Test report no. : 230524-3

Item tested : CC2538EM

Type of equipment : 2.4 GHz Transceiver

FCC ID : ZAT2538EM

Client : Texas Instruments Norway AS

FCC Part 15.247
Digital Transmission System

RSS-210, Issue 8
Low Power Licence-Exempt
Radiocommunication Devices

11 March 2013

Authorized by : .....
Frode Sveinsen
Technical Verificator

CONTENTS

1 GENERAL INFORMATION

1.1 Testhouse Info

Name :	Nemko AS
Address :	Nemko Kjeller Instituttveien 6, Box 96 NO-2027 Kjeller, NORWAY
Telephone :	+47 64 84 57 00
Fax :	+47 64 84 57 05
E-mail:	comlab@nemko.com
FCC test firm :	994405
IC OATS :	2040D-1
Total Number of Pages:	58

1.2 Client Information

Name :	Texas Instruments Norway AS
Address :	Gaustadalléen 21, NO-0349 Oslo, Norway
Telephone :	+47 22 95 85 44
Fax :	+47 22 95 85 46

Contact:

Name :	Dag Grini
Telephone :	+47 22 95 83 01
E-mail :	d.grini@ti.com

1.3 Responsible Manufacturer (If other than client)

Same as the client.

2 TEST INFORMATION

2.1 Test Item

Name :	Texas Instruments
FCC ID :	ZAT2538EM
IC :	451H-2538EM
Model/version :	CC2538EM
Serial number :	-
Hardware identity and/or version:	Rev 1.1.1
Software identity and/or version :	-
Frequency Range :	2405 – 2480 MHz
Number of Channels :	16
Type of Modulation :	250 kbps, OQPSK (Digital)
Conducted Output Power:	5.1 mW (Peak)
User Frequency Adjustment :	None
Type of Power Supply :	3.0V_{DC} (Two AAA 1.5 V_{DC} batteries)
Antenna Connector :	PCB antenna
Antenna Diversity Supported :	No
Desktop Charger :	None

Description of Test Item

The CC2538EM RF-transceiver module is an evaluation module developed for the 2.4 GHz ISM band. It is based on the CC2538 system on- chip device. The physical layer of the radio complies with the IEEE 802.15.4 standard with Direct Sequence Spread Spectrum (DSSS) and offset-QPSK modulation.

Exposure Evaluation

The EUT is exempted from RF Exposure Evaluation.

2.2 Test Environment

2.2.1 Normal test condition

Temperature:	19.6 – 21.5 °C
Relative humidity:	20.2 – 43.3 %
Normal test voltage:	Nominal 3.0 V DC (2 x AAA battery)

New batteries were used for all tests.

The values are the limit registered during the test period.

2.3 Test Period

Item received date:	2013-01-07
Test period :	from 2013-02-01 and 2013-03-04

3 TEST REPORT SUMMARY

3.1 General

Manufacturer: Texas Instruments

Model No.: CC2538EM

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-210 Issue 8.

Radiated tests were conducted in accordance with ANSI C63.4-2003. The radiated tests were made in a semi-anechoic chamber at measuring distances of 3m and 10m.

☒ 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".

TEST REPORT #: 230524-3

TESTED BY: _____ DATE: 2013-03-11

G.Suhanthakumar, Test engineer

3.2 Test Summary

Name of test	FCC Part 15 reference	RSS-210 Issue 8 reference	Result
Antenna Requirement	15.203	7.1.4 (RSS-GEN)	Pass
Power Line Conducted Emission	15.107(a) 15.207(a)	7.2.2 (RSS-GEN)	N/A*
Minimum 6 dB Bandwidth	15.247(a)(2)	A8.2	Pass
Peak Power Output	15.247(b)	A8.4	Pass
Power Spectral Density	15.247(d)	A8.2	Pass
Spurious Emissions (Antenna Conducted)	15.247(c)	A8.5	Pass
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	A8.5	Pass
Receiver Emissions (Radiated)	N/A	2.3	N/A

*EUT is battery operated only.

3.3 Description of modification for Modification Filing

Not applicable.

3.4 Comments

All ports were populated during spurious emission measurements.

3.5 Family List Rational

Not Applicable.

4 TEST RESULTS

4.1 Power Line Conducted Emissions

Para. No.: 15.207 (a)

The test is not applicable since the device is battery powered.

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

Measurement procedure: **ANSI C63.4-2003 using 50 µH/50 ohms LISN.**

Test Results: **-**

Measurement Data: **-**

4.2 Minimum 6 dB Bandwidth

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

Test Performed By: G.Suhanthakumar	**Date of Test: 18 Feb 2013**

Test Results: Complies

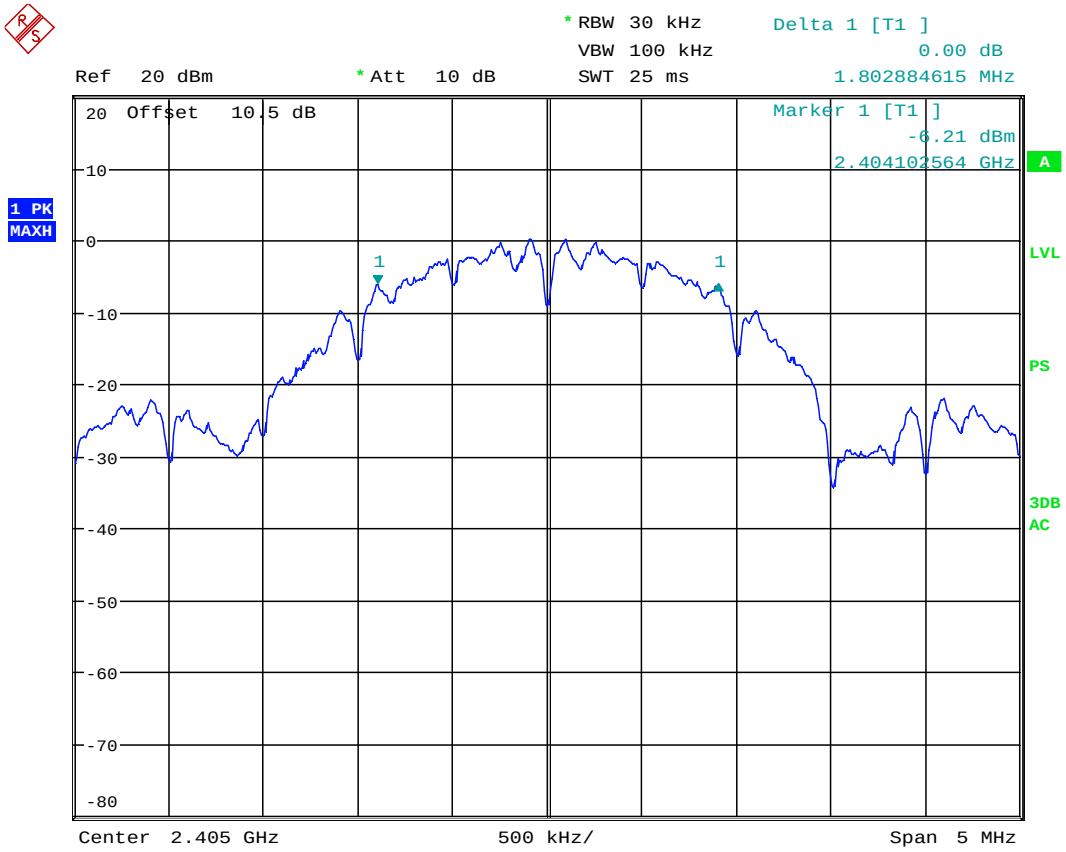
Measurement Data:

Measured 6 dB Bandwidth (MHz)		
2405MHz	**2440 MHz**	**2480MHz**
1.80	1.79	1.79

Tested according to KDB 558074 D01 DTS Meas Guidance v02, Section 7.1.

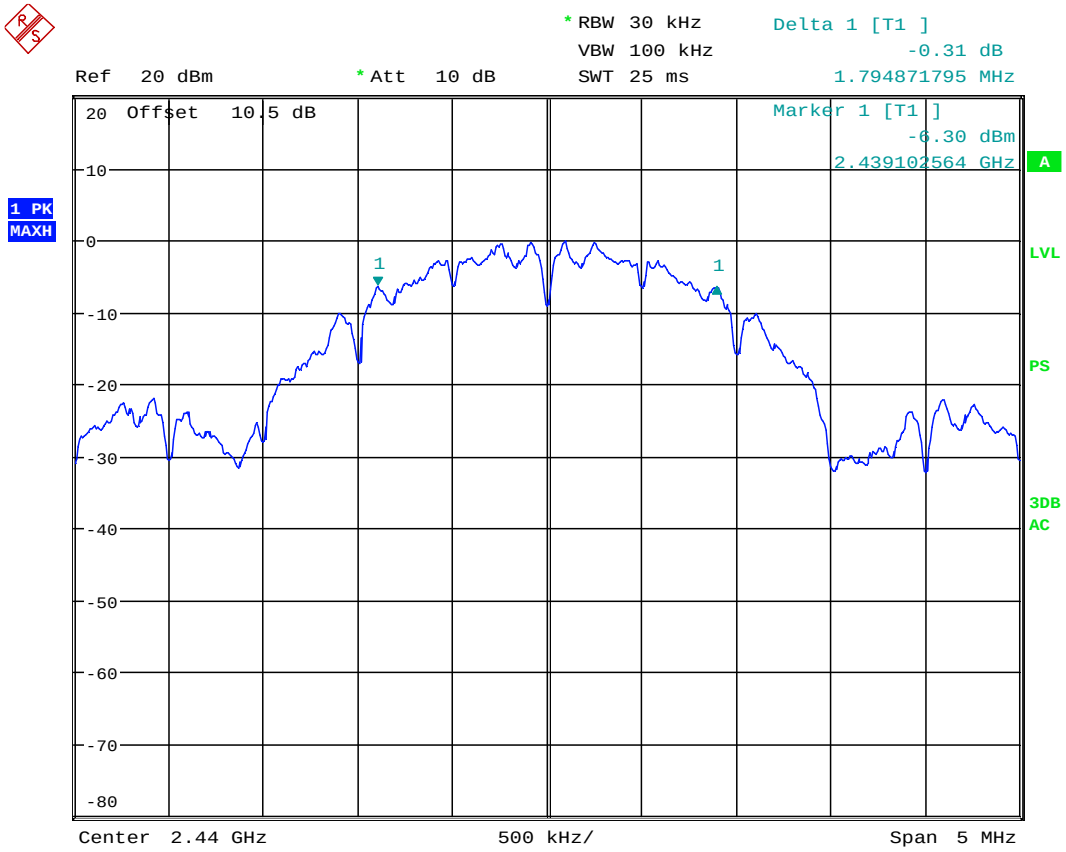
Requirements:

For Digital Transmission Systems in the 2400-2483.5 MHz band the minimum 6 dB bandwidth shall be at least 500 KHz.



Date: 18.FEB.2013 10:09:53

6 dB Bandwidth at 2405 MHz



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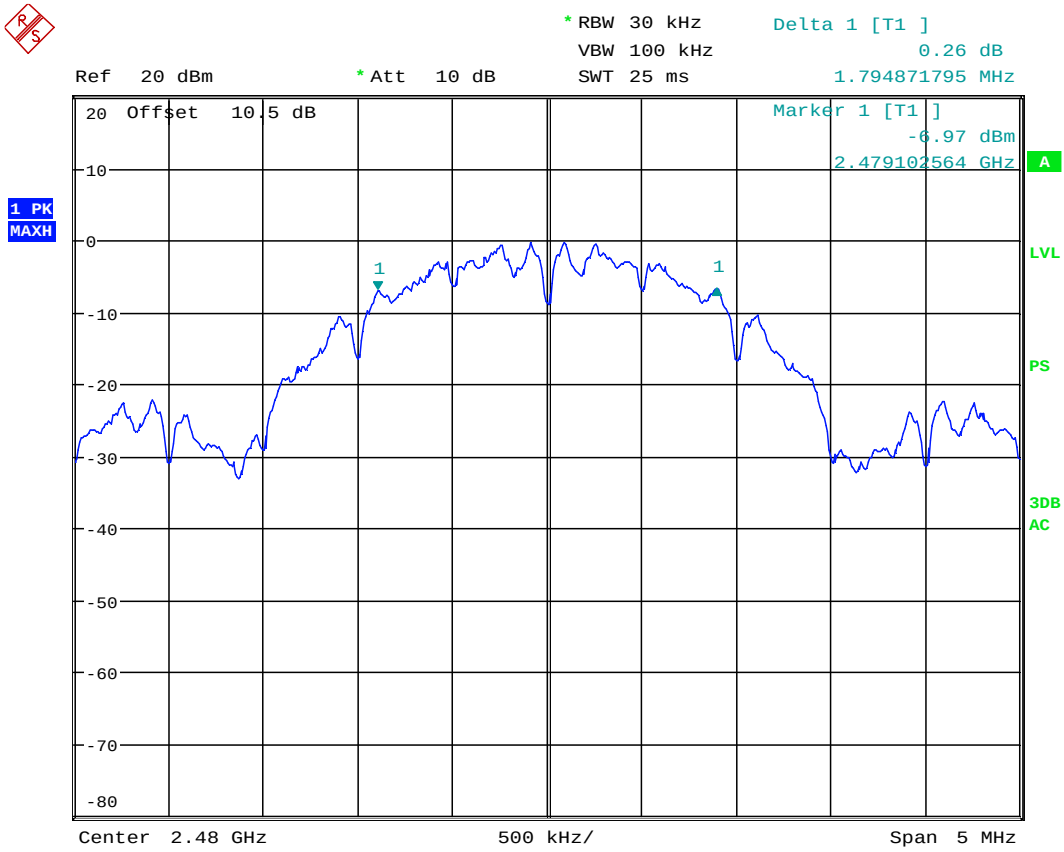
6 dB Bandwidth at 2440 MHz



Date: 18.FEB.2013 10:12:38

6 dB Bandwidth at 2480 MHz

4.3 20 dB Bandwidth

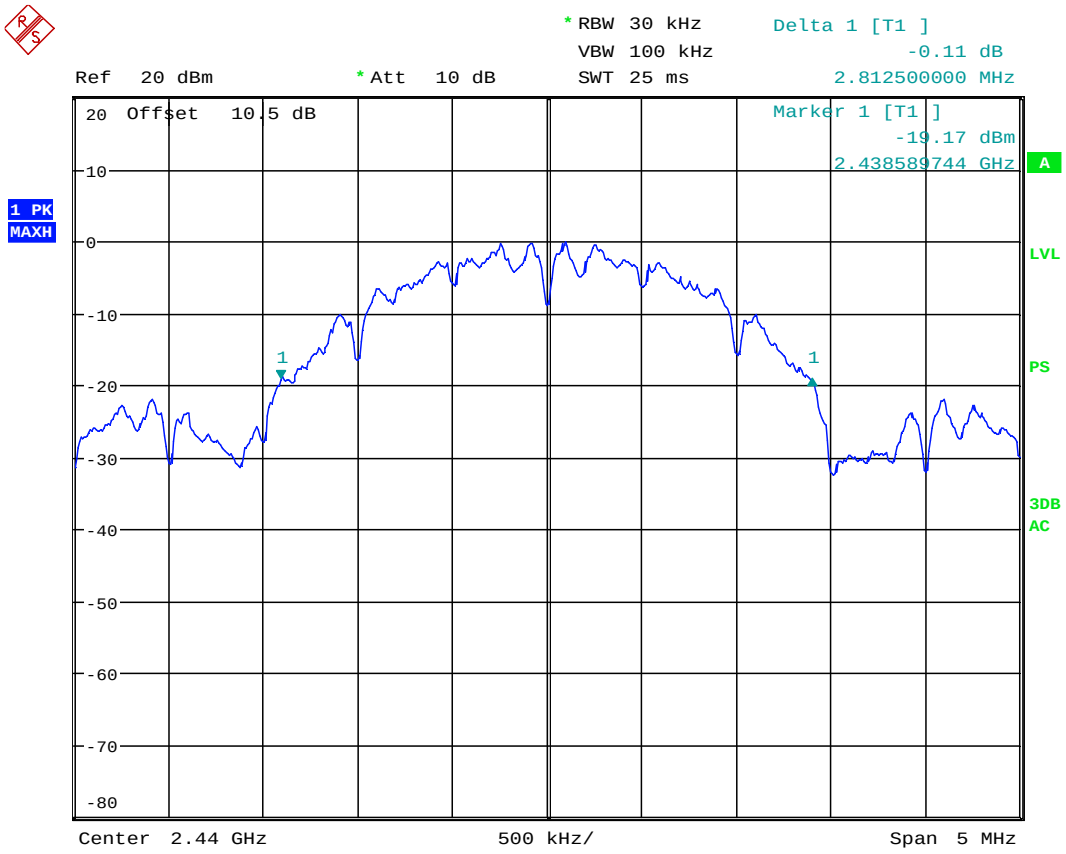
Test Performed By: G.Suhanthakumar	Date of Test: 18 Feb. 2013

Measurement Data:

Measured 20 dB Bandwidth (MHz)
2440 MHz
2.8

Requirements:

No requirements. Reported for information only.



