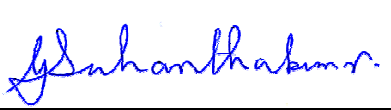
Report No. 303241-2

Test Report

Product	Sonitor Sense Tags
Name and address of the applicant	Sonitor Technologies AS Drammensveien 288, 0283 Oslo, Norway
Name and address of the manufacturer	Sonitor Technologies AS Drammensveien 288, 0283 Oslo, Norway
Model	Tag-H00 and Tag-H150
Rating	Primary Li-MnO_2, 3V thin cell battery
Trademark	Sonitor Technologies
Serial number	Tag-H00: 0009269a43c Tag-H150:00096203d07b
Additional information	This test report covers only wi-fi spurious emissions with PCB antenna. All tags contain's 125 kHz low frequency class 3 receiver and module approved 2.4GHz wifi. The tags do not have 125 kHz transmitter.
Tested according to	**FCC Part 15.247** Frequency Hopping Transmitters / Digital Transmission Systems **Industry Canada RSS-247, Issue 1** Low Power Licence-Exempt Radiocommunications Devices
Order number	303241
Tested in period	2016.02.04 - 2016.02.10
Issue date	2016.03.02
Name and address of the testing laboratory	Nemko 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 [G.Suhanthakumar] Approved by [Frode Sveinsen]

Template version: B

CONTENTS

1 INFORMATION

1.1 Test Item

Name :	Sonitor Sense tags
FCC ID :	2AD7T11115110402
Industry Canada ID :	20330-11115110402
Model/version :	Tag-H00 and Tag-H150
Serial number :	Tag-H00: 0009269a43c Tag-H150:00096203d07b
Hardware identity and/or version:	V0.5.0
Software identity and/or version :	-
Frequency Range :	2412 - 2462 MHz
Number of Channels :	11
Operating Modes :	IEEE 802.11g
Type of Modulation :	OFDM
User Frequency Adjustment :	None
Output Power :	0.0067W (Conducted)
Type of Power Supply :	3.0Vdc , Battery
Number of Antennas :	1
Antenna Type :	Johanson Technology, Part number 2450AT42A100
Antenna Gain (Peak) :	0 dBi

Description of Test Item

Sonitor Sense tags are used in the Sonitor's real time locating system to detect the location of the person or object carrying the tag. All Tag-H models can be used as personnel tags or as equipment tag to track the location of the person or the equipment in real time.

Theory of Operation

The tags listen to ultrasound transmission from the infrastructure units called Location Transmitter. (Note: the tags with external sensor do not have the ability to receive ultrasound). The tag decodes the ultrasound location information sent by the Location Transmitter and sends the information about its location to the infrastructure using wifi multicast messages on channels 1, 6 and 11. The wifi radio can be also used to send information from the infrastructure to the tags, for example firmware updates.

The tags have 125 kHz wake-up receiver and two transponder inductors for the reception of the 125 kHz low frequency signal transmitted by the Location Transmitter. When tag detects low frequency, it sends wifi multicast messages on channels 1, 6 and 11 to the infrastructure. Based on the use case, different things can happen when the infrastructure receives this information. Typically, low frequency functionality is used to create choke points or monitor doors.

1.2 Test Environment

1.2.1 Normal test condition

Temperature:	20 - 23 °C
Relative humidity:	20 - 47 %
Normal test voltage:	3.0Vdc

The values are the limit registered during the test period.

1.3 Test Engineer(s)

G.Suhanthakumar

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 15, paragraph 15.247 and Industry Canada RSS-247 Issue 1.

Tests were performed in accordance with ANSI C63.4-2014 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)	N/A[1]
Antenna Requirement	15.203	8.3 (RSS-GEN)	N/A[2]
Power Line Conducted Emission	15.107(a) 15.207(a)	8.8 (RSS-GEN)	N/A[1]
20 dB Bandwidth	N/A	6.6 (RSS-GEN)	
Peak Power Output	15.247(b)	5.4 (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

[1] Fully chaged battery is used

[2] Integral antenna

2.3 Description of modification for Modification Filing

Not applicable.

2.4 Comments

Fully charged battery is used.

2.5 Family List Rational

The following model variations are considered covered by this report

VA no.	Variant	Comment	Investigated
1	Tag–H00	See explanation below	Yes
2	Tag-H150	See explanation below	no
3	Tag-H120	See explanation below	no
4	Tag-H122	See explanation below	no
5	Tag-H130	See explanation below	no
6	Tag-H135	See explanation below	no
7	Tag-H140	See explanation below	no

Note: Items that are shaded have been subject to testing documented in this report. Opinions expressed regarding application of test results to variant models are not part of our current accreditation.

EUT1 description Tag-H00, a root variant of the product containing all possible functionality:

Firmware version: v0.5.0

S/N: 0009269a43c

The model tested has a PCB version **where every possible function** (except telemetry and external temperature sensor) **is implemented both in HW and SW**. It is a worst case model that will not be mass produced but represents all the variants that are made commercially available.

	Ultrasound receiver	125kHz low frequency receiver	WiFi	Accelerometer	Tamper detection	Internal temperature sensor (on main PCB)
Tag-H000	X	X	X	x	-	x

Table 1 Tag-H EUT 1 functionality

EUT2 description Tag-H150, external temperature sensor:

Firmware version: v0.5.0

S/N: 00096203d07b

The model tested is the one with external temperature sensor, Tag-H150. The sensor PCB used to connect the external sensor to the tag main PCB is the same in case of external temperature sensor and telemetry.

	Ultrasound receiver	125kHz low frequency receiver	WiFi	Accelerometer	Tamper detection	External temperature sensor	Telemetry (Binary status via cable)
Tag-H150	-	X	X	-	-	x	-

Table 2 Tag-H EUT2 functionality

The full list of Tag-H models that these two EUTs represent is given in Table 3:

Product	Ultrasound receiver	125kHz low frequency receiver	WiFi	Accelerometer	Mechanical tamper detection (tamper pin)	Temperature sensor	Telemetry (Binary status via cable)
Tag-H120	X	X	X				
Tag-H122	X	X	X	X			
Tag-H130	X	X	X		X		
Tag-H135		X	X				X
Tag-H140	X	X	X			X (on PCB)	
Tag-H150		X	X			X (External, via a cable)	

Table 3 List of Tag-H models covered by the EMC testing

3 TEST RESULTS

3.1 Power Line Conducted Emissions

Para. No.: 15.207 (a)

Test Performed By: -	**Date of Test: -**

Measurement procedure: **ANSI C63.4-2014 using 50 μH/50 ohms LISN.**

Test Results: **N/A**

Measurement Data:

3.2 Minimum 20 dB Bandwidth

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

Test Performed By: G.Suhanthakumar	**Date of Test: 2016.02.10**

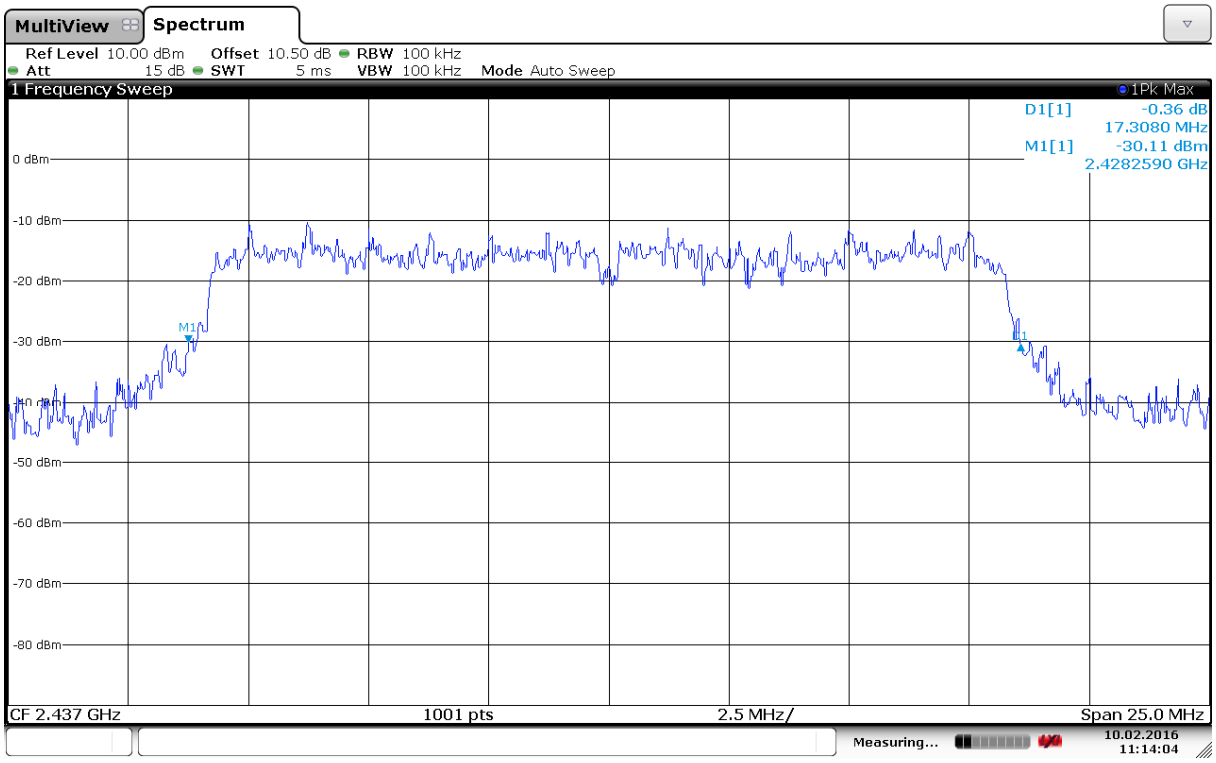
Test Results: Complies

Measurement Data:

Measured 20 dB Bandwidth (MHz)		
-	**2427 MHz, Ch 6**	**-**
-	17.3	-

Requirements:

No requirements, just for information.



Date: 10.FEB.2016 11:14:04

20 dB BW, Ch2437MHz

3.3 Peak Power Output

Para. No.: 15.247 (b)

Test Results: Complies

Measurement Data:

	2412 MHz	2437 MHz	2462 MHz
Conducted Power (dBm)	8.06	8.26	8.21
Conducted Power (Watts)	0.0064	0.0067	0.0066

See attached graph.

Detachable antenna? ☐ Yes ☒ No

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

Type of antenna connector: N/A

Requirements:

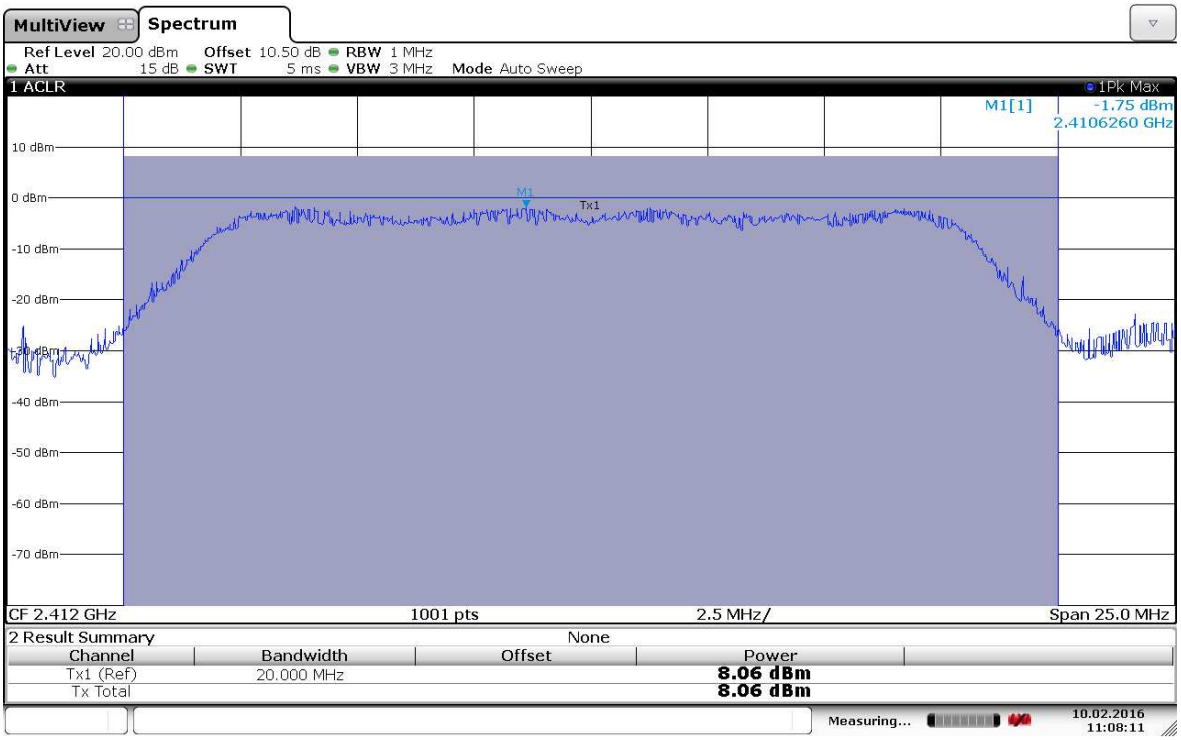
The maximum peak output power shall not exceed the following limits:

