



Test report no. : 171701-4

Item tested : CC2531NANO

Type of equipment : IEEE 802.15.4 - 2.4 GHz

FCC ID: ZAT2531NANO

Client : Texas Instruments Norway AS

FCC Part 15.247

Digital Transmission System

RSS-210, Issue 8 & RSS-Gen, Issue 3

Low Power Licence-Exempt
Radio communication Devices

25 January 2012

Authorized by :

A handwritten signature in blue ink, reading 'Frode Sveinsen'.

Frode Sveinsen
Technical Verificator

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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
Email: comlab@nemko.no
FCC test firm : 994405
IC OATS : 2040D-1
Total Number of Pages: 56

1.2 Client Information

Name : Texas Instruments Norway AS
Address : Gaustadallen 21,
0349 Oslo, Norway
Telephone : +47 22 95 85 44
Fax : +47 22 95 85 46

Contact:

Name : Espen Slette
Telephone : +47 22 95 82 15
E-mail : e.slette@ti.com

1.3 Manufacturer

Same as client

2 Test Information

2.1 Test Item

Name :	CC2531NANO
Model/version :	CC2531NANO
FCC ID :	ZAT2531NANO
Industry Canada ID :	451H-2531NANO
Serial number :	-
Hardware identity and/or version:	-
Software identity and/or version :	-
Frequency Range :	2405 – 2480 MHz
Number of Channels :	16
Operating Modes :	TX & RX
Type of Modulation :	Digital (DSSS and O-QPSK)
User Frequency Adjustment :	None, Software controlled
Conducted Output Power :	0.0019 W (Calculated)
Type of Power Supply :	USB power *
Antenna Connector :	No, Integral antenna
Antenna type:	-
Antenna Diversity Supported :	None

* Tested using USB 2.0 connector but power is supplied by 4.5V DC battery pack (3x 1.5V AA). Since the EUT has low drop out (LDO) regulator and also it is designed for USB application, the voltage variation of 2.7 to 6.5 V DC does not affect output power or frequency tolerance.

Theory of Operation

The CC2531NANO USB stick is USB enabled system –on-chip for the 2.4 GHz ISM band. It is based on a system on- chip device. The physical layer of the radio is according to IEEE 802.15.4 with Direct Sequence Spread Spectrum(DSSS) and offset-QPSK modulation.

2.2 Test Environment

2.2.1 Normal test condition

Temperature: 20 - 22 °C

Relative humidity: 20 - 40 %

Normal test voltage: 4.5 V DC

The values are the limit registered during the test period.

2.3 Test Period

Item received date: 2011-04-12

Test period : from 2011-04-12 to 2011-04-14

3 TEST REPORT SUMMARY

3.1 General

Manufacturer: Texas Instruments Norway AS

Model No.: CC2531NANO

Serial No.: -

All measurements are traceable to national standards.

The tests were conducted for the purpose of demonstrating compliance with FCC CFR 47 Part 15.247.

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 3 and 10 meters.

☒ New Submission

☒ Production Unit

☐ Class II Permissive Change

☐ Pre-production Unit

DTS Equipment Code

☐ Family Listing

THIS TEST REPORT RELATES ONLY TO THE ITEM (S) TESTED.

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



TEST REPORT #: 171701-4

TESTED BY: G. Suhanthakumar
G. Suhanthakumar, Test engineer

DATE: 2012-01-25

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This test report applies only to the items and configurations tested.

3.2 Test Summary

Name of test	FCC Part 15 ref.	RSS-210 Issue 8 & RSS Gen Issue 3	Result
Supply voltage variations	15.31 (e)	8 (RSS-GEN)	Complies ²
Number of operating frequencies	15.31 (m)	A8.1	Complies
Power-line Conducted Emissions (Receiver)	15.107(a)	7.2.2 (RSS-GEN)	Complies
Radiated Emissions limits (receiver)	15.109(a)	6 (RSS-GEN)	ref. 15.209(a)
Antenna requirement	15.203	7.1.4 (RSS-GEN)	NA ¹
Radiated emissions limits for restricted bands	15.205(a)		Complies
Power Line Conducted Emissions	15.207(a)	7.2.2 (RSS-GEN)	Complies
Radiated emission limits	15.209(a)	A8.5	Complies
Bandwidth	15.247(a)(2)	A8.2	Complies
Peak Power Output	15.247(b)(3)	A8.4	Complies
Power Spectral Density	15.247(d)	A8.2	Complies
Out-of-band emissions (Antenna Conducted)	15.247(c)	A8.5	Complies ¹
Out-of-band emissions (Radiated)	15.247(c)	A8.5	Complies
Lower band edge radiated emission	15.247(c)	A8.5	Complies
Upper band edge radiated emission	15.247(c)	A8.5	Complies

¹ Integral antenna only

² The power is taken from battery for testing purpose. The eut is a USB dongle, therefore power line conducted emission is performed with a lap top.

3.3 Description of modification for Modification Filing

Not applicable.

3.4 Comments

The channels are selected with a computer connected to the EUT. The computer is only used for selection of channels. The measurements are performed at channels near top Ch 26, near middle Ch 18 and near bottom Ch 11. And the output level is set to maximum in the software. The EUT complies at these channels.

During radiated tests the selection of channels are done by manufacturer outside the test chamber..

The radiated measurements are tested on three axis.

Power supply variation within manufacturer specified range 2.7 – 6.5V DC has no influence on measured values in this test report.

3.5 Family List Rationale

Not Applicable.

4 TEST RESULTS

4.1 Power-line Conducted Emissions

Para. No.: 15.207 (a)

Test Performed By: G.Suwanthakumar

Date of Test: 14-Apr-2011

Test Results: Complies.

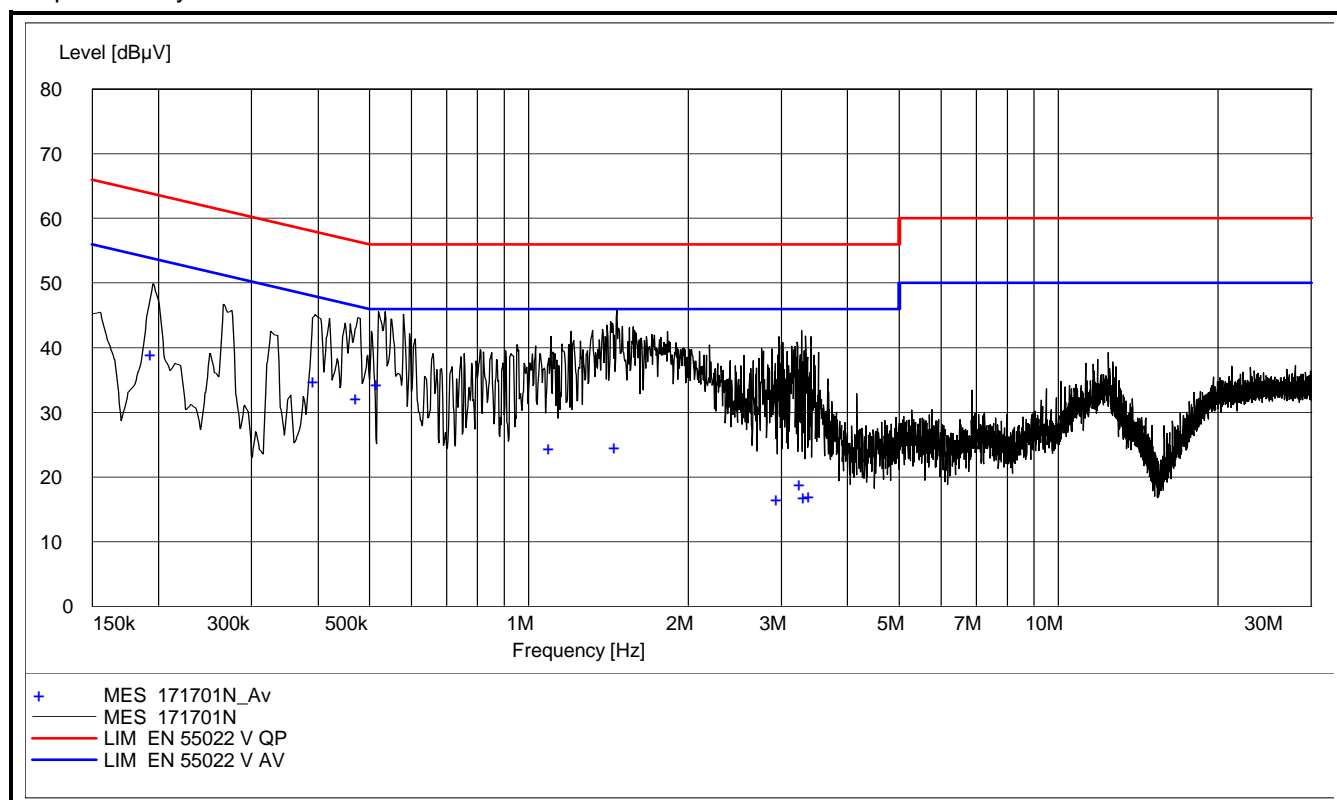
Measurement Data: Peak detector was used.

Lap-Top Dell Latitude D610

The measured peak values are below the Quasi-Peak and Average limit

See the attached graphs for peak scan..

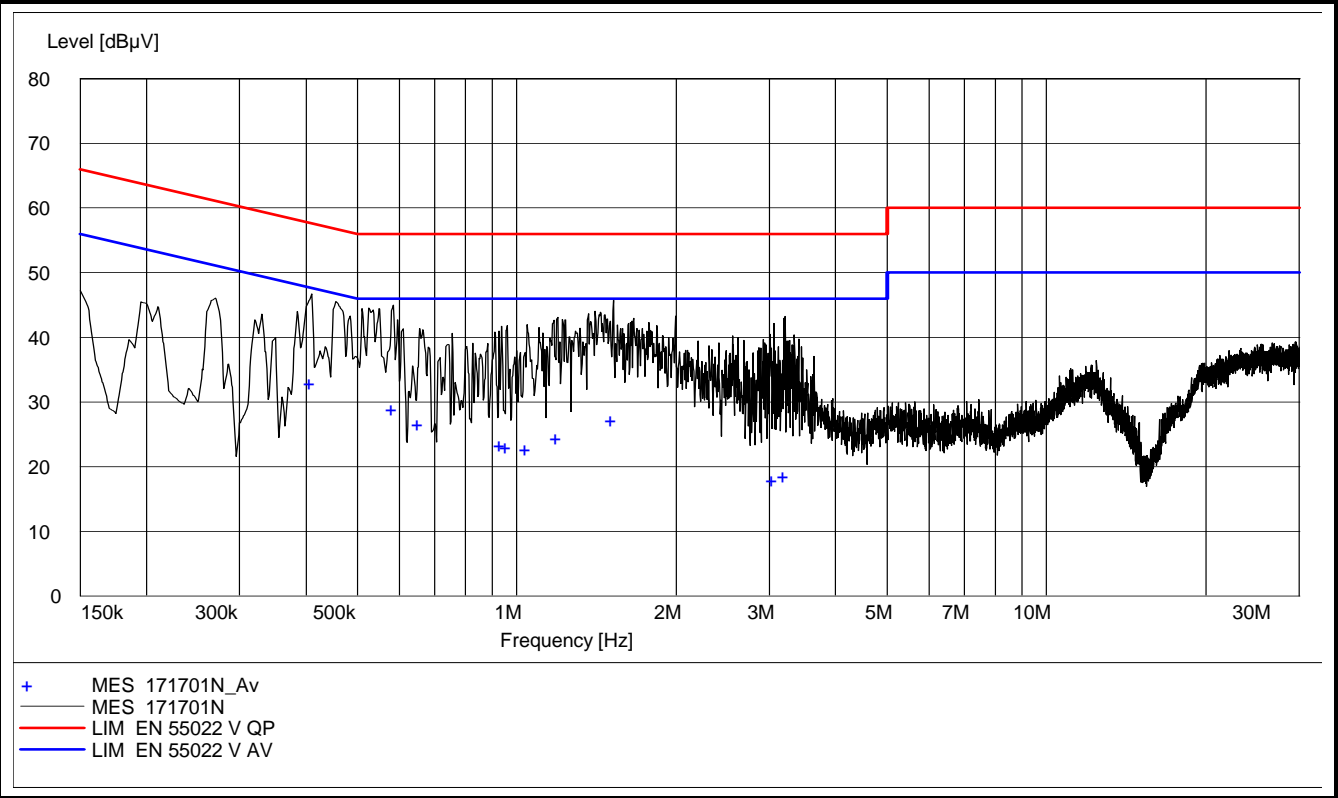
Lap-TOP only



Frequency [MHz]	Level [dBuV]	Af [dB]	Limit [dBuV]	Margin [dB]	Det	Position	Verdict [Pass/Fail]
0.195000	39.10	10.10	53.80	-14.70	AV	L1	Pass
0.395000	34.90	10.20	48.00	-13.10	AV	L1	Pass
0.475000	32.30	10.20	46.40	-14.10	AV	L1	Pass
0.520000	34.50	10.20	46.00	-11.50	AV	L1	Pass
1.100000	24.50	10.20	46.00	-21.50	AV	N	Pass
1.465000	24.70	10.20	46.00	-21.30	AV	L1	Pass
2.965000	16.60	10.30	46.00	-29.40	AV	L1	Pass
3.275000	18.90	10.30	46.00	-27.10	AV	L1	Pass
3.335000	16.90	10.30	46.00	-29.10	AV	L1	Pass
3.405000	17.10	10.30	46.00	-28.90	AV	L1	Pass

L1 & N polarity - power line conducted emission – Lap-top only

EUT with lap-top



L1 & N polarity - power line conducted emission – Lap-top & EUT

Frequency [MHz]	Level [dBuV]	Af [dB]	Limit [dBuV]	Margin [dB]	Det	Position	Verdict [Pass/Fail]
0.410000	32.90	10.20	47.60	-14.70	AV	L1	Pass
0.585000	28.90	10.20	46.00	-17.10	AV	L1	Pass
0.655000	26.70	10.20	46.00	-19.30	AV	L1	Pass
0.935000	23.40	10.20	46.00	-22.60	AV	L1	Pass
0.960000	23.10	10.20	46.00	-22.90	AV	L1	Pass
1.045000	22.90	10.20	46.00	-23.10	AV	N	Pass
1.195000	24.50	10.20	46.00	-21.50	AV	L1	Pass
1.520000	27.20	10.20	46.00	-18.80	AV	L1	Pass
3.060000	18.00	10.30	46.00	-28.00	AV	L1	Pass
3.210000	18.60	10.30	46.00	-27.40	AV	L1	Pass

4.2 Minimum 6 dB Bandwidth

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

Test Performed By: G.Suwanthakumar

Date of Test: 12-Apr-2011

Test Results: Complies

Measurement Data:

6 dB Bandwidth (MHz)		
Ch 11 2405MHz	Ch 18 2440MHz	Ch 26 2480MHz
1.66	1.59	1.65

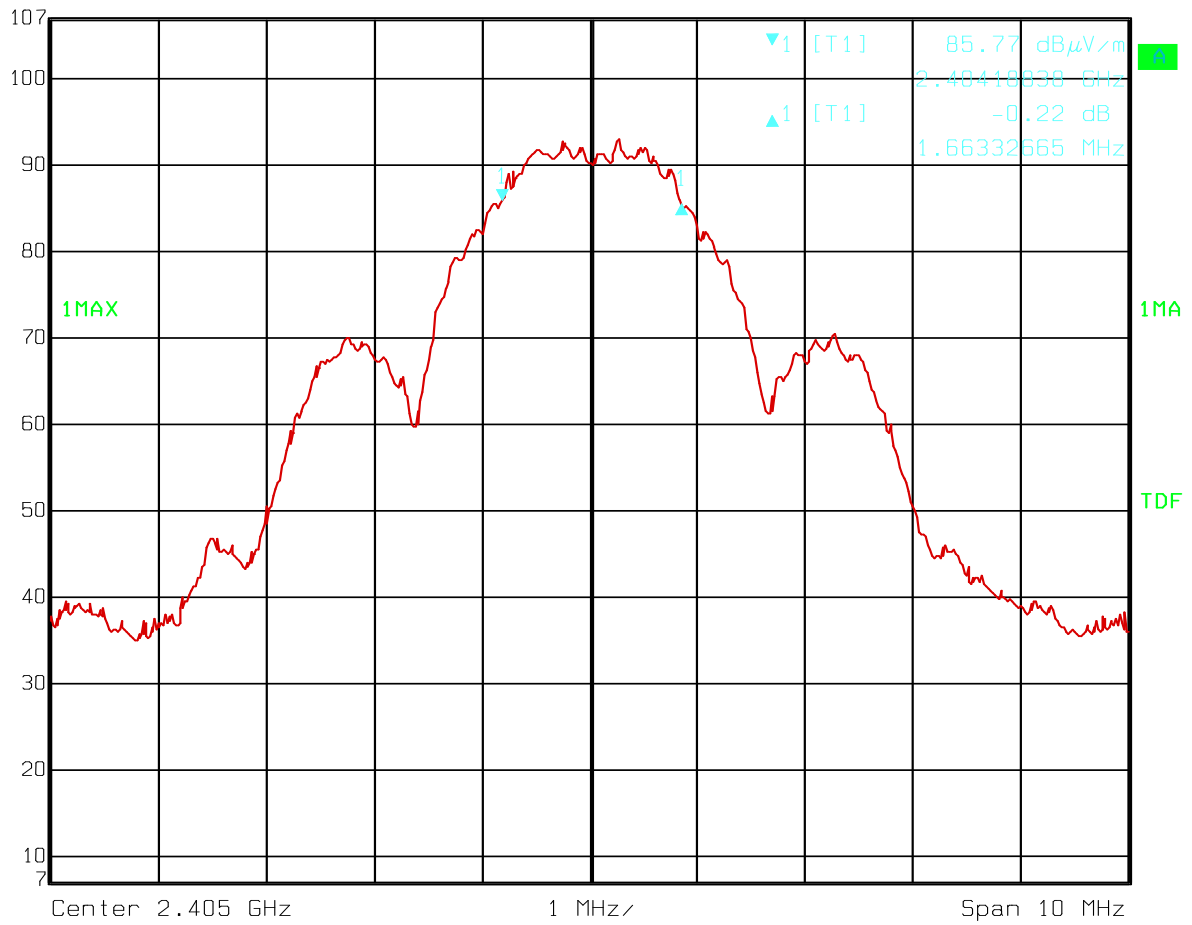
Power supply variation within manufacturer specified range 2.7 – 6.5V DC has no influence on measured value

