Radio Test Report

for

Renishaw Plc

on

RTS

Document No: TRA-007677-W-US1

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Section 1: Introduction

1.1 General

This report contains an assessment of an apparatus against Electromagnetic Compatibility Standards based upon tests carried out on samples submitted to the Laboratory.

Test performed by:

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1.2 Tests Requested By

This testing in this report was requested by:

Renishaw PLC
New Mills
Wotton Under Edge
Gloucestershire
GL12 8JR

1.3 Manufacturer

Same as above

1.4 Apparatus Assessed

The following apparatus was assessed between 8th and 20th February 2012:

RTS

The Radio Tool Setter (RTS) consists of an FHSS transmitter and a receiver operating in the 2.4GHz – 2.4835GHz ISM band.

1.5 Test Result Summary

Full details of test results are contained within Appendix A. The following table summarises the results of the assessment.

The statements relating to compliance with the standards below apply ONLY as qualified in the notes and deviations stated in sections 1.6 to 1.7 of this test report.

Full details of test results are contained within Appendix A. The following table summarises the results of the assessment.

Test Type	Regulation	Measurement standard	Result
Radiated spurious emissions (Restricted bands)	Title 47 of the CFR: Part 15 Subpart (c) 15.247	ANSI C63.10	Pass
Conducted spurious emissions (Non-restricted bands)	Title 47 of the CFR: Part 15 Subpart (c) 15.247	ANSI C63.10	Pass
20dB Bandwidth and Channel Spacing	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(i)	ANSI C63.10	Pass
Conducted Carrier Power	Title 47 of the CFR : Part 15 Subpart (c) 15.247(b)(2)	ANSI C63.10	Pass
Hopping Frequencies	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)	ANSI C63.10	Pass
Channel Occupancy	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(i)	ANSI C63.10	Pass
Unintentional Radiated Spurious Emissions	Title 47 of the CFR: Part 15 Subpart (b) 15.109	ANSI C63.10	Pass

Abbreviations used in the above table:

Mod : Modification
CFR : Code of Federal Regulations
REFE : Radiated Electric Field Emissions
ANSI : American National Standards Institution
PLCE : Power Line Conducted Emissions

1.6 Notes relating to the Assessment

With regard to this assessment, the following points should be noted:

The results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 1.7 of this test report (Deviations from Test Standards).

For emissions testing, throughout this test report, “Pass” indicates that the results for the sample as tested were below the specified limit (refer also to Section 2, Measurement Uncertainty).

Where relevant, the apparatus was only assessed using the monitoring methods and susceptibility criteria defined in this report.

All testing with the exception of testing at the Open Area Test Site was performed under the following environmental conditions:

Temperature	: 17 to 23 °C
Humidity	: 45 to 75 %
Barometric Pressure	: 86 to 106 kPa

All dates used in this report are in the format dd/mm/yy.

This assessment has been performed in accordance with the requirements of ISO/IEC 17025.

1.7 Deviations from Test Standards

There were no deviations from the standards tested to.

Section 2: Measurement Uncertainty

2.1 Measurement Uncertainty Values

For the test data recorded the following measurement uncertainty was calculated:

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95% confidence where no required test level exists.

[1] Adjacent Channel Power

Uncertainty in test result = **1.86dB**

[2] Carrier Power

Uncertainty in test result (Power Meter) = **1.08dB**
Uncertainty in test result (Spectrum Analyser) = **2.48dB**

[3] Effective Radiated Power

Uncertainty in test result = **4.71dB**

[4] Spurious Emissions

Uncertainty in test result = **4.75dB**

[5] Maximum frequency error

Uncertainty in test result (Power Meter) = **0.113ppm**
Uncertainty in test result (Spectrum Analyser) = **0.265ppm**

[6] Radiated Emissions, field strength OATS 14kHz-18GHz Electric Field

Uncertainty in test result (14kHz – 30MHz) = **4.8dB**,
Uncertainty in test result (30MHz – 1GHz) = **4.6dB**,
Uncertainty in test result (1GHz – 18GHz) = **4.7dB**

[7] Frequency deviation

Uncertainty in test result = **3.2%**

[8] Magnetic Field Emissions

Uncertainty in test result = **2.3dB**

[9] Conducted Spurious

Uncertainty in test result – Up to 8.1GHz = **3.31dB**
Uncertainty in test result – 8.1GHz – 15.3GHz = **4.43dB**
Uncertainty in test result – 15.3GHz – 21GHz = **5.34dB**
Uncertainty in test result – Up to 26GHz = **3.14dB**

[10] Channel Bandwidth

Uncertainty in test result = **15.5%**

[11] Amplitude and Time Measurement – Oscilloscope

Uncertainty in overall test level = **2.1dB**,
Uncertainty in time measurement = **0.59%,**
Uncertainty in Amplitude measurement = **0.82%**

[12] Power Line Conduction

Uncertainty in test result = **3.4dB**

[13] Spectrum Mask Measurements

Uncertainty in test result = **2.59% (frequency)**
Uncertainty in test result = **1.32dB (amplitude)**

[14] Adjacent Sub Band Selectivity

Uncertainty in test result = **1.24dB**

[15] Receiver Blocking – Listen Mode, Radiated

Uncertainty in test result = **3.42dB**

[16] Receiver Blocking – Talk Mode, Radiated

Uncertainty in test result = **3.36dB**

[17] Receiver Blocking – Talk Mode, Conducted

Uncertainty in test result = **1.24dB**

[18] Receiver Threshold

Uncertainty in test result = **3.23dB**

[19] Transmission Time Measurement

Uncertainty in test result = **7.98%**

Section 3: Modifications

3.1 Modifications Performed During Assessment

No modifications were performed during the assessment

Appendix A: Formal Emission Test Results

Abbreviations used in the tables in this appendix:

Spec	: Specification
Mod	: Modification
EUT	: Equipment Under Test
SE	: Support Equipment
L	: Live Power Line
N	: Neutral Power Line
E	: Earth Power Line
Pk	: Peak Detector
QP	: Quasi-Peak Detector
Av	: Average Detector
CDN	: Coupling & decoupling network

ALSR	: Absorber Lined Screened Room
OATS	: Open Area Test Site
ATS	: Alternative Test Site
Ref	: Reference
Freq	: Frequency
MD	: Measurement Distance
SD	: Spec Distance
Pol	: Polarisation
H	: Horizontal Polarisation
V	: Vertical Polarisation

A1 Transmitter Peak Output Power

Carrier power was verified with the EUT transmitting on its lowest, centre and highest carrier frequency in turn.

Test Details	
Regulation	Title 47 of the CFR: Part15 Subpart (c) 15.247(b)(1)
Measurement standard	ANSI C63.10:2003
EUT sample number	S07
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	18^0C

Channel Frequency (MHz)	Peak Carrier Power (mW)	Limit (W)	Result
2403	1.57	1	Pass
2442	1.53		Pass
2481	1.33		Pass

Notes:

- Highest Gain of any antenna to be used = 2.1dBi
- Number of hopping channels employed are 79
- Conducted measurements were performed with a temporary antenna connector provided by the client

A2 RF Antenna Conducted Spurious Emissions

Measurement of conducted spurious emissions at the antenna port was performed using a peak detector with the RBW set to 100kHz and the VBW>RBW. Frequencies were scanned up through to the 10th harmonic with the EUT transmitting on its lowest, centre and highest carrier frequency in turn.

Test Details: 2403 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2003
Frequency range	9 kHz to 25 GHz
EUT sample number	S07
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	18^0C

The worst case conducted emission measurements at the antenna port are listed below:

Ref No.	Emission Frequency (MHz)	Detector	Emission in restricted bands (Y/N)	Measured Peak Conducted power (dBuV)	15.247(d) Limit (dBuV)	Summary
No emissions detected within 20dB of the limit						

RF Antenna Conducted Spurious Emissions continued:

Test Details: 2442 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2003
Frequency range	9 kHz to 25 GHz
EUT sample number	S07
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	18^0C

The worst case conducted emission measurements at the antenna port are listed below:

Ref No.	Emission Frequency (MHz)	Detector	Emission in restricted bands (Y/N)	Measured Peak Conducted power (dBuV)	15.247(d) Limit (dBuV)	Summary
No emissions detected within 20dB of the limit						

RF Antenna Conducted Spurious Emissions continued:

Test Details: 2481 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2003
Frequency range	9 kHz to 25 GHz
EUT sample number	S07
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	18^0C

The worst case conducted emission measurements at the antenna port are listed below:

Ref No.	Emission Frequency (MHz)	Detector	Emission in restricted bands (Y/N)	Measured Peak Conducted power (dBuV)	15.247(d) Limit (dBuV)	Summary
No emissions detected within 20dB of the limit						

Notes:

1. The conducted emission limit for emissions outside the restricted bands, defined in 47CFR Part 15.205(a) are based on a transmitted carrier level of 15.247(b). With the EUT transmitting on its lowest, centre and highest carrier frequencies in turn, emissions from the EUT are required to be 20 dB below the level of the highest fundamental as measured within a 100 kHz RBW in accordance with 15.247(d) using a peak detector.
2. The RBW = 100 kHz, Video bandwidth (VBW) > RBW and the radio spectrum was investigated up to the 10th harmonic in accordance15.33 (a)(1).
3. The measurements at 2400 MHz and 2483.5 MHz were made to ensure band edge compliance.
4. The carrier level was measured whilst varying the supply voltage between 85% and 105% of the nominal supply voltage as required by 15.31(e). No variation in carrier level was observed. All other emissions were at least 20dB below the test limit.

The limit outside the restricted band in 100 kHz RBW is defined using the following formula in accordance with 15.247(d):

The limit in 100 kHz RBW = (Maximum Peak Conducted Carrier)-20dB

A3 Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 100kHz. The radiated electric field emission test applies to spurious emissions and harmonics that fall within the restricted bands listed in Section 15.205. The maximum permitted field strength is listed in Section 15.209. The EUT was set to transmit on its lowest, centre and highest carrier frequency.

The following test site was used for final measurements as specified by the standard tested to:

3m open area test site : [ ] 3m alternative test site : [X]

The effect of the EUT set-up on the measurements is summarised in note (c) below.

Test Details: 2403 MHz	
Regulation	Title 47 of the CFR , Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2003
Frequency range	30MHz – 25GHz
EUT sample number	S04
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	20^0C
Photographs (Appendix F)	Photograph 1 and 2

The worst case radiated emission measurements for spurious emissions and harmonics that fall within the restricted bands are listed below:

Frequency (MHz)	Meas Rx (dBuV)	Detector	Pol	Cable Loss (dB)	Antenna Fact (dB/m)	Pre-amp (dB)	Field Strength (uV/m)	Limit (uV/m)
7209.11	54.56	Peak	V	4.2	35.9	36.2	837.53	5000
7209.11	52.04	Avg	V	4.2	35.9	36.2	70.30*	500

*Duty cycle correction of 20logx = -19dB was used

Radiated Electric Field Emissions continued:

Test Details: 2442 MHz	
Regulation	Title 47 of the CFR , Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2003
Frequency range	30MHz – 25GHz
EUT sample number	S04
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	20^0C
Photographs (Appendix F)	Photograph 1 and 2

The worst case radiated emission measurements for spurious emissions and harmonics that fall within the restricted bands are listed below:

Frequency (MHz)	Meas Rx (dBuV)	Detector	Pol	Cable Loss (dB)	Antenna Fact (dB/m)	Pre-amp (dB)	Field Strength (uV/m)	Limit (uV/m)
7326.07	56.77	Peak	V	4.2	36.3	36.2	1131.10	5000
7326.07	52.20	Avg	V	4.2	36.3	36.2	74.98*	500

*Duty cycle correction of 20logx = -19dB was used

Radiated Electric Field Emissions continued:

Test Details: 2481 MHz	
Regulation	Title 47 of the CFR, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2003
Frequency range	30MHz – 25GHz
EUT sample number	S04
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	20^0C
Photographs (Appendix F)	Photograph 1 and 2

The worst case radiated emission measurements for spurious emissions and harmonics that fall within the restricted bands are listed below:

Frequency (MHz)	Meas Rx (dBuV)	Detector	Pol	Cable Loss (dB)	Antenna Fact (dB/m)	Pre-amp (dB)	Field Strength (uV/m)	Limit (uV/m)
7443.06	60.08	Peak	V	4.2	36.4	36.3	1655.77	5000
7443.06	57.43	Avg	V	4.2	36.4	36.3	136.93*	500

*Duty cycle correction of 20logx = -19dB was used

Notes:

1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.10: section 4.5, Table 1

2 In accordance with 15.35(b), above 1 GHz, emissions measured using a peak detector shall not exceed a level 20 dB above the average limit.

3 Measurements at 2400 & 2483.5 MHz were made to ensure band edge compliance.

4 Testing was performed with the EUT orientated in three orthogonal planes and the maximum emissions level recorded. In addition, the EUT antenna was varied within its range of motion in order to maximise emissions.

5 For Frequencies below 1 GHz, RBW= 100 kHz, testing was performed with CISPR16 compliant test receiver with QP detector. Above 1 GHz tests were performed using a spectrum analyser using the following settings:

Peak RBW=VBW= 1MHz
Average RBW=VBW= 1MHz

These settings as per ANSI C63.10 and DA 00-705.

6 In accordance with DA 00-705, the average level of the spurious radiated emission may be reduced by the duty cycle correction factor. If the dwell time per channel (refer to the measured channel occupancy time, section A7 of this test report) of the hopping signal is less than 100ms then the average measurement may be further adjusted by the duty cycle correction factor which is derived from

$$20\log_{10}\left(\frac{\text{dwell time}}{100ms}\right)$$

The upper and lower frequency of the measurement range was decided according to 47 CFR Part 15:Clause 15.33(a) and 15.33(a)(1).

Radiated emission limits (47 CFR Part 15: Clause 15.209) for emissions falling within the restricted bands defined in 15.205(a):

Frequency of emission (MHz)	Field strength (μV/m)	Measurement Distance (m)	Field strength (dBμV/m)
0.009-0.490	2400/F(kHz)	300	67.6/F (kHz)
0.490-1.705	24000/F(kHz)	30	87.6/F (kHz
1.705-30	30	30	29.5
30-88	100	3	40.0
88-216	150	3	43.5
216-960	200	3	46.0
Above 960	500	3	54.0

Notes:

(a) Where results have been measured at one distance, and a signal level displayed at another, the results have been extrapolated using the following formula:

$$\text{Extrapolation}\,(\text{dB}) = 20\log_{10}\left(\frac{\text{measurement distance}}{\text{specification distance}}\right)$$

The results displayed take into account applicable antenna factors and cable losses.

(b) The levels may have been rounded for display purposes.

(c) The following table summarises the effect of the EUT operating mode, internal configuration and arrangement of cables / samples on the measured emission levels:

	See (i)	See (ii)	See (iii)	See (iv)
Effect of EUT operating mode on emission levels	✓			
Effect of EUT internal configuration on emission levels		✓		
Effect of Position of EUT cables & samples on emission levels			✓	

(i) Parameter defined by standard and / or single possible, refer to Appendix D
(ii) Parameter defined by client and / or single possible, refer to Appendix D
(iii) Parameter had a negligible effect on emission levels, refer to Appendix D
(iv) Worst case determined by initial measurement, refer to Appendix D

A4 20dB Bandwidth and Carrier Frequency Separation

Title 47 of the CFR: Part 15 Subpart (c) 15.247(a)(1)(i) requires the measurement of the bandwidth of the transmission between the -20 dB points on the transmitted spectrum. The results of this test determine the limits for channel spacing. The channel separation shall be a minimum of 25 kHz or 2/3rd of the 20dB bandwidth, whichever is the greater. The formal measurements are detailed below:

Test Details	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) 15.247(a)(1)(i)
EUT sample number	S07
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
Temperature	18^{0}C
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Measured 20dB Bandwidth (kHz)	2/3rd of 20dB Bandwidth (kHz)
2403	1211.538	807.692
2442	1208.333	805.555
2481	1201.923	801.282

Measured Channel Spacing (kHz)	Limit	Result
993.590	807.692	Pass

Plots of the 20 dB bandwidth and channel spacing are contained in Appendix B of this test report.

A5 Hopping frequencies

Hopping frequencies were verified using a spectrum analyser, while the EUT was operating in its normal frequency hopping mode.

Test Details	
Regulation	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(i)
EUT sample number	S07
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
Temperature	18^0C
EUT set up	Refer to Appendix C

No. of Hopping Channels	Requirement	Result
79	>75	Pass

Plots showing the hopping channels are contained in Appendix B

A6 Channel Occupancy

Channel occupancy time was verified using a spectrum analyser in zero span mode, centred on the middle hopping channel frequency (2442 MHz), while the EUT was operating in its normal frequency hopping mode. The other channels were then verified to ensure that the channel occupancy was identical for all channels.