For frequency hopping systems employing at least 75 hopping channels: 1 Watt

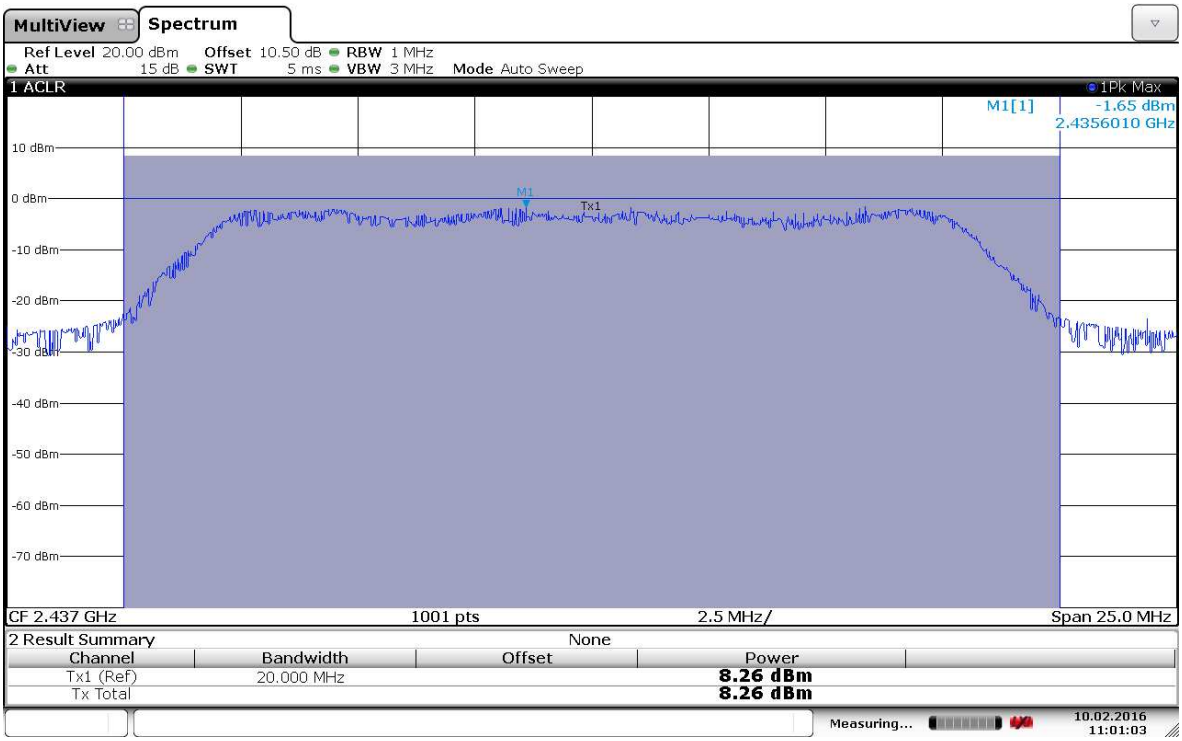
For all other frequency hopping systems in the 2400 - 2483.5 MHz band: 0.125 Watts

For Digital Transmission Systems in the 2400 - 2483.5 MHz band: 1 Watt

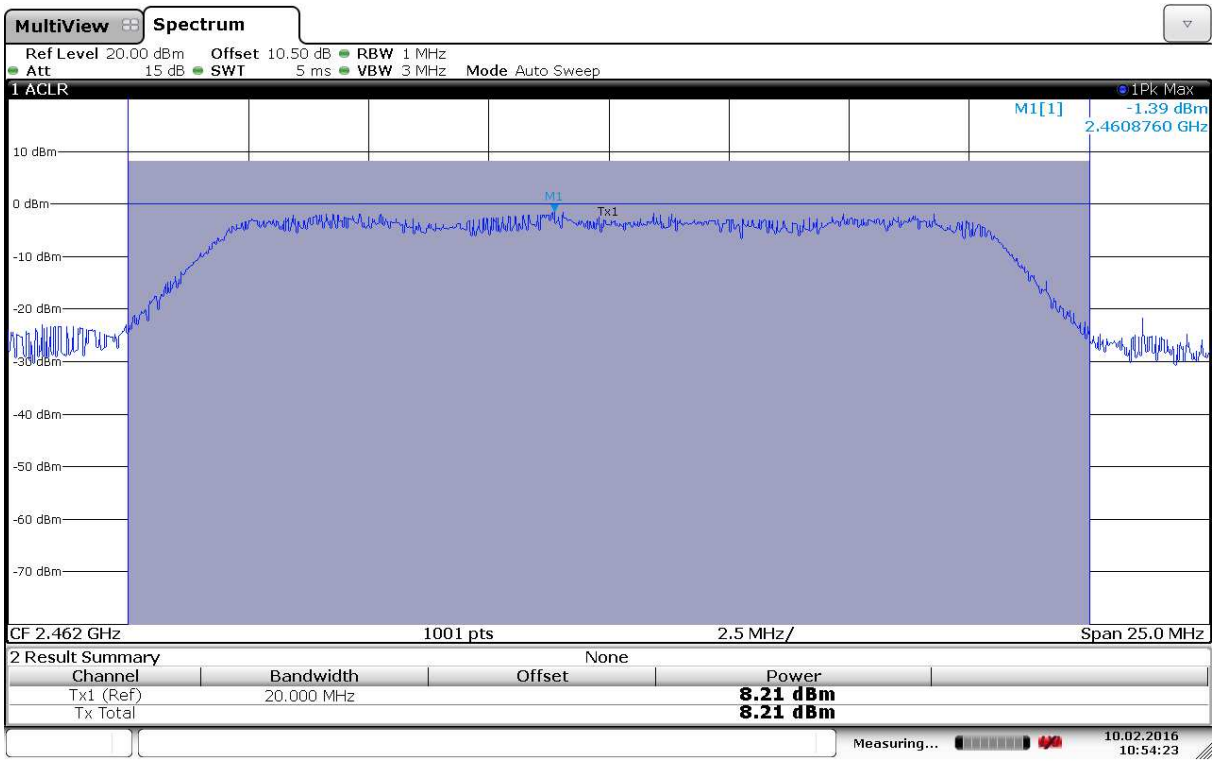
If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.



Conducted power 2412 MHz, ch01



Conducted power 2437 MHz, ch06



Conducted power 2462 MHz, ch11

3.4 Spurious Emissions (Radiated)

Para. No.: 15.247 (c)

Test Results: Complies

Measurement Data:

Band-edge conducted power

	Measured field strength (dBµV/m)		Limit	Margin	
	2390 MHz	2483.5 MHz	dBµV/m	dB	
Peak Detector	55.18	63.69	74	18.82	10.31
Average Detector	-	43.69	54	-	10.31

Average Detector values are measured with Peak Detector and corrected for Duty Cycle.

See attached plots.

Measured :

Duty Cycle Correction Factor Calculation:

Duty Cycle = 123.19µs / (123.19µs+5.076ms)

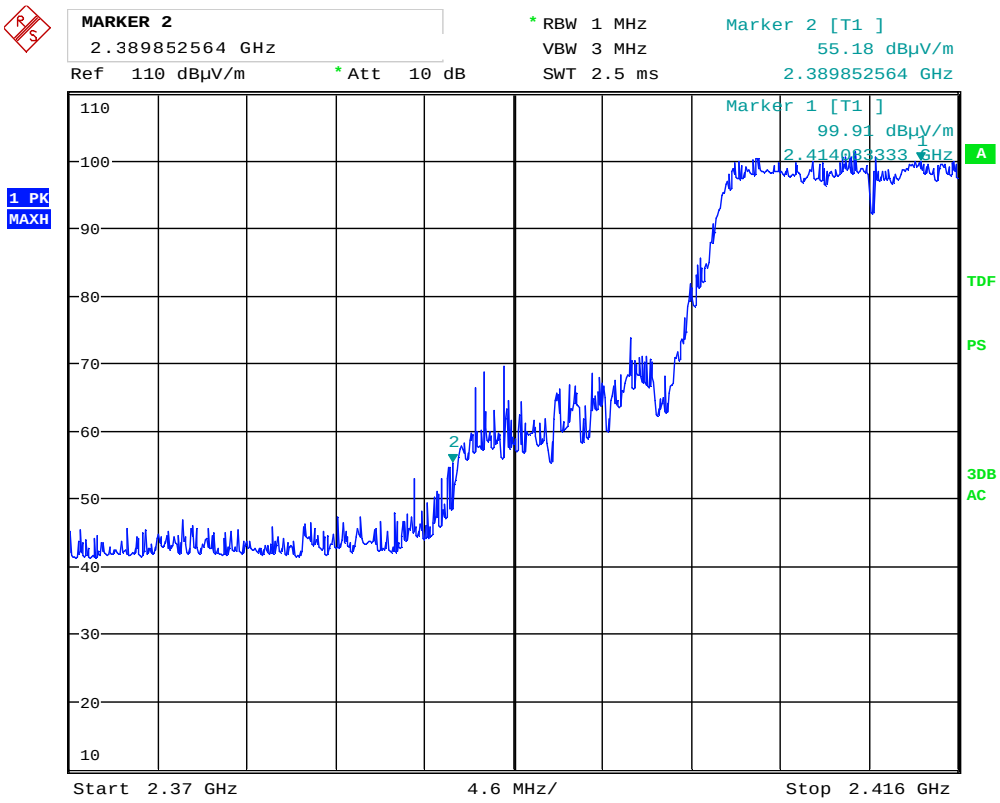
Duty Cycle Correction factor = -20 x log(0.0237) = 32.5 dB

Declared duty cycle by the manufacturer:

0.14% in normal use

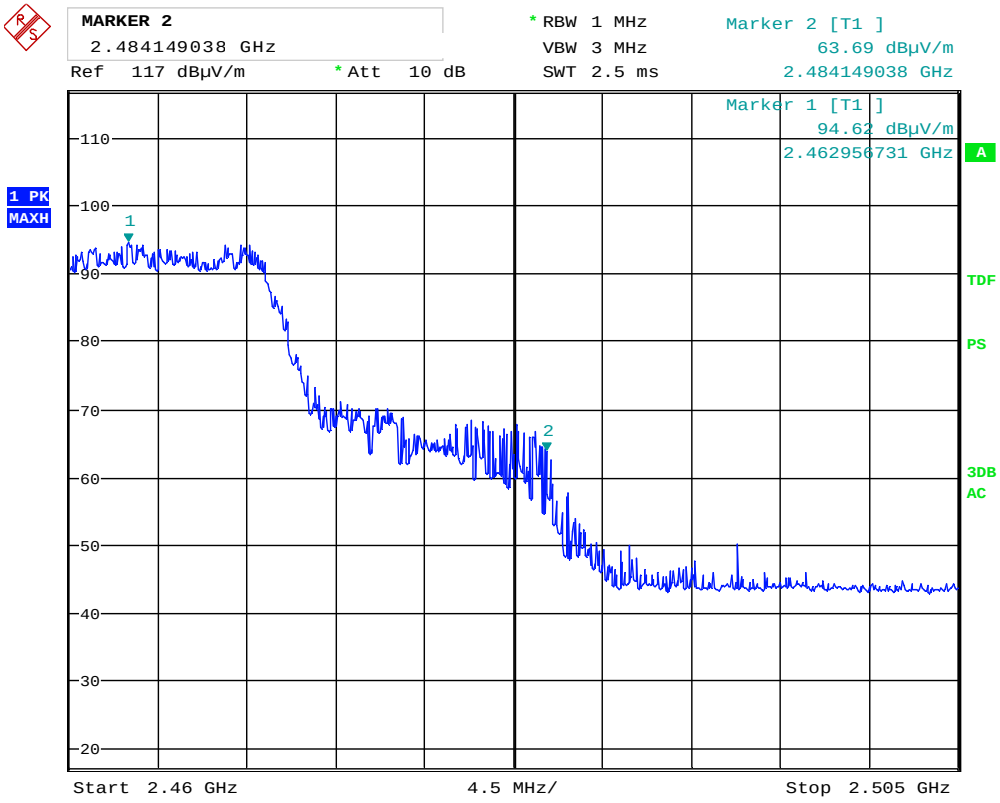
Duty Cycle Correction factor = -20 x log(0.014) = 37.1 dB