Requirements:

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



Ref Lvl 107 dB* Delta 1 [T1] -0.22 dB RBW 100 kHz RF Att 10 dB
 1.66332665 MHz VBW 100 kHz Unit dBμV/m
 SWT 5 ms



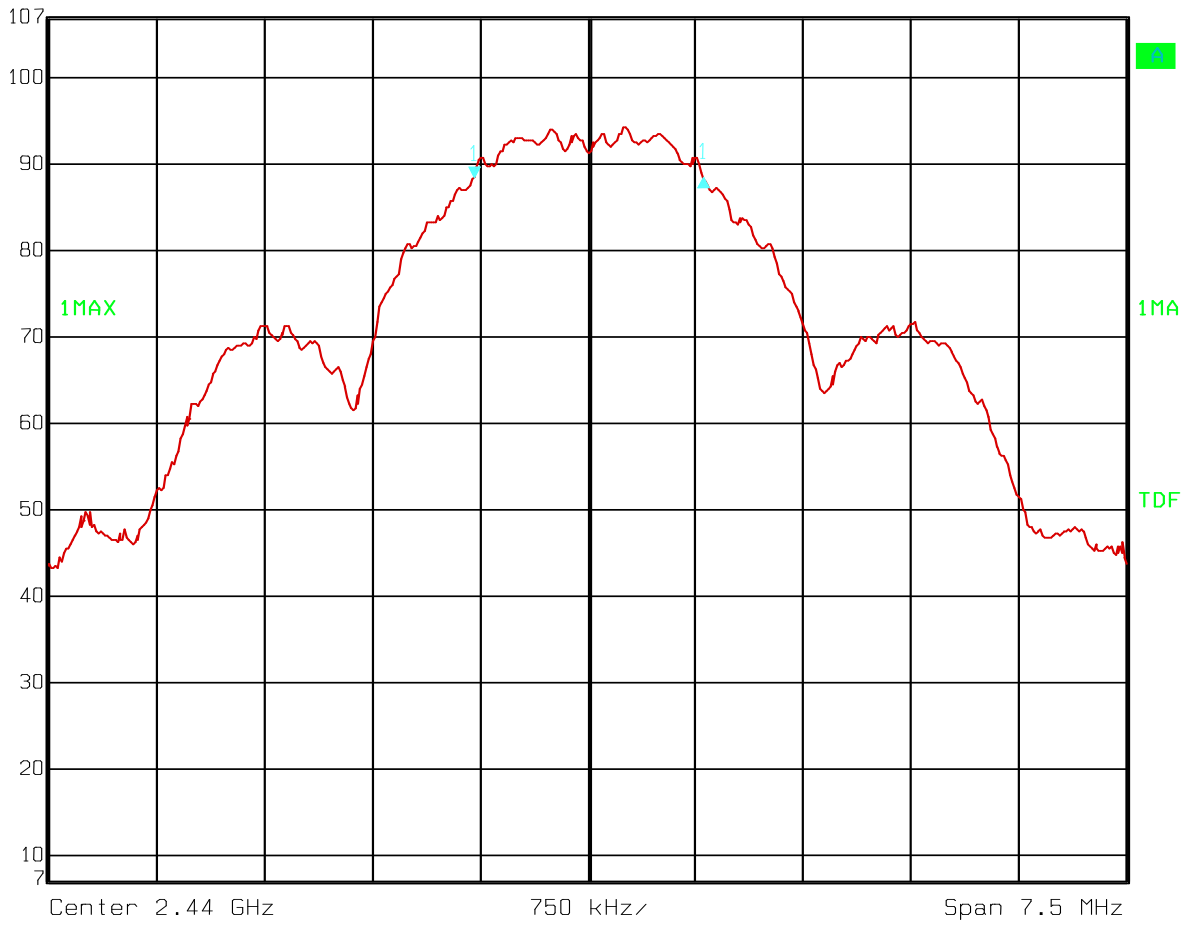
Center 2.405 GHz 1 MHz Span 10 MHz

Date: 12.APR.2011 11:20:18

Ch11 – 6 dB bandwidth – 1.66MHz



Ref Lvl 107 dB*
 Delta 1 [T1] 0.10 dB
 1.59318637 MHz
 RBW 100 kHz
 VBW 100 kHz
 SWT 5 ms
 RF Att 20 dB
 Unit dBμV/m



Date: 12.APR.2011 09:50:22

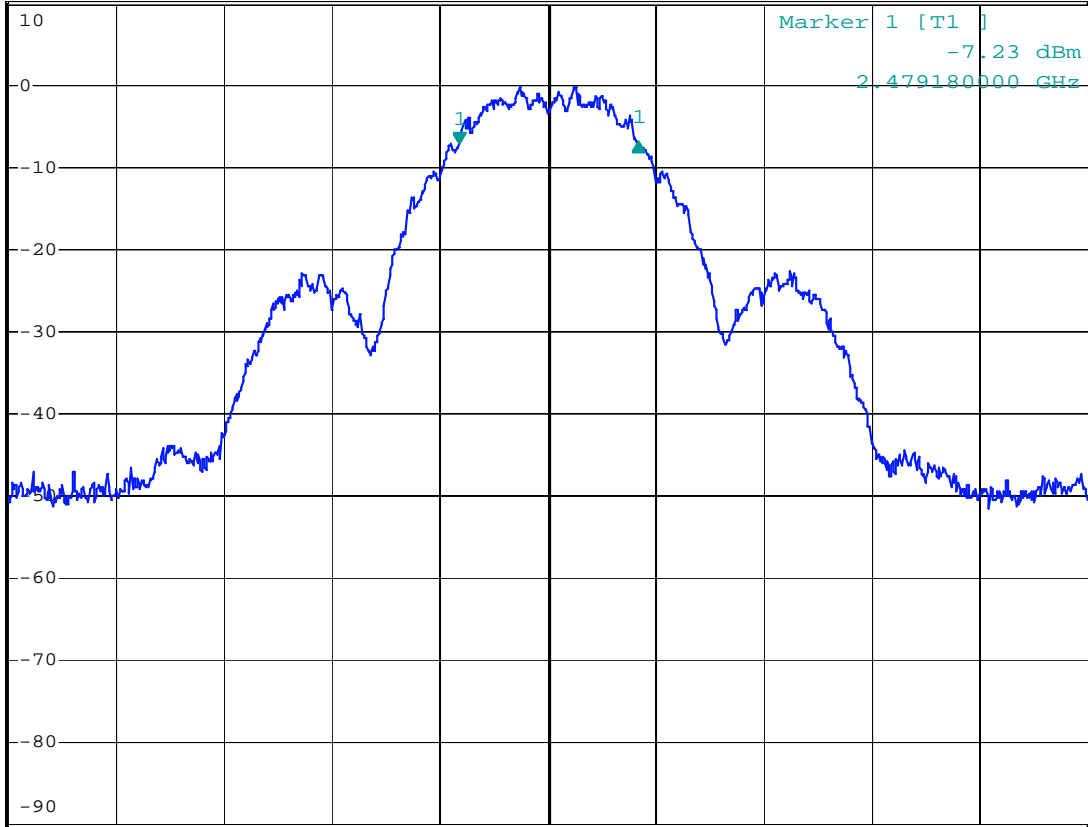
Ch18 – 6 dB bandwidth – 1.59MHz



DELTA MARKER 1
 1.65 MHz

Ref 10 dBm * Att 20 dB * RBW 100 kHz Delta 1 [T1] * VBW 100 kHz 0.27 dB SWT 5 ms 1.650000000 MHz

1 PK
MAXH



Center 2.48 GHz 1 MHz/ Span 10 MHz

Date: 13.APR.2011 11:11:47

CH26 – 6 dB bandwidth – 1.65MHz

4.3 20 dB Bandwidth

Para. No.: RSS-Gen

Test Performed By: G.Suwanthakumar

Date of Test: 12-Apr-2011

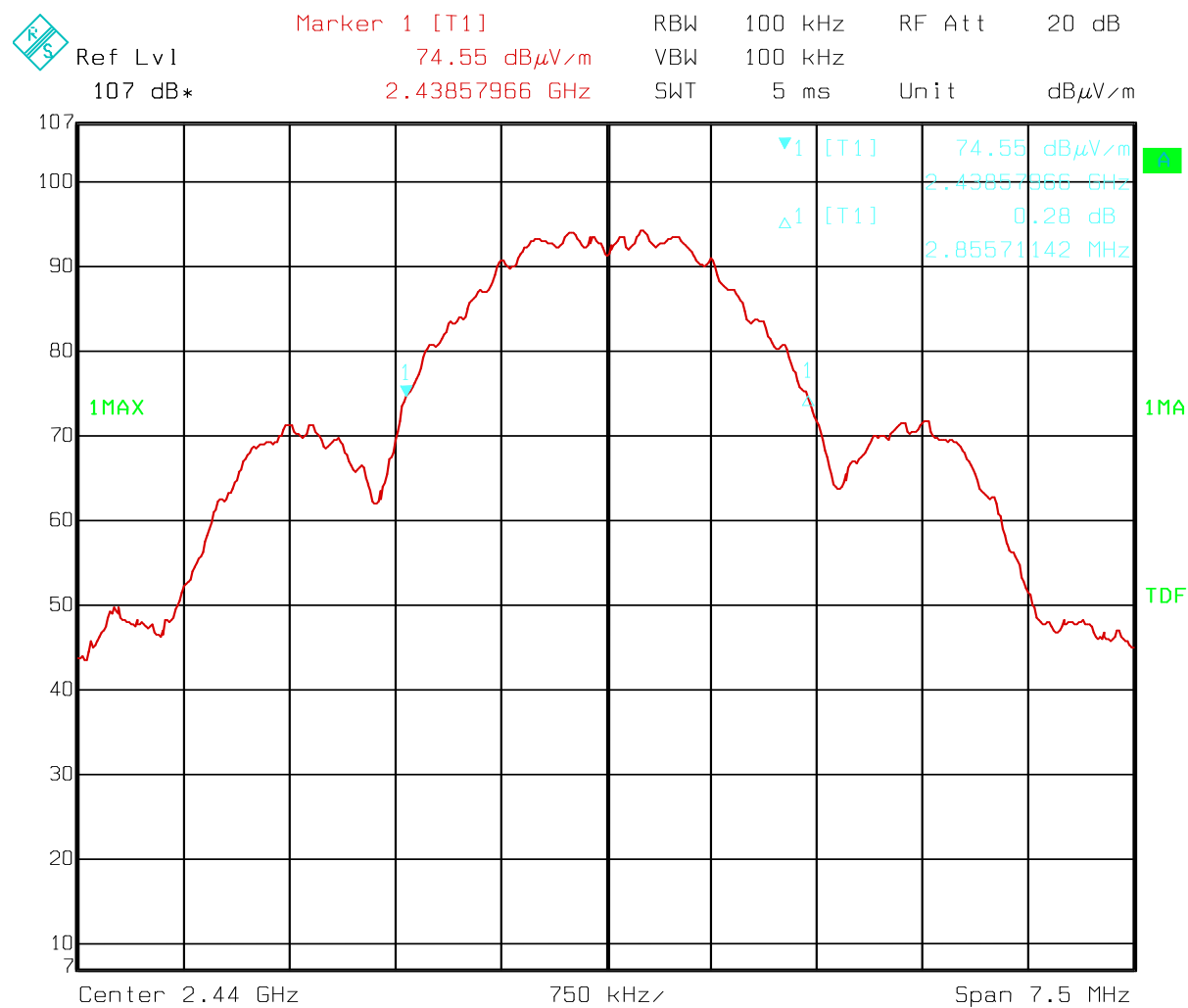
Measurement Data:

20 dB Bandwidth (MHz)		
Ch 11 2405MHz	Ch 18 2440MHz	Ch 26 2480MHz
-	2.86	-

Power supply variation within manufacturer specified range 2.7 – 6.5V DC has no influence on measured value

Requirements:

For information only.



Date: 12.APR.2011 09:51:32

Ch18 – 20 dB bandwidth – 2.86MHz

4.4 Peak Power Output

Para. No.: 15.247 (b)

Test Performed By: G.Suwanthakumar

Date of Test: 12-Apr-2011

Test Results: Complies

Measurement Data:

Measured Maximum Field strength

RF channel	Ch 11	Ch 18	Ch 26
VP: Measured value (dBμV/m)	96.69	98.30	100.3
HP: Measured value (dBμV/m)	94.20	95.38	96.52

Calculated Maximum Power, EIRP

RF channel	Ch 11	Ch 18	Ch 26
Calculated EIRP (Watts)	0.0014	0.0020	0.0032
Declared Antenna Gain (dBi)	-2.25		
Calculated Power to antenna (Watts)	0.0008	0.0012	0.0019

The EIRP is calculated from measured field strength by the formula in DA00-705.

Power supply variation within manufacturer specified range 2.7 – 6.5V DC has no influence on measured values in this test report.

Maximum power is measured with vertical polarization.

Detachable antenna?

☐ Yes ☒ No

If detachable, is the antenna connector non-standard?

☐ Yes ☐ No

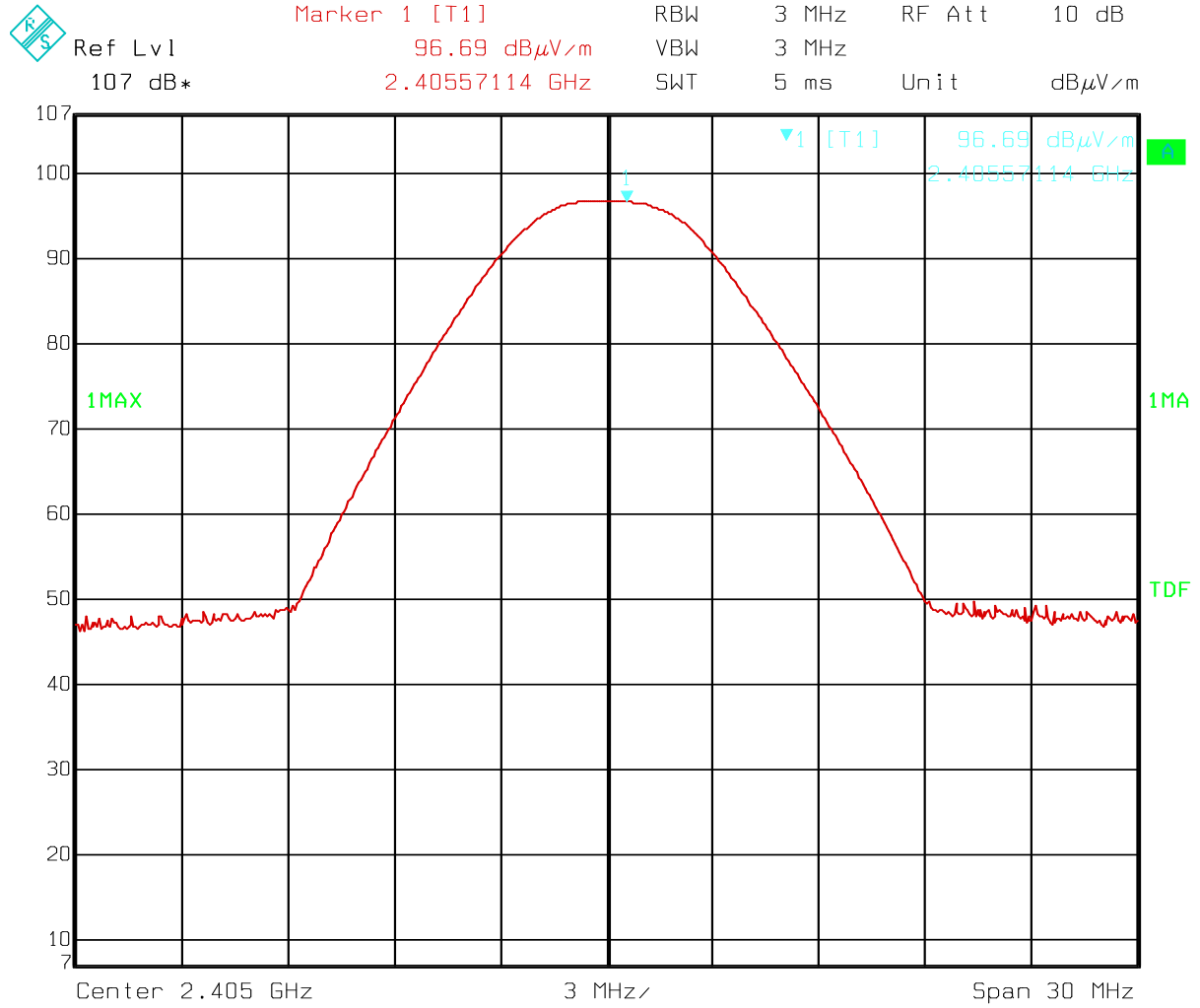
Integral antenna only

Requirements:

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

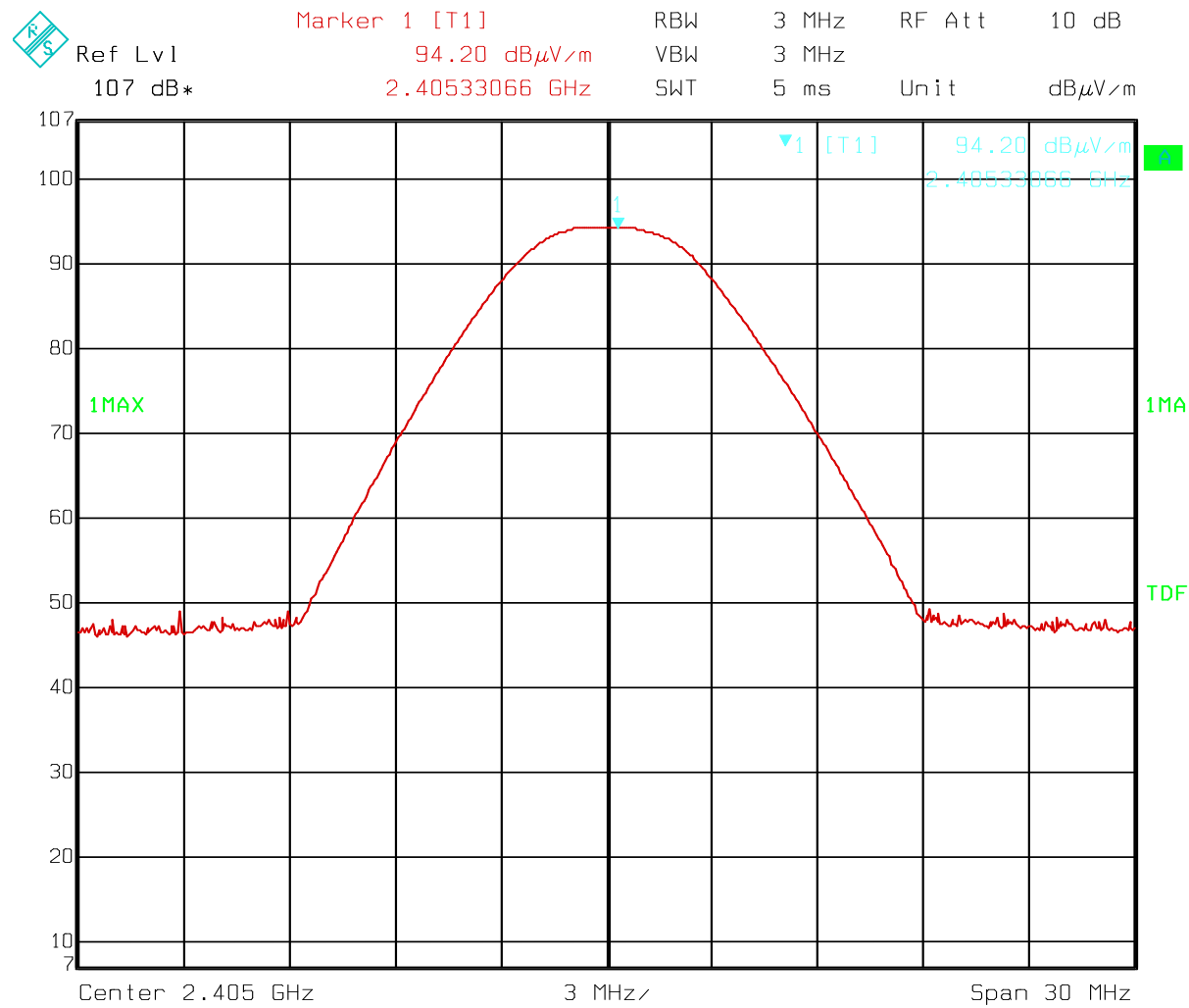
For Digital Transmission Systems in the 2400 - 2483.5 MHz band: 1 Watt

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.