Test Details	
Regulation	Title 47 of the CFR: Part15 Subpart (c) 15.247(a)(1)
EUT sample number	S07
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
Temperature	18^0C
EUT set up	Refer to Appendix C

Measured Channel Occupancy Time (µs)	Measured Channel Repetition Time (ms)	Calculated Average Channel retention Time (ms)	Average Channel Occupancy Time Limit (ms)	Result
181.346	79	3.63	400	Pass

Plots showing the channel occupancy time and time between successive transmissions are contained in Appendix B of this test report. These are identical for all modulation modes.

Average Channel Retention Time Calculation:

No. Of utilised hopping channels (N) = 79
Measured channel repetition time (T_{rep}) = 79ms
Measured channel occupancy time (T_{occ}) = 181.346µs

No. of transmission cycles in specified averaging period =

$$\frac{0.4 \times \mathrm{N}}{\mathrm{T_{rep}}(ms)} = \text{cycles} \qquad \therefore \frac{0.4 \times 79}{1.58s} = 20 \text{ cycles}$$

$\therefore$ **The Average Retention Time =**

Total activation time T_{occ} x No. of transmission cycles in specified averaging period

Average Channel Occupancy Time = 181.346µs x 20 = 3.63ms

A7 Antenna Gain

The maximum antenna gain for the antenna types to be used with the EUT, as declared by the client, is 2.1dBi

A8 Unintentional Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 100kHz. The maximum permitted field strength is listed in Section 15.109. The EUT was set to receive mode only on its lowest, centre and highest carrier frequency in turn.

The following test site was used for final measurements as specified by the standard tested to:

3m open area test site : [ ] 3m alternative test site : [X]

Test Details: Rx Mode with Hopping	
Regulation	Title 47 of the CFR: Part 15 Subpart (b) Clause 15.109
Measurement standard	ANSI C63.10:2003
Frequency range	30MHz to 25 GHz
EUT sample number	S04
Modification state	0
SE in test environment	N/A
SE isolated from EUT	N/A
EUT set up	Refer to Appendix C
Temperature	18^0C
Photographs (Appendix F)	Photograph 1 and 2

The worst case radiated emission measurements for spurious emissions and harmonics that fall within the restricted bands are listed below:

Ref No.	Freq (MHz)	Pol.	Result (dBμV/m)	Spec. Limit (dBμV/m)	Margin (dB)	Summary
No emissions detected within 20dB of the limit						

Appendix B: Supporting Graphical Data

This appendix contains graphical data obtained during testing.

Notes:

(a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.

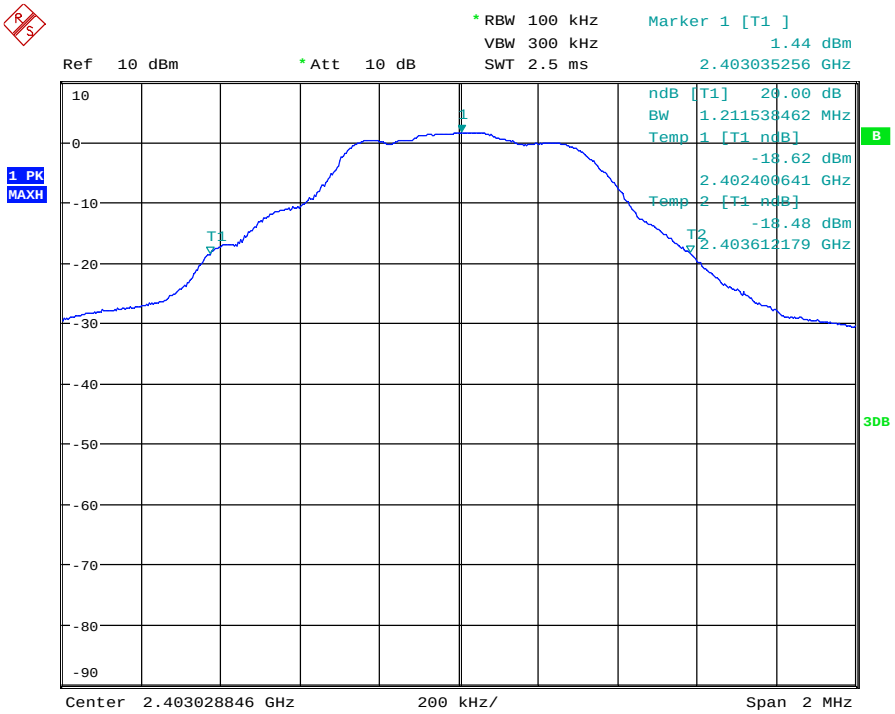
(b) The time and date on the plots do not necessarily equate to the time of the test.

(c) Where relevant, on power line conducted emission plots, the limit displayed is the average limit, which is stricter than the quasi peak limit.

(d) Appendix C details the numbering system used to identify the sample and its modification state.

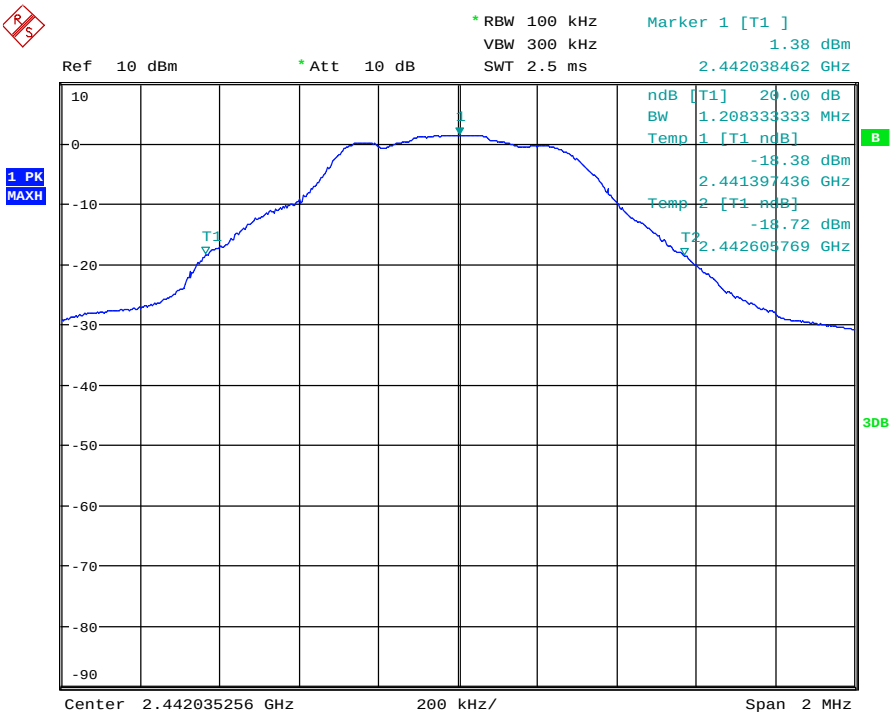
(e) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.

20dB Bandwidth – 2403MHz



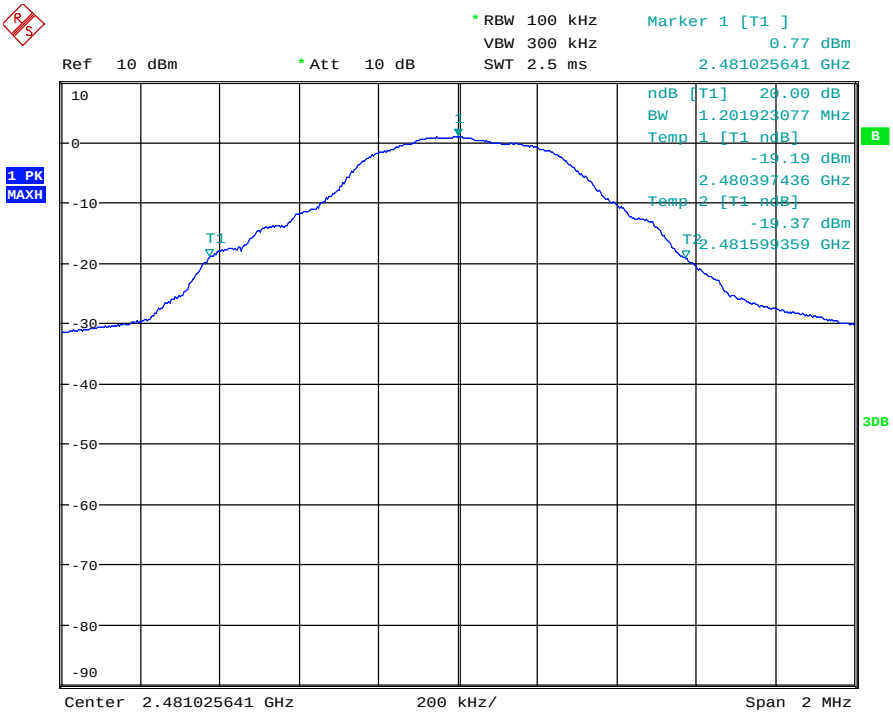
Date: 9.FEB.2012 16:30:22

20dB Bandwidth – 2442MHz



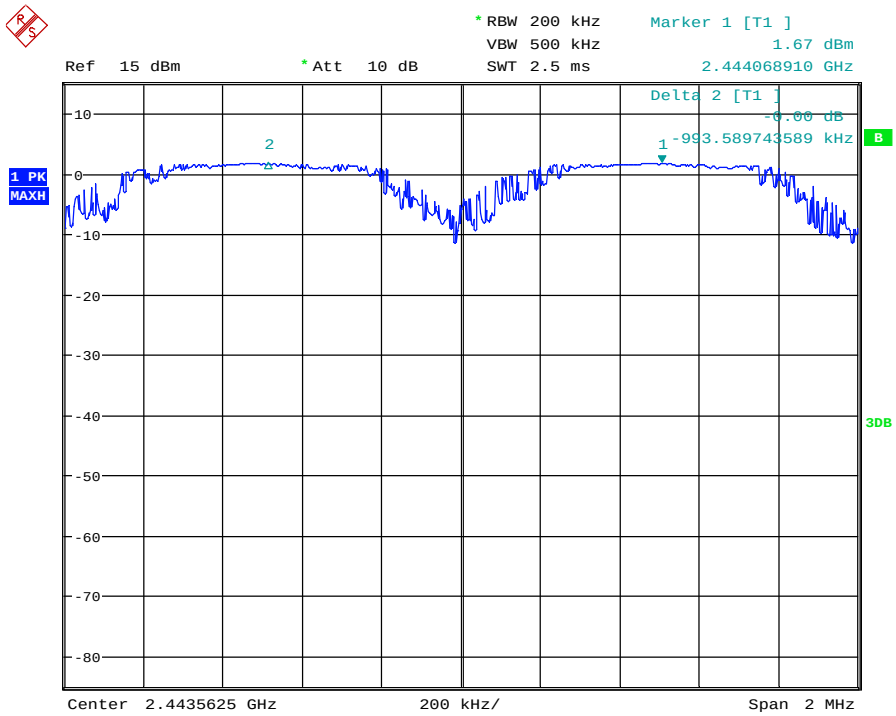
Date: 9.FEB.2012 16:33:28

20dB Bandwidth – 2481MHz



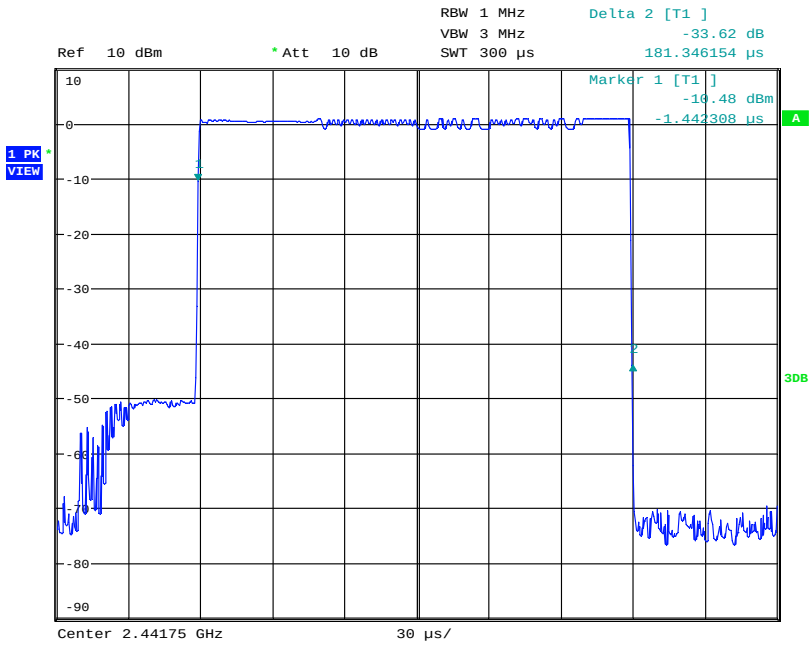
Date: 9.FEB.2012 16:35:26

Channel Spacing



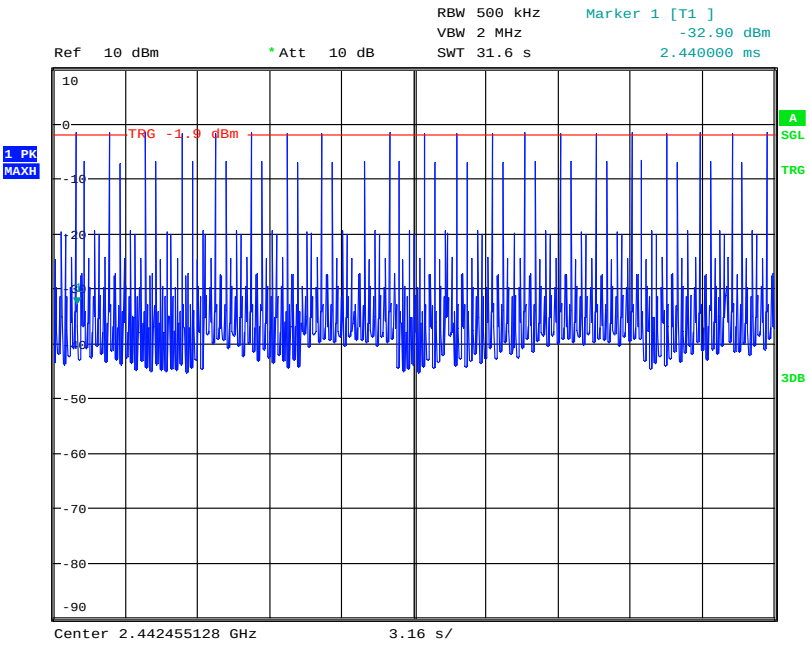
Date: 10.FEB.2012 10:39:19

Channel Occupancy Time



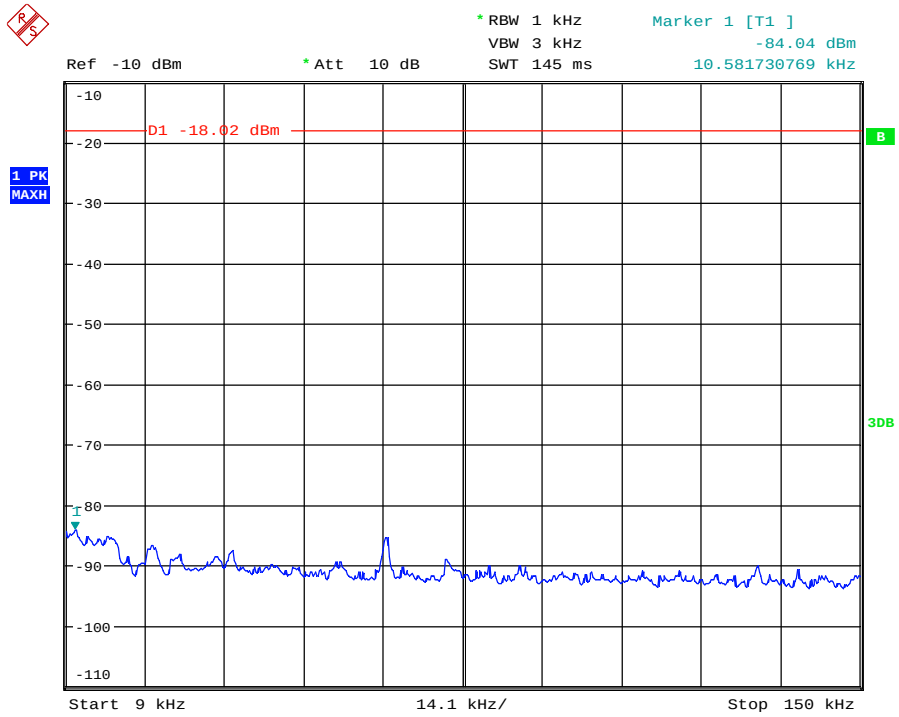
Date: 24.FEB.2012 11:08:57

Channel repetition in 31.6s



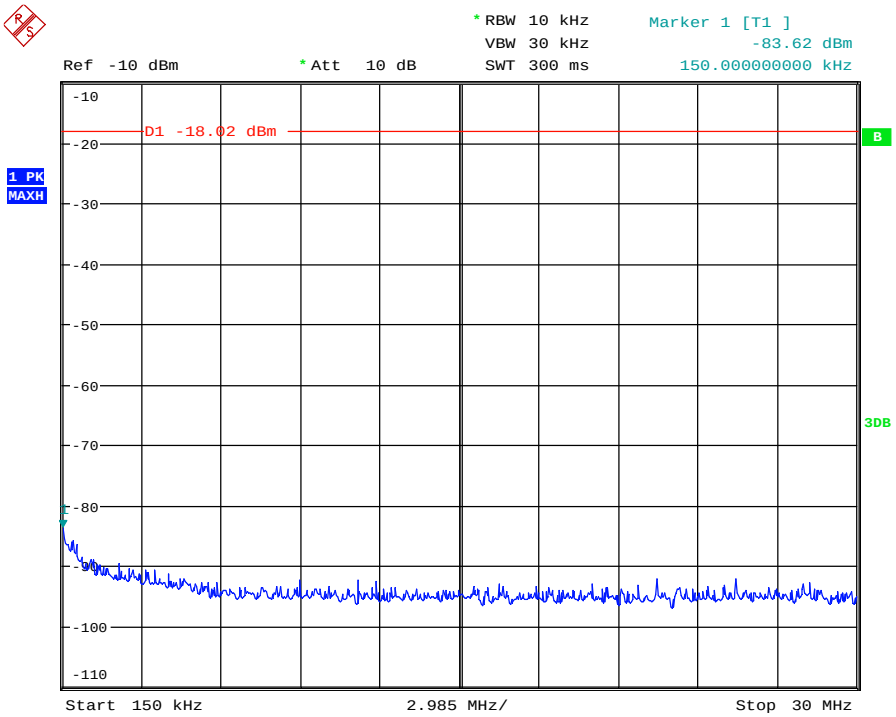
Date: 24.FEB.2012 11:15:53

Conducted spurious emissions 9kHz – 150kHz (2403MHz)