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



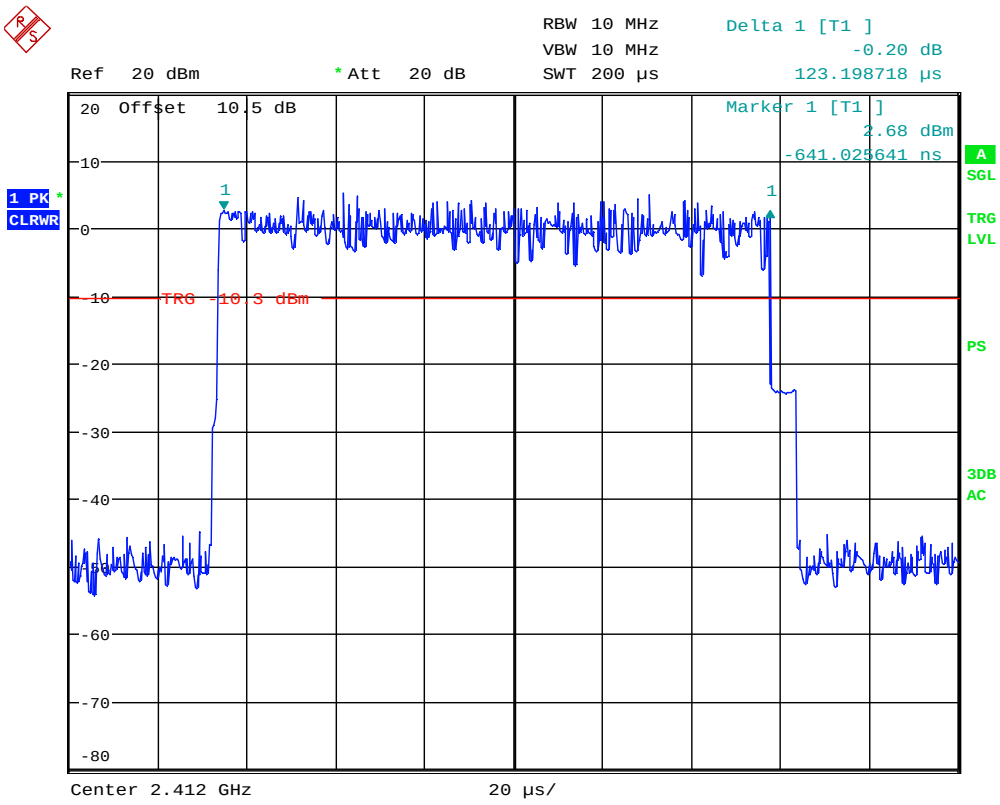
Date: 4.FEB.2016 11:15:00

Lower Band Edge, Ch01, 2412MHz, PK



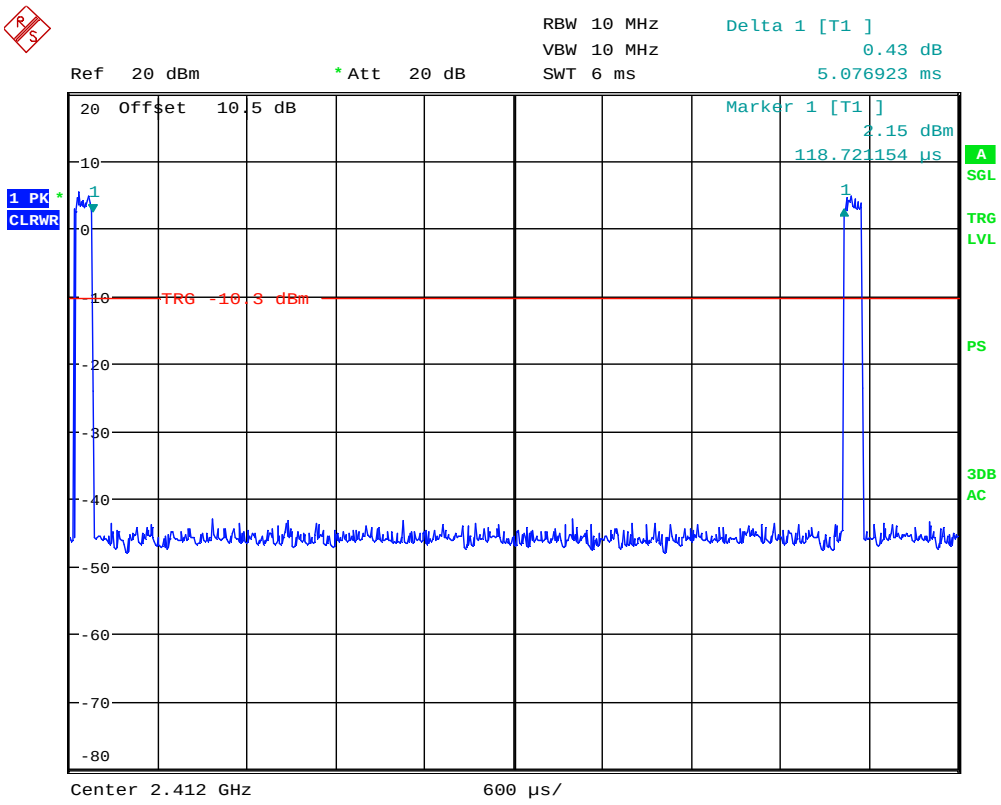
Date: 4.FEB.2016 13:49:27

Upper Band Edge ch11, 2462MHz, PK



Date: 4.FEB.2016 08:37:35

Burst ON-time



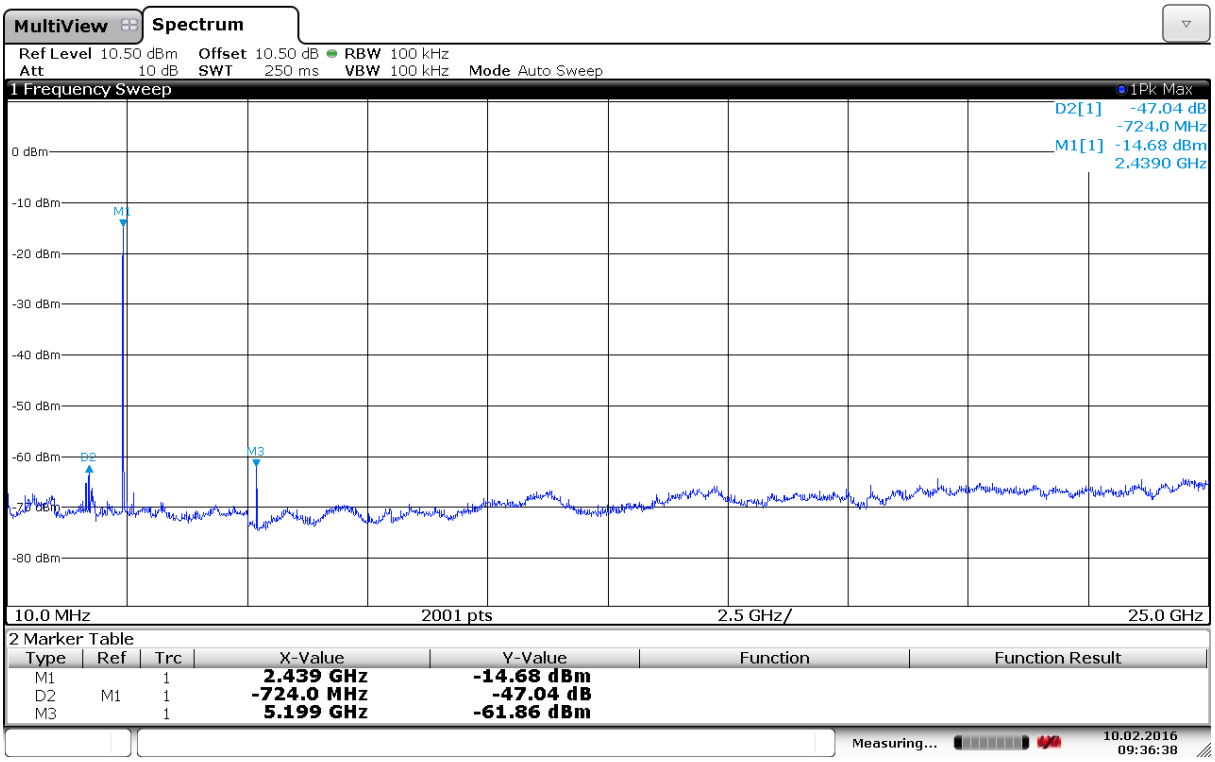
Date: 4.FEB.2016 08:39:16

Burst OFF-time

RF conducted power to 25 GHz see attached graph.

Maximum RF level outside operating band:

RF ch ch01, ch06 & ch11: 47 dB/C, margin >20 dB



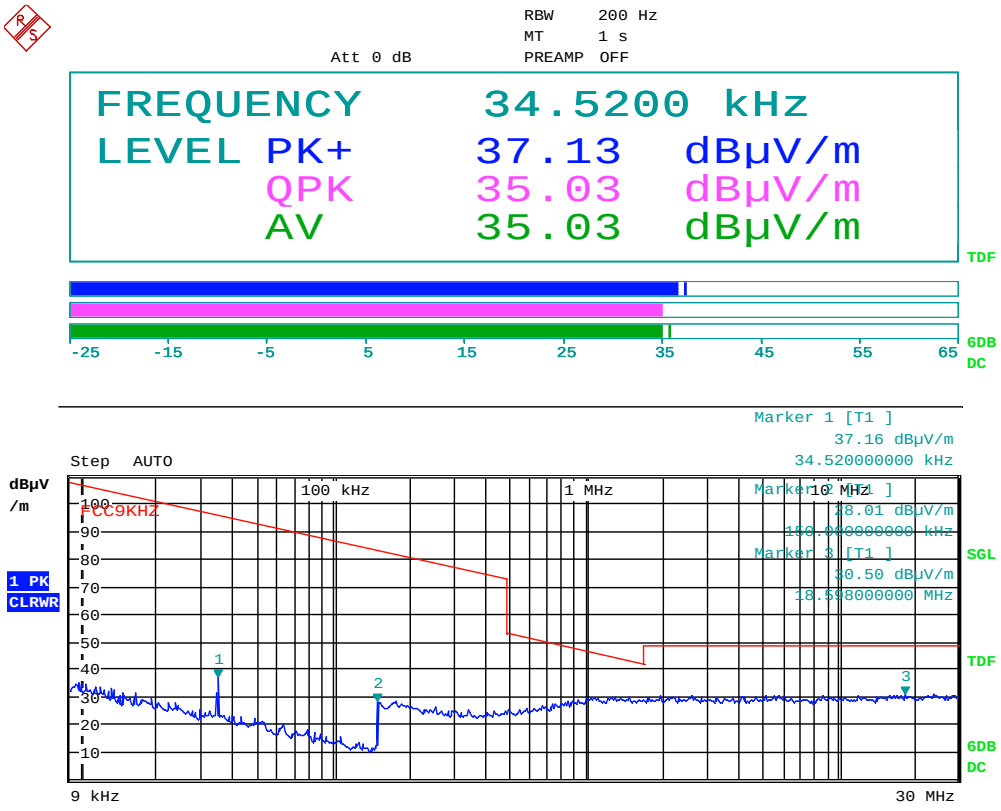
Conducted spurious emissions, 10MHz – 25GHz

Radiated emissions 10 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: 10.JUN.2015 08:40:49

Radiated emission 30 – 1000 MHz.

Detector: Quasi-Peak

Measuring distance 3 m according to ANSI C63.4-2014.

All values are below the limit even when measured with Peak Detector.