Date: 18.FEB.2013 10:13:44

20 dB Bandwidth at 2440 MHz

4.4 Peak Power Output

Para. No.: 15.247 (b)

Test Performed By: G.Suhanthakumar	**Date of Test: 01 Feb 2013**

Test Results: Complies

Measurement Data:

RF channel	**2405 MHz**	**2440 MHz**	**2480 MHz**
Measured Maxium Field strength (dBµV/m) –VP	108.1	107.4	99.3
Calc. Radiated Power (dBm)	12.9	12.2	4.1
Calc. Radiated Power (mW)	19.4	16.5	2.6
Measured Conducted Power (dBm)	7.1	6.9	-1.0
Measured Conducted Power (mW)	5.1	4.9	0.8
Calculated Antenna Gain (dBi)	5.8	5.3	5.1

Tested according to KDB 558074 D01 DTS Meas Guidance v02, Section 8.1.1.

EIRP is calculated according to KDB 558074 D01 DTS Meas Guidance v02, Section 10.2.2.1

The maximum field strength is obtained in XY plane and Vertical polarization.

See attached graph.

Detachable antenna? ☐ Yes ☒ No

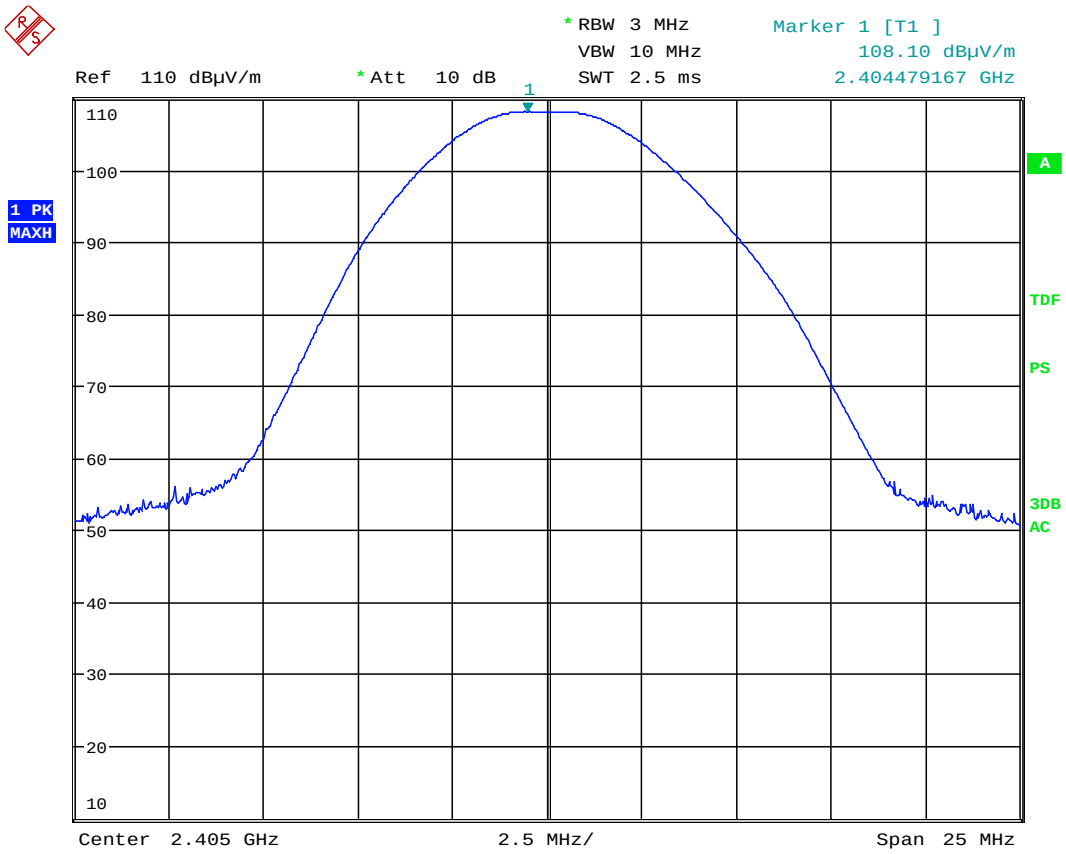
If detachable, is the antenna connector non-standard? ☐ Yes ☐ No

Requirements:

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

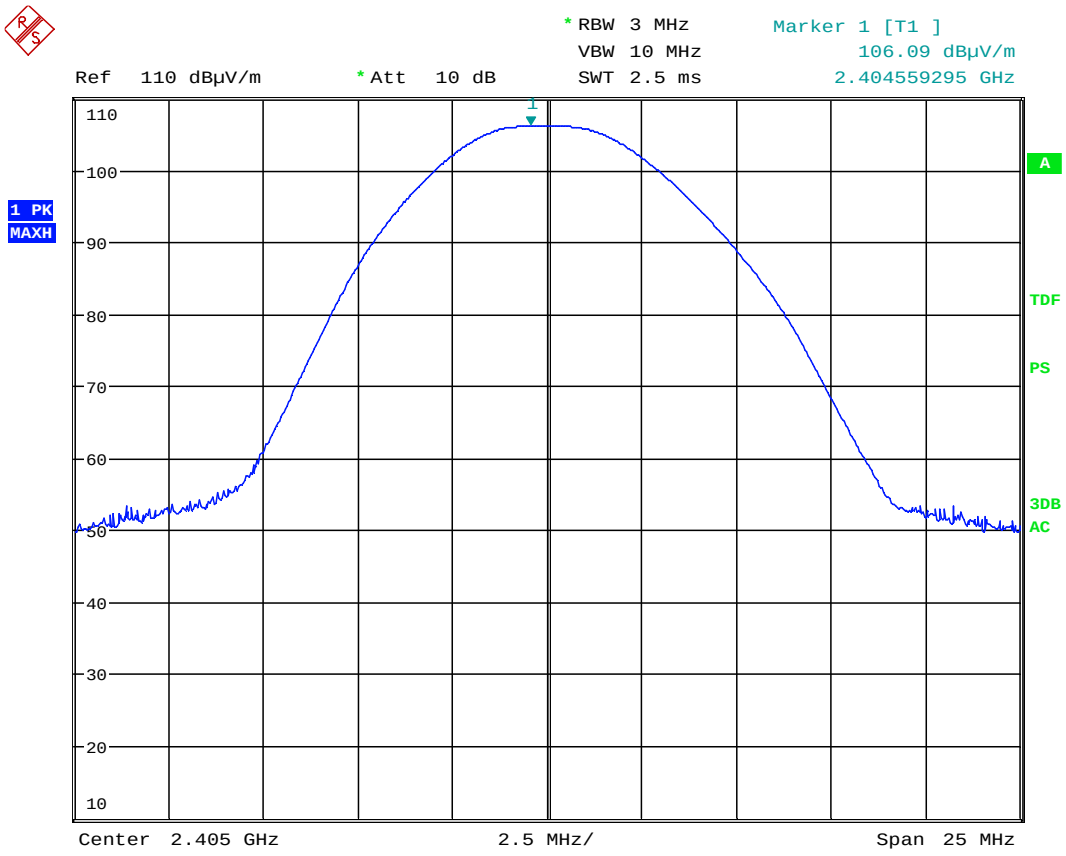
For Digital Transmission Systems in the 2400 - 2483.5 MHz band: 1 Watt

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.



Date: 1.FEB.2013 14:45:31

Radiated Field strength, VP , 2405 MHz



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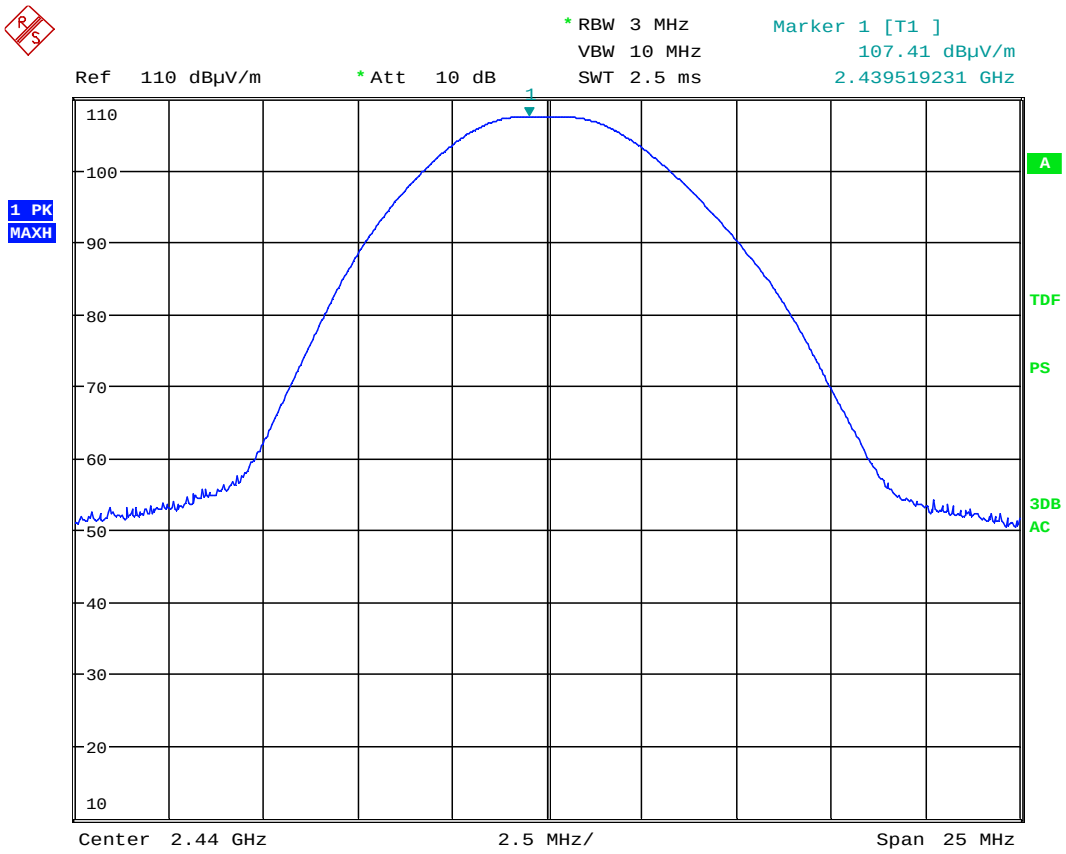
Radiated field strength, HP, 2405 MHz



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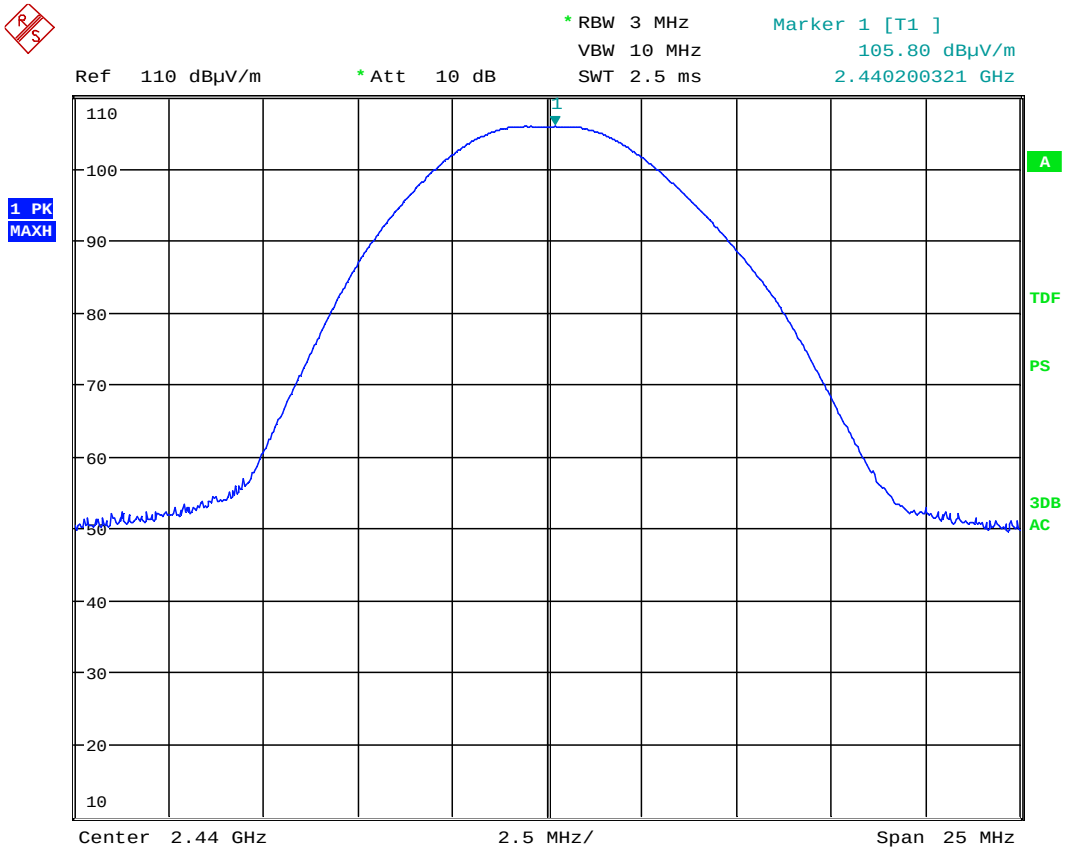
Radiated field strength, VP, 2440 MHz



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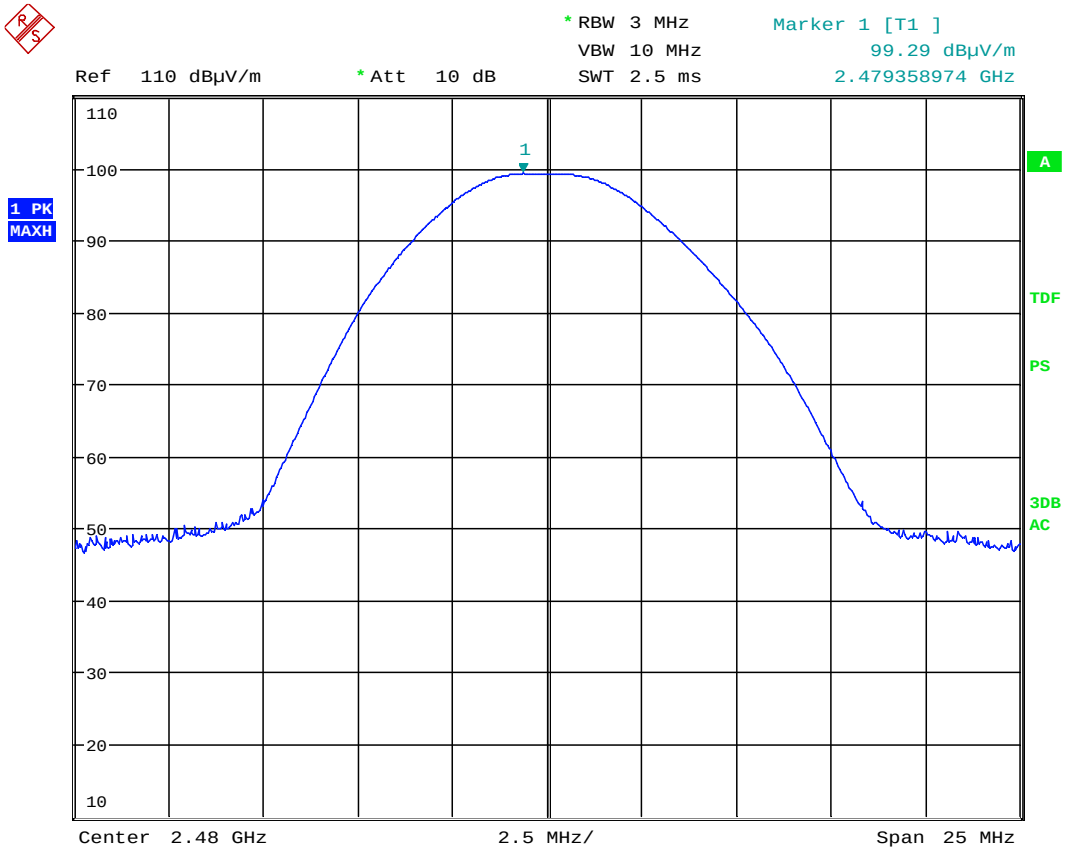
Radiated field strength, HP, 2440 MHz