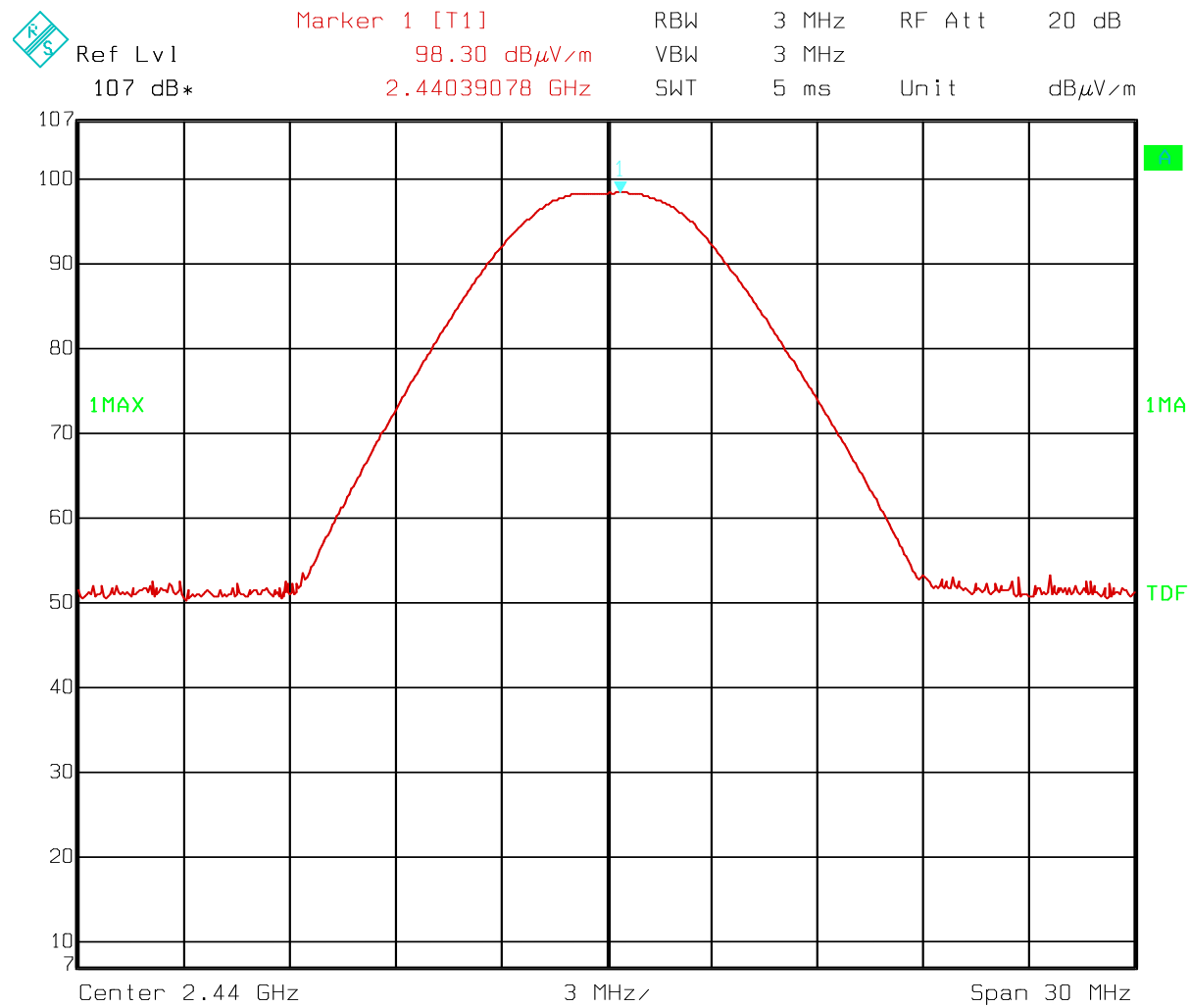
Date: 12.APR.2011 11:19:19

VP: Ch11 – Field strength



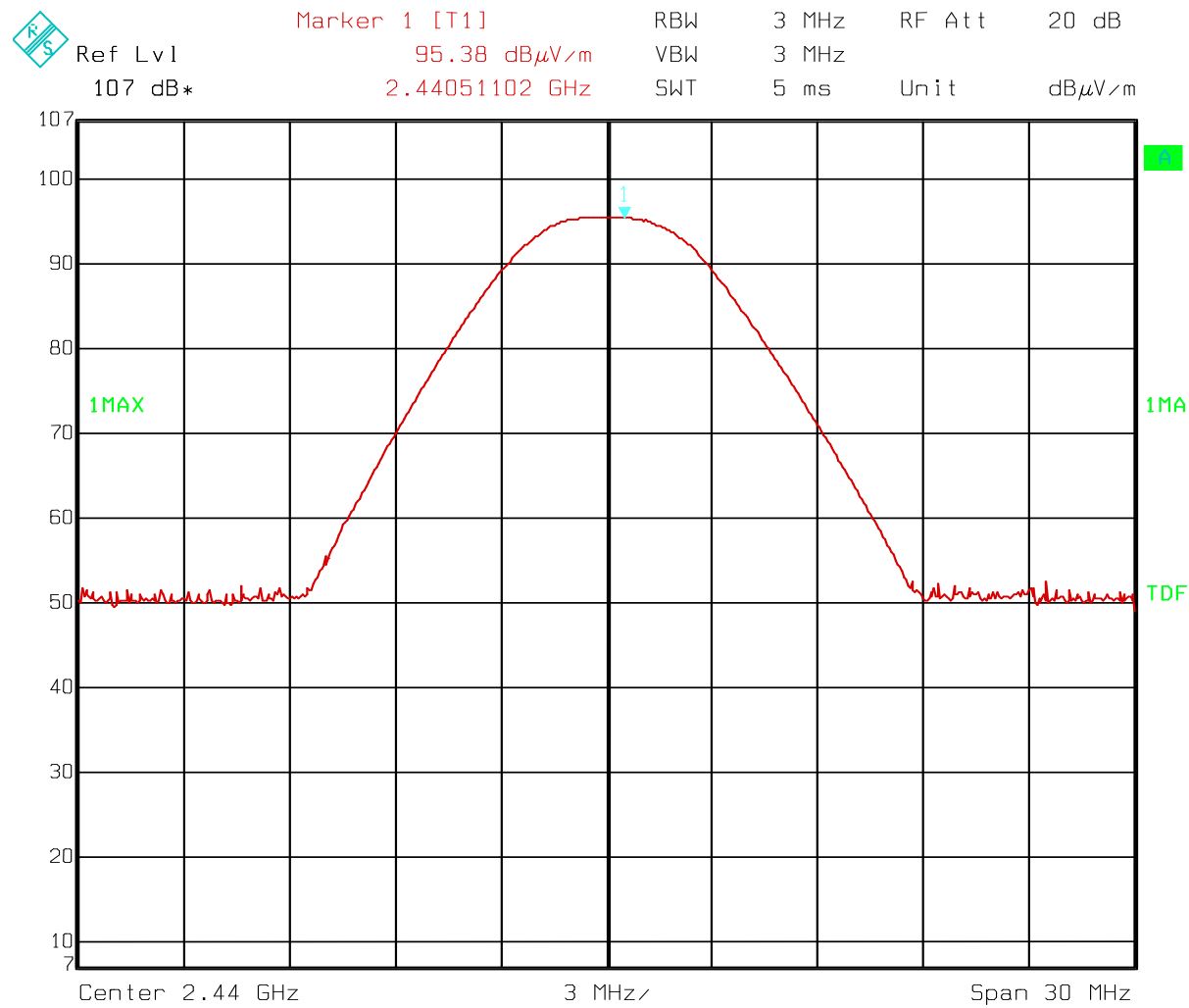
Date: 12.APR.2011 11:17:32

HP: Ch11 – Field strength



Date: 12.APR.2011 09:41:03

VP: Ch18 – Field strength

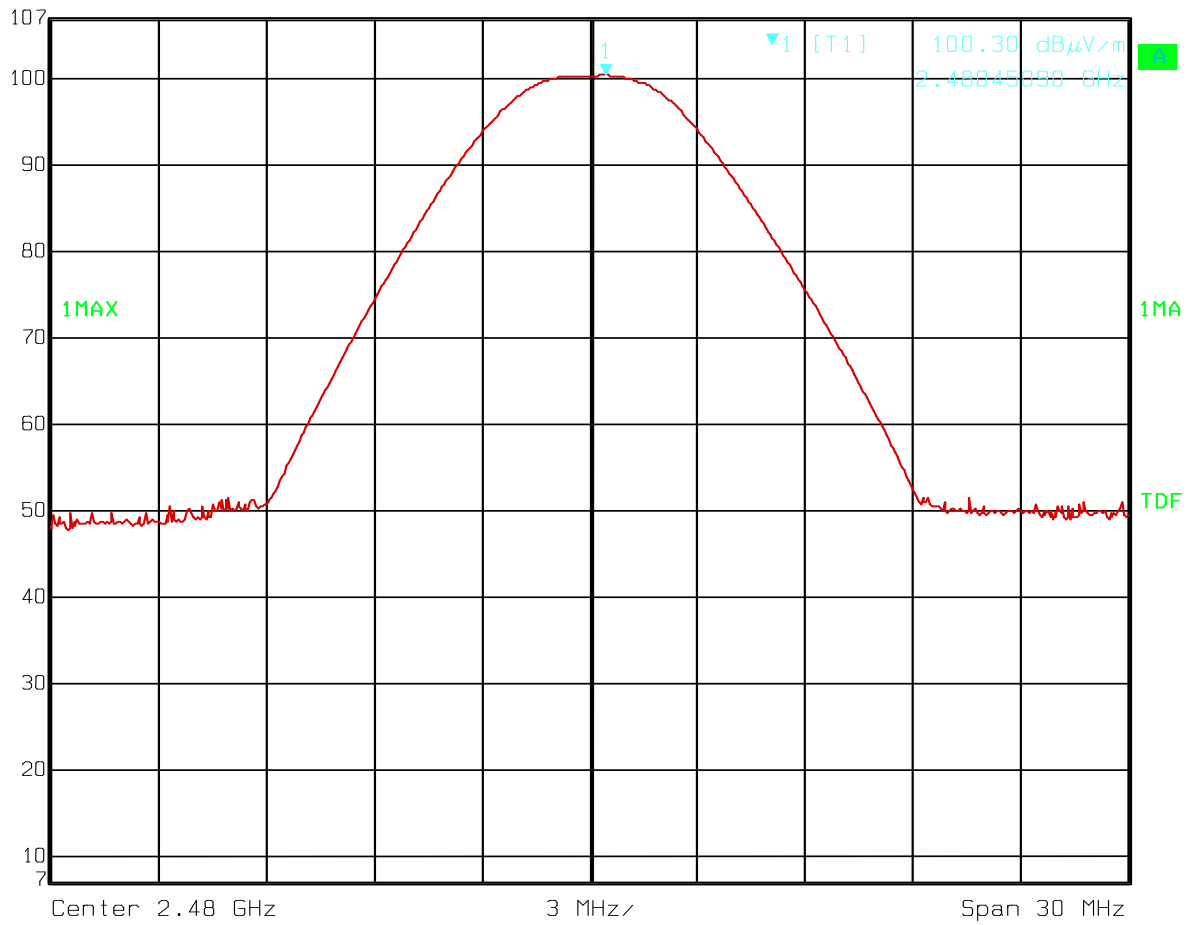


Date: 12.APR.2011 09:48:04

HP: Ch18 – Field strength

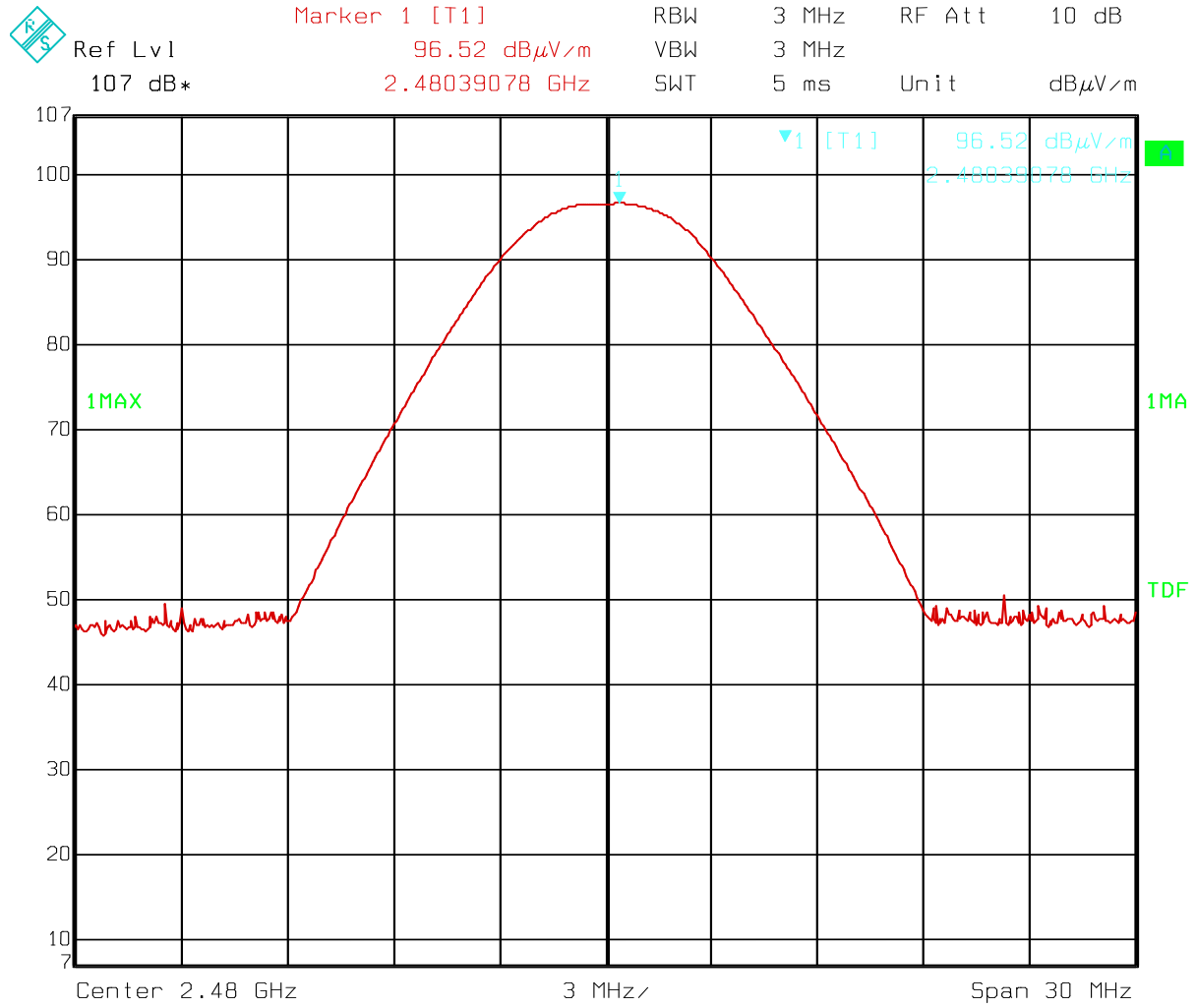


Ref Lvl 107 dB* Marker 1 [T1] 100.30 dB μ V/m 2.48045090 GHz RBW 3 MHz RF Att 10 dB VBW 3 MHz SWT 5 ms Unit dB μ V/m



Date: 12.APR.2011 12:01:59

VP: Ch26 – Field strength



Date: 12.APR.2011 12:06:20

HP: Ch26 – Field strength

4.5 Spurious Emissions (Radiated)

Para. No.: 15.247 (c)

Test Performed By: G.Suhanthakumar

Date of Test: 12.Apr.2011

Test Results: Complies

Measurement Data:

Lower Band-edge radiated measurements

Frequency	Power below nearest channel, dB	Limit	Margin
GHz	RF ch 11 DSS	dB	dB
2.4	53.91	-20	33.91

Band-edge field strength 2.4 GHz:

Marker Delta 100kHz RBW: 53.91dB

Peak Field Strength $96.38 - 53.91 = 42.47$ dB μ V/m

Upper Band-edge radiated measurements

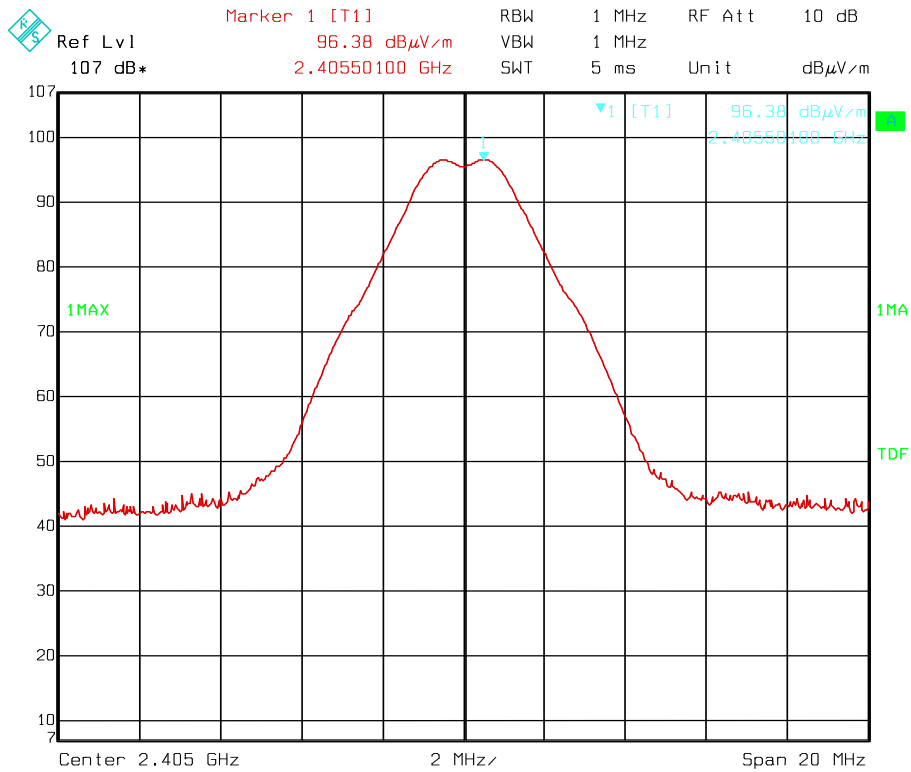
Frequency	Power below nearest channel, dB	Limit	Margin
GHz	RF ch 26 DSS	dB	dB
2.4835	49.95	-20	29.95

Band-edge field strength 2.4835 GHz:

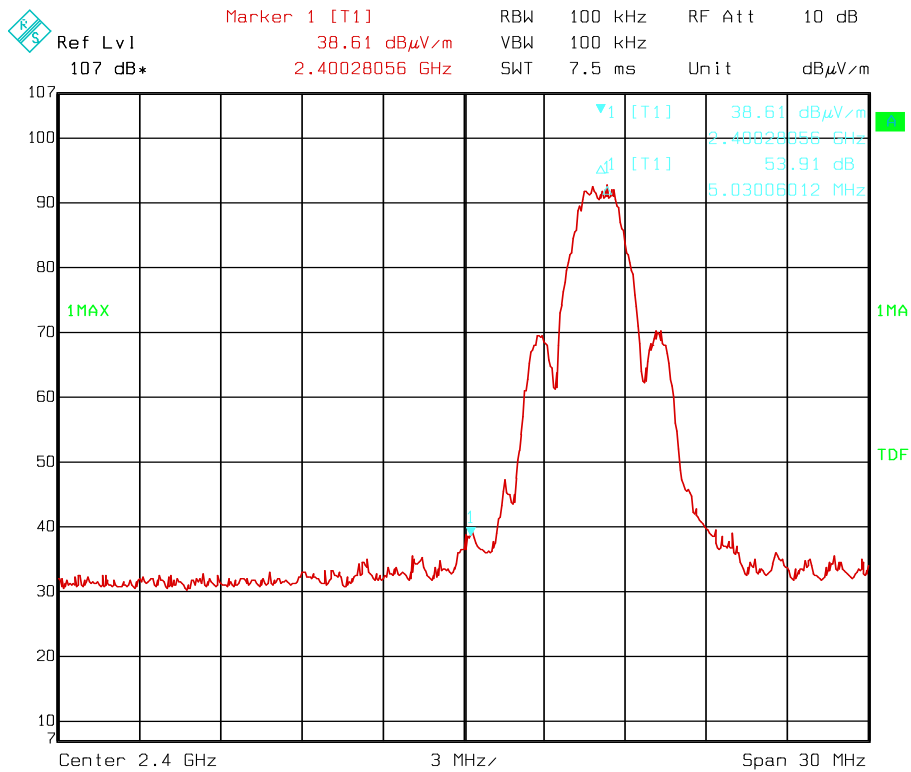
Marker Delta 100kHz RBW: 49.95 dB

Peak Field Strength: $100.11 - 49.95 = 50.16$ dB μ V/m

100% duty cycle

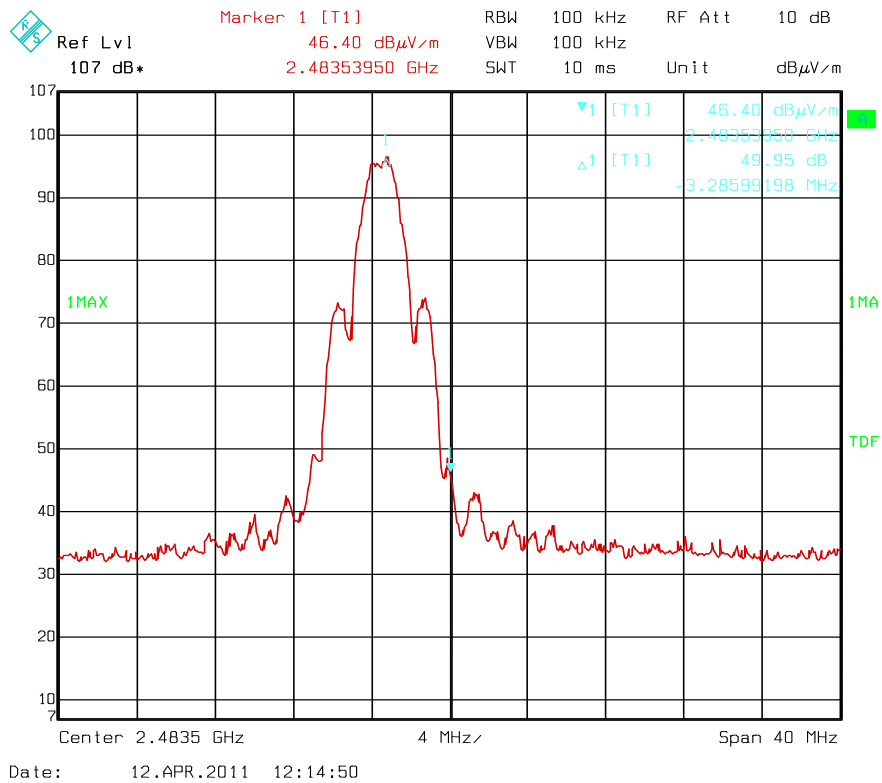
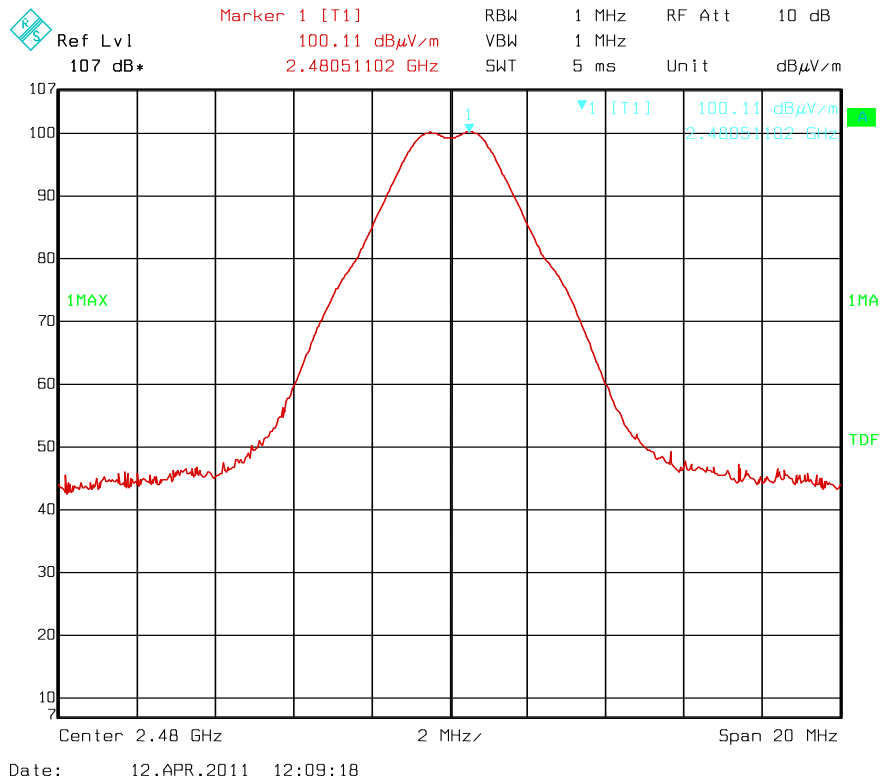


Date: 12.APR.2011 11:22:16



Date: 12.APR.2011 11:23:53

Ch11 – Lower-band-edge – Delta-marker



Ch26 – Upper-band-edge – Delta-Marker

Duty Cycle Calculation:

RF duty cycle: Calculation according to RF burst Para 15.35 (c)

Not given in this test report

Radiated Emissions with antenna, 1-25 GHz, peak

1-18 GHz measured at a distance of 3m, 18-25 GHz measured at 1m.

Measured with Peak Detector

Frequency	RF channel	Dist. corr. factor	Field strength, Peak, 3m	Duty cycle corr. factor	Limit	Margin
GHz	11-26	dB	dB μ V/m	dB	dB μ V/m	dB
4.811	11	0	49.13	-	74	24.9
4.881	18	0	50.73	-	74	23.3
4.960	26	0	52.54	-	74	21.5
5 - 25	11,18,26	0	None detected	-	-	-

Radiated emissions with antenna, 1- 25 GHz, Average

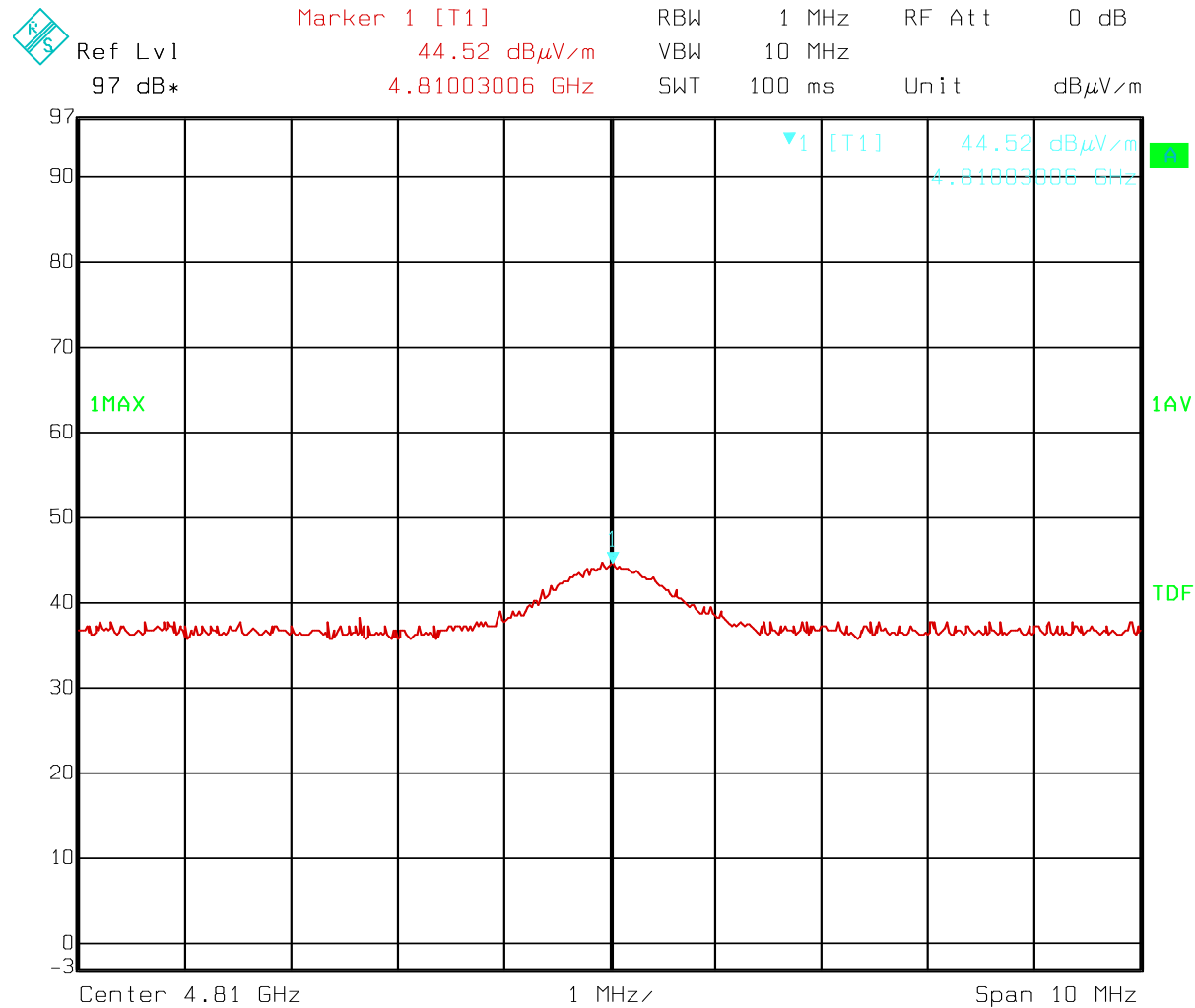
Measured with Average Detector

Frequency	RF channel	Dist. corr. factor	Field strength, Peak, 3m	Duty Cycle correction factor	Limit	Margin
GHz	11-26	dB	dB μ V/m	dB	dB μ V/m	dB
4.809	11	0	44.52	-	54	9.48
4.889	18	0	44.79	-	54	9.21
4.958	26	0	45.55	-	54	8.45
5 - 25	11,18,26	0	None detected	-	-	-

Measured with continuous transmission (100% duty cycle)

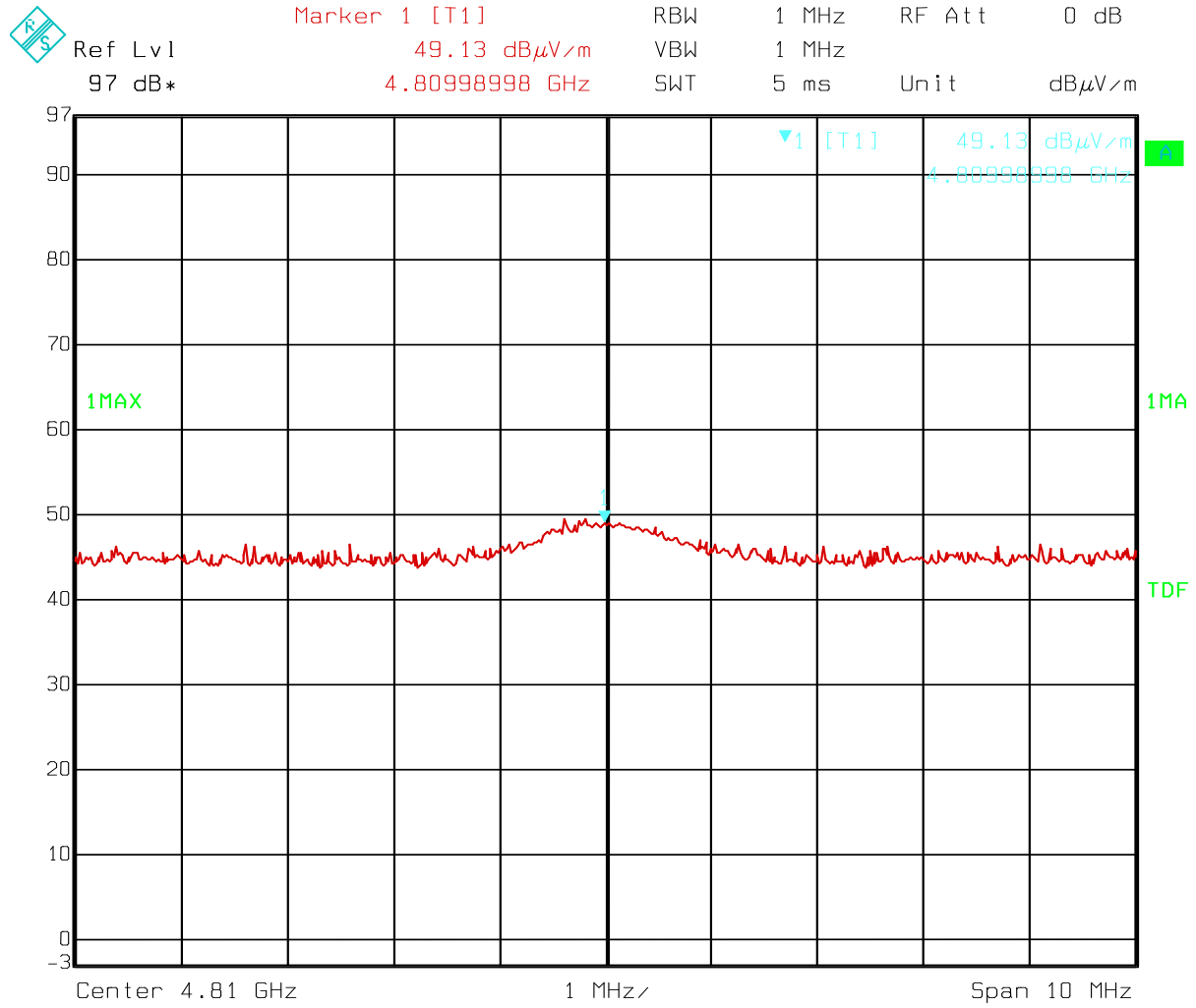
The maximum is observed in vertical polarization