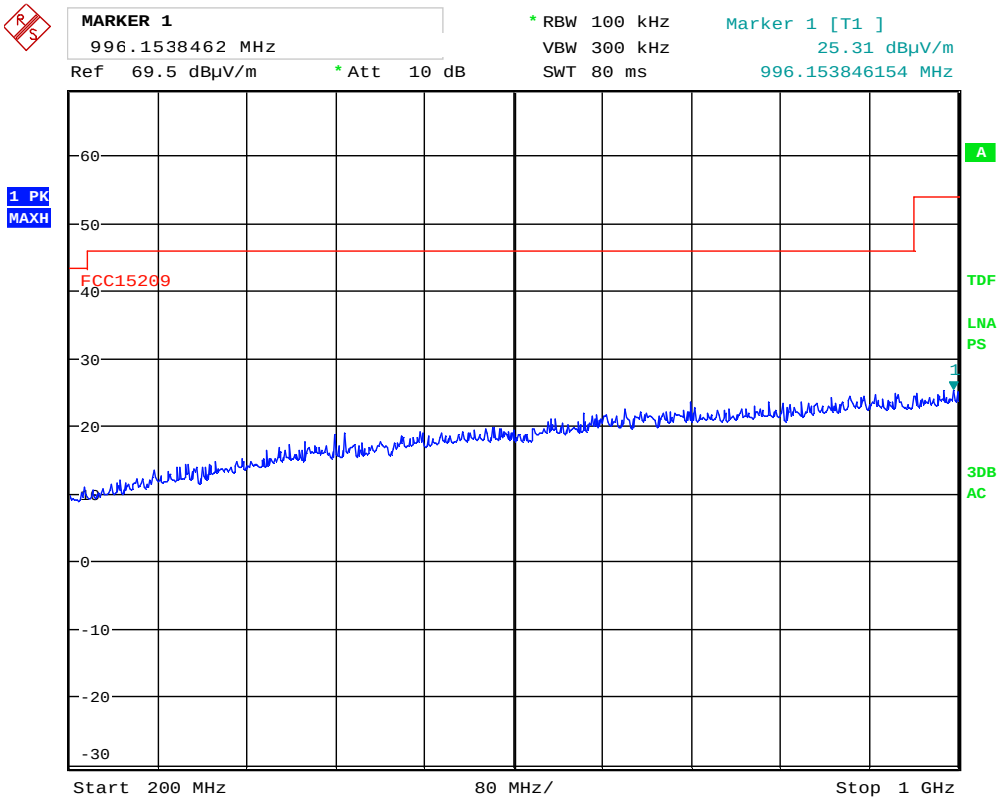
Frequency	Operational condition	Field strength	Measuring distance	Limit FCC15.209	Margin
MHz		dBµV/m	metres	dBµV/m	dB
All freqs	TX on	/	3	/	>10

Tested only with Peak Detector.

See attached graphs.

Antenna factor, amplifier gain and cable loss are included in Spectrum Analyzer “Transducer factor”.

See attached graphs.



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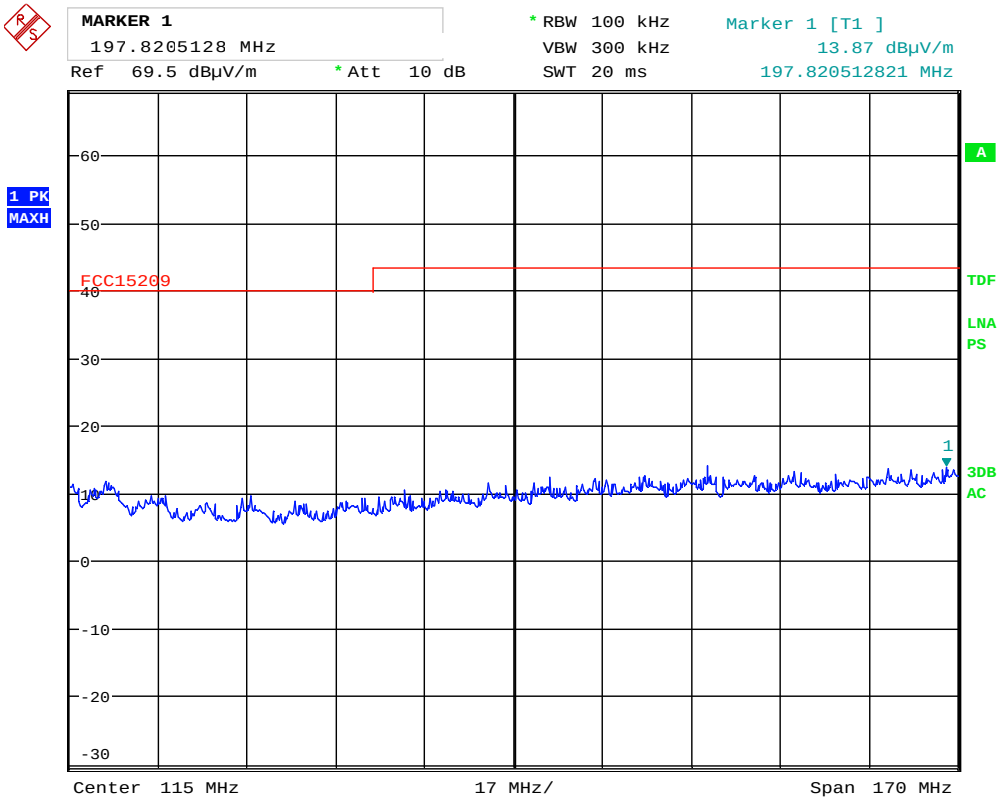
VP: 30 - 200MHz, Tag-H



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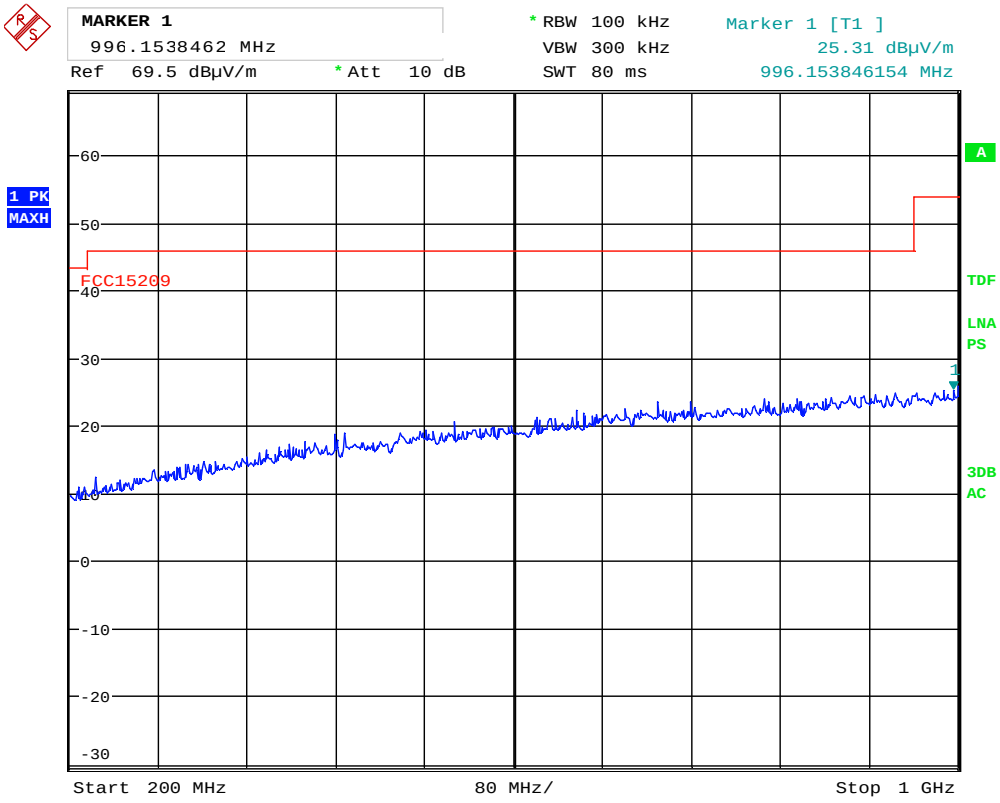
HP: 30 - 200MHz, Tag-H



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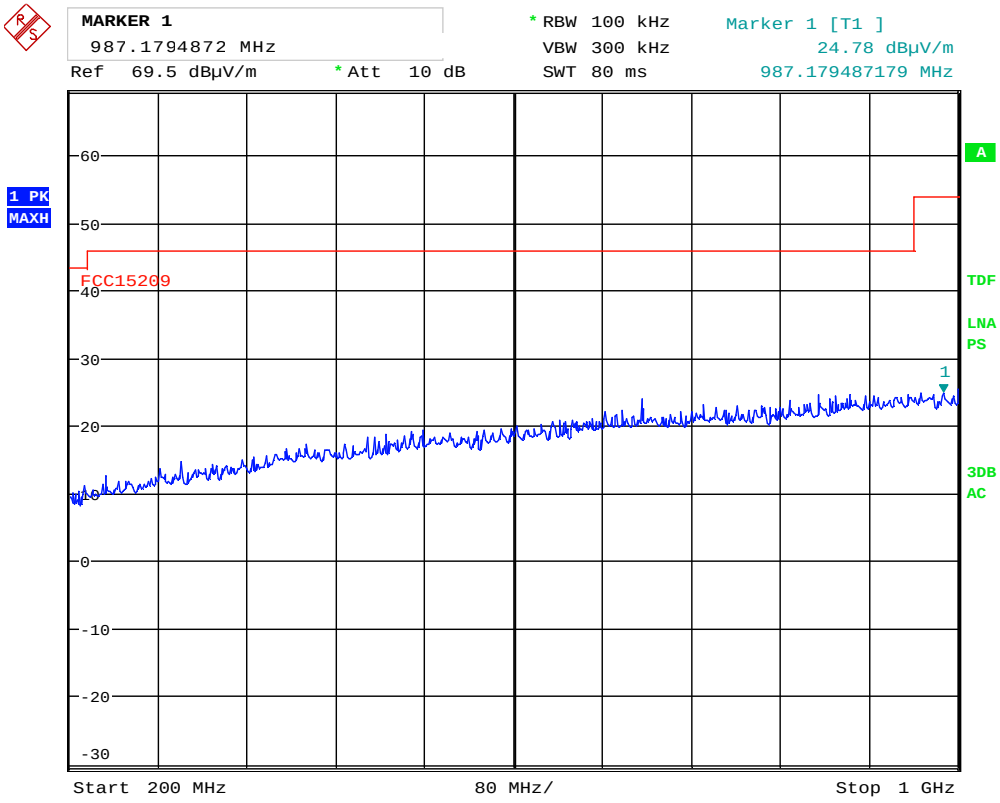
VP: 200 - 1000MHz, Tag-H



Date: 4.FEB.2016 16:40:29

HP: 200 - 1000MHz, Tag-H

Radiated Emissions, 1-25 GHz

Measuring distance: 3m (1 – 3 GHz)
1m (3 – 18 GHz)

A pre-scan was performed above 18 GHz, no spurious emissions were detected.

Peak Detector:

Frequency	RF channel	Dist. corr. factor	Field strength, Peak Detector, 1m	Duty cycle corr. factor	Limit	Margin
GHz	L,M,H	dB	dBµV/m	dB	dBµV/m	dB
4.824	L	-9.5*	37.63	0	74	>20
4.874	M	-9.5*	37.75	0	74	>20
4.924	H	-9.5*	37.61	0	74	>20
7.236	L	-9.5*	41.75	0	74	>20
7.311	M	-9.5*	40.90	0	74	>20
7.386	H	-9.5*	40.90	0	74	>20
Other freqs	L,M,H	-9.5*	None detected	0	74	>20

Average Detector:

Frequency	RF channel	Dist. corr. factor	Field strength, Peak Detector, 1m	Duty cycle corr. factor	Limit	Margin
GHz	L,M,H	dB	dBµV/m	dB	dBµV/m	dB
4.824	L	-9.5*	37.63	20	54	>30
4.874	M	-9.5*	37.75	20	54	>30
4.924	H	-9.5*	37.61	20	54	>30
7.236	L	-9.5*	41.75	20	54	>30
7.311	M	-9.5*	40.90	20	54	>30
7.386	H	-9.5*	40.90	20	54	>30
Other freqs	L,M,H	-9.5*	None detected	20	54	>30

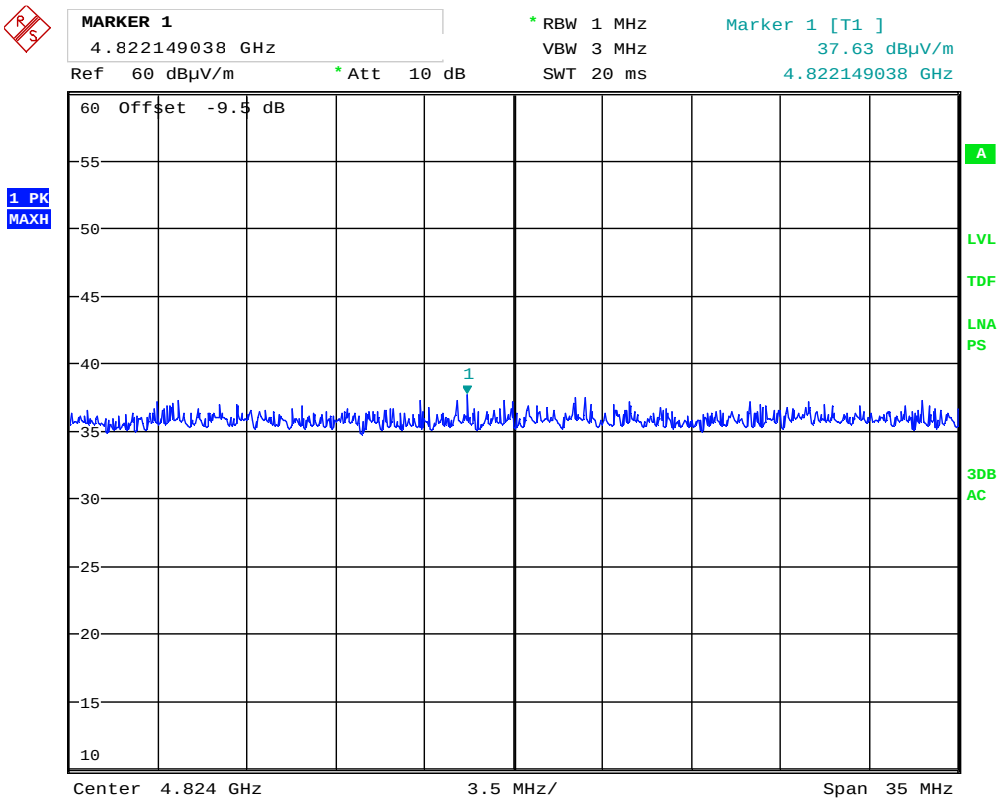
*distance correction is included in the measured value

EUT was positioned on a 1.5m high stand for all tests above 1 GHz.