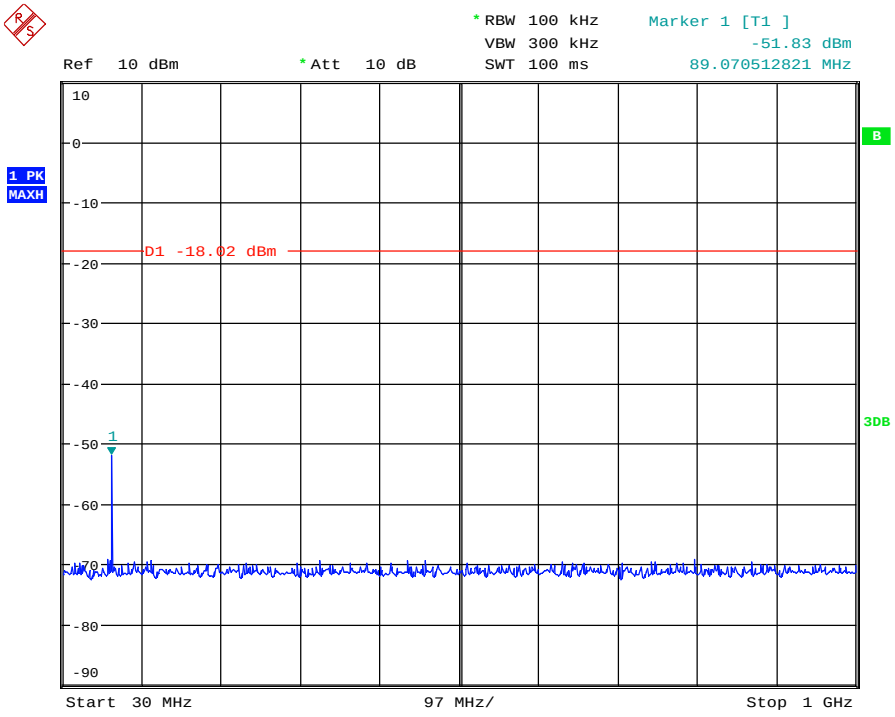
Date: 10.FEB.2012 12:49:41

Conducted spurious emissions 150kHz – 30MHz (2403MHz)



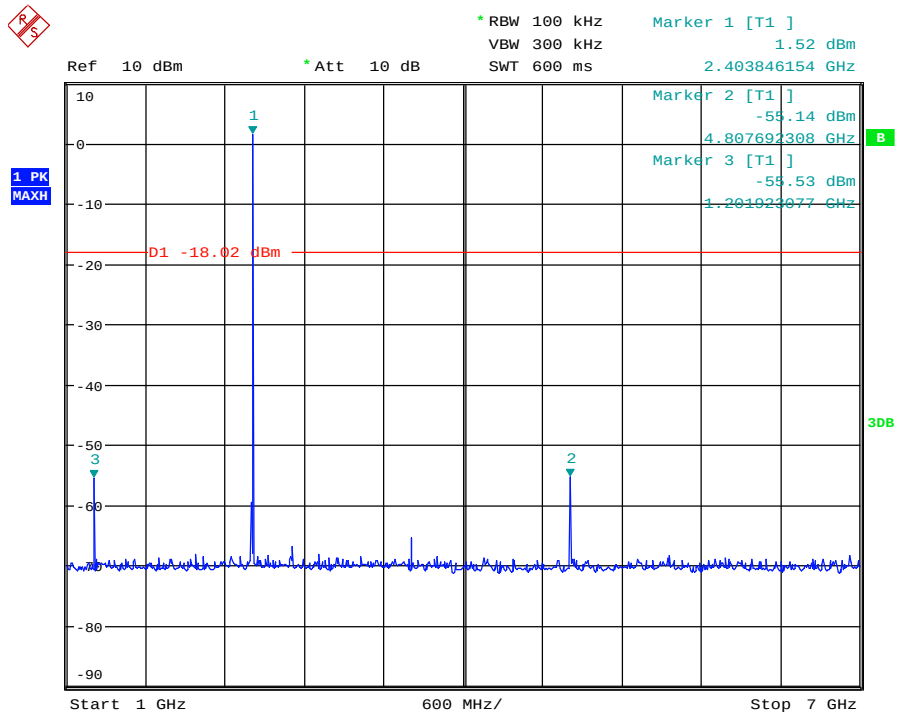
Date: 10.FEB.2012 12:51:12

Conducted spurious emissions 30MHz – 1GHz (2403MHz)



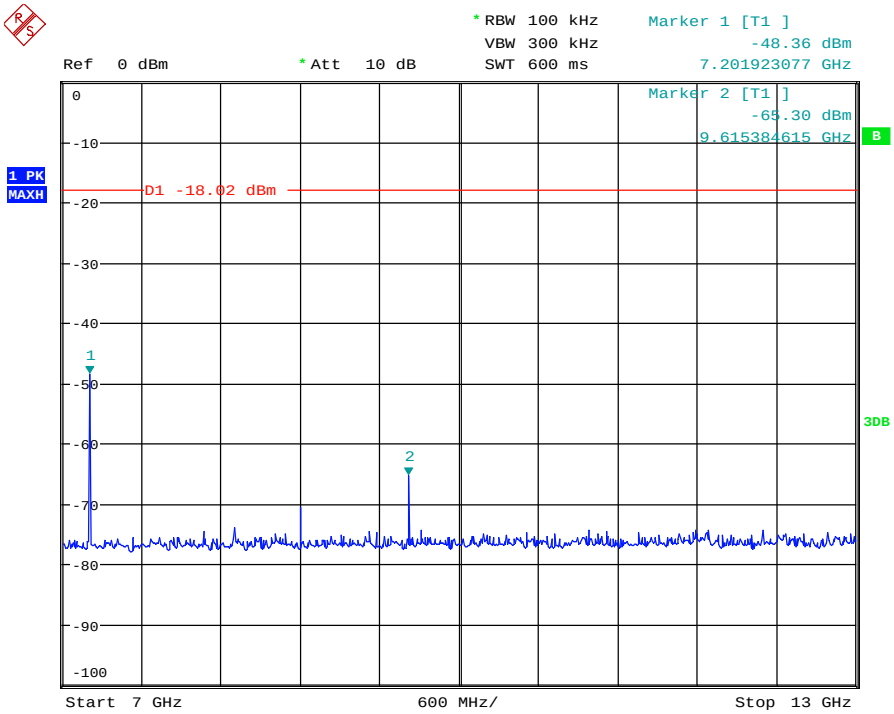
Date: 10.FEB.2012 12:53:18

Conducted spurious emissions 1GHz – 7GHz (2403MHz)



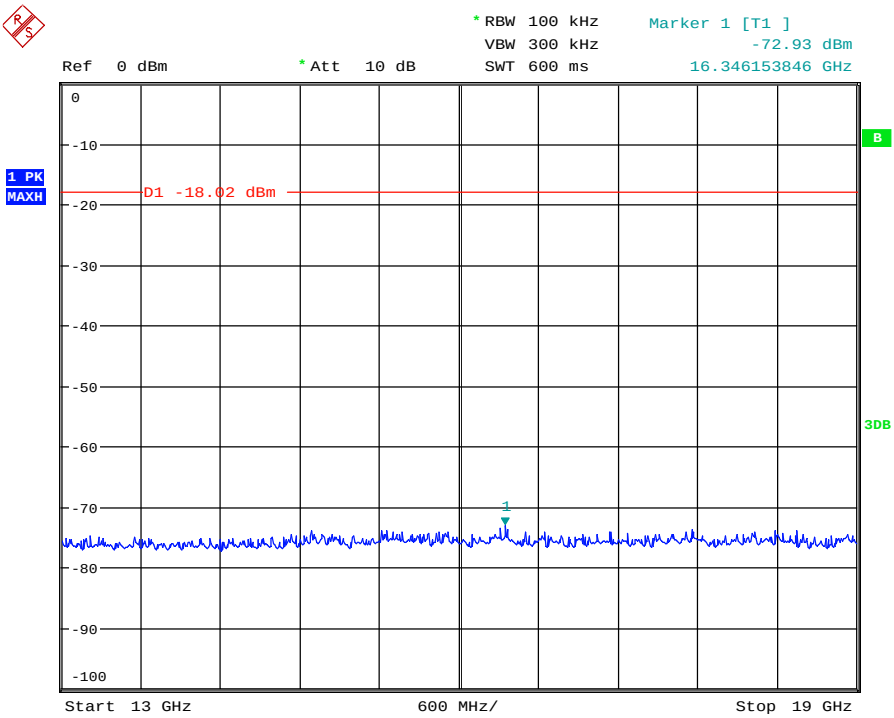
Date: 10.FEB.2012 12:52:49

Conducted spurious emissions 7GHz – 13GHz (2403MHz)



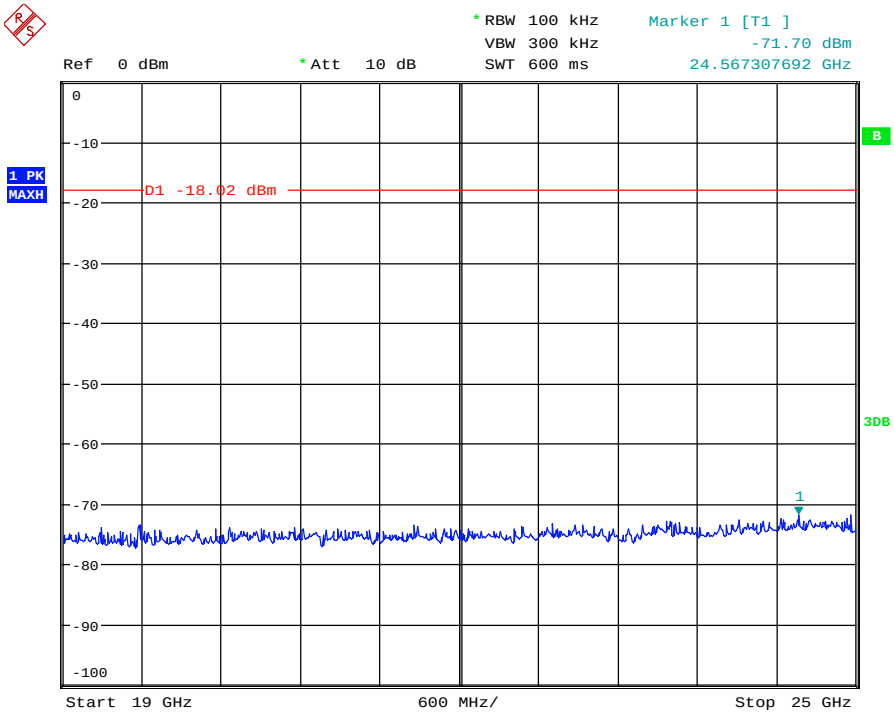
Date: 10.FEB.2012 12:54:53

Conducted spurious emissions 13GHz – 19GHz (2403MHz)



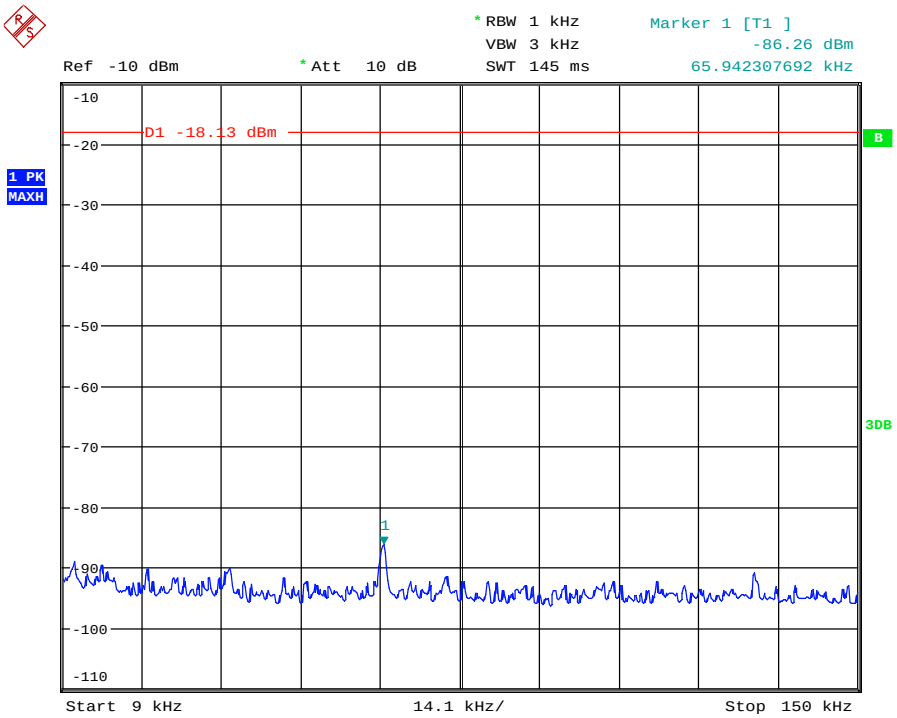
Date: 10.FEB.2012 12:55:20

Conducted spurious emissions 19GHz – 25GHz (2403MHz)



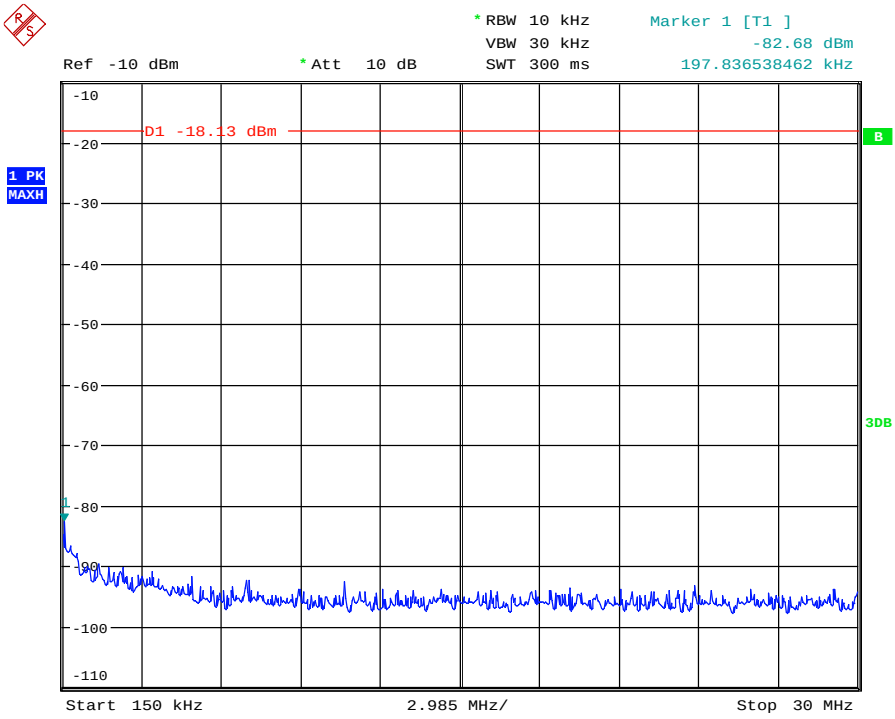
Date: 10.FEB.2012 12:55:38

Conducted spurious emissions 9kHz – 150kHz (2442MHz)



