

RADIO TEST REPORT

No. 1121176-2 Ed. 3

EQUIPMENT UNDER TEST

Equipment: Radio module
Type / model: Grundfos Radiomodule 2G4
Manufacturer: Grundfos Holding A/S
Tested by request of: Grundfos Holding A/S

SUMMARY

The equipment complies with the requirements of the following standards:

47 CFR, Part 15, Subpart B (2012) and Subpart C (2012);

RSS-GEN, Issue 3 (Dec 2010)

RSS-210, Issue 8 (Dec 2010)

Industry Canada listed test facility No. IC 2042G-2

Date of issue: 26 June 2013

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Approved by:



Niklas Boström

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Revision History

Edition	Date	Description	Changes
1	2012-02-27	First release	
2	2013-06-03		New date for FCC 47 CFR, Part 15, Subpart B (2012) and Subpart C (2012);
3	2013-06-26		Section 9.4 Measurement setup was edited and clarified.

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1. CLIENT INFORMATION

The EUT has been tested by request of

Company: Grundfos Holding A/S
Name of contact: Nikolaj Haahr Korshoj

2. EQUIPMENT UNDER TEST (EUT)

2.1 Identification of the EUT according to the manufacturer/client declaration

Equipment: Radio module
Type/Model: Grundfos Radiomodule 2G4
Brand name: Grundfos Radiomodule 2G4
Serial number: No visible serial number on EUT
Manufacturer: Grundfos Holding A/S
Rating/Supplying voltage: 5.2 V
Rating RF output power: 1.78 dBm (measured)
External antenna connector: NO
Operating temperature range: -20 to +55 °C
Frequency range: 2405 – 2480 MHz
Number of channels: 16
Modulation characteristics: IEEE 802.15.4 (PSK)

2.2 Additional hardware information about the EUT

The radio module has two antenna selections (0 and 1).

2.5 Modifications during the test

The EUT was modified with software that made it possible to step between different TX-modes. It was possible to set the EUT to modulated carriers for the transmitting channels. The unit could also be set for RX tests.

For some of the tests the antenna was replaced by an SMA connector.

3. TEST SPECIFICATIONS

3.1 Standards

FCC 47 CFR part 15 (2012) Subpart B – Unintentional radiators

FCC 47 CFR part 15 (2012) Subpart C – Intentional Radiators; §15.247 Operation within the bands 902-928 MHz, 2400 – 2483.5 MHz and 5725 – 5850 MHz.

Measurements methods according to ANSI C63.4-2009 - Methods of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

RSS-Gen, Issue 3 (Dec 2010): General Requirements and Information for the Certification of Radiocommunication Equipment

RSS-210, Issue 8 (Dec 2010): Low Power Licence-Exempt Radio communication Devices (All Frequency Bands): Category I Equipment.

3.2 Additions, deviations and exclusions from standards

No additions, deviations or exclusions have been made from standards.

3.3 Test set-up

Measurement set-ups for the test of out-of-band spurious emissions test are described in corresponding sections. During other tests the EUT was connected to the spectrum analyzer by cable.

3.4 Operating environment

If not additionally specified, the tests were performed under the following environmental conditions:

Air temperature: 20-25 °C

Relative humidity: 25-40 %

4. TEST PLAN

The results in this report apply only to the sample tested.

FCC reference	IC reference	Test	Result	Note
15.247(b)	RSS-210 A8.4 (4)	Peak output power	PASS	
15.247(a)	RSS-210 A8.2 (a)	6 dB Bandwidth	PASS	
15.247(a)	RSS-210 A8.2 (b)	Spectral power density	PASS	
15.247(d)	RSS-210 A8.5	Band edge compliance	PASS	
15.247(d)	RSS-210 A8.5	Out of band spurious emissions, radiated	PASS	
15.247(d)	RSS-210 A8.5	Out of band spurious emissions, conducted	PASS	
15B	RSS-Gen Table 5	Out of band spurious emissions, radiated	PASS	1
15B	RSS-Gen Table 4	Conducted emission at AC port	N/A	
	RSS-GEN 4.6.1	Occupied Bandwidth	PASS	

N/A = Not applicable

1) The measured result is below the limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliance based on the 95 % level of confidence. However, the result indicates that compliance is more probable than non-compliance with the specification limit.

5. PEAK OUTPUT POWER

5.1 Test protocol

Date of test: 2011-11-02

EUT mode of operation: continuous TX. Modulation on

Spectrum analyzer settings:

Span: 5 MHz

RBW: 5 MHz

VBW: 10 MHz

Sweep time: Auto

Detector: Peak

Trace: Max Hold

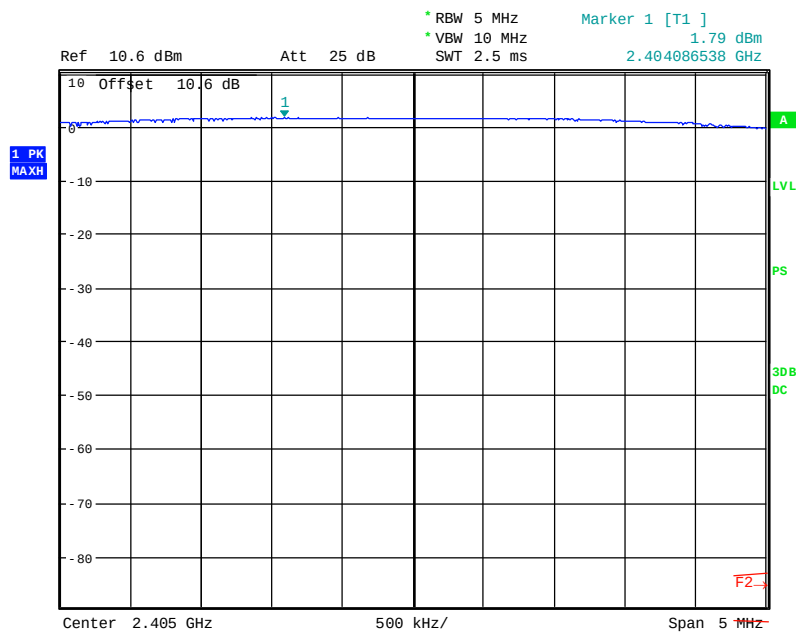
Channel (MHz)	Peak Output Power (dBm)	Plot	Limit value (dBm)
2405	1.79	plot P5.1.	30
2440	1.29	plot P5.2	
2480	0.86	plot P5.3	

Measurement results are corrected for attenuation in the set-up configuration and antenna gain declared by the manufacturer.

Example calculation:

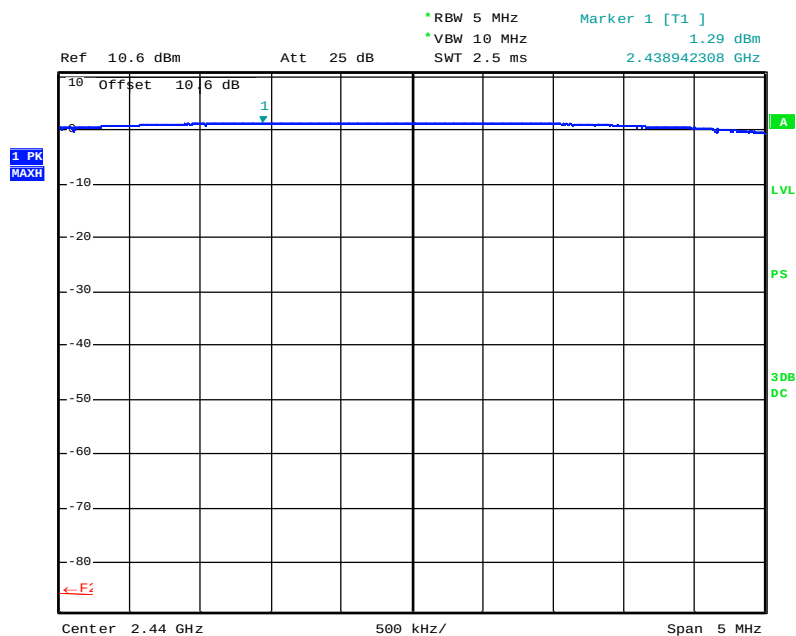
Peak output power [dBm] = Analyser reading [dBm] + cable loss [dB] + EUT antenna gain [dBi]

Plot P5.1



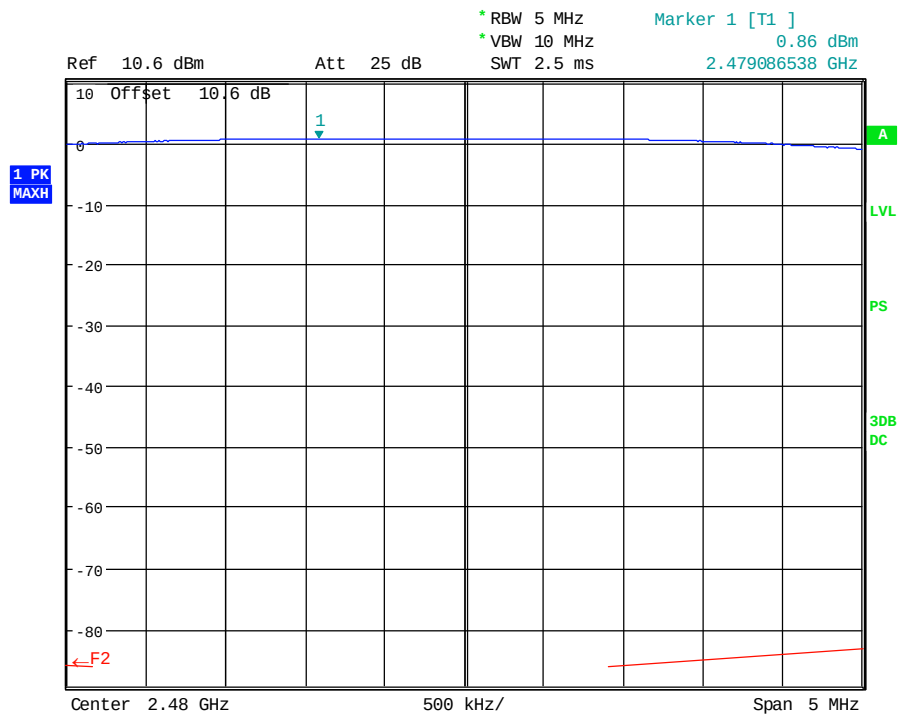
Date: 2.NOV.2011 13:57:09

Plot P5.2



Date: 2.NOV.2011 13:54:37

Plot P5.3



Date: 2.NOV.2011 13:46:43

6. 6 dB BANDWIDTH

6.1 Test protocol

Date of test: 2011-11-03

EUT mode of operation: continuous TX. Modulation on

Spectrum analyzer settings:

Span: 6.25 MHz
 RBW: 100 kHz
 VBW: 100 kHz
 Sweep time: 5 ms
 Detector: Peak
 Trace: Max Hold

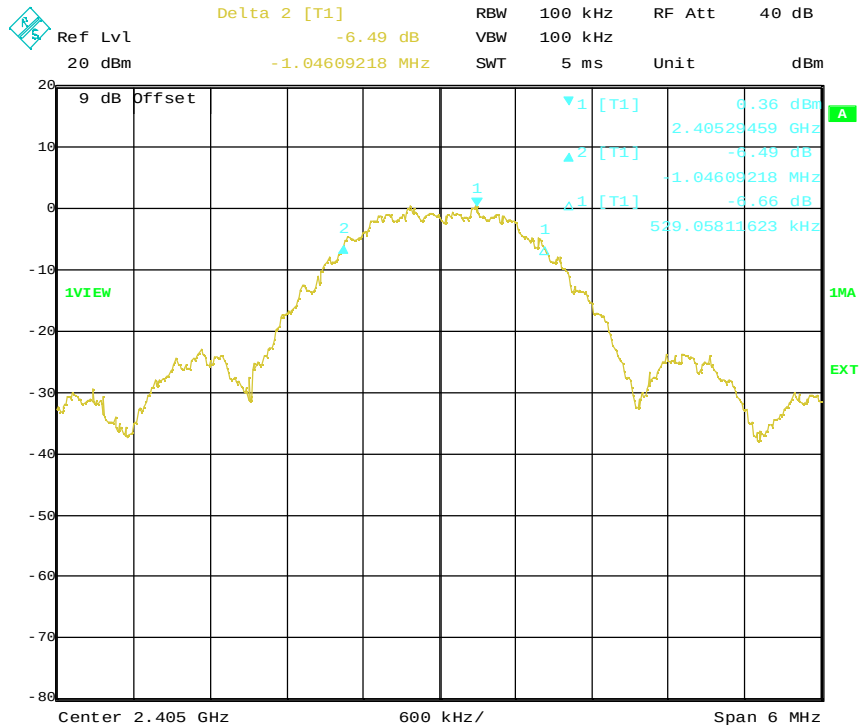
Channel (MHz)	6 dB Bandwidth (MHz)	Plot	Limit value (MHz)
Low	1,575	plot P6.1	> 0.5
Mid	1,575	plot P6.2	
High	1,551	plot P6.3	

Measurement results are corrected for attenuation in the set-up configuration and antenna gain declared by the manufacturer.

Example calculation:

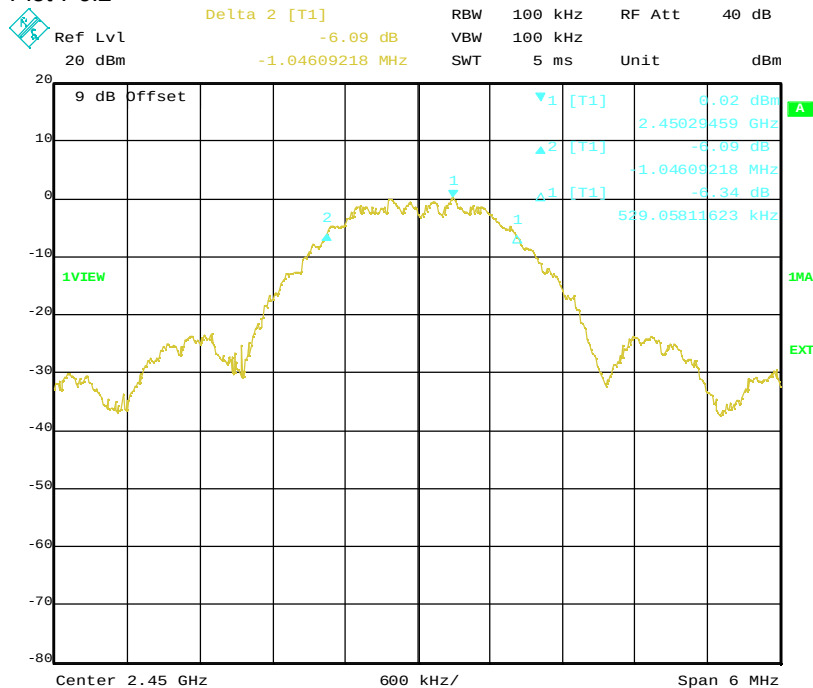
Peak output power [dBm] = Analyser reading [dBm] + cable loss [dB] + EUT antenna gain [dBi]