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

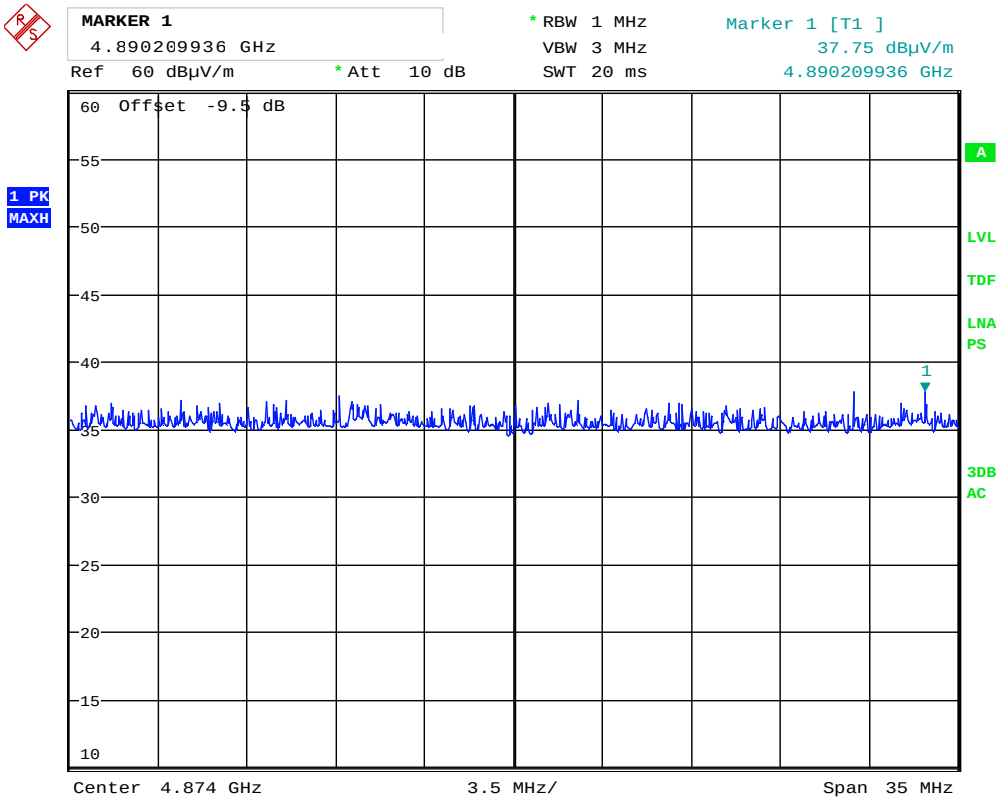
Antenna factor, amplifier gain and cable loss are included in spectrum analyzer “Transducer factor”.

See plots.



Date: 4.FEB.2016 15:28:17

VP: Ch01, 2412MHz, 2nd harmonic @1m (distance correction is given in the graph)



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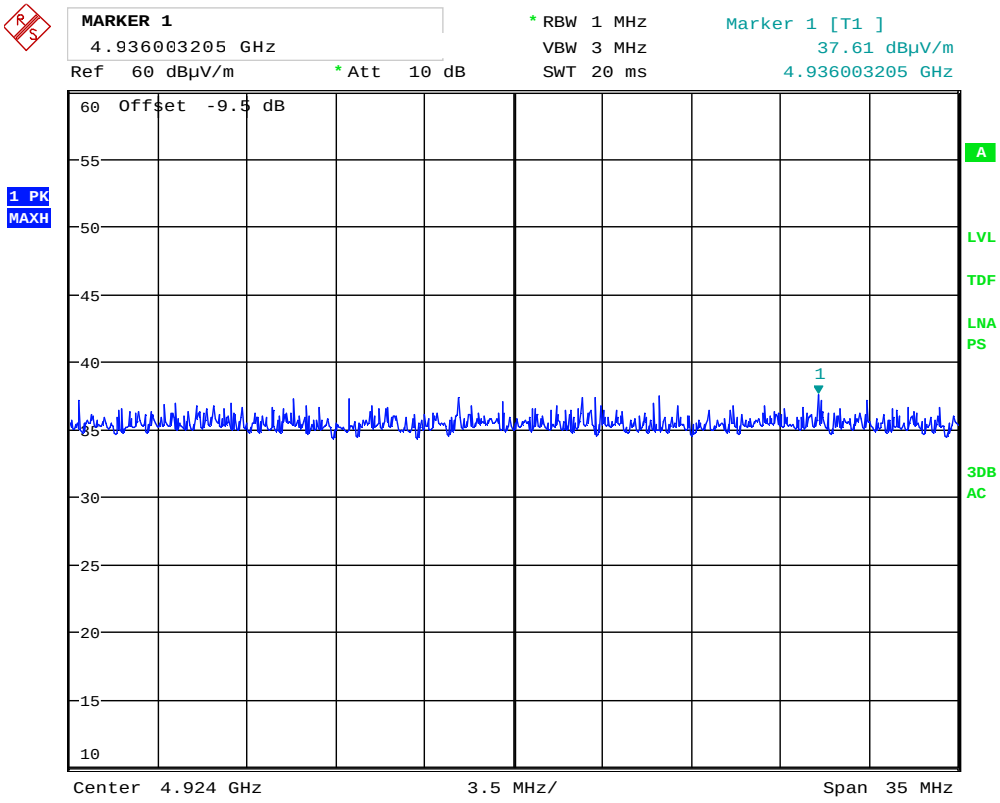
VP: Ch06, 2437MHz, 2nd harmonic @1m (distance correction is given in the graph)



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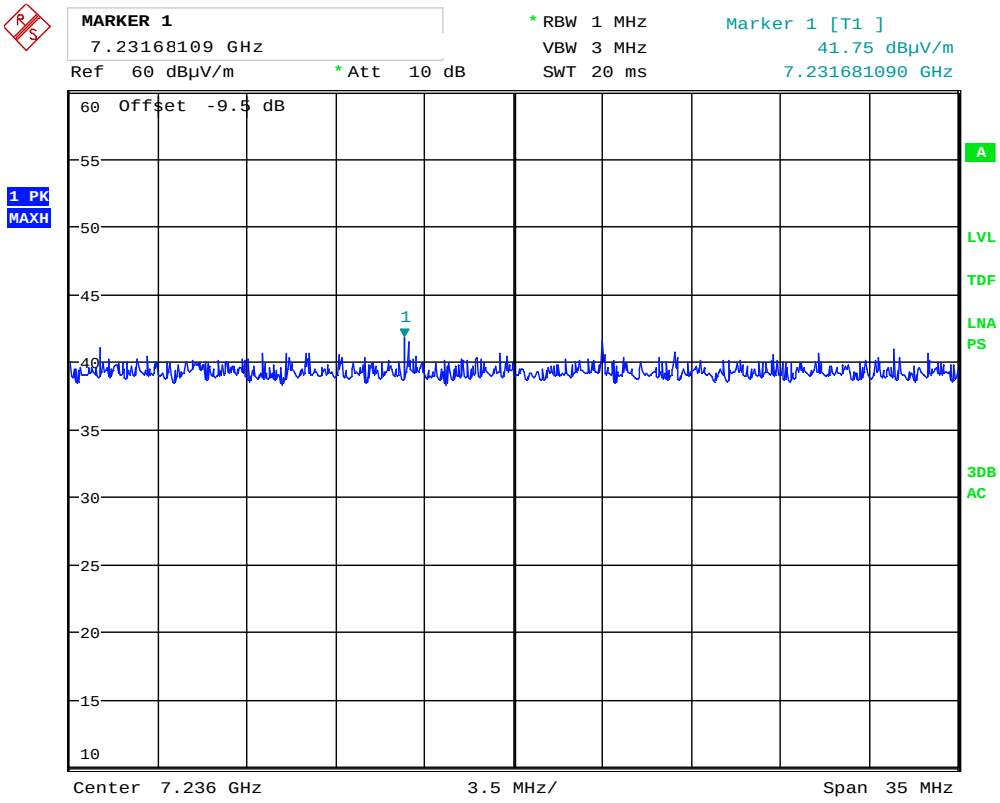
VP: Ch11, 2462MHz, 2nd harmonic @1m (distance correction is given in the graph)



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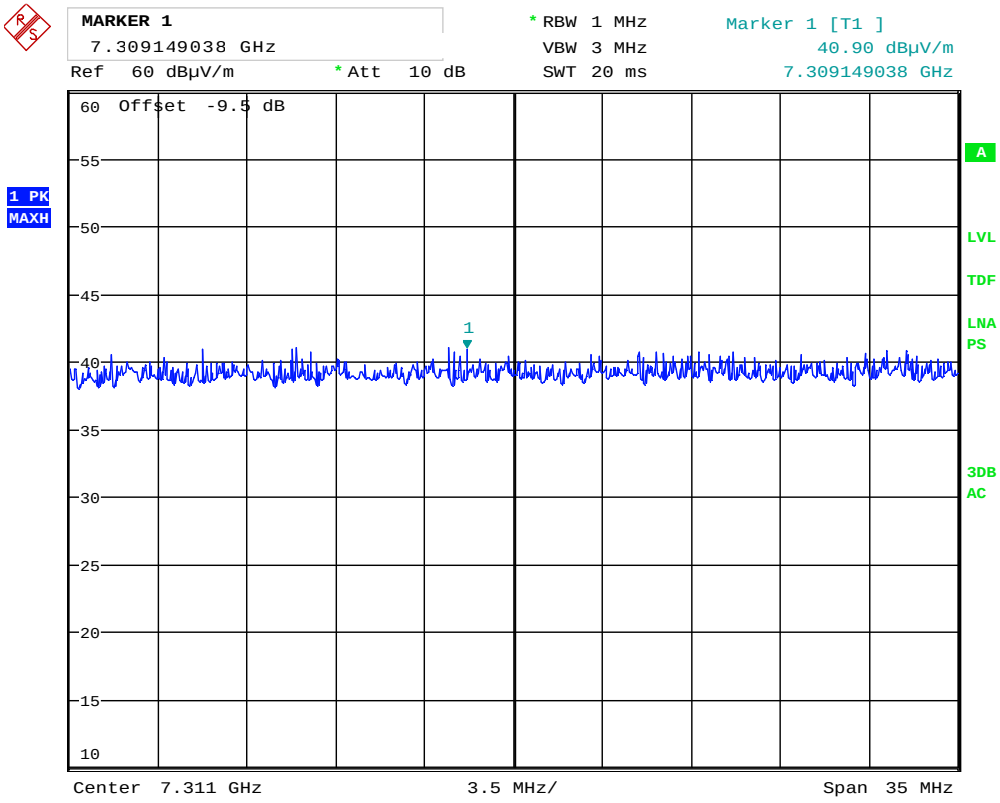
VP: Ch01, 2412MHz, 3rd harmonic @1m (distance correction is given in the graph)



