10	10.70	56.00	34.90	AV	L1	Pass
0.225000	17.70	10.70	52.60	34.90	AV	L1	Pass
0.245000	18.00	10.60	51.90	33.90	AV	N	Pass
0.265000	49.50	10.60	51.30	1.80	AV	N	Pass
0.295000	14.70	10.50	50.40	35.70	AV	L1	Pass
0.315000	14.00	10.50	49.80	35.80	AV	N	Pass
0.350000	13.90	10.40	49.00	35.10	AV	L1	Pass
0.375000	15.10	10.40	48.40	33.30	AV	L1	Pass
0.400000	42.30	10.40	47.90	5.60	AV	N	Pass
0.470000	12.00	10.30	46.50	34.50	AV	L1	Pass
0.500000	12.30	10.20	46.00	33.70	AV	N	Pass
0.530000	39.70	10.20	46.00	6.30	AV	L1	Pass
0.605000	11.70	10.20	46.00	34.30	AV	L1	Pass
0.645000	14.40	10.20	46.00	31.60	AV	L1	Pass
0.665000	35.50	10.20	46.00	10.50	AV	N	Pass
0.705000	12.10	10.20	46.00	33.90	AV	L1	Pass
0.730000	11.70	10.20	46.00	34.30	AV	N	Pass
0.795000	37.30	10.20	46.00	8.70	AV	L1	Pass
0.845000	12.10	10.30	46.00	33.90	AV	N	Pass
0.930000	31.40	10.30	46.00	14.60	AV	L1	Pass



13.8 V DC



28.0 V DC

3.2 Occupied Bandwidth

Para. No.: 15.247 (a)(1)(iii)

Test Results: Complies

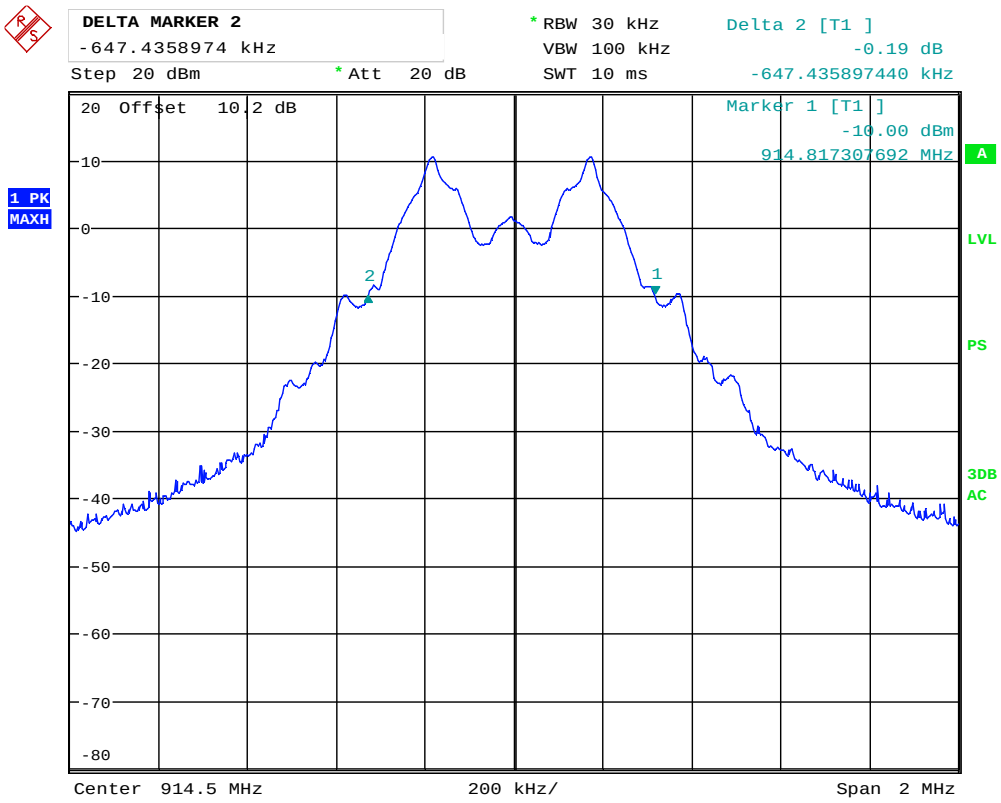
Measurement Data:

20 dB BW Measured on Centre Channel 914.5 MHz	647 kHz

See attached plots.

Requirements:

No requirement for 20 dB BW, reported for information only.



Date: 4.JAN.2016 17:01:06

20 dB Bandwidth

3.3 Minimum 6 dB Bandwidth

Para. No.: 15.247 (a)(2)

Test Results: Complies

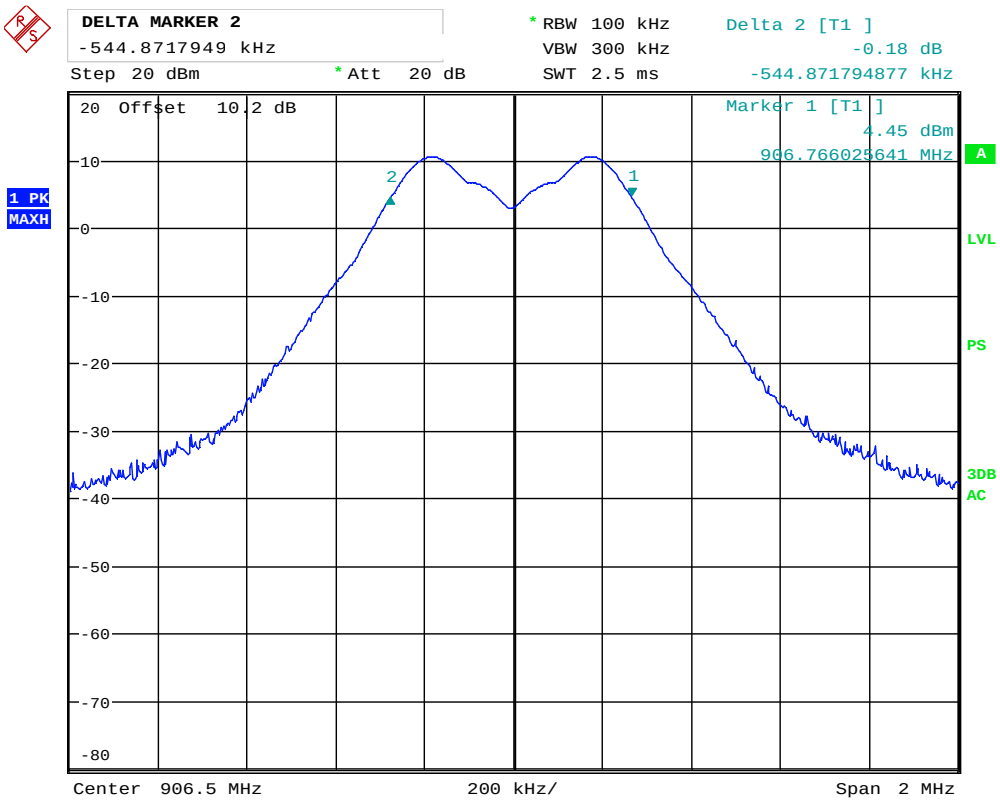
Measurement Data:

Measured 6 dB Bandwidth (kHz)		
906.5 MHz	**914.5 MHz**	**922.5 MHz**
544	548	554

Power supply variation within 85 % to 115% of nominal value has no influence on measured value.

Requirements:

For Digital Transmission Systems in the 902 - 928 MHz band the minimum 6 dB bandwidth shall be at least 500 KHz.



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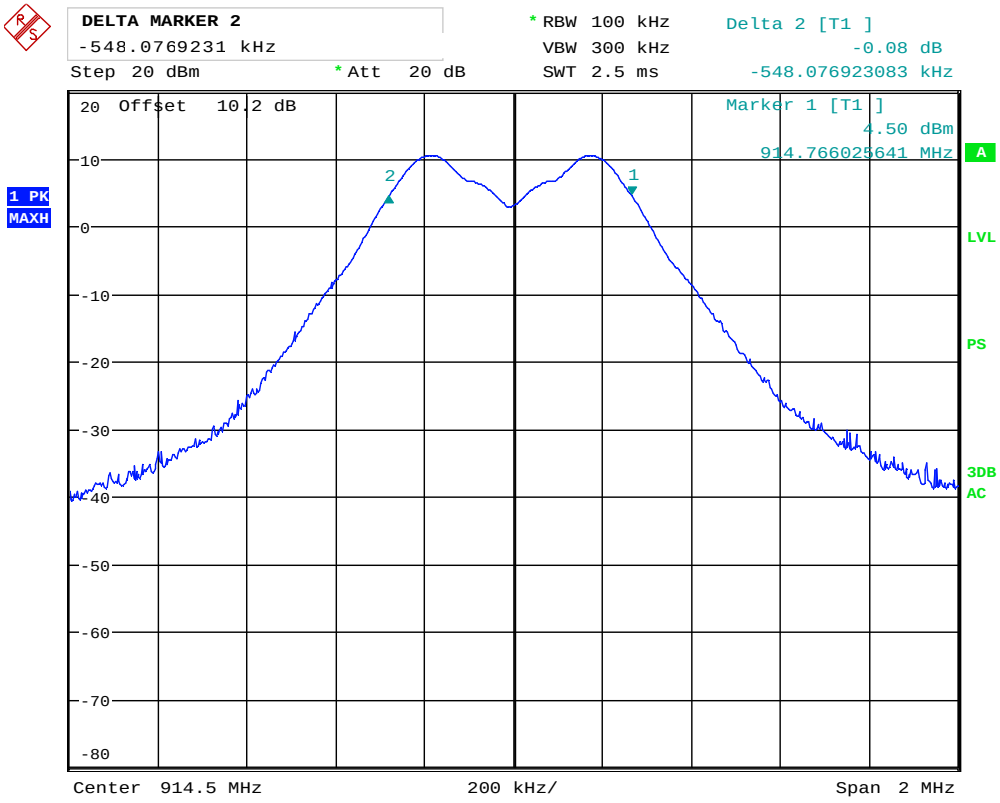
Minimum 6 dB Bandwidth, 906.5 MHz



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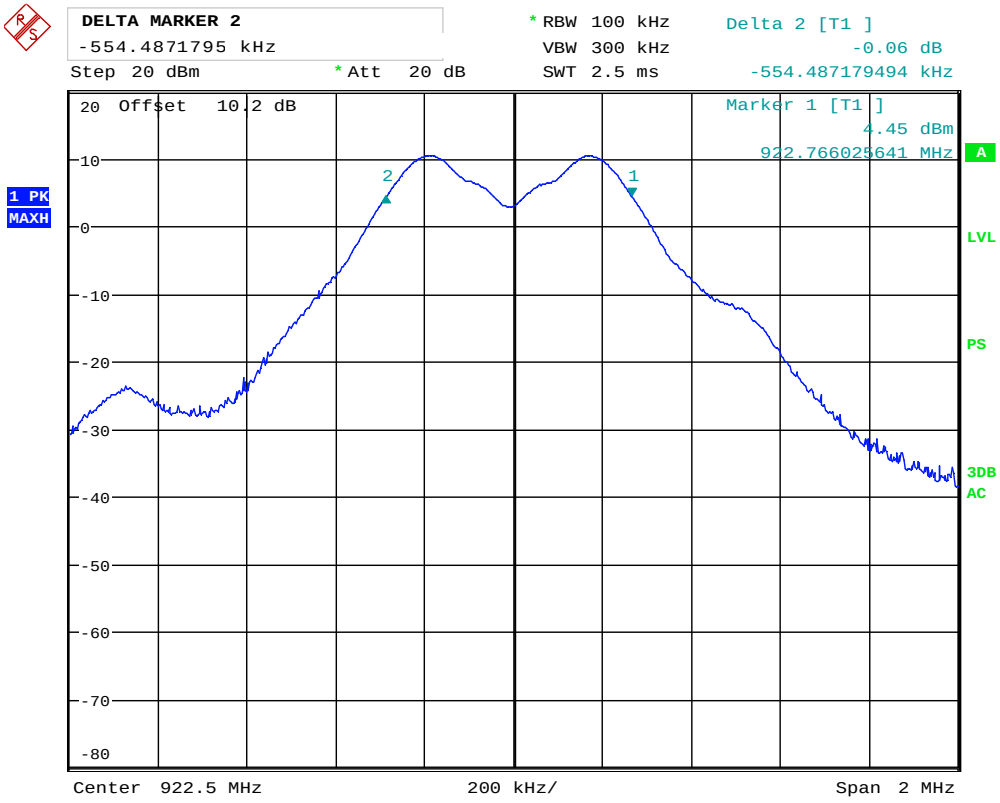
Minimum 6 dB Bandwidth, 914.5 MHz



Date: 4.JAN.2016 16:54:51

Minimum 6 dB Bandwidth, 922.5 MHz

3.4 Peak Power Output

Para. No.: 15.247 (b)

Test Results: Complies

Measurement Data:

	906.5 MHz	914.5 MHz	922.5 MHz
Conducted Power (dBm)	10.8	10.8	10.7
Conducted Power (mW)	11.9	11.9	11.7
Field Strength (dBµV/m)	110.4	110.1	109.7
EIRP, Calculated (mW)	32.5	30.4	27.8
Antenna gain (dBi)	4.4	4.1	3.8

Antenna gain = 10*log(EIRP/Conducted power) dBi

EIRP is calculated from measured field strength by the formulas in KDB 412172 D01 Determining ERP and EIRP v01.

See attached graph.