Plot P6.1



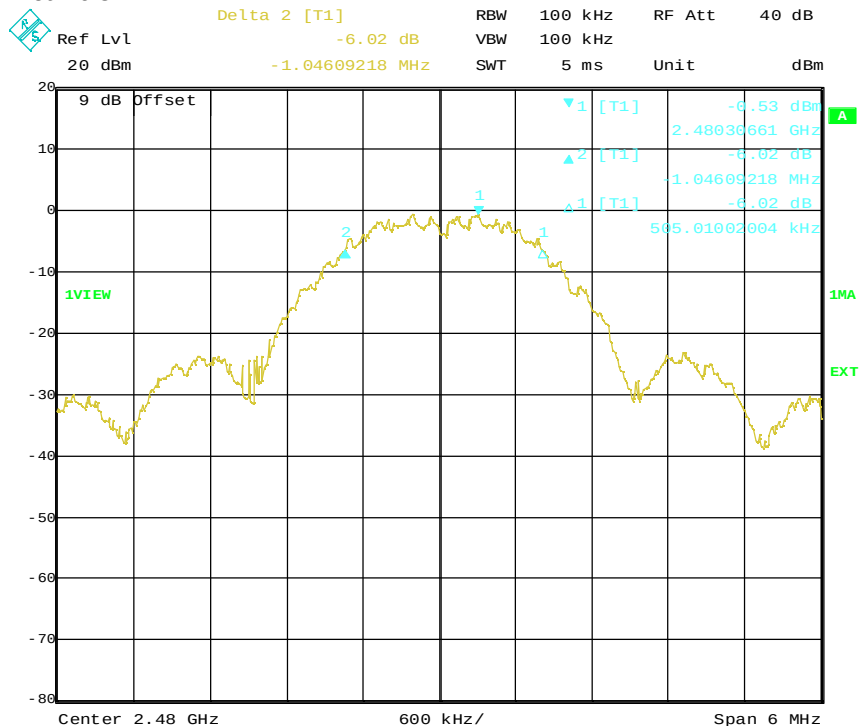
Date: 29.DEC.2011 13:00:01

Plot P6.2



Date: 29.DEC.2011 13:02:33

Plot P6.3



Date: 29.DEC.2011 13:09:28

7. SPECTRAL POWER DENSITY

7.1 Test protocol

Date of test: 2011-11-03

EUT mode of operation: continuous TX. Modulation on

Spectrum analyzer settings:

Span: 3 MHz

RBW: 3 kHz

VBW: 10 kHz

Sweep time: 1000 s

Detector: Peak

Trace: Max Hold

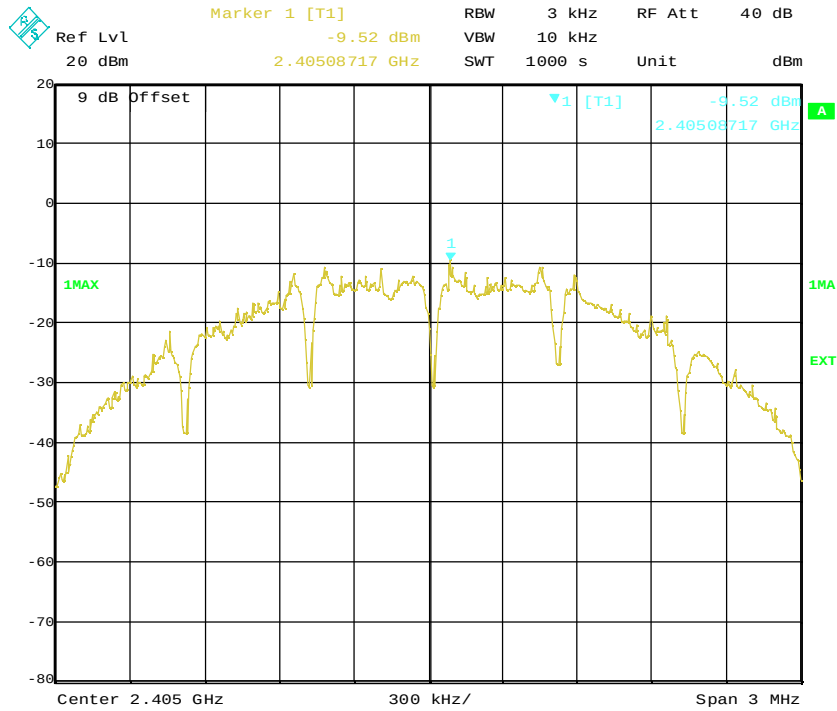
Channel	Power spectral density (dBm)	Plot	Limit value (dBm)
Low	-9.5	plot P7.1	8
Mid	-9.9	plot P7.2	8
High	-10.6	plot P7.3	8

Measurement results are corrected for attenuation in the set-up configuration and antenna gain declared by the manufacturer.

Example calculation:

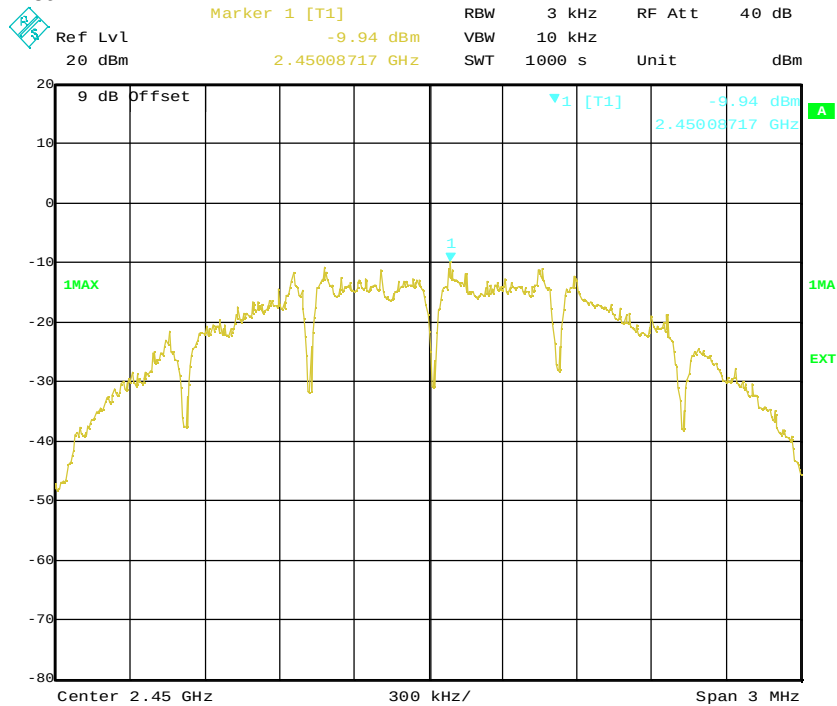
Power spectral density [dBm] = Analyser reading [dBm] + cable loss [dB] + EUT antenna gain [dBi]

PlotP7.1



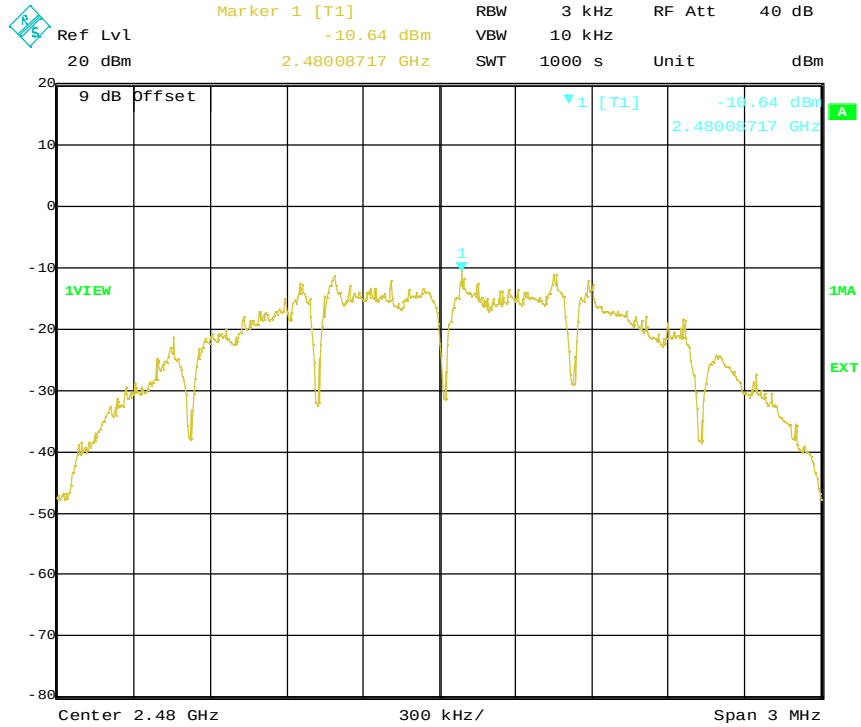
Date: 29.DEC.2011 14:08:39

Plot P7.2



Date: 29.DEC.2011 13:50:15

Plot P7.3



Date: 29.DEC.2011 13:30:05

8. BAND EDGE COMPLIANCE

8.1 Test protocol

Date of test: 2011-11-03

EUT mode of operation: continuous TX. Modulation on

Spectrum analyzer settings:

Span: 80 MHz
RBW: 100 kHz
VBW: 300 kHz
Sweep time: Auto
Detector: Peak
Trace: Max Hold

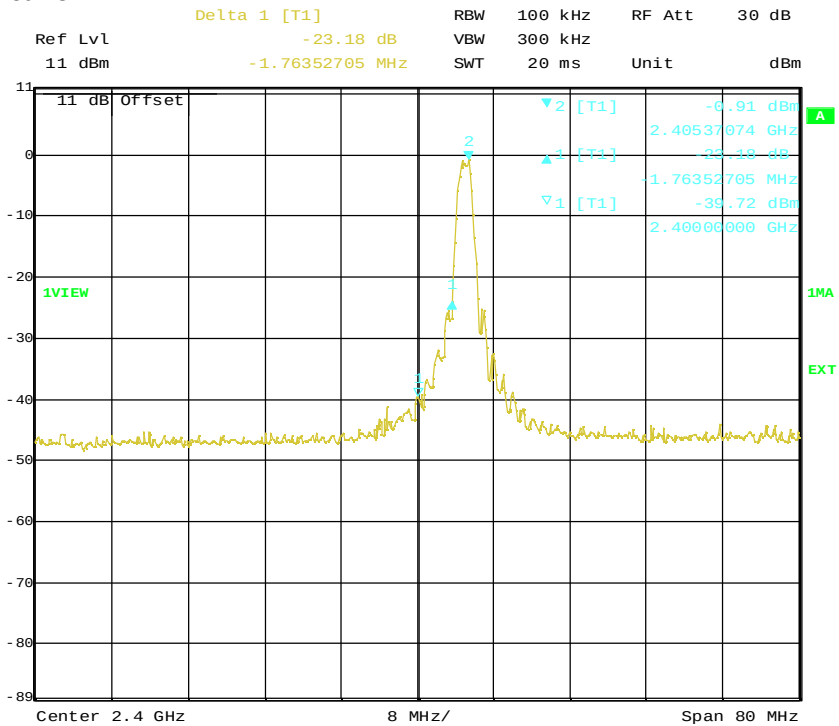
Channel	Plot	Results	Limit value (dBc)
Low	plot P8.1	PASS	20
High	plot P8.2	PASS	20

Measurement results are corrected for attenuation in the set-up configuration and antenna gain declared by the manufacturer.

Example calculation:

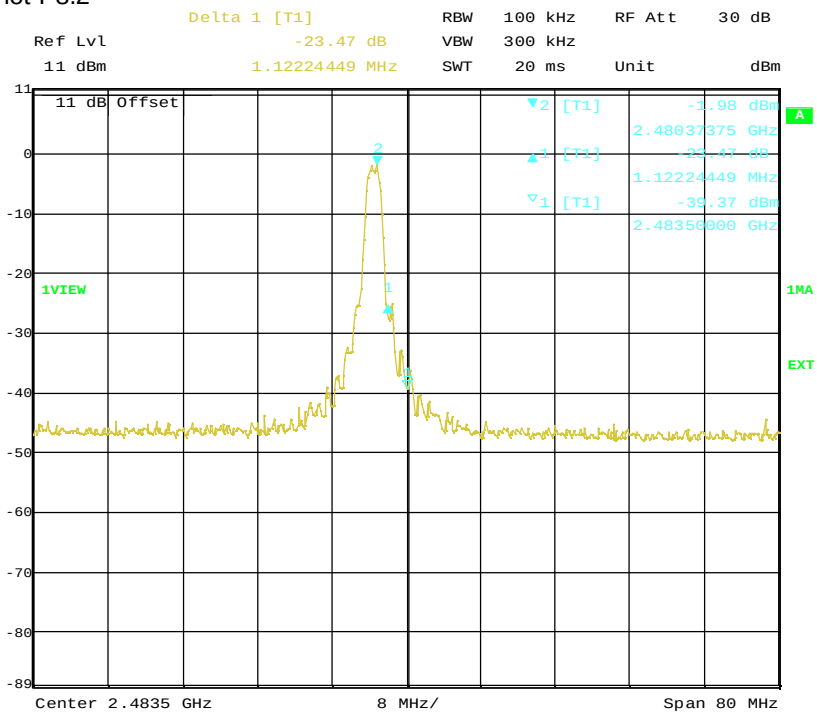
Peak output power [dBm] = Analyser reading [dBm] + cable loss [dB] + EUT antenna gain [dBi]

Plot P8.1



Date: 4.JAN.2012 14:32:22

Plot P8.2



Date: 4.JAN.2012 15:08:18

9. RADIATED SPURIOUS EMISSIONS

9.1 Operating environment

Temperature: 20-25 °C (10 – 40 °C)
Relative Humidity: 25-40 % (10 - 90 %)

9.2 Measurement uncertainty

Radiated disturbance electric field intensity, 30 – 1000 MHz: $\pm 4,6$ dB
Radiated disturbance electric field intensity, 1000 – 26000 MHz: $\pm 6,0$ dB

The measurement uncertainty describes the overall uncertainty of the given measured value during operation of the EUT.

Measurement uncertainty is calculated in accordance with EA-4/02-1997.
The measurement uncertainty is given with a confidence of 95%.

9.3 Test equipment

Equipment	Manufacturer	Type	SEMKO No.
Equipment	Manufacturer	Type	SEMKO No.
<i>Test site: Semi-anechoic shielded chamber</i>			30300
Software:	Rohde & Schwarz	EMC 32	
Measurement receiver:	Rohde & Schwarz	ESU 8	12866
Antenna, bilog:	Chase	CBL6111B	12474
<i>Test site: Radio anechoic shielded chamber</i>			12285
Software:	Rohde & Schwarz	ES-K1, V1.70	
Signal analyser:	Rohde & Schwarz	FSIQ 40	40023
Preamplifier:	MITEQ	AFS6/AFS44	12335
Antennas:			
Double Ridge Guide Horn:	EMCO	3115	4936
Horn antenna:	EMCO	3160-08	30099
Horn antenna:	EMCO	3160-09	30101
High pass filter	K & L	4410-X4500/18000-0	5133
Band rejection filter	K & L	6N45-2450/T 100-0/0	12389
Transformer	Tufvassons	AFM-1500	30317

9.4 Measurement set-up

Test site: Semi-anechoic shielded chamber (30 – 1000 MHz)

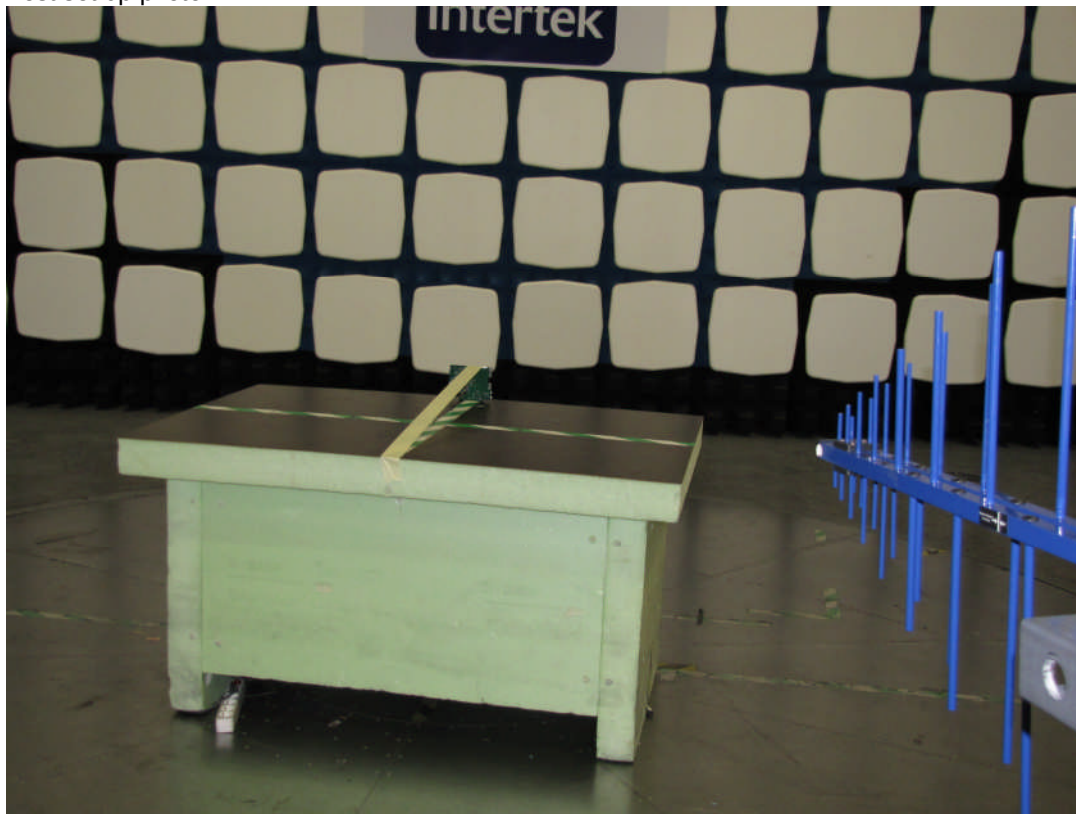
The radiated disturbance electric field intensity was measured in a semi-anechoic chamber at a distance of 3 m and the EUT was placed on a non-metallic table, 0,8 m above the reference ground plane. The specified test mode was enabled. Test set-up photo is given below.