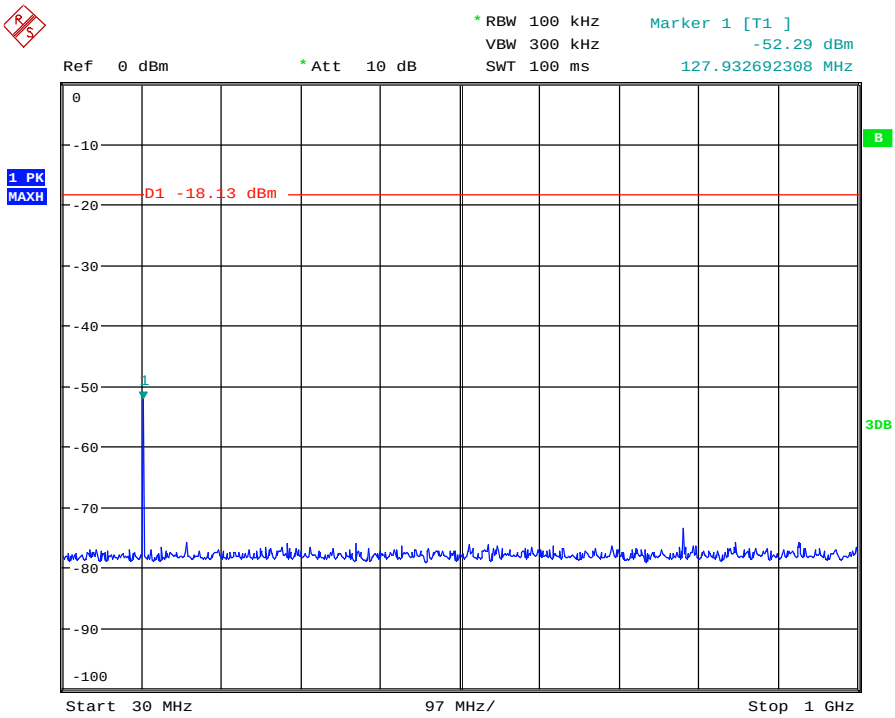
Date: 10.FEB.2012 12:56:38

Conducted spurious emissions 150kHz – 30MHz (2442MHz)



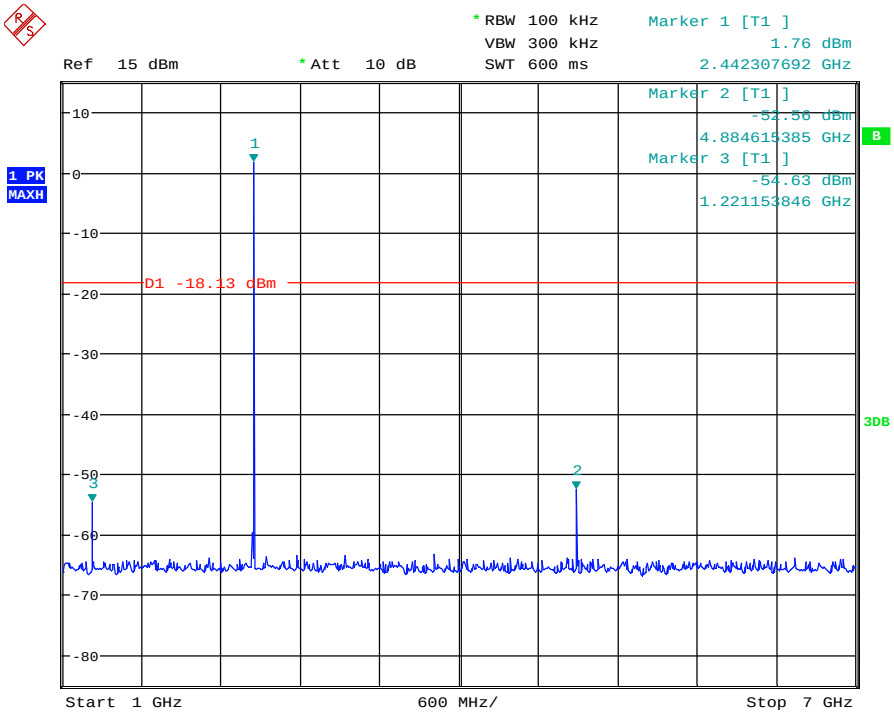
Date: 10.FEB.2012 12:57:02

Conducted spurious emission 30MHz – 1GHz (2442MHz)



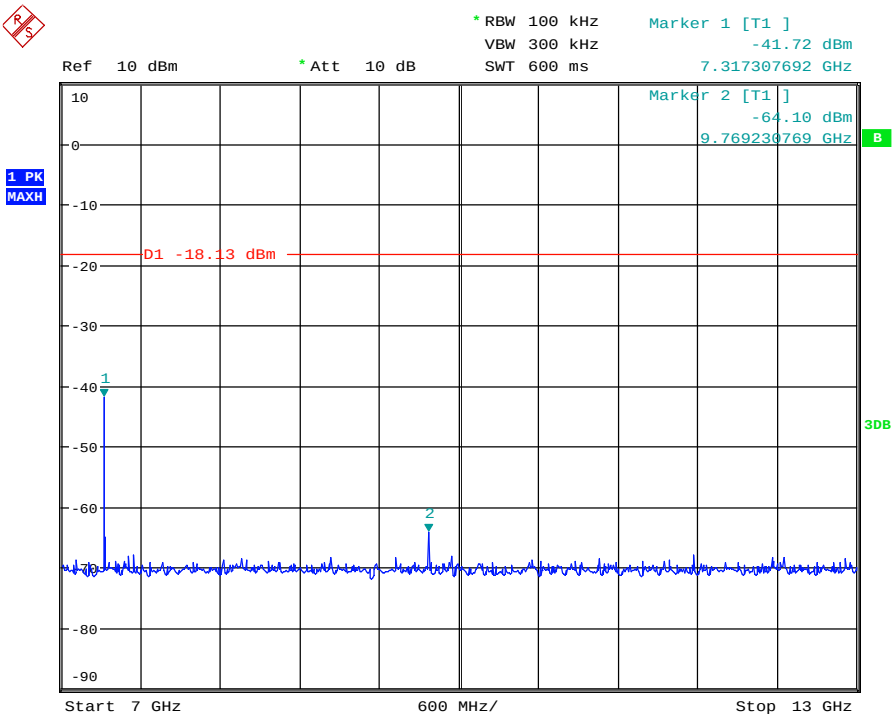
Date: 10.FEB.2012 12:57:40

Conducted spurious emissions 1GHz – 7GHz (2442MHz)



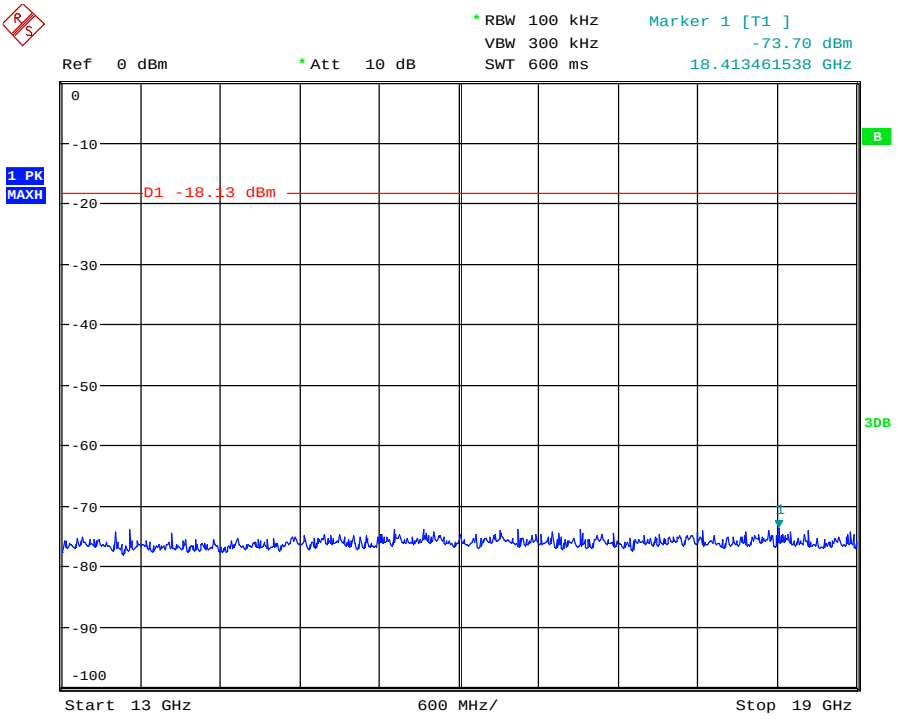
Date: 10.FEB.2012 12:58:07

Conducted spurious emissions 7GHz – 13GHz (2442MHz)



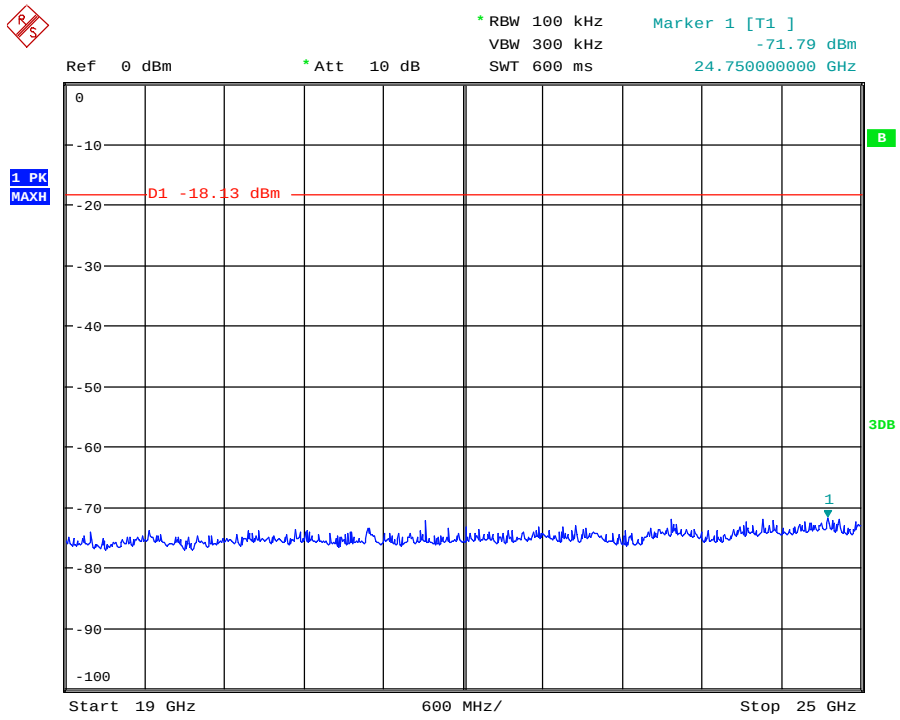
Date: 10.FEB.2012 12:58:37

Conducted spurious emissions 13GHz – 19GHz (2442MHz)



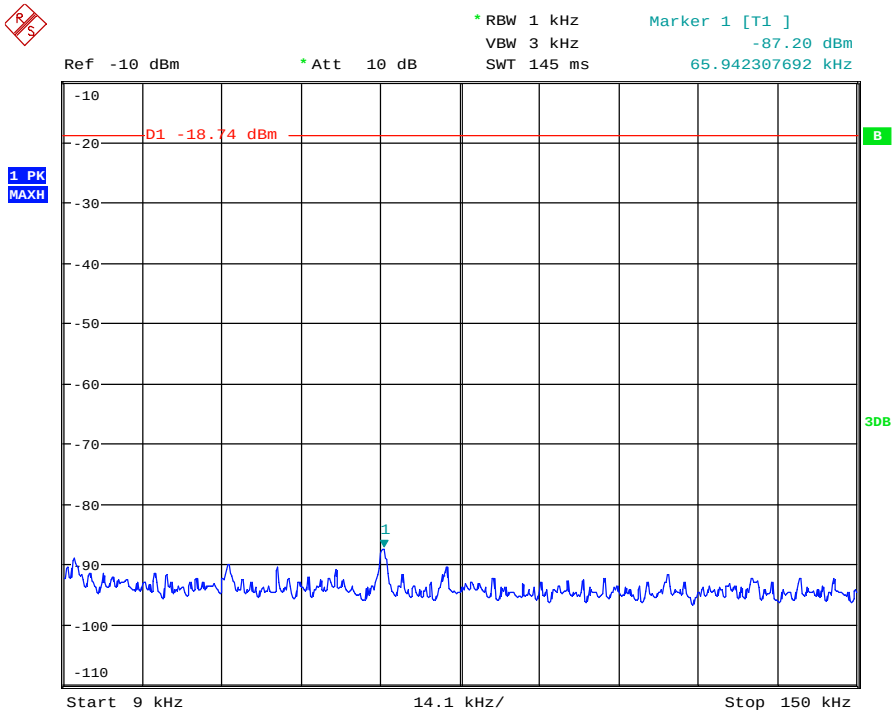
Date: 10.FEB.2012 12:59:00

Conducted spurious emissions 19GHz – 25GHz (2442MHz)



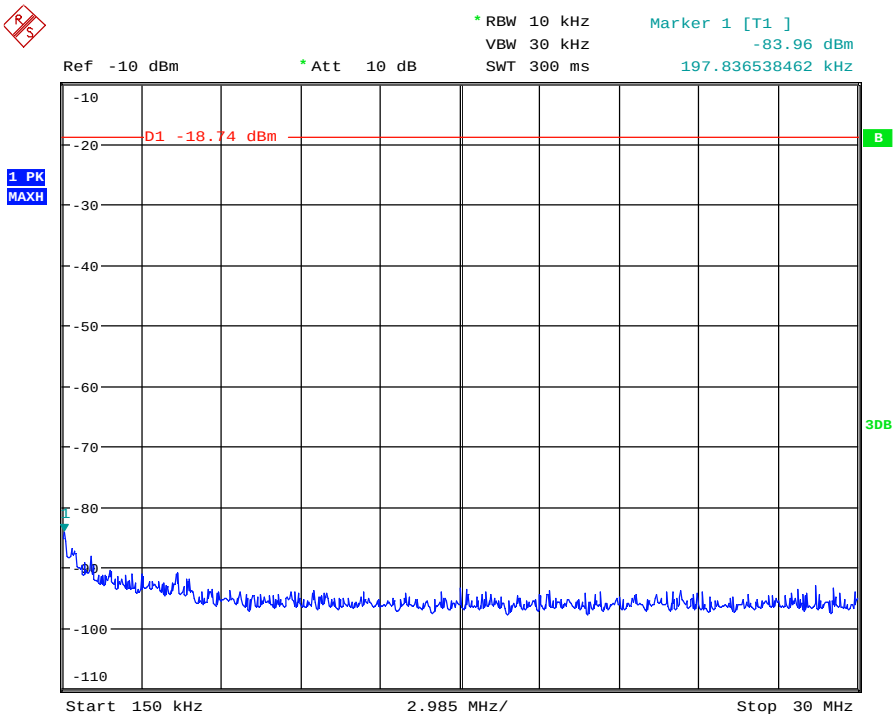
Date: 10.FEB.2012 12:59:18

Conducted spurious emissions 9kHz – 150kHz (2481MHz)