Detachable antenna? ☒ Yes ☐ No

If detachable, is the antenna connector non-standard? ☒ Yes ☐ No

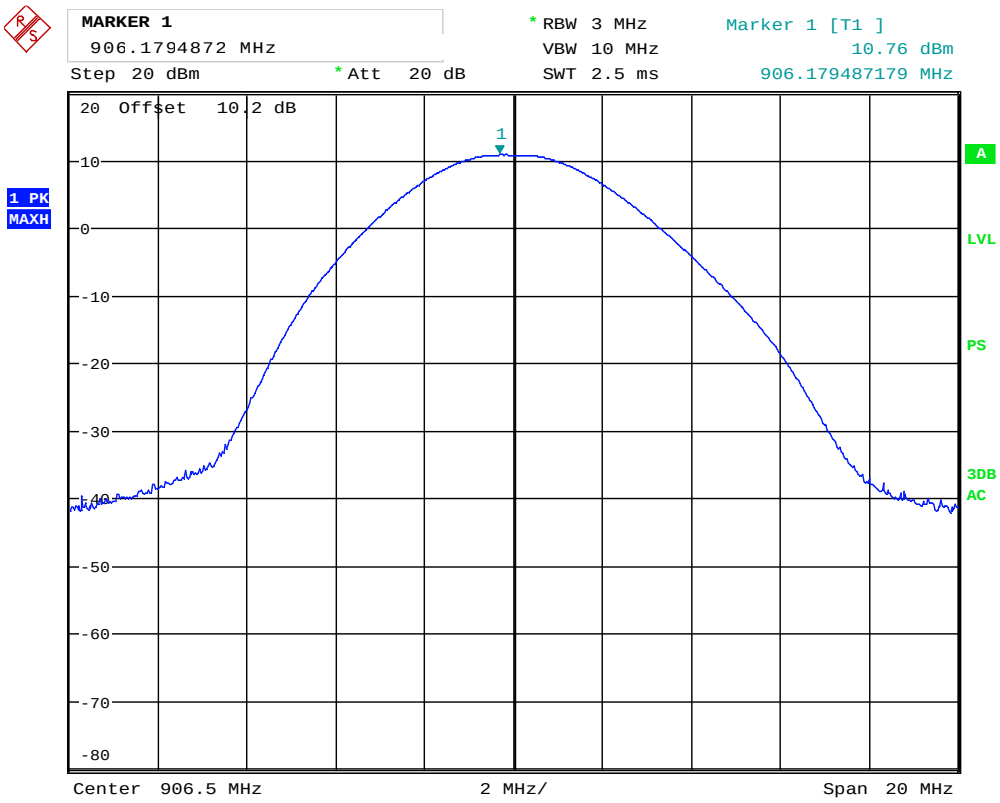
Type of antenna connector: Reverse SMA

Requirements:

The maximum peak output power shall not exceed the following limits:

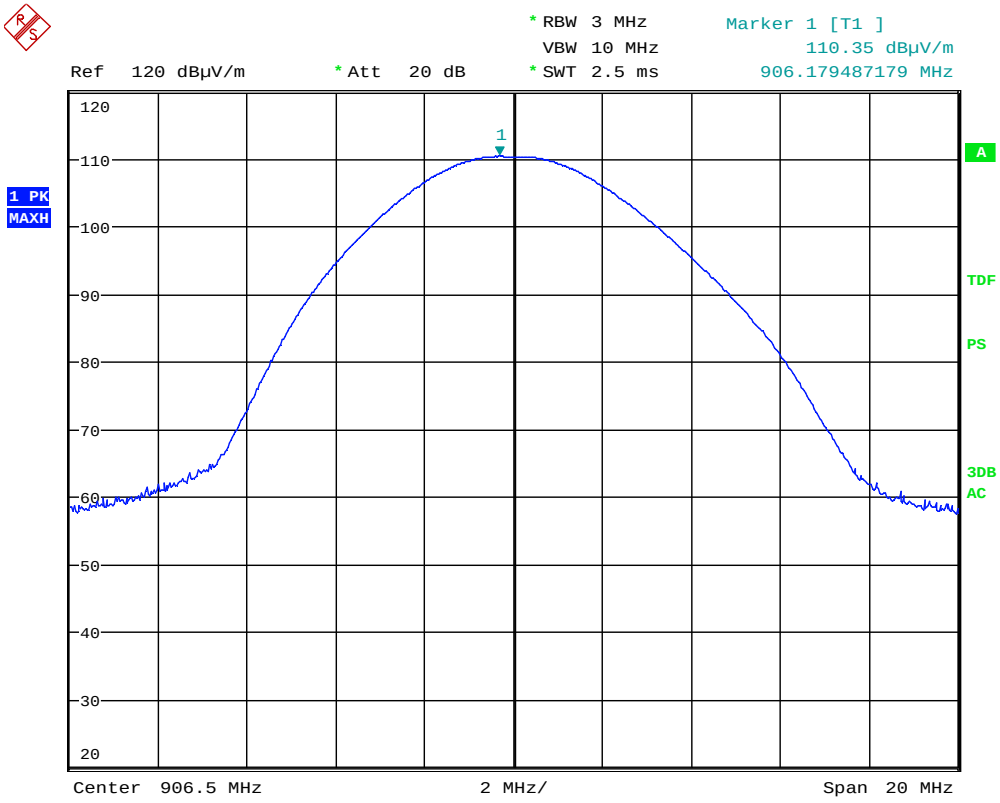
For Digital Transmission Systems in the 902 - 928 MHz band: 1 Watt

If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.



Date: 4.JAN.2016 16:52:39

Conducted Power, 906.5 MHz



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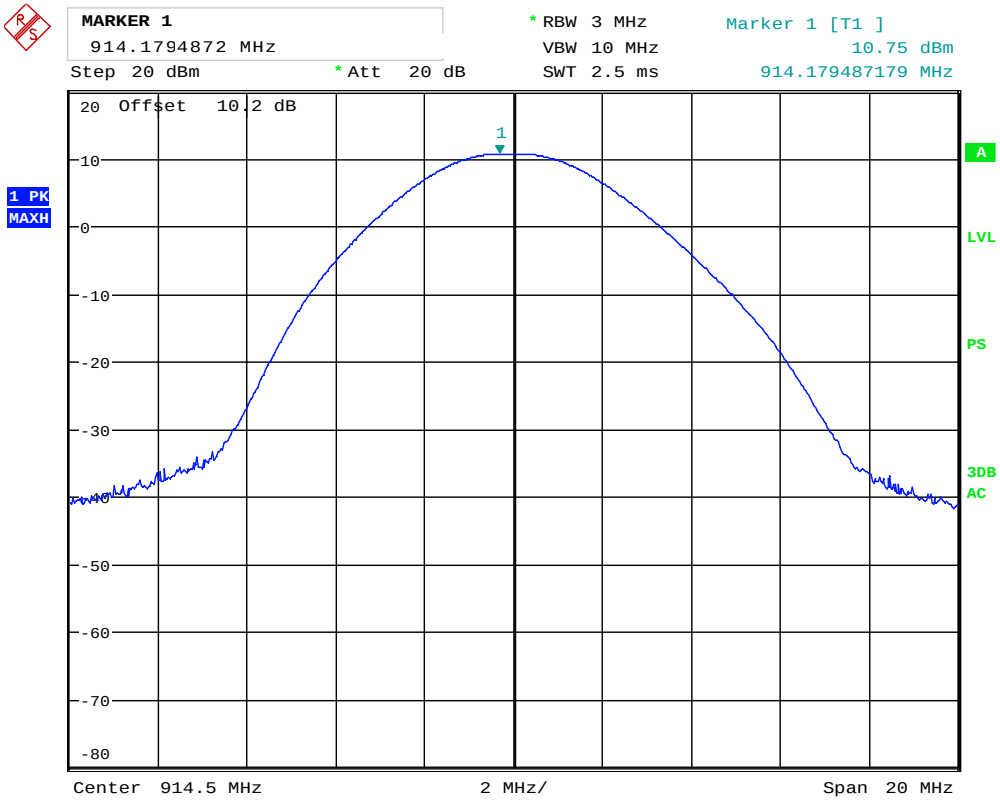
Radiated Power, 906.5 MHz (Ext. Ant, HP)



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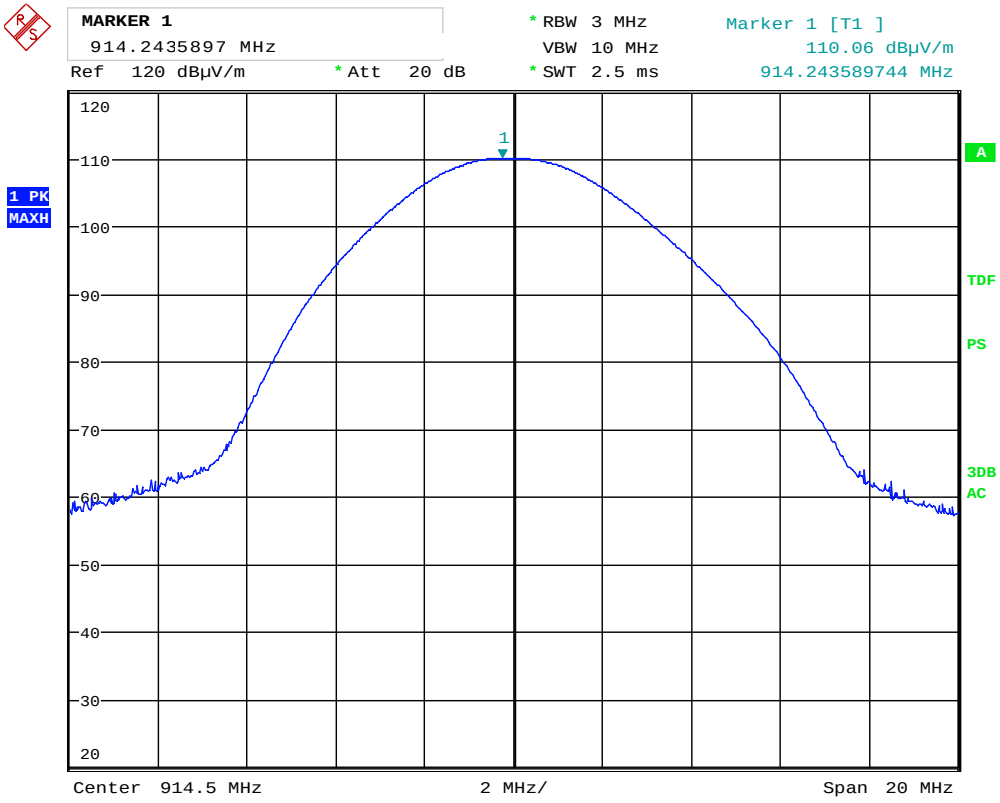
Conducted Power, 914.5 MHz



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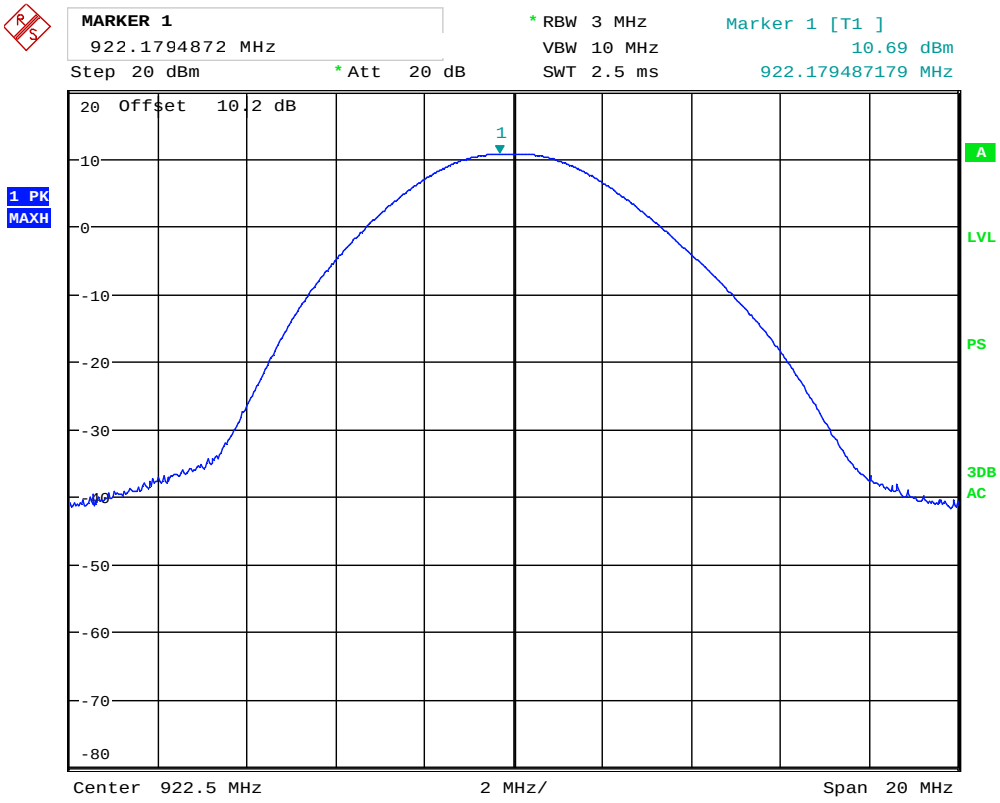
Radiated Power, 914.5 MHz (Ext. Ant, HP)



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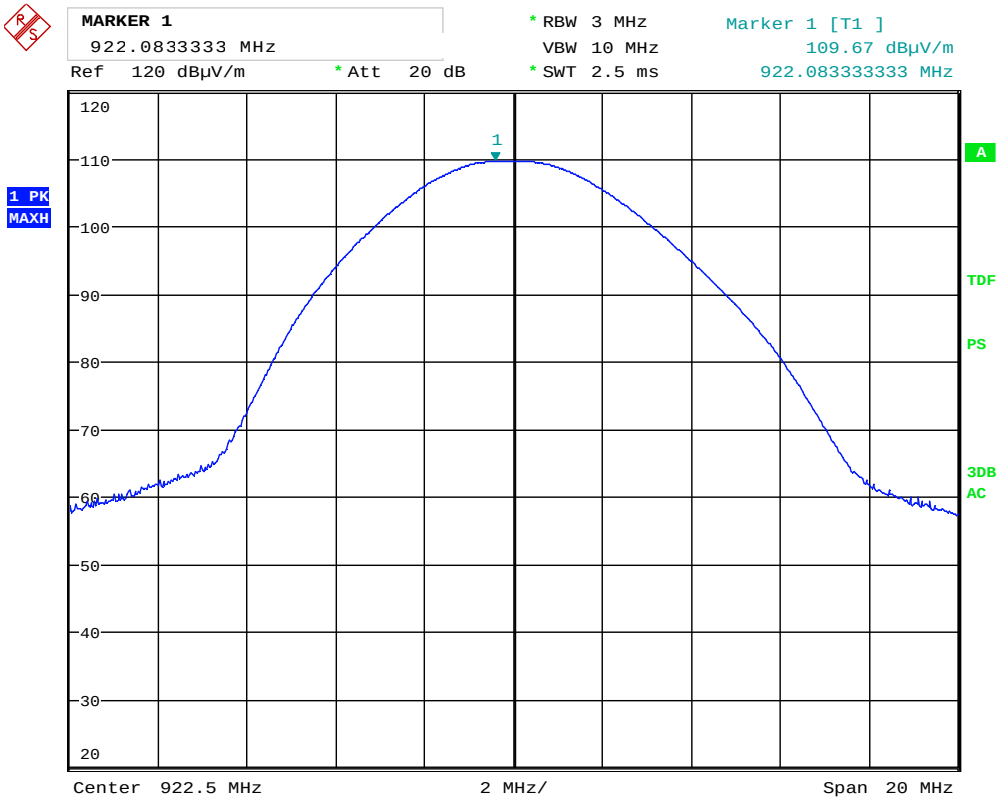
Conducted Power, 922.5 MHz



Radiated Power, 922.5 MHz (Ext. Ant, HP)

3.5 Spurious Emissions (Radiated)

Para. No.: 15.247 (c)

Test Results: Complies

Measurement Data:

Band-edge radiated power

Frequency	Measured field strength (dBµV/m) Peak Detector	Limit dBµV/m	Margin dB
614 MHz	< 30	46	>16
960 MHz	< 40	54	>14

See attached plots.