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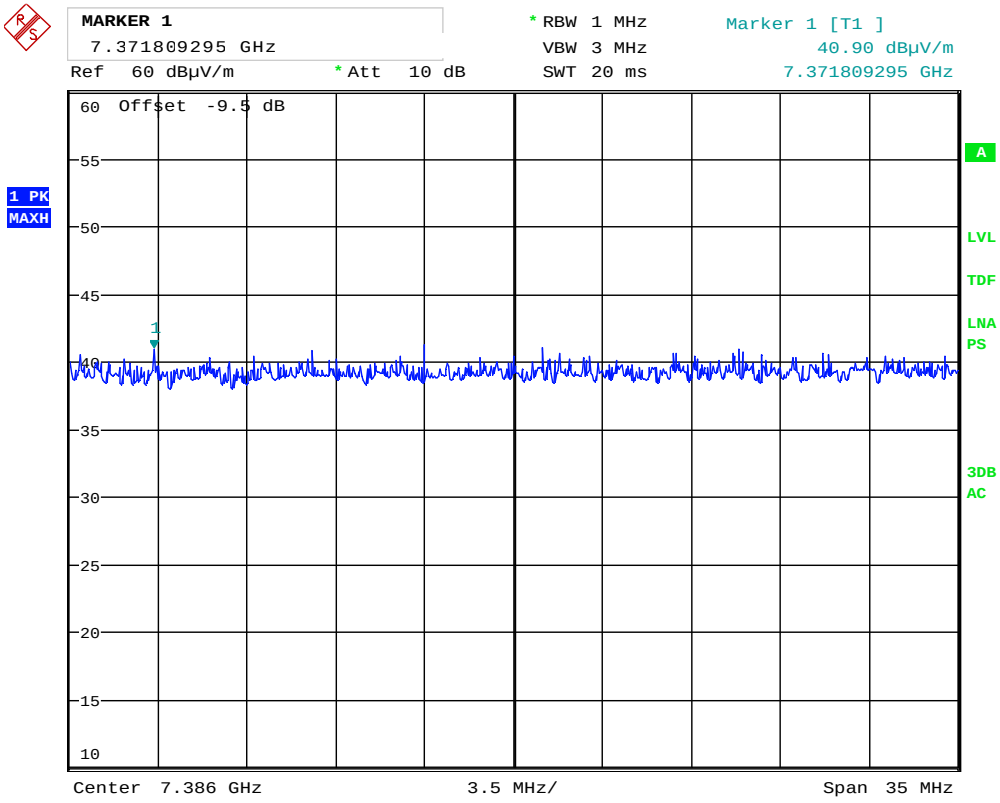
VP: Ch06, 2437MHz, 3rd harmonic @1m (distance correction is given in the graph)



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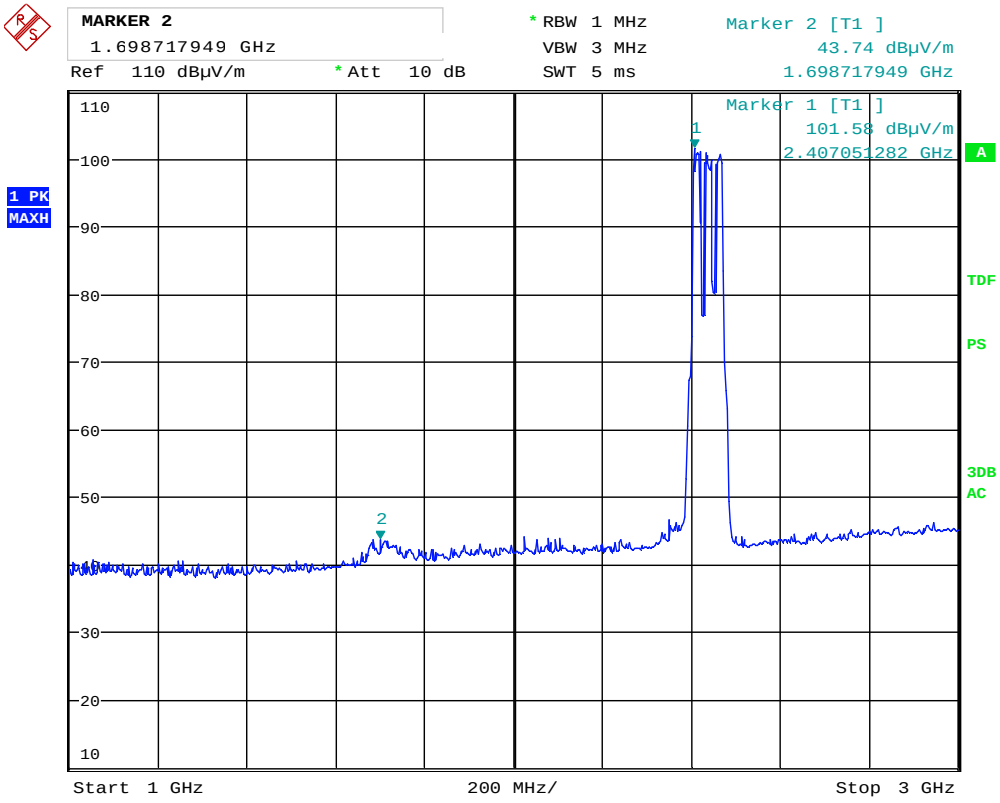
VP: Ch11, 2462MHz, 3rd harmonic @1m (distance correction is given in the graph)



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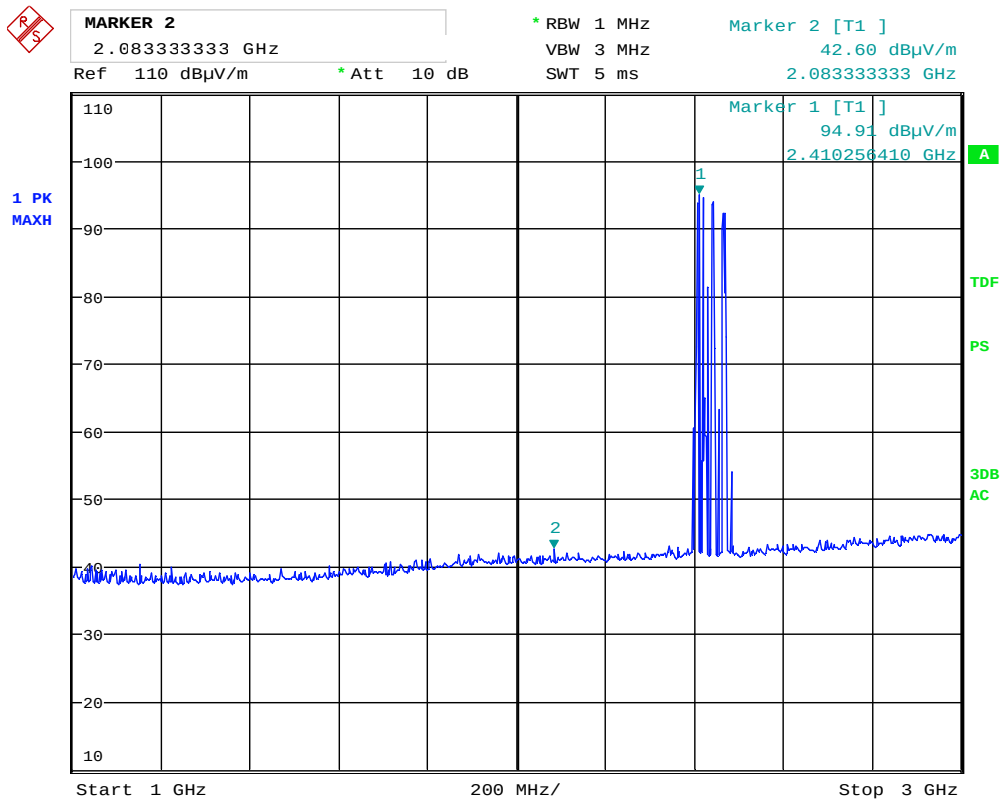
VP: Ch01, Ch06 & Ch11, 1 - 3GHz, Pk scan, @3m



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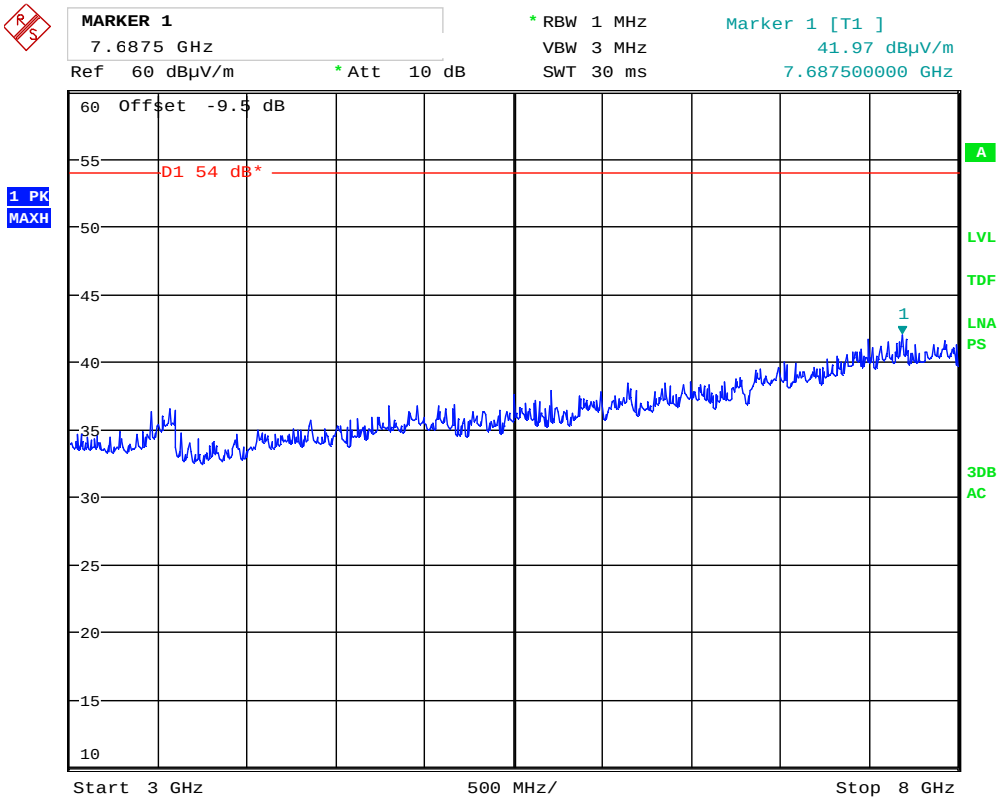
HP: Ch01, Ch06 & Ch11, 1 - 3GHz, Pk scan, @3m



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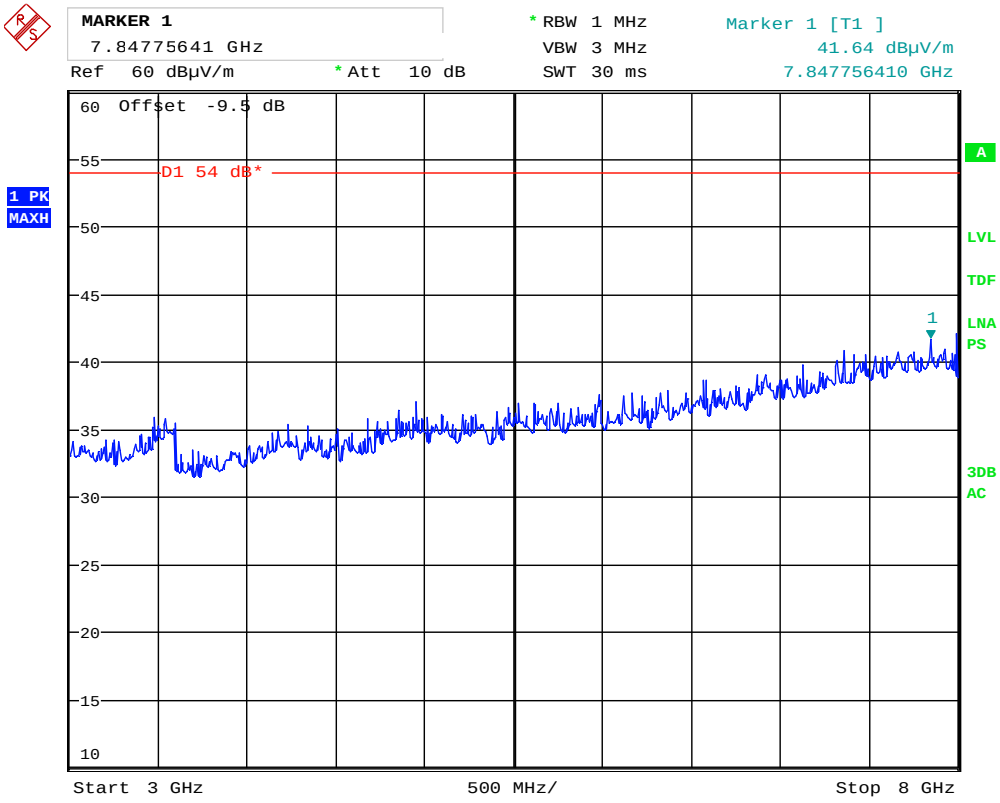
VP: Ch01, Ch06 & Ch11, 3 - 8GHz, Pk scan, @1m (distance correction is given in the graph)