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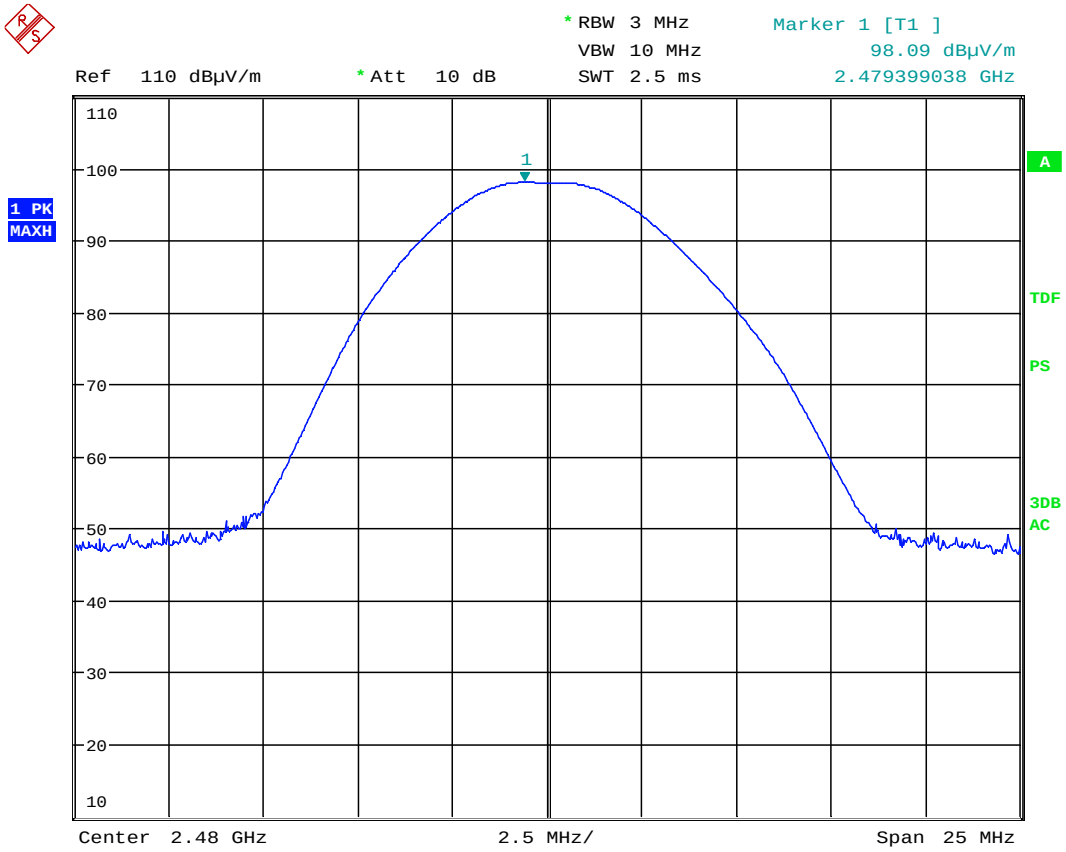
Radiated field strength, VP, 2480 MHz



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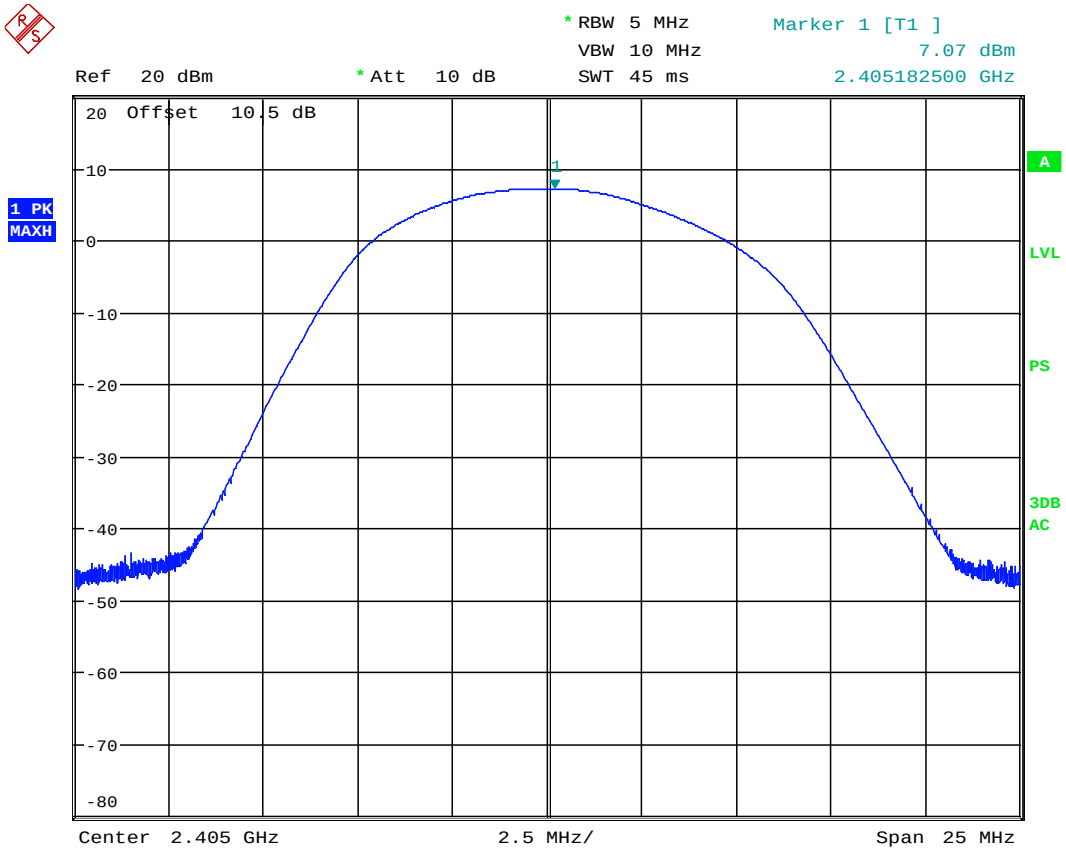
Radiated field strength, HP, 2480 MHz



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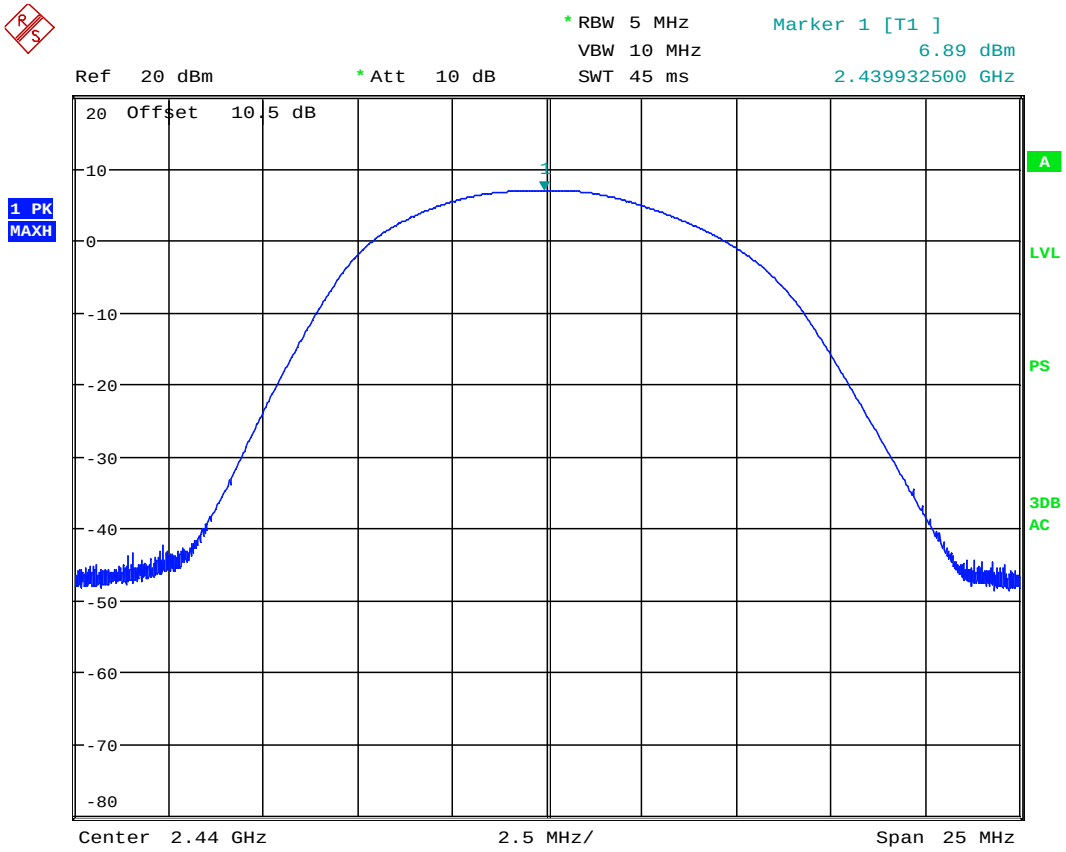
Conducted power – 2405MHz



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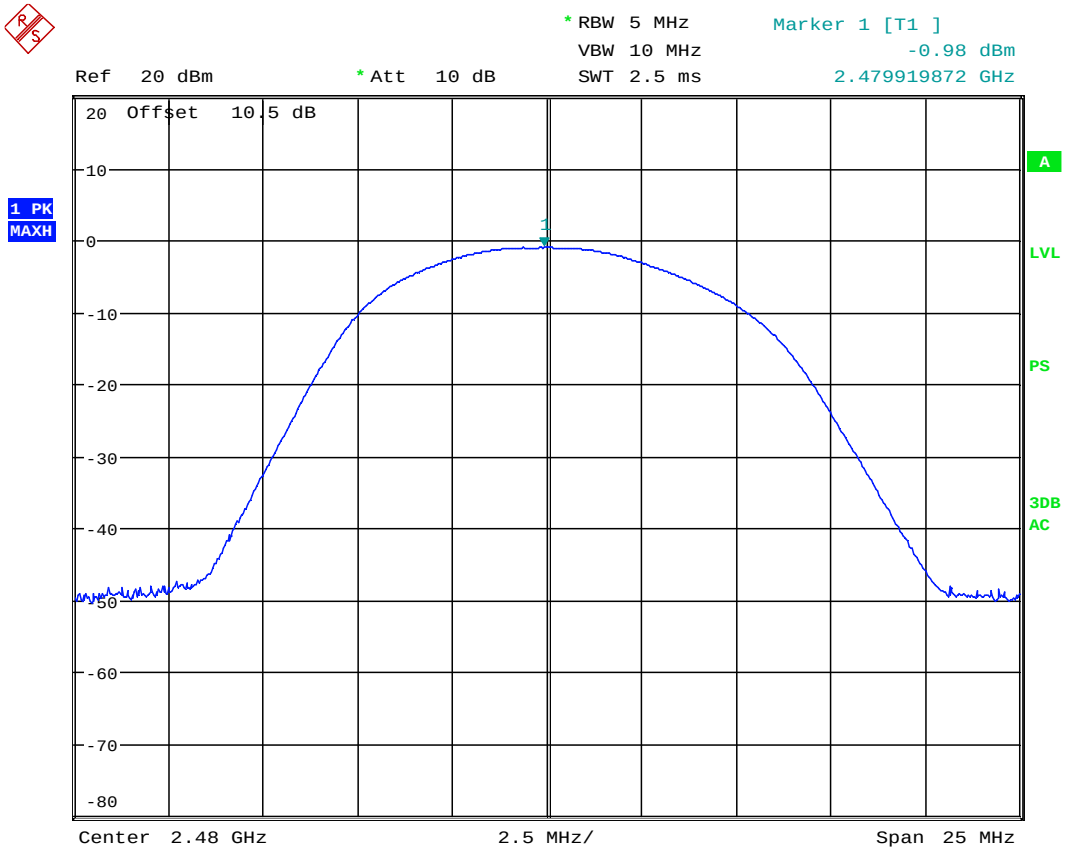
Conducted power – 2440MHz



Date: 18.FEB.2013 10:25:13

Conducted power – 2480MHz

4.5 Spurious Emissions (Radiated)

Para. No.: 15.247 (c)

Test Performed By: G.Suhanthakumar	**Date of Test: 1 & 18 Jan 2013**

Test Results: Complies

Measurement Data:

Band-edge, @3m

Frequency	Measured Field Strength @3m, dBµV/m	Detector	Limit dBµV/m	Margin dB
2.39 GHz	45.3	PK	74	28.7
	37.5	AV	54	16.5
2.4835 GHz	68.3	PK	74	5.7
	51.7	AV	54	2.3

Tested according to KDB 913591.

Band-edge field strength 2.4835 GHz:

Marker Delta 100kHz RBW: 47.44 dB

Average Field Strength: 99.11– 47.44 = 51.67 dBµV/m

100% duty cycle

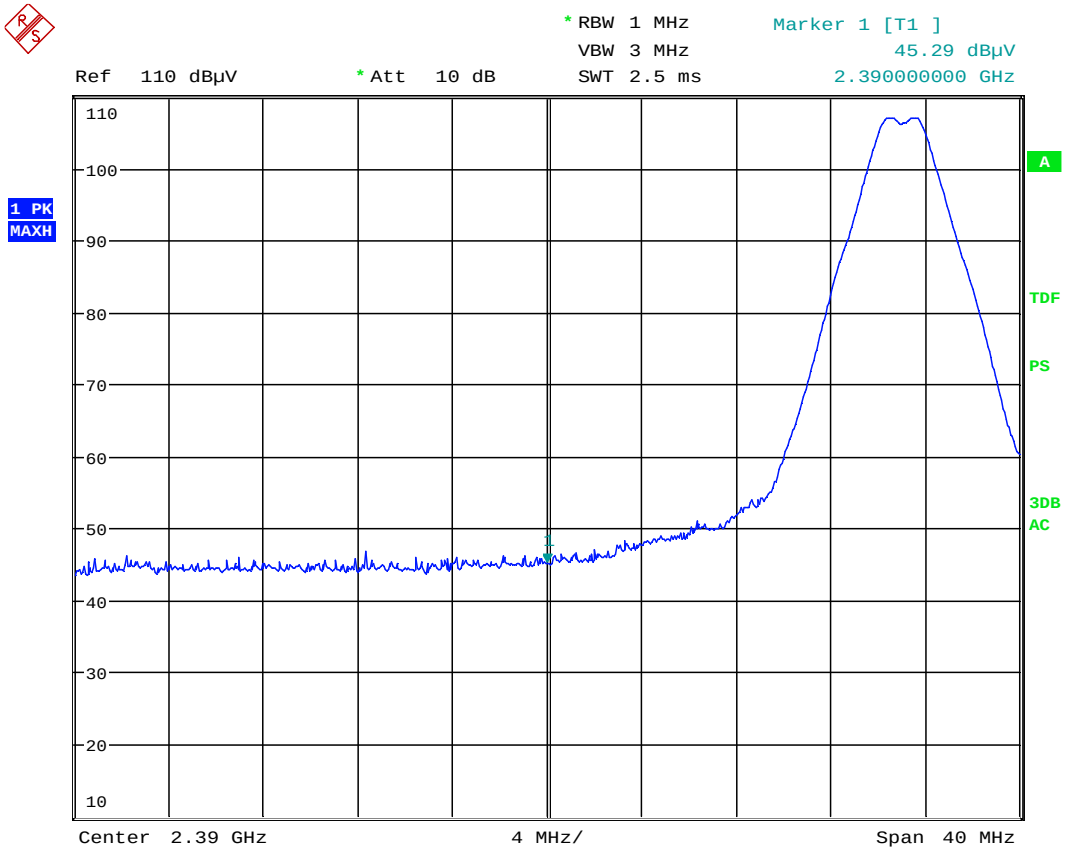
See attached plots.

RF conducted power

Scan performed radiated with 100 kHz Bandwidth from 0.01 to 25 GHz.

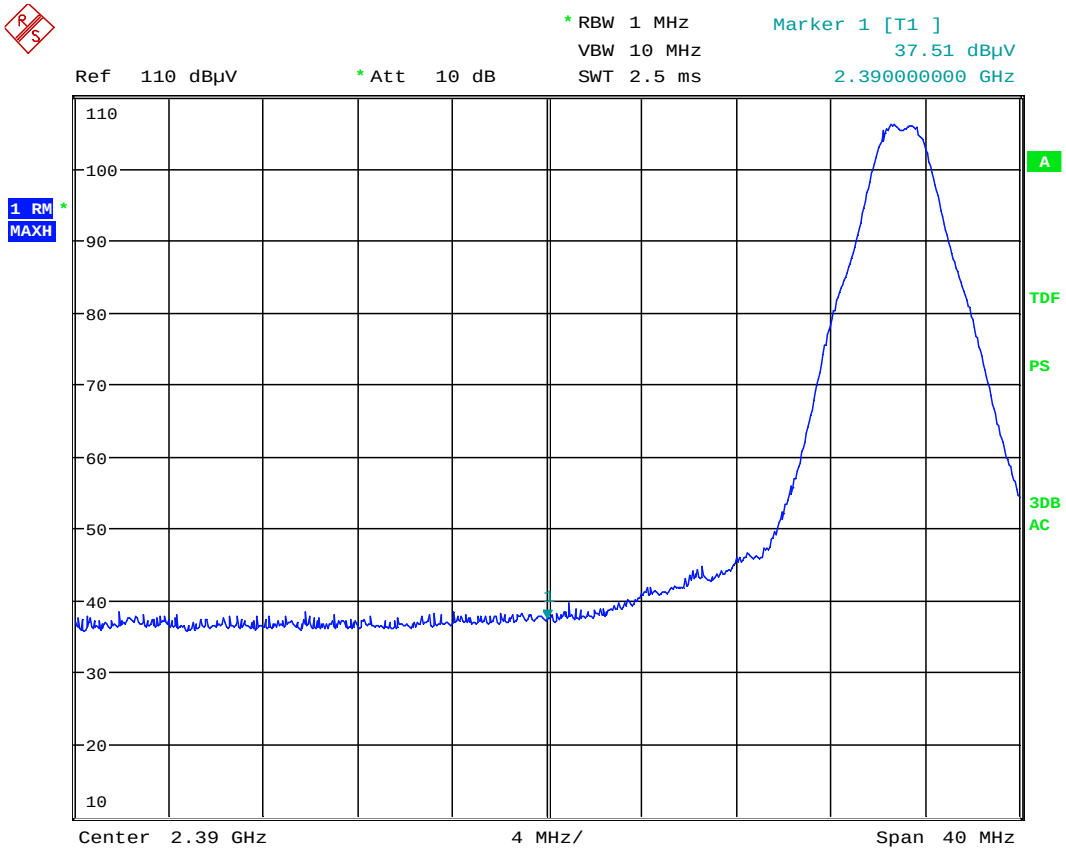
All emissions are more than 20dB below carrier.