Duty Cycle Correction Factor Calculation:

Duty Cycle = slot length / frame length

Duty Cycle Correction factor = -20 x log(1.8%) = 34.9 dB

Maximum Duty Cycle Correction Factor according to Para 15.35 (b): 20 dB

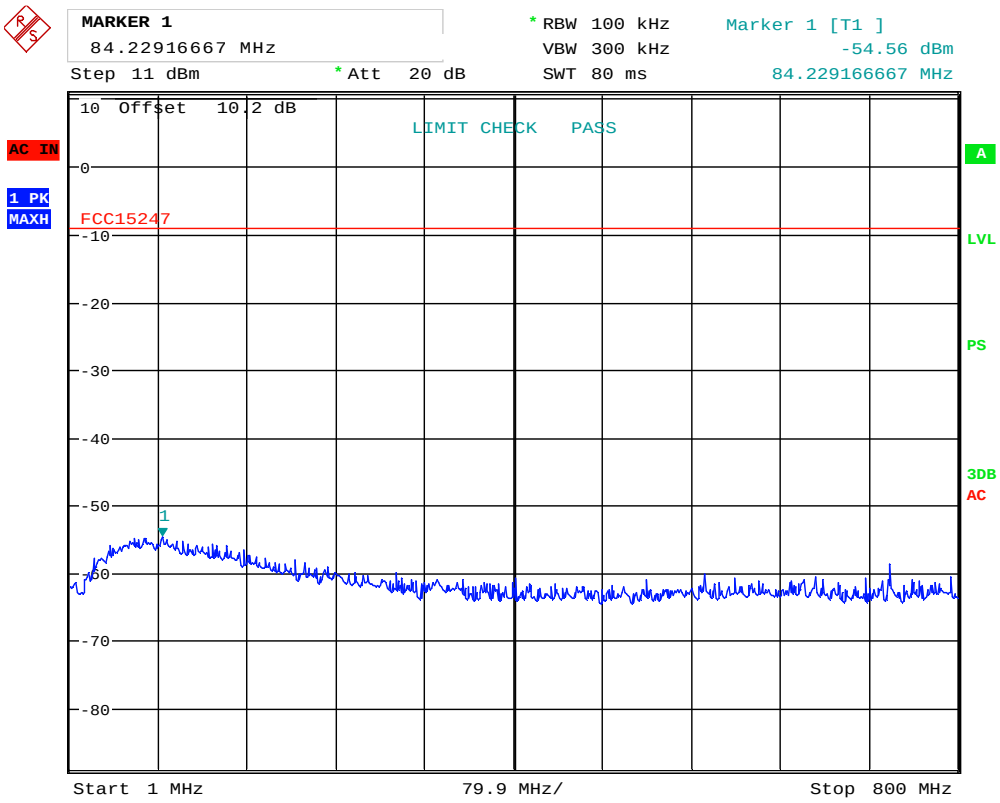
RF conducted power to 25 GHz see attached graph.

Maximum RF level outside operating band:

RF 906.5 MHz: >40 dB/C, margin >20 dB

RF 914.5 MHz: >40 dB/C, margin >20 dB

RF 922.5 MHz: >40 dB/C, margin >20 dB



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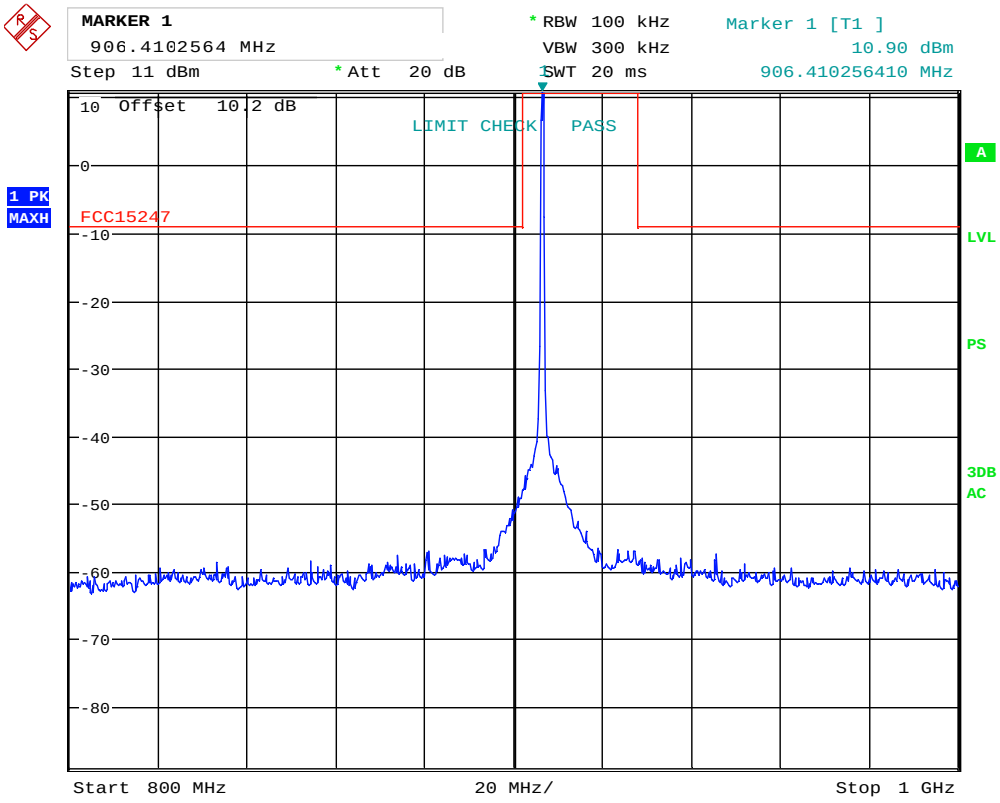
Conducted Emissions, 1 – 800 MHz, 906.5 MHz



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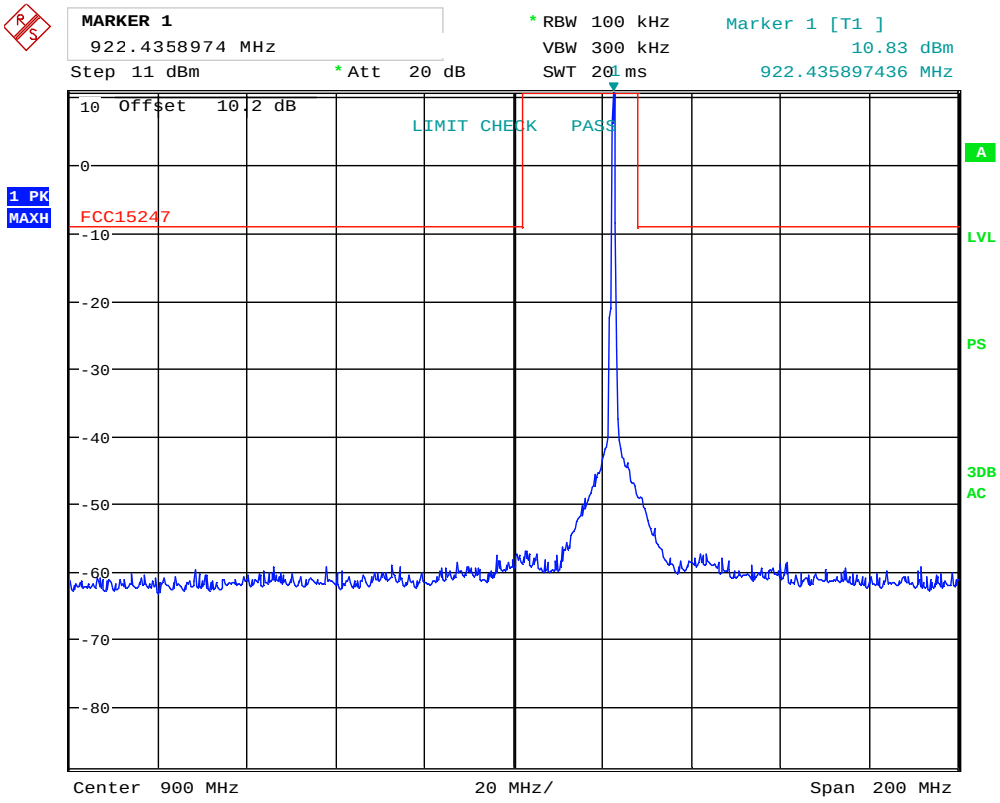
Conducted Emissions, 800 - 1000 MHz, 906.5 MHz



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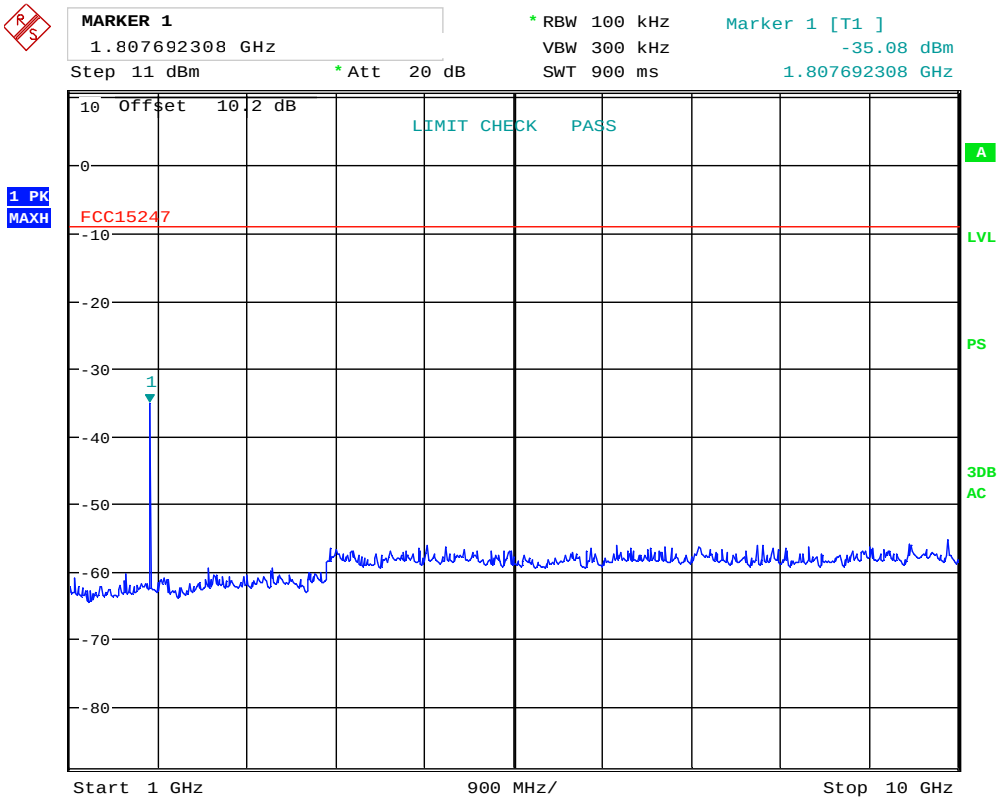
Conducted Emissions, 800 - 1000 MHz, 922.5 MHz



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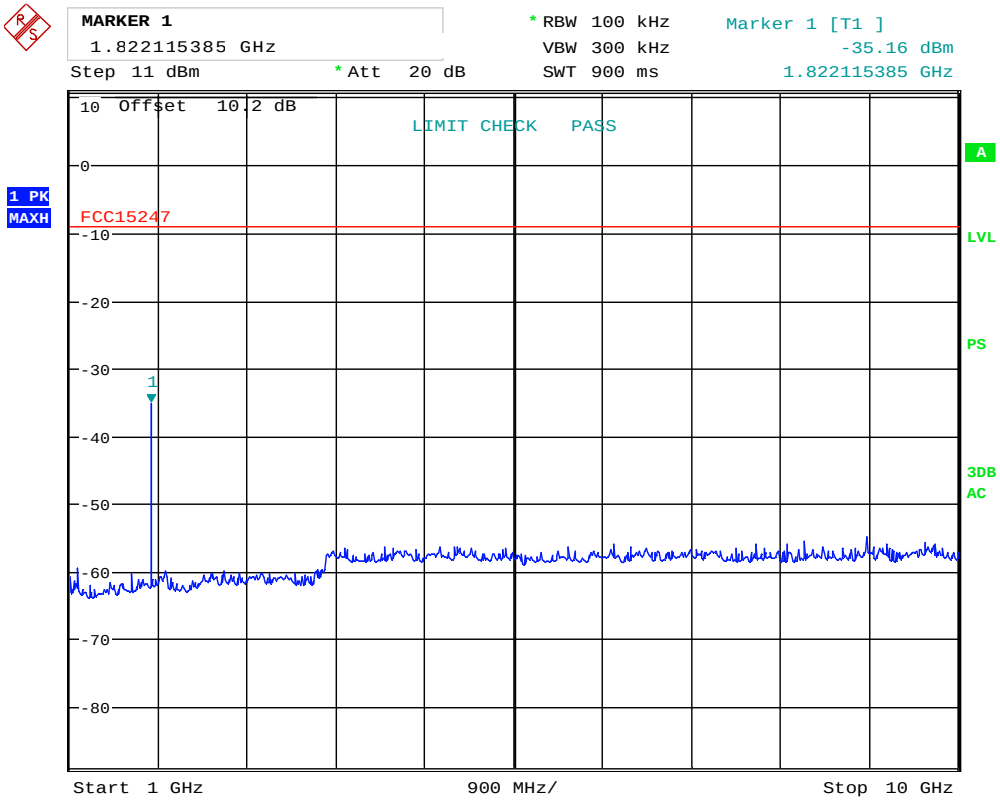
Conducted Emissions, 1 - 10 GHz, 906.5 MHz