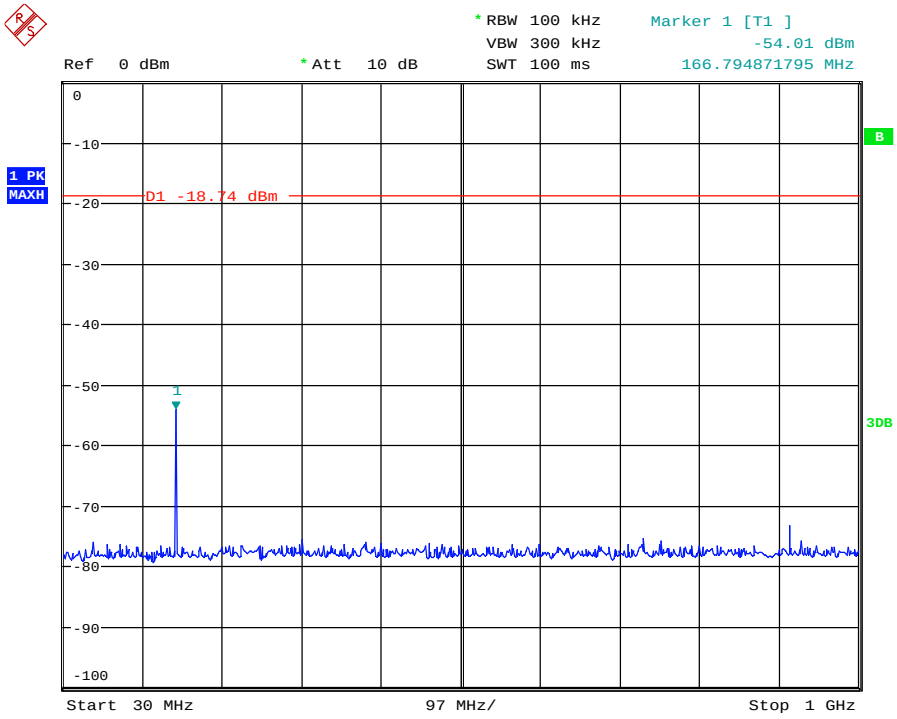
Date: 10.FEB.2012 13:00:30

Conducted spurious emissions 150kHz – 30MHz (2481MHz)



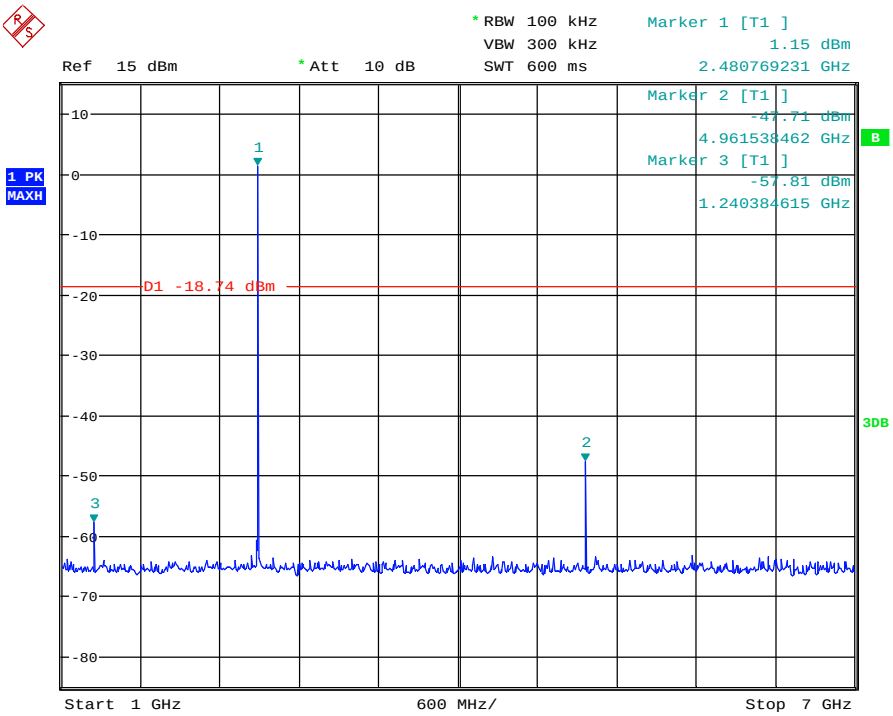
Date: 10.FEB.2012 13:00:55

Conducted spurious emissions 30MHz – 1GHz (2481MHz)



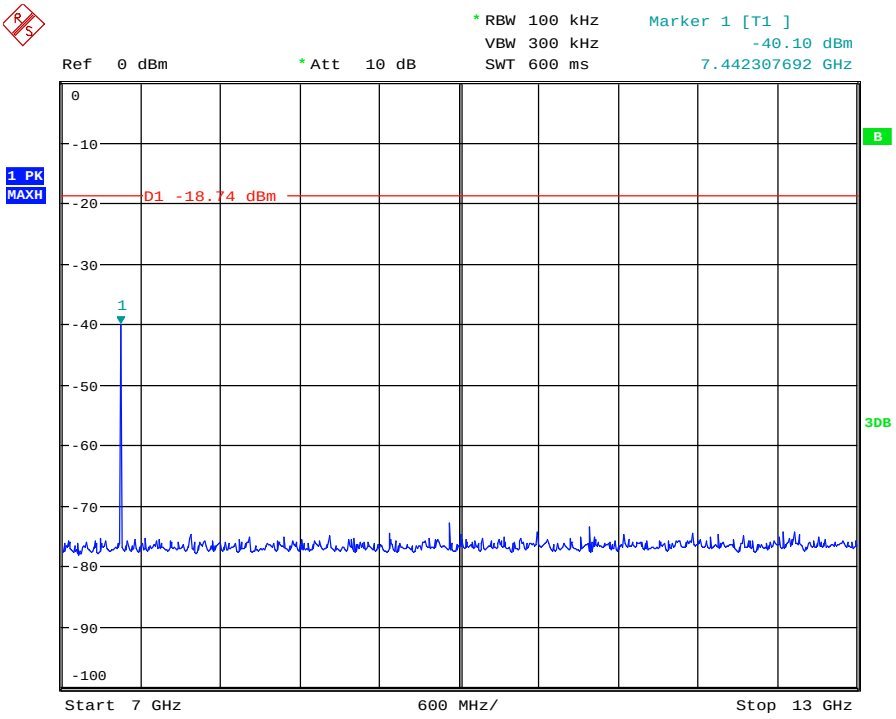
Date: 10.FEB.2012 13:01:24

Conducted spurious emissions 1GHz – 7GHz (2481MHz)



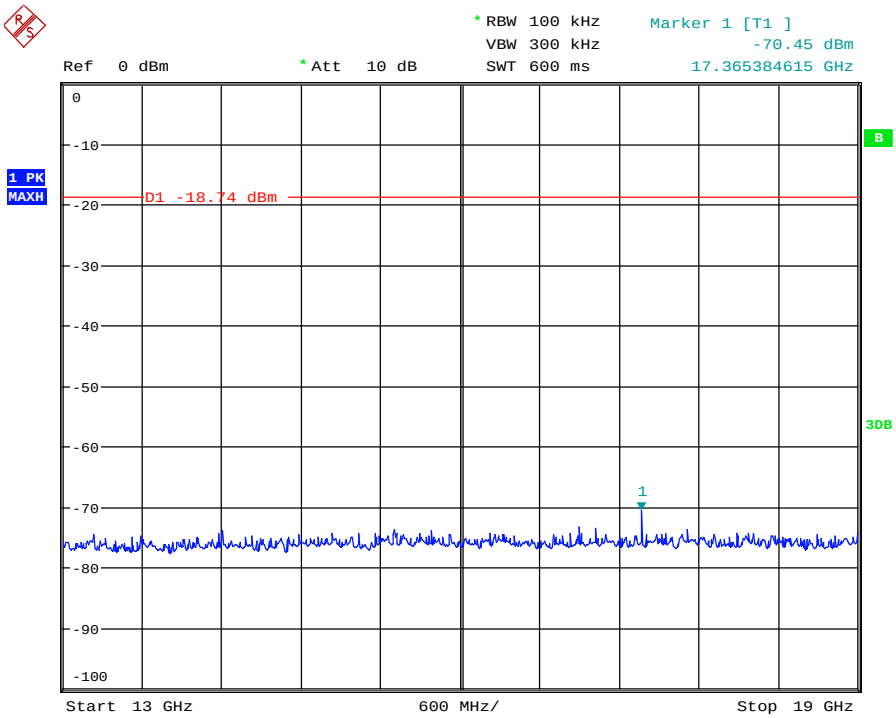
Date: 10.FEB.2012 13:02:01

Conducted spurious emissions 7GHz – 13GHz (2481MHz)



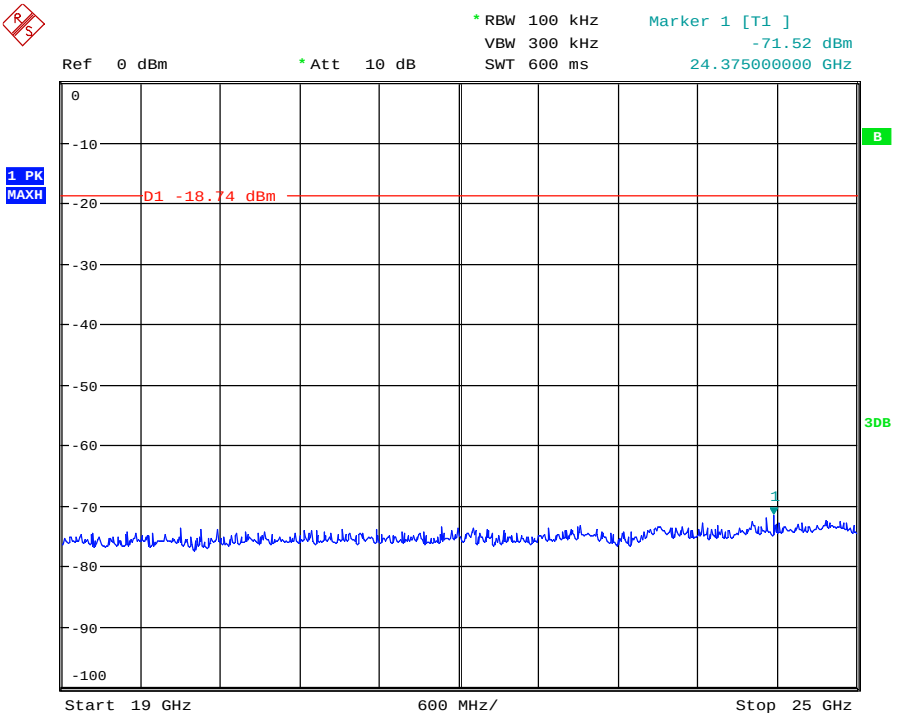
Date: 10.FEB.2012 13:02:28

Conducted spurious emissions 13GHz – 19GHz (2481MHz)



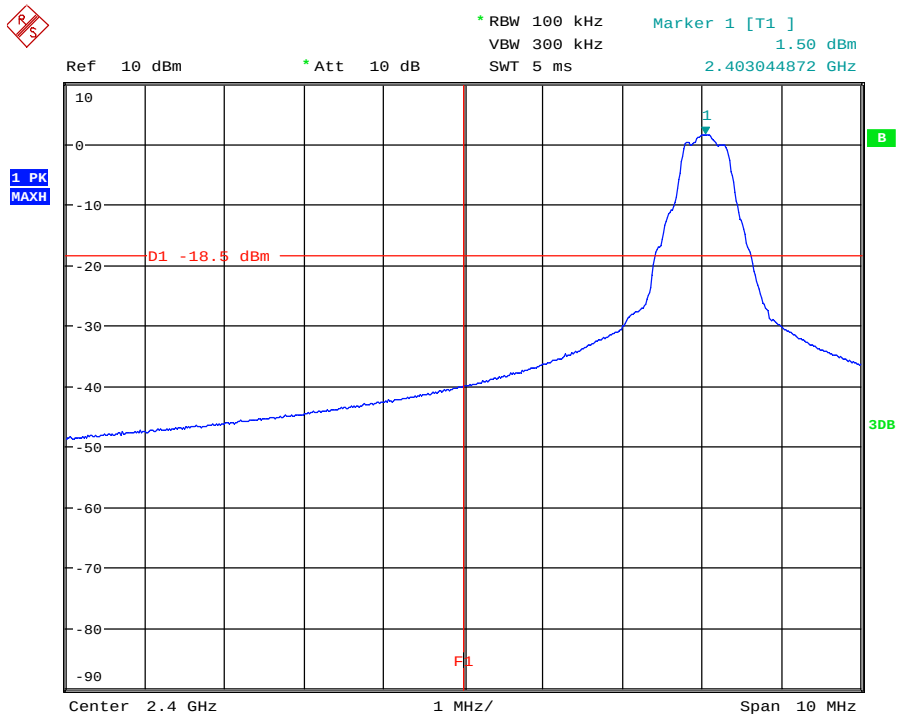
Date: 10.FEB.2012 13:02:48

Conducted spurious emissions 19GHz – 25GHz (2481MHz)



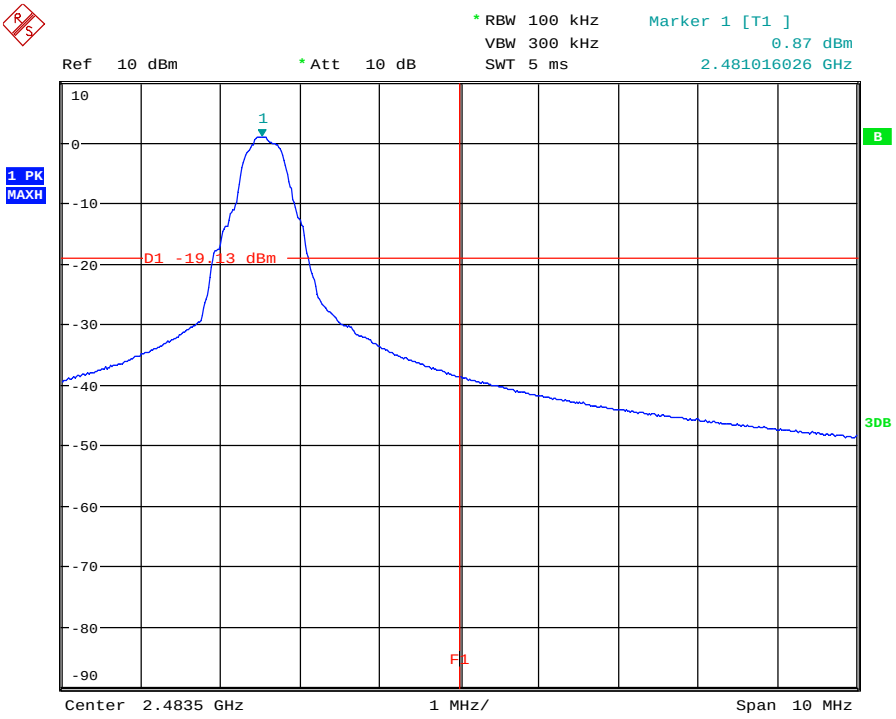
Date: 10.FEB.2012 13:03:03

Conducted Bandedge Compliance - Lower Bandedge (2403MHz)



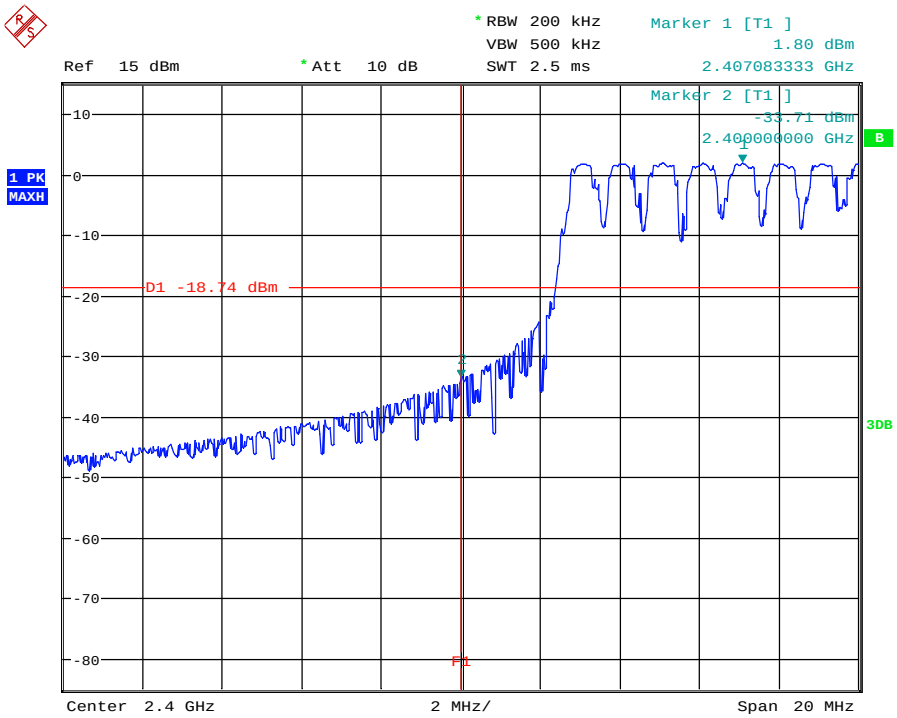
Date: 10.FEB.2012 09:54:22

Conducted Bandedge Compliance - Upper Bandedge (2481MHz)