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



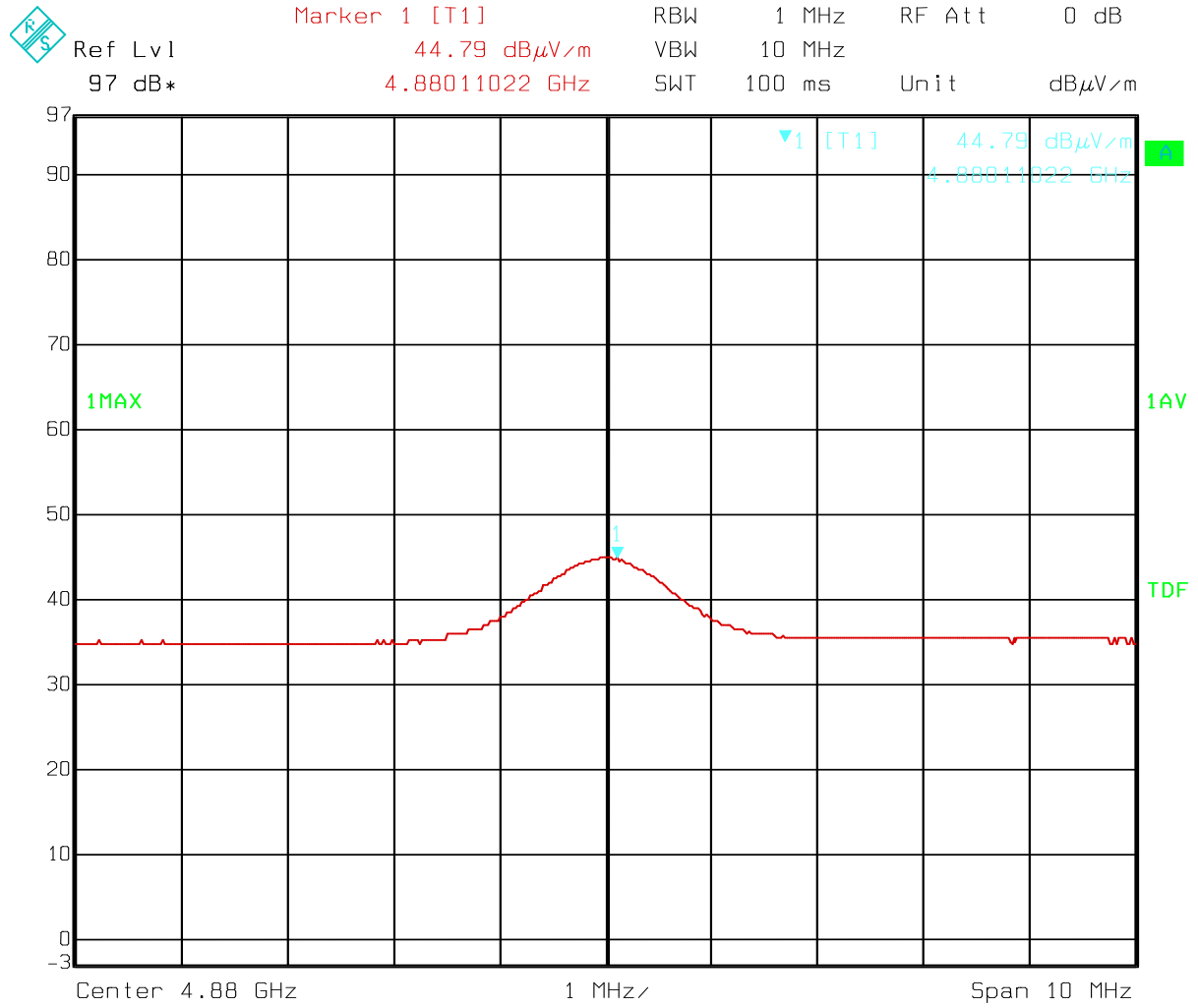
Date: 12.APR.2011 11:39:11

Ch11 – 2nd harmonic- AV detector



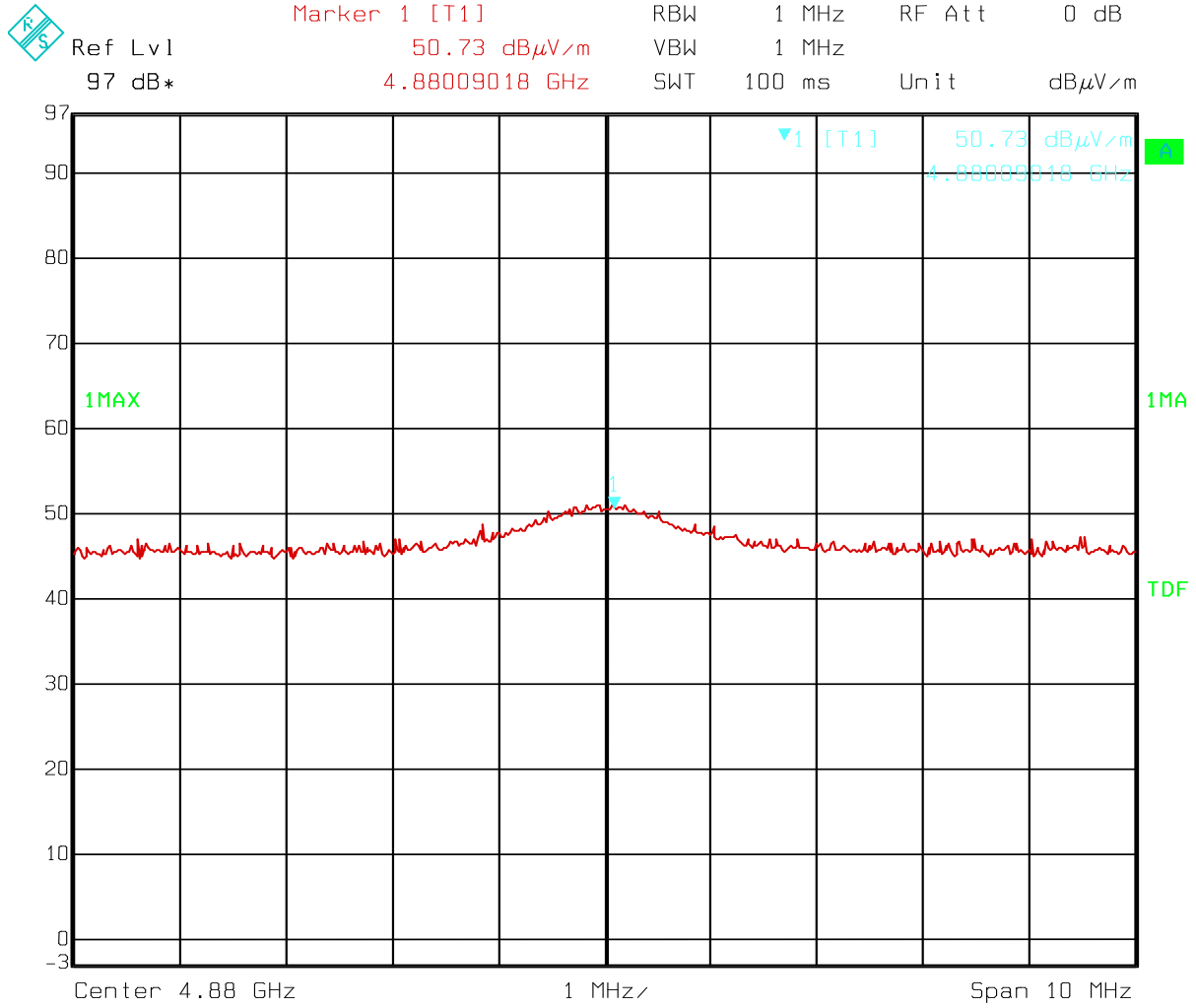
Date: 12.APR.2011 11:38:25

Ch11 – 2nd harmonic- Peak detector



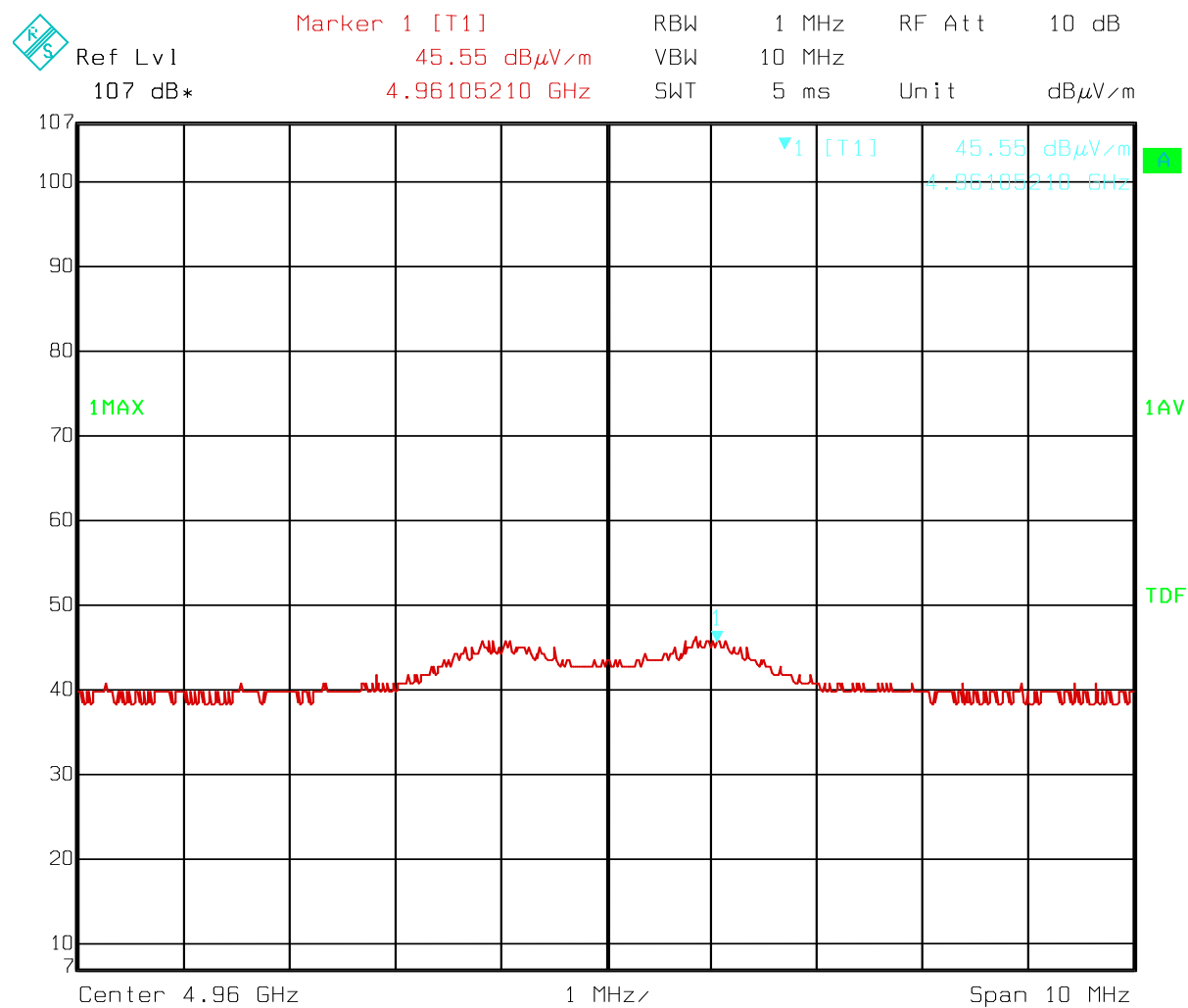
Date: 12.APR.2011 10:19:31

Ch18 – 2nd Harmonic- AV detector



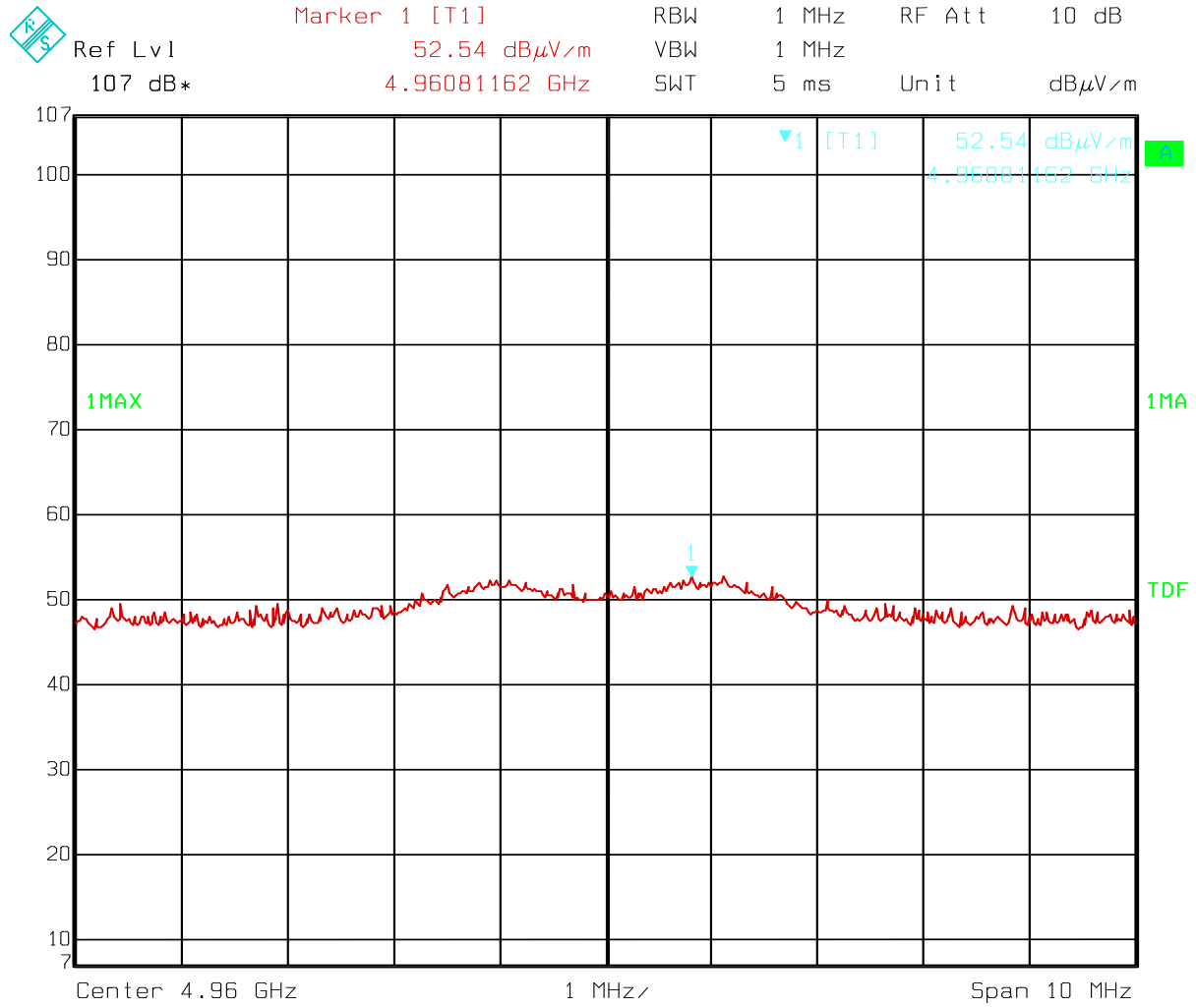
Date: 12.APR.2011 10:20:24

Ch18 – 2nd harmonic- Peak detector



Date: 12.APR.2011 12:31:10

Ch26 – 2nd Harmonic – AV detector



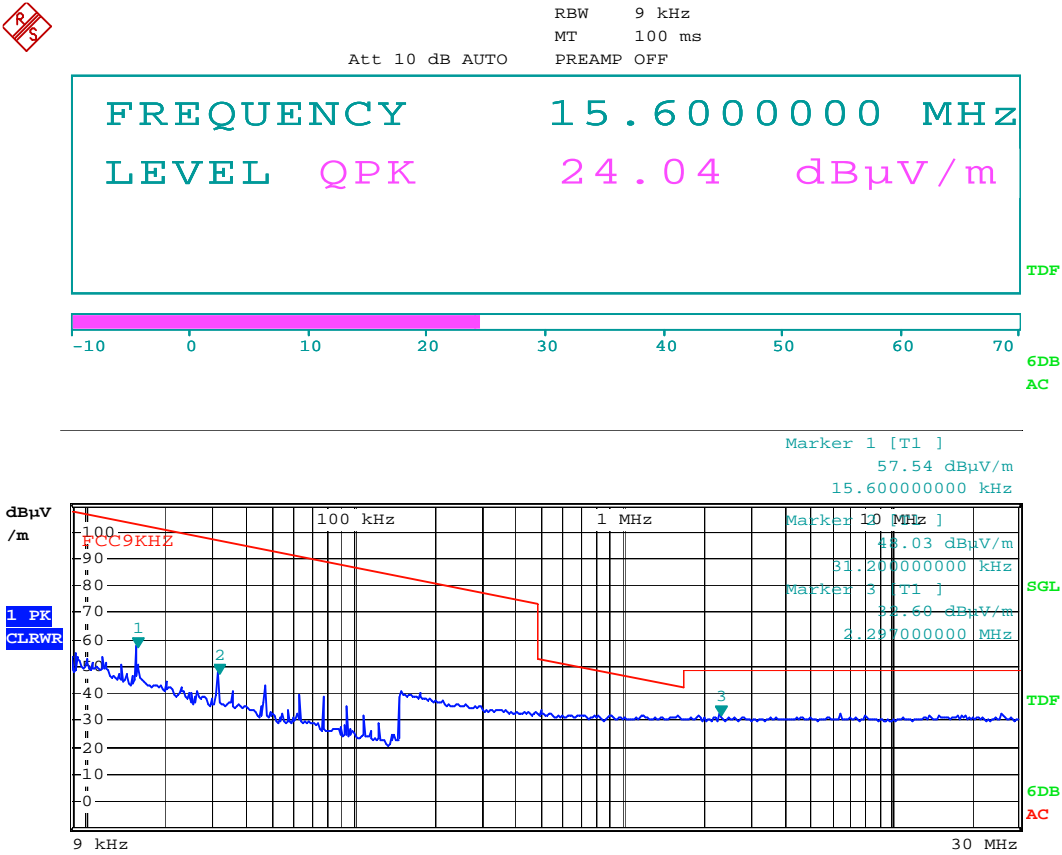
Date: 12.APR.2011 12:30:31

Ch26 – 2nd harmonic- Peak detector

Radiated emissions 9kHz - 30 MHz.