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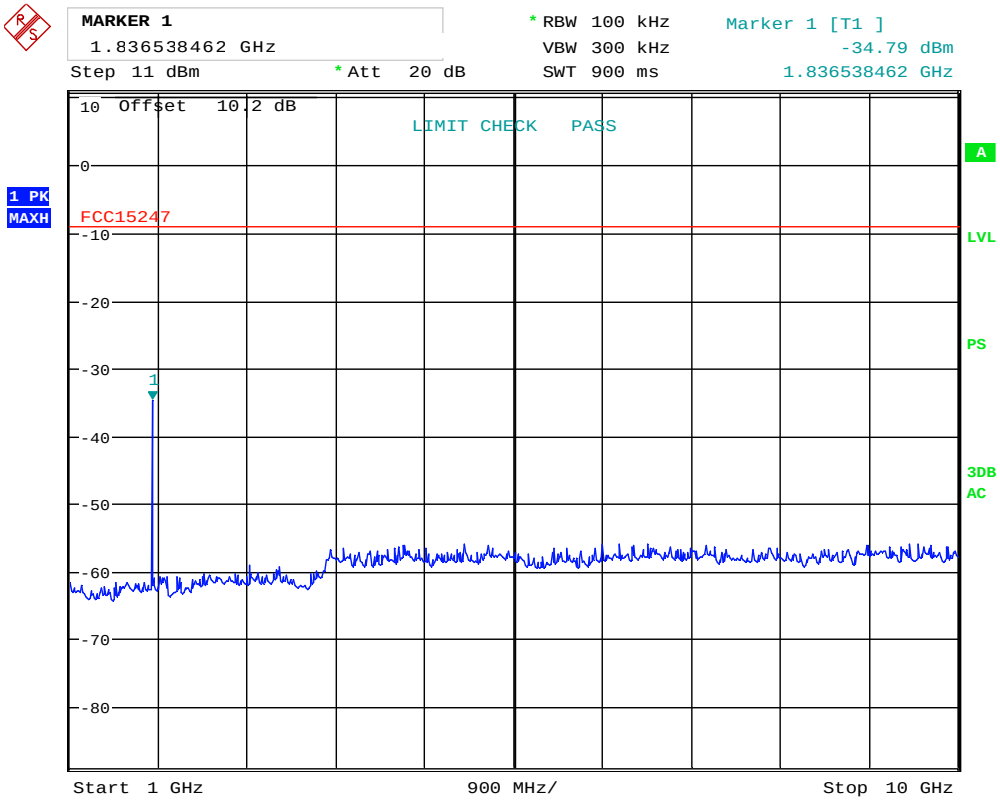
Conducted Emissions, 1 - 10 GHz, 914.5 MHz



Date: 4.JAN.2016 16:49:22

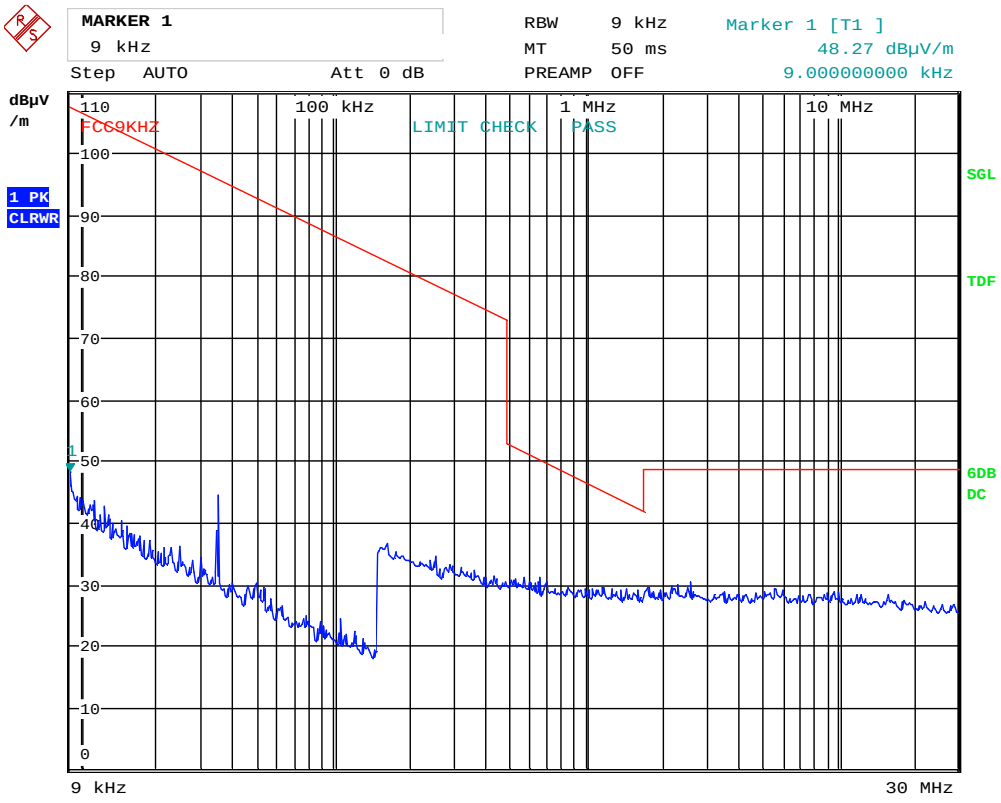
Conducted Emissions, 1 - 10 GHz, 922.5 MHz

Radiated emissions 9 kHz -30 MHz.

Measuring distance 10 m, measured with Peak detector.

No component detected, see attached graph.

Limit is converted to 10 m using 40 dB/decade according to 15.31 (f) (2).



Date: 4.JAN.2016 16:09:08

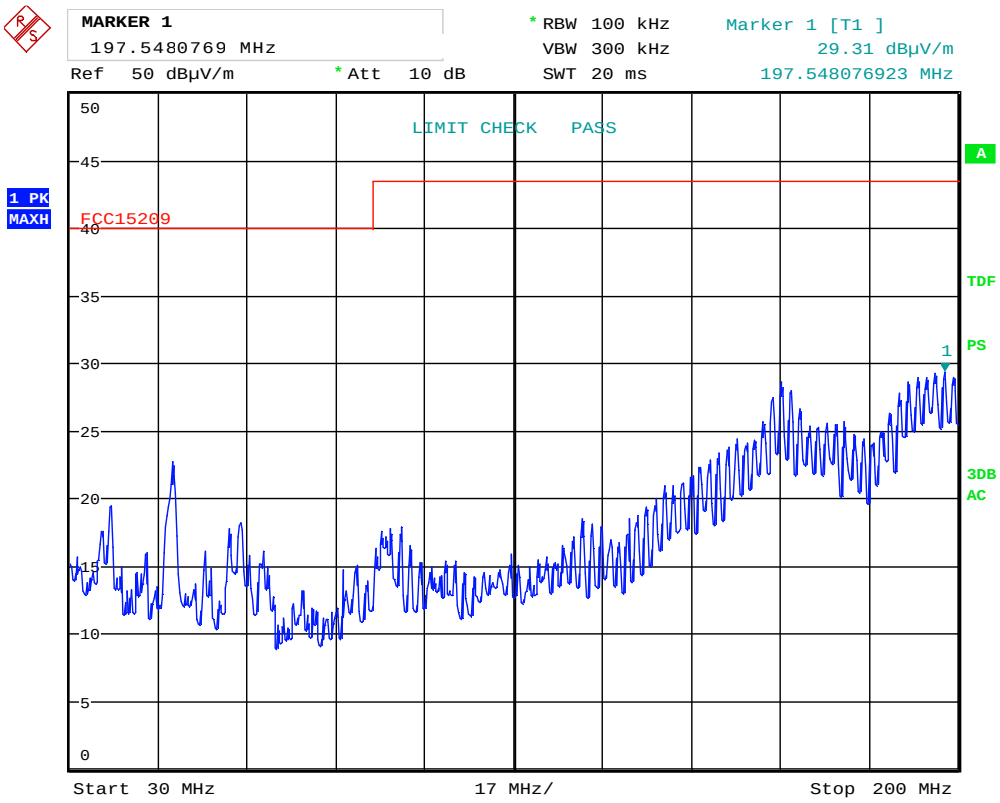
Radiated emission 30 – 1000 MHz.

Detector: Peak Detector

Measuring distance 3m

Tested in normal mode with active connection.

See attached graphs



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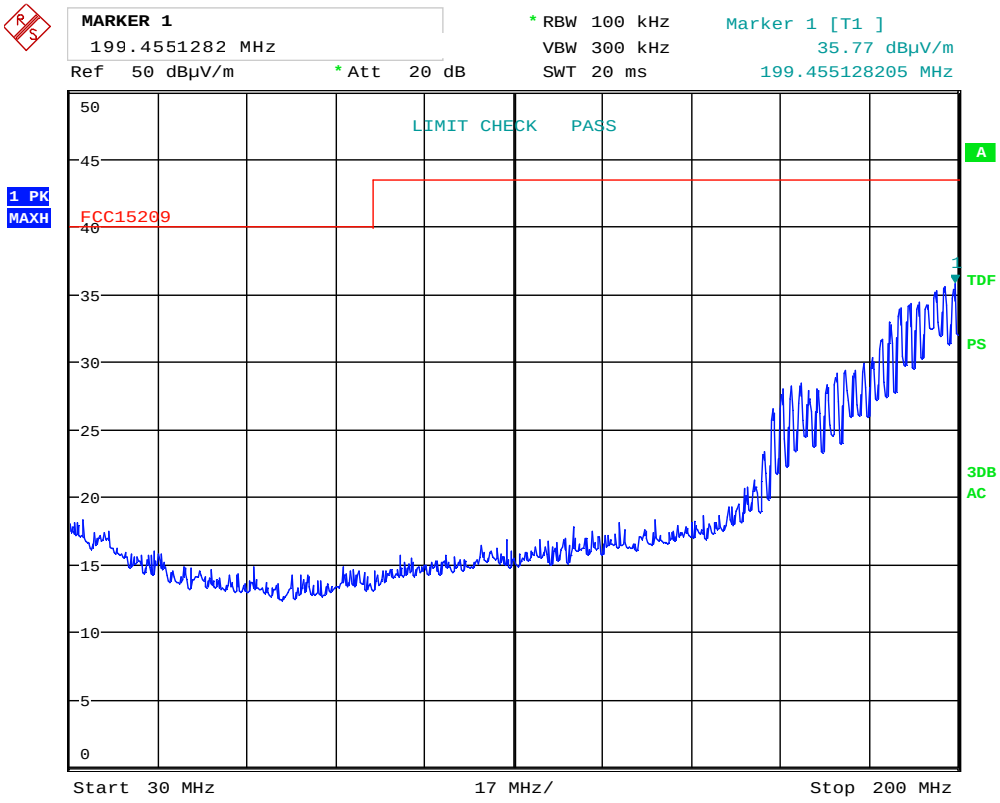
Radiated Emissions, 30 – 200 MHz, VP



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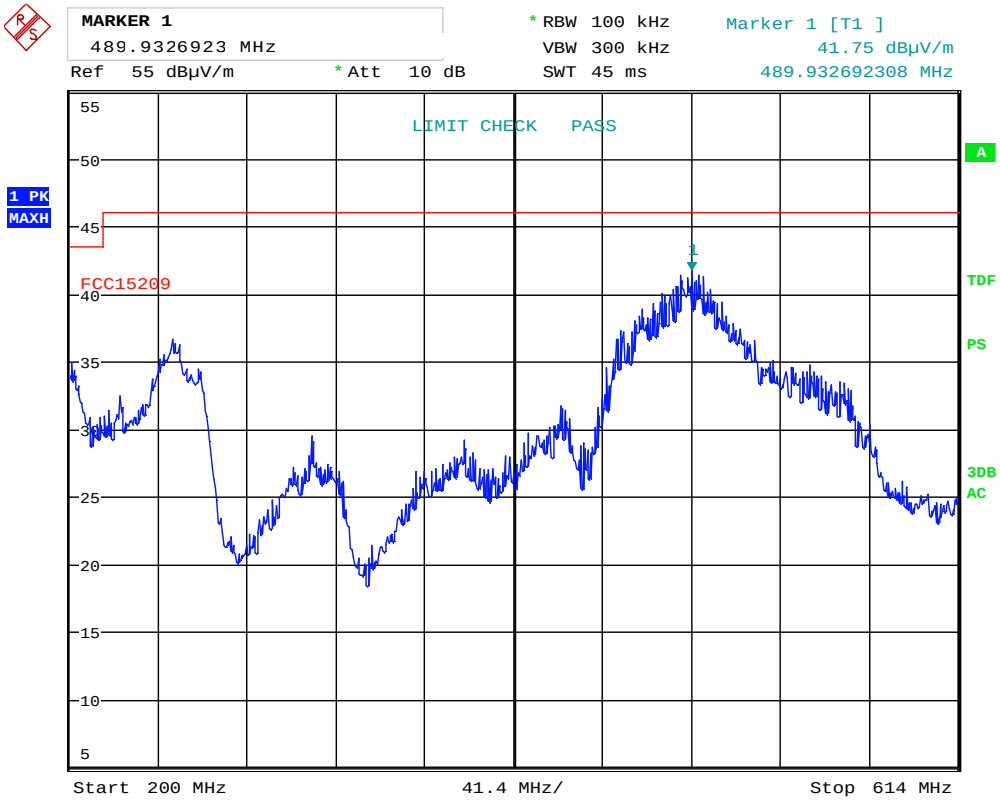
Radiated Emissions, 30 – 200 MHz, HP