An overview sweep with peak detection of the electric field intensity was performed with the measurement receiver in max-hold and with the antenna placed 1,5 m, 2,5 m and 3,5 m above the floor. The polarisation was horizontal and vertical. The measurements were repeated with the EUT rotated in 90-degree steps.

At the frequencies where high disturbance levels were found a search for max disturbance level was performed in the semi-anechoic chamber with variations of azimuth angle 0 - 360 degrees and antenna height 1 – 4 m.

With the EUT and antenna in the worst-case configuration new measurements were carried out.

Test set-up photo:



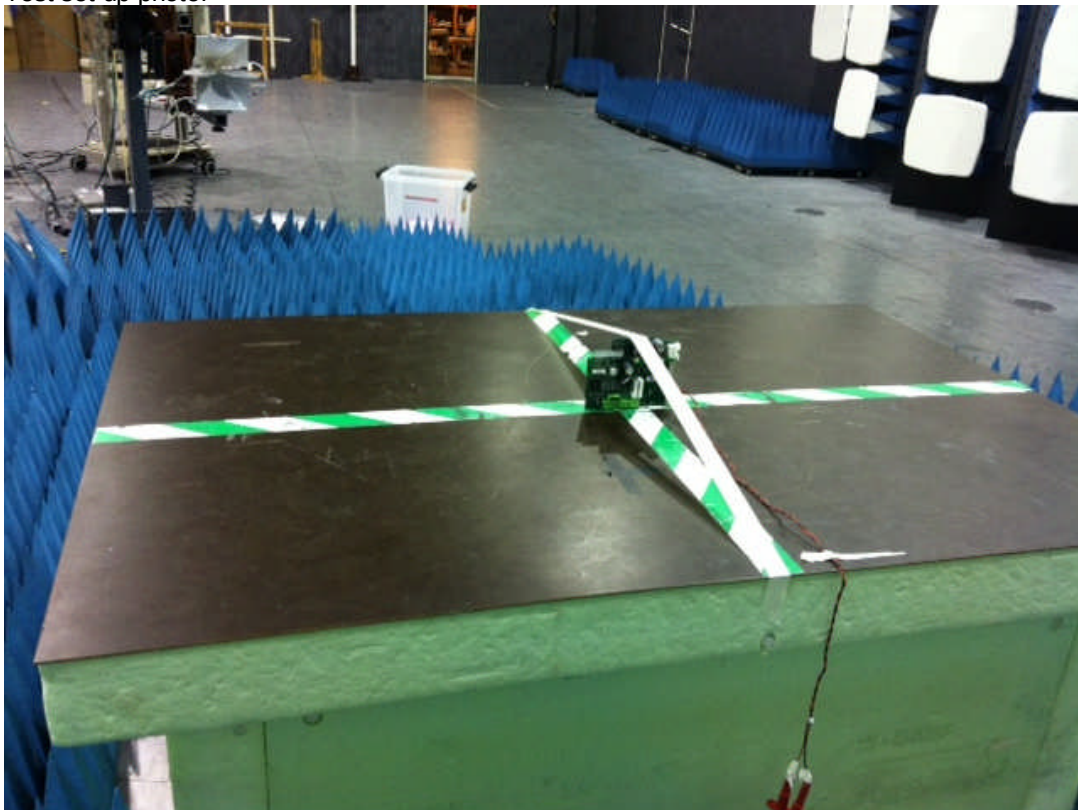
Test site: Radio anechoic shielded chamber (1 – 26 GHz)

In the Radio anechoic chamber the EUT was placed on a non-metallic table, 1,4 m above the floor. The radiated disturbance electric field intensity was measured at a distance of 3 m. The specified test mode was enabled.

An overview sweep with peak detection of the electric field intensity was performed with the spectrum analyser in max-hold and with the antenna placed 1,4 m above the floor. The polarisation was horizontal and vertical. The measurements were repeated with the EUT rotated in 90-degree steps.

At the frequencies where high disturbance levels were found a search for max disturbance level was performed in the semi-anechoic chamber with variations of azimuth angle 0 - 360 degrees and antenna height 1 – 4 m.. With the EUT and antenna in the worst-case configuration new measurements were carried out.

Test set-up photo:



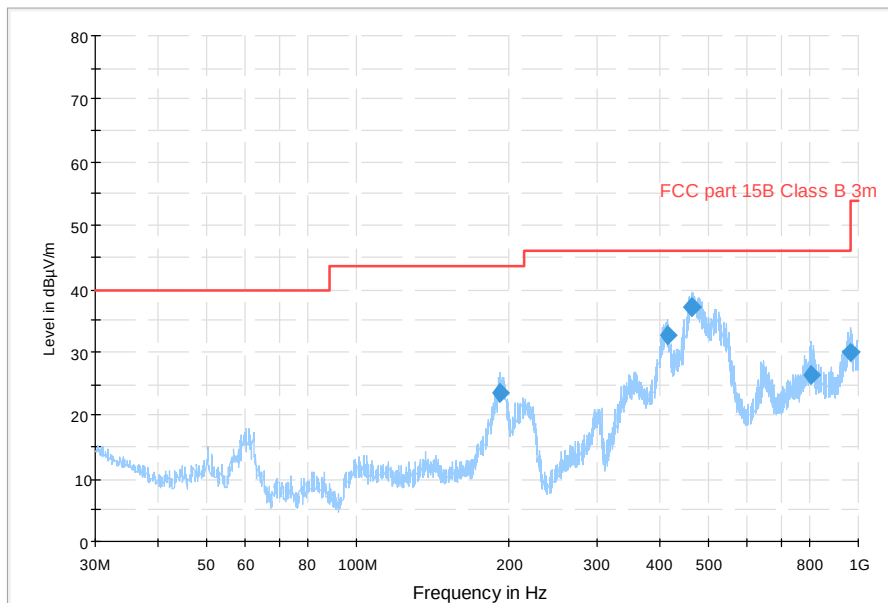
9.5 Test protocol

Semi-anechoic shielded chamber

Date of test: 2011-11-10

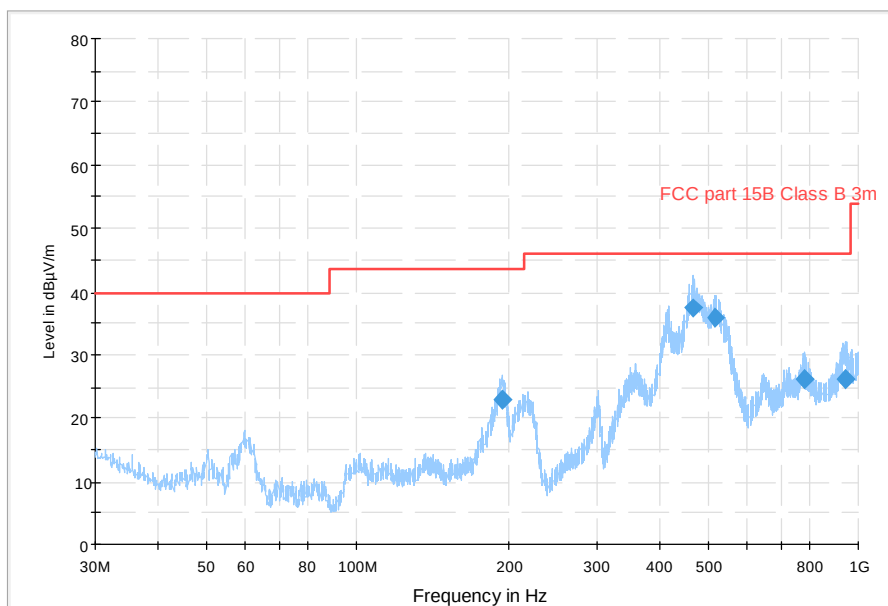
30 – 1000 MHz, max peak at a distance of 3 m on the lower TX channel antenna selection 0

FCC 30 - 1000 MHz FCC class B 3m



30 – 1000 MHz, max peak at a distance of 3 m on the lower TX channel antenna selection 1

FCC 30 - 1000 MHz FCC class B 3m



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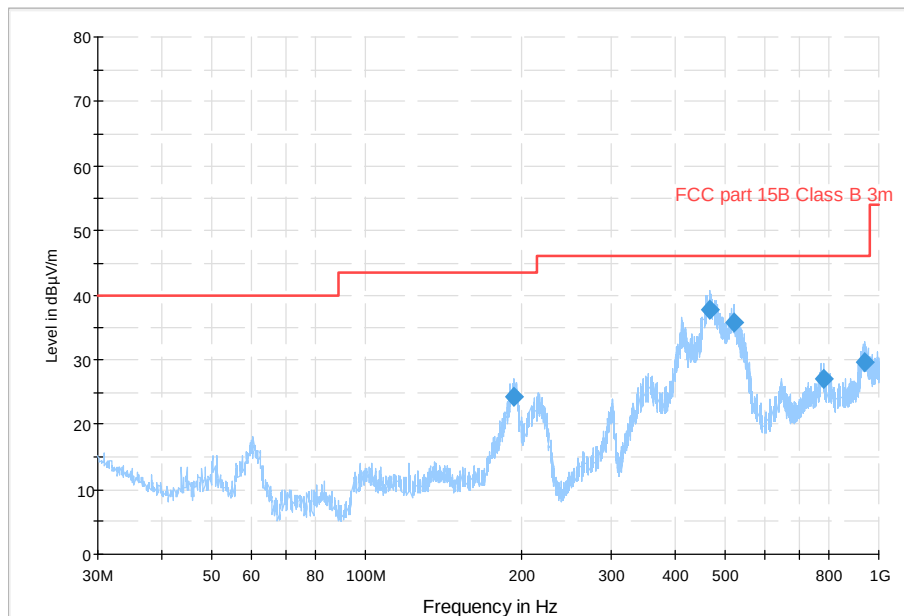
Telephone +46 8 750 00 00, Fax +46 8 750 60 30

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Registered in Sweden: No: SE556024059901, Registered office: As address

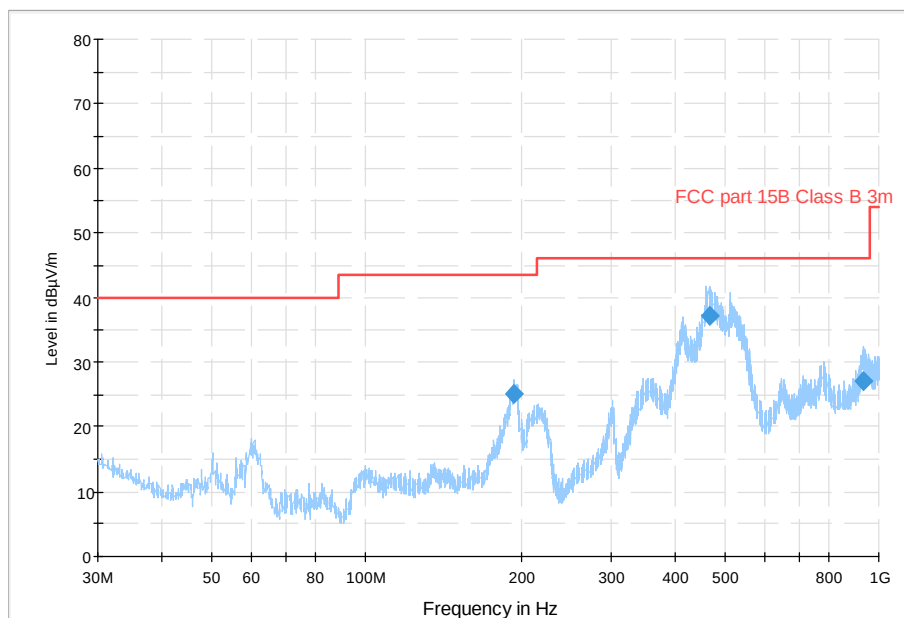
30 – 1000 MHz, max peak at a distance of 3 m on the middle TX channel antenna selection 0

FCC 30 - 1000 MHz FCC class B 3m



30 – 1000 MHz, max peak at a distance of 3 m on the middle TX channel antenna selection 1

FCC 30 - 1000 MHz FCC class B 3m



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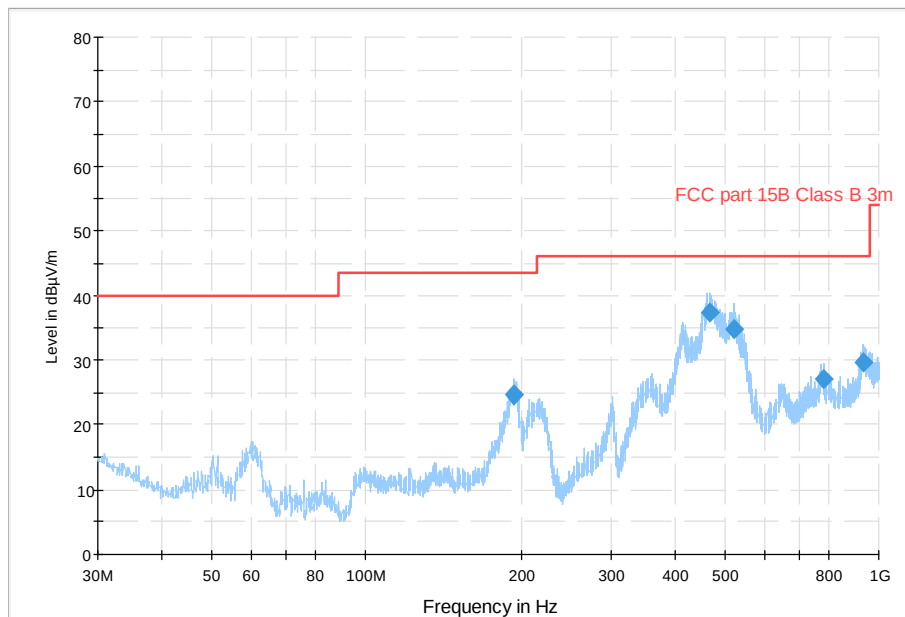
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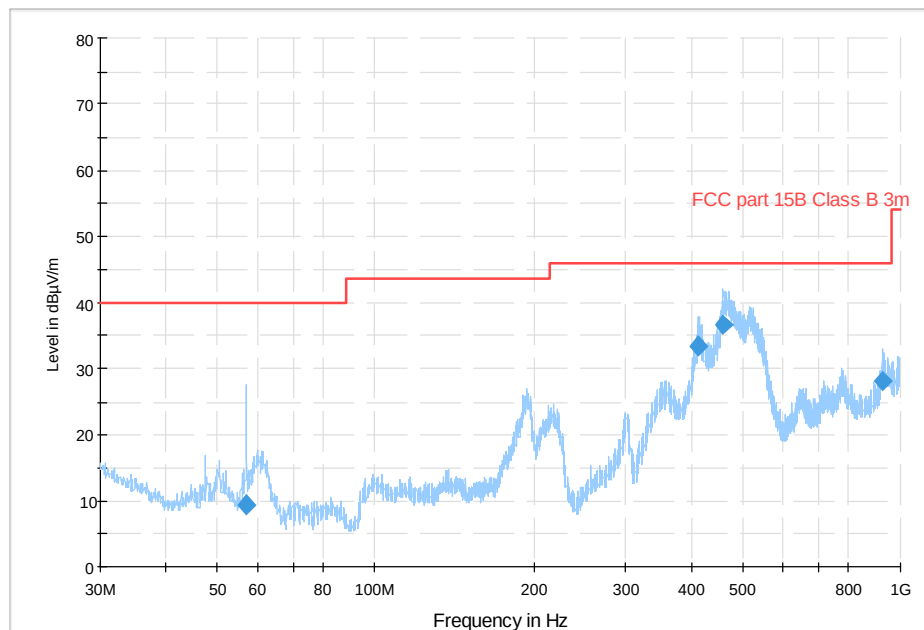
30 – 1000 MHz, max peak at a distance of 3 m on the upper TX channel antenna selection 0