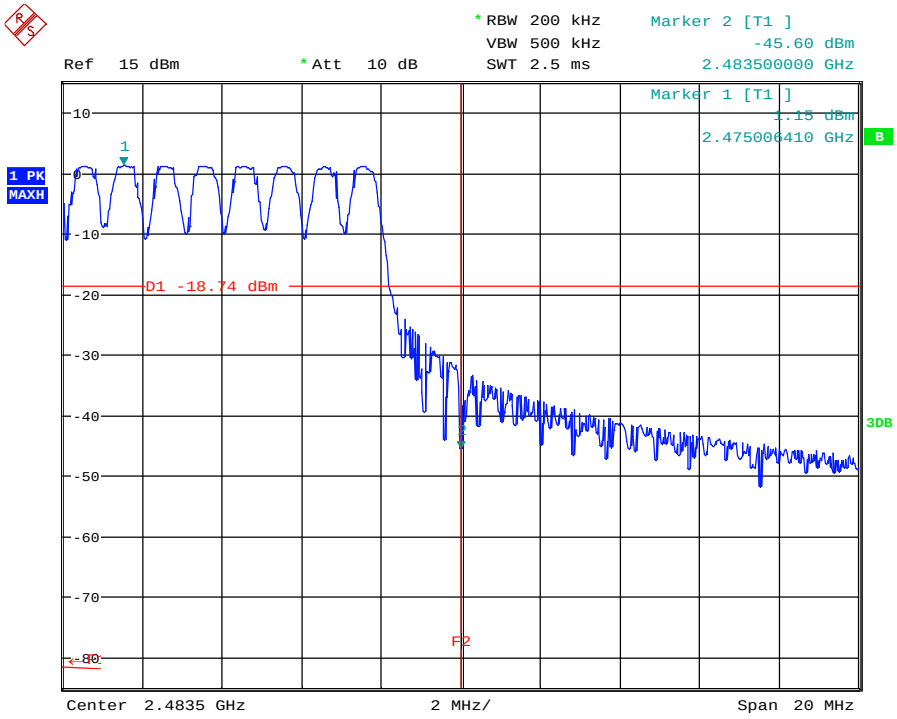
Date: 10.FEB.2012 09:56:29

Conducted Bandedge Compliance - Lower Bandedge (Hopping)



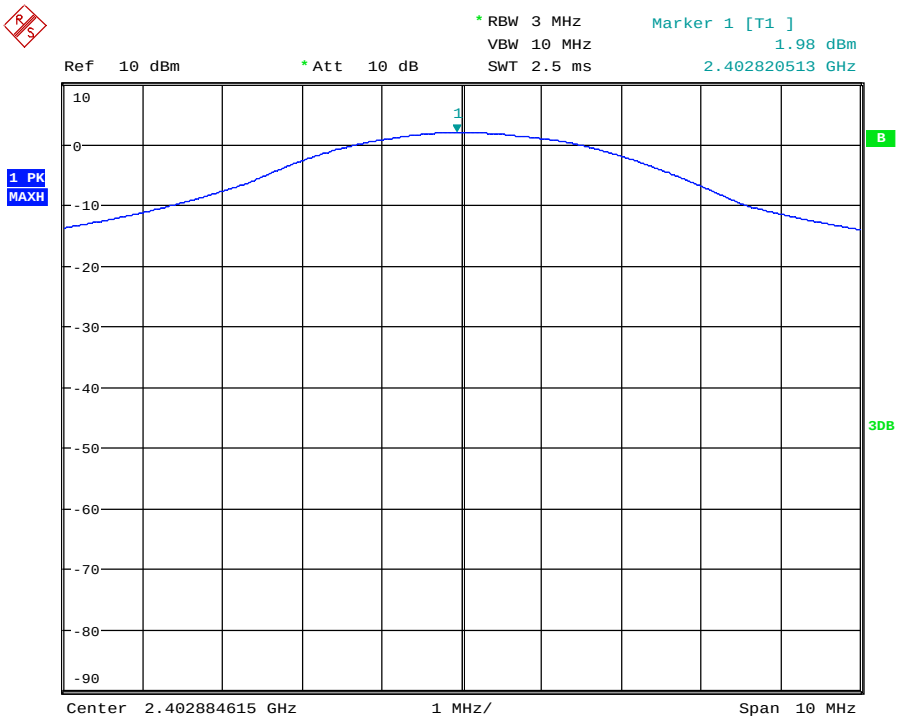
Date: 10.FEB.2012 14:07:24

Conducted Bandedge Compliance – Upper Bandedge (Hopping)



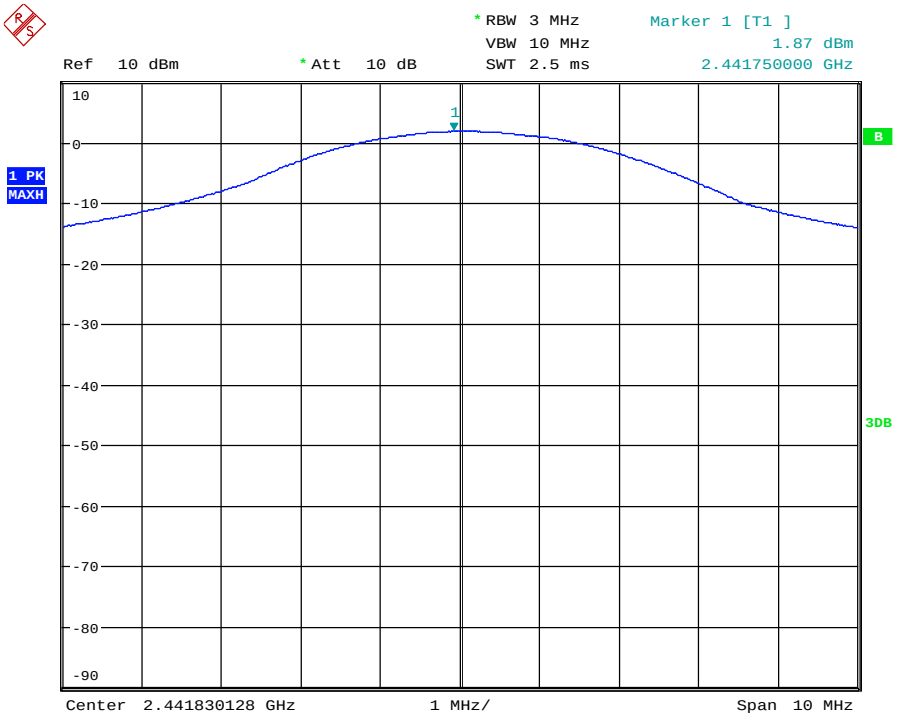
Date: 10.FEB.2012 14:13:19

Conducted carrier power - 2403MHz



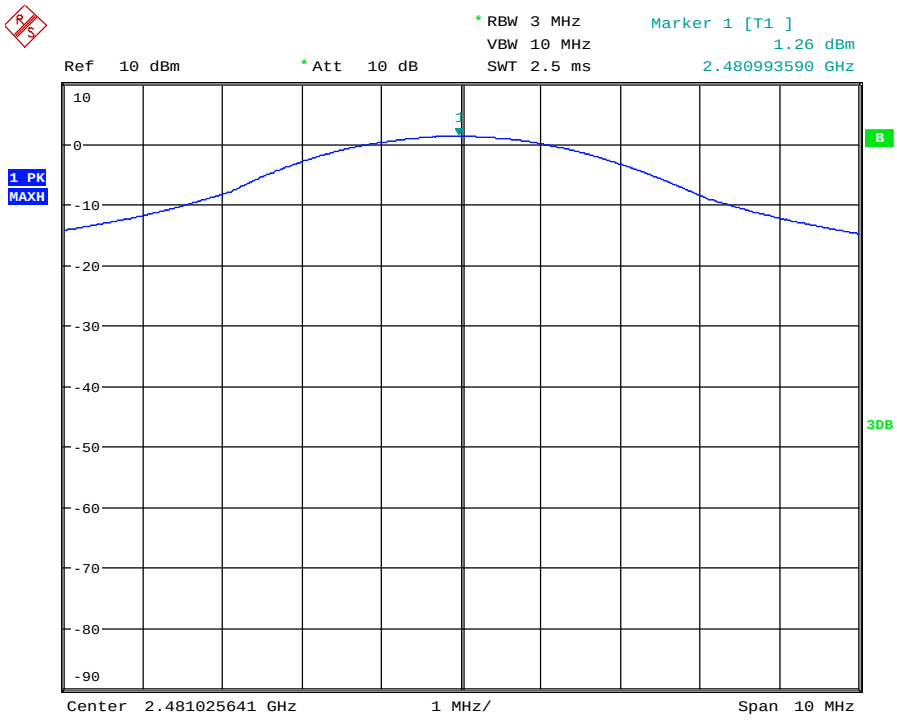
Date: 9.FEB.2012 16:46:11

Conducted carrier power - 2442MHz



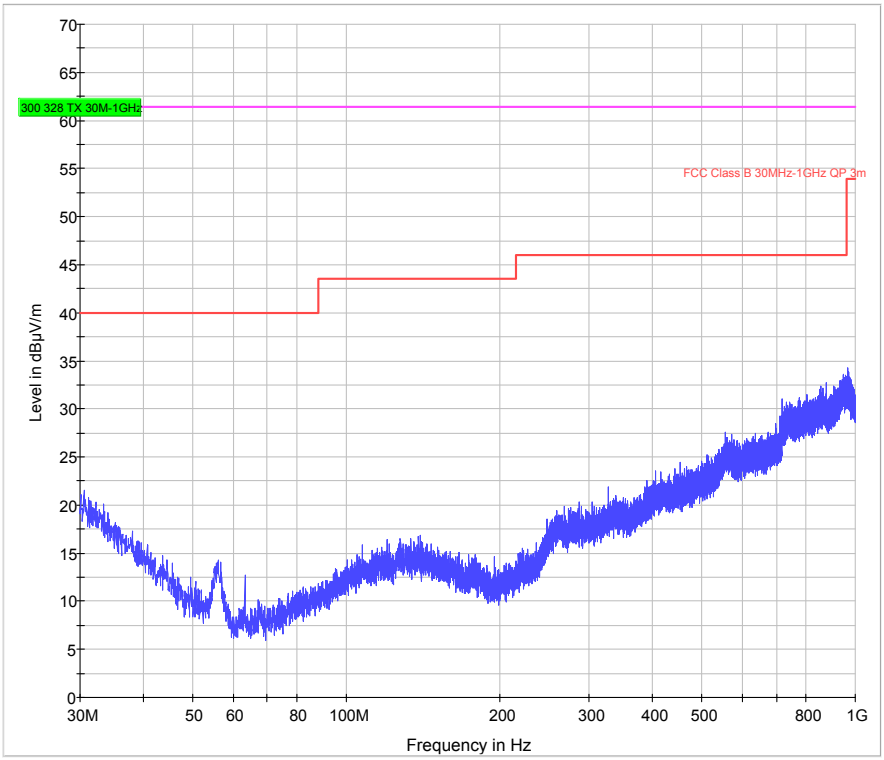
Date: 9.FEB.2012 16:41:43

Conducted carrier power - 2481MHz

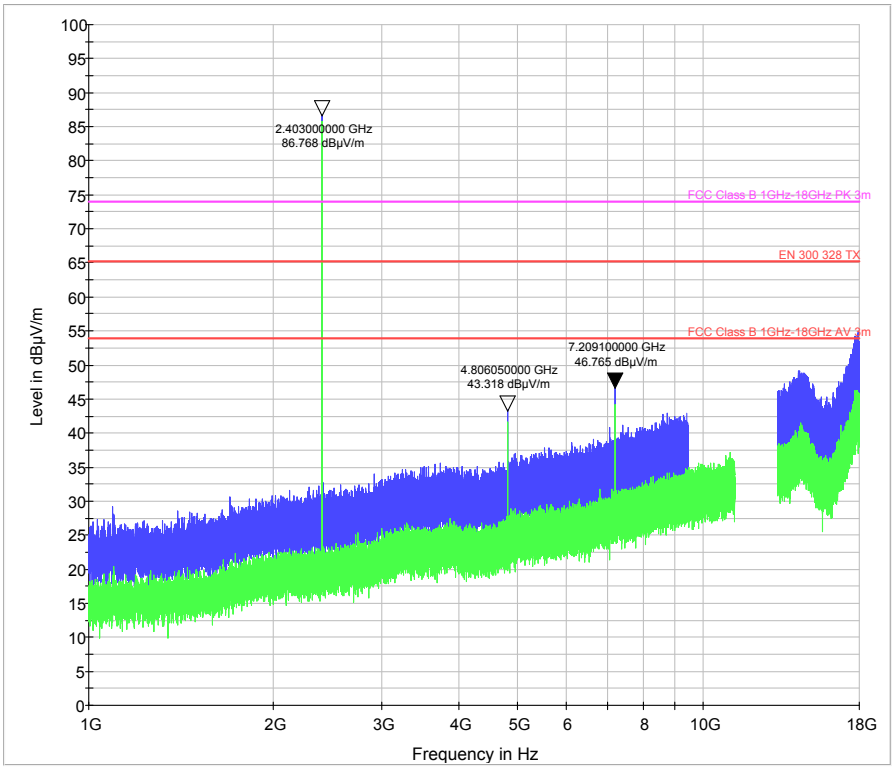


Date: 9.FEB.2012 16:40:36

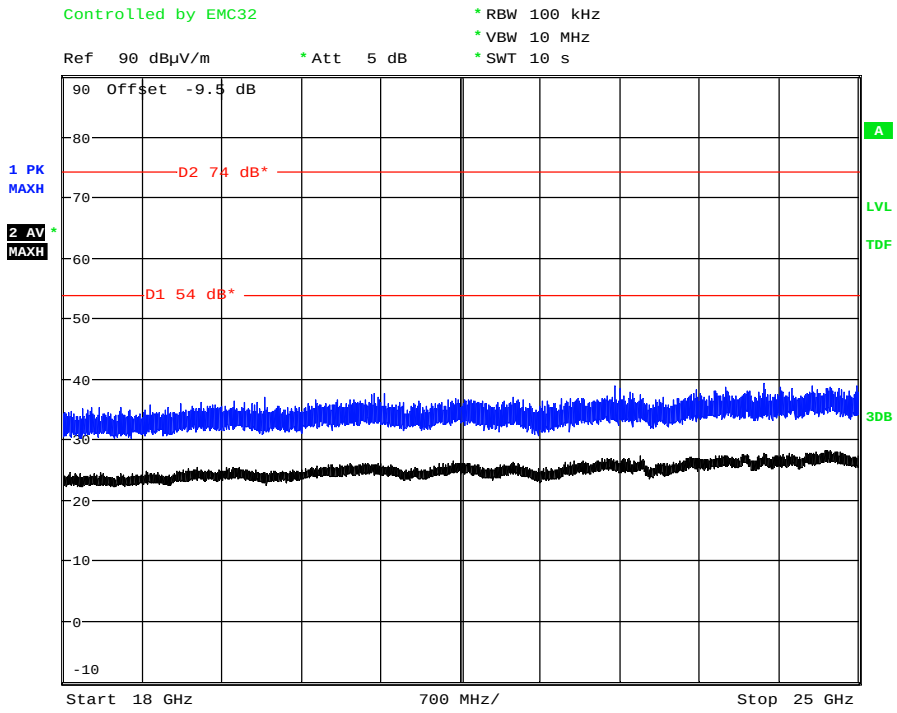
Radiated spurious emissions 30MHz – 1GHz (2403MHz)



Radiated spurious emissions 1GHz – 18GHz (2403MHz)

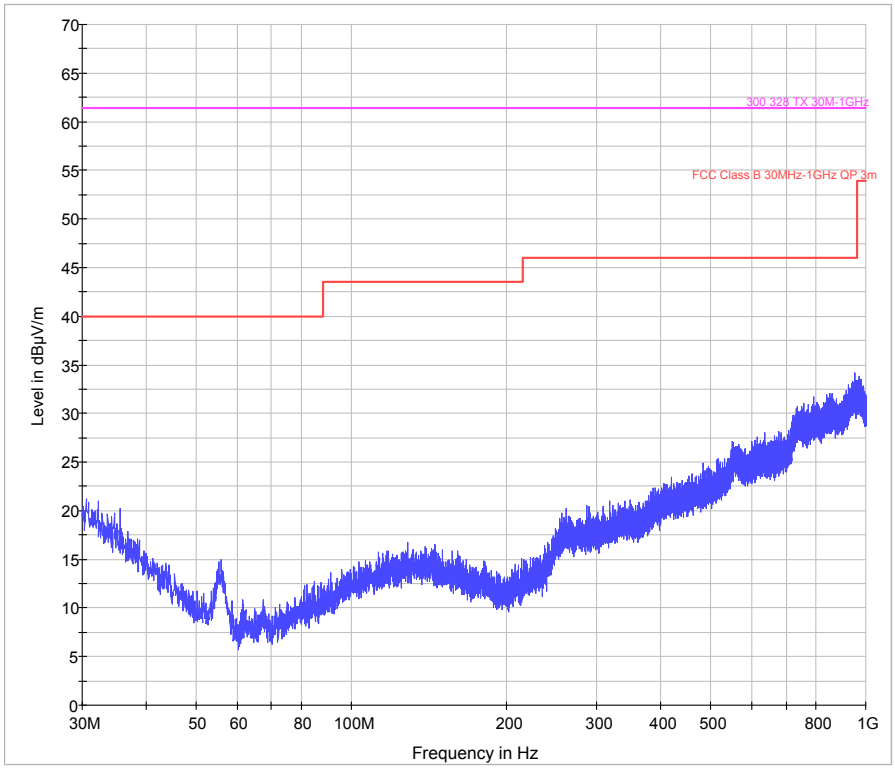


Radiated spurious emissions 18GHz – 25GHz (2403MHz)