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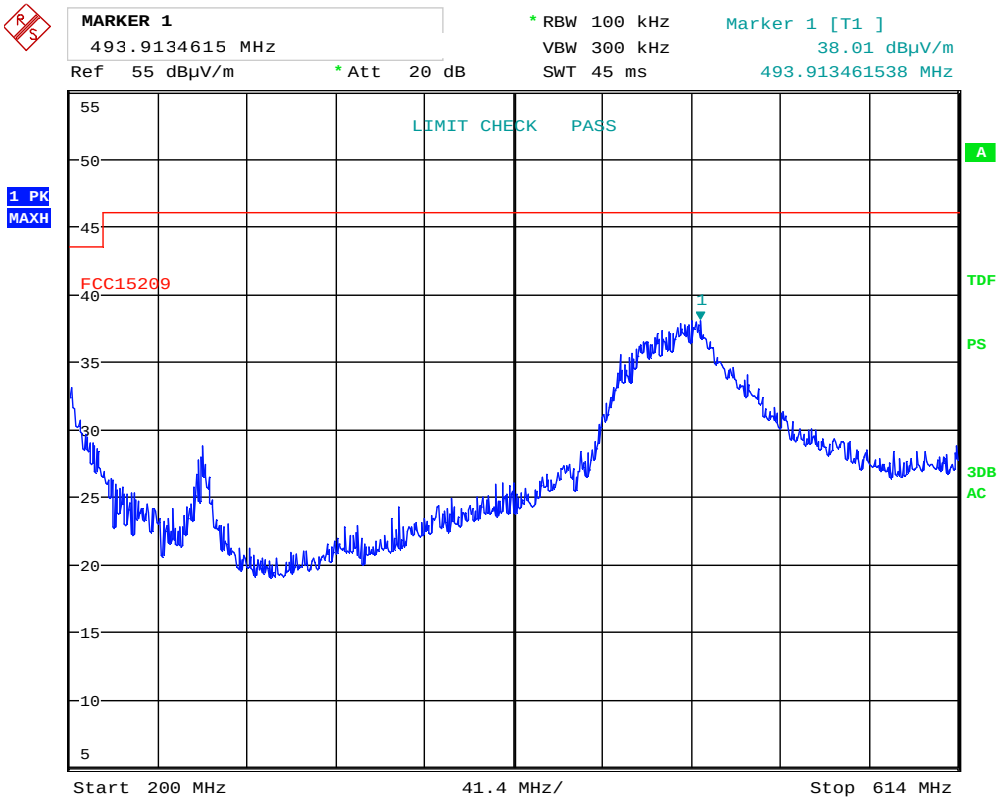
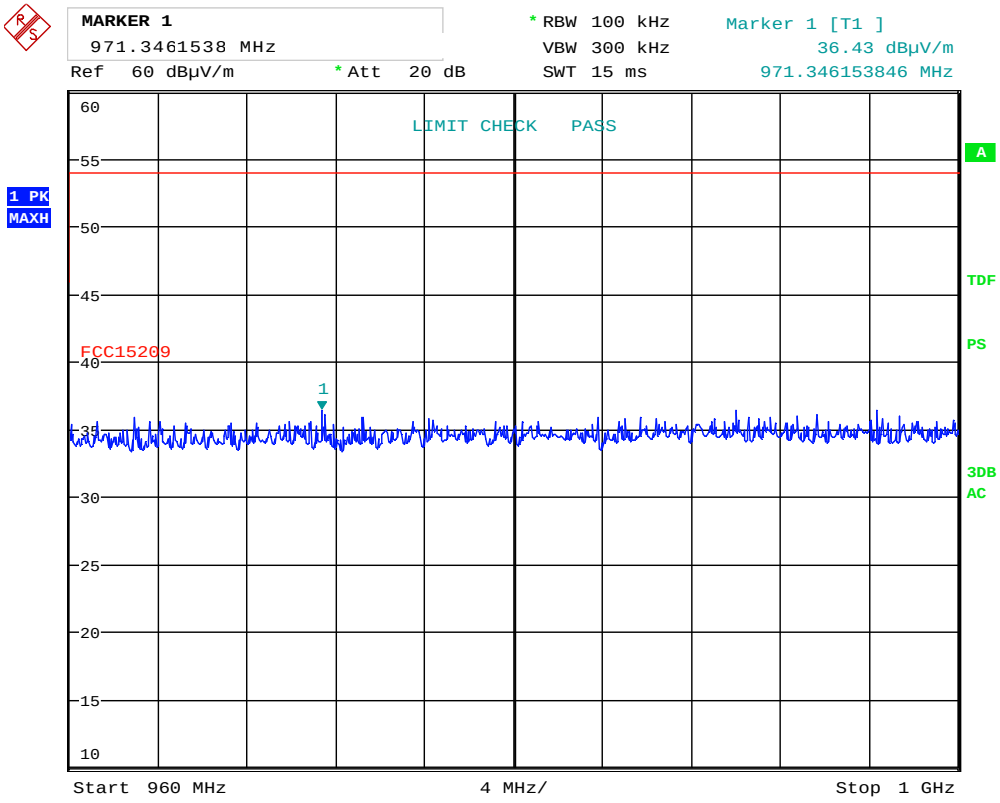
Radiated Emissions, 200 - 614 MHz, VP



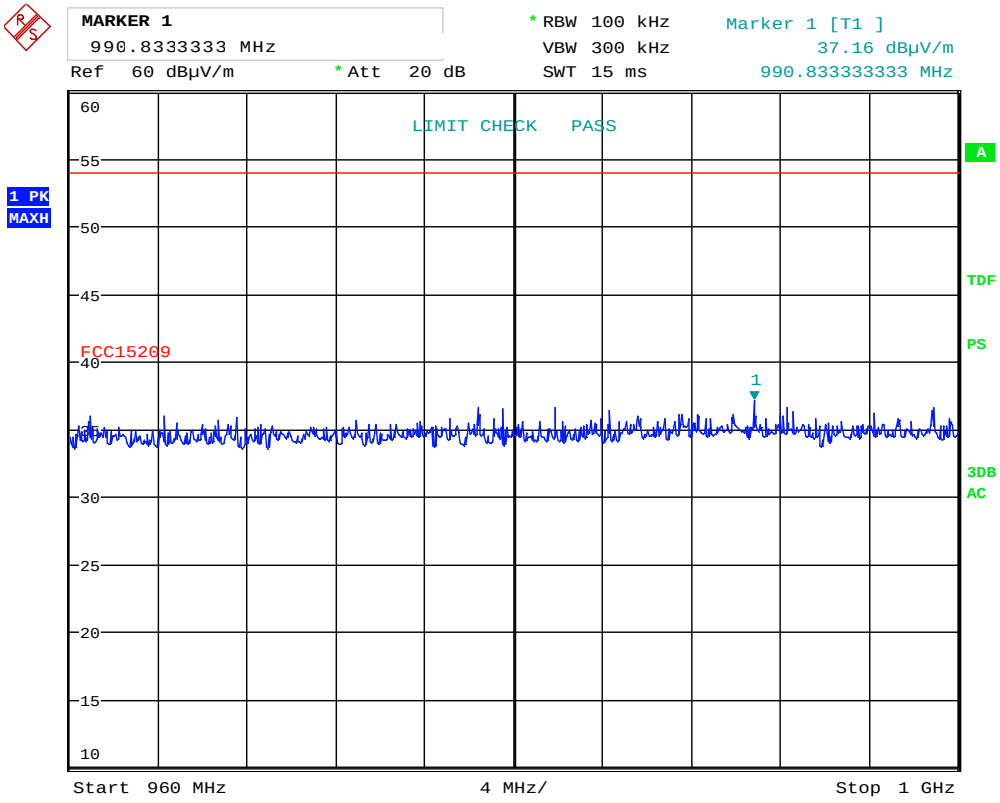
Date: 4.JAN.2016 10:22:54

Radiated Emissions, 200 - 614 MHz, HP



Date: 4.JAN.2016 10:26:04

Radiated Emissions, 960 - 1000 MHz, VP



Date: 4.JAN.2016 10:29:49

Radiated Emissions, 960 - 1000 MHz, HP

Radiated Emissions, 1 - 10 GHz

Measuring distance: 3m (1 – 8.5 GHz)
1m (8.5 – 10 GHz)

Peak Detector:

Frequency	RF channel	Field strength, Peak Detector, 3m	Limit	Margin
GHz	L,M,H	dBµV/m	dBµV/m	dB
All freqs	L,M,H	< 54	74	>20

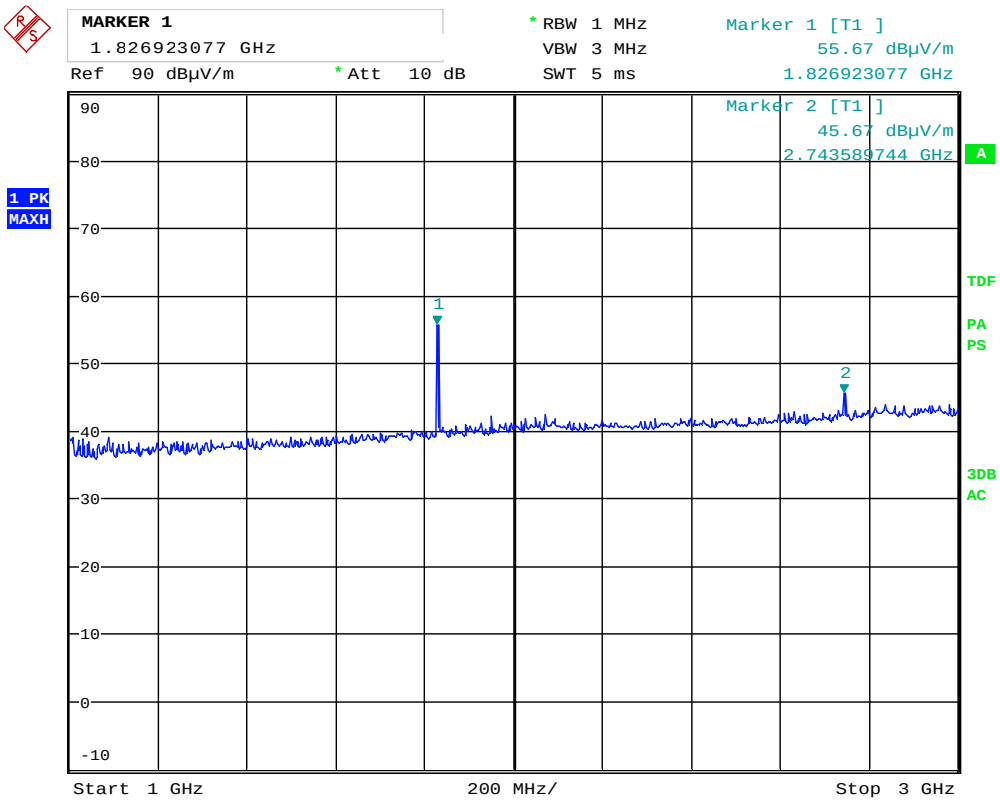
Average Detector:

Frequency	RF channel	Field strength, Peak Detector, 3m	Limit	Margin
GHz	L,M,H	dBµV/m	dBµV/m	dB
All freqs	L,M,H	< 34	54	>20

Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

Antenna factor, amplifier gain and cable loss are included in spectrum analyzer “Transducer factor”.

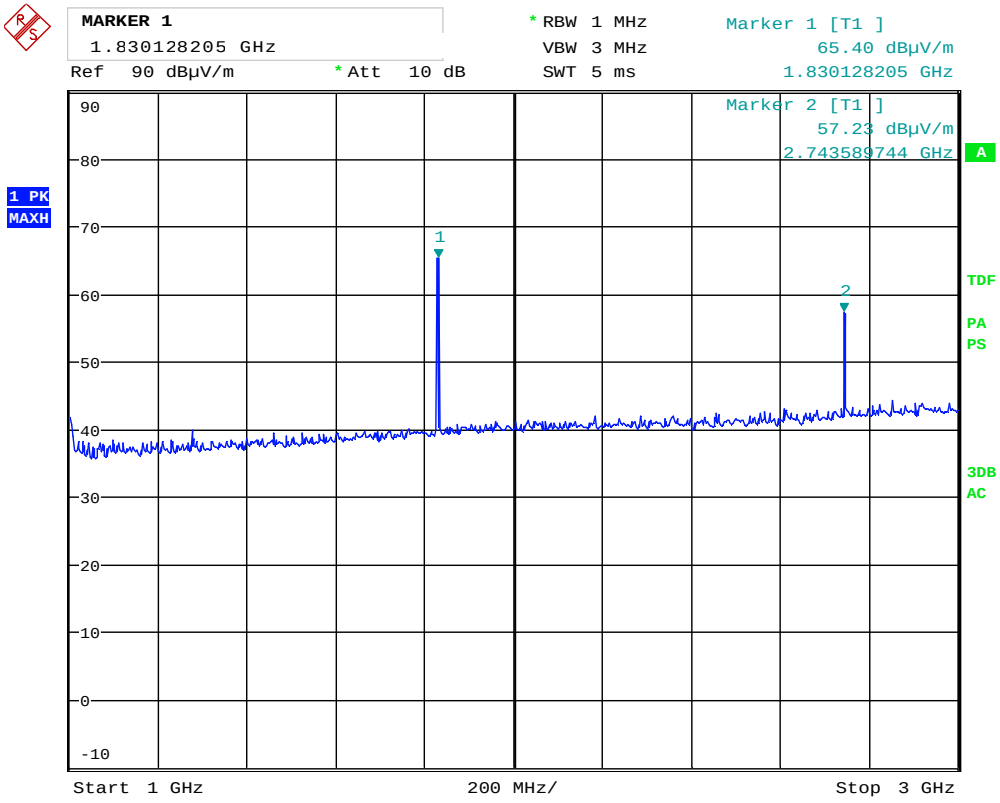
See plots.



Date: 4.JAN.2016 13:44:19

Radiated Emissions, 1 – 3 GHz, VP, Ext. Ant., w/o filter

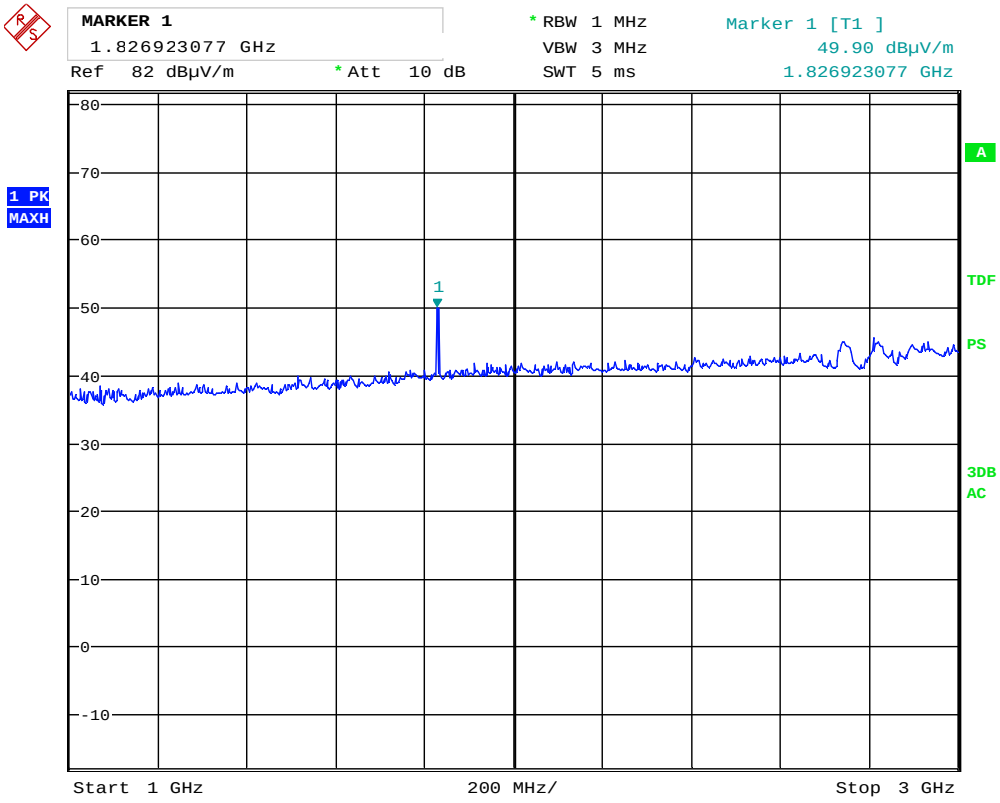
For frequencies above 1.5 GHz see plot with HP filter