FCC 30 - 1000 MHz FCC class B 3m



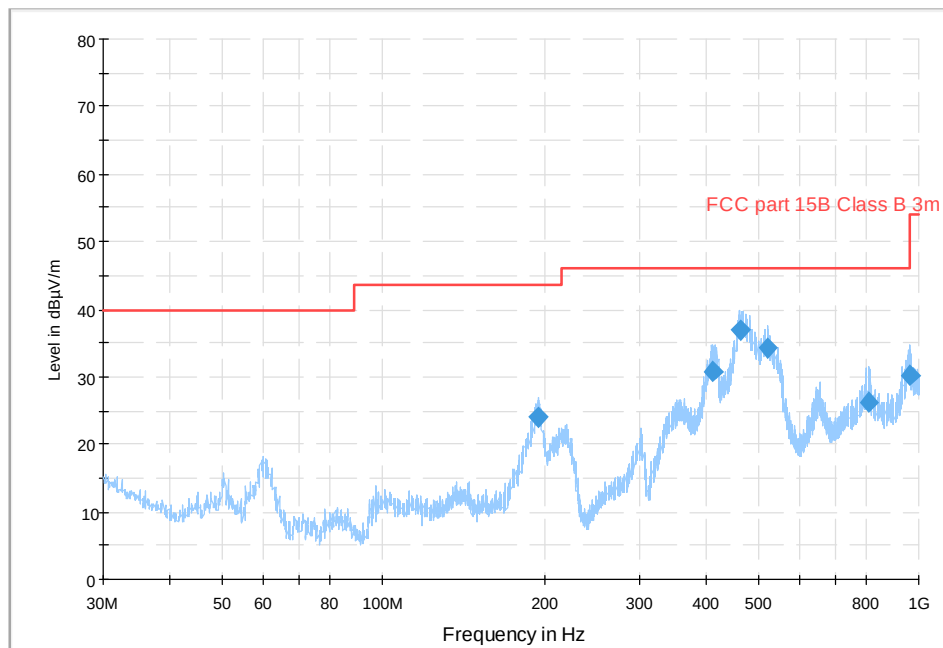
30 – 1000 MHz, max peak at a distance of 3 m on the upper TX channel antenna selection 1

FCC 30 - 1000 MHz FCC class B 3m



30 – 1000 MHz, max peak at a distance of 3 m in the RX mode

FCC 30 - 1000 MHz FCC class B 3m



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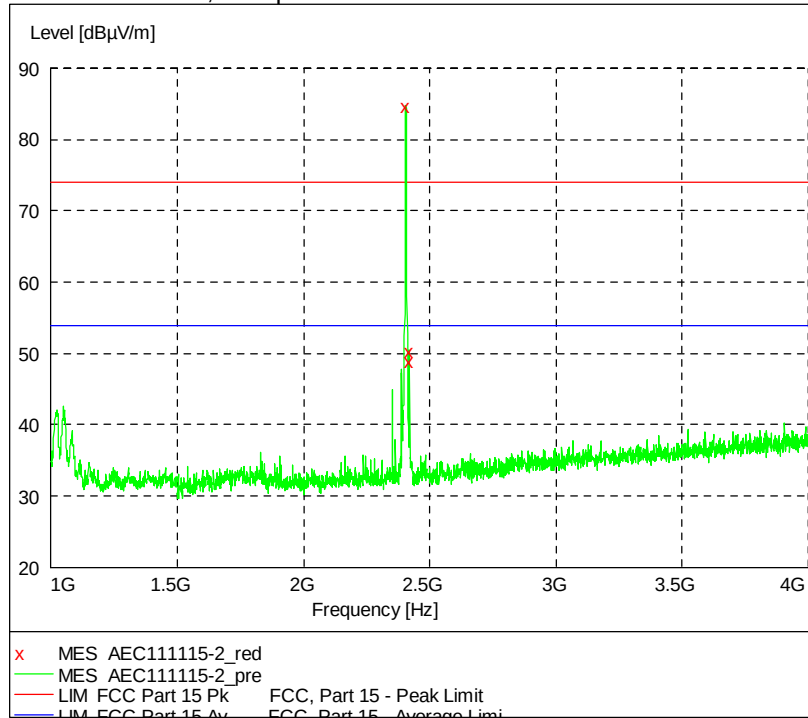
www.intertek.se

Registered in Sweden: No: SE556024059901, Registered office: As address

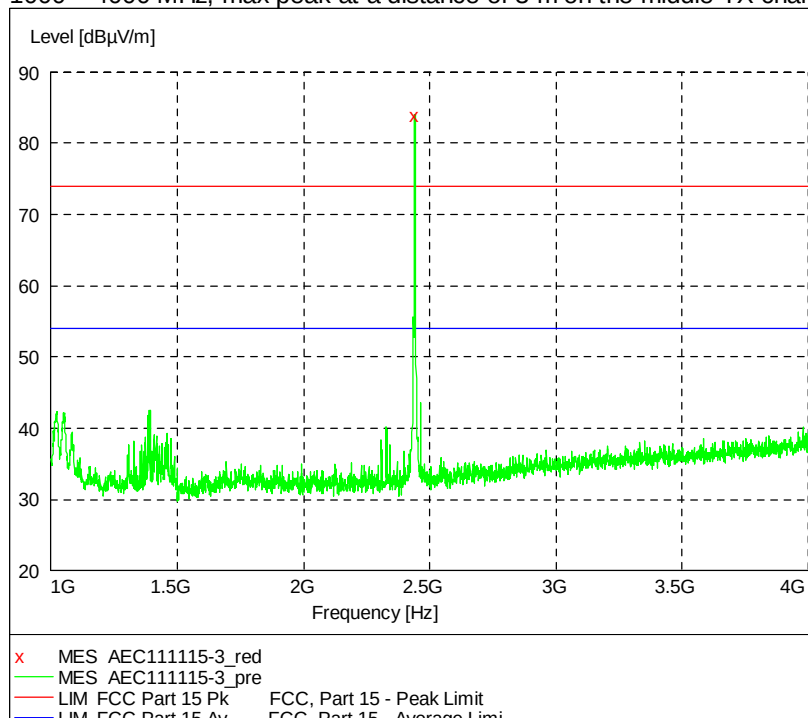
Radio anechoic shielded chamber

Date of test: 2011-11-15

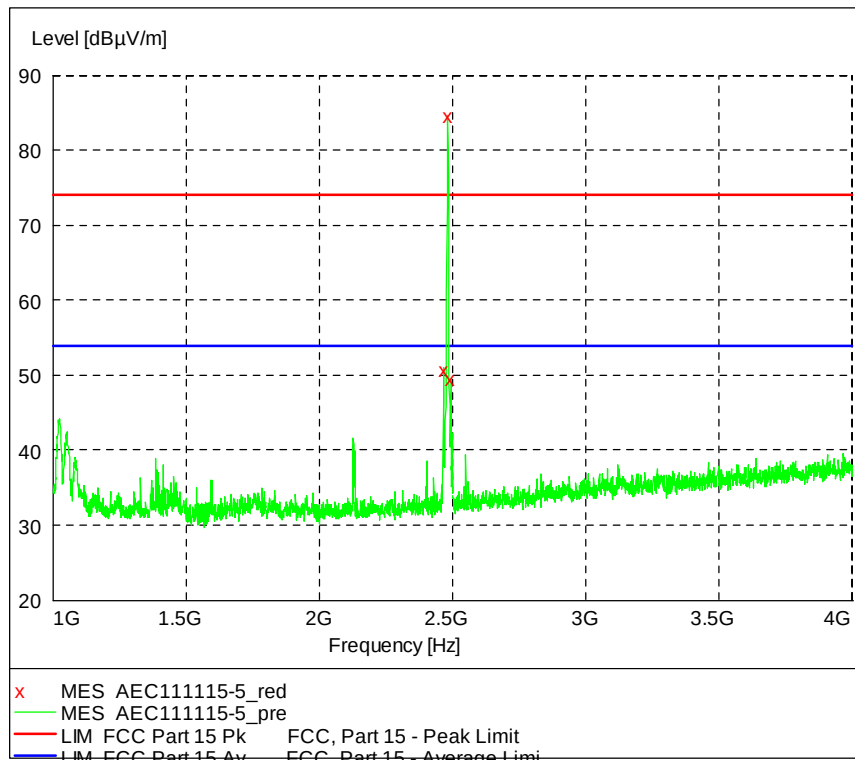
1000 – 4000 MHz, max peak at a distance of 3 m on the lower TX channel, antenna selection 0.



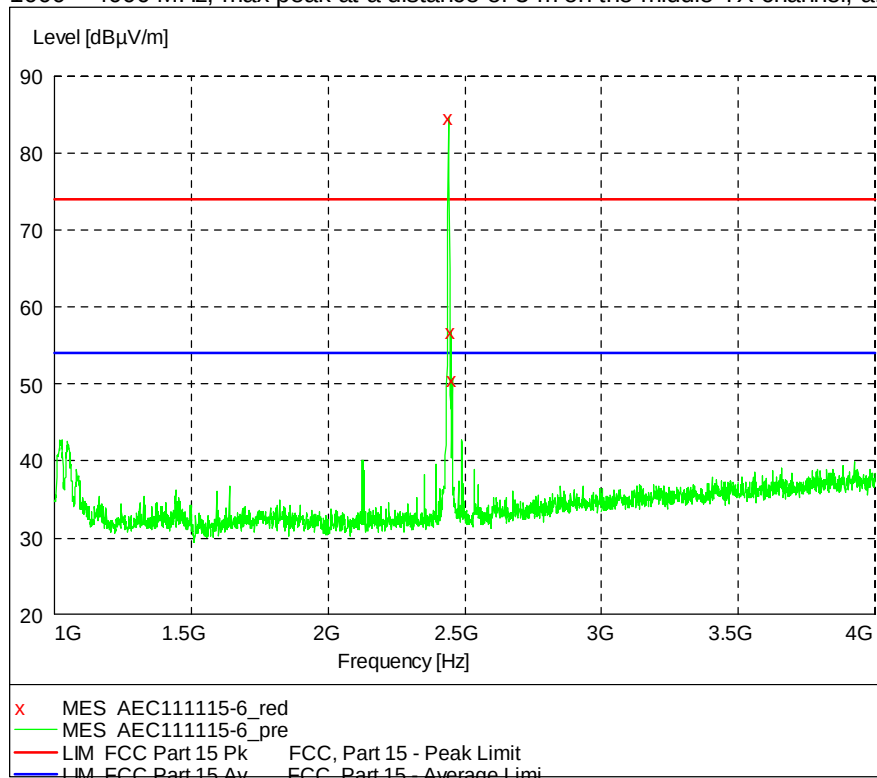
1000 – 4000 MHz, max peak at a distance of 3 m on the middle TX channel, antenna selection 0.



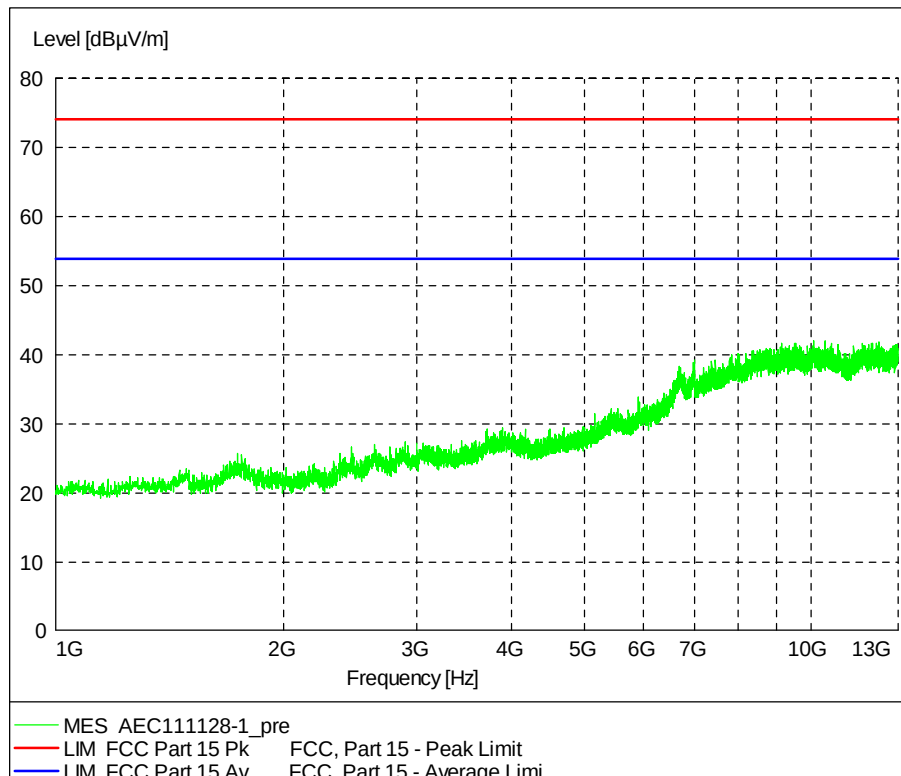
1000 – 4000 MHz, max peak at a distance of 3 m on the high TX channel, antenna selection 0.