See plots.



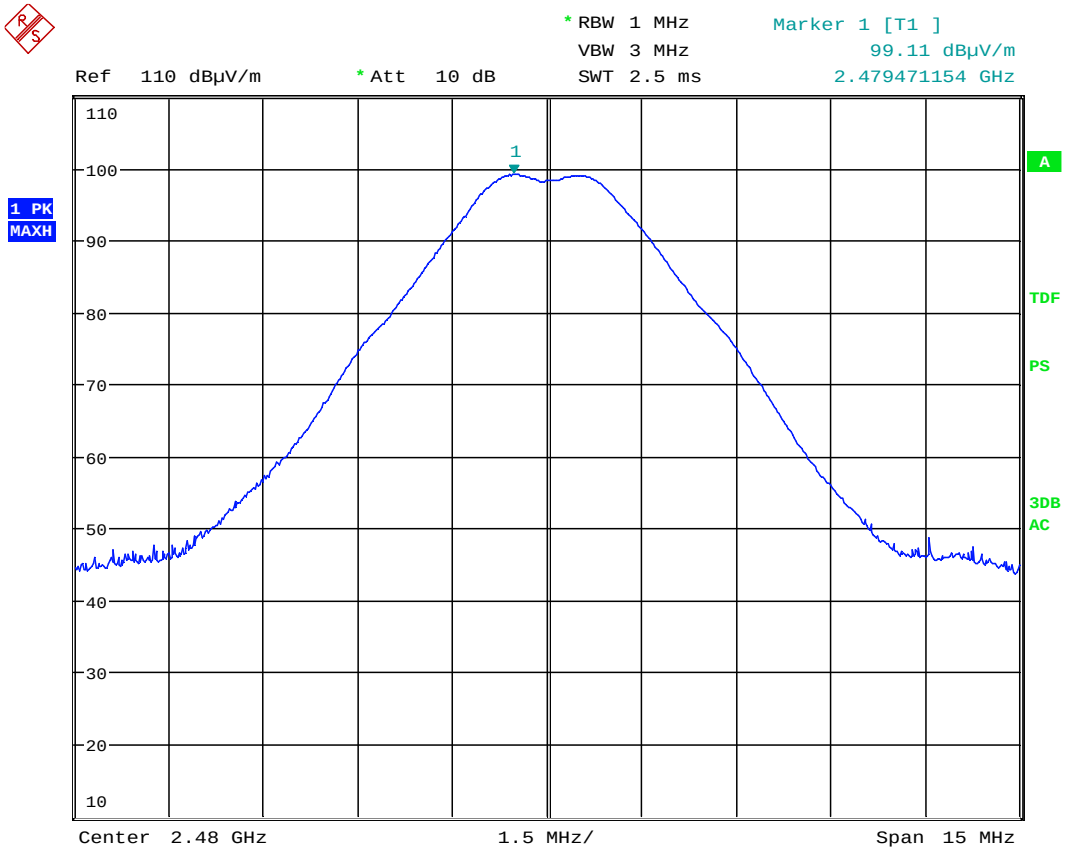
Date: 18.FEB.2013 10:40:42

Band Edge, 2390 MHz, Peak Detector



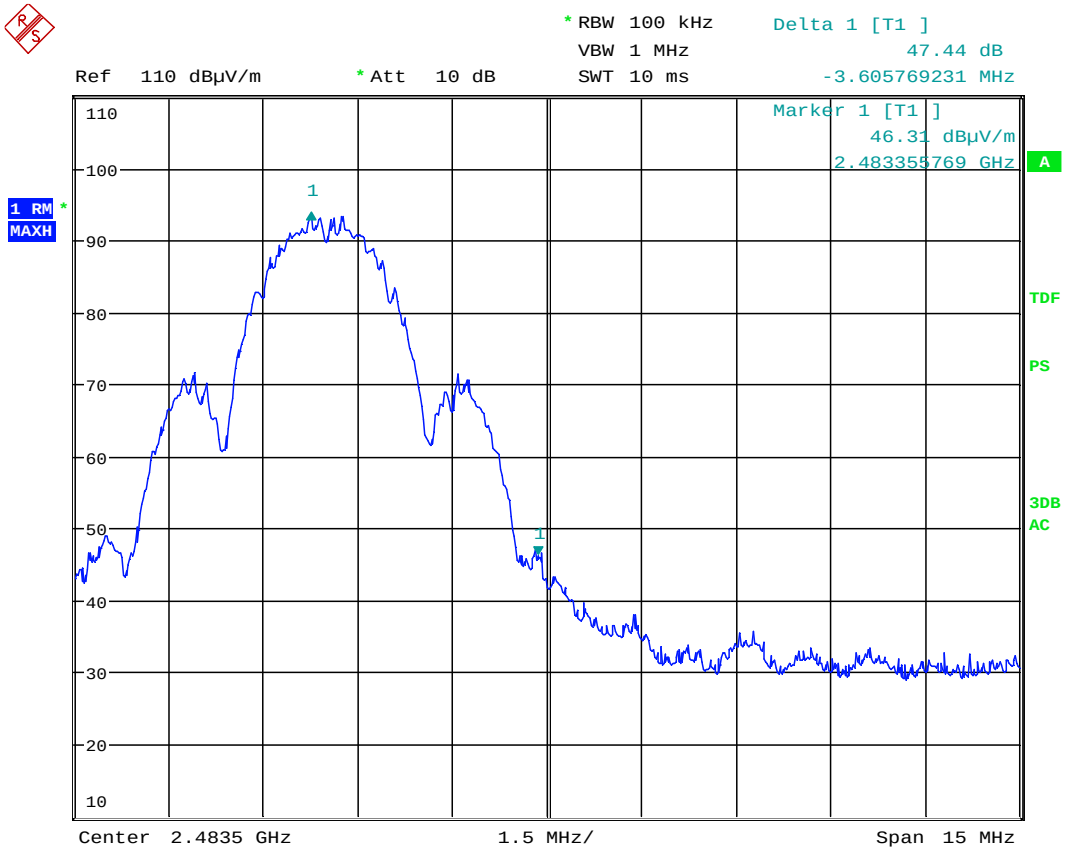
Date: 18.FEB.2013 10:41:18

Band Edge, 2390 MHz, Average Detector



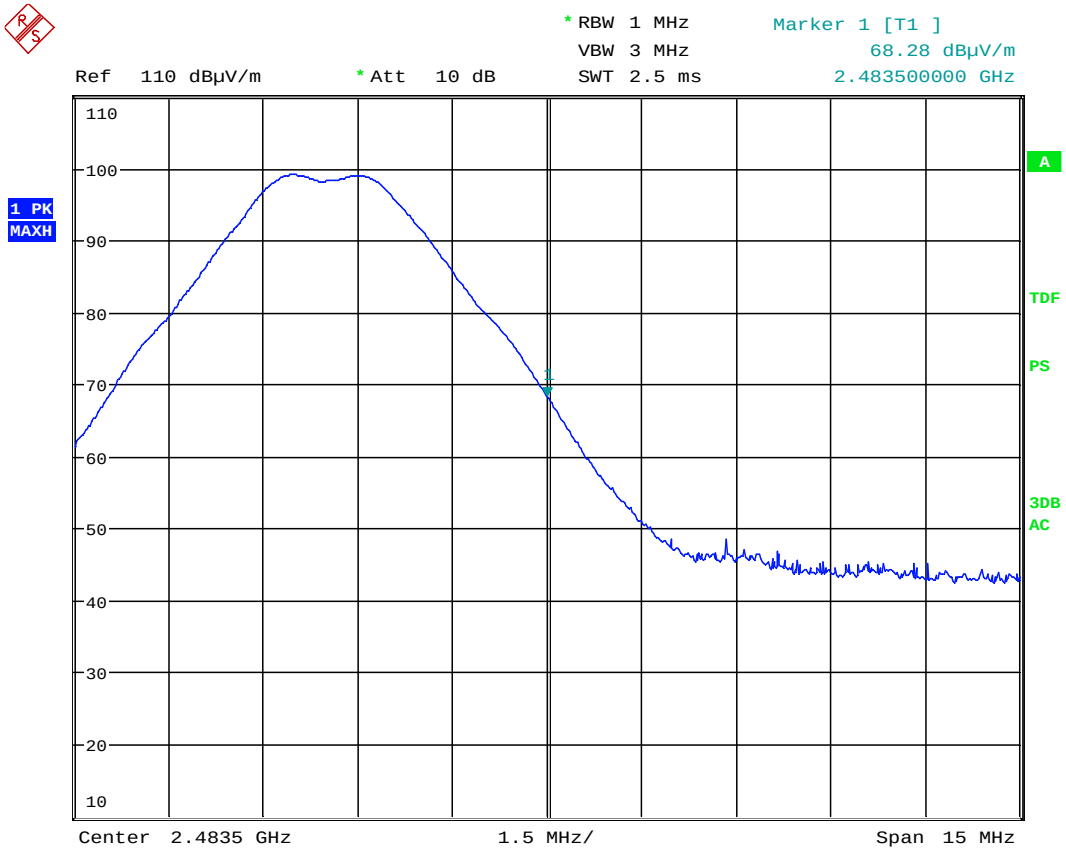
Date: 1.FEB.2013 15:09:18

Field strength at 2480MHz for delta marker



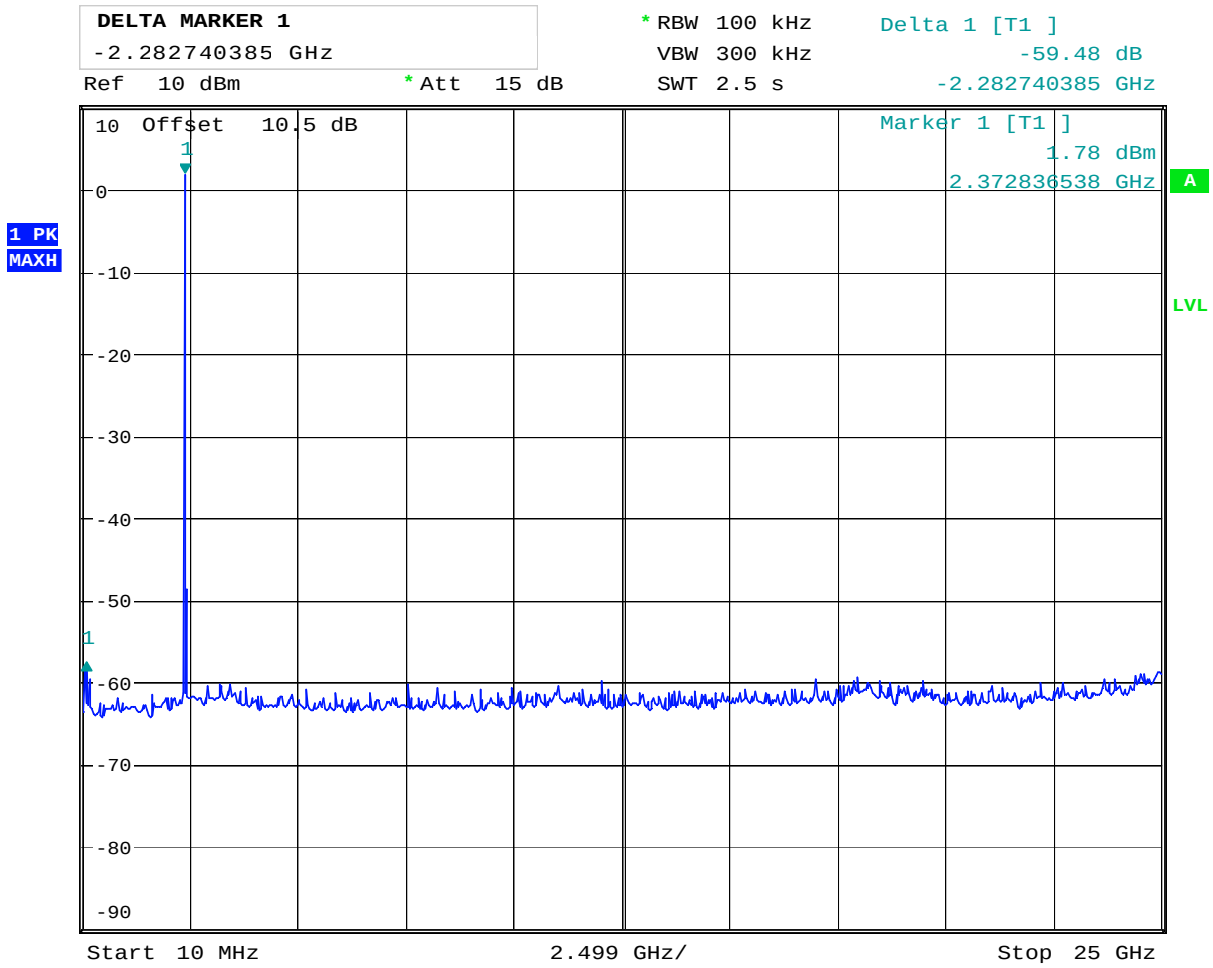
Date: 1.FEB.2013 15:11:42

Delta marker, 2483.5MHz, AV detector



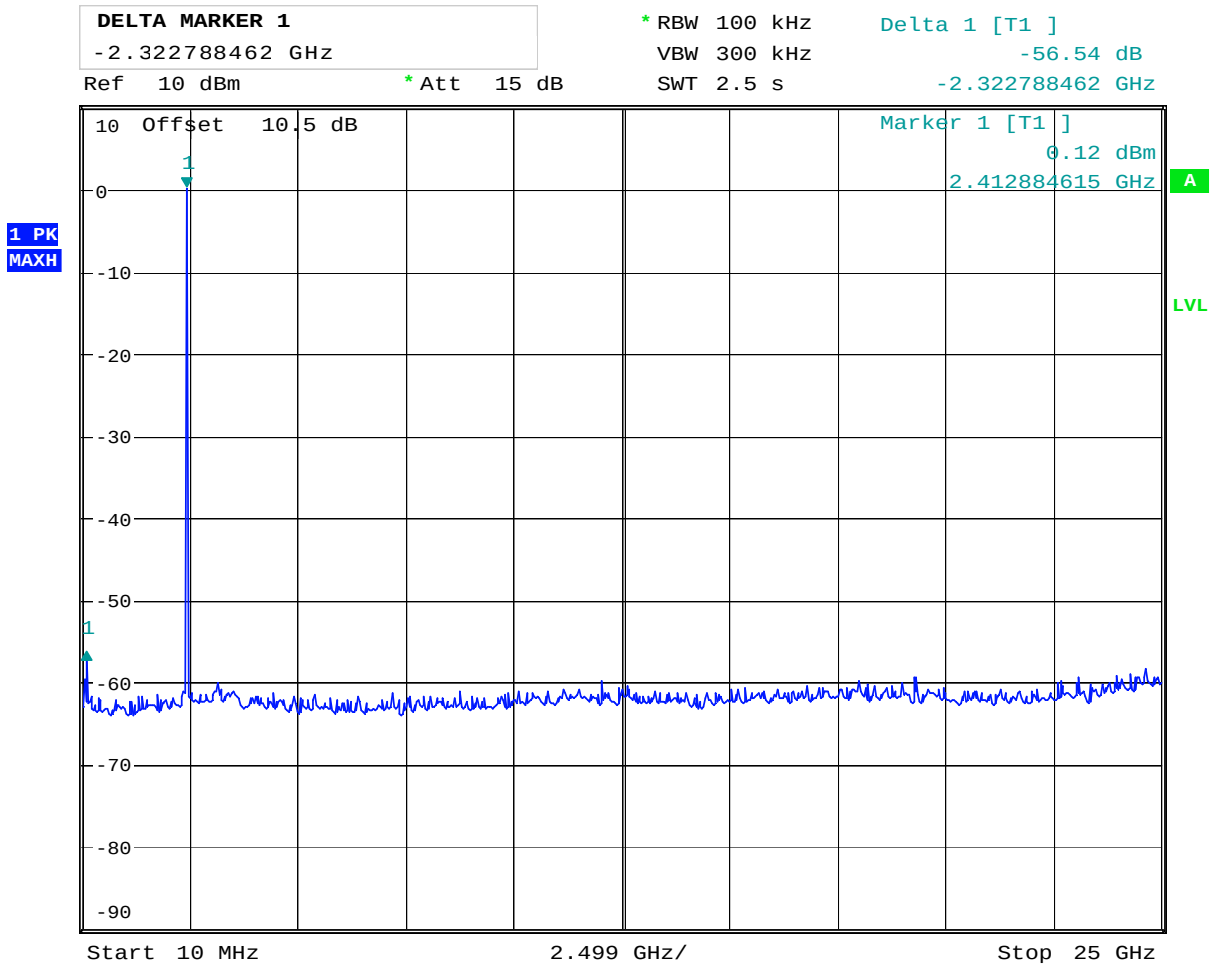
Date: 1.FEB.2013 15:10:29

Band Edge, 2483.5 MHz, Peak Detector



Date: 11.MAR.2013 16:43:43

Conductd spurious emission 10MHz – 25GHz - ch2405MHz



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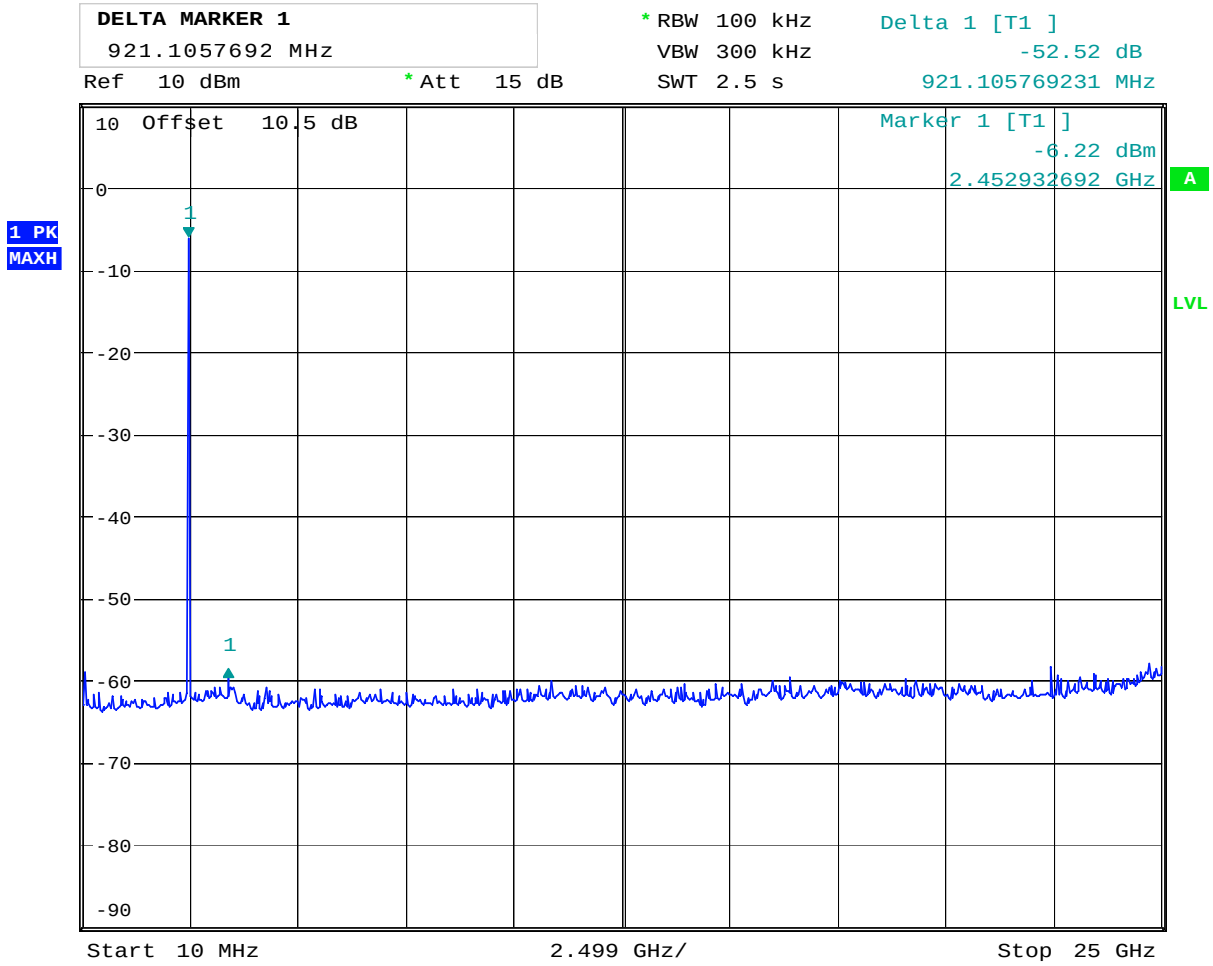
Conductd spurious emission 10MHz – 25GHz - ch2440MHz



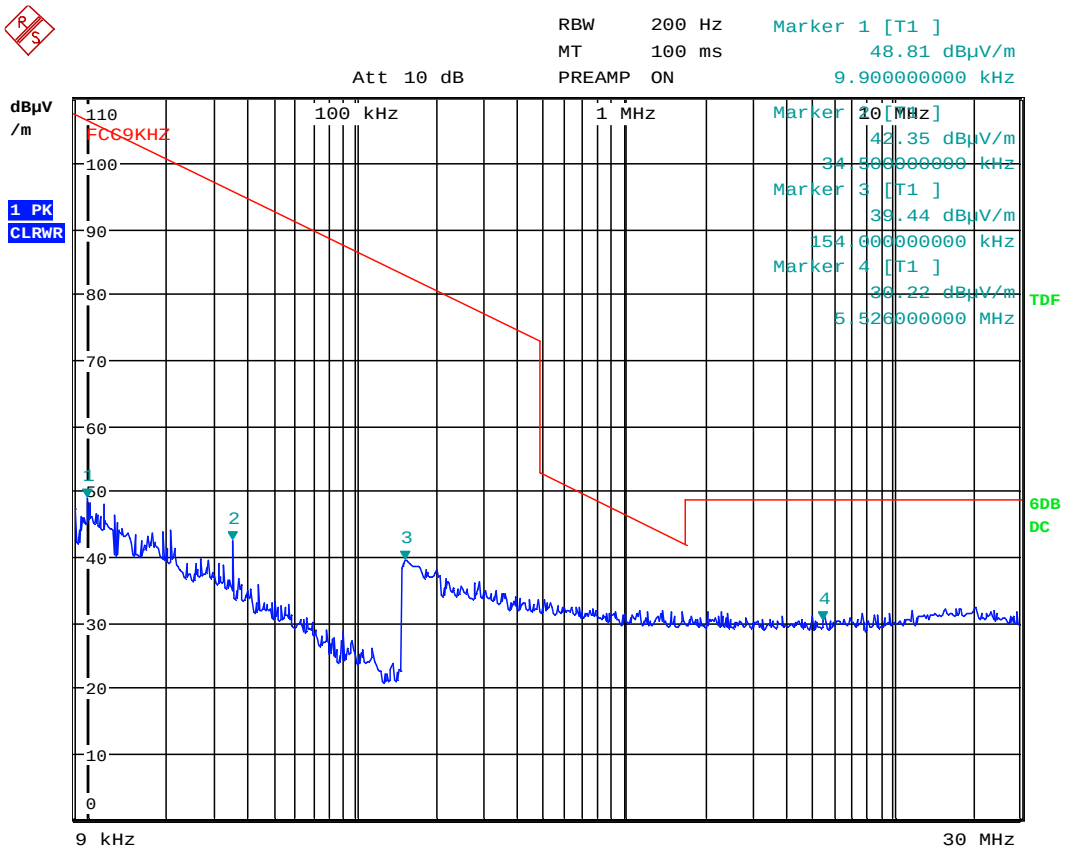
Date: 11.MAR.2013 16:45:10

Conducted spurious emission 10MHz – 25GHz - ch2480MHz