Date: 4.JAN.2016 13:47:32

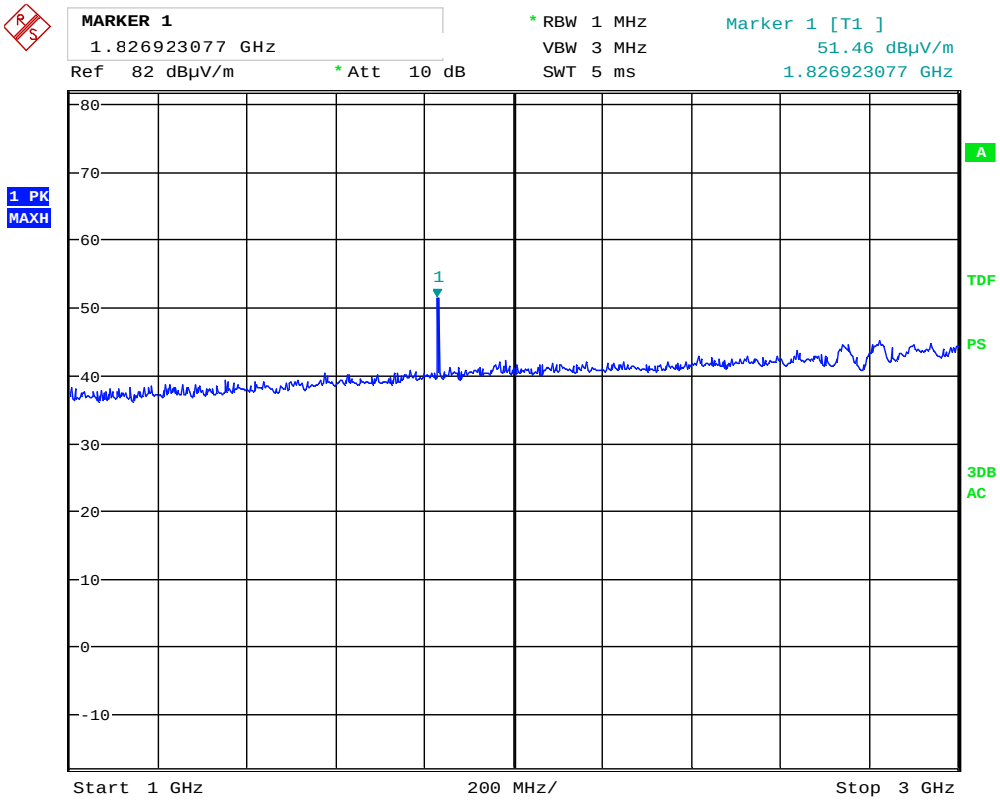
Radiated Emissions, 1 – 3 GHz, HP, Ext. Ant., w/o filter