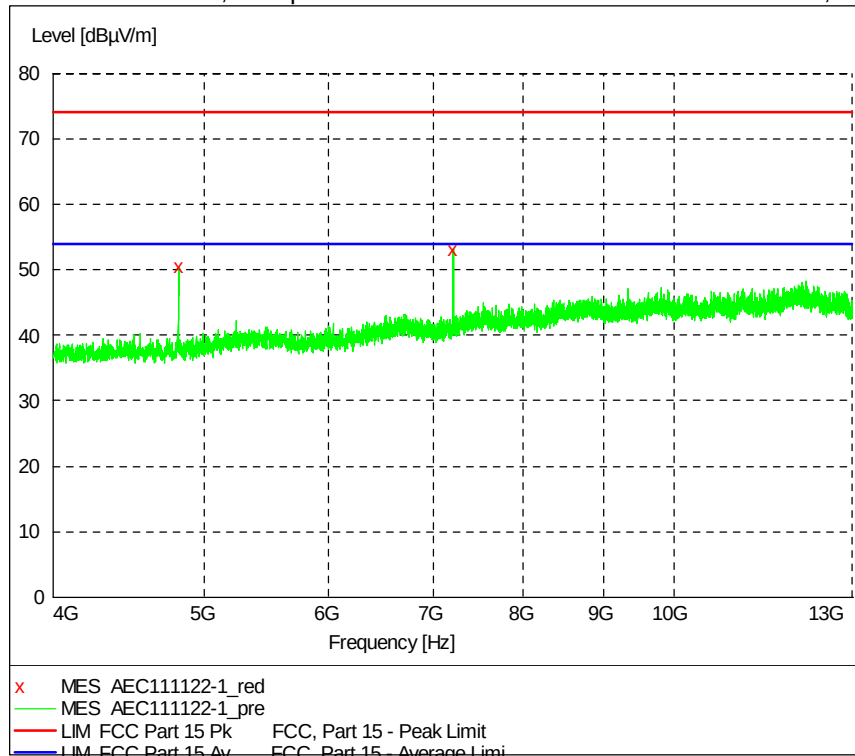
1000 – 4000 MHz, max peak at a distance of 3 m on the middle TX channel, antenna selection 1



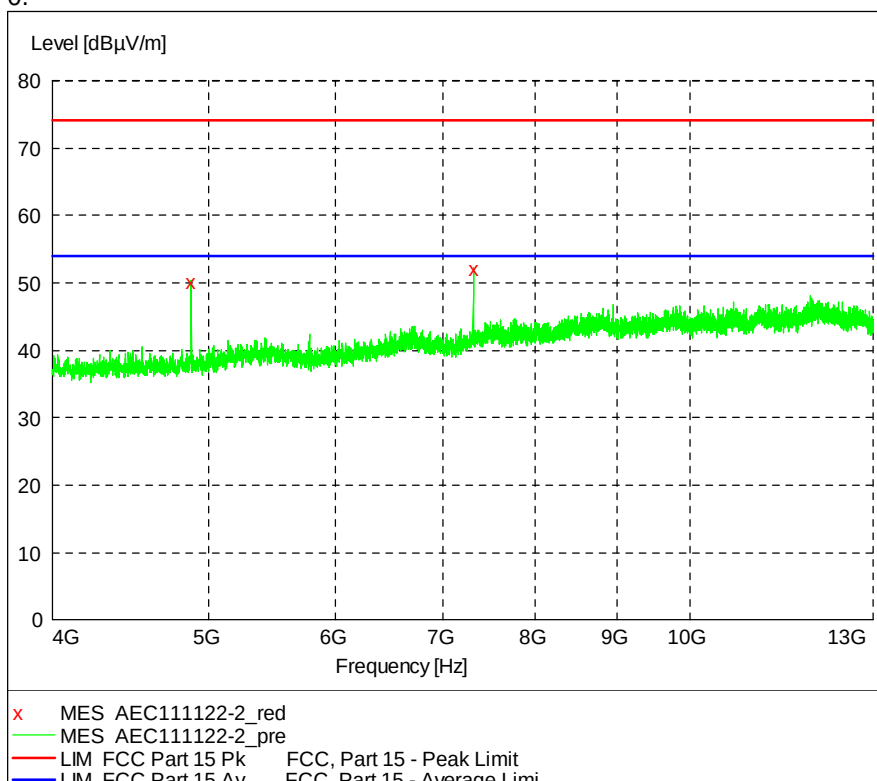
1000 – 13000 MHz, max peak at a distance of 3 m on RX mode



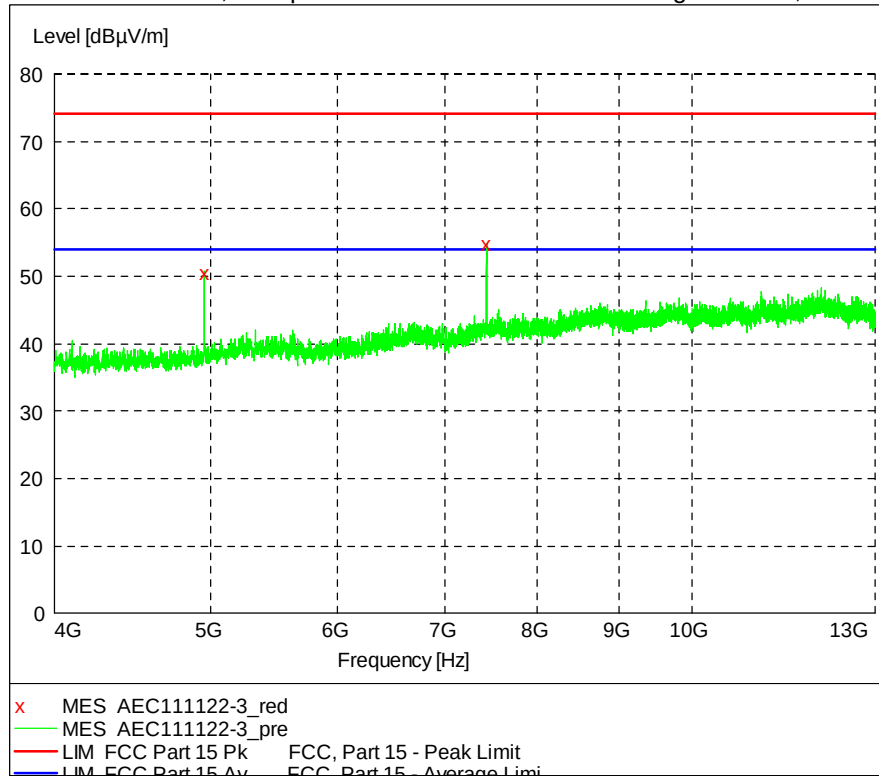
4000 – 13000 MHz, max peak at a distance of 3 m on the low TX channel, antenna selection 0.



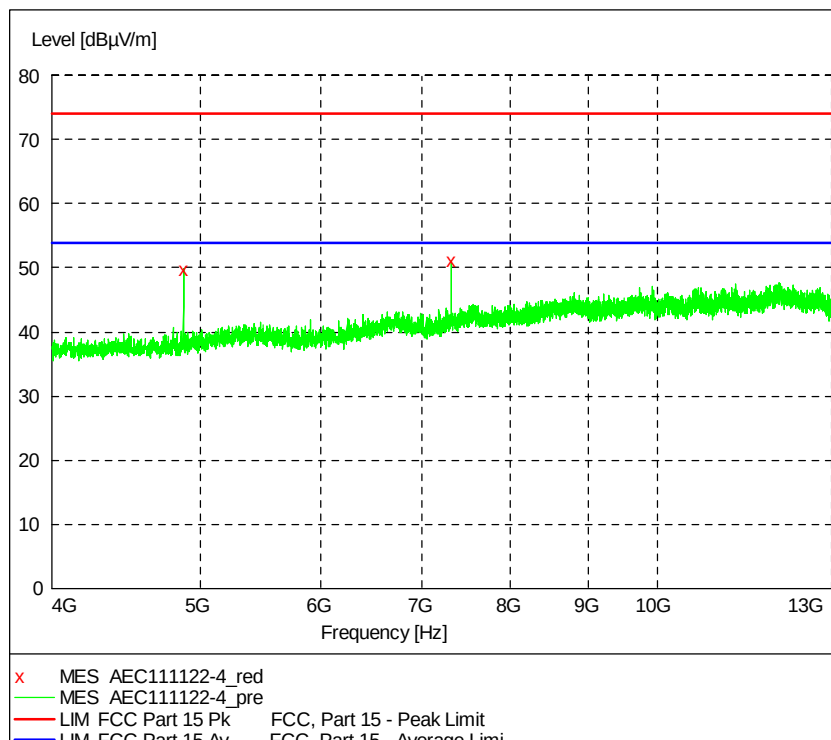
4000 – 13000 MHz, max peak at a distance of 3 m on the middle TX channel, antenna selection 0.



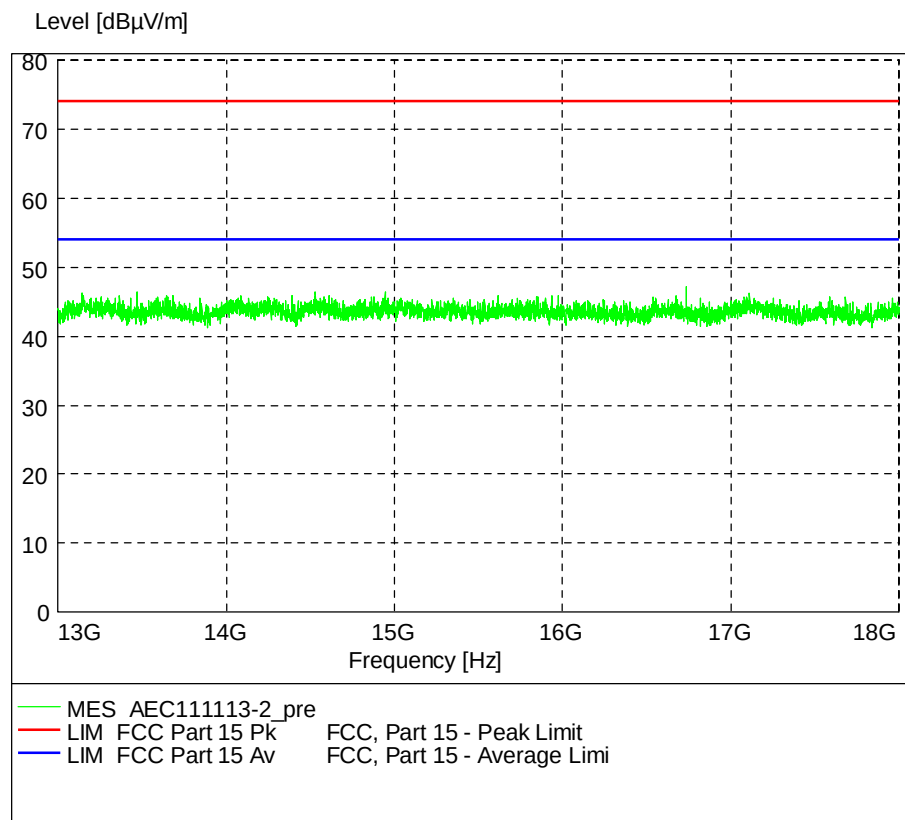
4000 – 13000 MHz, max peak at a distance of 3 m on the high channel, antenna selection 0.



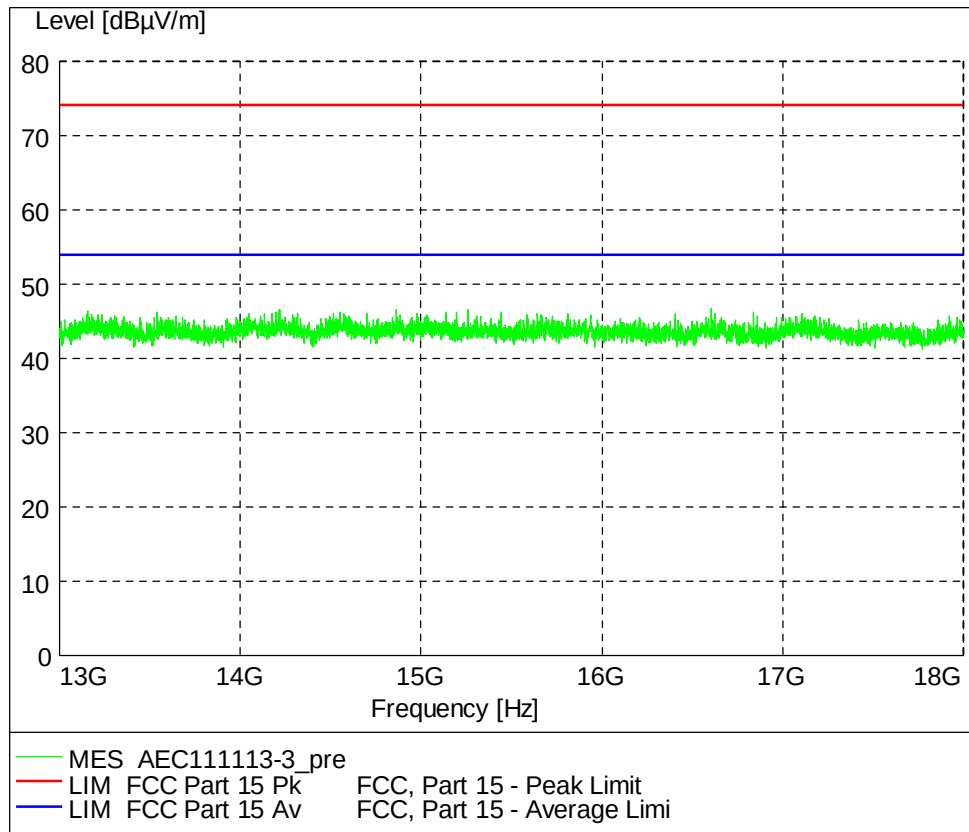
4000 – 13000 MHz, max peak at a distance of 3 m on the middle channel, antenna selection 1.



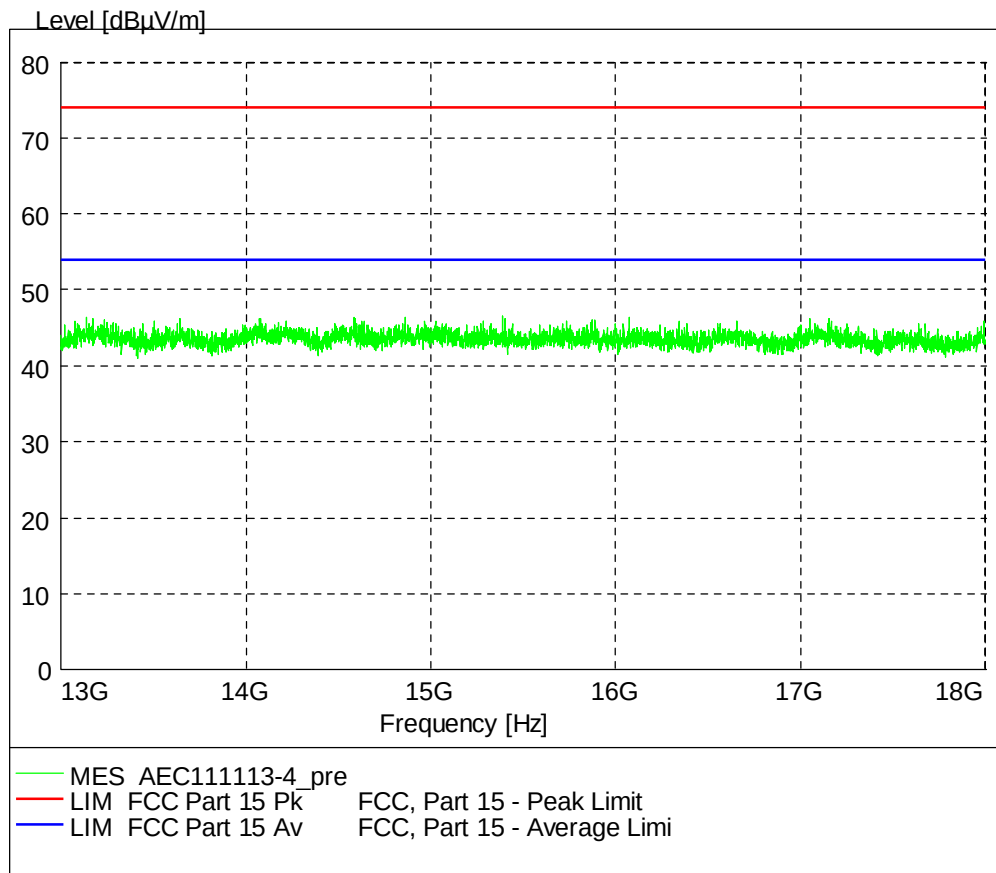
13000 – 18000 MHz, max peak at a distance of 3 m on the lower TX channel, antenna selection 0.