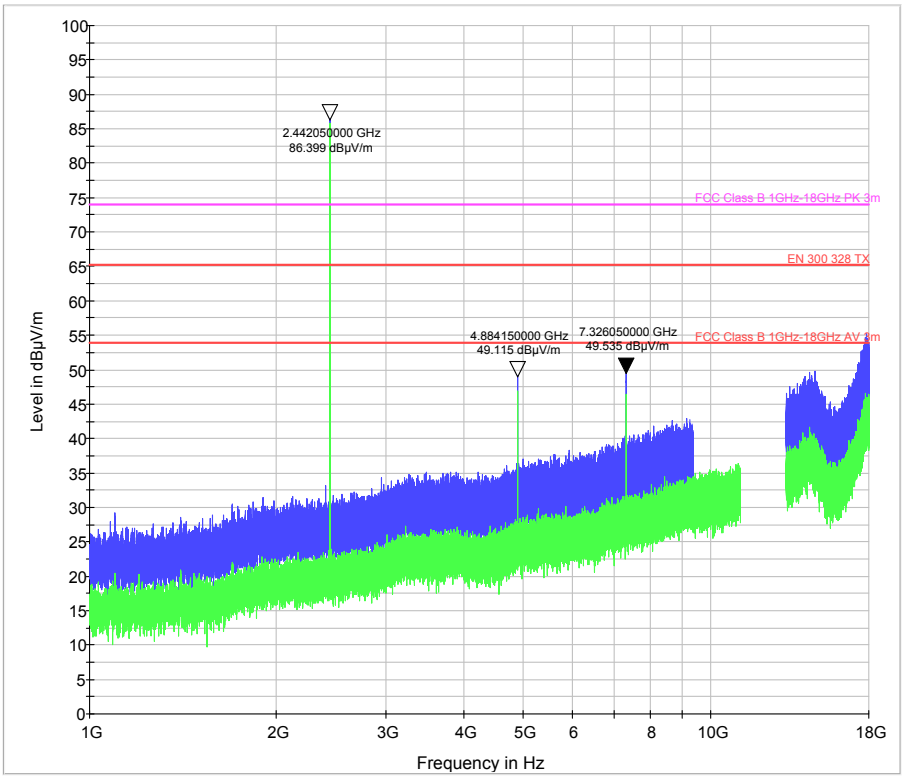


Date: 14.FEB.2012 17:50:17

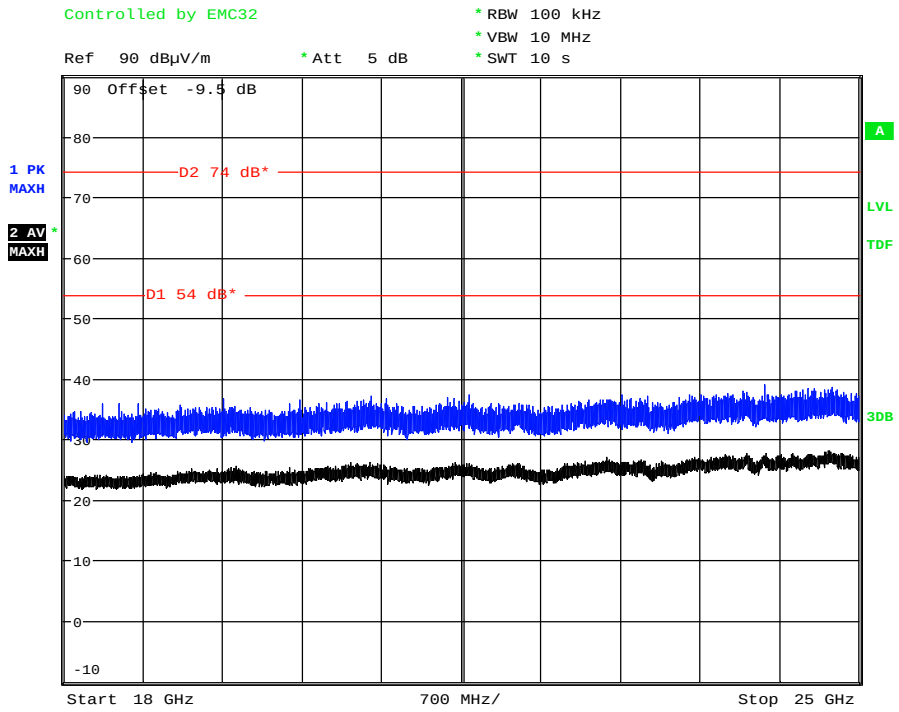
Radiated spurious emissions 30MHz – 1GHz (2442MHz)



Radiated spurious emissions 1GHz – 18GHz (2442MHz)

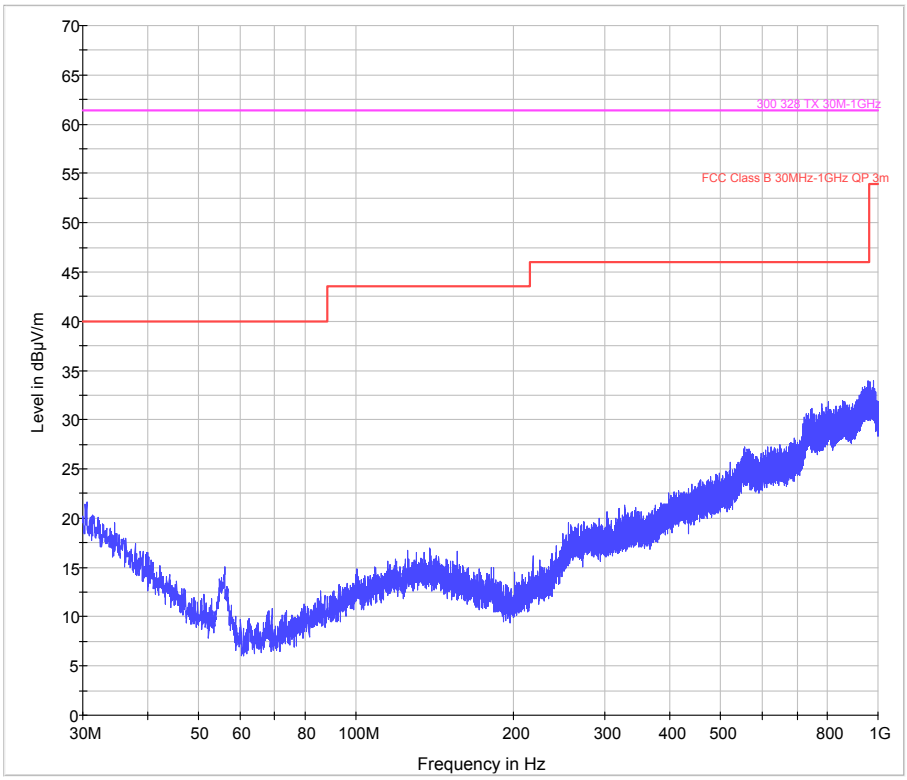


Radiated spurious emissions 18GHz – 25GHz (2442MHz)

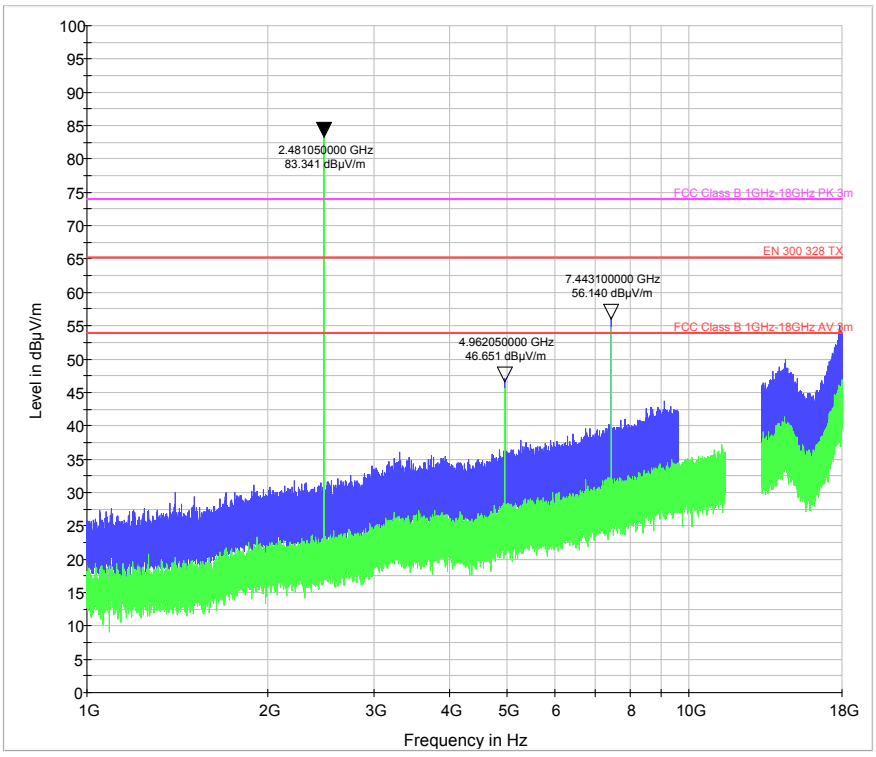


Date: 14.FEB.2012 17:50:58

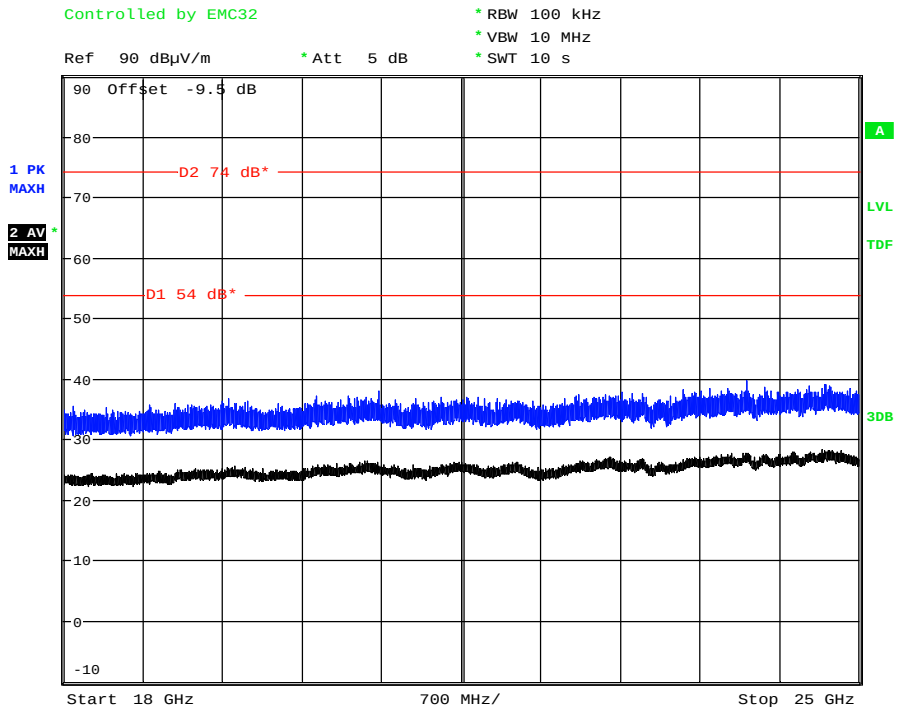
Radiated spurious emissions 30MHz – 1GHz (2481MHz)



Radiated spurious emissions 1GHz – 18GHz (2481MHz)

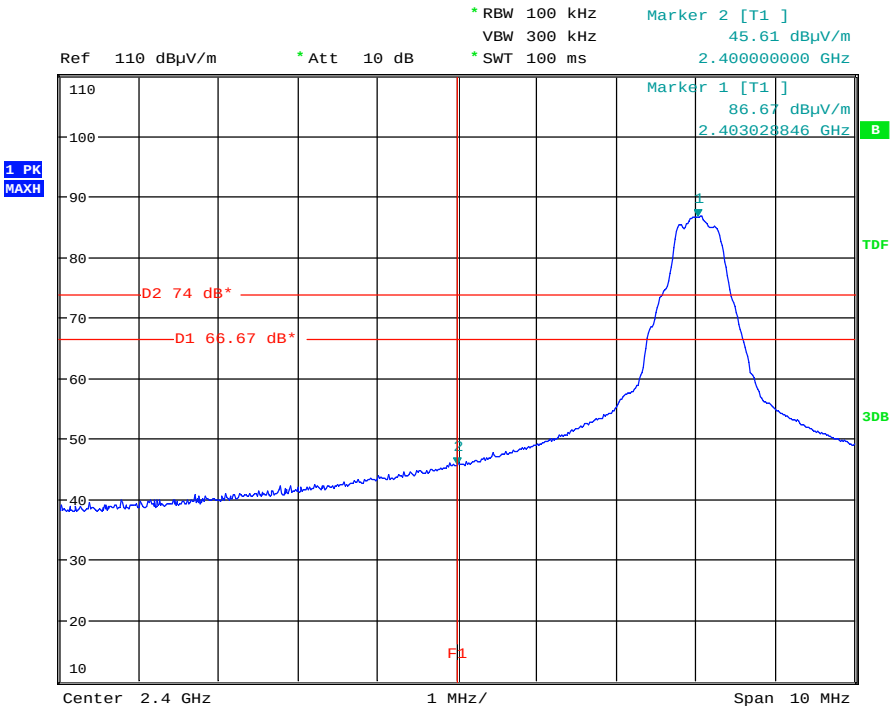


Radiated spurious emissions 18GHz – 25GHz (2481MHz)



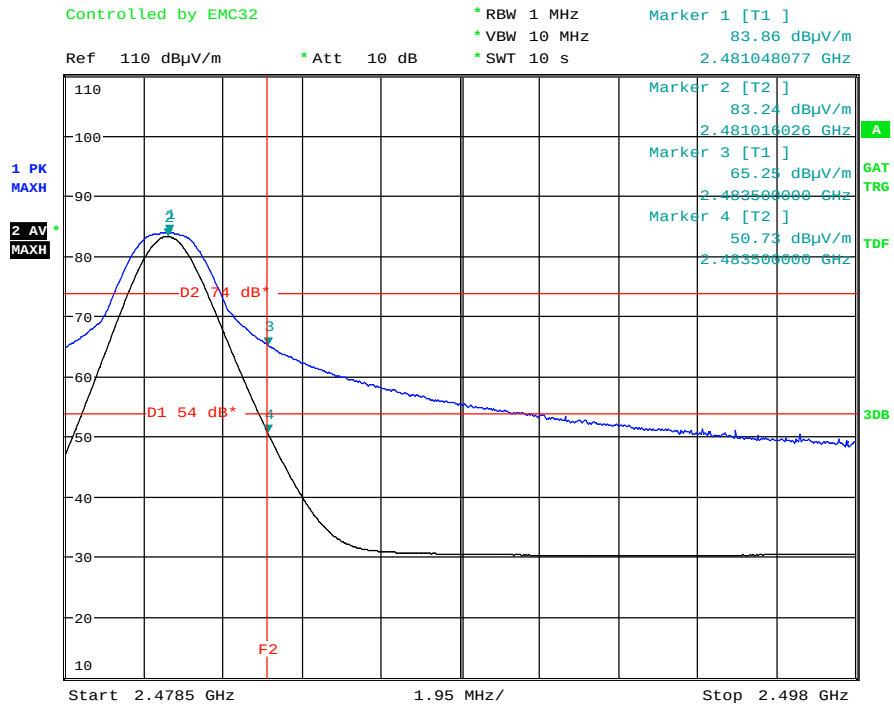
Date: 14.FEB.2012 17:52:55

Radiated Bandedge Compliance - Lower Bandedge (2403MHz)