For frequencies above 1.5 GHz see plot with HP filter



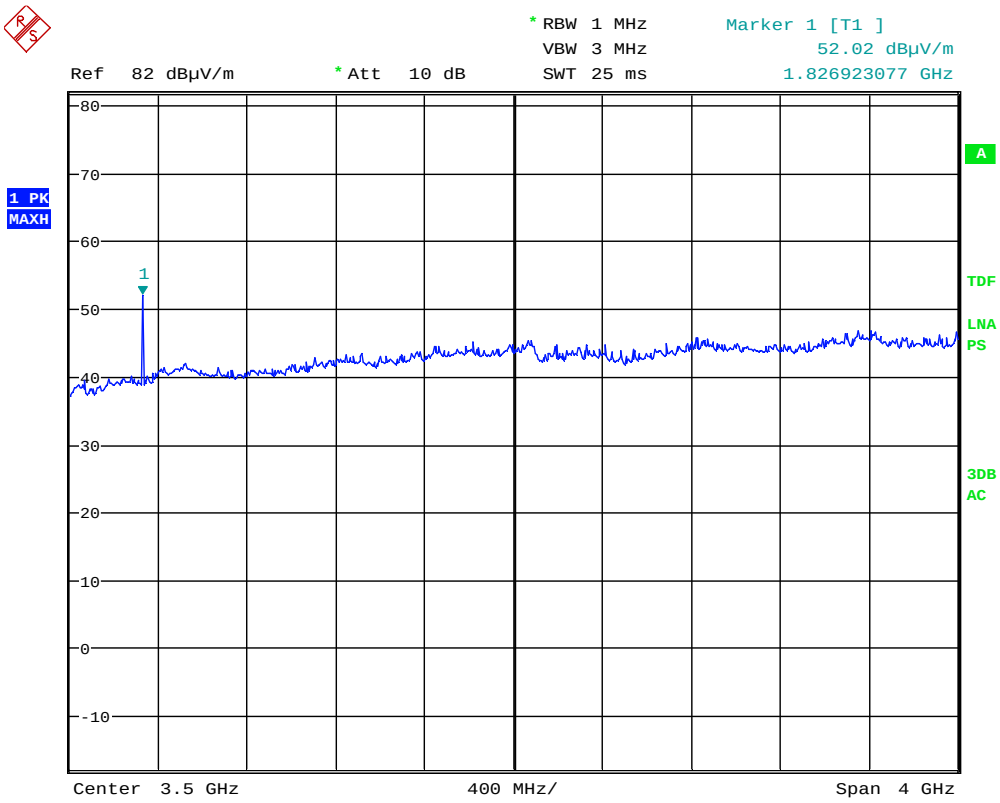
Date: 4.JAN.2016 14:40:35

Radiated Emissions, 1 – 3 GHz, VP, Int. Ant., w/ Band Reject filter



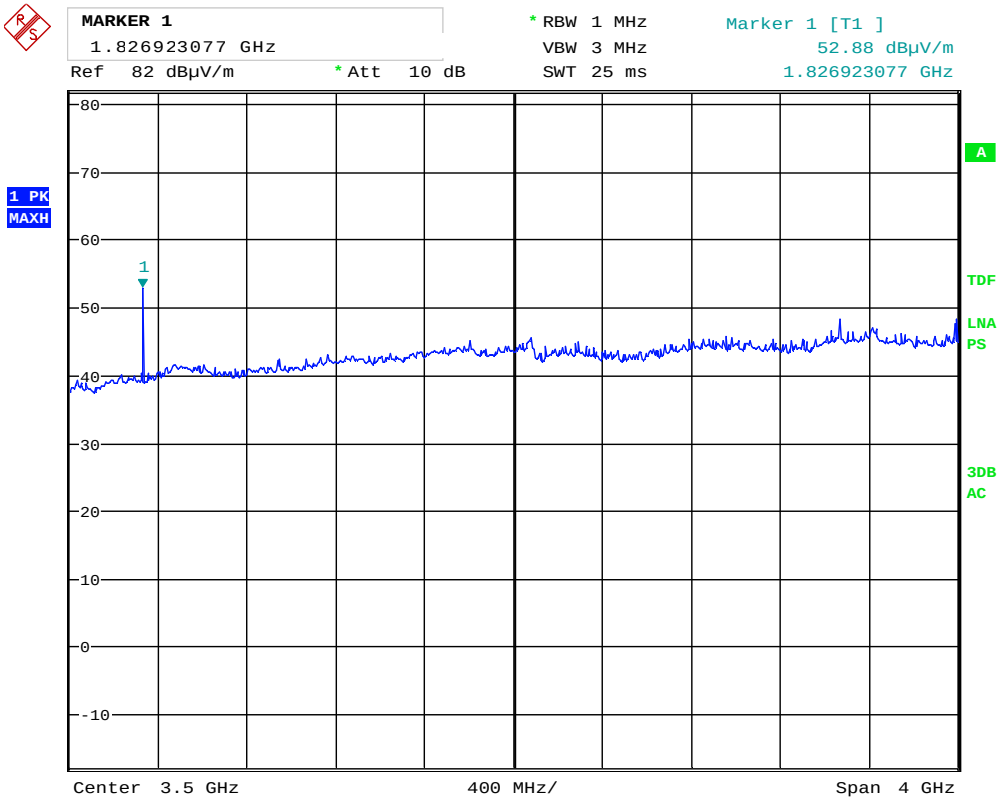
Date: 4.JAN.2016 14:38:25

Radiated Emissions, 1 – 3 GHz, HP, Int. Ant., w/ Band Reject filter



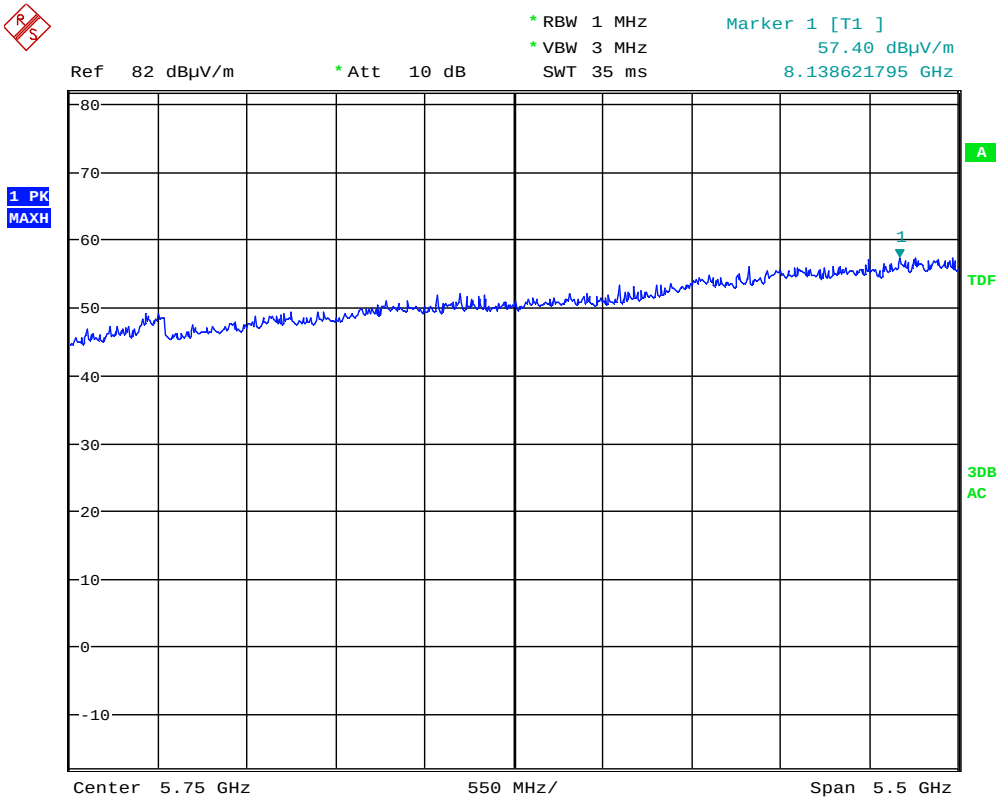
Date: 4.JAN.2016 14:12:45

Radiated Emissions, 1.5 – 5.5 GHz, VP, Ext. Ant., w/ HP filter



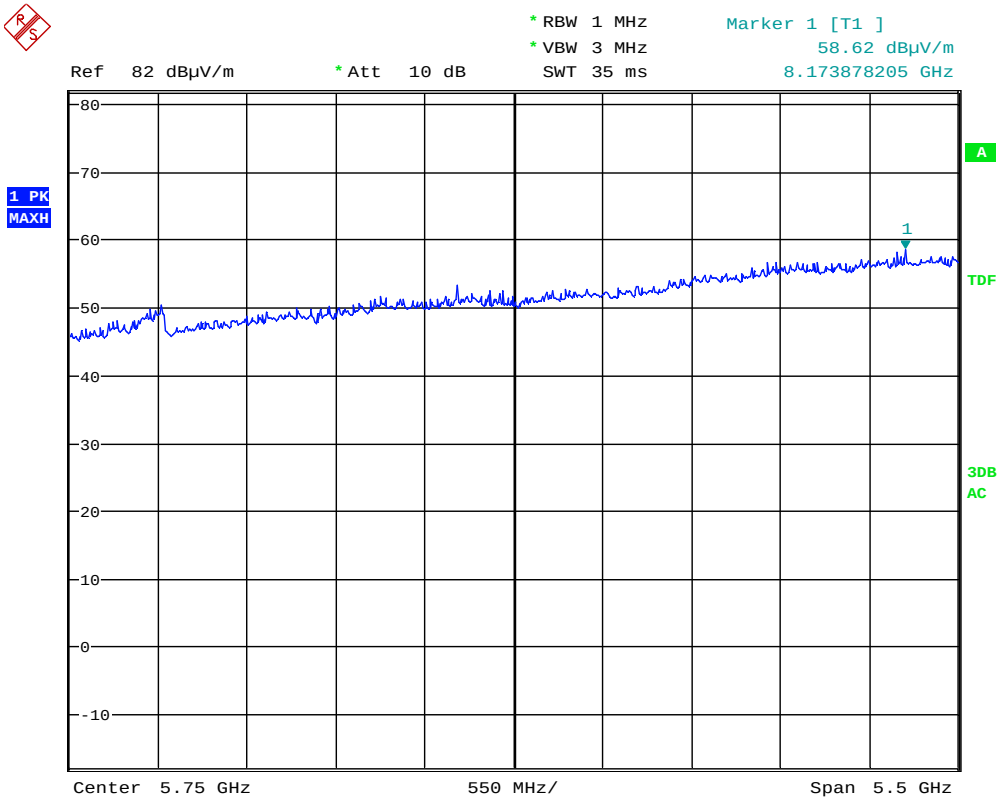
Date: 4.JAN.2016 14:15:16

Radiated Emissions, 1.5 – 5.5 GHz, HP, Ext. Ant., w/ HP filter



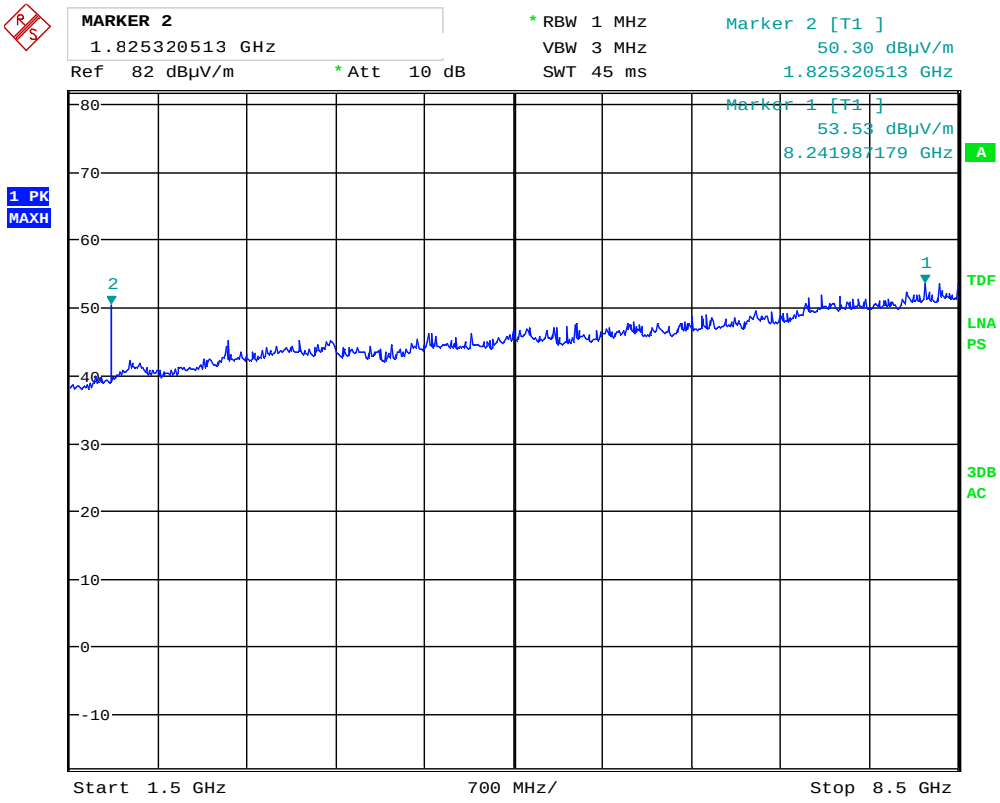
Date: 4.JAN.2016 13:50:59

Radiated Emissions, 3 – 8.5 GHz, VP, Ext. Ant., w/ HP filter



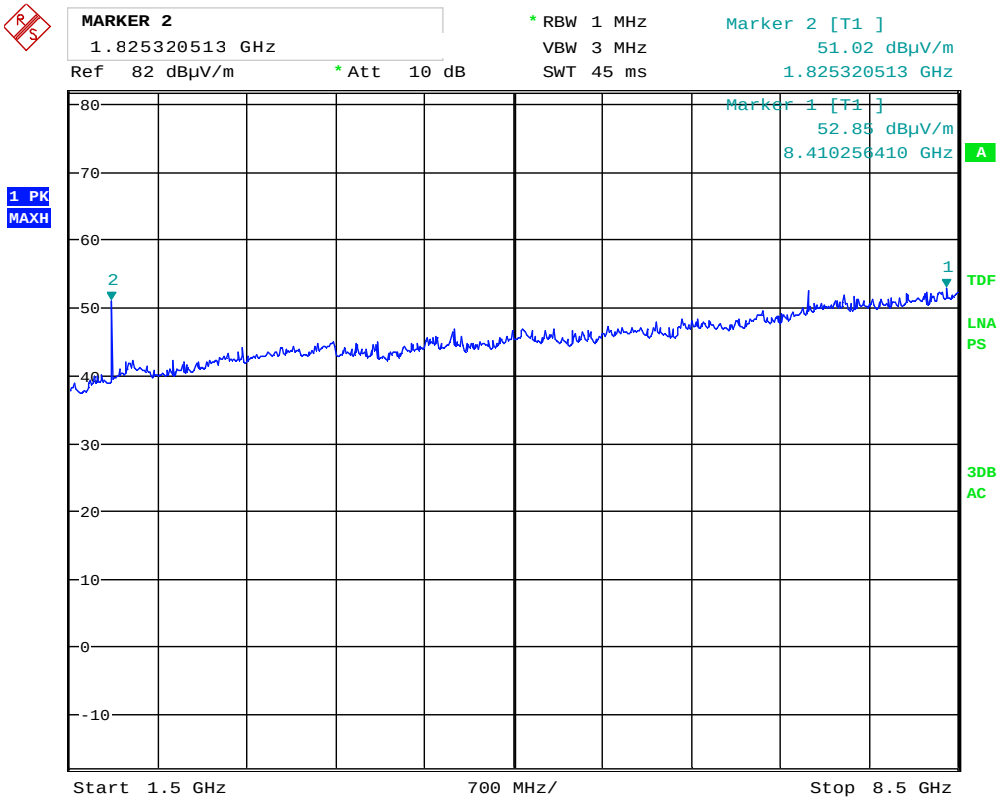
Date: 4.JAN.2016 13:52:52

Radiated Emissions, 3 – 8.5 GHz, HP, Ext. Ant., w/ HP filter



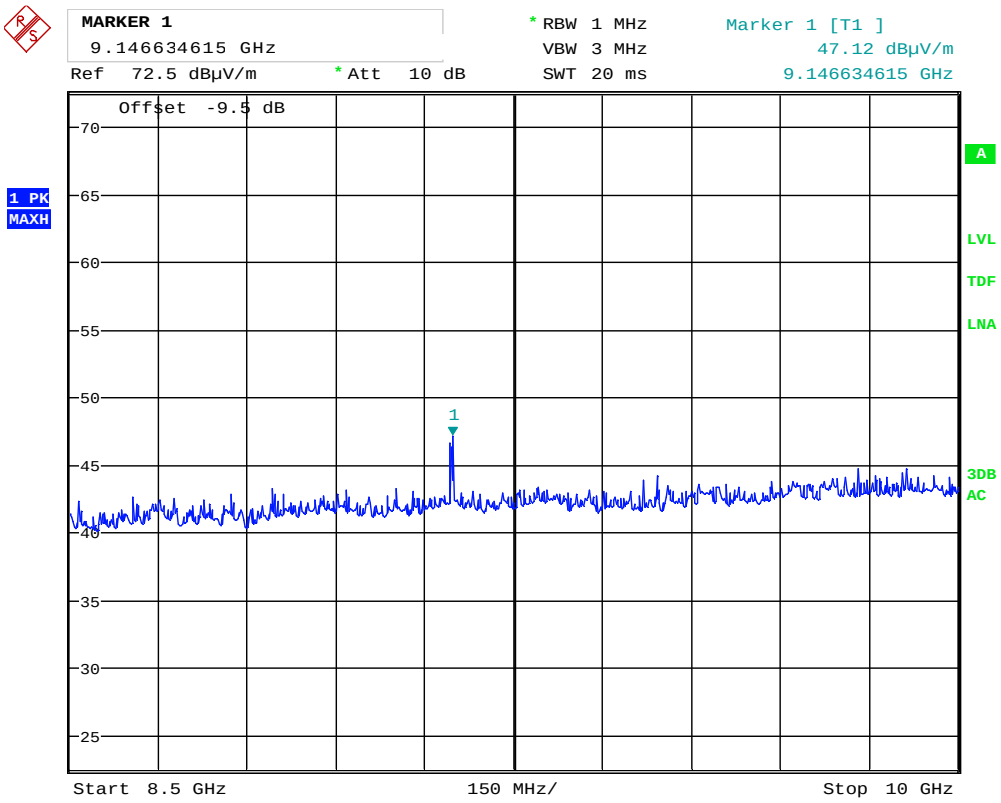
Date: 4.JAN.2016 14:26:07

Radiated Emissions, 1.5 – 8.5 GHz, VP, Int. Ant., w/ HP filter



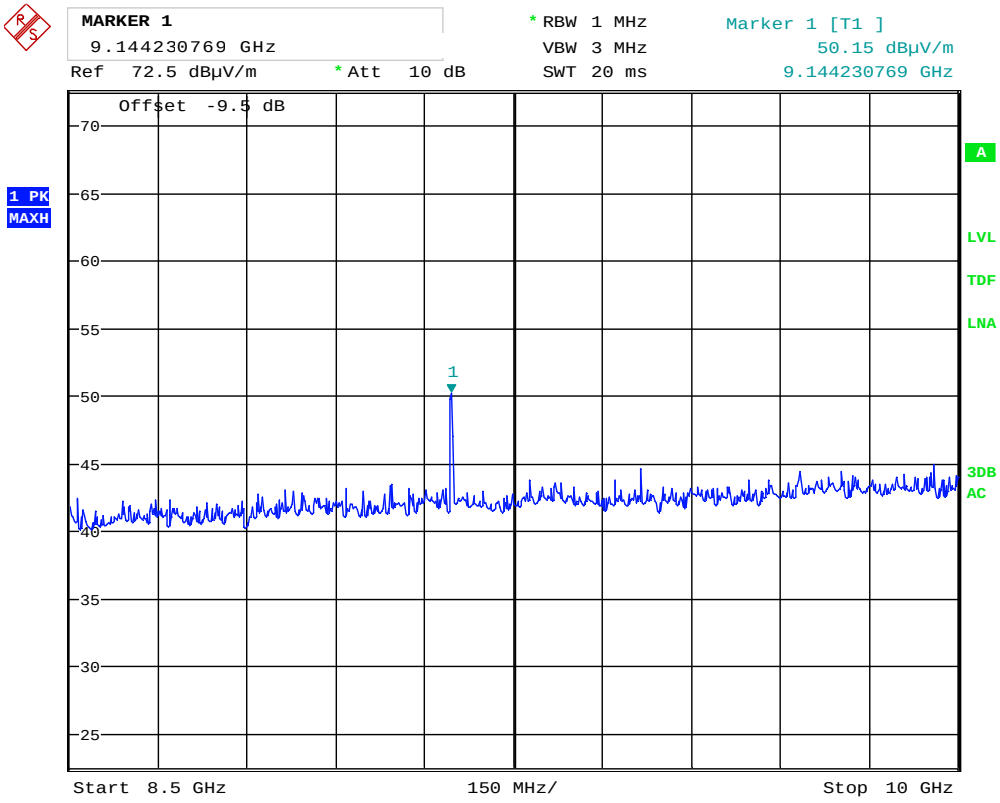
Date: 4.JAN.2016 14:28:46

Radiated Emissions, 1.5 – 8.5 GHz, HP, Int. Ant., w/ HP filter



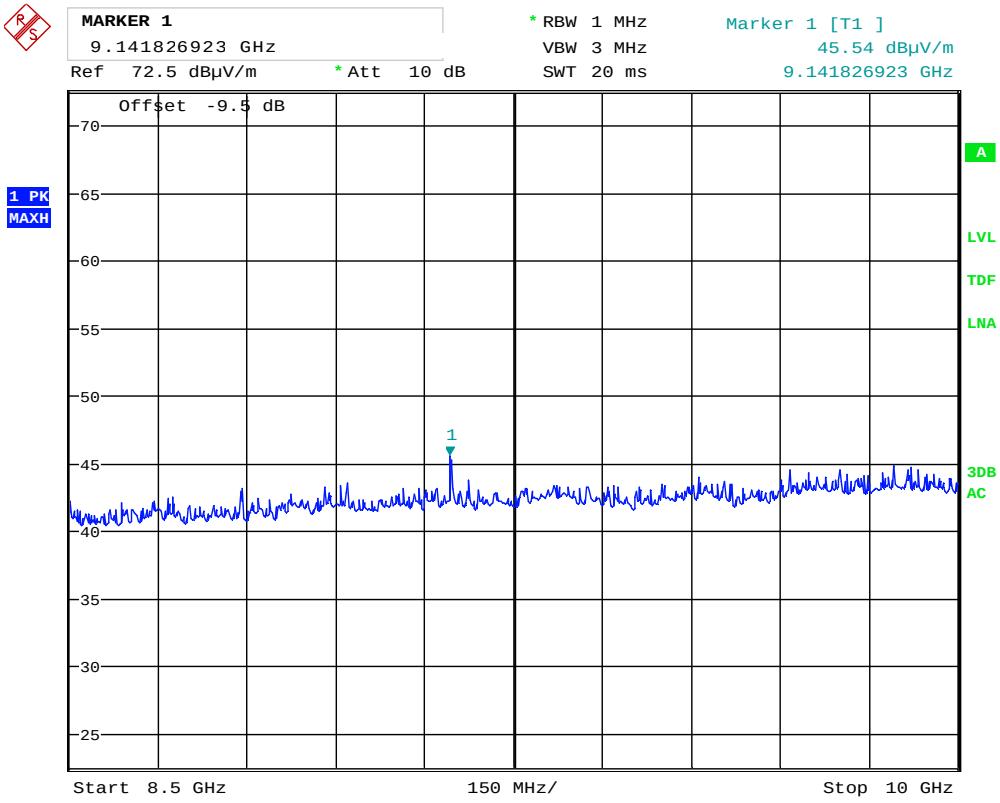
Date: 4.JAN.2016 15:16:44

Radiated Emissions, 8.5 – 10 GHz, VP, Ext. Ant., 1m



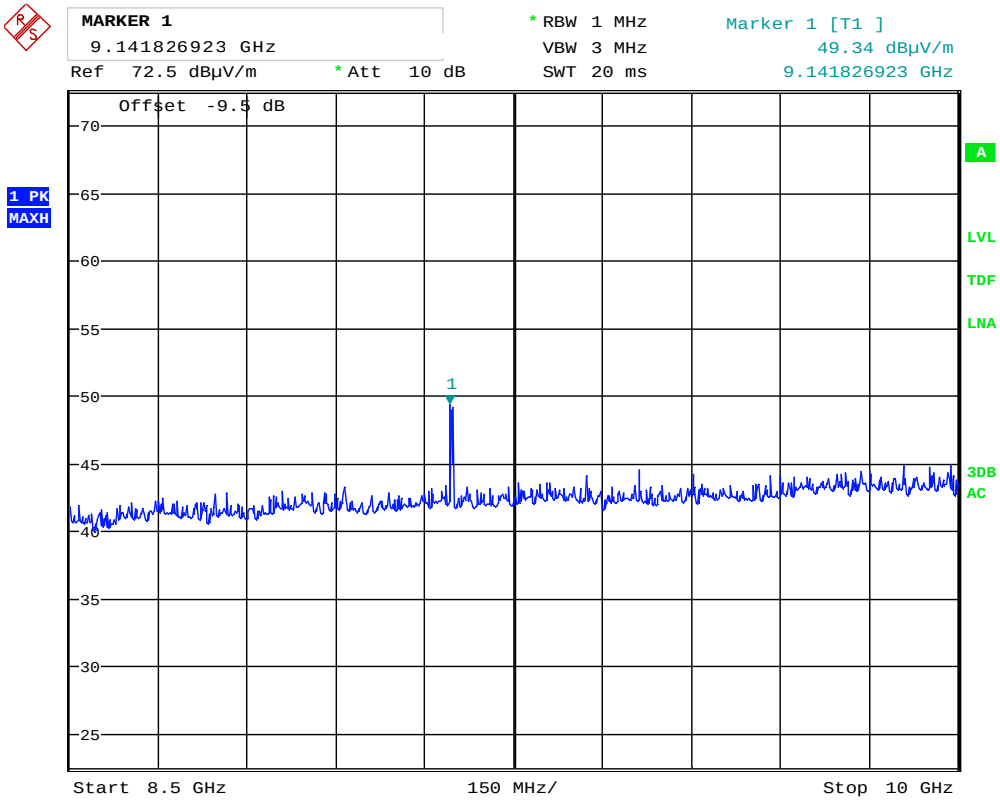
Date: 4.JAN.2016 15:19:44

Radiated Emissions, 8.5 – 10 GHz, HP, Ext. Ant., 1m



Date: 4.JAN.2016 15:24:13

Radiated Emissions, 8.5 – 10 GHz, VP, Int. Ant., 1m



Date: 4.JAN.2016 15:27:47

Radiated Emissions, 8.5 – 10 GHz, HP, Int. Ant., 1m

3.6 Power Spectral Density (PSD)

Para. No.: 15.247 (d)