Detector: Quasi-Peak
 Measuring distance 10 m.

Frequency	Operational condition	Field strength	Measuring distance	Limit FCC15.209	Margin
MHz		dBµV/m	m	dBµV/m	dB
15.6	TX on	24.04	10	48.6	24.56



Date: 12.APR.2011 14:45:39

9kHz - 30MHz

Radiated emissions 30 – 1000 MHz.

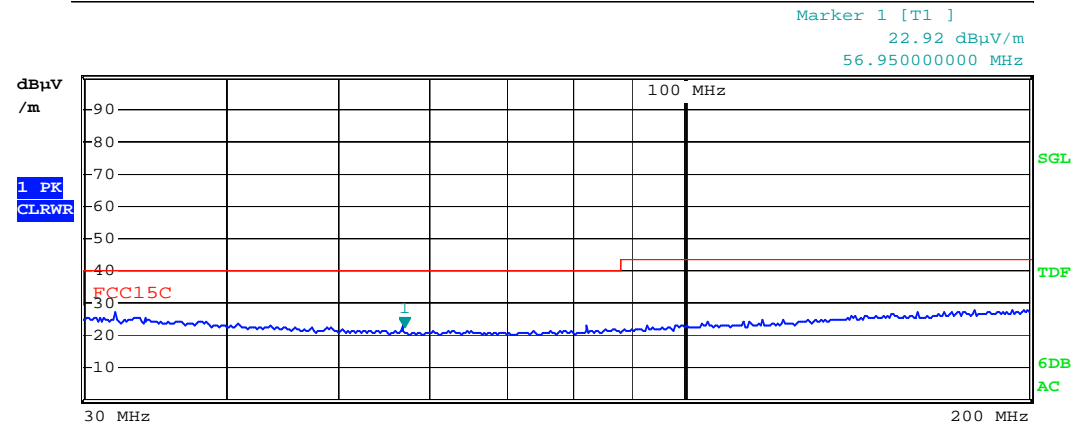
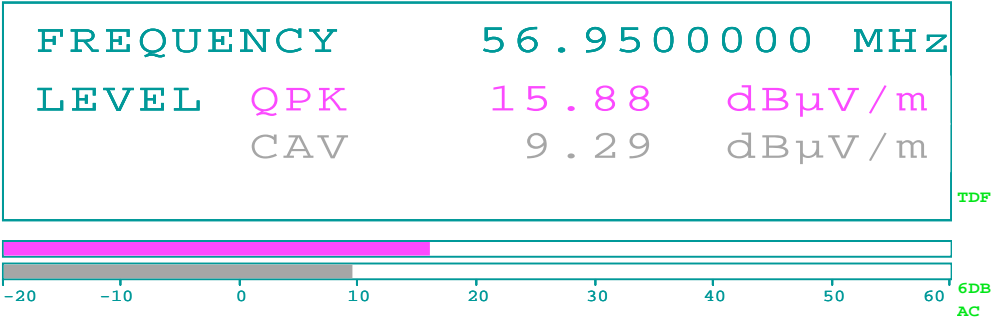
Detector: Quasi-Peak

Measuring distance 3 m.

Frequency	Operational condition	Field strength	Measuring distance	Polarization	Limit FCC15.209	Margin
MHz		dB μ V/m	m	-	dB μ V/m	dB
56.95	TX ON	15.88	3	VP	40	24.1
82.95	TX ON	15.98	3	HP	40	24.0
486.8	TX ON	33.80	3	VP	46	12.2
979.6	TX ON	35.96	3	HP	54	18.0

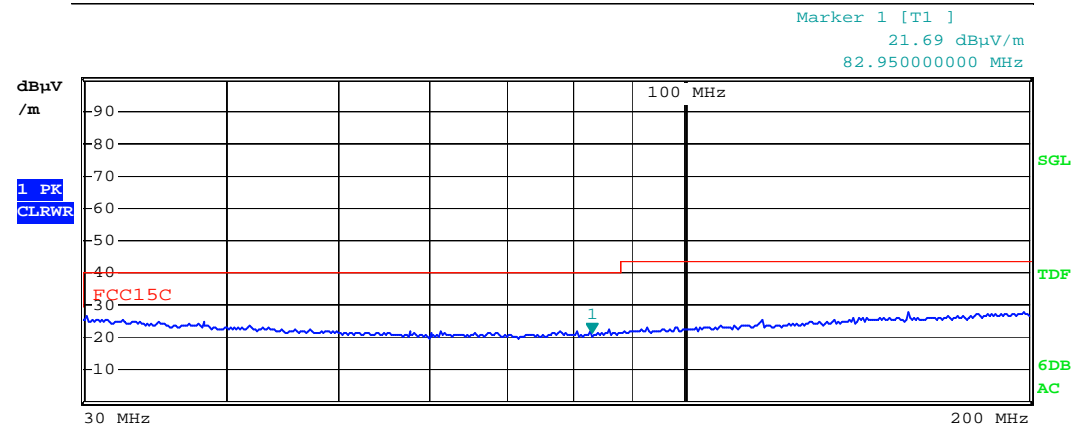
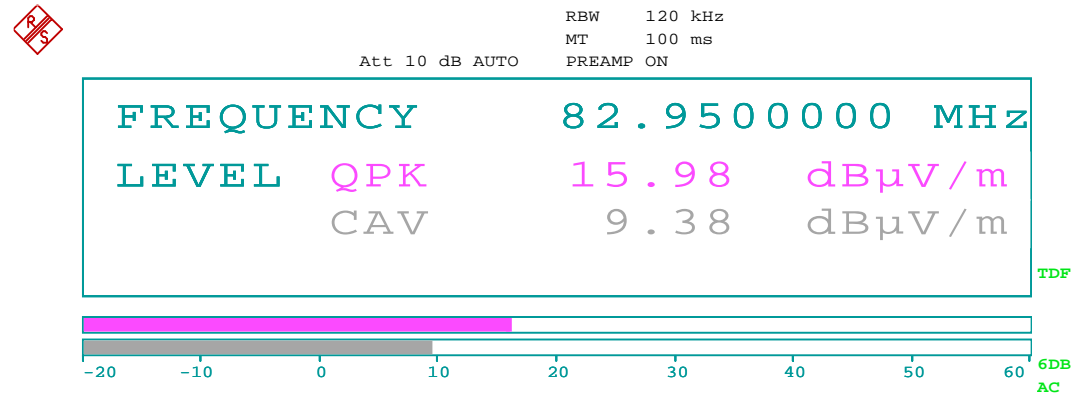


Att 10 dB AUTO RBW 120 kHz
MT 100 ms
PREAMP ON



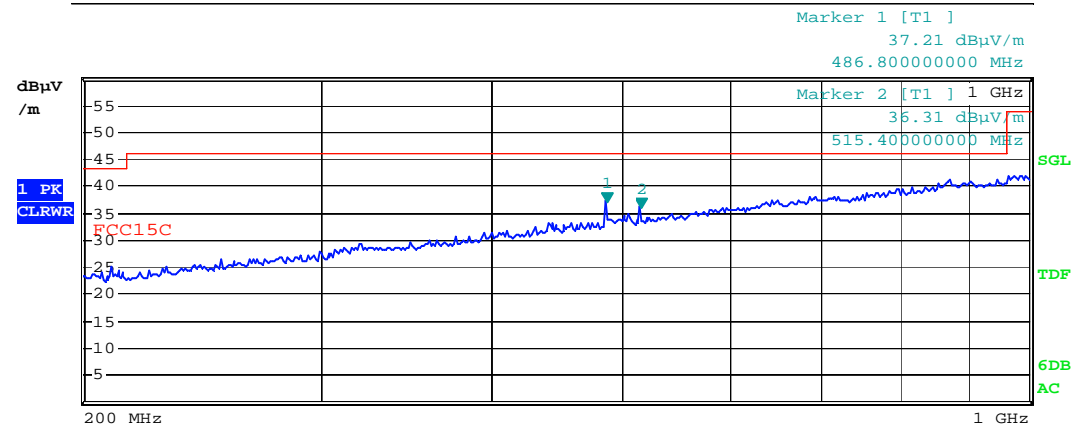
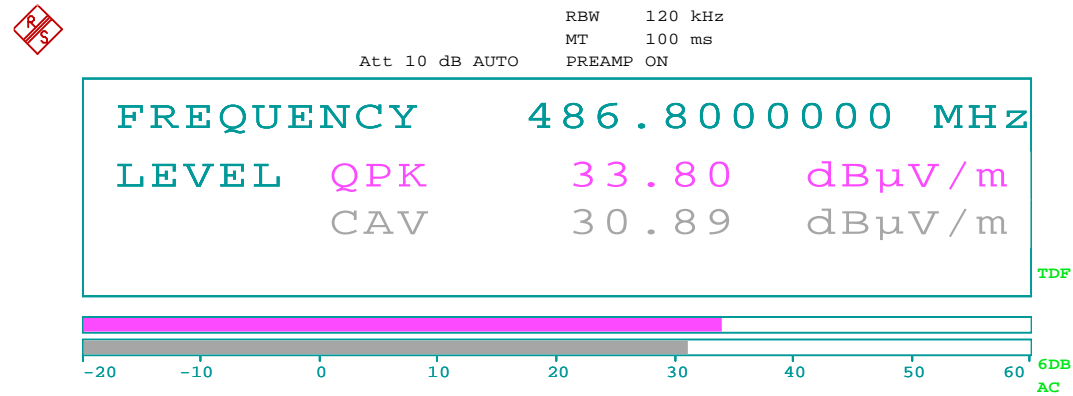
Date: 12.APR.2011 08:31:25

VP – 30 – 200 MHz



Date: 12.APR.2011 08:36:33

HP – 30 – 200MHz

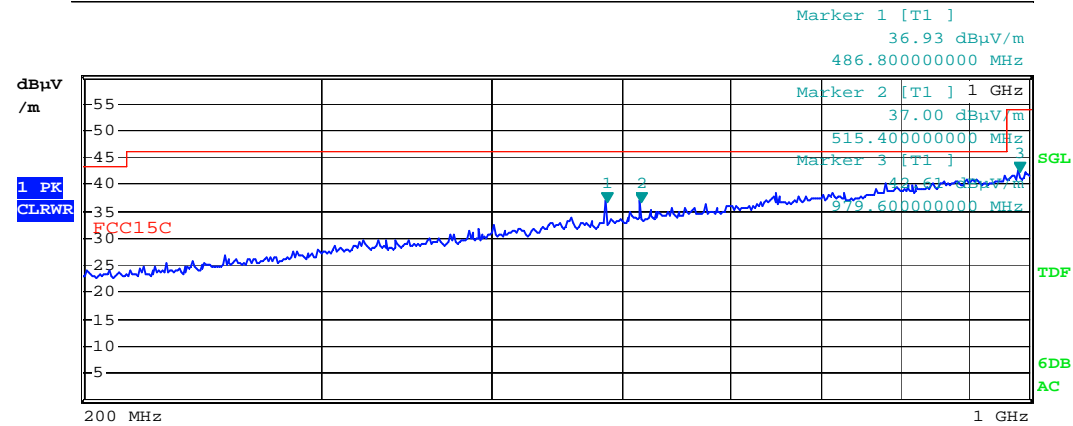
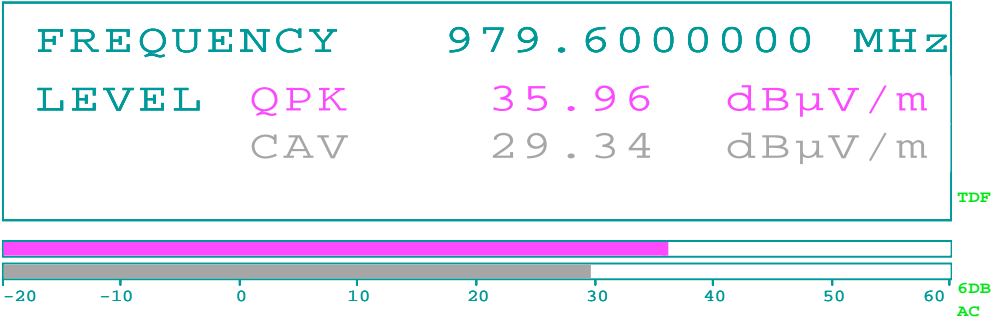


Date: 12.APR.2011 09:56:05

VP – 200 – 1000MHz



RBW 120 kHz
MT 100 ms
Att 10 dB AUTO
PREAMP ON



Date: 12.APR.2011 09:44:43

HP 200 – 1000MHz

4.6 Receiver Spurious Emissions (Radiated)

Para. No.: RSS-Gen (6)

Test Performed By: G.Suwanthakumar

Date of Test: 12.04.2011

Test Results: Complies

Measurement Data:

Radiated Emissions with antenna, 30MHz - 25 GHz, peak

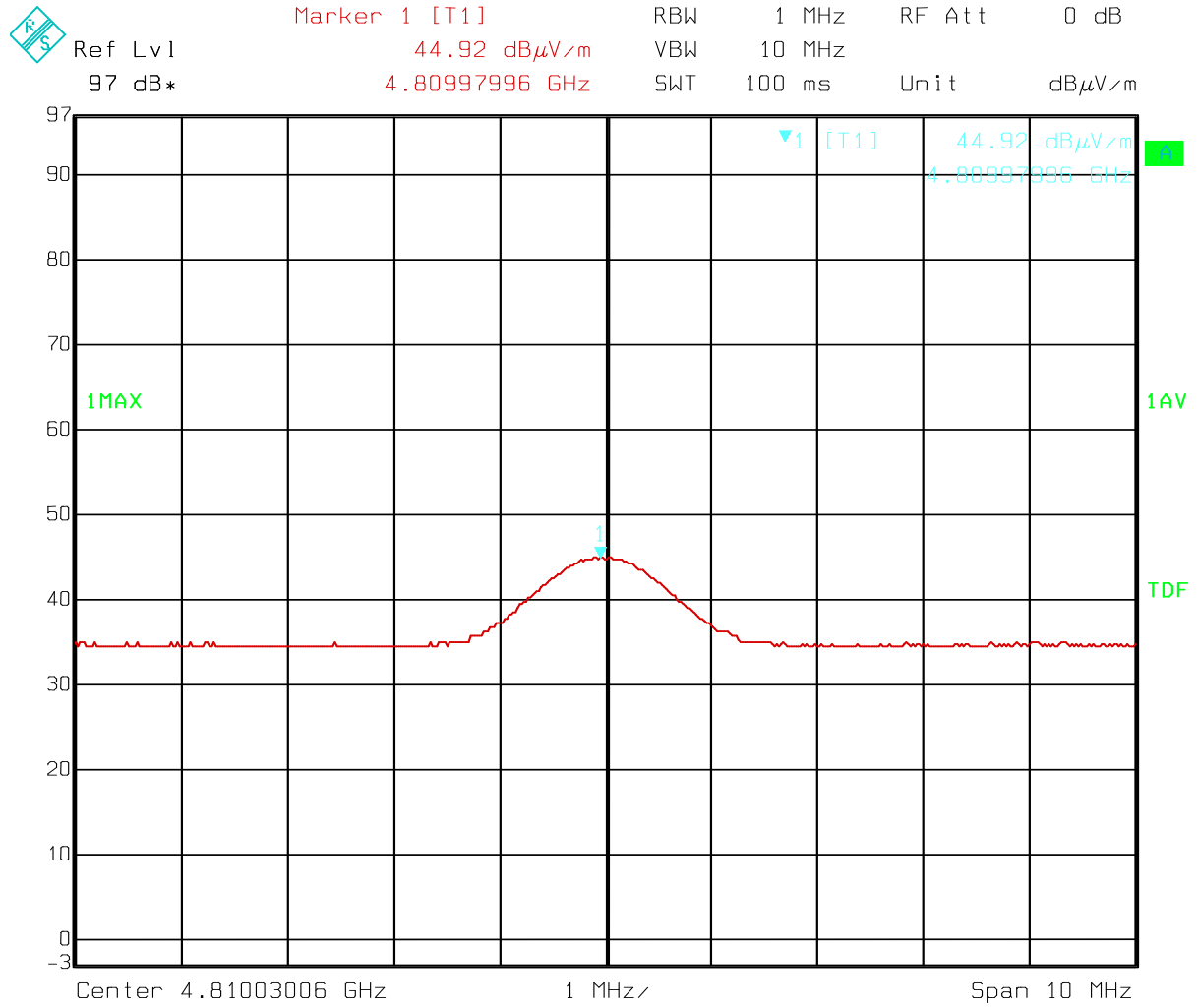
30 - 1000MHz measured at 10m

4.8 GHz is measured at 3m

Measured with Peak Detector

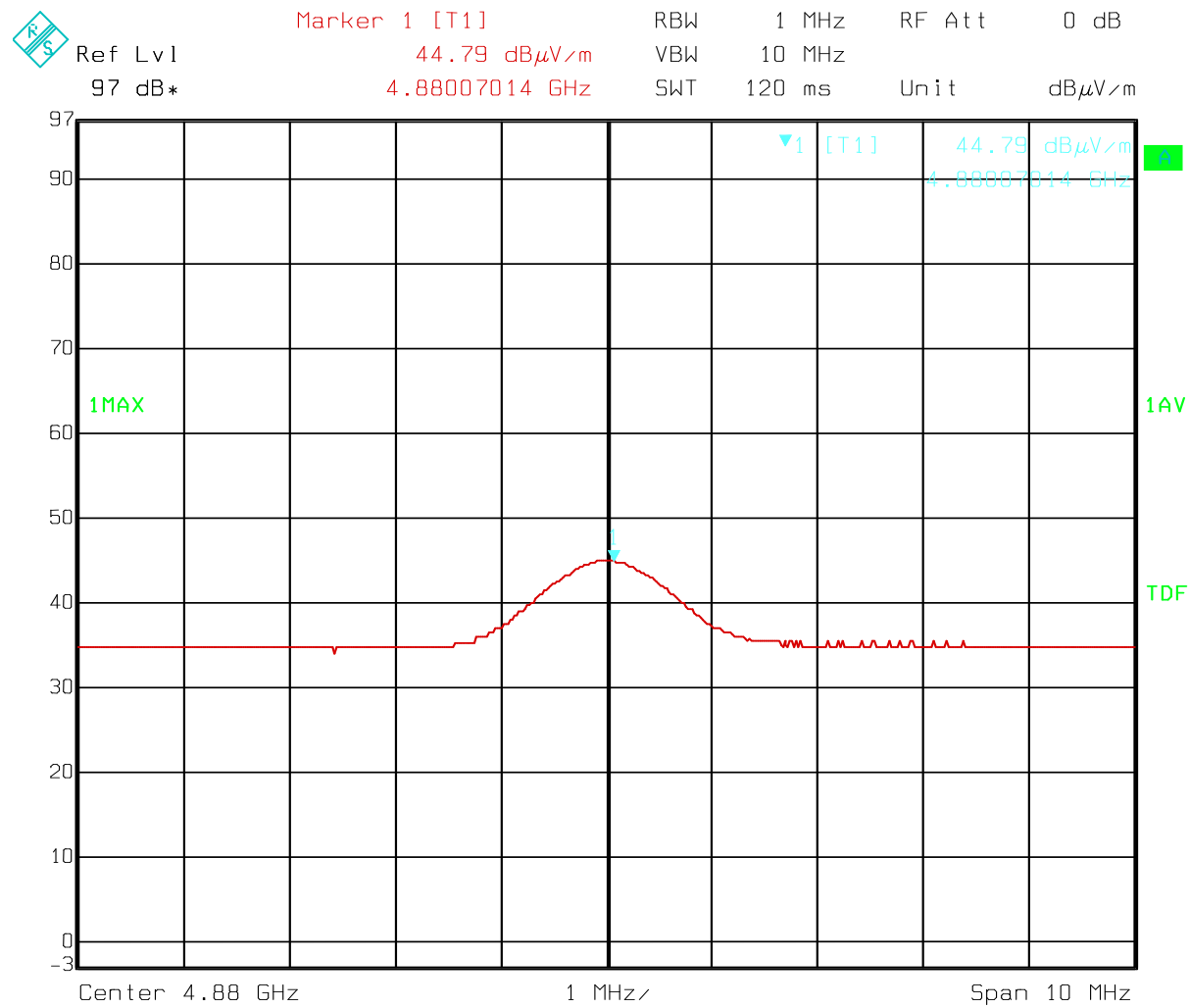
Frequency	RF channel	Dist. corr. factor	Field strength, Peak Det, @3m	Duty cycle corr. factor	Limit	Margin
GHz	11-26	dB	dB μ V/m	dB	dB μ V/m	dB
4.81	11	0	44.92	-	54	9.1
4.88	18	0	44.79	-	54	9.2
4.96	26	0	42.17	-	54	11.8
0.030 – 0.088	18	0	< 20	-	40	>10
0.088 – 0.216	18	0	< 21	-	43	>22
0.216 – 0.960	18	0	< 34	-	46	>12
5 – 25	18	0	None detected	-	54	-

The only detected spurious radiation is VCO leakage from the receiver, this is only a CW signal

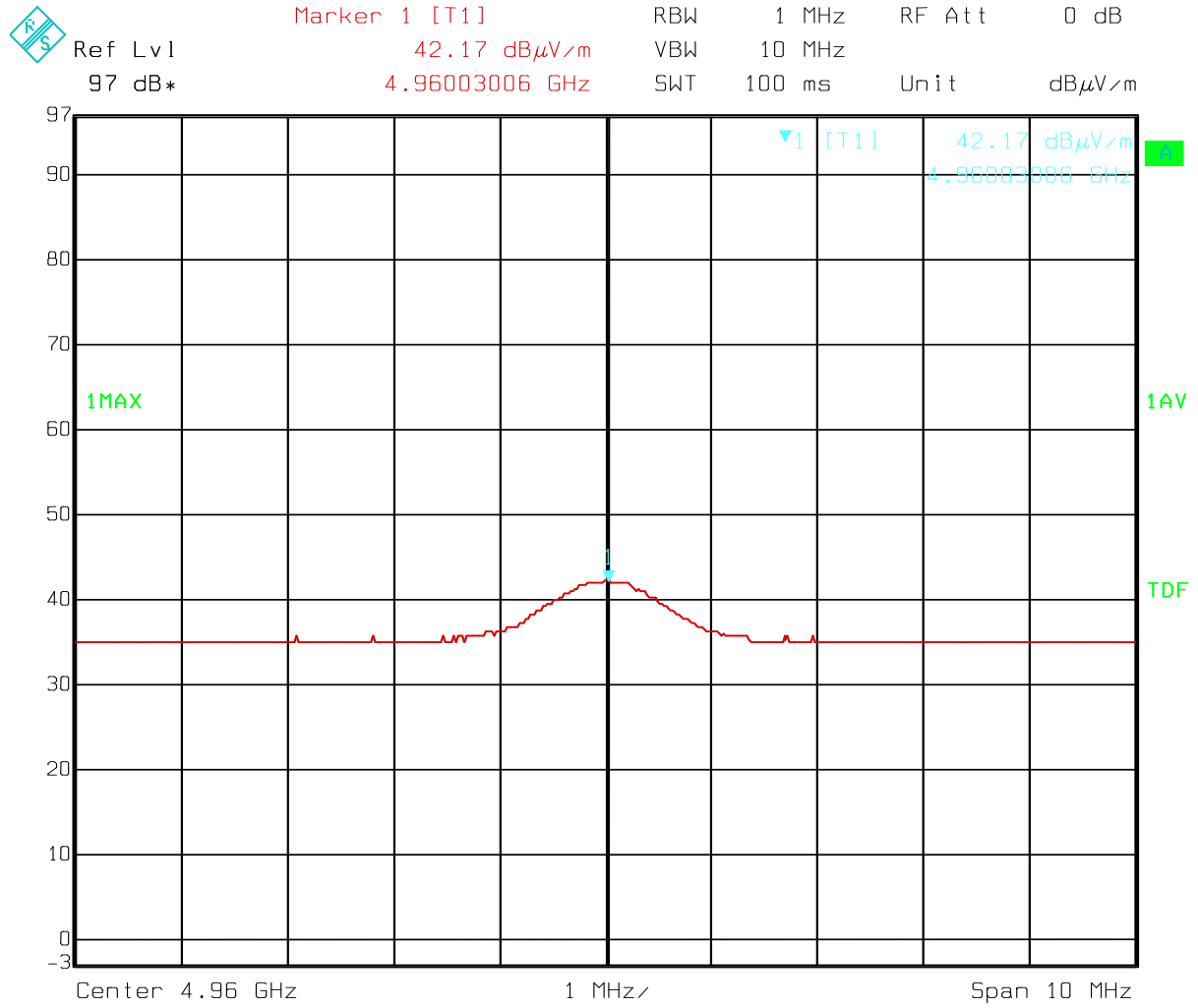


Date: 12.APR.2011 11:50:41

HP: VCO leakage- Ch2405MHz

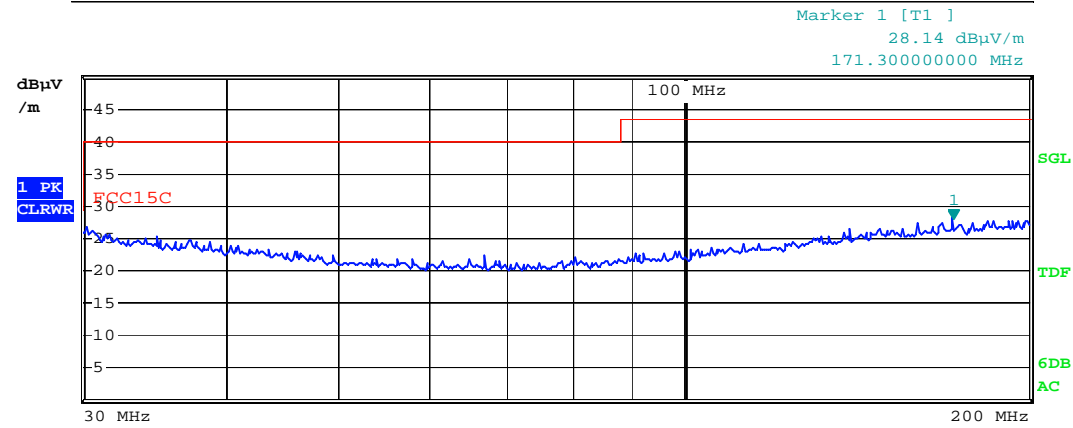
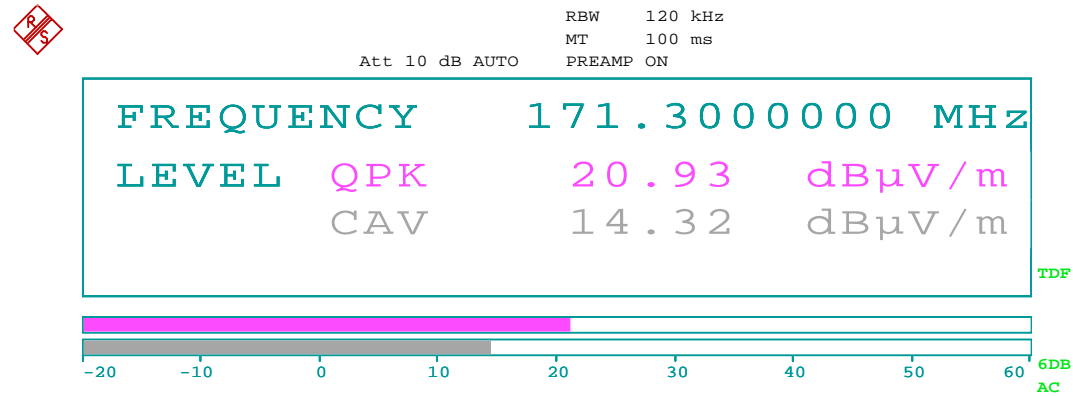


Date: 12.APR.2011 11:02:40
 HP: VCO leakage- Ch2440MHz



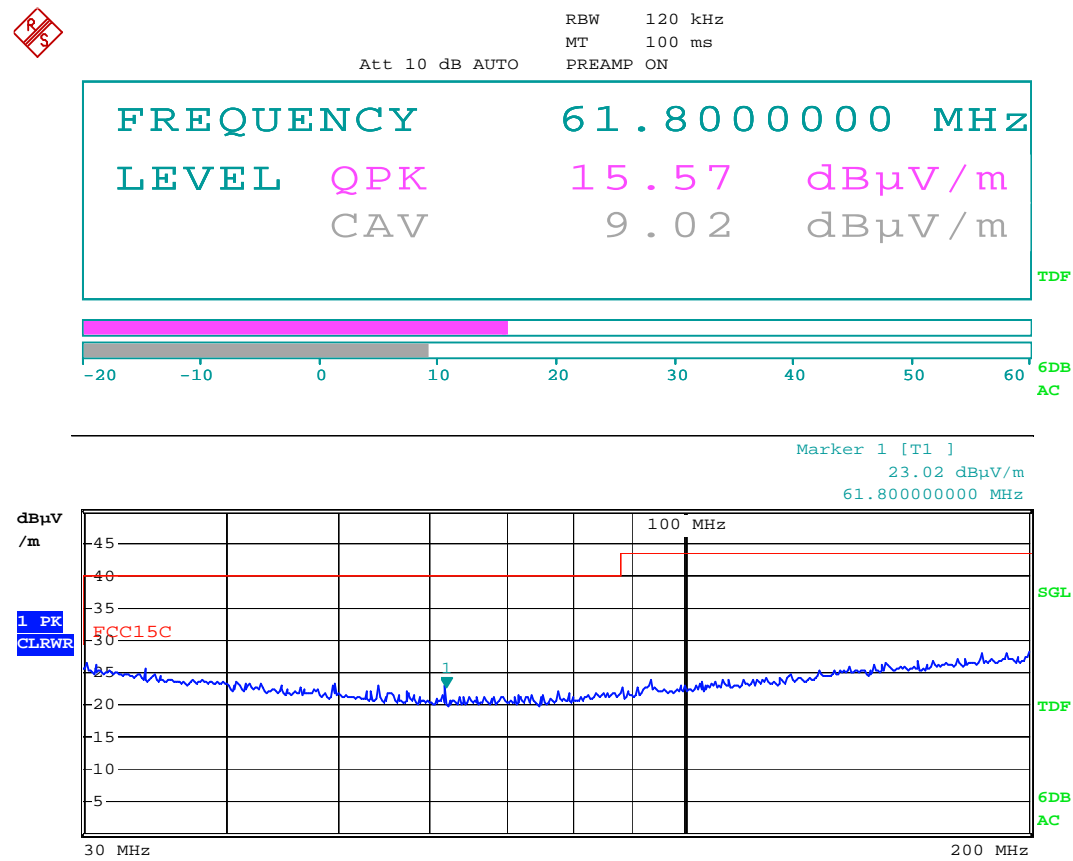
Date: 12.APR.2011 11:55:04

HP: VCO leakage- Ch2480MHz



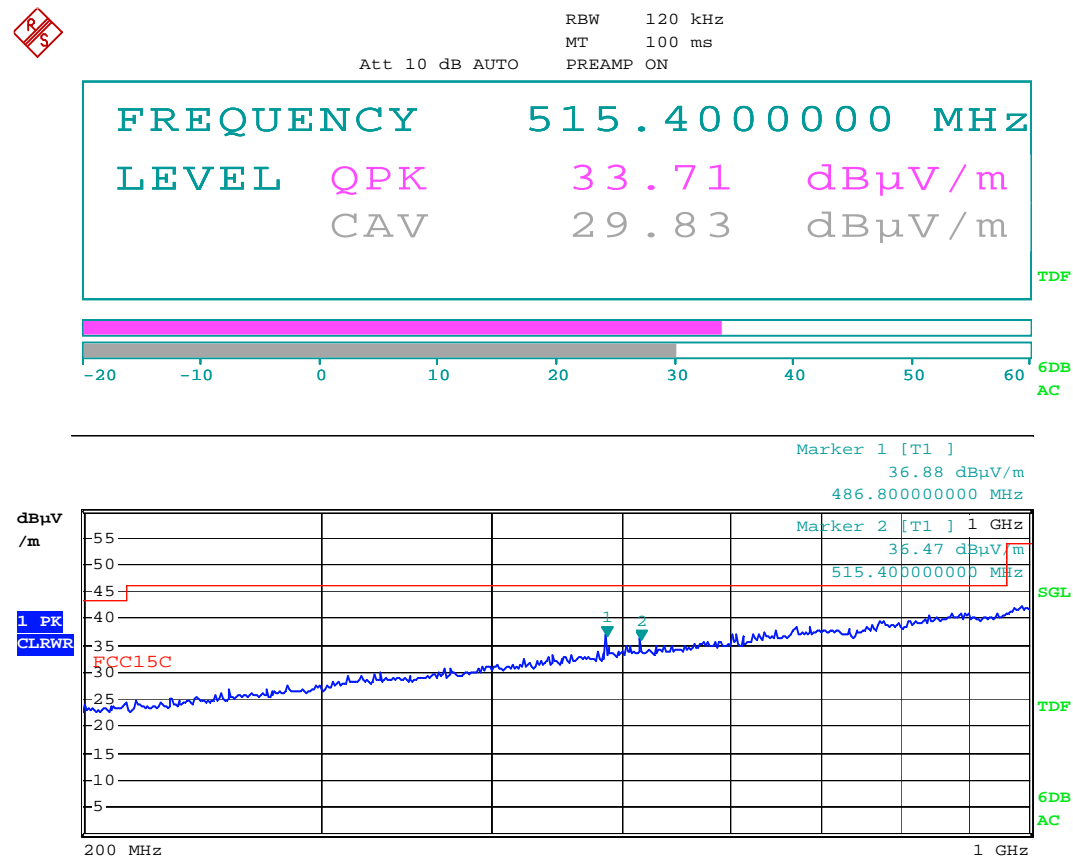
Date: 12.APR.2011 08:45:22

RX: HP, 30 - 200MHz



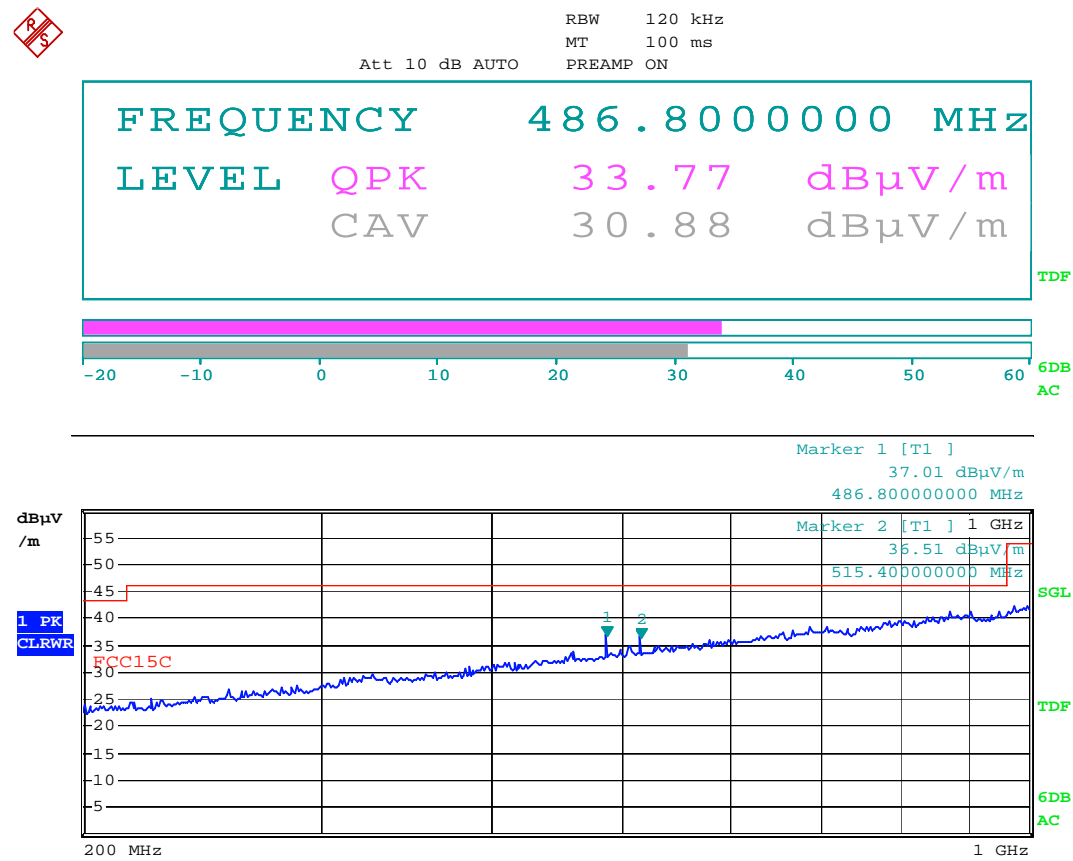
Date: 12.APR.2011 08:49:38

RX: VP, 30 - 200MHz



Date: 12.APR.2011 09:32:27

RX: HP, 200 - 1000MHz



Date: 12.APR.2011 09:23:55

RX: VP, 200 - 1000MHz

4.7 Power Spectral Density (PSD)

Para. No.: 15.247 (d)

Test Performed By: G.Suwanthakumar

Date of Test: 12-Apr-2011

Test Results: Passed

Measured and Calculated Data:

The alternative test procedures in point 2) A , B and formula 1 described in guidance on measurements for Digital Transmission Systems is used.