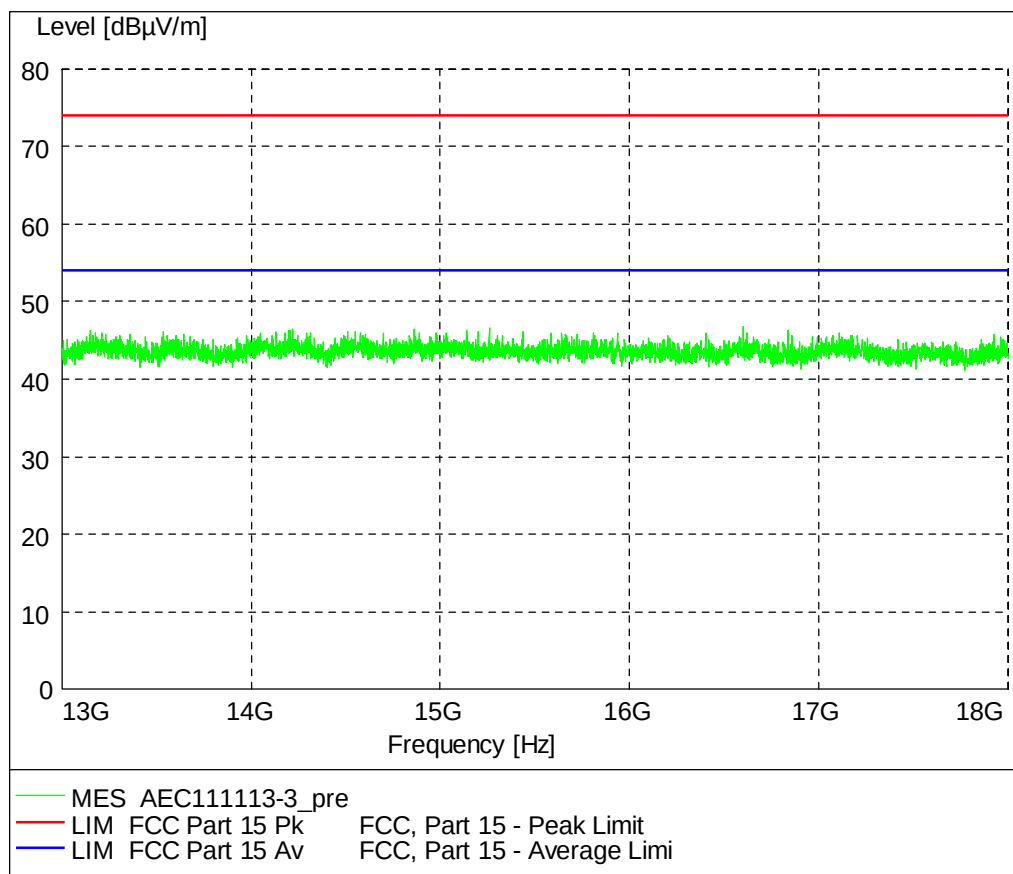
13000 – 18000 MHz, max peak at a distance of 3 m on the mid TX channel, antenna selection 0.



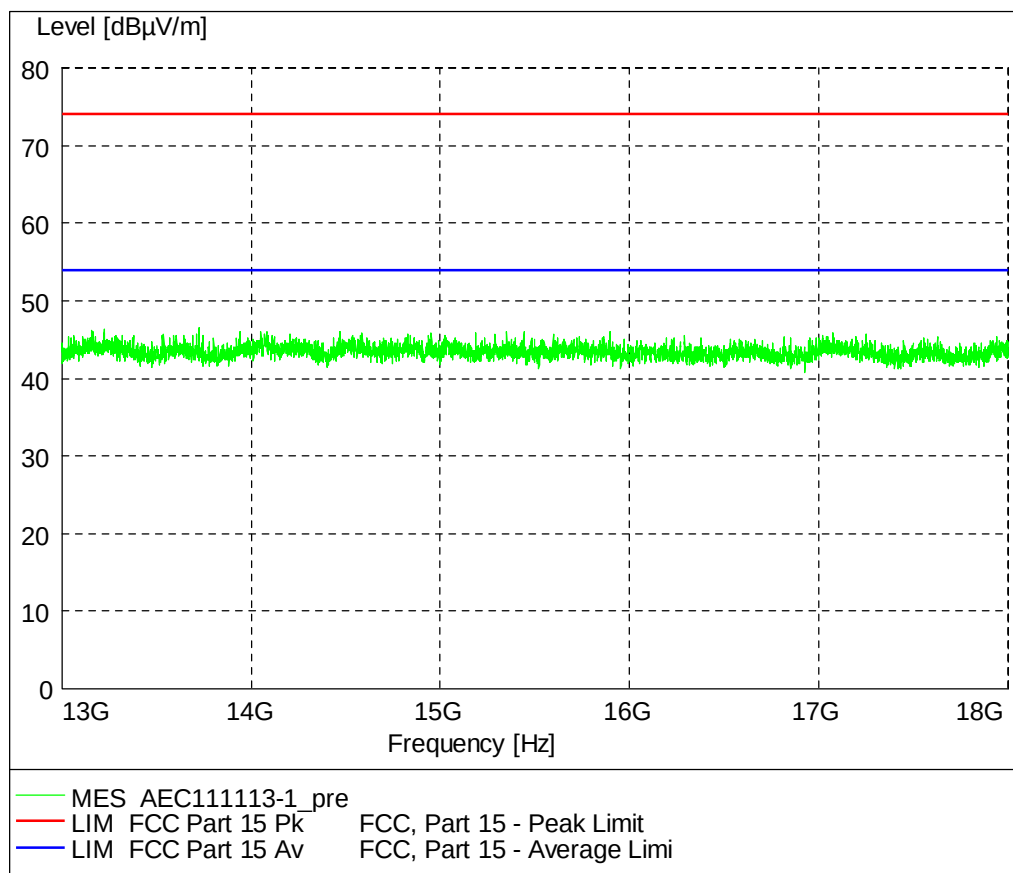
13000 – 18000 MHz, max peak at a distance of 3 m on the high TX channel, antenna selection 0.



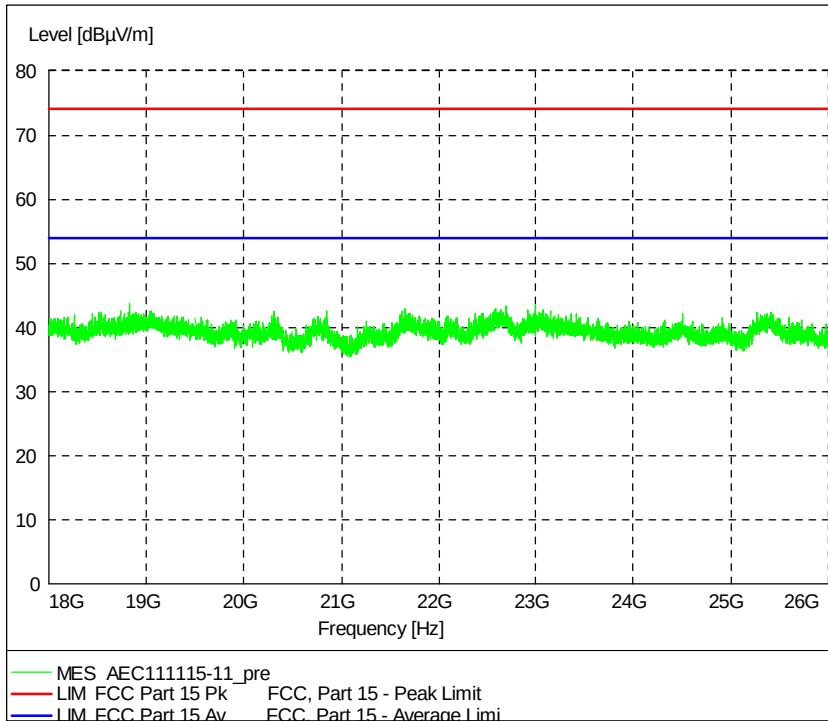
13000 – 18000 MHz, max peak at a distance of 3 m on the mid TX channel, antenna selection 1



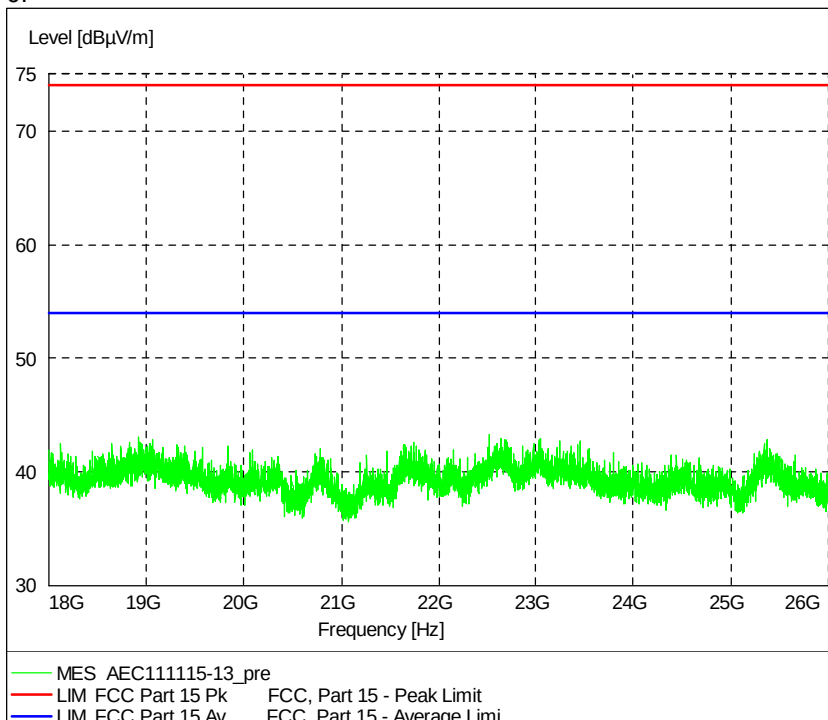
13000 – 18000 MHz, max peak at a distance of 3 m on RX



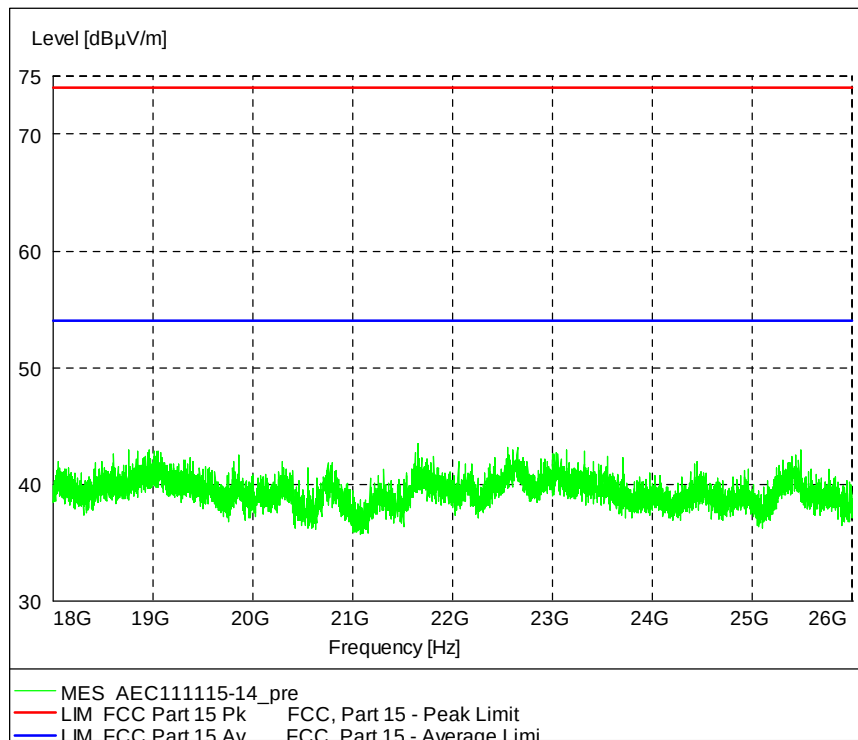
18000 – 26000 MHz, max peak at a distance of 3 m on the lower TX channel, antenna selection 0.



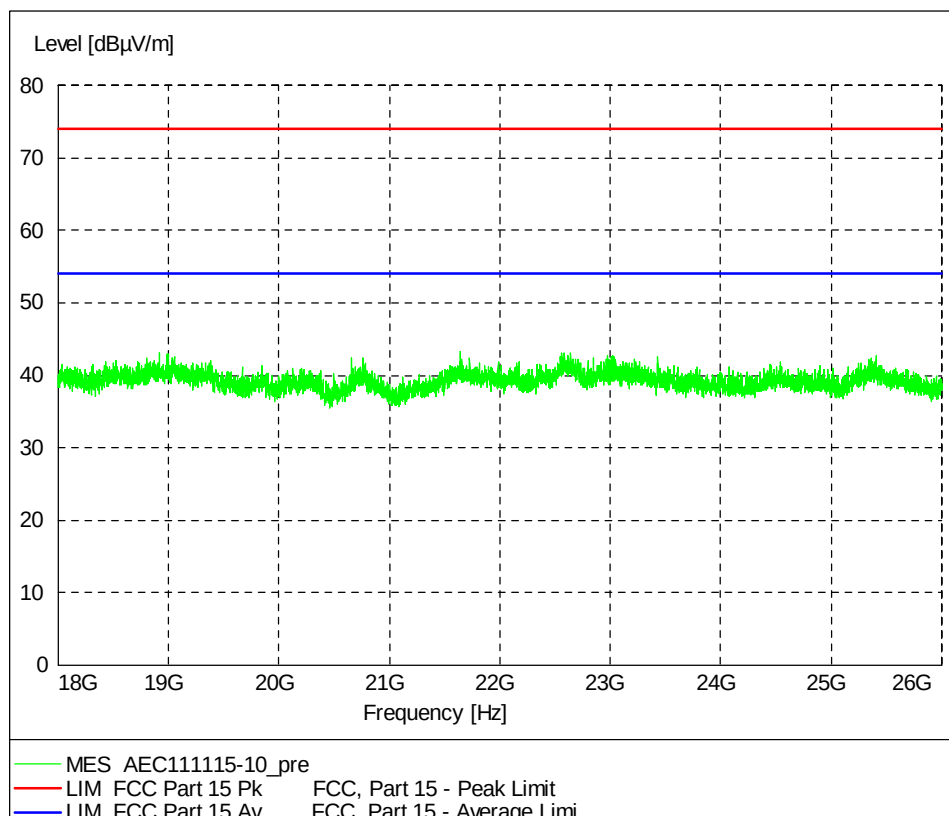
18000 – 26000 MHz, max peak at a distance of 3 m on the middle TX channel, antenna selection 0.



18000 – 26000 MHz, max peak at a distance of 3 m on the middle TX channel, antenna selection 1.