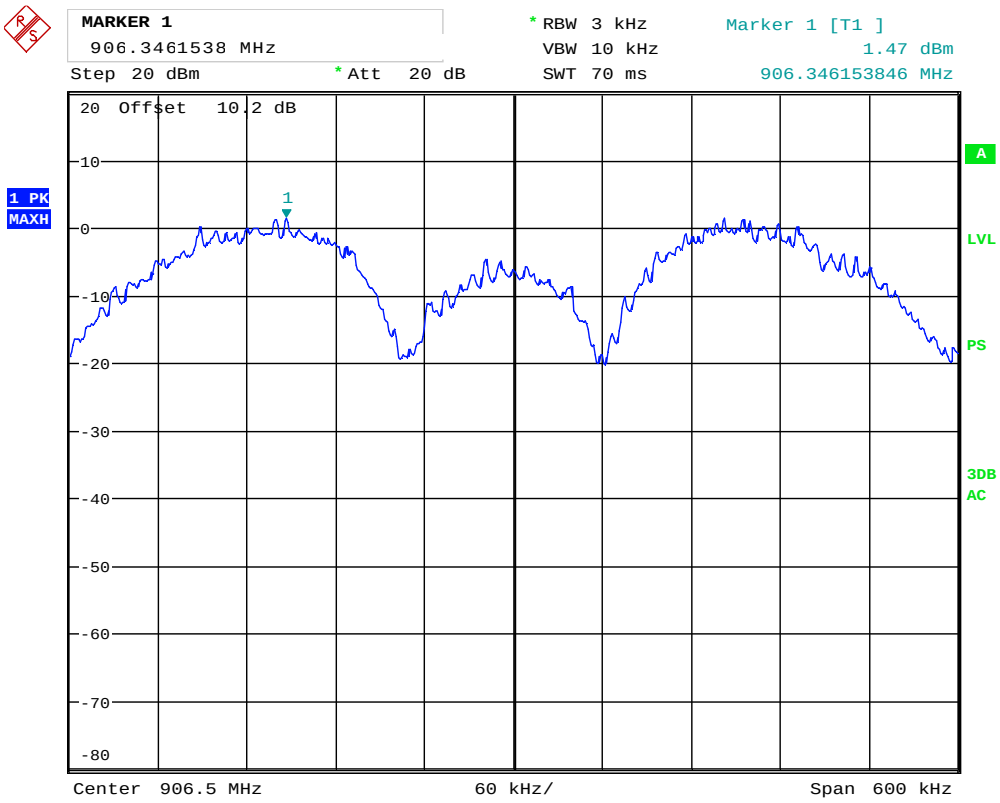
Test Results: Passed

Measured and Calculated Data:

	906.5 MHz	914.5 MHz	922.5 Mhz
Measured value (dBm)	**1.5**	**1.1**	**1.1**

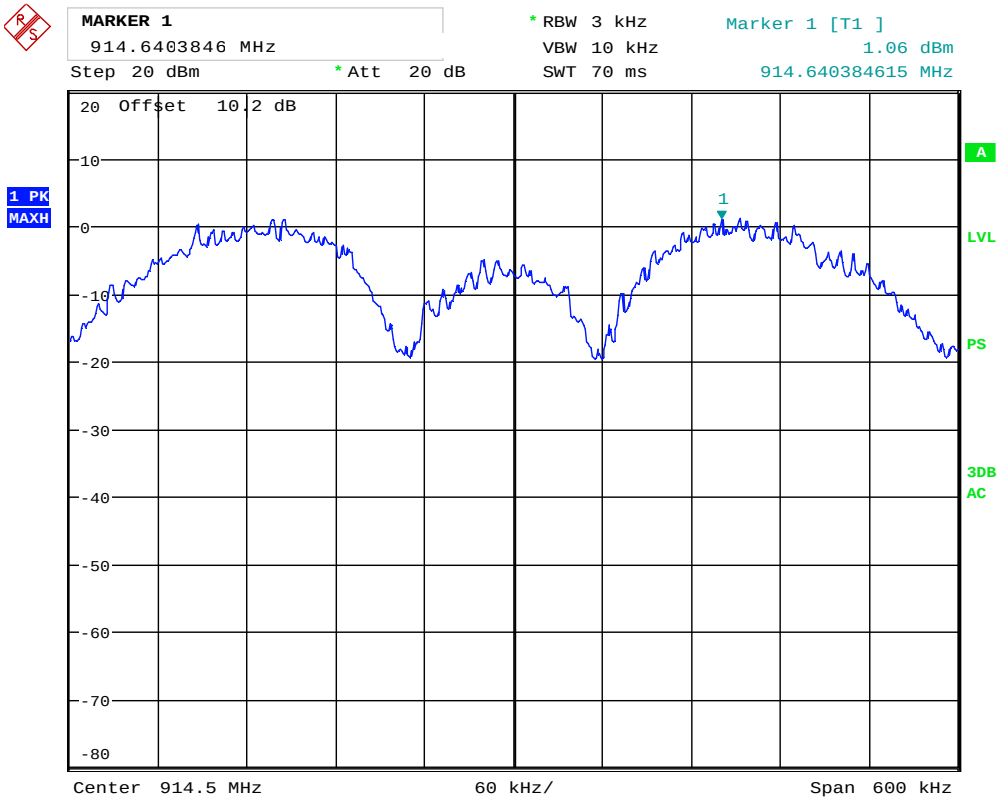
Requirements:

The Power Spectral Density of a Digital Transmission System shall be no greater than +8 dBm in any 3 kHz band



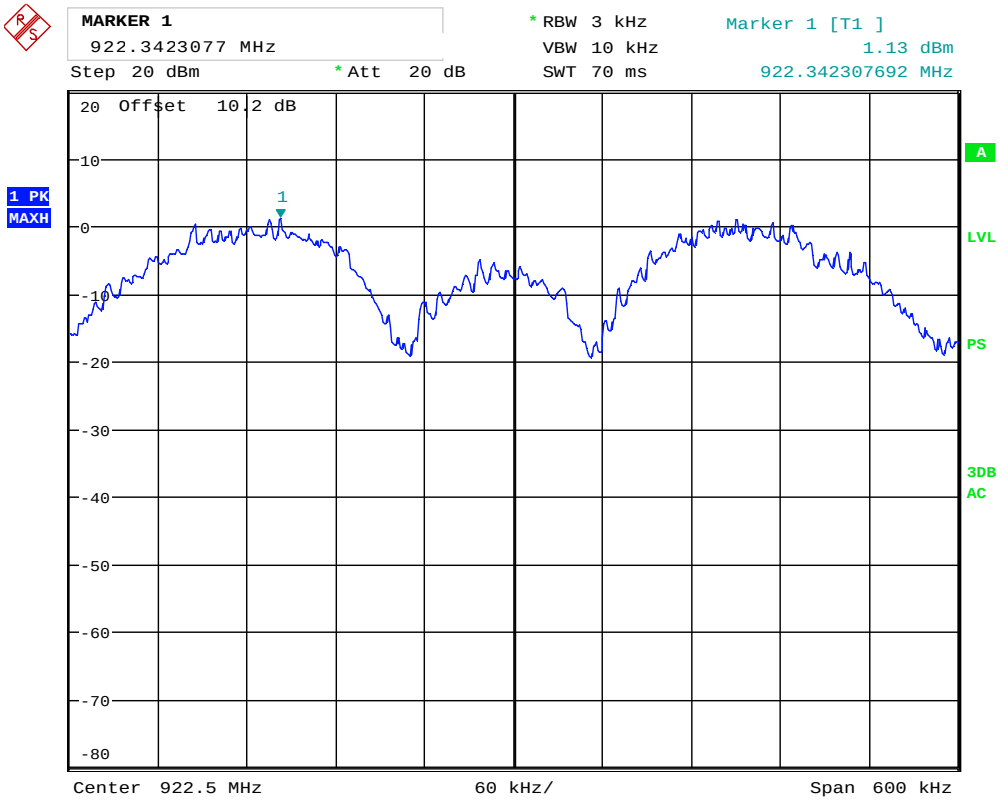
Date: 4.JAN.2016 16:58:39

PSD, 906.5 MHz



Date: 4.JAN.2016 16:59:19

PSD, 914.5 MHz



Date: 4.JAN.2016 17:02:36

PSD, 922.5 MHz

4 Measurement Uncertainty

Measurement Uncertainty Values		
Test Item		**Uncertainty**
Output Power		±0.5 dB
Power Spectral Density		±0.5 dB
Out of Band Emissions, Conducted	**< 3.6 GHz**	±0.6 dB
	> 3.6 GHz	±0.9 dB
Spurious Emissions, Radiated	**< 1 GHz**	±2.5 dB
	> 1 GHz	±2.2 dB
Emission Bandwidth		±4 %
Power Line Conducted Emissions		+2.9 / -4.1 dB
Spectrum Mask Measurements	**Frequency**	±5 %
	Amplitude	±1.0 dB
Frequency Error		±0.6 ppm
Temperature Uncertainty		±1 °C

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2

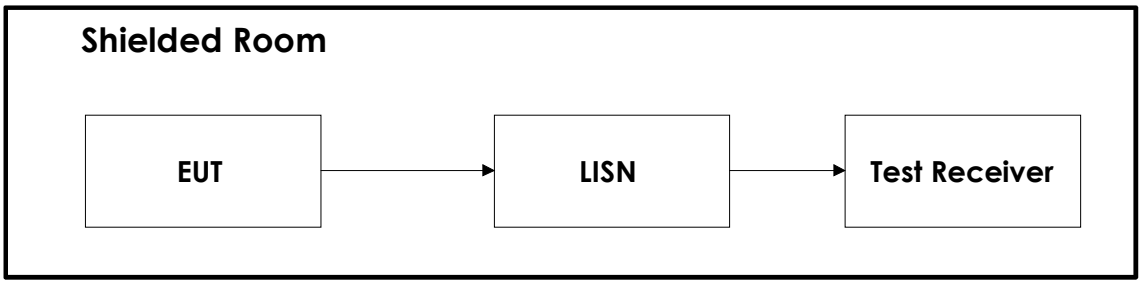
5 LIST OF TEST EQUIPMENT

To facilitate inclusion on each page of the test equipment used for related tests, each item of test equipment and ancillaries are identified (numbered) by the Test Laboratory.

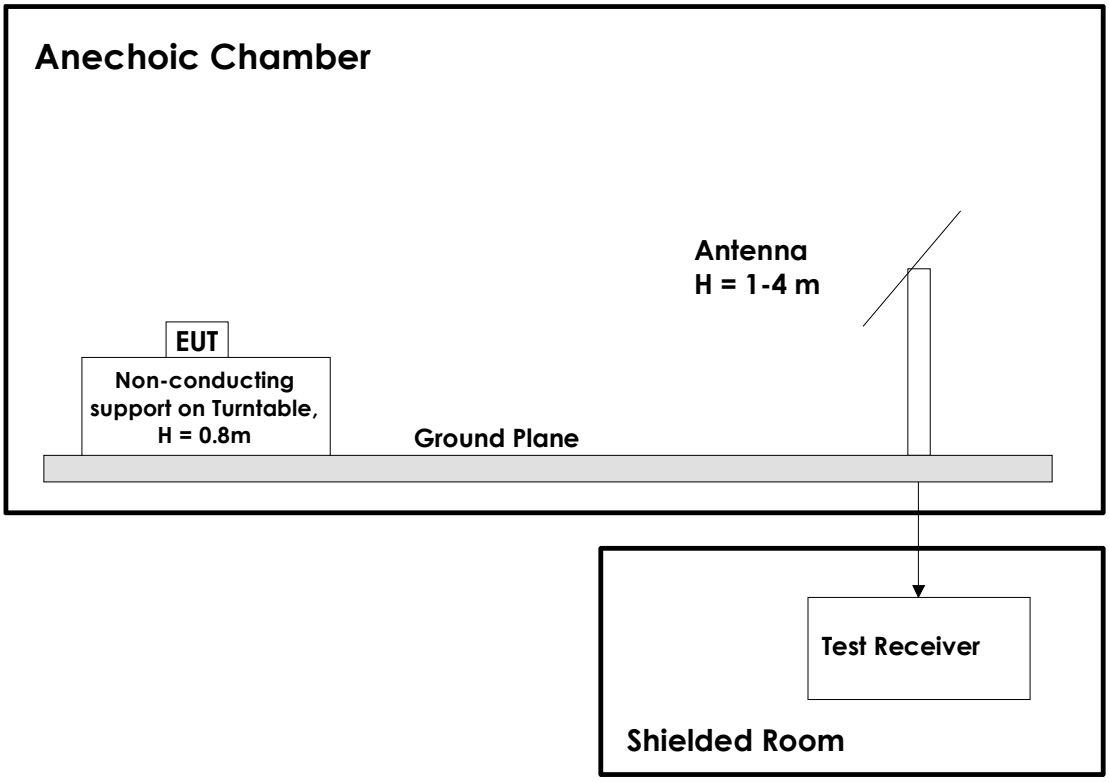
No.	Model number	Description	Manufacturer	Ref. no.	Cal. date	Cal. Due
1	ESU40	Measuring Receiver	Rohde & Schwarz	LR 1639	2015.11	2016.11
2	6810A.17B	Attenuator	Suhner	LR 1669	Cal b4 use	
3	6HC1500/18000	Highpass Filter	Trilithic	LR 1612	Cal b4 use	
4	HL223	LogPeriod Antenna	Rohde & Schwarz	LR 1261	2013.12	2017.12
5	HK116	Biconical Antenna	Rohde & Schwarz	LR 1260	2013.12	2017.12
6	HFH2-Z2	Loop Antenna	Rohde & Schwarz	LR 1660	2014.10	2016.10
7	3115	Horn Antenna	EMCO	LR 1226	2013.12	2018.12
8	PM7320X	Antenna Horn	Sivers Lab	LR 103	2009.01.26	2017.01.26
9	HP 10855A	Preamplifier	Hewlett Packard	LR 1445	2015.10	2016.10
10	8449A	Pre-amplifier	Hewlett Packard	LR 1322	2015.10	2016.10
11	Model 87V	Multimeter	Fluke	N-4669	2015.10	2016.10
12	B32-10R	Power Supply	Oltronics	LR 015	Cal b4 use	

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission



Revision history

Version	Date	Comment	Sign
1.0	2016.01.31	Version for TCB review	FS
2.0	20.02.23	Corrected version	FS