Radiated emissions 9kHz - 30 MHz.

Detector: Quasi-Peak

Measuring distance 10 m.



Date: 1.FEB.2013 16:50:17

Radiated Emissions, 9 kHz – 30 MHz @10m

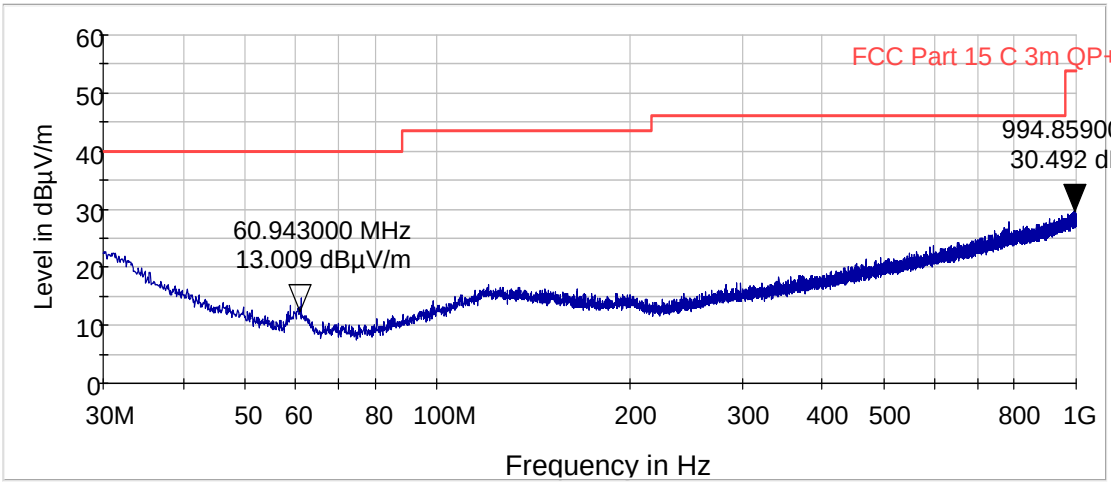
Radiated emission 30 – 1000 MHz.

Detector: Peak

Measuring distance at 3m.

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

See attached plot.



Radiated Emissions, 30 – 1000 MHz, VP and HP, @3m

Radiated Emissions, 1-25 GHz

1-8 GHz measured at a distance of 3 m

8 - 25 GHz measured at 1m

Peak detector

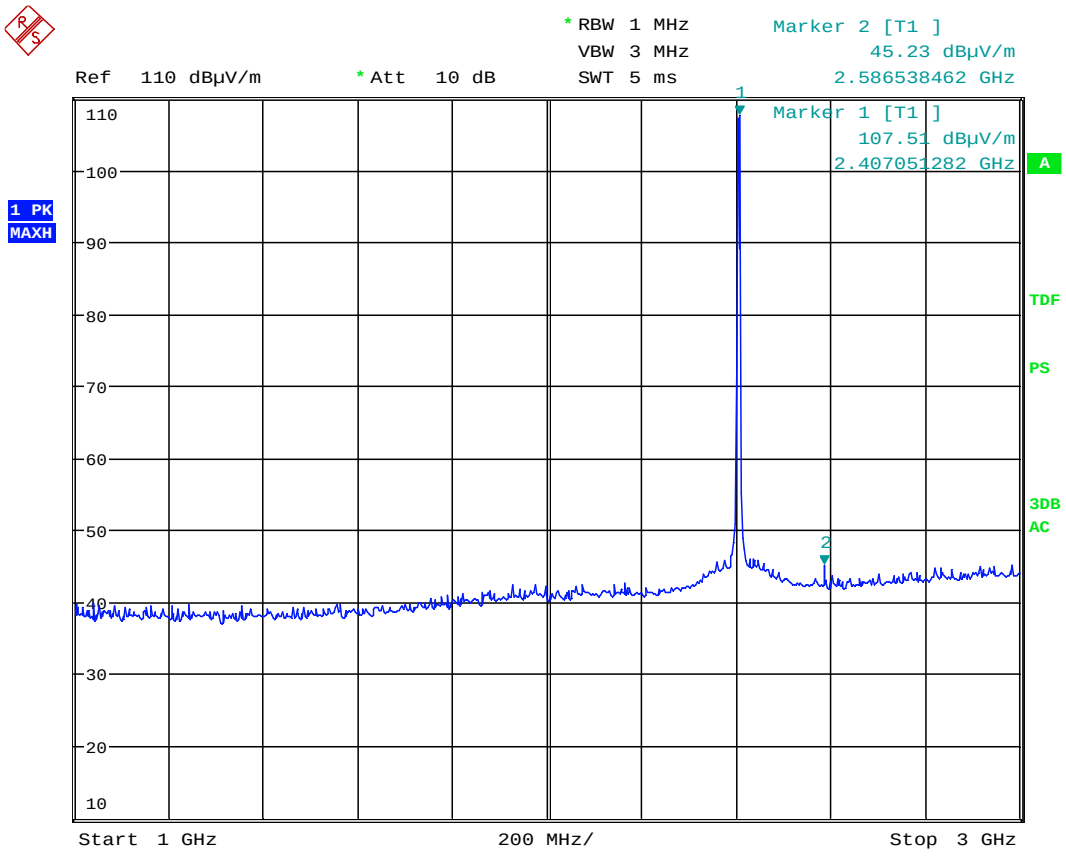
Frequency MHz	Field Strength @3m dBµV/m	Detector	Limit dBµV/m	Margin dB
All freqs	None detected	Pk	74	-

Average detector

Frequency MHz	Field Strength @3m dBµV/m	Detector	Limit dBµV/m	Margin dB
All freqs	None detected	Av	54	-

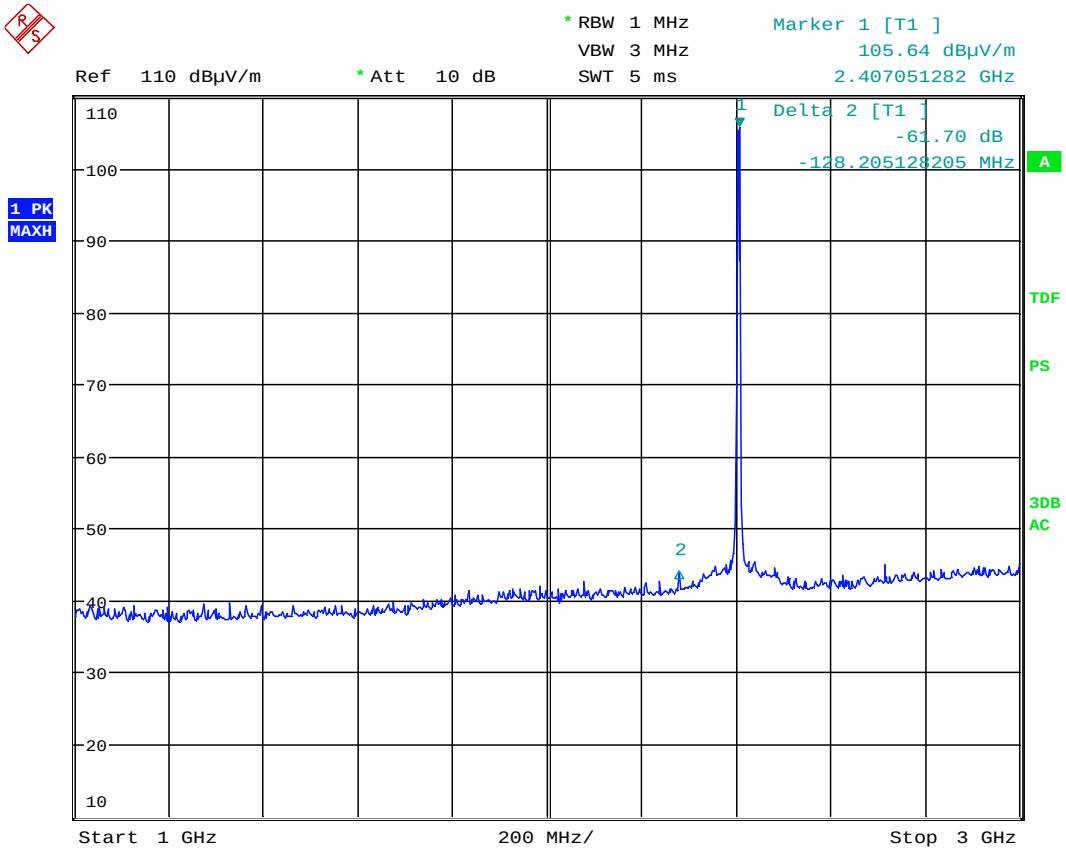
Antenna factor, amplifier gain and cable loss are included in Spectrum Analyzer “Transducer factor”.

See attached graphs.