18000 – 26000 MHz, max peak at a distance of 3 m on the RX mode



Data summary

Field strength of spurious emissions low channel

Frequency (MHz)	QuasiPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
193.02	23.5	120	213.0	V	148.0	-23.1	43.5	20.0
416.70	32.8	120	115.0	V	44.0	-13.1	46.0	13.2
463.61	37.2	120	121.0	V	121.0	-12.3	46.0	8.8
803.88	26.4	120	146.0	V	225.0	-4.2	46.0	19.6
959.14	30.0	120	164.0	H	-1.0	-1.1	46.0	16.0

Frequency (MHz)	MaxPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
4811.10	59.0	1000	152.0	H	143.0	-2.0	74.0	15.0
7326.00	45.8	1000	224.0	H	179.0	2.2	74.0	28.2

Frequency (MHz)	Average (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
4811.10	53.8	1000	152.0	H	143.0	-2.0	54.0	0.2 ⁽¹⁾
7326.00	40.6	1000	224.0	H	179.0	2.2	54.0	13.4

Field strength of spurious emissions middle channel

Frequency (MHz)	QuasiPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
194.17	24.5	120	206.0	V	184.0	-23.1	43.5	19.0
466.96	37.8	120	118.0	V	123.0	-12.1	46.0	8.2
519.84	35.7	120	115.0	V	147.0	-10.4	46.0	10.3
778.32	27.0	120	116.0	H	33.0	-4.5	46.0	19.0
938.94	29.7	120	100.0	H	26.0	-0.9	46.0	16.3

Frequency (MHz)	MaxPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
4879.04	53.4	1000	157.0	V	126.0	-1.9	74.0	20.6
7321.52	58.9	1000	134.0	H	143.0	2.1	74.0	15.1

Frequency (MHz)	Average (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
4879.04	48.2	1000	157.0	V	126.0	-1.9	54.0	5.8
7321.52	53.7	1000	134.0	H	143.0	2.1	54.0	0.3 ⁽¹⁾

Field strength of spurious emissions high channel

Frequency (MHz)	QuasiPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
194.72	24.7	120	245.0	V	163.0	-23.2	43.5	18.8
467.82	37.4	120	133.0	V	225.0	-12.1	46.0	8.6
519.73	34.9	120	121.0	V	192.0	-10.4	46.0	11.1
778.98	27.1	120	115.0	H	29.0	-4.5	46.0	18.9
933.46	29.7	120	100.0	H	19.0	-1.3	46.0	16.3

Frequency (MHz)	MaxPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
4961.00	57.0	1000	143.0	H	139.0	-1.7	74.0	17.0
7441.60	58.8	1000	116.0	H	140.0	2.9	74.0	15.2

Frequency (MHz)	Average (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
4961.00	51.8	1000	143.0	H	139.0	-1.7	54.0	2.2
7441.60	53.5	1000	116.0	H	140.0	2.9	54.0	0.5 ⁽¹⁾

(1) The measured result is below the limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliance based on the 95 % level of confidence. However, the result indicates that compliance is more probable than non-compliance with the specification limit.

Field strength of spurious emissions RX mode

Frequency (MHz)	QuasiPeak (dBμV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Limit (dBμV/m)	Margin (dB)
194.81	24.1	120	237.0	V	184.0	-23.2	43.5	19.4
414.21	30.9	120	100.0	V	82.0	-13.1	46.0	15.1
464.45	37.0	120	127.0	V	111.0	-12.3	46.0	9.0
521.20	34.3	120	126.0	V	200.0	-10.4	46.0	11.7
803.84	26.3	120	170.0	V	203.0	-4.2	46.0	19.7
958.30	30.3	120	145.0	H	-11.0	-1.1	46.0	15.7
1000-26000	-	1000	-	-	-	-	-	-

No significant peaks above the noise floor above 1000 MHz.

Example calculation:

Measured level [dBμV/m] = Analyser reading [dBμV] + cable loss [dB] – preamplifier gain [dB] + antenna factor [1/m]

10. OUT OF BAND SPURIOUS EMISSIONS, CONDUCTED AT ANTENNA PORT

Date of test: 2011-11-03

EUT mode of operation: continuous TX.

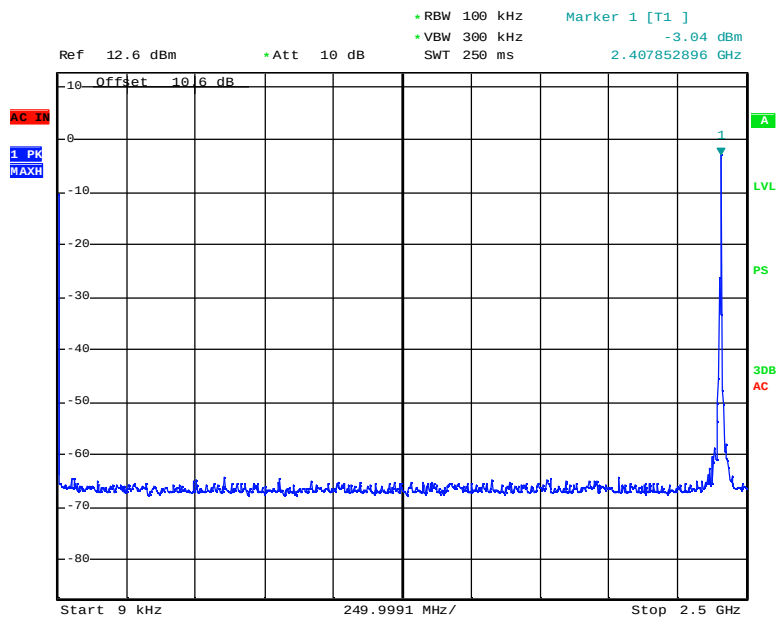
Spectrum analyzer settings:

RBW: 100 kHz
 VBW: 100 kHz
 Sweep time: Auto
 Detector: Peak
 Trace: Max Hold

Channel	Plot	Results	Limit value (dBc)
Low	10.1 – 10.4	PASS	20
Middle	10.5 – 10.8	PASS	20
High	10.9 – 10.12	PASS	20

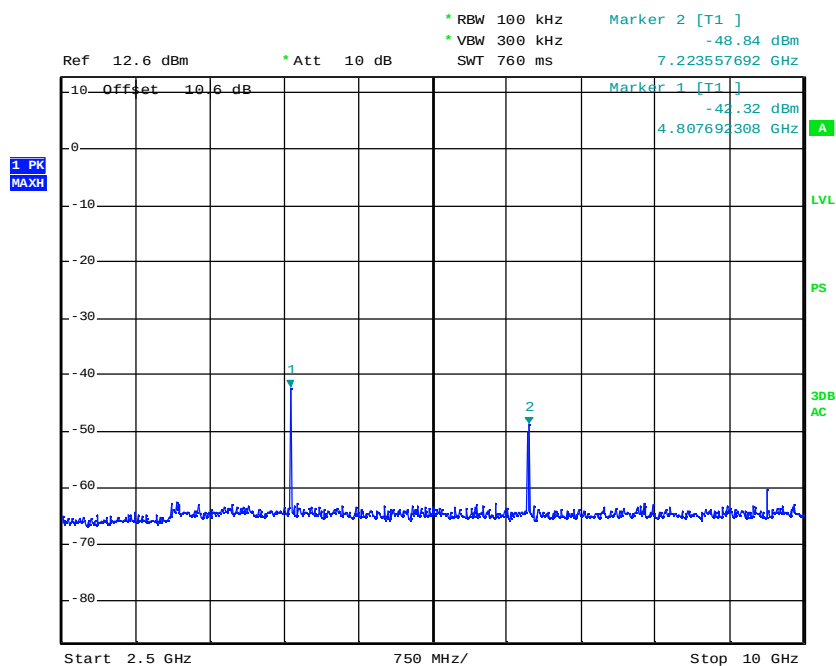
Limit: In any 100 kHz bandwidth outside the operating frequency band (2400 – 2483.5 MHz), the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