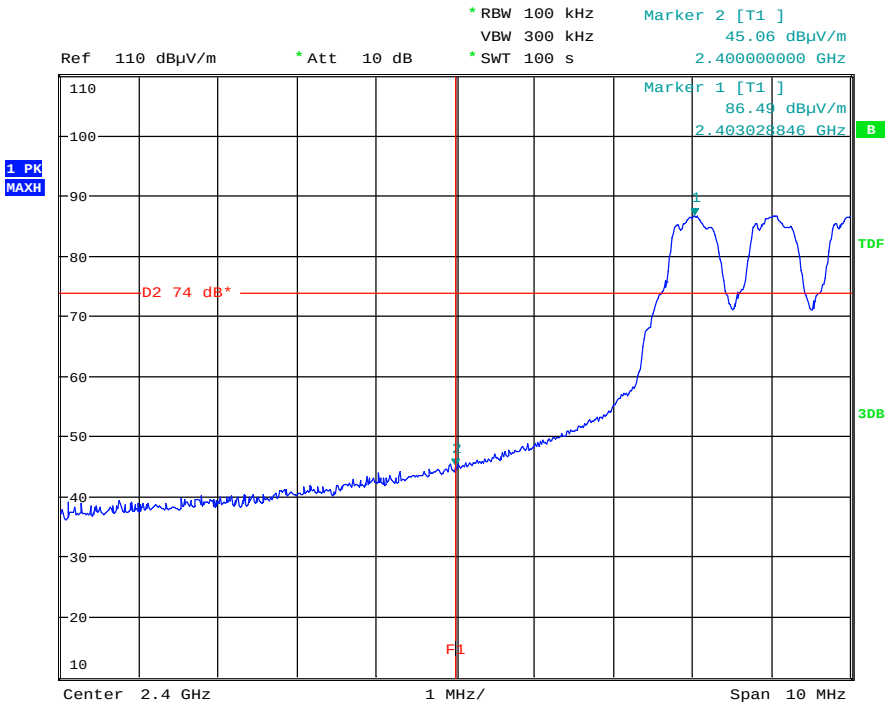
Date: 14.FEB.2012 16:51:35

Radiated Bandedge Compliance - Upper Bandedge (2481MHz)



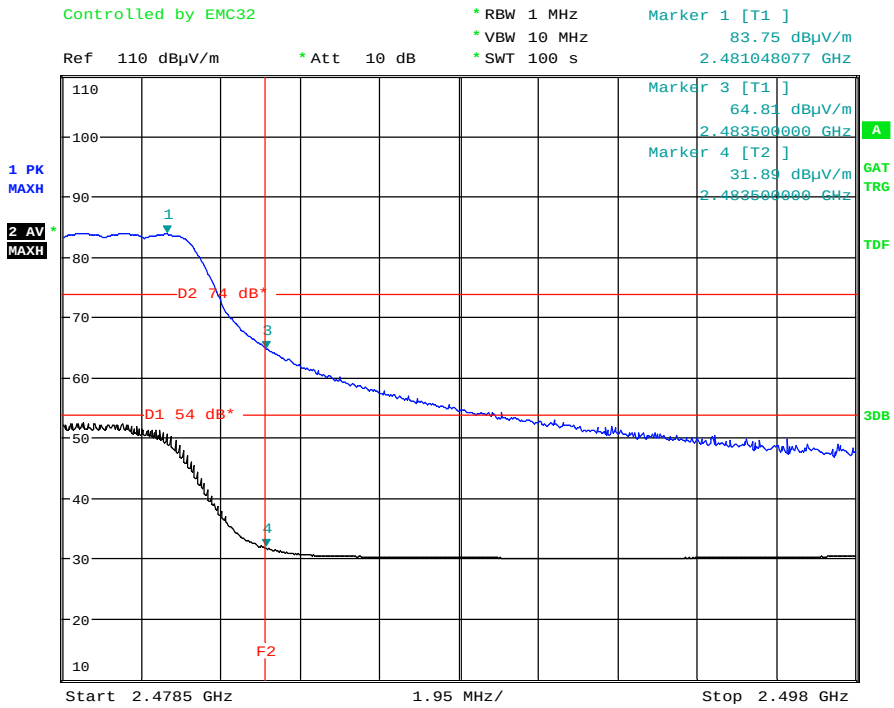
Date: 14.FEB.2012 16:37:36

Radiated Bandedge Compliance - Lower Bandedge (Hopping)



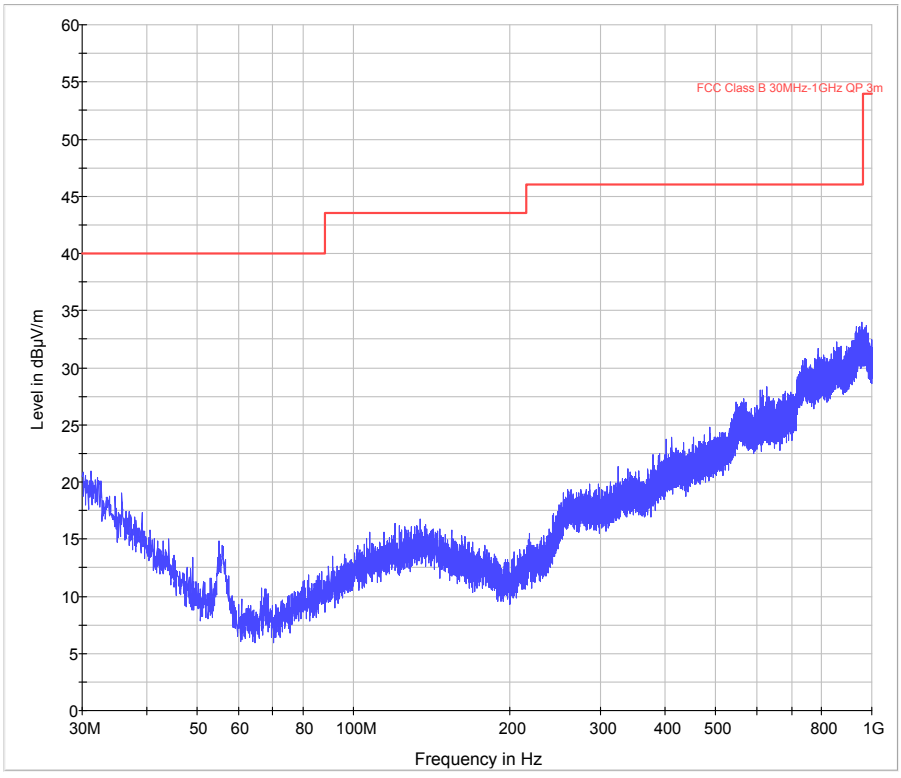
Date: 14.FEB.2012 16:46:25

Radiated Bandedge Compliance - Upper Bandedge (Hopping)

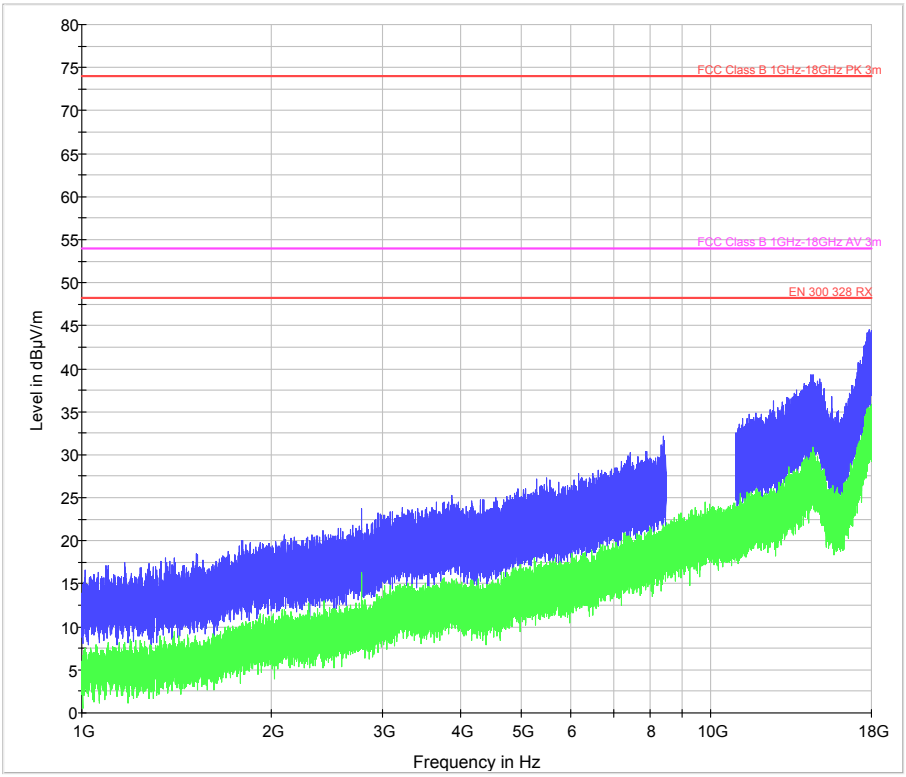


Date: 14.FEB.2012 16:50:10

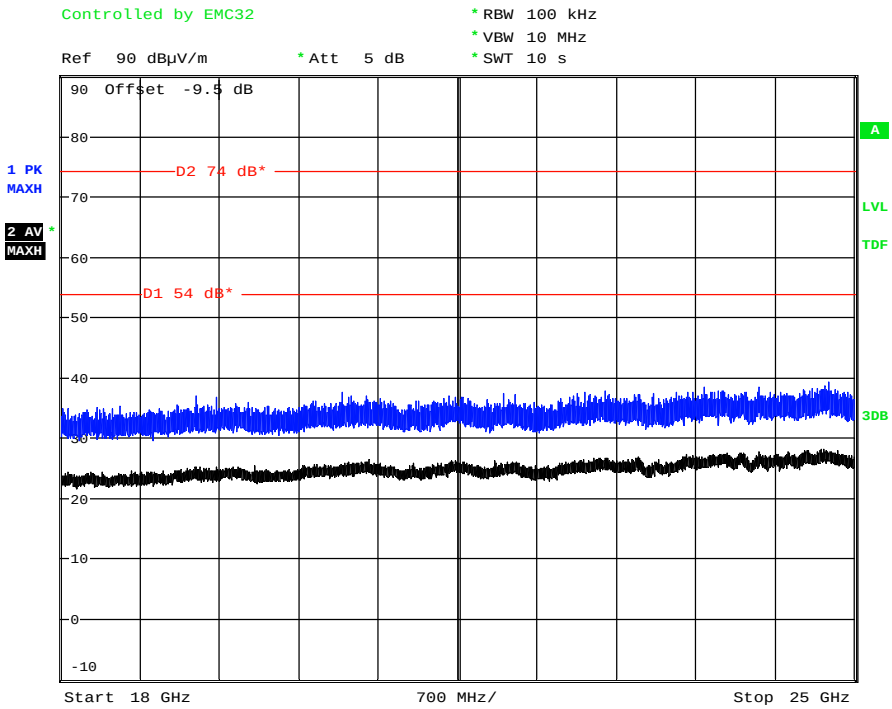
Unintentional radiated spurious emissions 30MHz - 1GHz



Unintentional radiated spurious emissions 1GHz – 18GHz



Unintentional radiated spurious emissions 18GHz – 25GHz



Date: 14.FEB.2012 17:48:33

Appendix C: Additional Test and Sample Details

This appendix contains details of:

1. The samples submitted for testing.
2. Details of EUT operating mode(s)
3. Details of EUT configuration(s) (see below).
4. EUT arrangement (see below).

Throughout testing, the following numbering system is used to identify the sample and it's modification state:

Sample No: Sxx Mod w

where:

xx = sample number eg. S01
w = modification number eg. Mod 2

The following terminology is used throughout the test report:

Support Equipment (SE) is any additional equipment required to exercise the EUT in the applicable operating mode. Where relevant SE is divided into two categories:

SE in test environment: The SE is positioned in the test environment and is not isolated from the EUT (e.g. on the table top during REFE testing).

SE isolated from the EUT: The SE is isolated via filtering from the EUT. (e.g. equipment placed externally to the ALSR during REFE testing).

EUT configuration refers to the internal set-up of the EUT. It may include for example:

Positioning of cards in a chassis.
Setting of any internal switches.
Circuit board jumper settings.
Alternative internal power supplies.

Where no change in EUT configuration is **possible**, the configuration is described as “single possible configuration”.

EUT arrangement refers to the termination of EUT ports / connection of support equipment, and where relevant, the relative positioning of samples (EUT and SE) in the test environment.

For further details of the test procedures and general test set ups used during testing please refer to the related document "EMC Test Methods - An Overview", which can be supplied by TRaC Global upon request.

C1 Test samples

The following samples of the apparatus were submitted by the client for testing:

Sample No.	Description	Identification
S04	RTS (sample for radiated tests)	None
S07	RTS (sample for conducted tests)	Cables/Antenna ports

C2 EUT operating mode during testing

During testing, the EUT was exercised as described in the following table:

Test	Description of Operating Mode
Carrier power, spurious emissions, dwell time, bandwidth tests	EUT constantly transmitting on bottom, middle and top channels, done one at a time
Band-edge tests, channel separation, number of channels, hop frequency	EUT transmitting, hopping on all channels
Unintentional spurious emissions	EUT in receive mode, hopping on all channels

C3 EUT Configuration Information

The EUT was submitted for testing in one single possible configuration.

C4 List of EUT Ports

The tables below describe the termination of EUT ports:

Sample : S07
Tests : Conducted

Port	Description of Cable Attached	Cable length	Equipment Connected
1	Short SMA	22cm	TRaC Test equipment*
2	Short SMA	22cm	50Ω Load*

Sample : S04
Tests : Radiated Emissions

Port	Description of Cable Attached	Cable length	Equipment Connected
None			

* Only connected during setup.

C5 Details of Equipment Used

TRAC Ref	Type	Description	Manufacturer	Date Calibrated
TRLUH281	FSU46	Spectrum Analyser	Rohde & Schwarz	09/02/2012
TRL138	3115	1-18GHz Horn Antenna	EMCO	08/11/2011
TRL139	3115	1-18GHz Horn Antenna	EMCO	14/09/2011
TRL572	8499B	1 – 26.5 GHz Pre Amplifier	Agilent	24/11/2010
TRLUH93	CBL6112B	BiLog Periodic Antenna	Chase	20/06/2011
TRLUH04	ESVS	E-field Receiver	Rohde & Schwarz	12/01/2012

Appendix D: Additional Information

The following declaration was made to TRaC Global Ltd.

Renishaw plc
New Mills, Wotton-under-Edge,
Gloucestershire GL12 8JR
United Kingdom

Tel +44 (0) 1453 524524
Fax +44 (0) 1453 524901
Email uk@renishaw.com
www.renishaw.com

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15 February 2012

DECLARATION

RTS Operating details

The RTS uses the Nordic Semiconductor nRF2401A in 'Direct' mode. This has a synthesiser settling time of approximately 200µs. There is a period of approximately 23µs where the system is modulating the carrier (with white data) before the message payload is transmitted (88µs in length). Therefore each transmission phase is 'on-air' for approximately 111µs. The repetition rate under normal operation varies from between 1ms to 20ms (i.e. 1000 transmissions per second to 50 transmissions per second) depending on whether the RTS receives an acknowledgement message from the RMI.

It should be noted that the test modes used within the RTS use PN9 modulated data (512µs) with a repetition rate of 1ms. The actual 'on-air' period starts 23µs before the PN9 data is transmitted, therefore giving a total time of 535µs.

Signed by

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Appendix E: Calculation of the duty cycle correction factor

Using a spectrum analyser in zero span mode, centred on the fundamental carrier frequency with a RBW of 1MHz and a video Bandwidth of 1MHz the sweep time was set accordingly to capture the pulse train. The transmit pulsewidths and period was measured. A plot of the pulse train is contained in Appendix B of this test report.

If the pulse train was less than 100 ms, including blanking intervals, the duty cycle was calculated by averaging the sum of the pulsewidths over one complete pulse train. However if the pulse train exceeds 100ms then the duty cycle was calculated by averaging the sum of the pulsewidths over the 100ms width with the highest average value. (The duty cycle is the value of the sum of the pulse widths in one period (or 100ms), divided by the length of the period (or 100ms). The duty cycle correction factor was then expressed in dB and the peak emissions adjusted accordingly to give an average value of the emission.

Correction factor dB = 20 x (Log_{10} Calculated Duty Cycle)

Therefore the calculated duty cycle was determined:

The pulse train period was greater than >100ms and in as shown from the plots in contained in appendix B of this test report.

Duty cycle = $\frac{\text{the sum of the highest average value pulsewidths over 100ms}}{\text{100ms}}$

e.g

$$= \frac{7.459ms}{100ms} = 0.07459$$

0.07459 or 7.459%

Correction factor (dB) = 20 x (Log_{10} 0.07459) = -22.54dB

Appendix F: Photographs and Figures

The following photographs were taken of the test samples:

1. Radiated tests setup – front view (<=1GHz)
2. Radiated tests setup – front view (>1GHz)

Photograph 1

Photograph 2