Date: 1.FEB.2013 15:18:23

Radiated Emissions ch. 2405 MHz, 1 – 3 GHz, VP, @3m – Pre-scan with Peak detector



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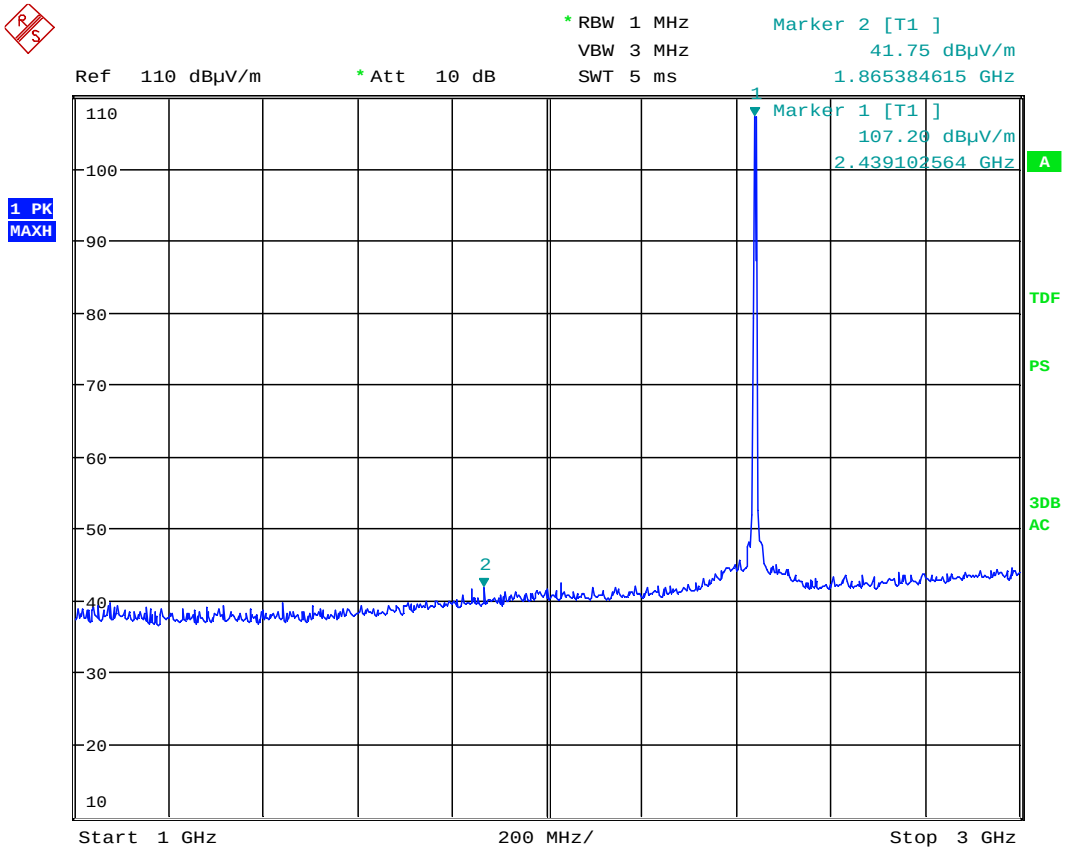
Radiated Emissions ch. 2405 MHz, 1 – 3 GHz, HP, @3m – Pre-scan with Peak detector



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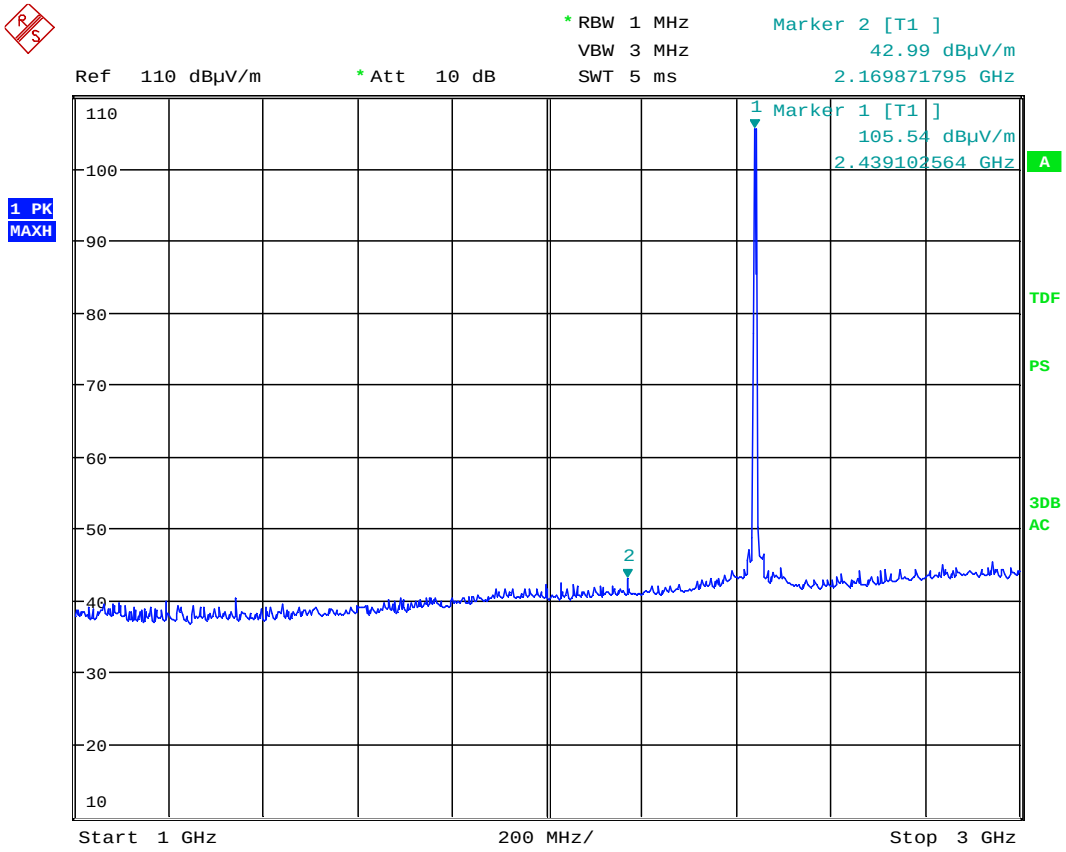
Radiated Emissions ch. 2440 MHz, 1 – 3 GHz, VP, @3m – Pre-scan with Peak detector



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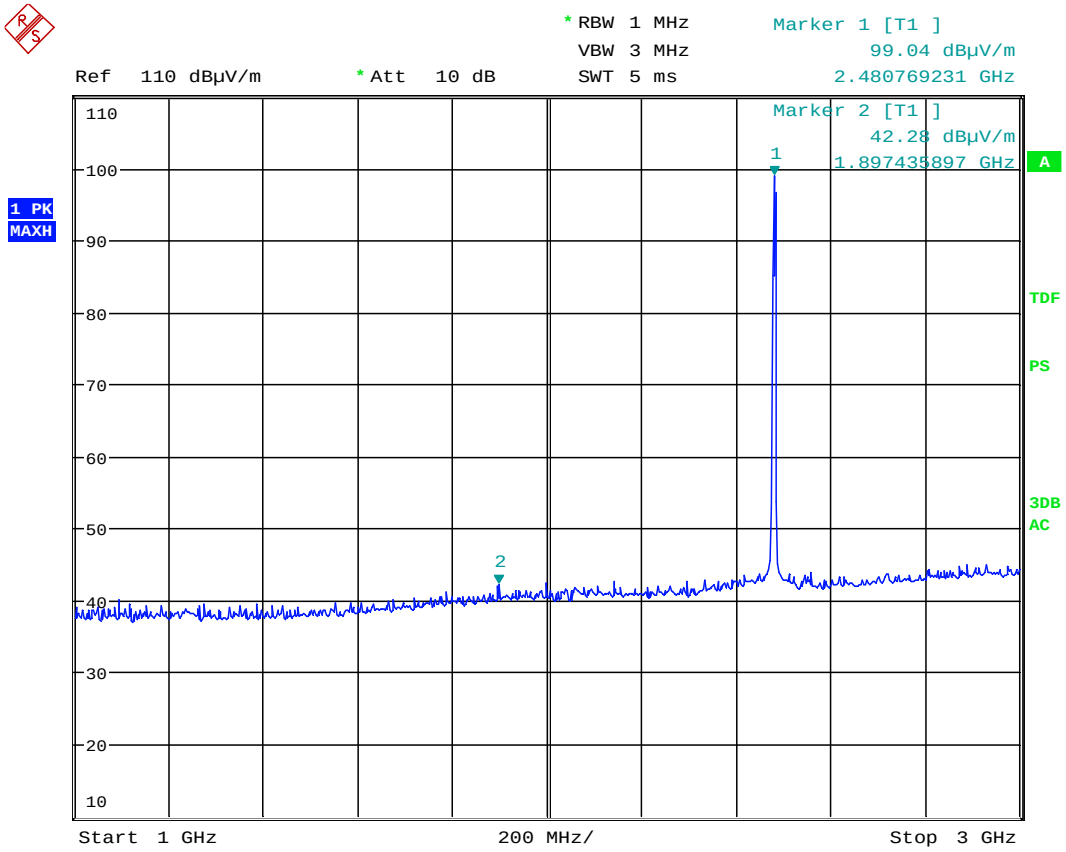
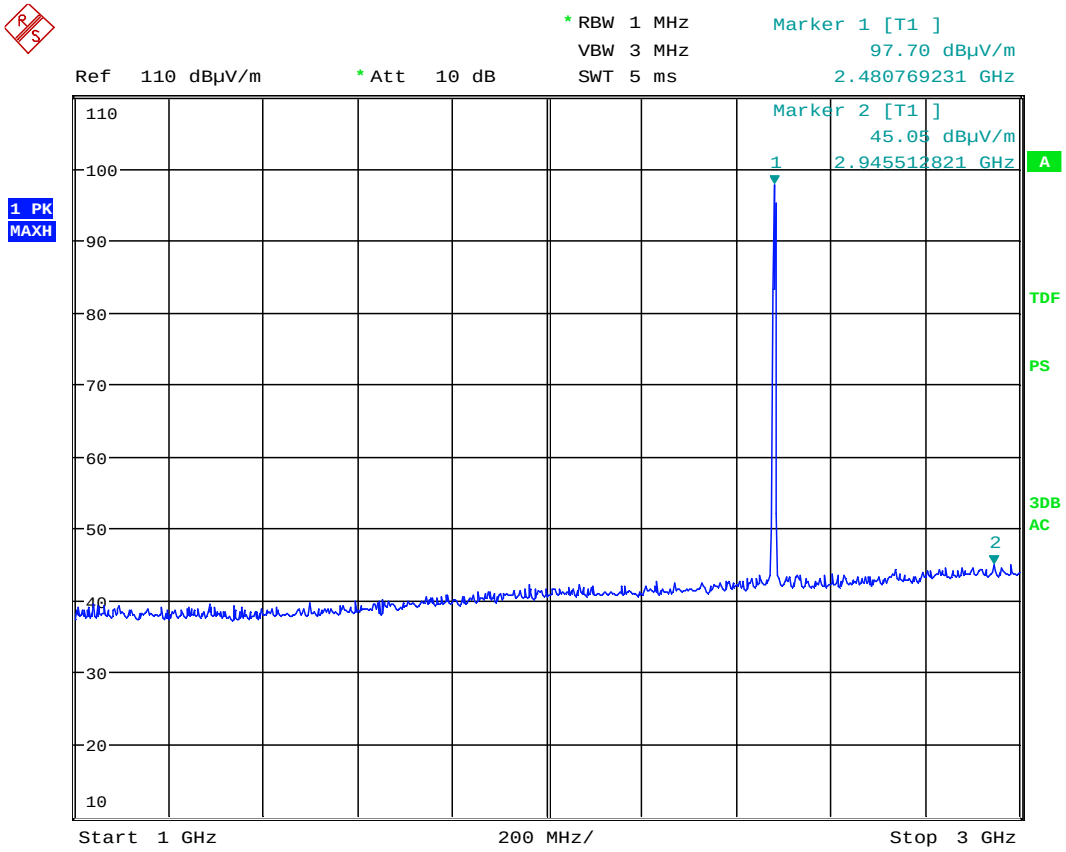
Radiated Emissions ch. 2440 MHz, 1 – 3 GHz, HP, @3m – Pre-scan with Peak detector



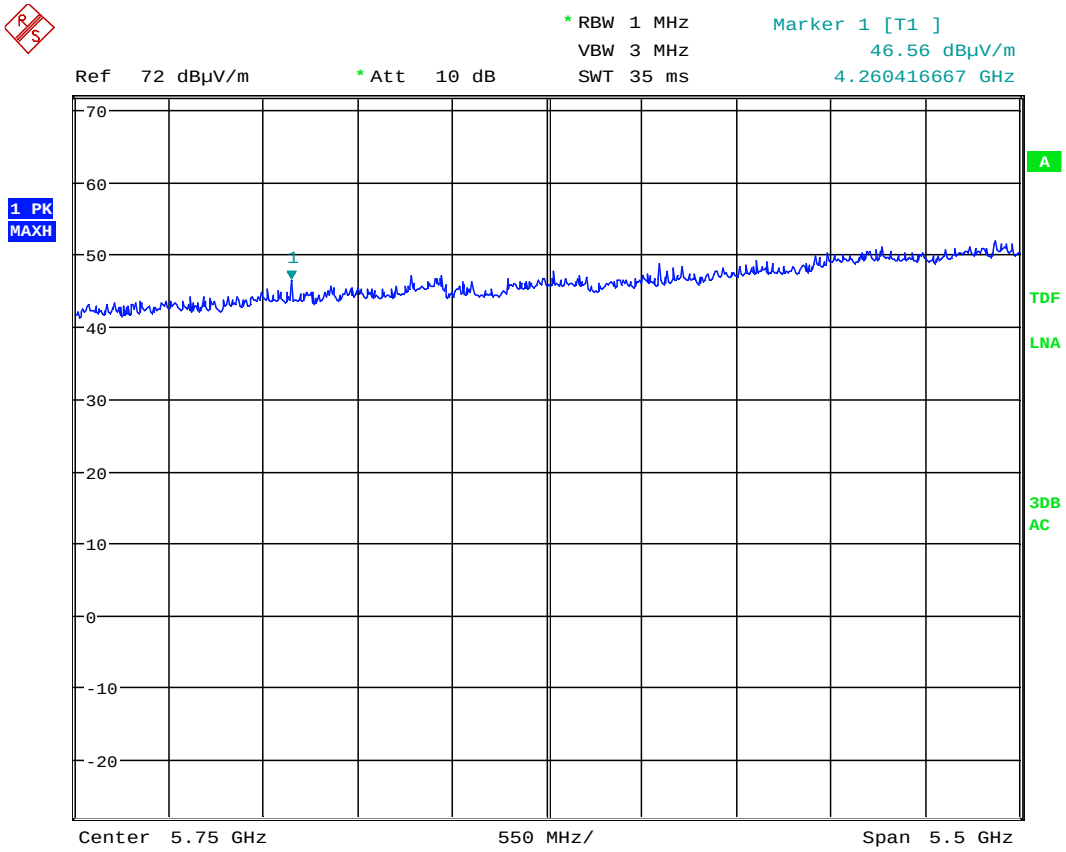
Date: 1.FEB.2013 15:13:43

Radiated Emissions ch. 2480 MHz, 1 – 3 GHz, VP, @3m – Pre-scan with Peak detector



Date: 1.FEB.2013 15:15:07

Radiated Emissions ch. 2480 MHz, 1 – 3 GHz, HP, @3m – Pre-scan with Peak detector



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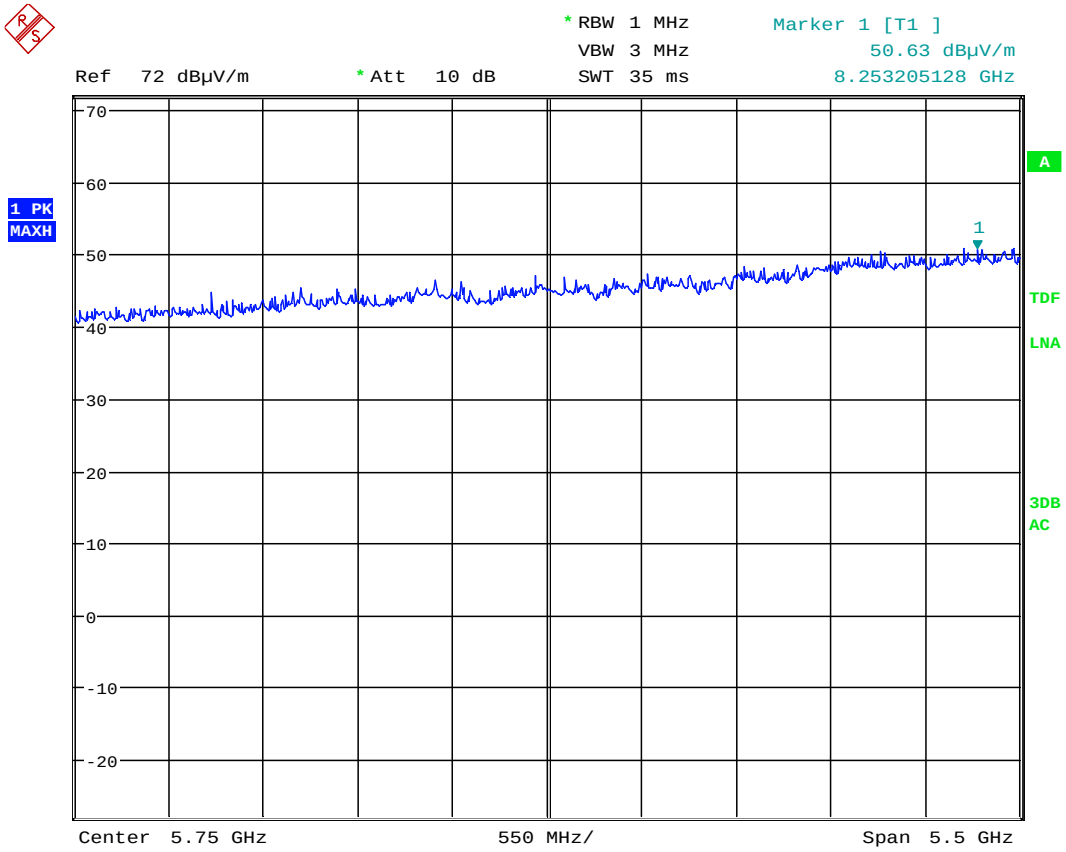
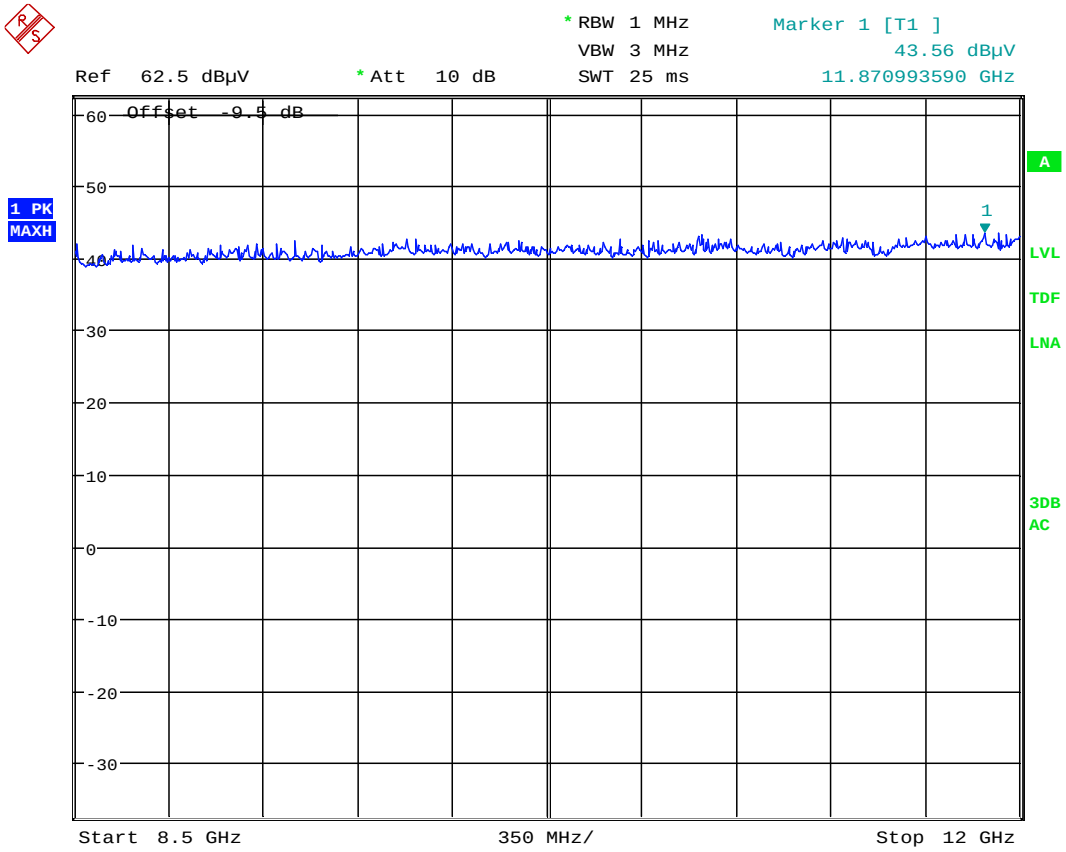
Radiated Emissions ch. 2405 MHz, 3 – 8.5 GHz, VP, @3m – Pre-scan with Peak detector