Plot P10.1



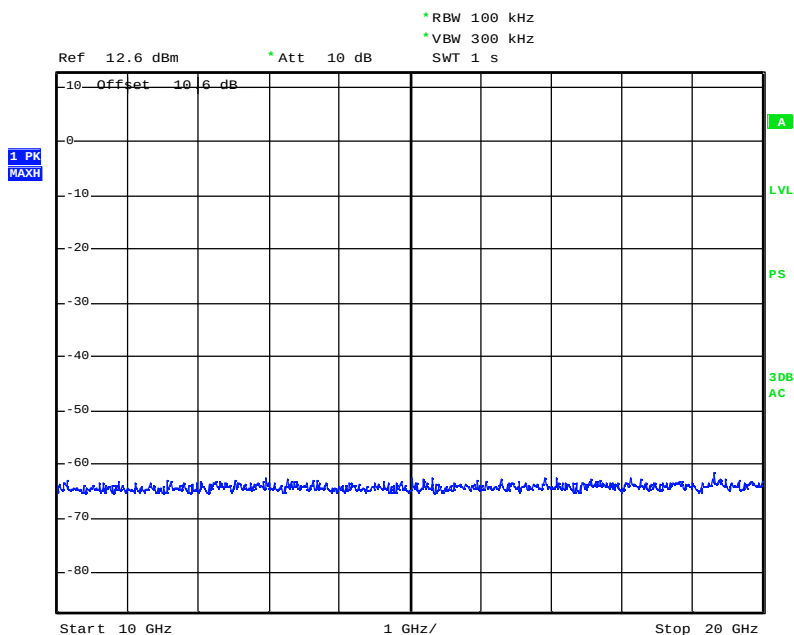
Date: 3.NOV.2011 13:50:38

Plot P10.2



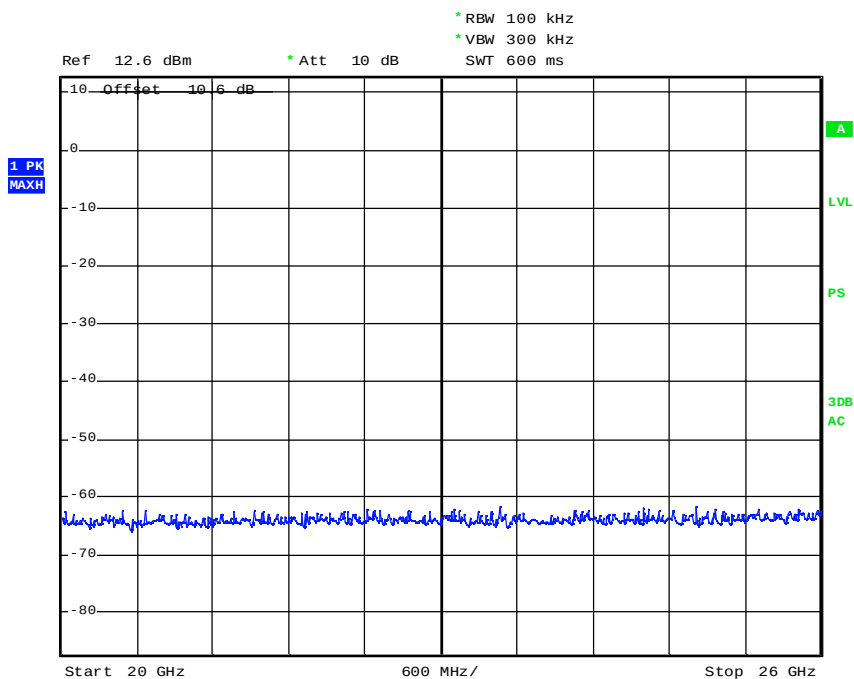
Date: 3.NOV.2011 13:51:59

Plot P10.3



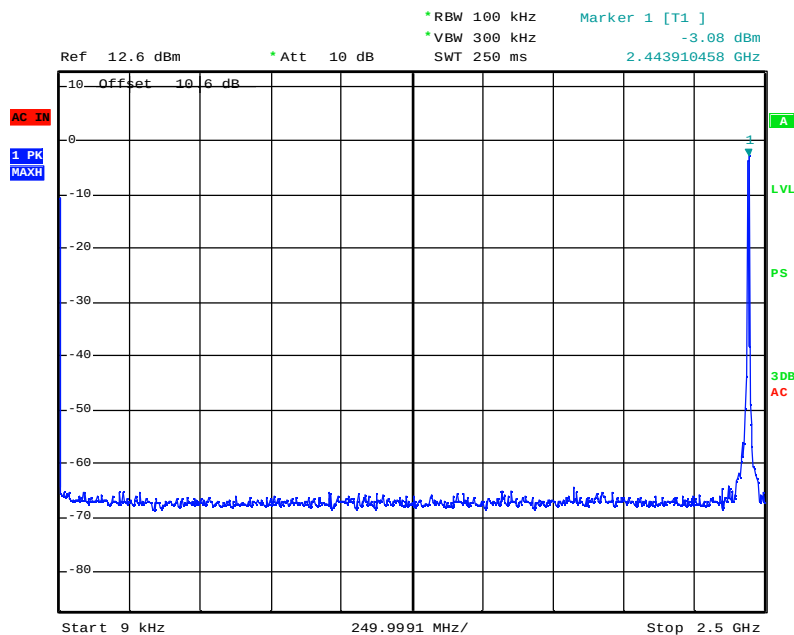
Date: 3.NOV.2011 13:52:58

Plot P10.4



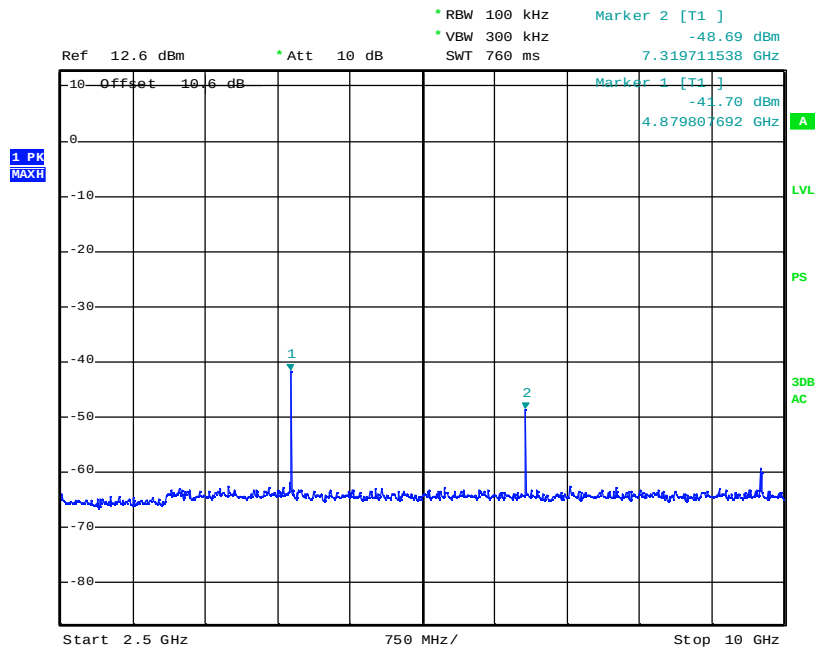
Date: 3.NOV.2011 13:53:37

Plot P10.5



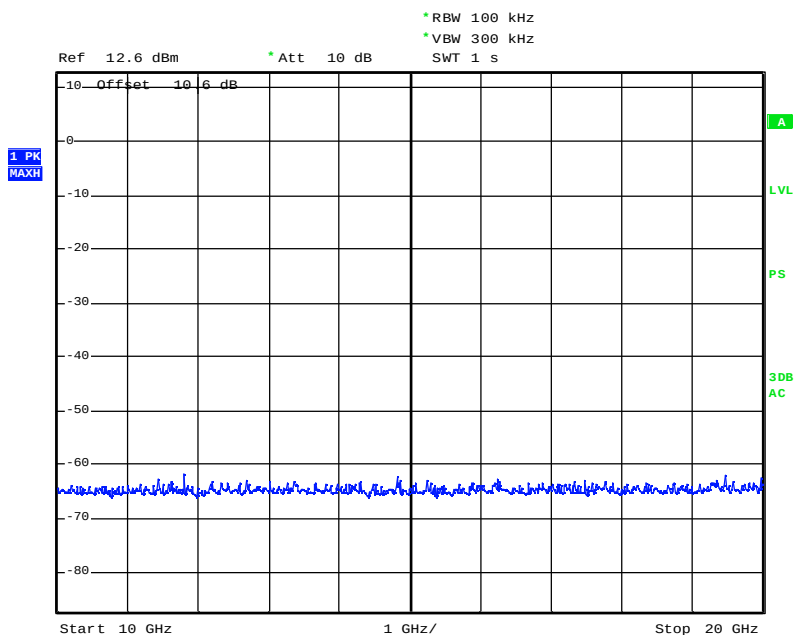
Date: 3.NOV.2011 13:55:45

Plot P10.6



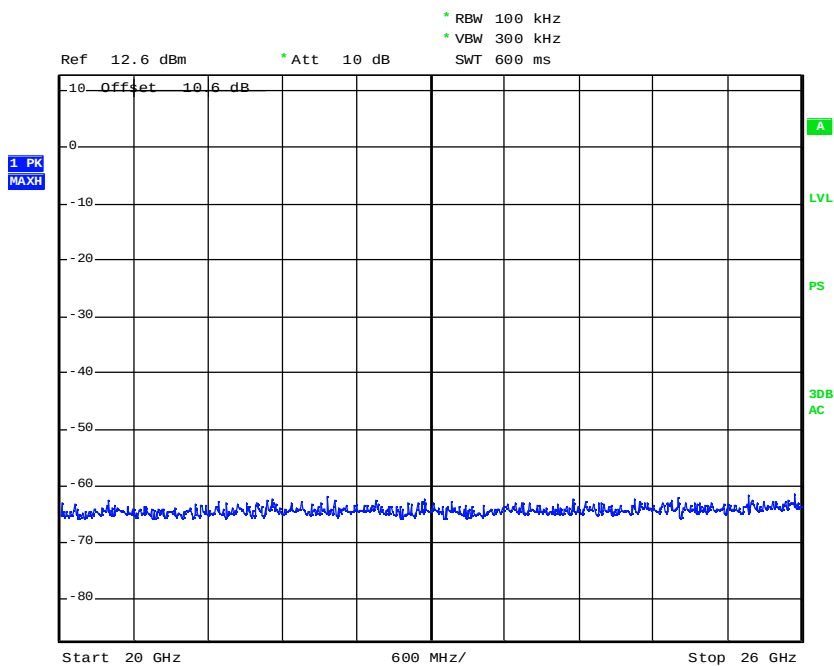
Date: 3.NOV.2011 13:57:43

Plot P10.7



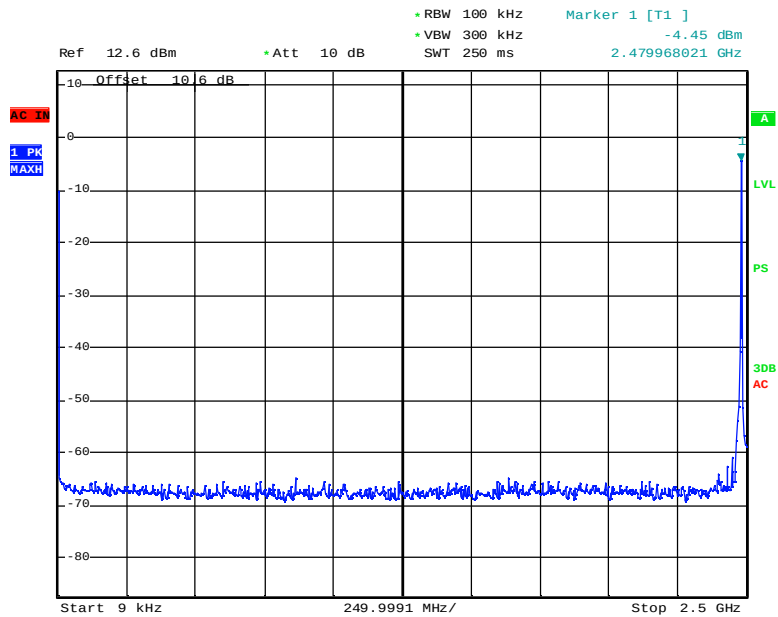
Date: 3.NOV.2011 13:58:09

Plot P10.8



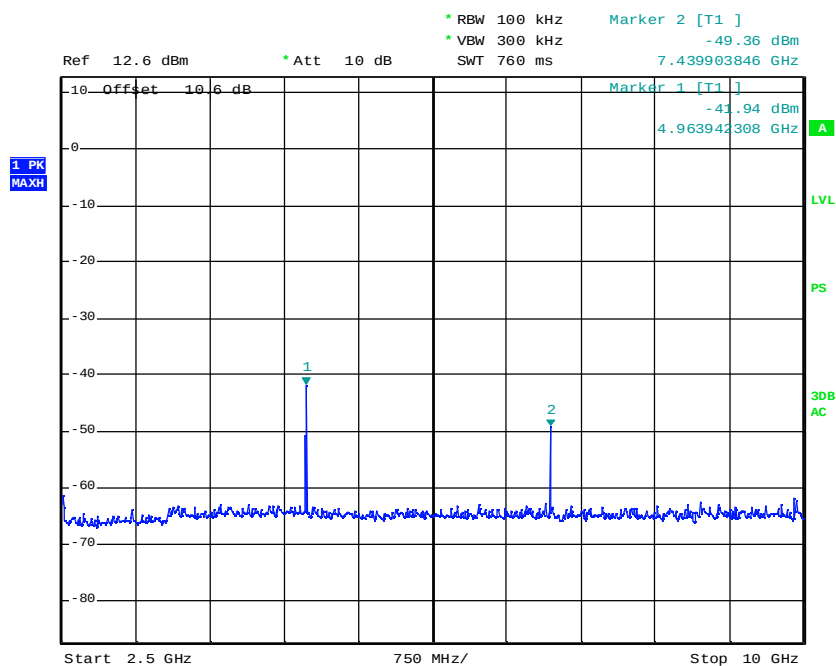
Date: 3.NOV.2011 13:58:43

Plot P10.9



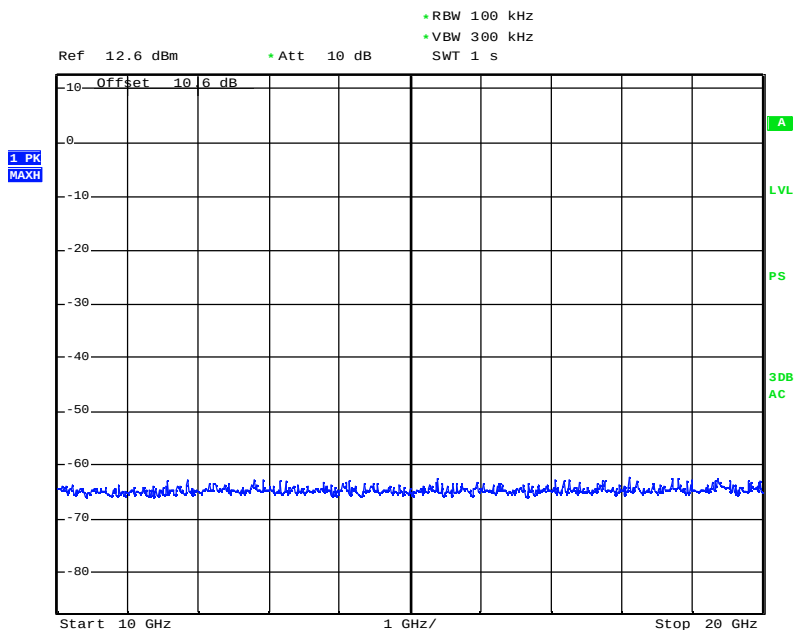
Date: 3.NOV.2011 14:00:02

Plot P10.10



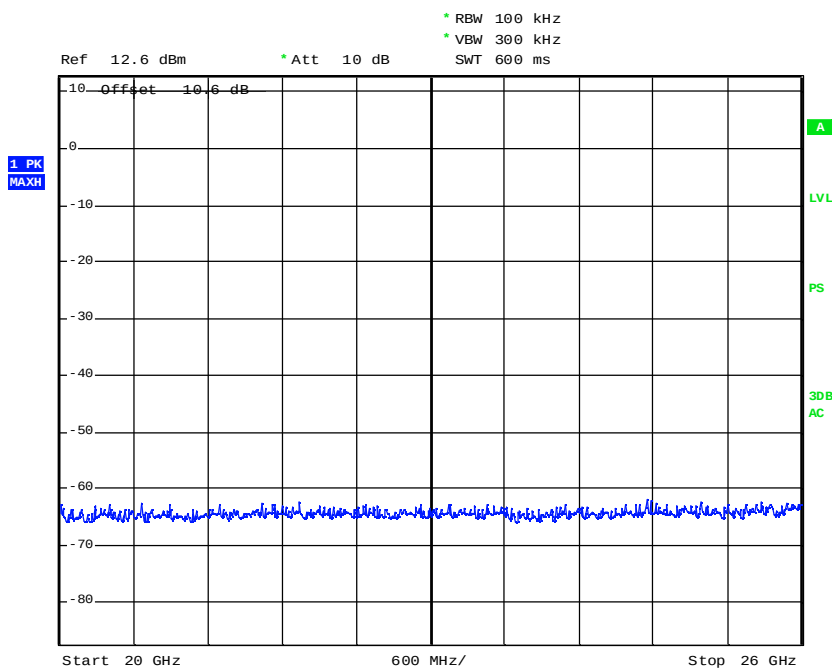
Date: 3.NOV.2011 14:00:47

Plot P10.11



Date: 3.NOV.2011 14:01:14

Plot P10.12



Date: 3.NOV.2011 14:01:43

11. 99% BANDWIDTH

11.1 Test protocol

Date of test:

EUT mode of operation: continuous TX. Modulation on

Spectrum analyzer settings:

Span: 10 MHz
RBW: 100 kHz
VBW: 300 kHz
Sweep time: Auto
Detector: Sample
Trace: Max Hold

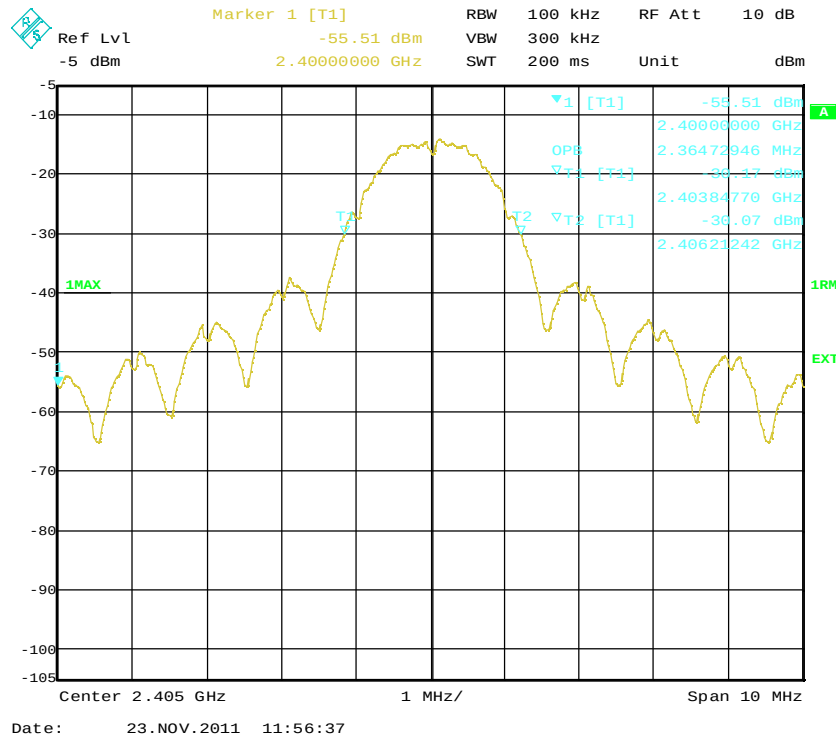
Channel	Plot	Measured value MHz	Limit value MHz
Low	plot 11.1	2.36	-
Middle	plot 11.2	2.36	-
High	plot 11.3	2.40	-

Measurement results are corrected for attenuation in the set-up configuration and antenna gain declared by the manufacturer.

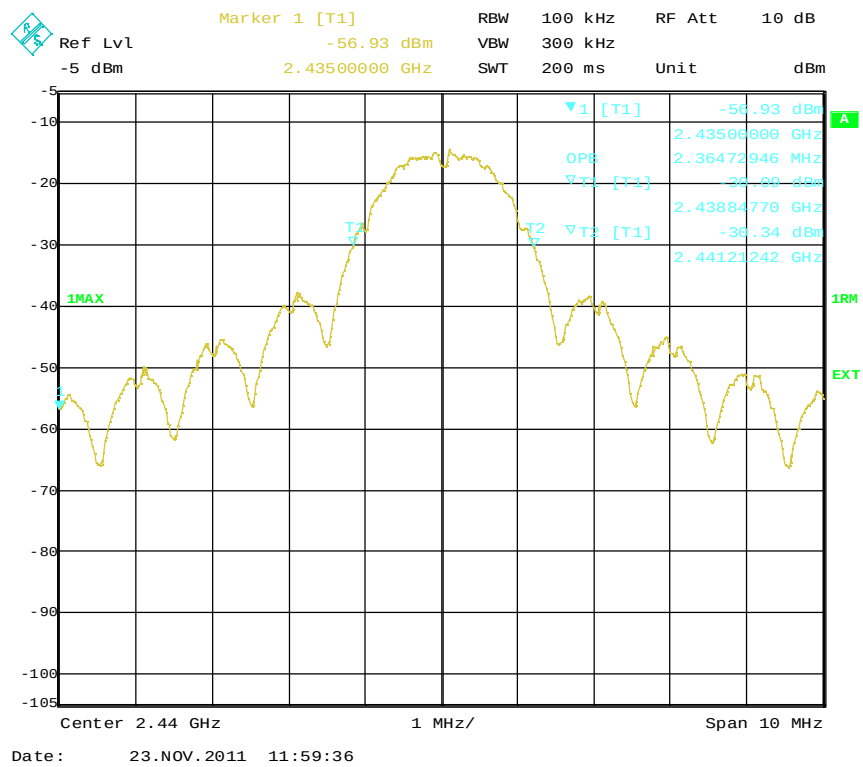
Example calculation:

Peak output power [dBm] = Analyser reading [dBm] + cable loss [dB] + EUT antenna gain [dBi]

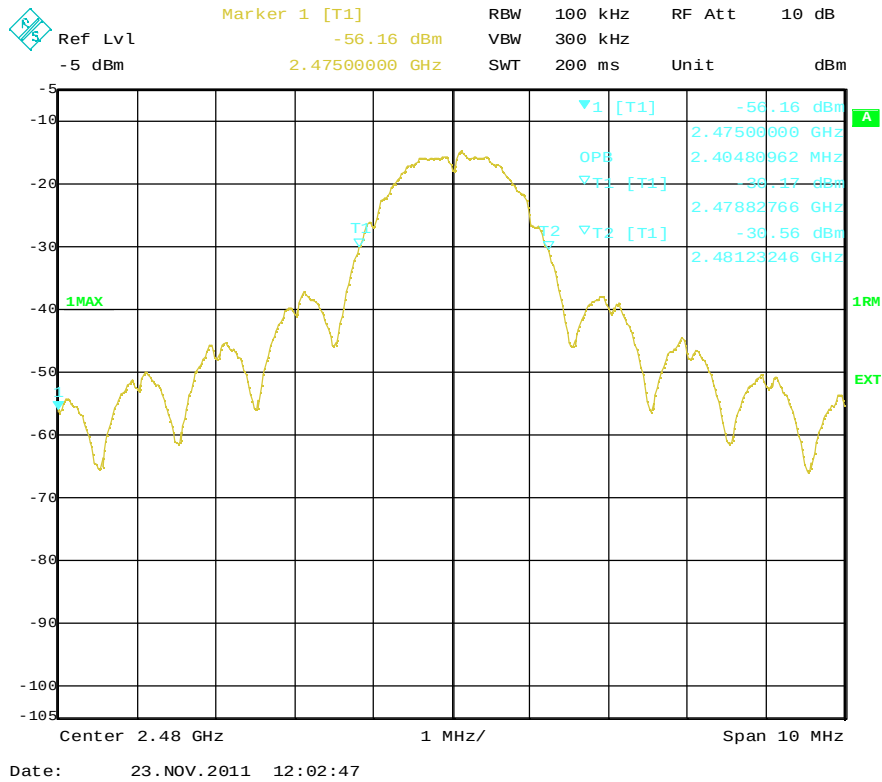
Plot P11.1



Plot P11.2



Plot P11.3



APPENDIX – PHOTOS OF THE EUT