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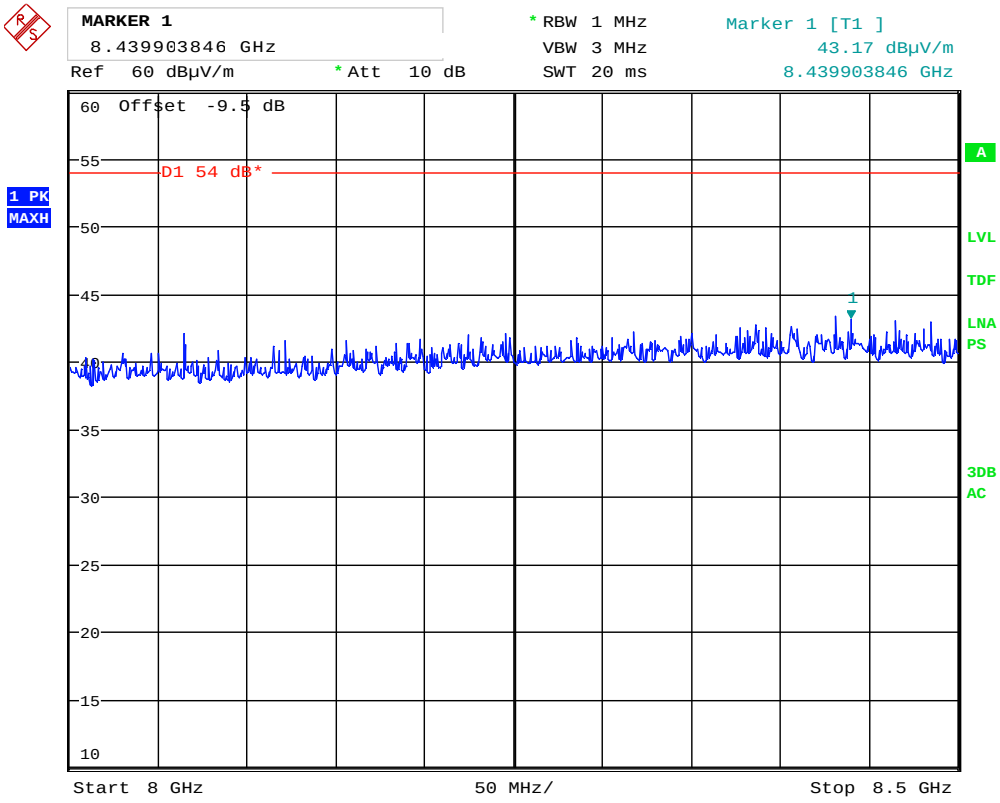
HP: Ch01, Ch06 & Ch11, 3 - 8GHz, Pk scan, @1m (distance correction is given in the graph)



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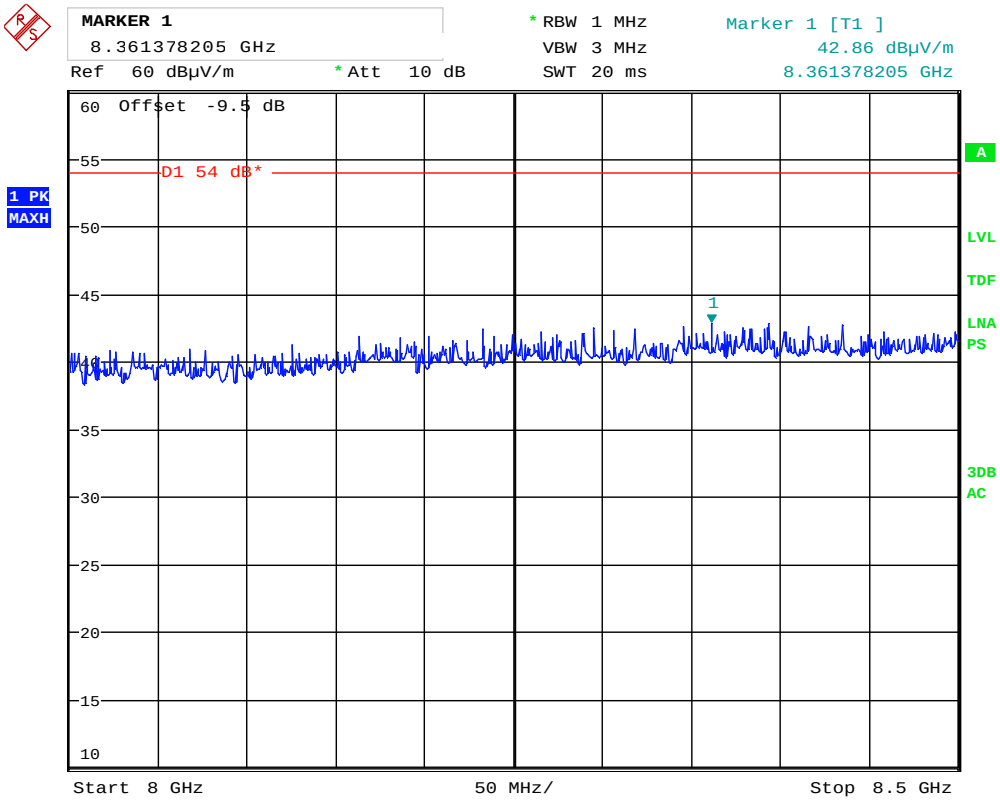
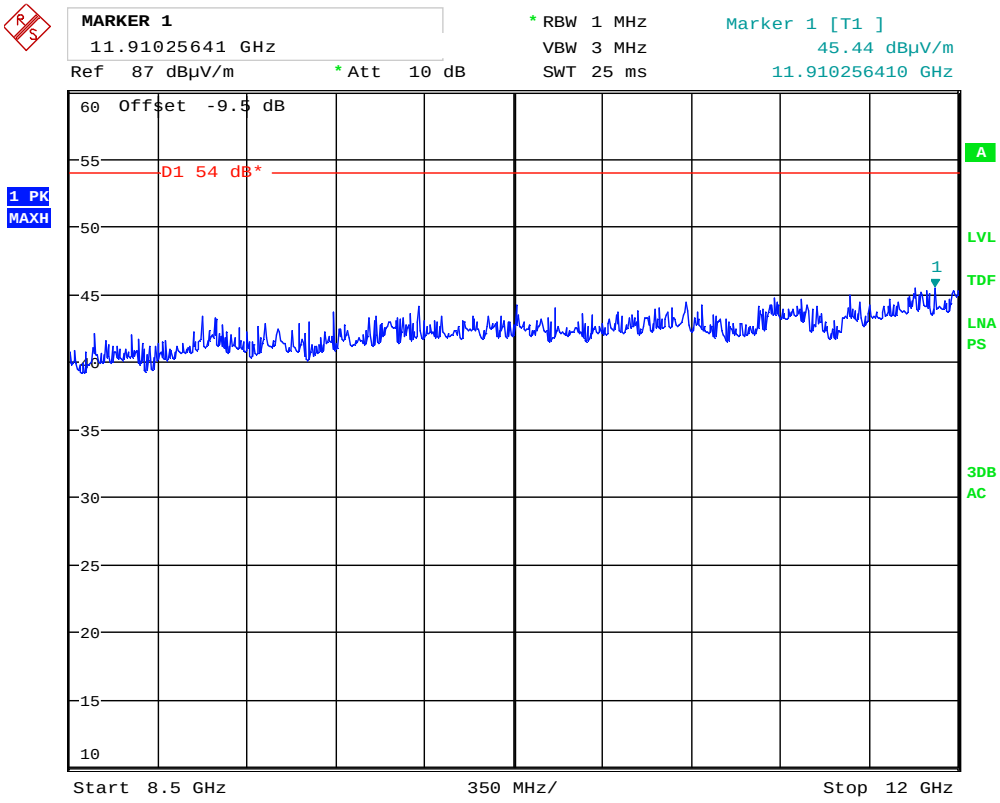


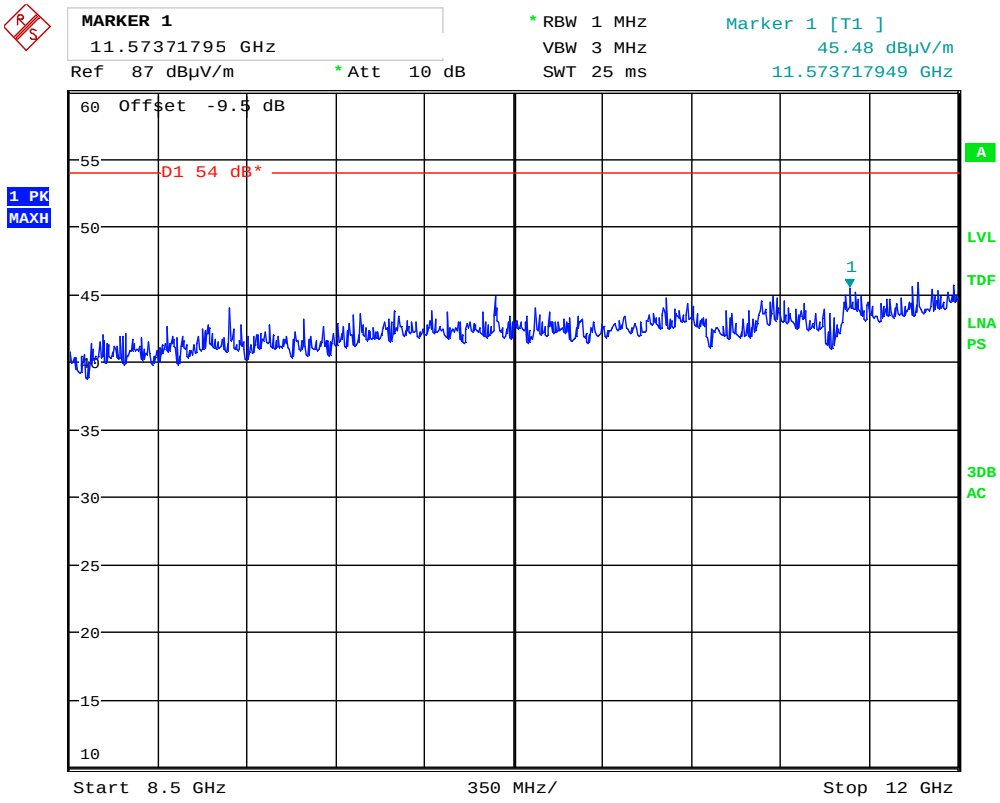
Date: 4.FEB.2016 16:18:12

HP: Ch01, Ch06 & Ch11, 8 - 8.5GHz, Pk scan, @1m (distance correction is given in the graph)



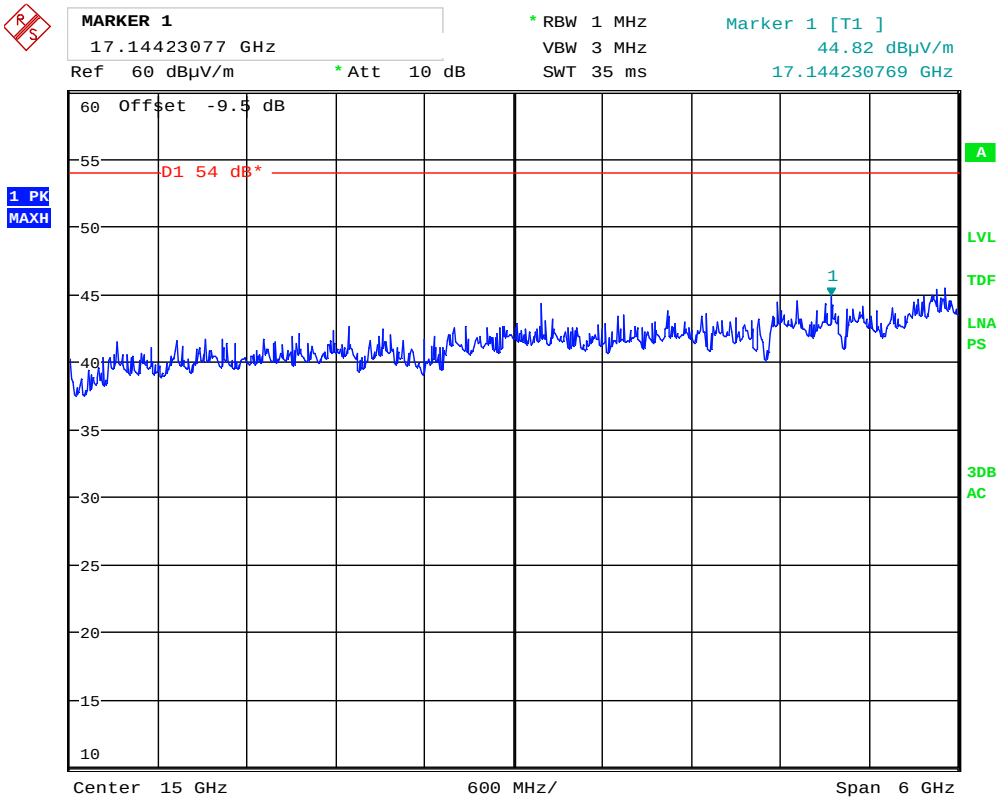
Date: 4.FEB.2016 16:01:20

VP: Ch01, Ch06 & Ch11, 8.5 - 12GHz, Pk scan, @1m (distance correction is given in the graph)