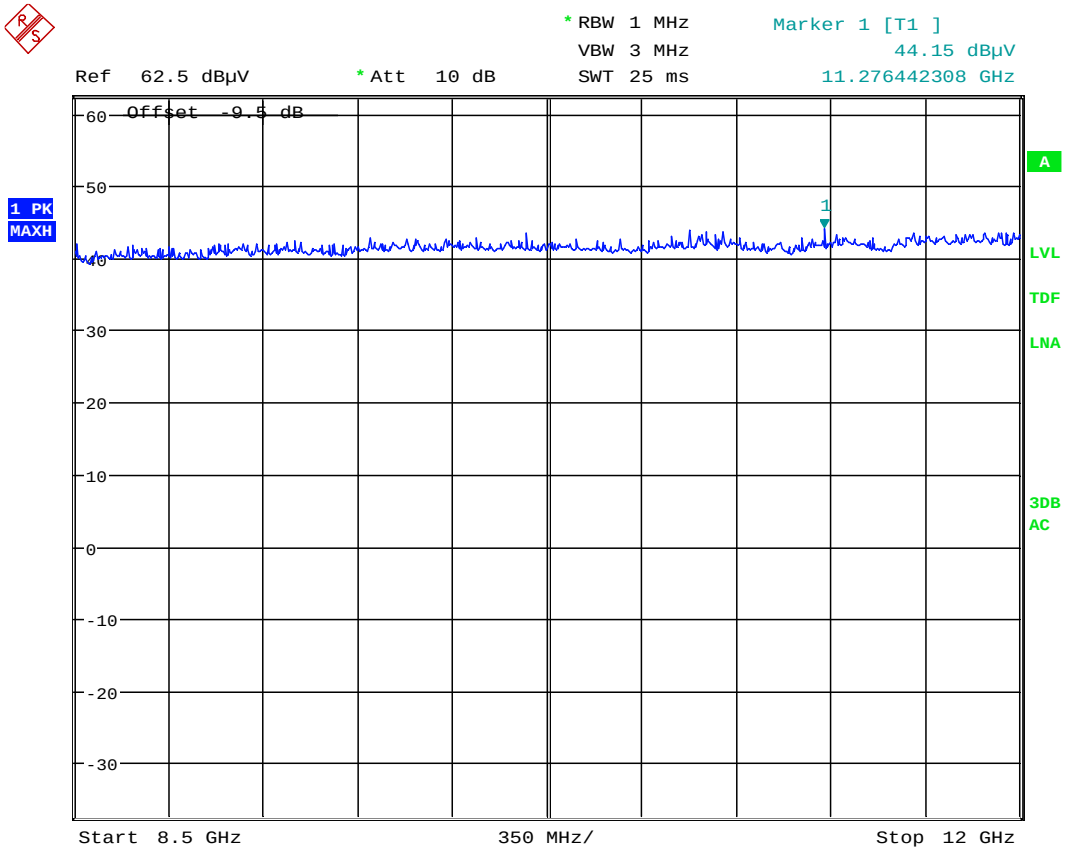
Date: 1.FEB.2013 16:05:52

Radiated Emissions ch. 2405 MHz, 3 – 8.5 GHz, HP, @3m – Pre-scan with Peak detector



Date: 1.FEB.2013 16:16:04

Radiated Emissions ch. 2405 MHz, 8.5 – 12 GHz, VP, @1m – Pre-scan with Peak detector , Distance Correction factor of -9.5 dB is included in the graph



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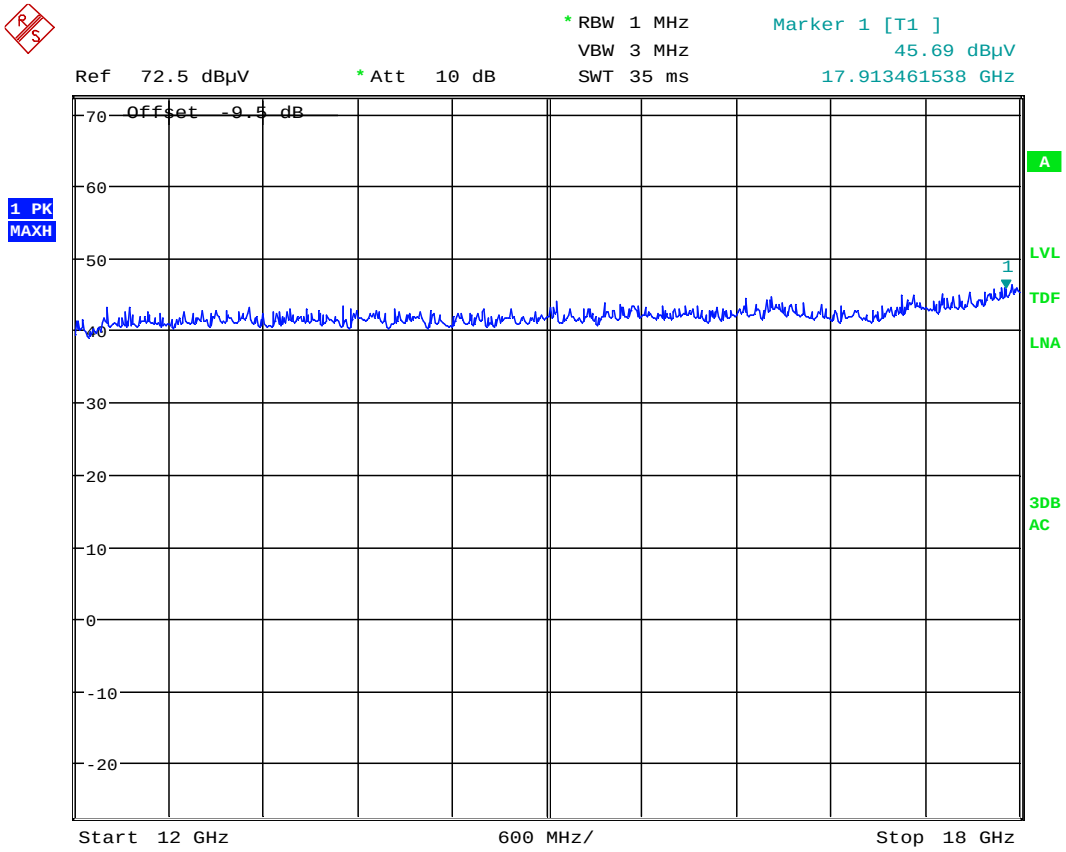
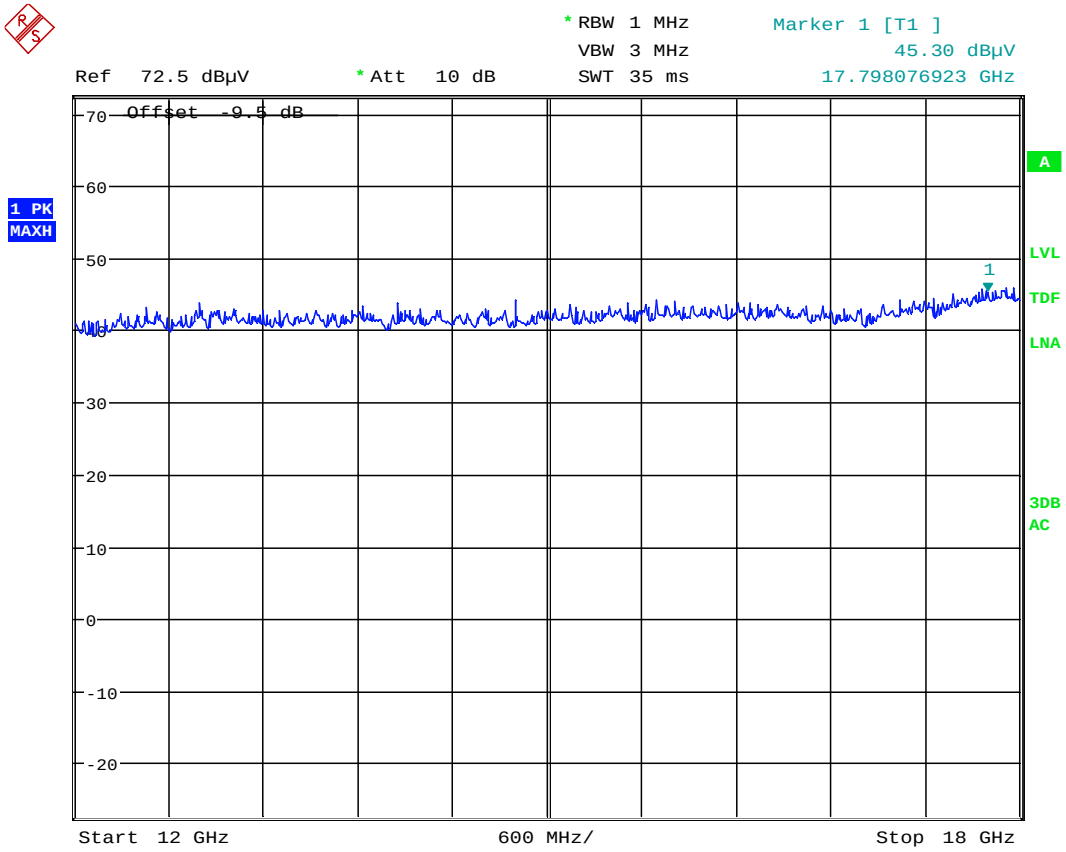
Radiated Emissions ch. 2405 MHz, 8.5 – 12 GHz, HP, @1m – Pre-scan with Peak detector , Distance Correction factor of -9.5 dB is included in the graph.



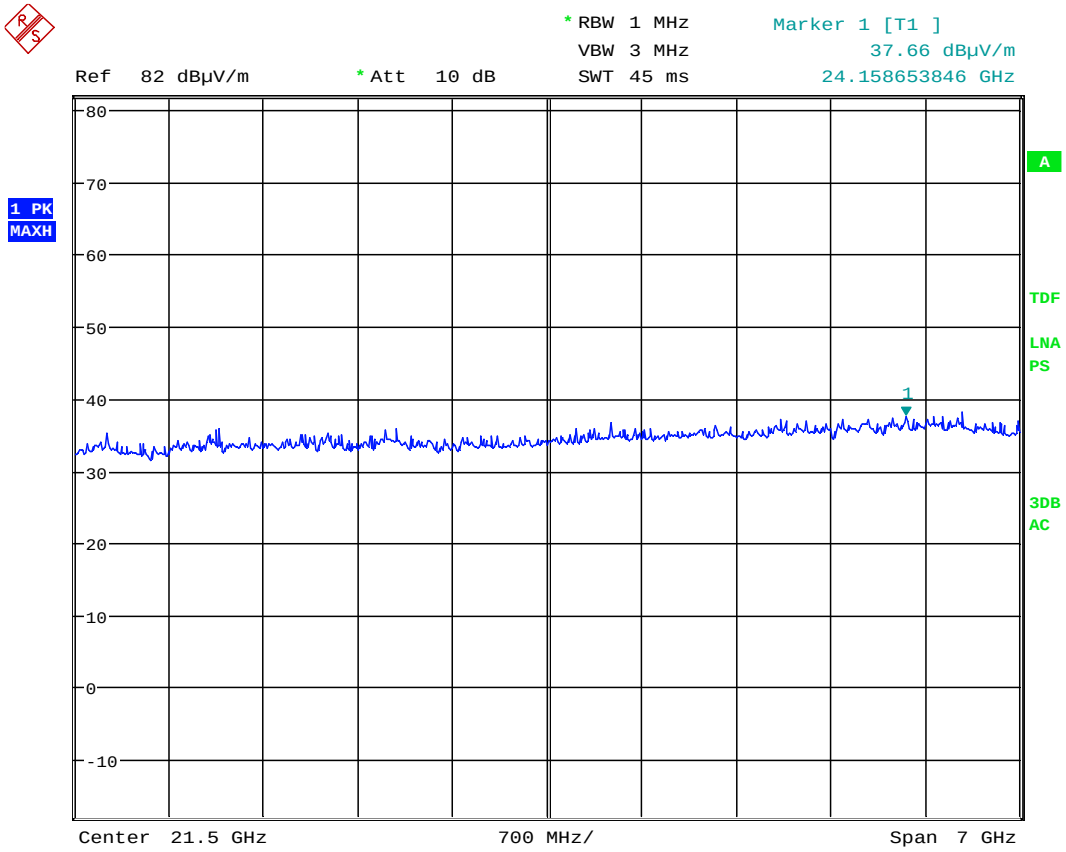
Date: 1.FEB.2013 16:28:04

Radiated Emissions ch. 2405 MHz, 12 – 18 GHz, VP, @1m – Pre-scan with Peak detector, Distance Correction factor of -9.5 dB is included in the graph.



Date: 1.FEB.2013 16:27:46

Radiated Emissions ch. 2405 MHz, 12 – 18 GHz, HP, @1m – Pre-scan with Peak detector, Distance Correction factor of -9.5dB is included in the graph.



Date: 5.MAR.2013 17:59:54

Radiated Emissions ch. 2405 MHz, 18 – 25 GHz, VP/HP, Pre-scan with Peak detector, Distance Correction factor -9.5dB is not included in the graph.