Power value is calculated from field strength using the free field formula.

Ch11 - Lower Channel:

$$\text{PSD} = 82.55 \text{ dB}\mu\text{V/m} = -12.68 \text{ dBm}$$

Ch18 - Middle Channel:

$$\text{PSD} = 84.05 \text{ dB}\mu\text{V/m} = -11.18 \text{ dBm}$$

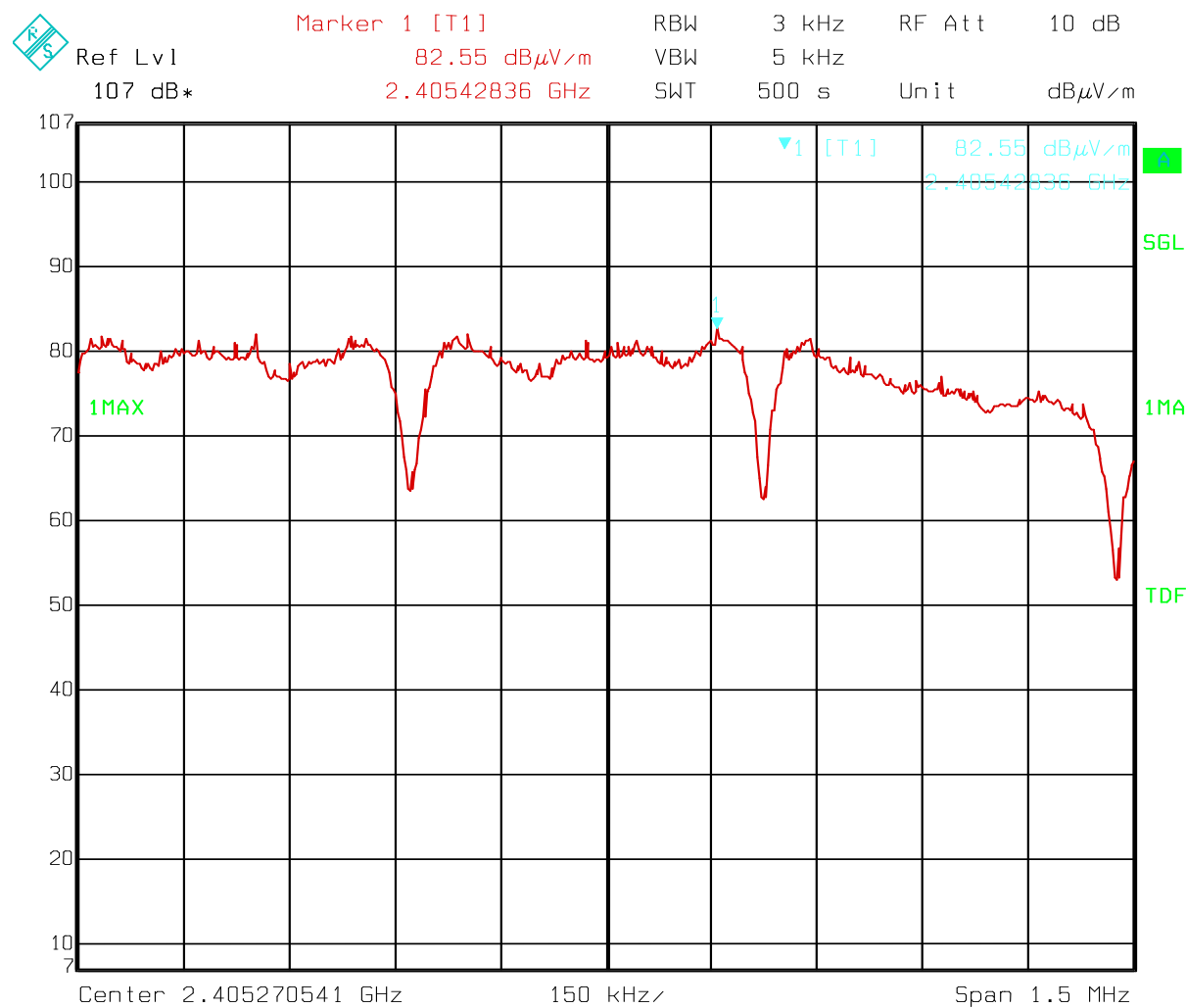
Ch 26 - Upper Channel:

$$\text{PSD} = 86.58 \text{ dB}\mu\text{V/m} = -8.65 \text{ dBm}$$

Requirements:

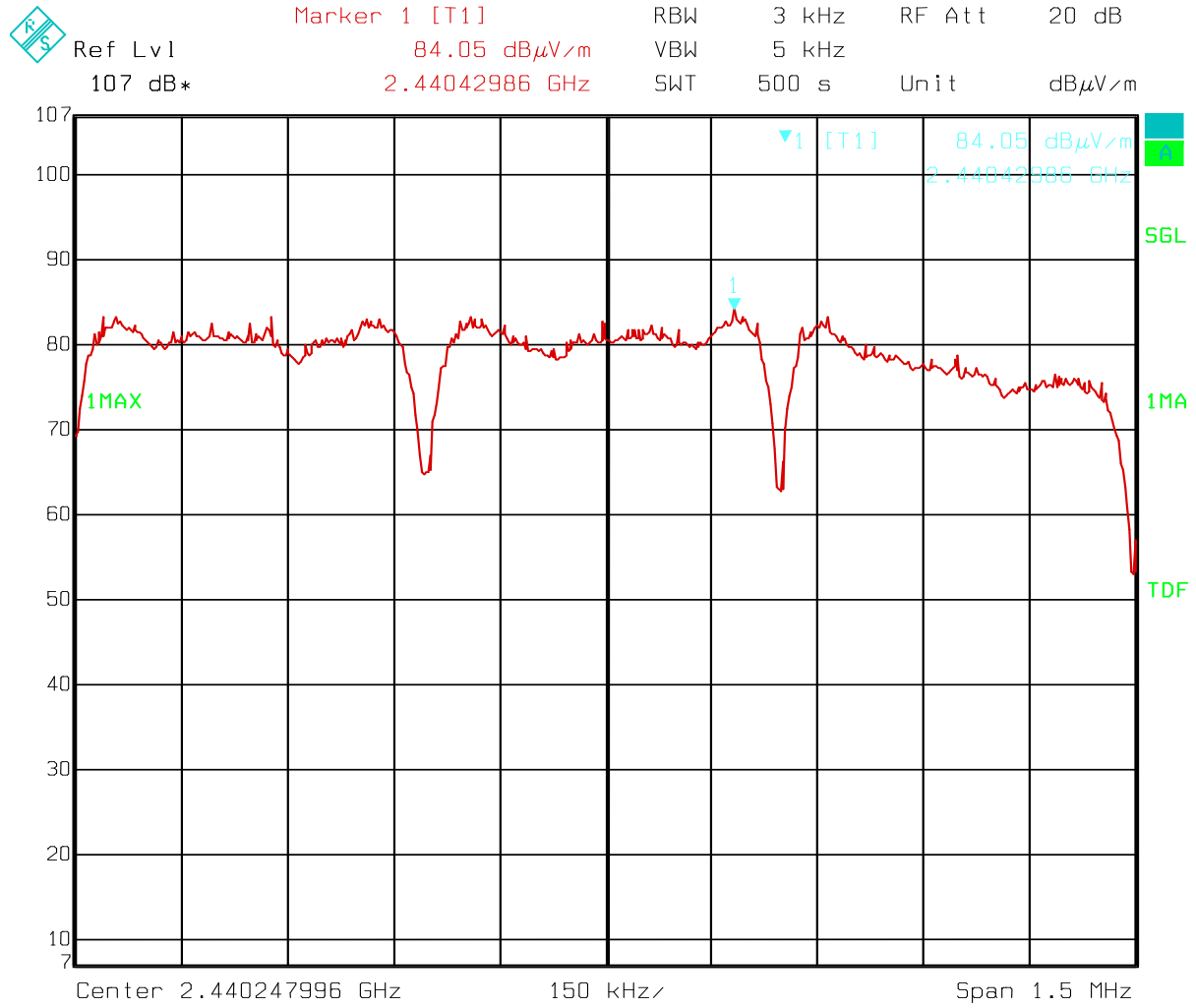
The Power Spectral Density of a Digital Transmission System shall be no greater than +8 dBm in any 3 kHz band

No requirements for Frequency Hopping Systems.



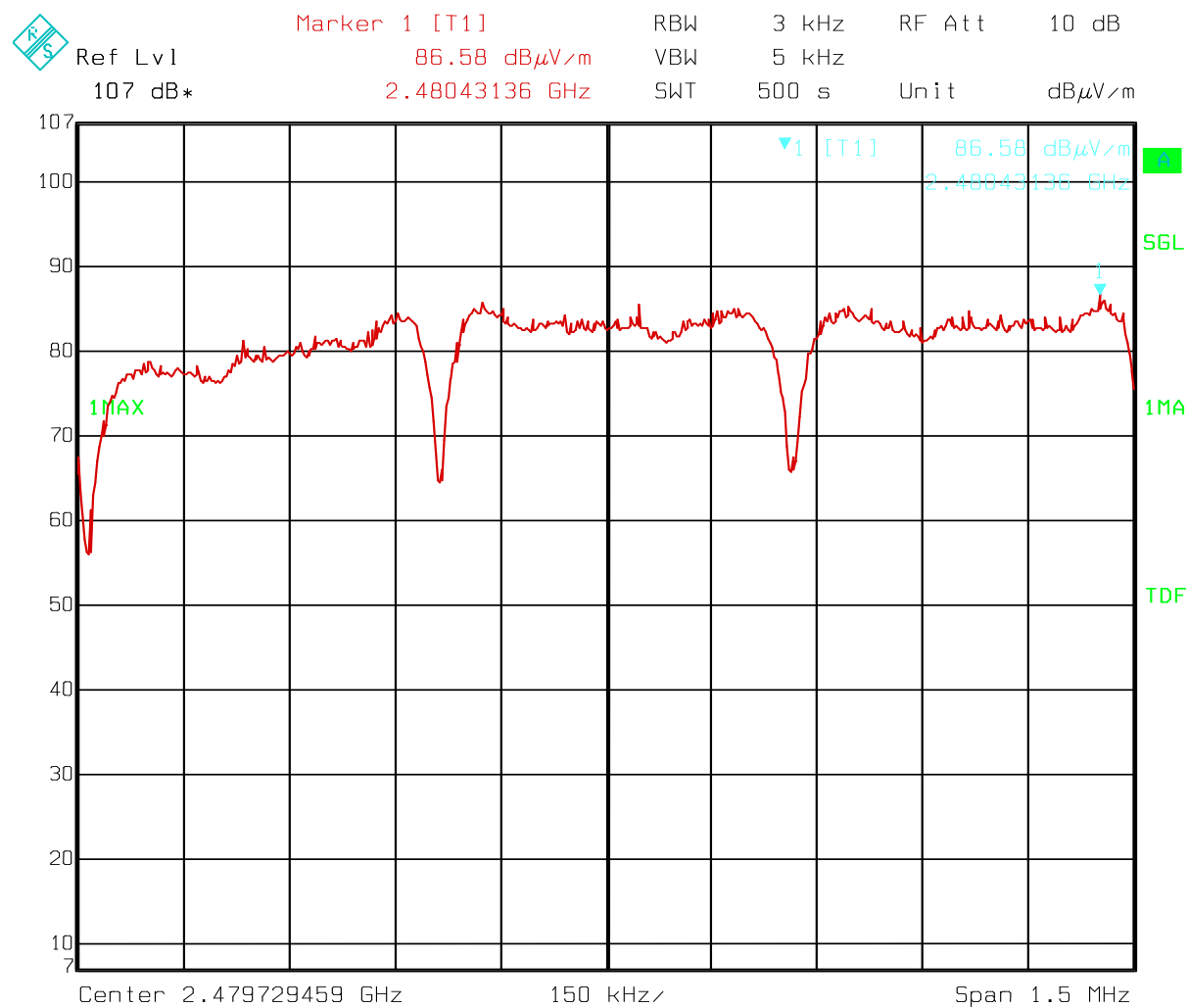
Date: 12.APR.2011 11:34:32

Ch11 – Power Density – radiated measurement



Date: 12.APR.2011 10:05:53

Ch18 – Power Density – radiated measurement



Date: 12.APR.2011 12:24:44

Ch26 – Power Density – radiated measurement

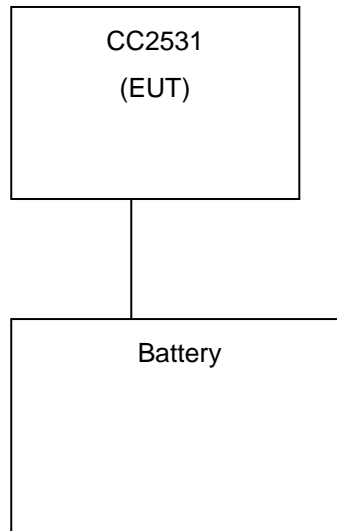
5 LIST OF TEST EQUIPMENT

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.	FSU26	Spectrum Analyzer	Rohde & Schwarz	LR 1504	28.09.2010	28.09.2011
2.	ESCI	EMI Receiver	Rohde & Schwarz	N 4259	09.09.2010	09.09.2011
3.	FSEK 1088,3494,30	Spectrum Analyzer	R&S	1337	15.12.2010	15.12.2011
4.	U2000A	USB power meter	Agilent Technology	LR 1523	15.01.2011	15.01.2012
5.	3115	Antenna horn	EMCO	LR 1330	05.08.2010	05.08.2013
6.	643	Antenna horn	Narda	LR 093	26.01.2009	26.01.2012
7.	642	Antenna horn	Narda	LR 220	26.01.2009	26.01.2012
8.	PM7320X	Antenna horn	Sivers lab	LR 103	26.01.2009	26.01.2012
9.	DBF-520-20	Antenna horn	Systron Donner	LR 101	26.01.2009	26.01.2012
10.	638	Antenna horn	Narda	LR 098	26.01.2009	26.01.2012
11.	Sucoflex 102E	Cable microwave	Suhner	LR 1370	-	-
12.	6032A	Power supply	HP	LR 1062	-	-
13.	77	Multimeter, Digital	Fluke	LR155	03.11.2010	03.11.2011
14.	8449B	Amplifier	Hewlett Packard	LR 1322	04.08.2009	04.08.2011
15.	HFH2-Z2	Antenna loop	Rohde and Schwarz	LR 285	08.10.2010	08.10.2013
16.	10855A	Amplifier	Hewlett Packard	LR 1445	04.08.2010	04.08.2011
17.	HL223	Antenna log.per	Rohde & Schwarz	LR 1261	19.05.2010	09.05.2013
18.	HK116	Antenna biconic	Rohde & Schwarz	LR 1260	19.05.2010	09.05.2013
19.	ESN	Test Receiver	Rohde & Schwarz	LR 1237	16.09.2010	06.09.2011
20.	ESH3-Z3	LISN	Rohde & Schwarz	LR 1076	22.10.2009	22.10.2011
21.	B32-10R	Power supply	Oltronix	LR 126	-	-
22.	ESHS 30	EMI Receiver	Rohde & Schwarz	N-3529	04.08.2011	04.08.2012
23.	ESH3-Z2	Pulse Limiter	Rohde & Schwarz	LR 1074	03.03.2010	03.03.2012

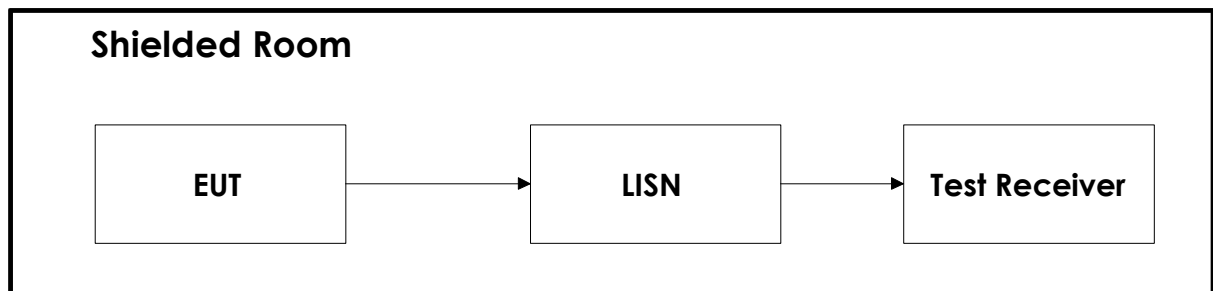
6 BLOCK DIAGRAM

6.1 System set up for radiated measurements



Test equipment: 1, 2, 3, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

6.2 Powerline Conducted Emission



Test equipment: 20,21,22,23

6.3 Test Site Radiated Emission