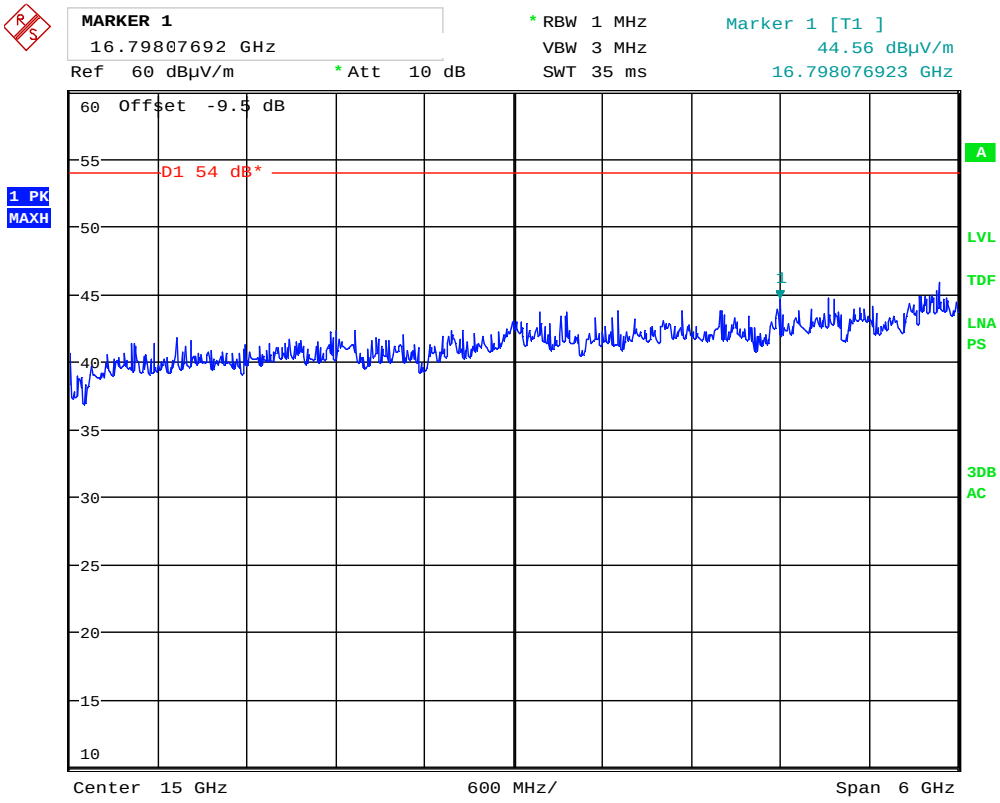
Date: 4.FEB.2016 16:02:13

HP: Ch01, Ch06 & Ch11, 8.5 - 12GHz, Pk scan, @1m (distance correction is given in the graph)



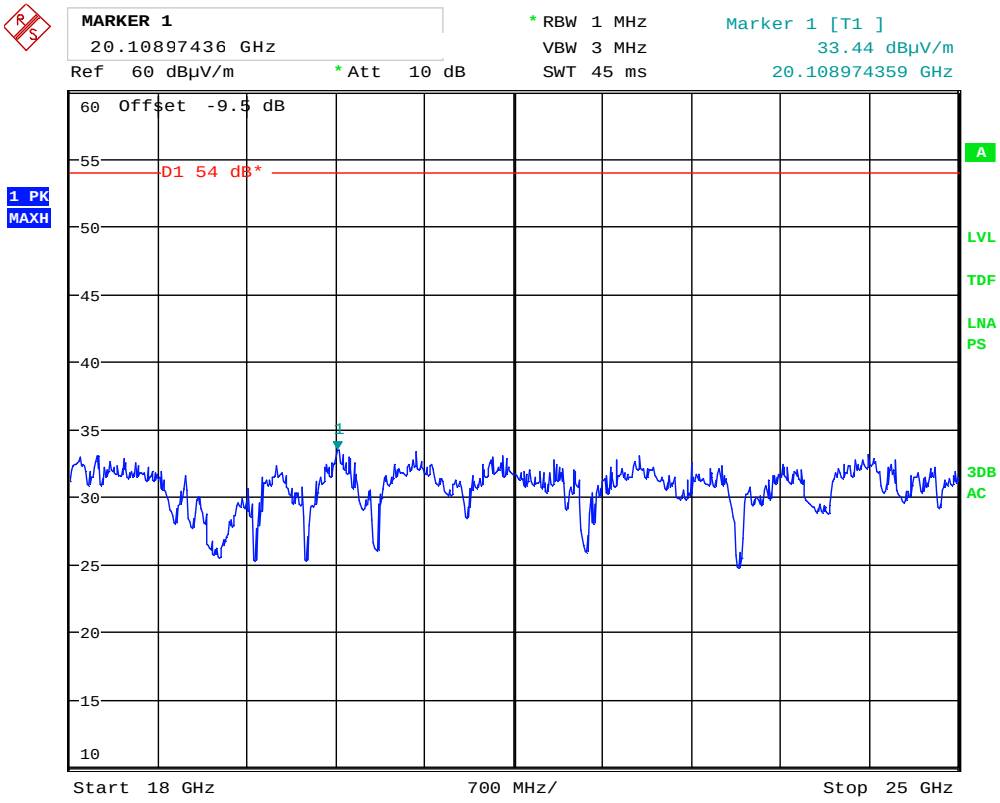
Date: 4.FEB.2016 16:04:10

VP: Ch01, Ch06 & Ch11, 12 - 18GHz, Pk scan, @1m (distance correction is given in the graph)



Date: 4.FEB.2016 16:04:45

VP: Ch01, Ch06 & Ch11, 12 - 18GHz, Pk scan, @1m (distance correction is given in the graph)



Date: 4.FEB.2016 16:13:11

VP/HP: Ch01, Ch06 & Ch11, 18 - 25GHz, Pre-Scan, @1m (distance correction is given in the graph)

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

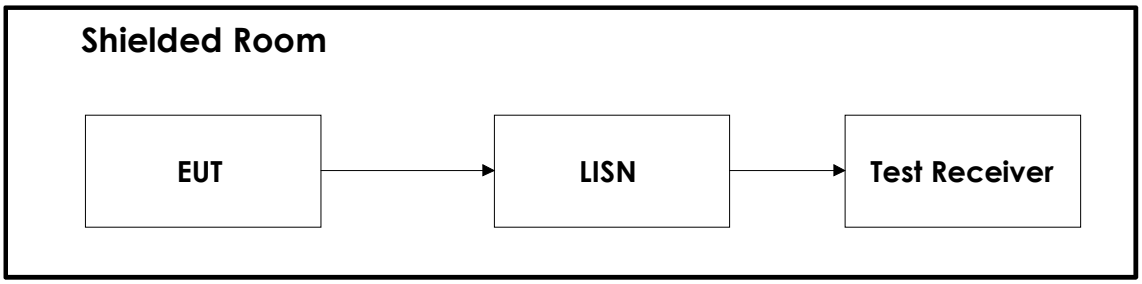
5 LIST OF TEST EQUIPMENT

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.

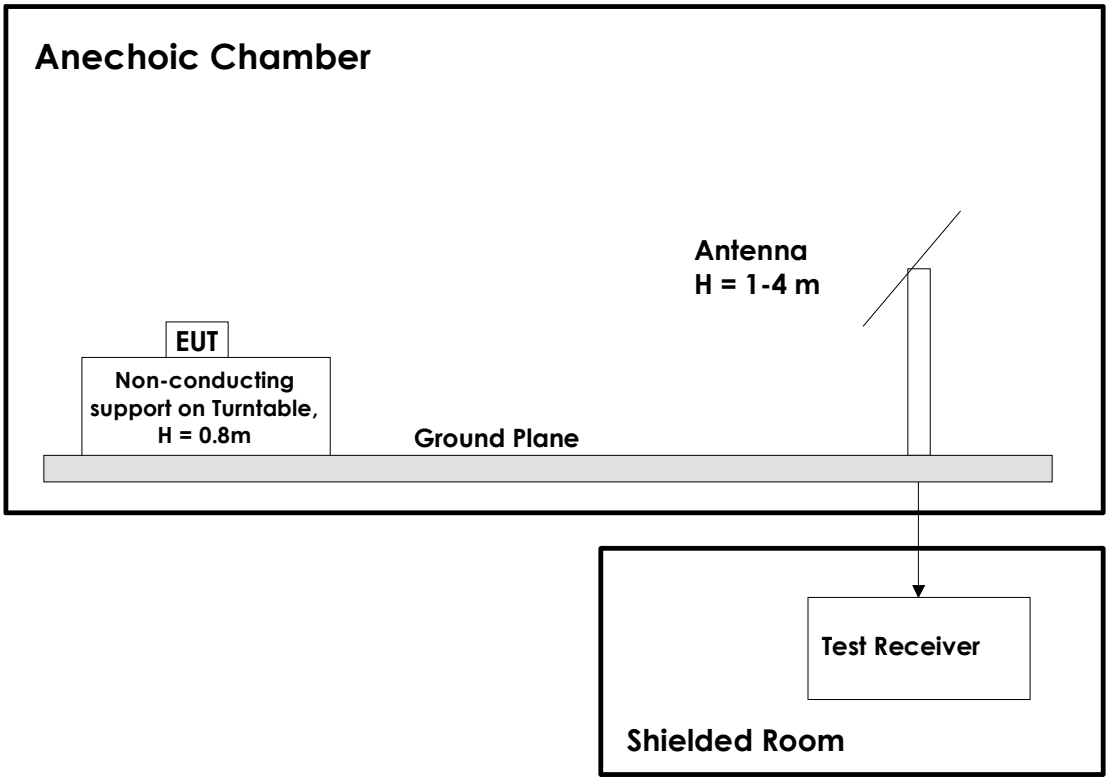
No.	Instrument/ ancillary	Type of instrument/ ancillary	Manufacturer	Ref. no.	Cal. Date	Cal. Due
1.	ESU40	EMI Receiver	Rohde & Schwarz	LR1639	2015.11	2016.11
2.	FSW26	Spectrum Analyzer	Rohde & Schwarz	LR 1640	2015.11	2017.11
3.	HFH2-Z2	Loop antenna	Rohde & Schwarz	LR1660	2014.10	2017.10
4.	3115	Antenna horn	EMCO	LR 1330	2010.08	2017.08
5.	HK116	Biconical Antenna	Rohde & Schwarz	LR 1260	2013.12	2016.12
6.	HL223	Log Periodic antenna	Rohde & Schwarz	LR 1261	2013.12	2016.12
7.	643	Antenna Horn	Narda	LR 093	2009.01	2017.01
8.	PM7320X	Antenna Horn	Sivers Lab	LR 102	2009.01	2017.01
9.	DBF-520-20	Antenna Horn	Systron Donner	LR 100	2009.01	2017.01
10	638	Antenna Horn	Narda	LR 1480	2009.01	2017.01
11	4768-10	Attenuator	Narda	LR 1773	Cal b4 use	
12	6HC3000/18000	Highpass Filter	Trilithic	LR 1614	Cal b4 use	
13	8449B	Pre-amplifier	Hewlett Packard	LR 1322	2015.09	2016.09
14	HP 10855A	Pre-amplifier	Hewlett Packard	LR 1445	2015.10	2016.10
15	Model 87 V	Multimeter	Fluke	LR 1597	2015.10	2016.10

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission



Revision history

Version	Date	Comment	Sign
1	2016.02.10	Test report	GNS
2	2016.03.02	Editorial corrections	FS