In receive mode detected LO leakage emissions:

Peak detector

Frequency MHz	Channel MHz	Field Strength @3m dBµV/m	Detector	Limit dBµV/m	Margin dB
4809	2405	47.2	Pk	74	26.8
4879	2440	-	Pk	74	-
4959	2480	-	Pk	74	-

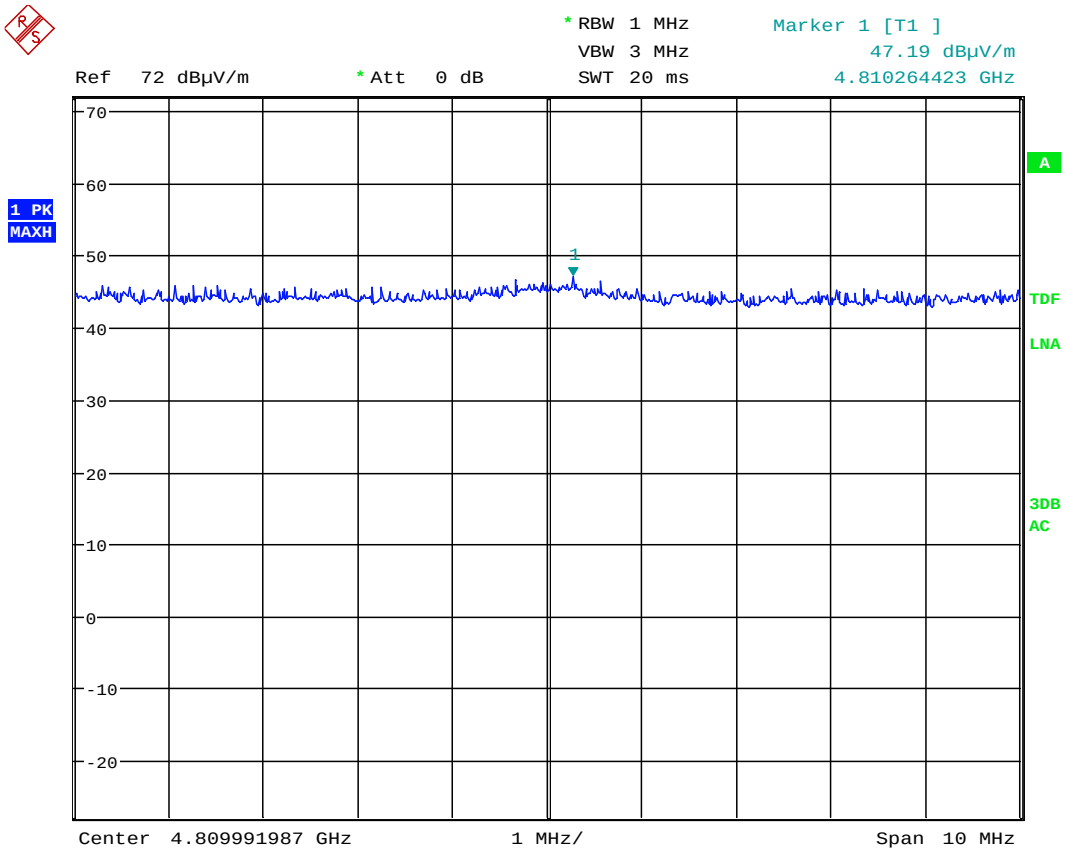
Average detector

Frequency MHz	Channel MHz	Field Strength @3m dBµV/m	Detector	Limit dBµV/m	Margin dB
4809	2405	34.6	Av	54	19.4
4879	2440	-	Av	54	-
4959	2480	-	Av	54	-

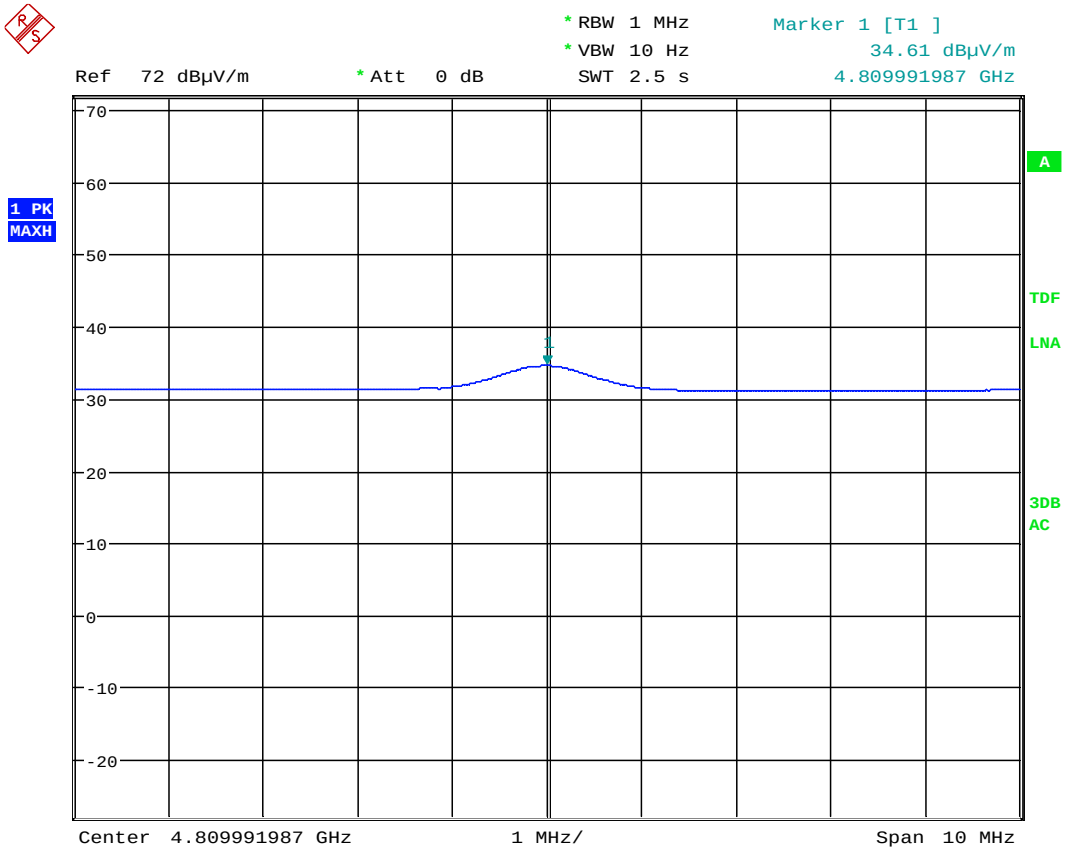
The detected spurious emissions are within the restricted band (4.5 - 5.15 GHz).

The maximum is detected in vertical polarization.

See attached graphs.



LO leakgage at ch 2405MHz – VP : PK detector



Date: 1.FEB.2013 15:32:50

LO leagage at ch 2405MHz – VP : AV detector

4.6 Power Spectral Density (PSD)

Para. No.: 15.247 (e)

Test Performed By: G.Suhanthakumar	**Date of Test: 18 Feb. 2013**

Test Results: Complies

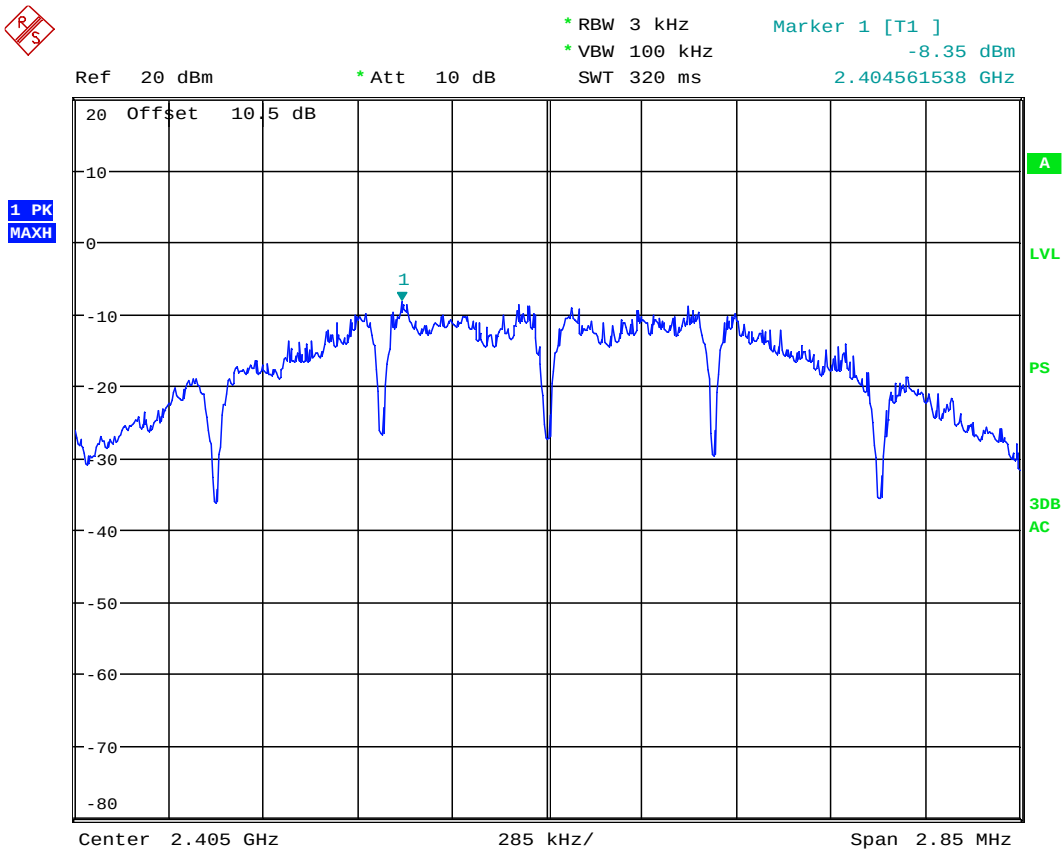
Measured and Calculated Data:

	calculated peak PSD dBm
Power Spectral Density @2405 MHz	-8.4
Power Spectral Density @2440 MHz	-9.2
Power Spectral Density @2480 MHz	-16.7

Tested according to KDB 558074 D01 DTS Meas Guidance v02, Section 9.1.

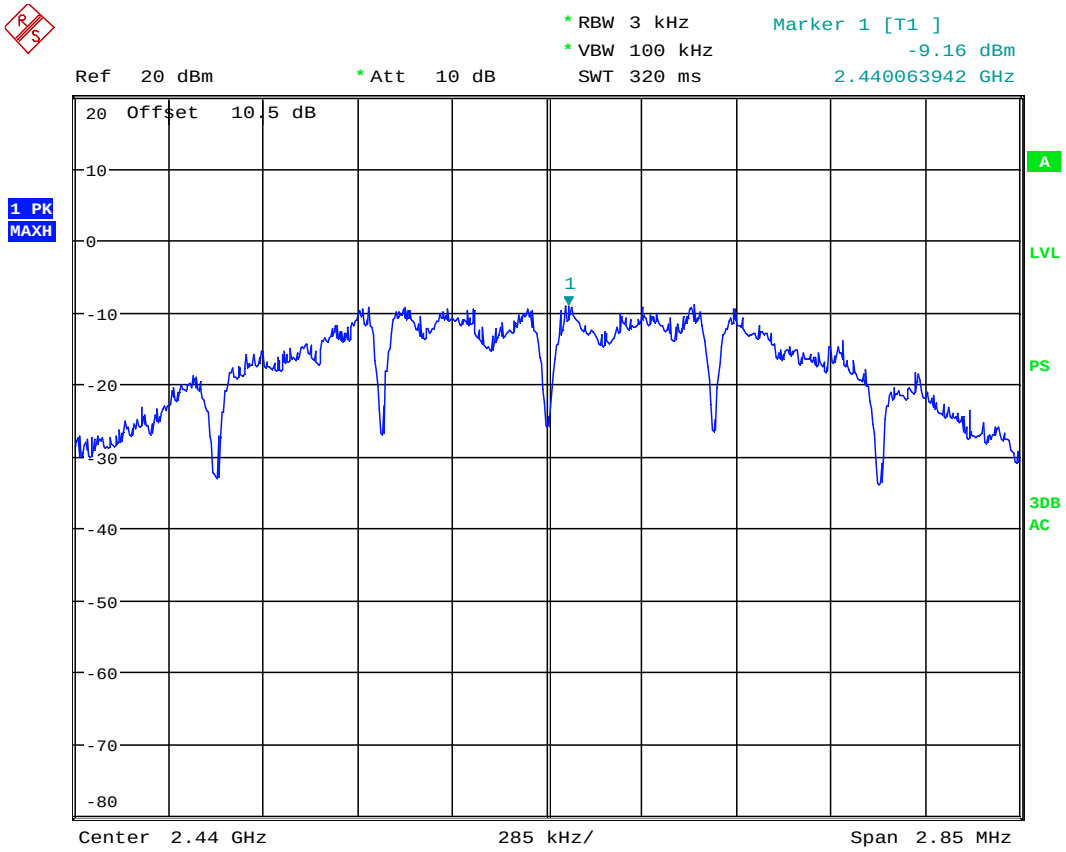
Requirements:

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



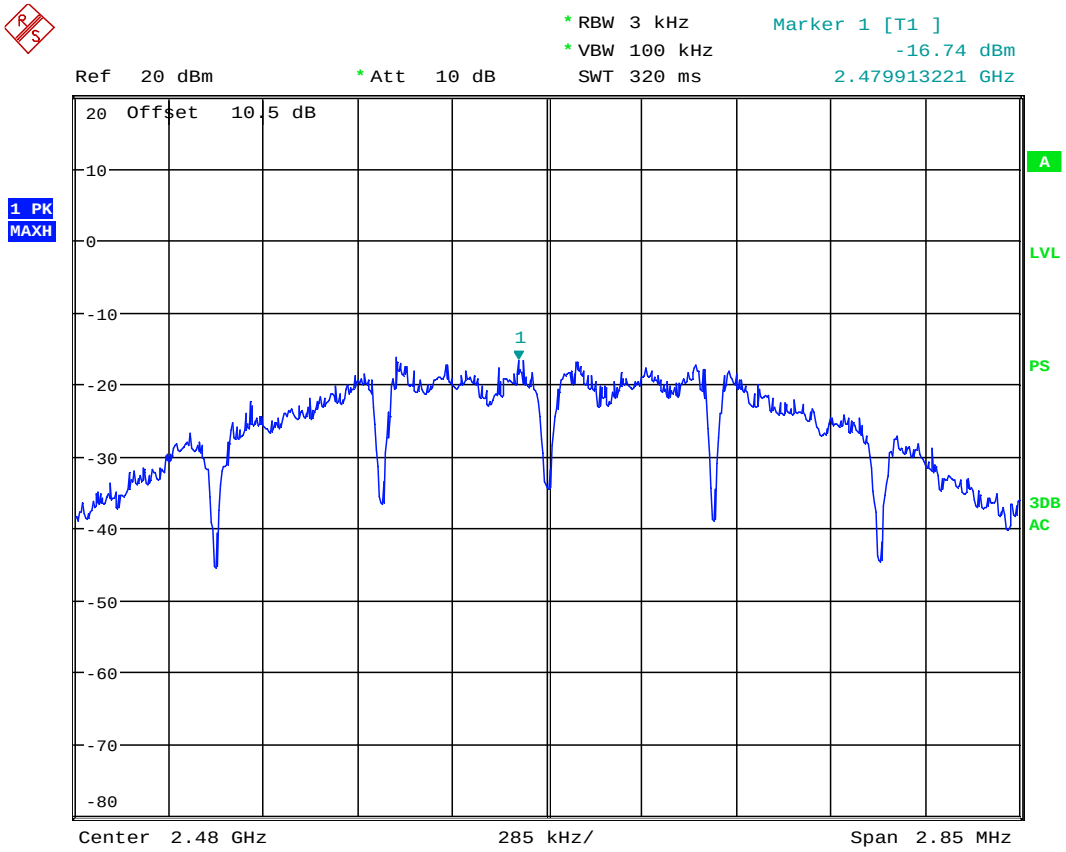
Date: 18.FEB.2013 10:22:20

PSD Measurement - 2405MHz



Date: 18.FEB.2013 10:21:03

PSD Measurement – 2440MHz



Date: 18.FEB.2013 10:23:04

PSD Measurement - 2480MHz

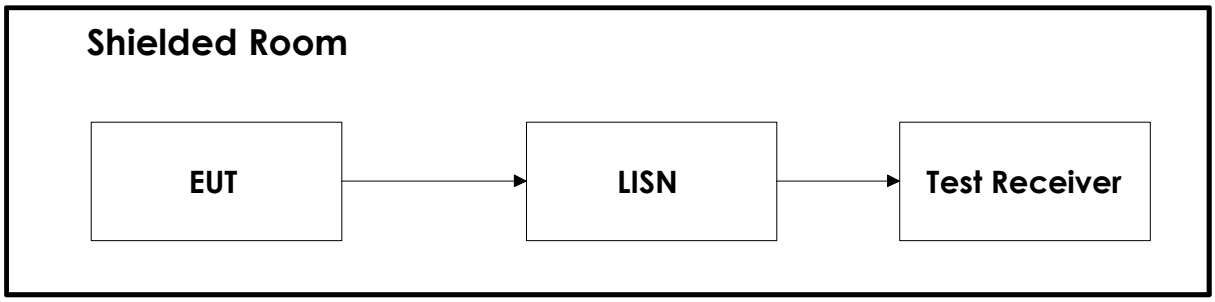
5 LIST OF TEST EQUIPMENT

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	FSP30	Spectrum Analyzer	Rohde & Schwarz	LR 1551	2012.04.05	2013.04.05
2	ESU40	EMI Receiver	Rohde & Schwarz	LR1639	2010.06	2013.06
3	3115	Antenna horn	EMCO	LR 1330	2010.08.05	2013.08.05
4	643	Antenna horn	Narda	LR 093	2009.01.26	2014.01.26
5	642	Antenna horn	Narda	LR 220	2009.01.26	2014.01.26
6	PM7320X	Antenna horn	Siverts lab	LR 103	2009.01.26	2014.01.26
7	DBF-520-20	Antenna horn	Systron Donner	LR 101	2009.01.26	2014.01.26
8	638	Antenna horn	Narda	LR 098	2010.06.17	2015.06.17
9	VULB 9163	Antenna TriLog	Schwarzbeck	LR1616	2012-08	2013-08
10	8449B	Pre-amplifier	Hewlett Packard	LR 1322	2012-09-27	2013-09-27
11	LNA6900	Pre-amplifier	Teseq	LR 1593	2012-11	2013-11
14	80S	Signal Generator	Powertron	LT 502	Cal b4 use	
15	Model 87 V	Multimeter	Fluke	LR 1598	2012-12-14	2014-12-14
17	6810.17A	10 attenuator	Suhner	LR 1143	2012.09.15	2014.09.15
18	FA210A1010003030	Microwave cable	Rosenberger	LR1566	Cal b4 use	
19	6HC 3000-18000	HP Filter	Trithlic	LR1614	Cal b4 use	
20	6HC 2500-18000	HP Filter	Trithlic	LR1615	Cal b4 use	
21	FSW	Spectrum Analyzer	Rohde & Schwarz	LR1640	2012.06	2014.06

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission