

Radio Test Report

for

Renishaw Plc

on

RMP60 & RMP60M

Document No: TRA-0087868-W-US-1

TRaC Wireless Test Report : TRA-008786-W-US-1

Applicant : Renishaw Plc

Apparatus : RMP60 & RMP60M

Specification(s) : CFR47 Part 15.247

FCCID : KQGRMP60Q

Purpose of Test : Certification

Authorised by :



(Radio Products Manager)

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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: TRaC Global []
Unit E
South Orbital Trading Park
Hedon Road
Hull, HU9 1NJ.
United Kingdom.

Telephone: +44 (0) 1482 801801
Fax: +44 (0) 1482 801806

TRaC Global [X]
Unit 1
Pendle Place
Skelmersdale
West Lancashire, WN8 9PN
United Kingdom

Telephone: +44 (0) 1695 556666
Fax: +44 (0) 1695 577077

Email: test@tracglobal.com
Web site: <http://www.tracglobal.com>

Tests performed by: Daniel Winstanley, Sandeep Bharat

Author(s): Daniel Winstanley, Sandeep Bharat

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1.2 Tests Requested By

All 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 products were assessed between 30th July and 10th August 2012:

RMP60: This device consists of a GFSK transceiver employing FHSS operating in the 2400MHz to 2483.5MHz ISM band. The settings are changed by deflected a stylus inserted at the bottom of the device.

RMP60M: This device consists of a GFSK transceiver employing FHSS operating in the 2400MHz to 2483.5MHz ISM band. The settings are changed by shorting two metal notches at the bottom of the device.

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 C63.10:2009	Pass
Conducted spurious emissions (Non-restricted bands)	Title 47 of the CFR: Part 15 Subpart (c) 15.247	ANSI C63.10:2009	Pass
AC Power conducted emissions	Title 47 of the CFR: Part 15 Subpart (c) 15.207	ANSI C63.10:2009	N/A Note 1
20dB Bandwidth and Channel Spacing	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(i)	ANSI C63.10:2009	Pass
Conducted Carrier Power	Title 47 of the CFR : Part 15 Subpart (c) 15.247(b)(2)	ANSI C63.10:2009	Pass
Hopping Frequencies	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)	ANSI C63.10:2009	Pass
Channel Occupancy	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(i)	ANSI C63.10:2009	Pass
Unintentional Radiated Spurious Emissions	Title 47 of the CFR: Part 15 Subpart (b) 15.109	ANSI C63.10:2009	Pass

Note 1: The RMP60 and RMP60M are both battery power devices.

Abbreviations used in the above table:

ANSI C 63.10:2009 is outside the scope of the laboratories UKAS accreditation.

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

The following table contains the measurement uncertainties for TRaC Global measurements

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	ALSR	: Absorber Lined Screened Room
Mod	: Modification	OATS	: Open Area Test Site
EUT	: Equipment Under Test	ATS	: Alternative Test Site
SE	: Support Equipment	Ref	: Reference
L	: Live Power Line	Freq	: Frequency
N	: Neutral Power Line	MD	: Measurement Distance
E	: Earth Power Line	SD	: Spec Distance
Pk	: Peak Detector	Pol	: Polarisation
QP	: Quasi-Peak Detector	H	: Horizontal Polarisation
Av	: Average Detector	V	: Vertical Polarisation
CDN	: Coupling & decoupling network		

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	S05
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Peak Carrier Power (mW)	Limit (W)	Result
2403 MHz	0.79	1	Pass
2442 MHz	1.01	1	Pass
2481 MHz	1.15	1	Pass

Notes:

- 1 Number of hopping channels employed is 79
- 2 Measured Peak Carrier power does not include gain of any antenna to be used.
- 3 Highest Gain of any antenna to be used = 2.1dBi
- 4 Conducted measurements were performed with a temporary antenna connector provided by the client.

A2 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	
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	S05
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

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

2403 MHz						
Ref No.	Measured Freq (MHz)	Det.	Is measured Frequency within the Restricted bands (Y/N)	Measured Peak Conducted power (RBW =100kHz) (dBuV)	15.247(d) Limit (dBuV)	Summary
1	No Significant Emissions Within 20 dB of limit					

2442 MHz						
Ref No.	Measured Freq (MHz)	Det.	Is measured Frequency within the Restricted bands (Y/N)	Measured Peak Conducted power (RBW =100kHz) (dBuV)	15.247(d) Limit (dBuV)	Summary
1	No Significant Emissions Within 20 dB of limit					

2481 MHz						
Ref No.	Measured Freq (MHz)	Det.	Is measured Frequency within the Restricted bands (Y/N)	Measured Peak Conducted power (RBW =100kHz) (dBuV)	15.247(d) Limit (dBuV)	Summary
1	No Significant Emissions Within 20 dB of limit					

Notes:

1. The conducted emission limit for emissions outside the restricted bands, defined in 47CFR15.205(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 accordance 15.33 (a)(1)
3. The measurements at 2400 MHz and 2483.5 MHz were made to ensure band edge compliance
4. Conducted spurious emissions plots for the worst case channel are included in Appendix B of this report
5. 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 Emissions – RMP60

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 :

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 to 25 GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
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)	Detector	Measured Level (dBµV)	Cable Loss [#] (dB)	Antenna Factor (dB/m)	Preamp Gain (dB)	Field Strength (dBµV/m)	DCF* (dB)	Field Strength (µV/m)	Limit (µV/m)
4806	Peak	64.93	4.3	32.6	35.7	66.13	N/A	2025.4	5000
4806	Average	59.17	4.3	32.6	35.7	60.37	19	117	500

[#] Includes high pass filter loss

*Duty-cycle Correction Factor = $20 \cdot \log(1/x) = 20 \cdot \log(1/0.11) \approx 19\text{dB}$

Where duty cycle, $x = T_{on}/(T_{on} + T_{off}) = 111\mu\text{s}/1\text{ms} = 0.111 \approx 11\%$

Radiated Emissions – RMP60 continued:

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

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 to 25 GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
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)	Detector	Measured Level (dB μ V)	Cable Loss [#] (dB)	Antenna Factor (dB/m)	Preamp Gain (dB)	Field Strength (dB μ V/m)	DCF* (dB)	Field Strength (μ V/m)	Limit (μ V/m)
4884	Peak	65.97	4.4	32.9	35.7	67.57	N/A	2390.6	5000
4884	Average	60.32	4.4	32.9	35.7	61.92	19	139.9	500

[#] Includes high pass filter loss

*Duty-cycle Correction Factor = $20 \cdot \log(1/x) = 20 \cdot \log(1/0.11) \approx 19\text{dB}$

Where duty cycle, $x = T_{on}/(T_{on} + T_{off}) = 111\mu\text{s}/1\text{ms} = 0.111 \approx 11\%$

Radiated Emissions – RMP60 continued:

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

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 to 25 GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
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)	Detector	Measured Level (dB μ V)	Cable Loss [#] (dB)	Antenna Factor (dB/m)	Preamp Gain (dB)	Field Strength (dB μ V/m)	DCF* (dB)	Field Strength (μ V/m)	Limit (μ V/m)
4962	Peak	66.33	4.1	33.1	35.7	67.83	N/A	2463.2	5000
4962	Average	60.6	4.1	33.1	35.7	62.10	19	142.9	500

[#] Includes high pass filter loss

*Duty-cycle Correction Factor = $20 \cdot \log(1/x) = 20 \cdot \log(1/0.11) \approx 19\text{dB}$

Where duty cycle, $x = T_{on}/(T_{on} + T_{off}) = 111\mu\text{s}/1\text{ms} = 0.111 \approx 11\%$

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 ($\mu\text{V}/\text{m}$)	Measurement Distance (m)	Field strength ($\text{dB}\mu\text{V}/\text{m}$)
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:

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

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 Radiated Emissions – RMP60M

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 :

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 to 25 GHz
EUT sample number	S02
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 3 and 4

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

Frequency (MHz)	Detector	Measured Level (dB μ V)	Cable Loss [#] (dB)	Antenna Factor (dB/m)	Preamp Gain (dB)	Field Strength (dB μ V/m)	DCF* (dB)	Field Strength (μ V/m)	Limit (μ V/m)
4806	Peak	61.75	4.3	32.6	35.7	62.95	N/A	1404.4	5000
4806	Average	55.85	4.3	32.6	35.7	57.05	19	79.89	500

[#] Includes high pass filter loss

*Duty-cycle Correction Factor = $20 \cdot \log(1/x) = 20 \cdot \log(1/0.11) \approx 19\text{dB}$

Where duty cycle, $x = T_{\text{on}} / (T_{\text{on}} + T_{\text{off}}) = 111\mu\text{s} / 1\text{ms} = 0.111 \approx 11\%$

Radiated Emissions – RMP60M continued:

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

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 to 25 GHz
EUT sample number	S02
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 3 and 4

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

Frequency (MHz)	Detector	Measured Level (dB μ V)	Cable Loss [#] (dB)	Antenna Factor (dB/m)	Preamp Gain (dB)	Field Strength (dB μ V/m)	DCF* (dB)	Field Strength (μ V/m)	Limit (μ V/m)
4884	Peak	64.39	4.4	32.9	35.7	65.99	N/A	1992.9	5000
4884	Average	58.72	4.4	32.9	35.7	60.32	19	116.4	500

[#] Includes high pass filter loss

*Duty-cycle Correction Factor = $20 \cdot \log(1/x) = 20 \cdot \log(1/0.11) \approx 19\text{dB}$

Where duty cycle, $x = T_{on}/(T_{on} + T_{off}) = 111\mu\text{s}/1\text{ms} = 0.111 \approx 11\%$

Radiated Emissions – RMP60M continued:

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

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 to 25 GHz
EUT sample number	S02
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 3 and 4

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

Frequency (MHz)	Detector	Measured Level (dB μ V)	Cable Loss [#] (dB)	Antenna Factor (dB/m)	Preamp Gain (dB)	Field Strength (dB μ V/m)	DCF* (dB)	Field Strength (μ V/m)	Limit (μ V/m)
4962	Peak	65.25	4.1	33.1	35.7	66.75	N/A	2175.2	5000
4962	Average	59.52	4.1	33.1	35.7	61.02	19	126.1	500

[#] Includes high pass filter loss

*Duty-cycle Correction Factor = $20 \cdot \log(1/x) = 20 \cdot \log(1/0.11) \approx 19\text{dB}$

Where duty cycle, $x = T_{on}/(T_{on} + T_{off}) = 111\mu\text{s}/1\text{ms} = 0.111 \approx 11\%$

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 ($\mu\text{V}/\text{m}$)	Measurement Distance (m)	Field strength ($\text{dB}\mu\text{V}/\text{m}$)
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:

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

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				

A5 20dB Bandwidth and Channel 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 separation, which shall be a minimum of 25 kHz or $2/3^{\text{rd}}$ of the 20dB bandwidth, whichever is 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	S05
Modification state	0
SE in test environment	None
SE isolated from EUT	S07
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Measured 20dB Bandwidth (kHz)	Limit	Result
2403 MHz	1129.808	>500kHz	Pass
2442 MHz	1145.833	>500kHz	Pass
2481 MHz	1113.782	>500kHz	Pass

Measured Channel Separation (kHz)	Limit	Result
1003.205	$\geq 2/3^{\text{rd}}$ of Measured 20dB Bandwidth	Pass

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

A6 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	S05
Modification state	0
SE in test environment	None
SE isolated from EUT	S07
EUT set up	Refer to Appendix C

No. of Hopping Channels	Requirement	Result
79	15	Pass

Plots showing the hopping channels are contained in Appendix B

A7 Channel Occupancy

Channel occupancy time was verified using a spectrum analyser in zero span mode, centred on the middle hopping channel frequency (2442MHz), 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	S05
Modification state	0
SE in test environment	None
SE isolated from EUT	S07
EUT set up	Refer to Appendix C

T_{occ} (ms)	MP (s)	MPTX	AOT (s)	Limit (s)	Result
0.151	31.6	23	0.003473	0.4	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 occupancy time (T_{occ}) = 0.151ms

Specified averaging period =

$$0.4 * N = SAP(seconds) \quad \therefore 0.4 * 79 = 31.6(Seconds)$$

\therefore The Average Retention Time =

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

Average Channel Occupancy Time = 0.151 ms x 23 = 0.003473 seconds

A8 Antenna Gain

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

A9 Unintentional Radiated Emissions – RMP60

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 whilst hopping on all channels.

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 :

Test Details	
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	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 1 and 2

The worst case unintentional radiated emission measurements that fall within the restricted bands are listed below:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
No emissions were detected within 20dB of the limit									

A10 Unintentional Radiated Emissions – RMP60M

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 whilst hopping on all channels.

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 :

Test Details	
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	S02
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 3 and 4

The worst case unintentional radiated emission measurements that fall within the restricted bands are listed below:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
No emissions were detected within 20dB of the limit									

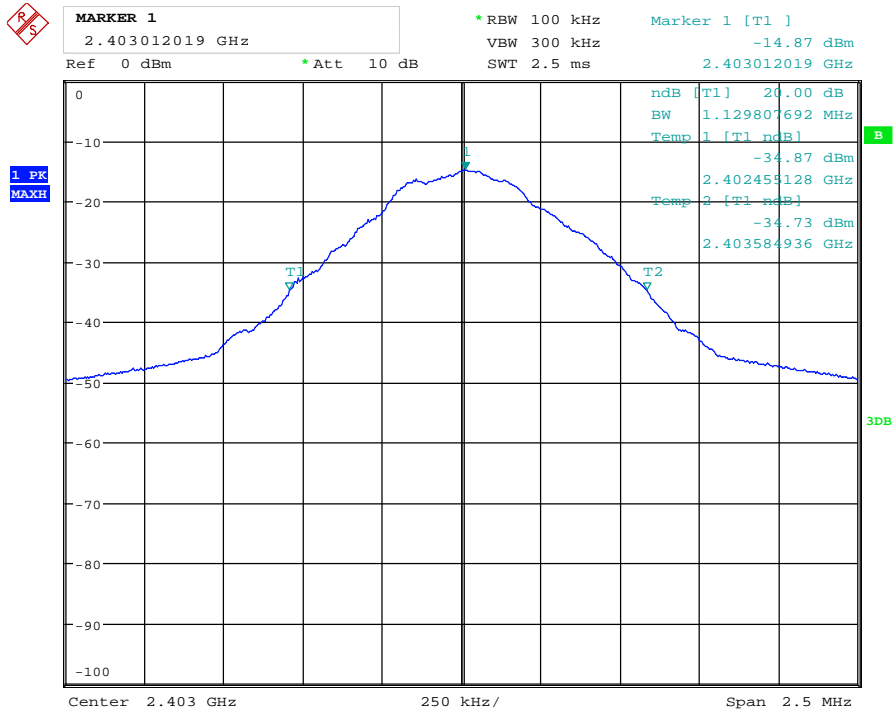
Appendix B:**Supporting Graphical Data**

This appendix contains graphical data obtained during testing.

Notes:

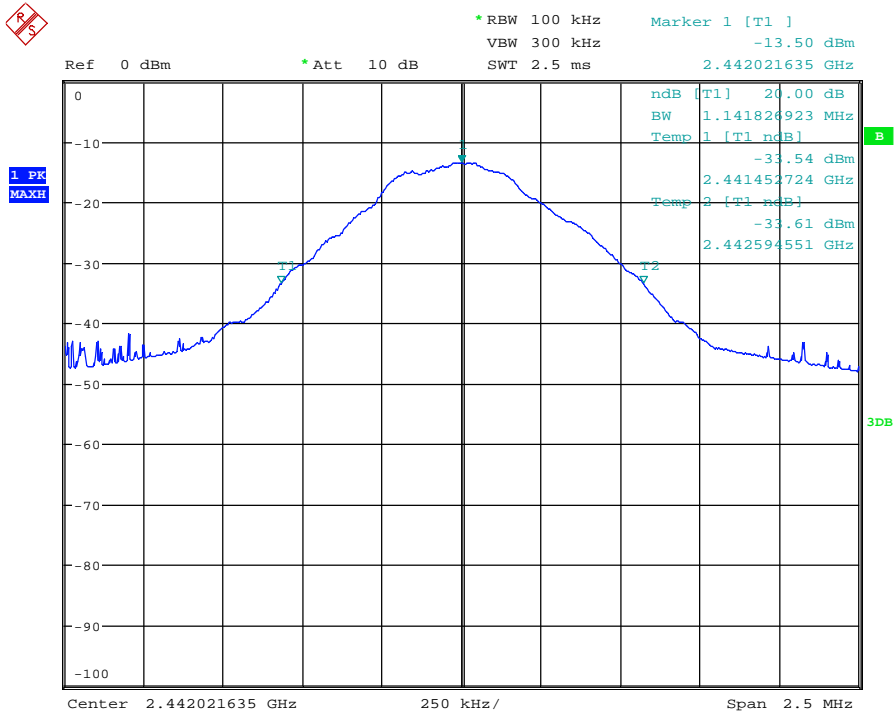
- (a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.
- (b) The time and date on the plots do not necessarily equate to the time of the test.
- (c) Where relevant, on power 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 Channel



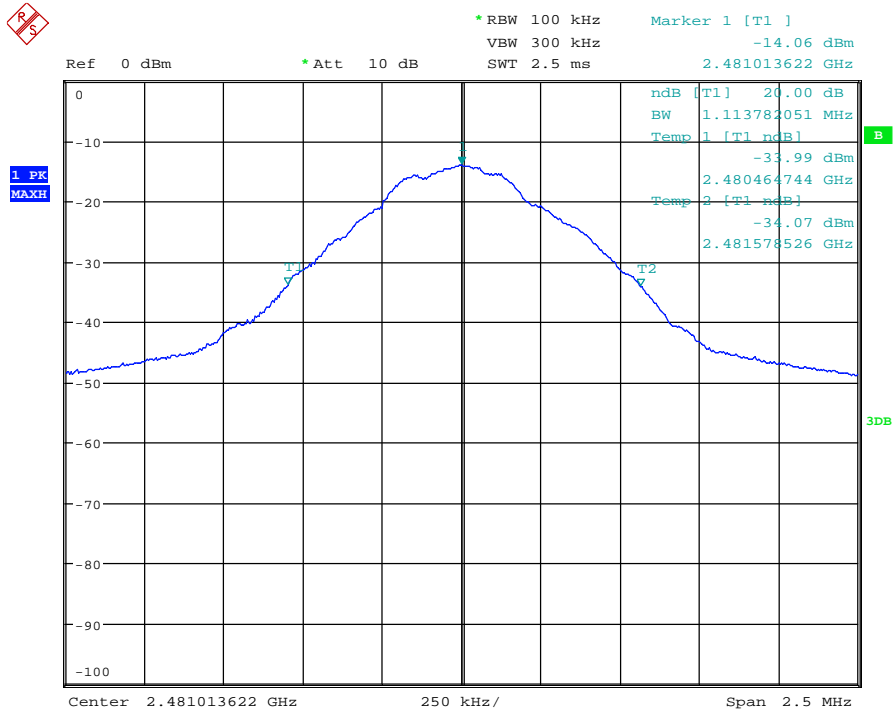
Date: 1.AUG.2012 09:15:35

20dB Bandwidth – 2442MHz Channel



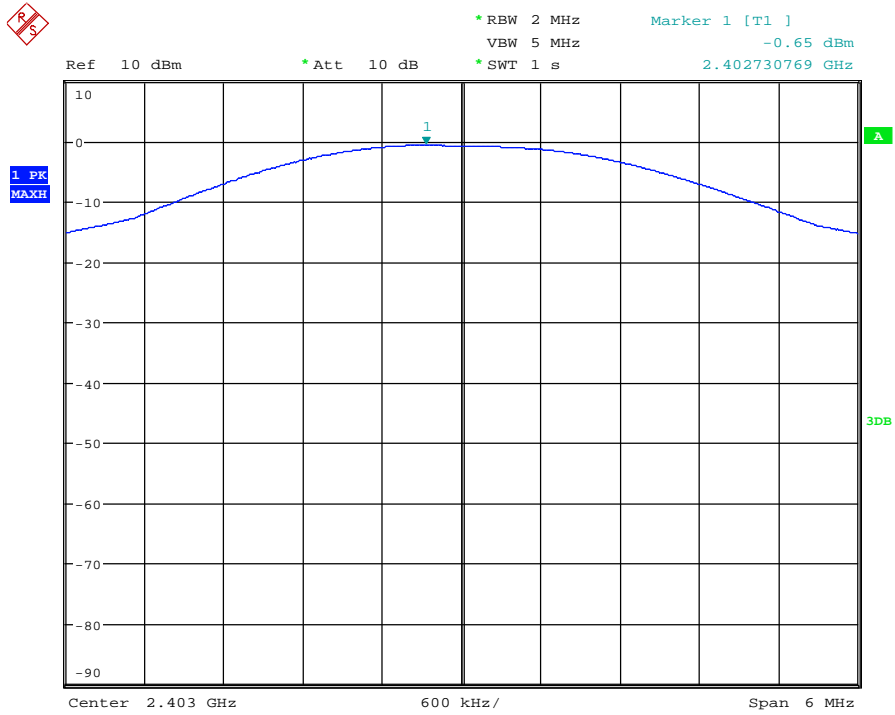
Date: 1.AUG.2012 09:27:14

20dB Bandwidth – 2481MHz Channel



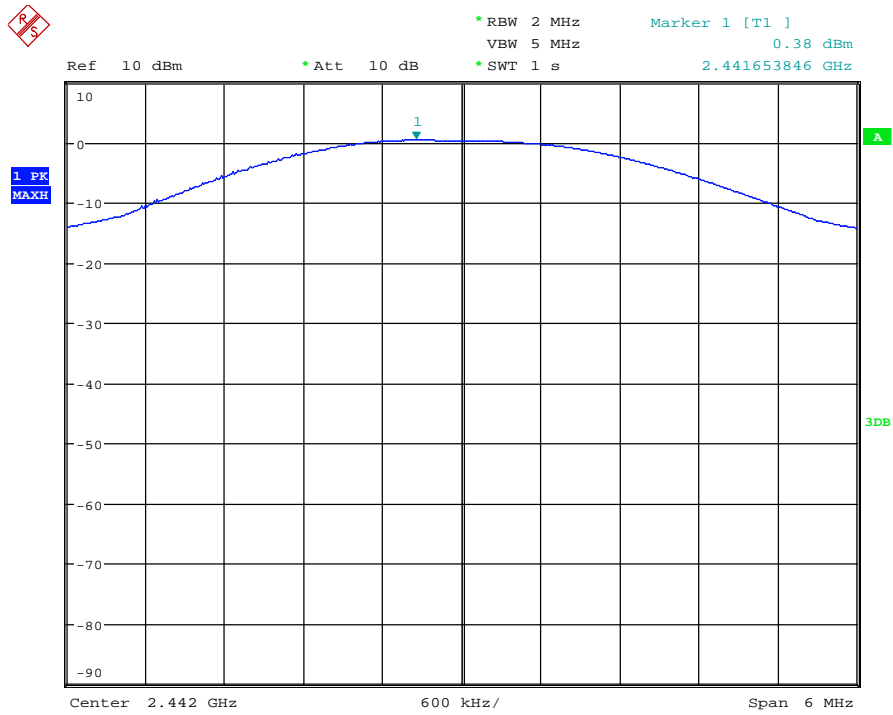
Date: 1.AUG.2012 09:30:17

Carrier Power – 2403MHz Channel



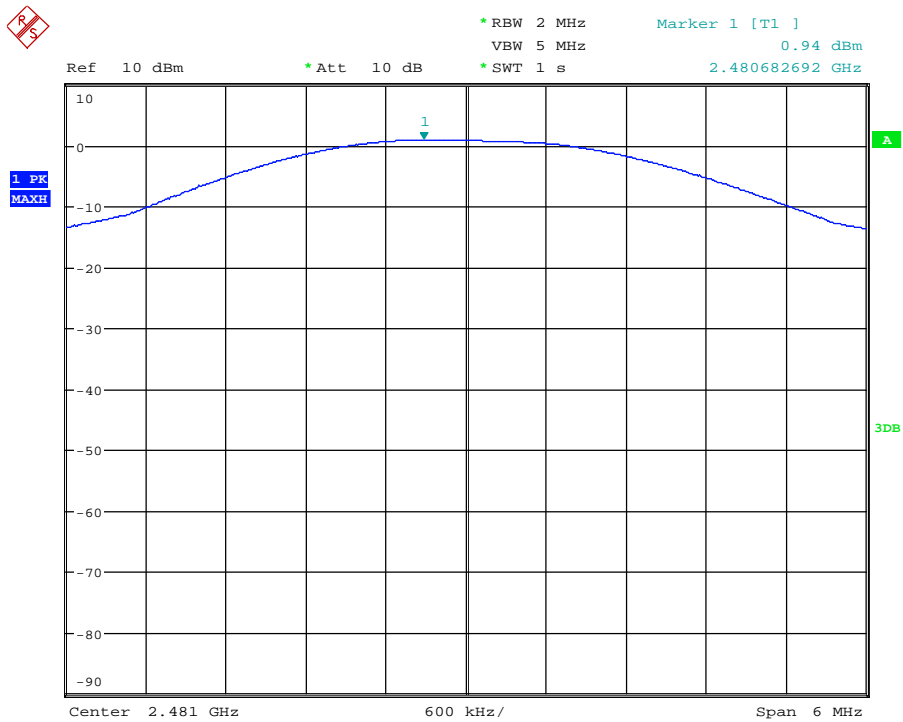
Date: 7.AUG.2012 13:29:01

Carrier Power – 2442MHz Channel



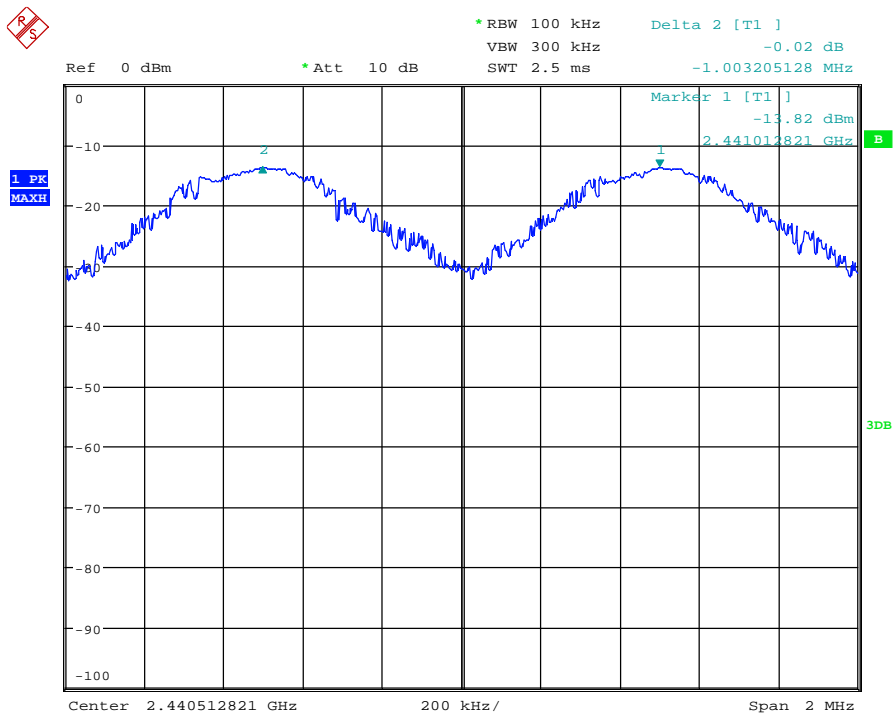
Date: 7.AUG.2012 13:29:20

Carrier Power – 2481MHz Channel



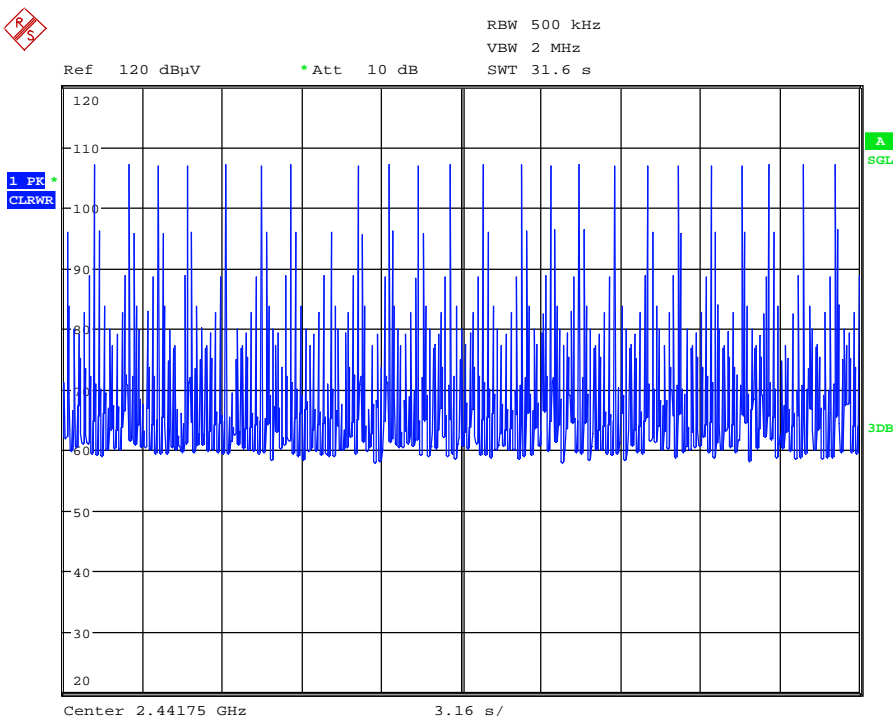
Date: 7.AUG.2012 13:29:39

Channel Separation



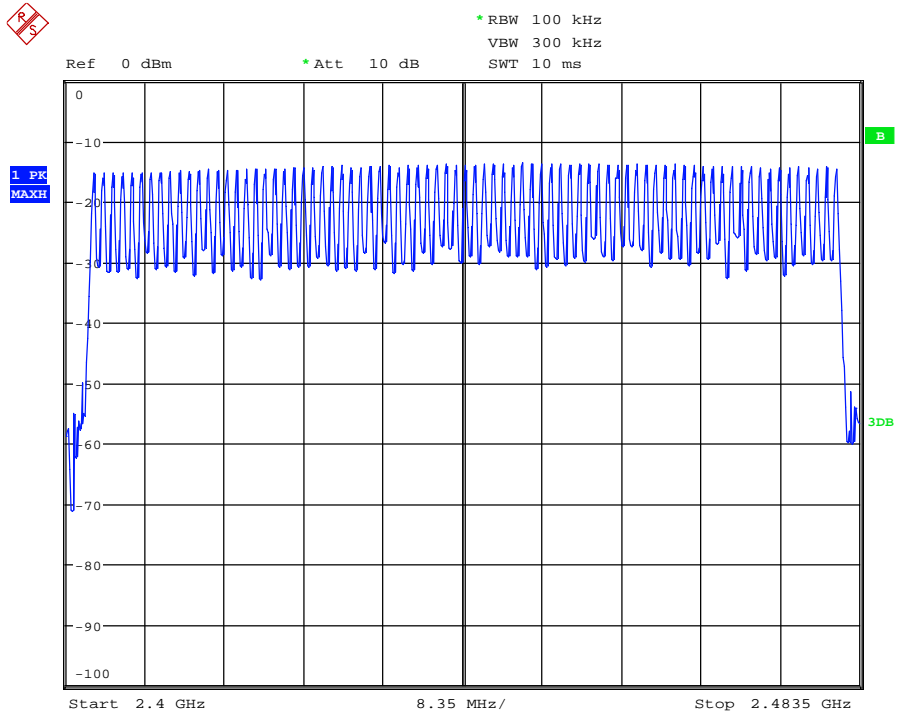
Date: 1.AUG.2012 08:55:29

Channel Repetitions



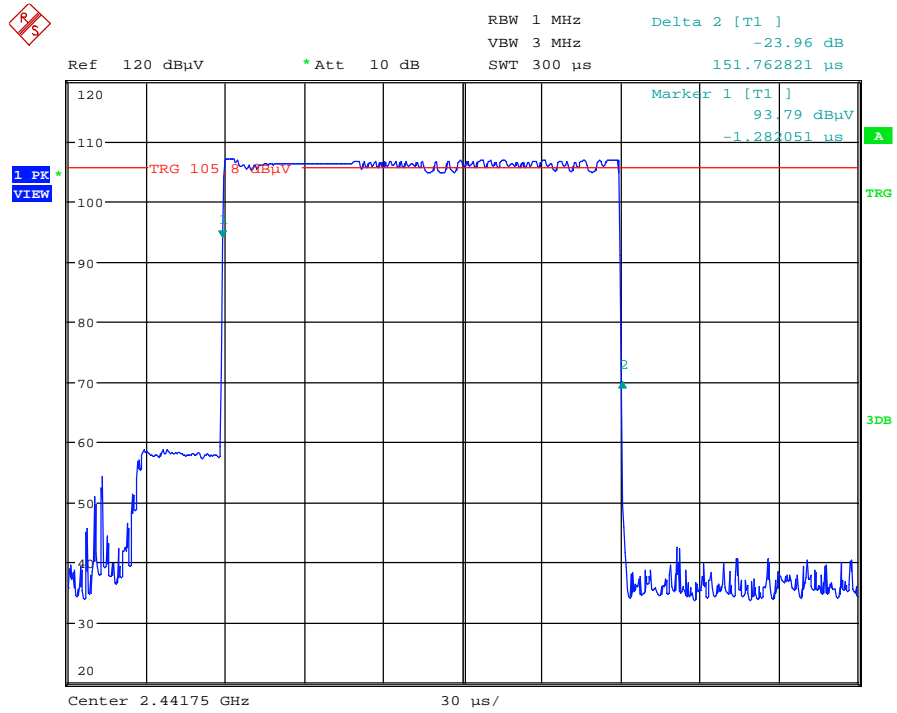
Date: 7.AUG.2012 15:17:25

Total Number of Hopping Channels



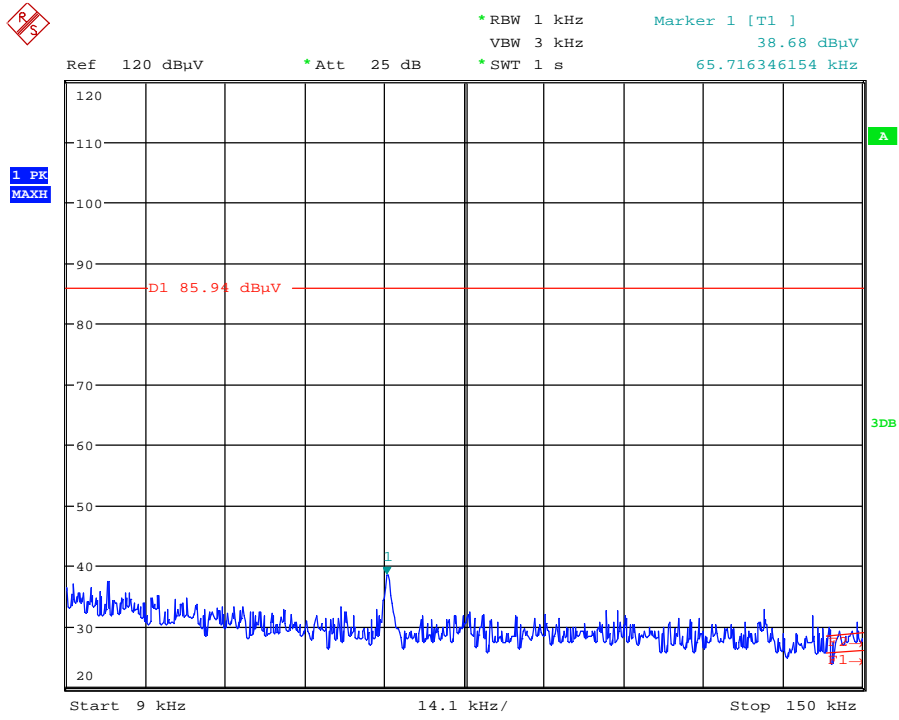
Date: 1.AUG.2012 08:57:26

Channel Dwell Time (Normal mode, partnered with RMI)



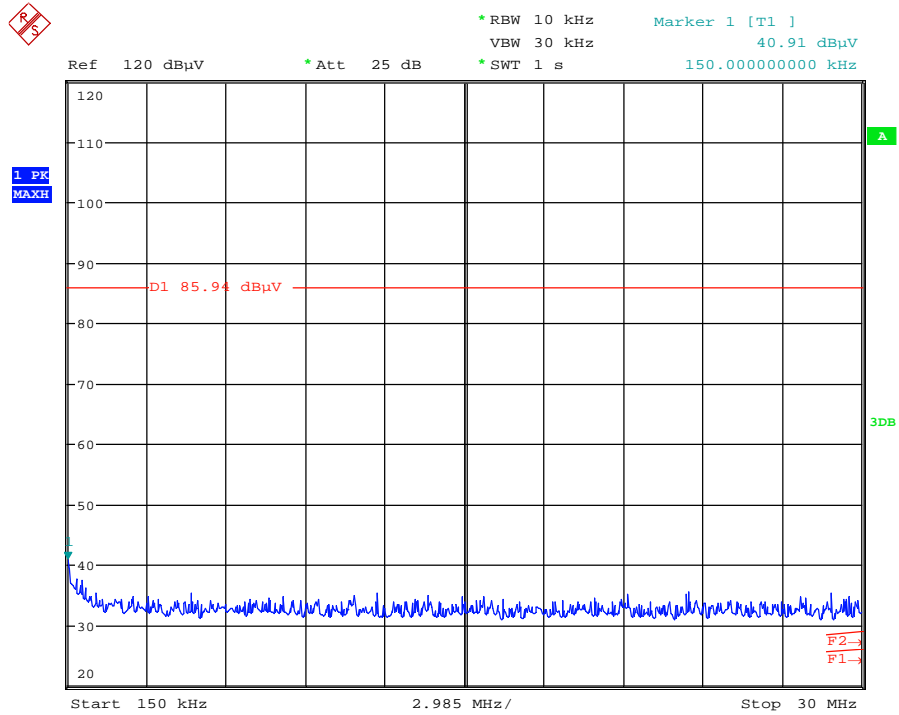
Date: 7.AUG.2012 15:07:56

Conducted Spurious Emissions 9kHz to 150kHz



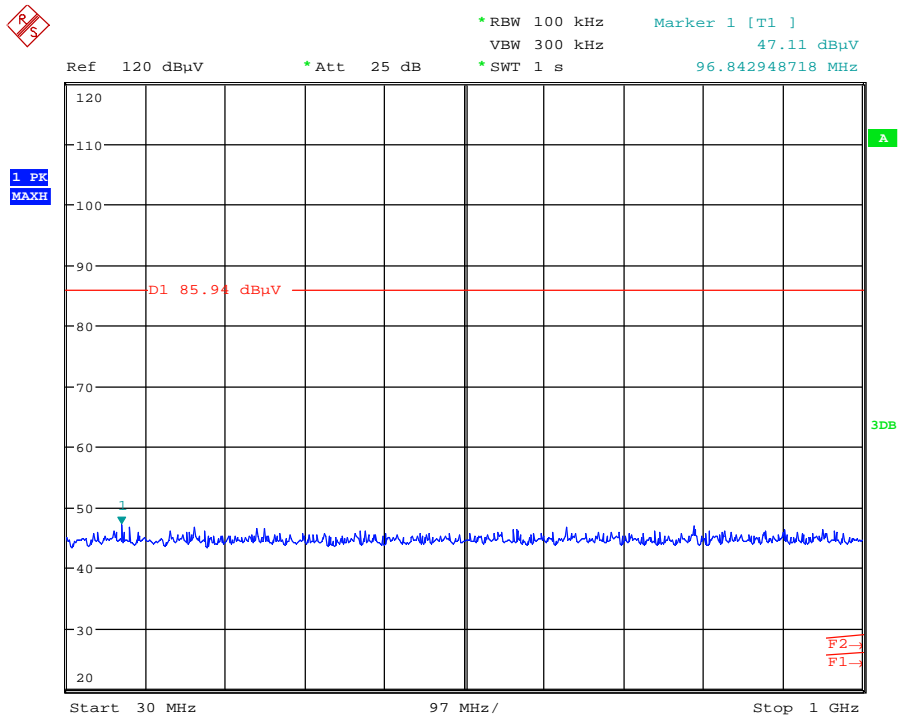
Date: 7.AUG.2012 13:39:38

Conducted Spurious Emissions 150kHz to 30MHz



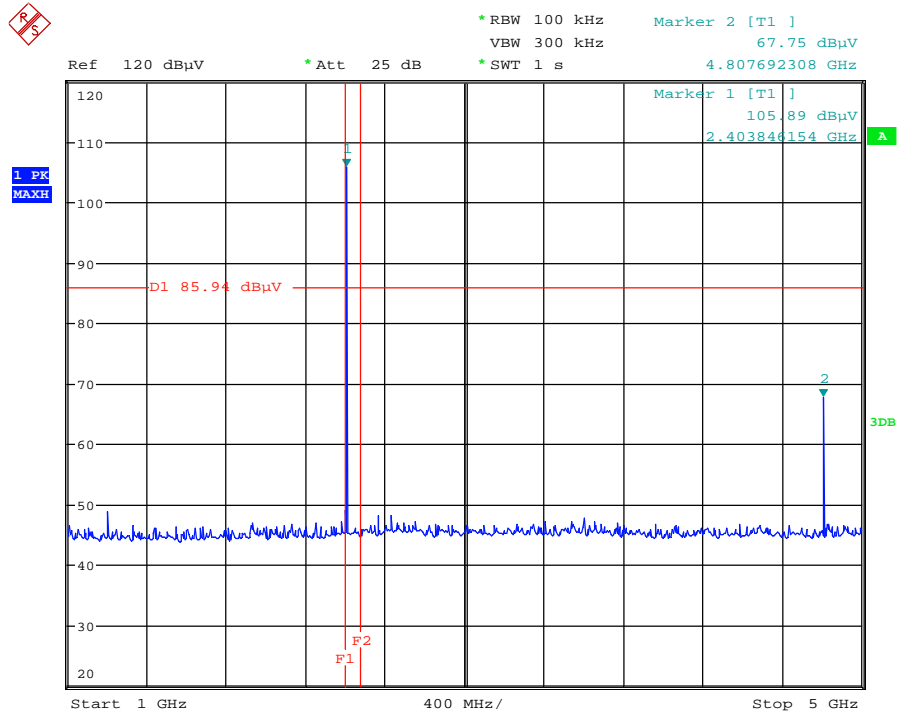
Date: 7.AUG.2012 13:39:54

Conducted Spurious Emissions 30MHz to 1GHz



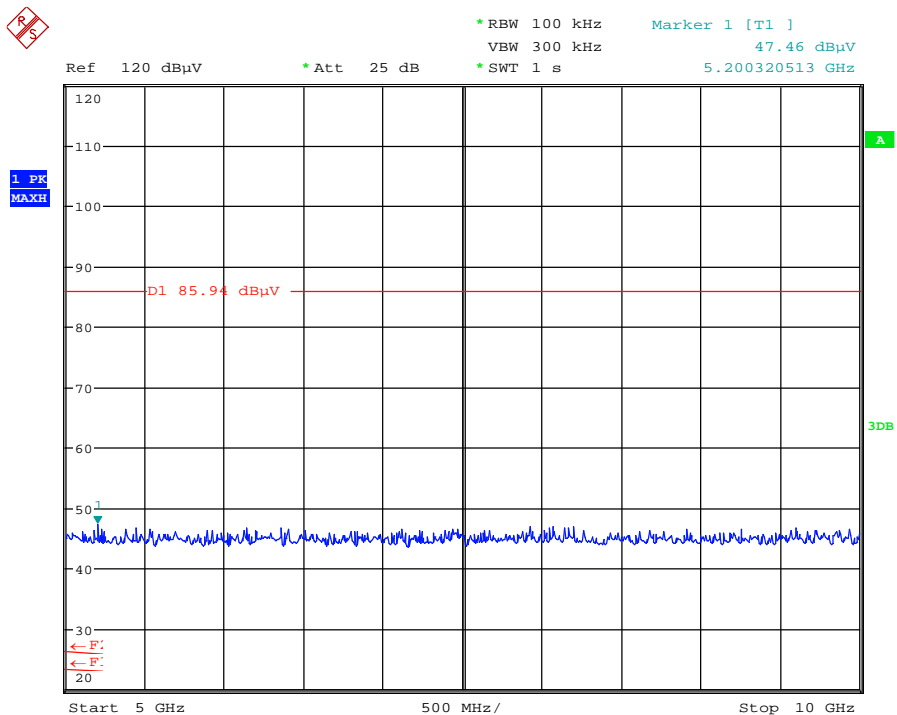
Date: 7.AUG.2012 13:40:11

Conducted Spurious Emissions 1GHz to 5GHz



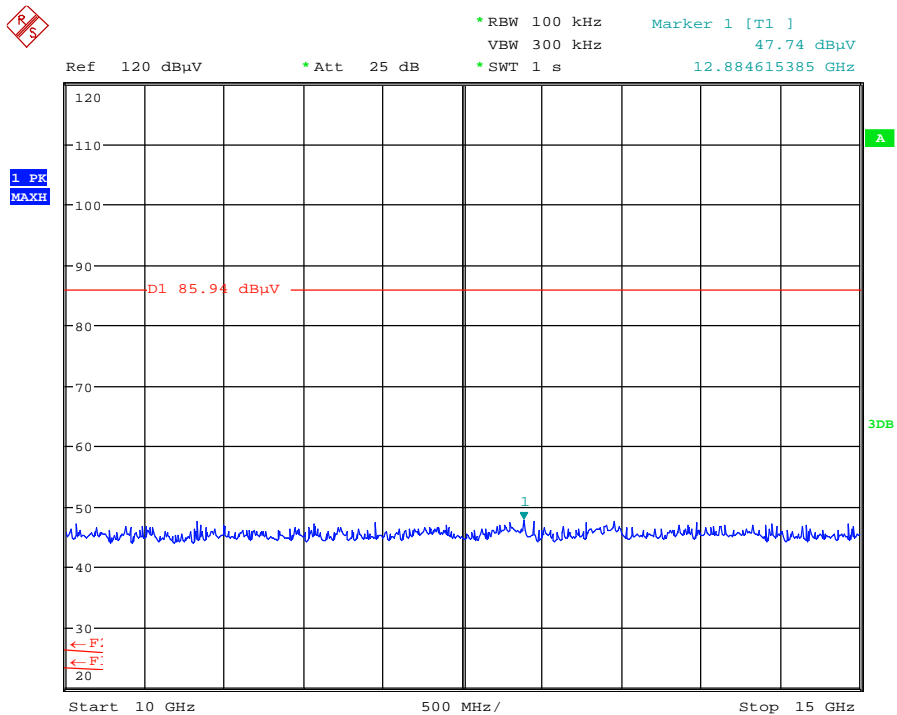
Date: 7.AUG.2012 13:37:47

Conducted Spurious Emissions 5GHz to 10GHz



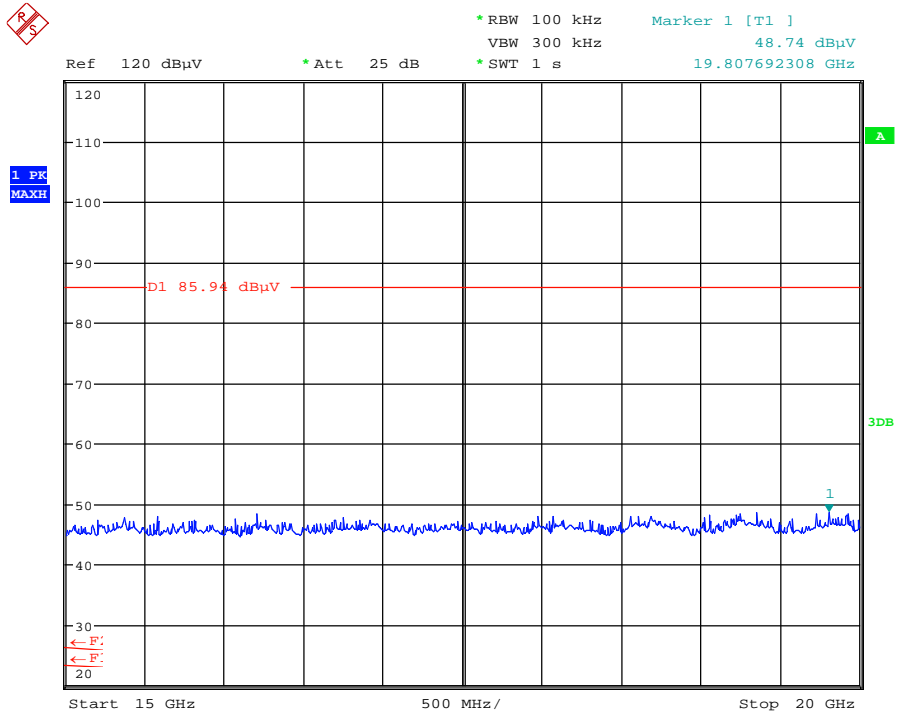
Date: 7.AUG.2012 13:38:05

Conducted Spurious Emissions 10GHz to 15GHz



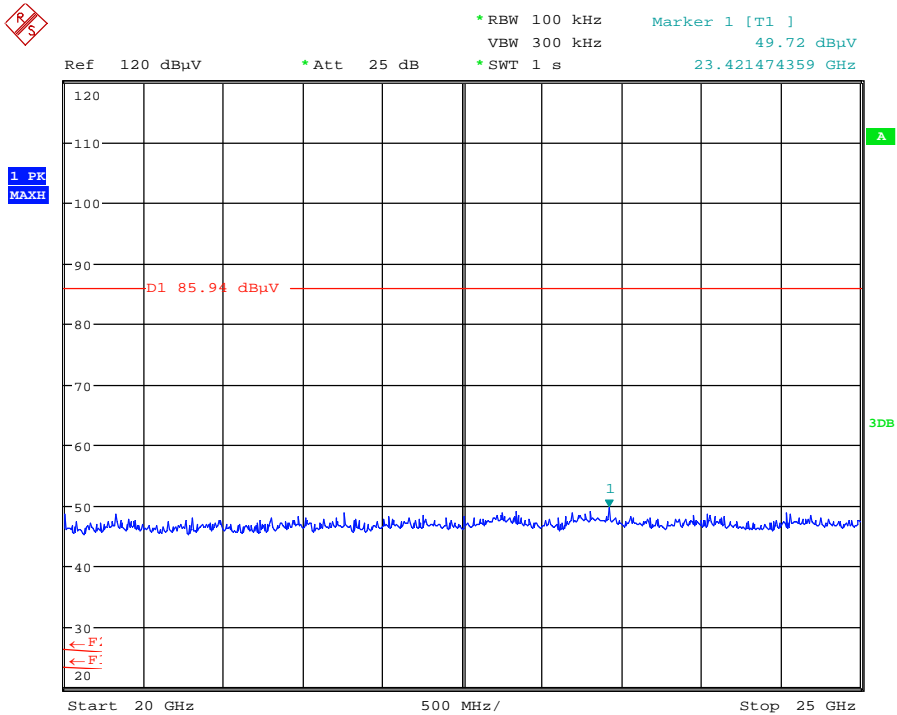
Date: 7.AUG.2012 13:38:22

Conducted Spurious Emissions 15GHz to 20GHz



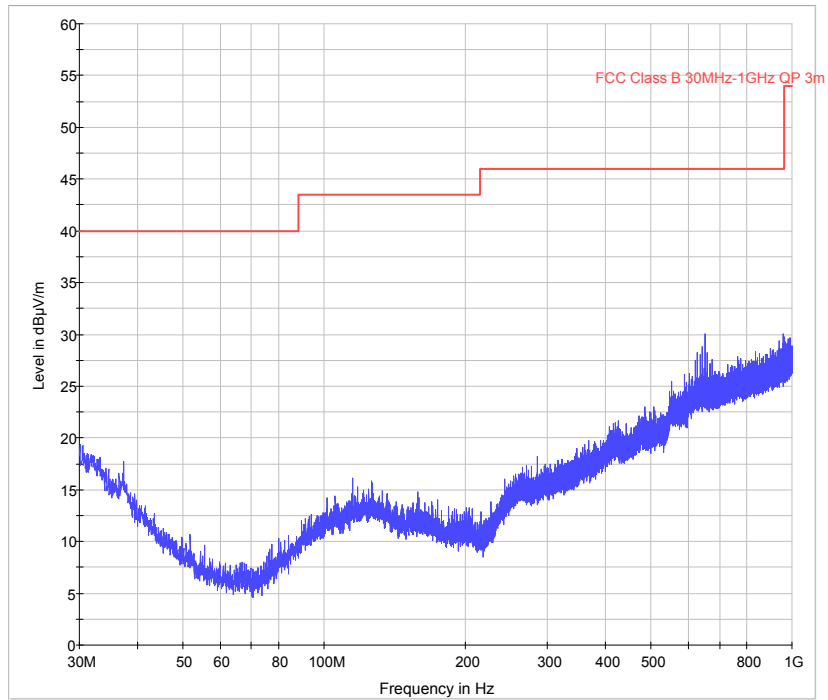
Date: 7.AUG.2012 13:38:43

Conducted Spurious Emissions 20GHz to 25GHz

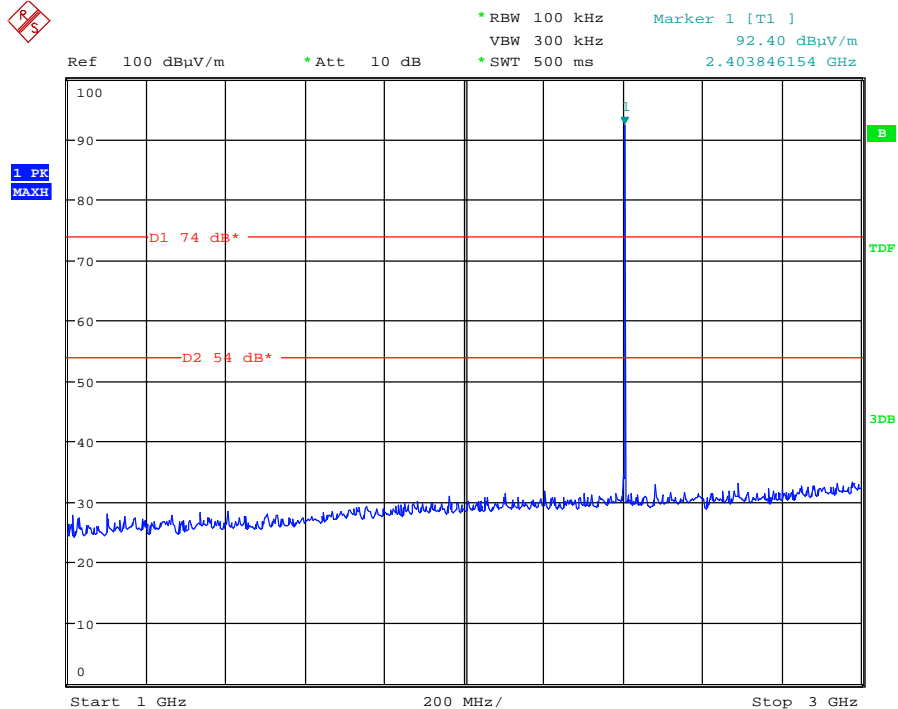


Date: 7.AUG.2012 13:39:25

RMP60 Radiated Spurious Emissions 30MHz to 1GHz – 2403MHz

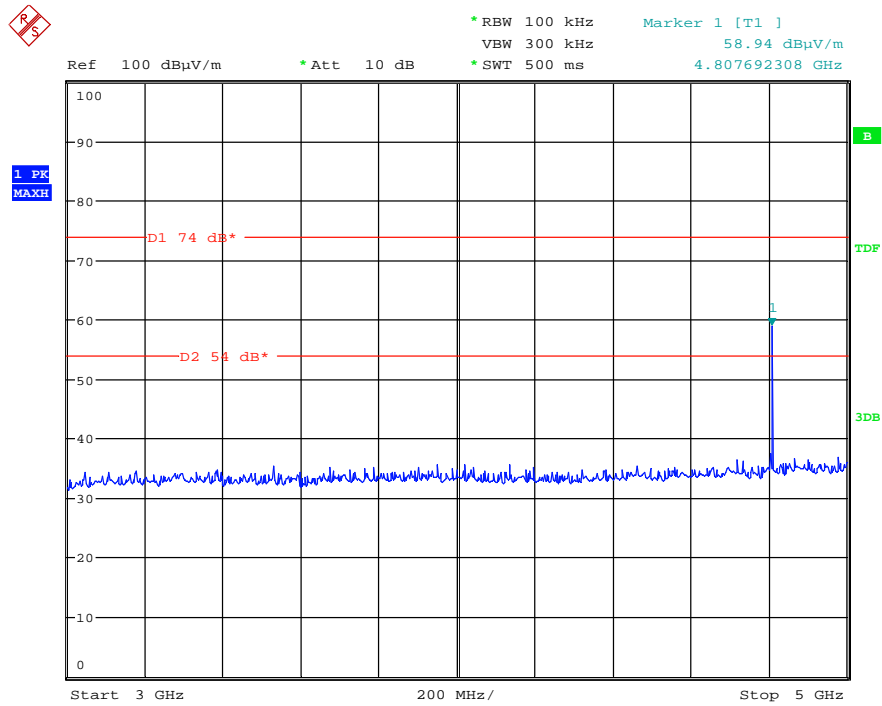


RMP60 Radiated Spurious Emissions 1GHz to 3GHz – 2403MHz



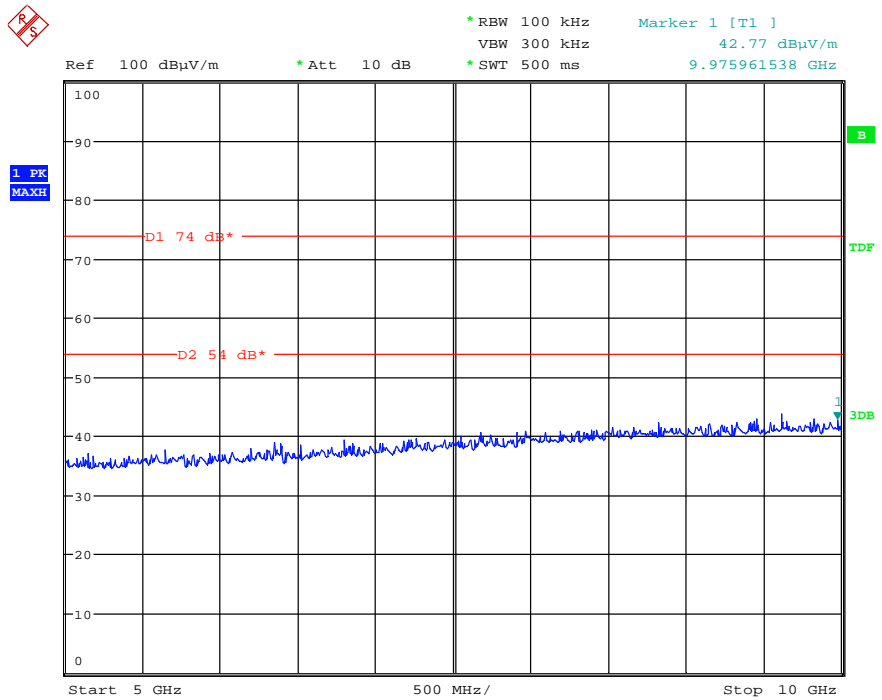
Date: 30.JUL.2012 10:34:49

RMP60 Radiated Spurious Emissions 3GHz to 5GHz – 2403MHz



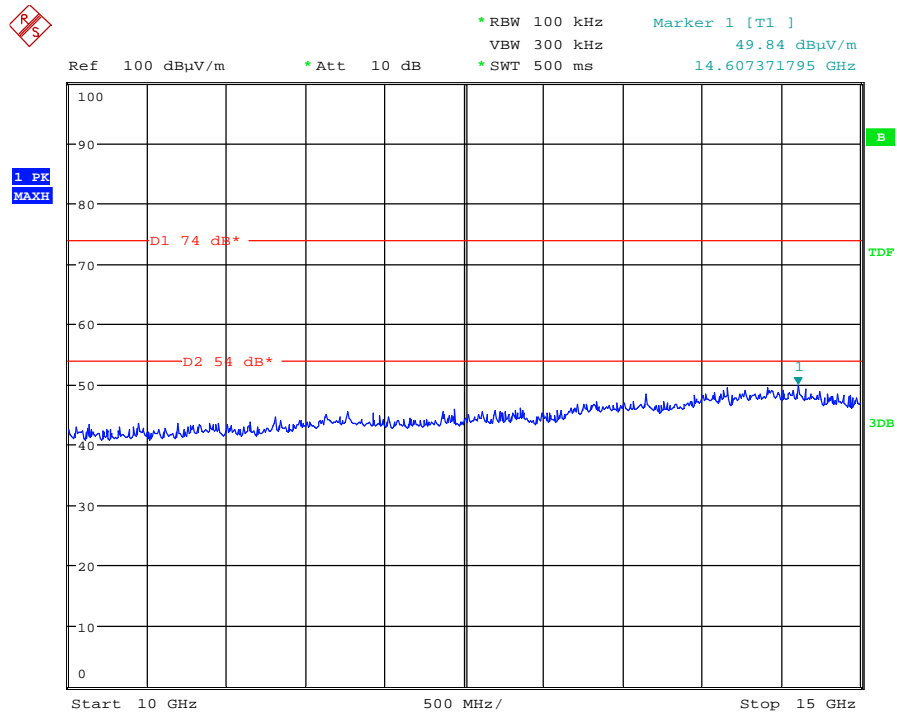
Date: 30.JUL.2012 10:35:12

RMP60 Radiated Spurious Emissions 5GHz to 10GHz – 2403MHz



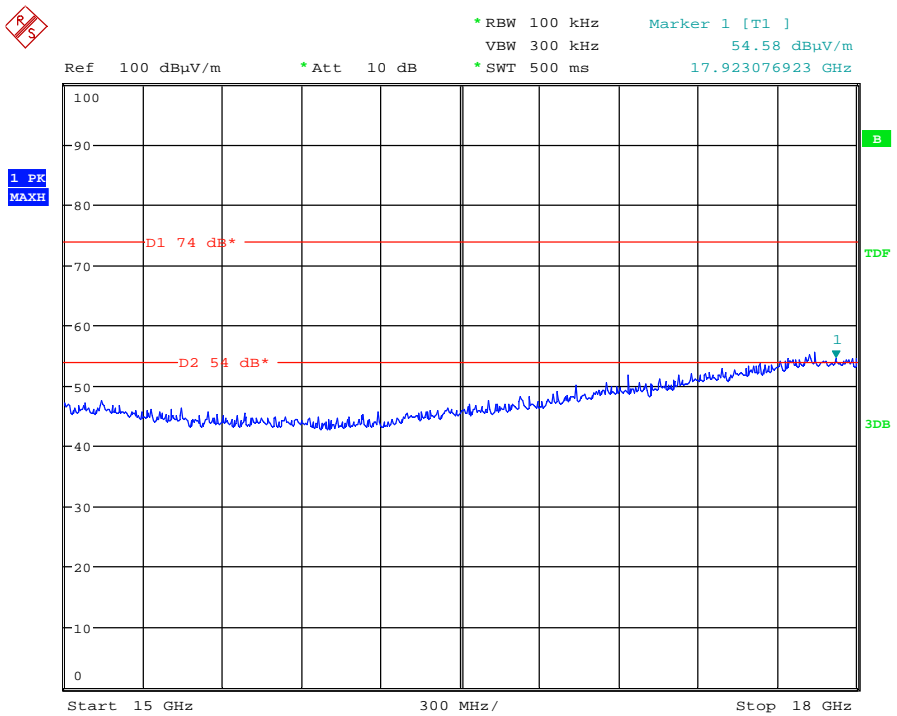
Date: 30.JUL.2012 10:35:39

RMP60 Radiated Spurious Emissions 10GHz to 15GHz – 2403MHz



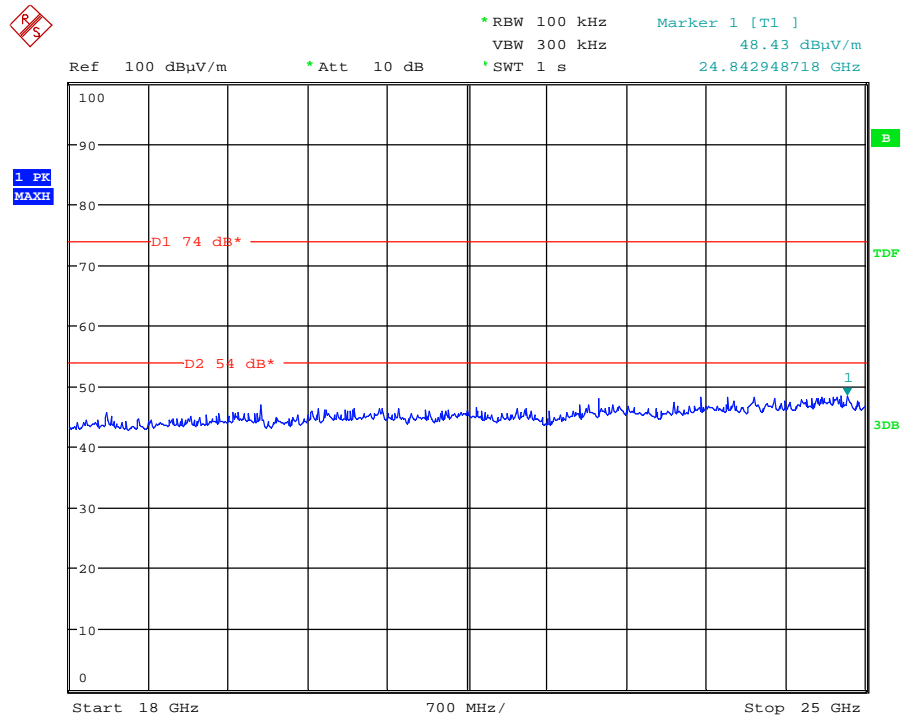
Date: 30.JUL.2012 10:36:15

RMP60 Radiated Spurious Emissions 15GHz to 18GHz – 2403MHz



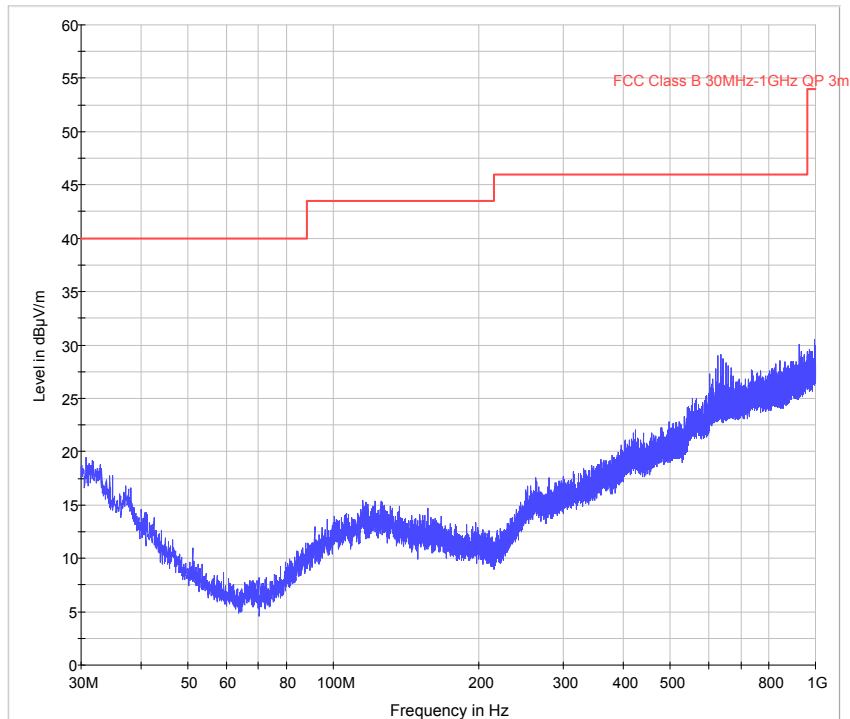
Date: 30.JUL.2012 10:36:49

RMP60 Radiated Spurious Emissions 18GHz to 25GHz – 2403MHz

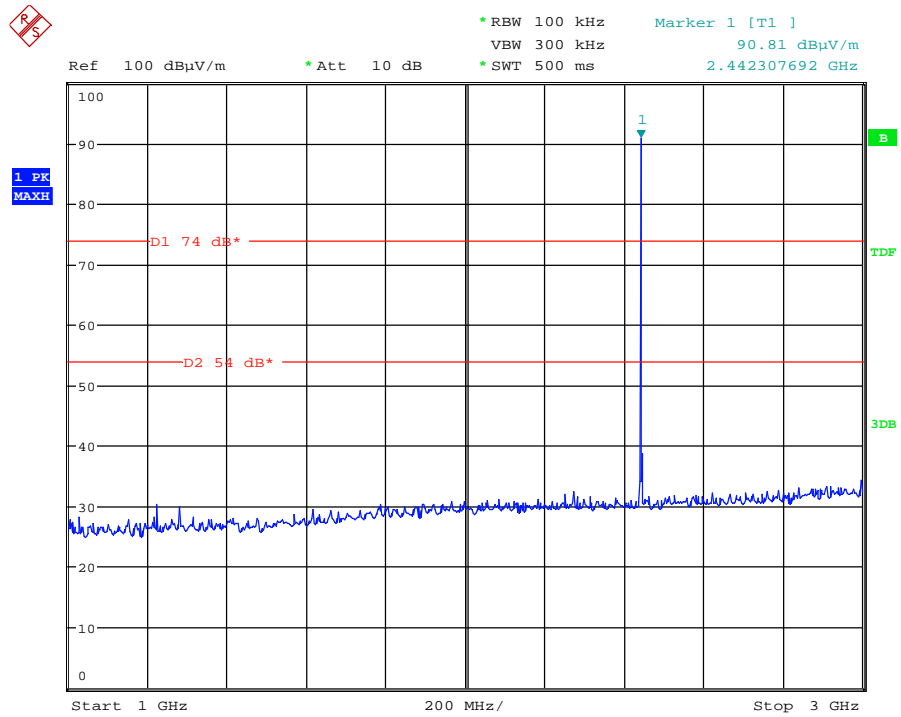


Date: 30.JUL.2012 11:20:08

RMP60 Radiated Spurious Emissions 30MHz to 1GHz – 2442MHz

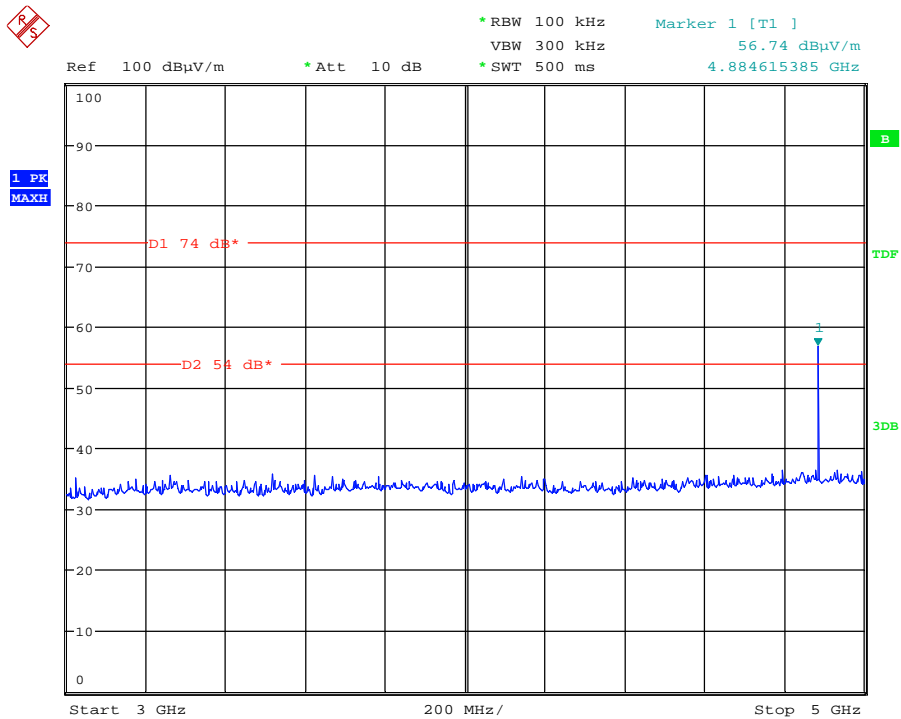


RMP60 Radiated Spurious Emissions 1GHz to 3GHz – 2442MHz



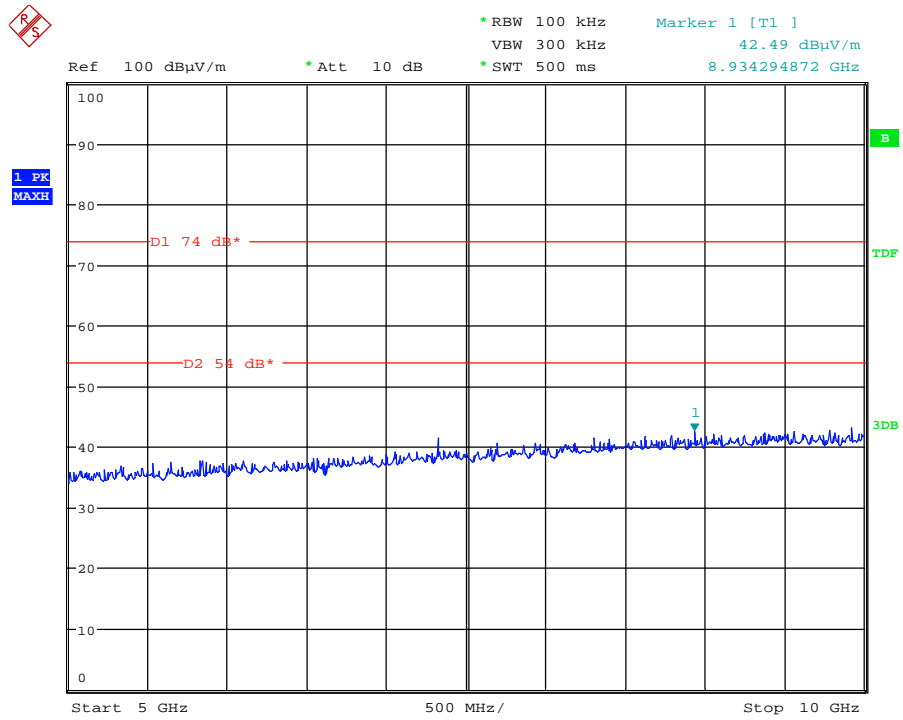
Date: 30.JUL.2012 10:45:34

RMP60 Radiated Spurious Emissions 3GHz to 5GHz – 2442MHz



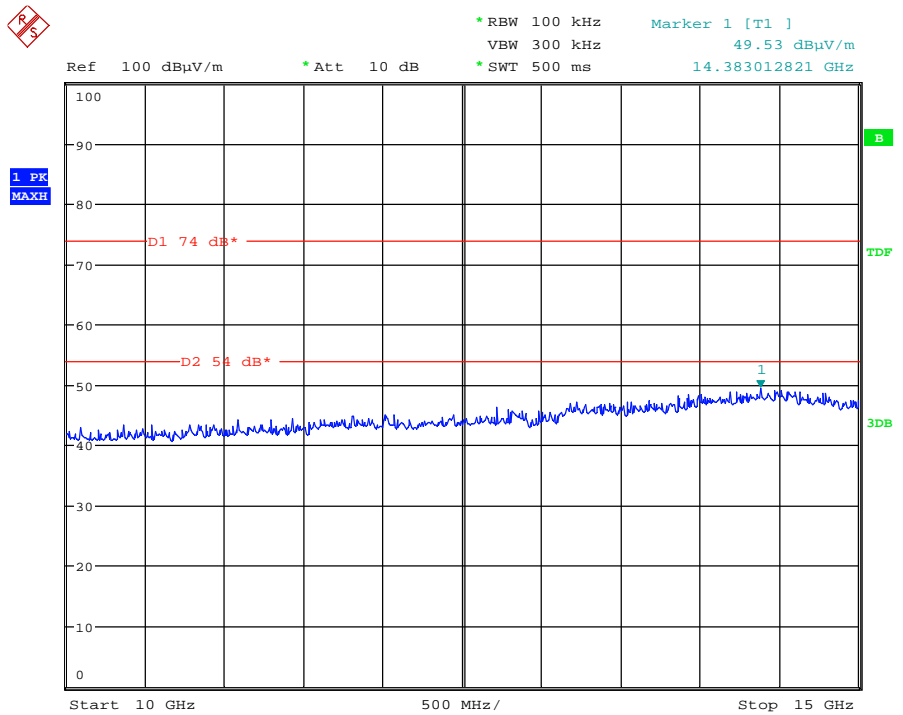
Date: 30.JUL.2012 10:46:03

RMP60 Radiated Spurious Emissions 5GHz to 10GHz – 2442MHz



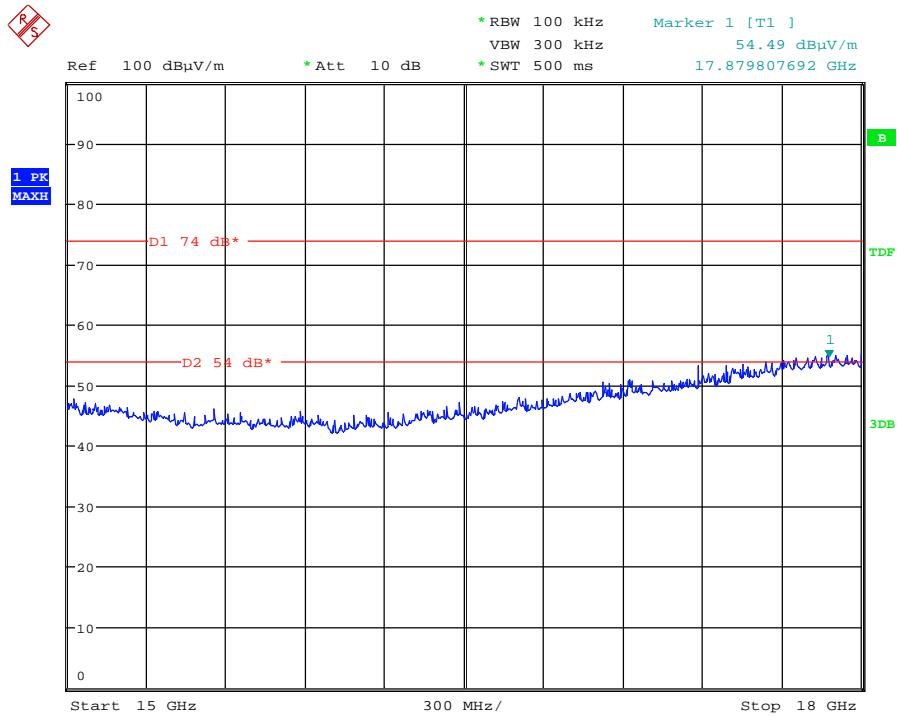
Date: 30.JUL.2012 10:46:28

RMP60 Radiated Spurious Emissions 10GHz to 15GHz – 2442MHz



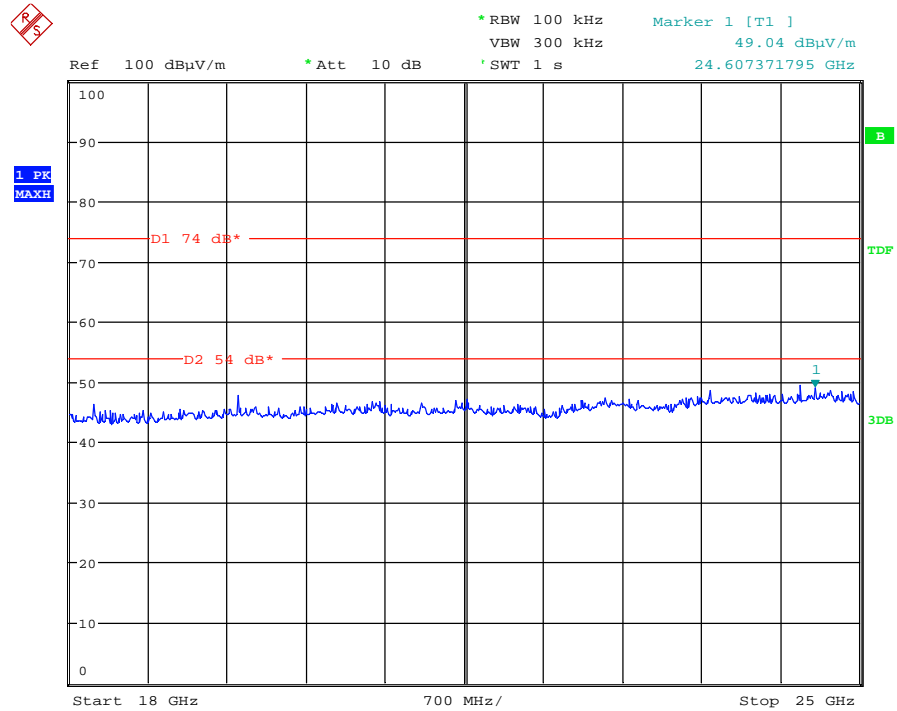
Date: 30.JUL.2012 10:46:54

RMP60 Radiated Spurious Emissions 15GHz to 18GHz – 2442MHz



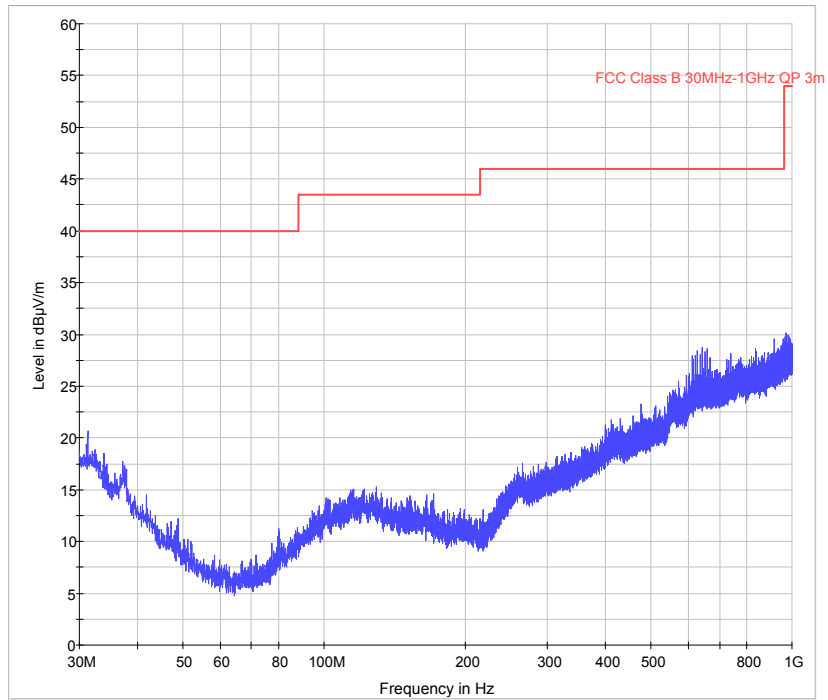
Date: 30.JUL.2012 10:47:19

RMP60 Radiated Spurious Emissions 18GHz to 25GHz – 2442MHz

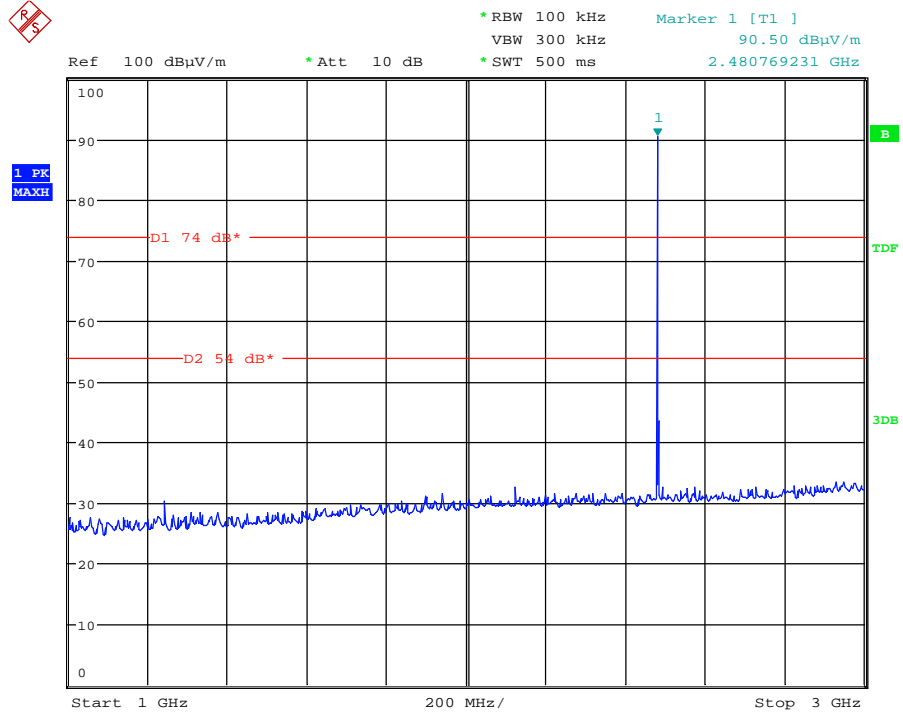


Date: 30.JUL.2012 11:22:50

RMP60 Radiated Spurious Emissions 30MHz to 1GHz – 2481MHz

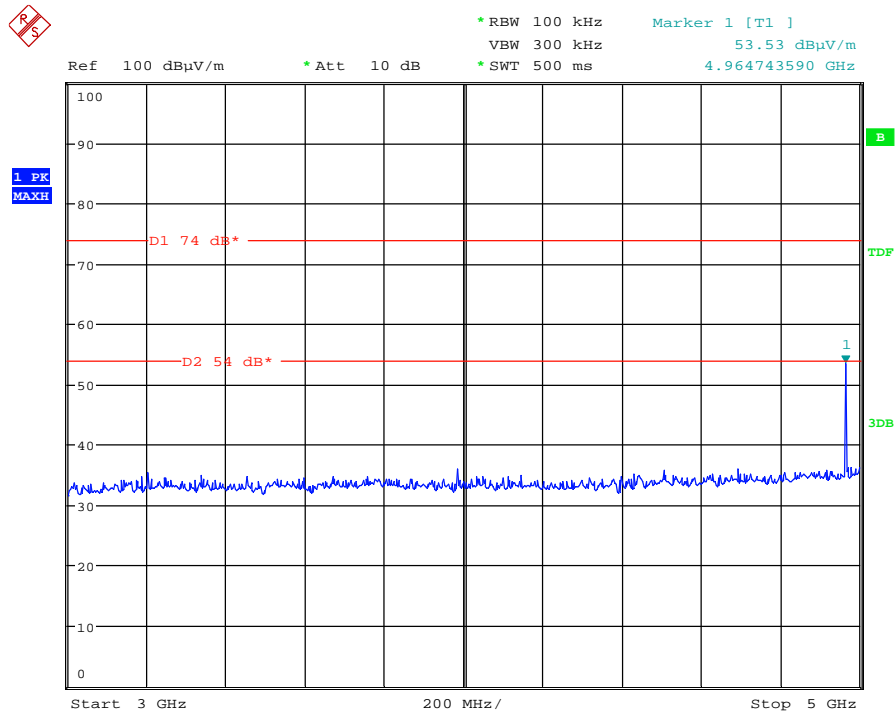


RMP60 Radiated Spurious Emissions 1GHz to 3GHz – 2481MHz



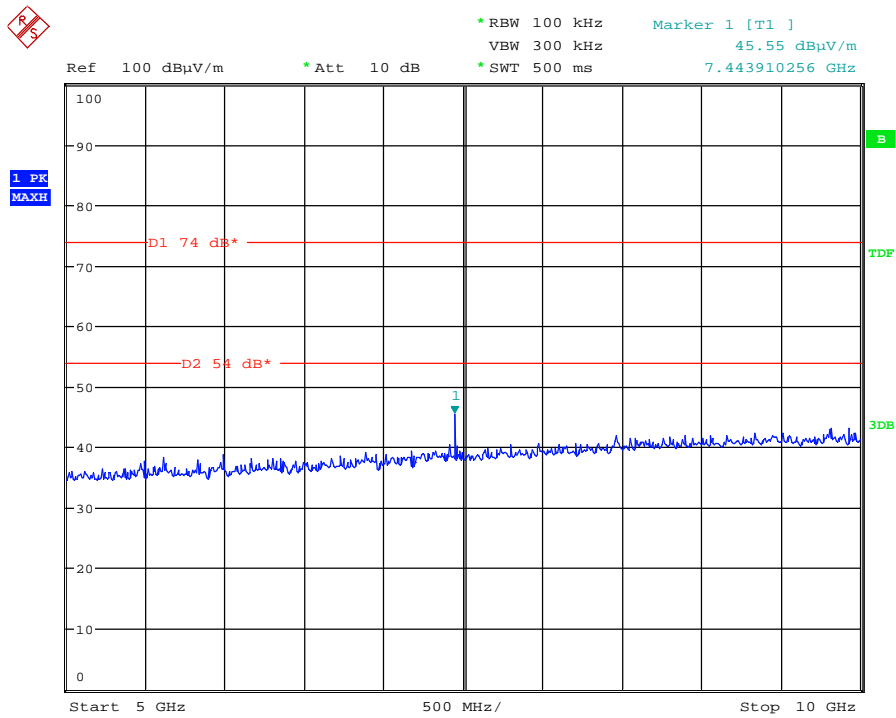
Date: 30.JUL.2012 10:51:27

RMP60 Radiated Spurious Emissions 3GHz to 5GHz – 2481MHz



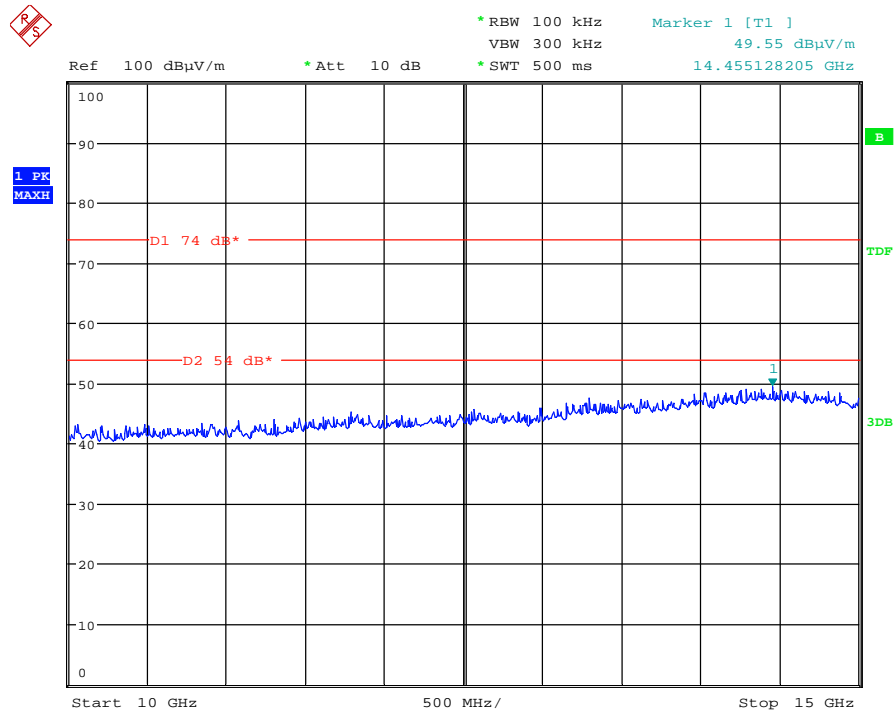
Date: 30.JUL.2012 10:51:48

RMP60 Radiated Spurious Emissions 5GHz to 10GHz – 2481MHz



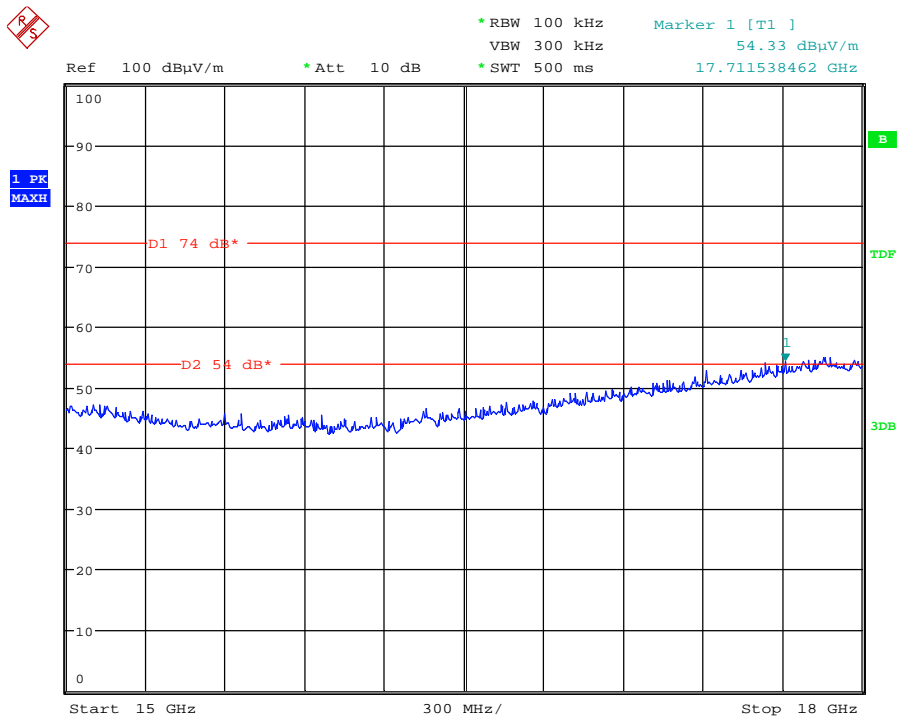
Date: 30.JUL.2012 10:52:30

RMP60 Radiated Spurious Emissions 10GHz to 15GHz – 2481MHz



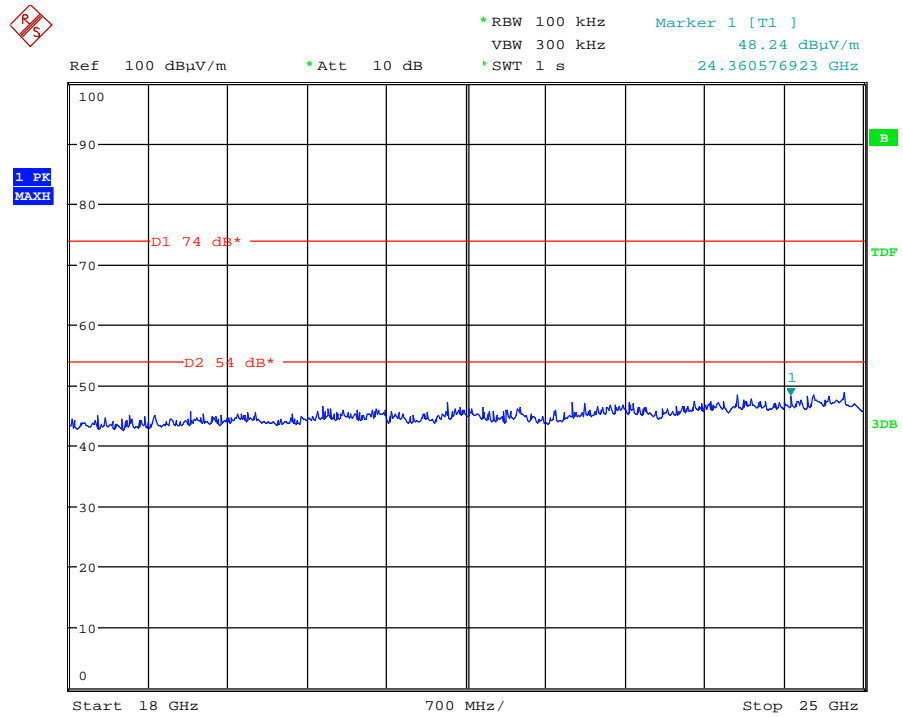
Date: 30.JUL.2012 10:52:56

RMP60 Radiated Spurious Emissions 15GHz to 18GHz – 2481MHz



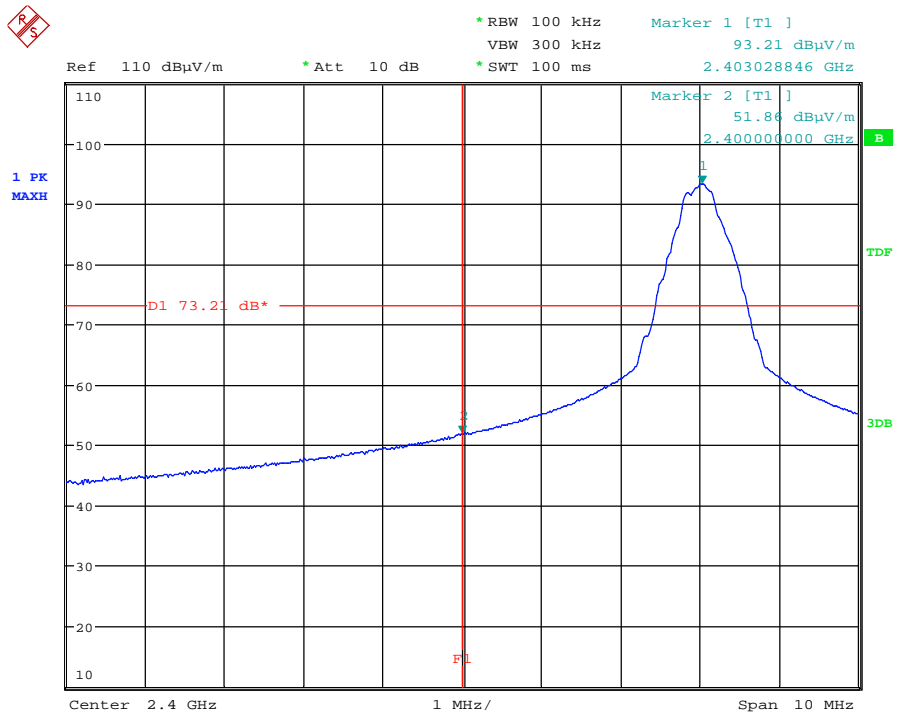
Date: 30.JUL.2012 10:53:21

RMP60 Radiated Spurious Emissions 18GHz to 25GHz – 2481MHz



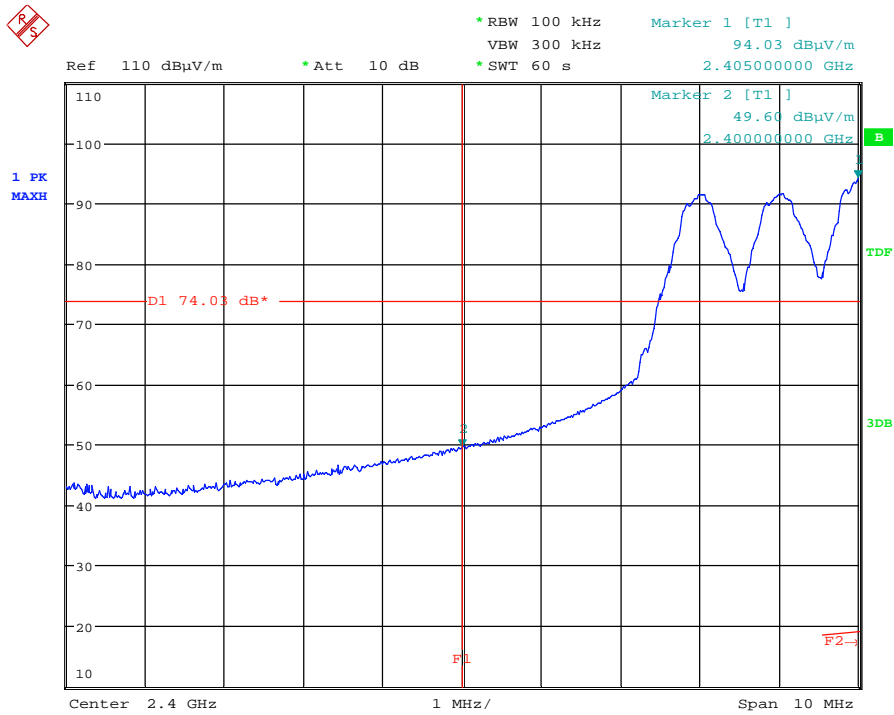
Date: 30.JUL.2012 11:25:12

RMP60 Radiated Lower Band-edge Compliance



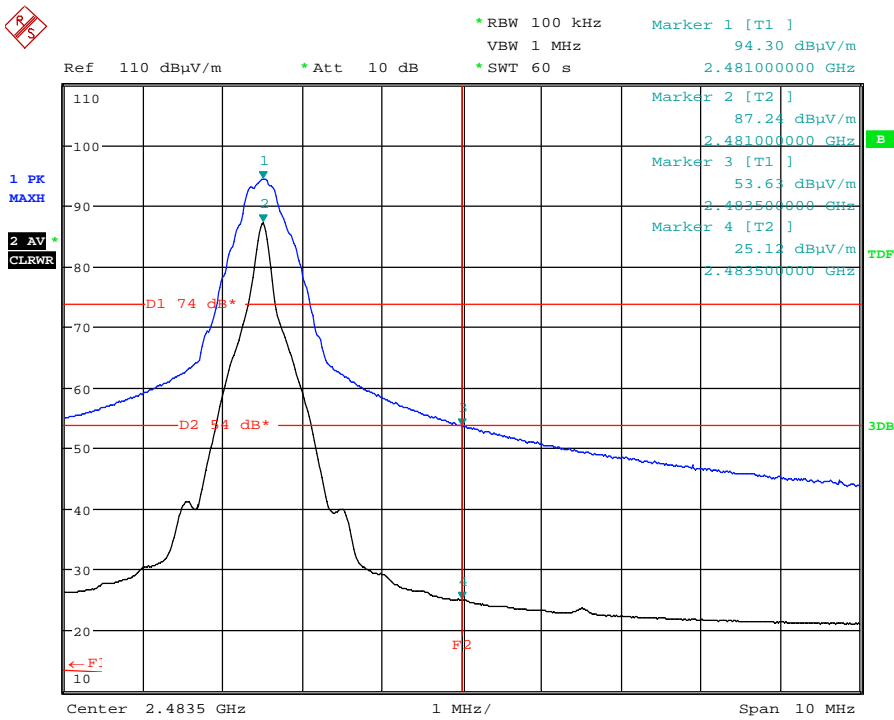
Date: 3.AUG.2012 15:18:13

RMP60 Radiated Lower Band-edge Compliance – Hopping mode



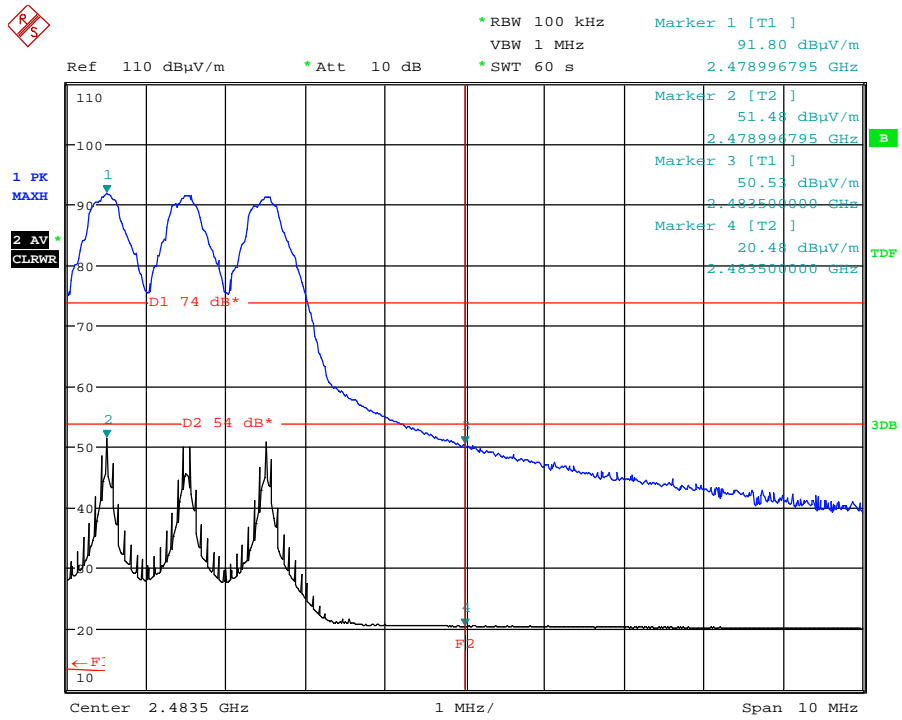
Date: 3.AUG.2012 15:34:03

RMP60 Radiated Upper Band-edge Compliance



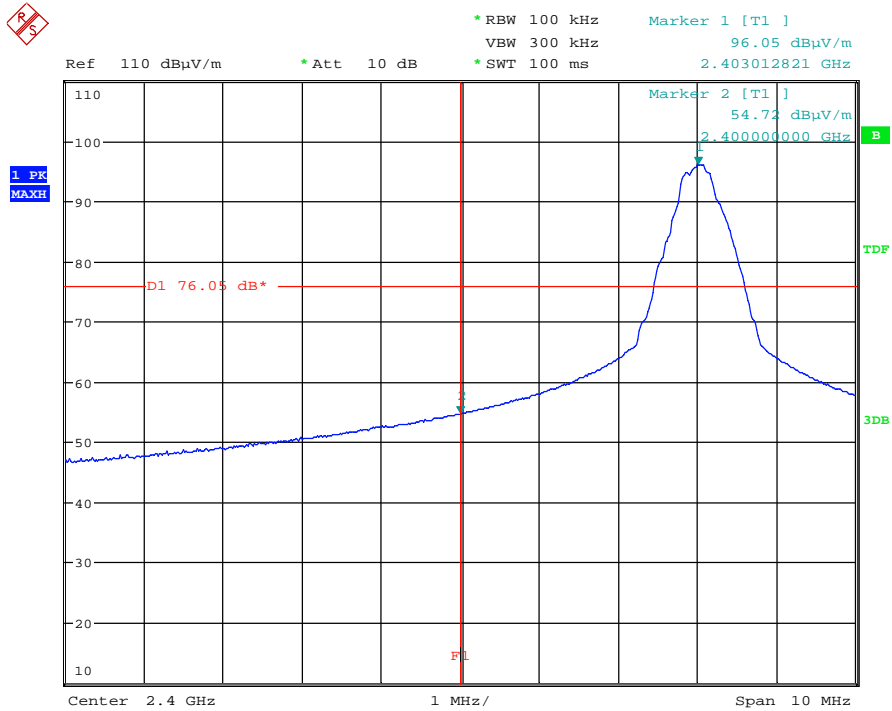
Date: 3.AUG.2012 15:25:12

RMP60 Radiated Lower Band-edge Compliance – Hopping mode



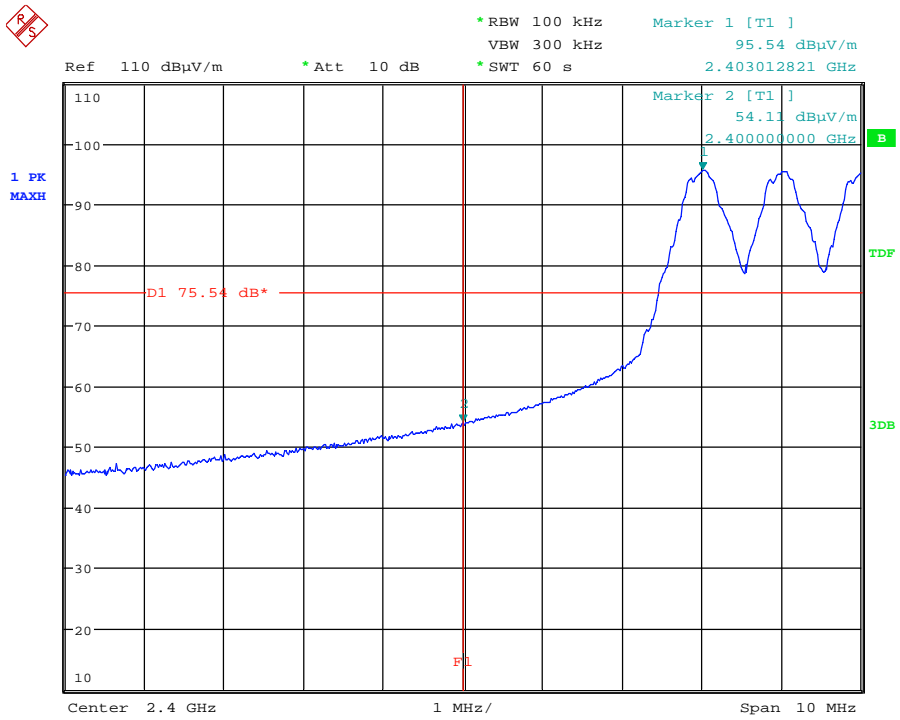
Date: 3.AUG.2012 15:28:29

RMP60M Radiated Lower Band-edge Compliance



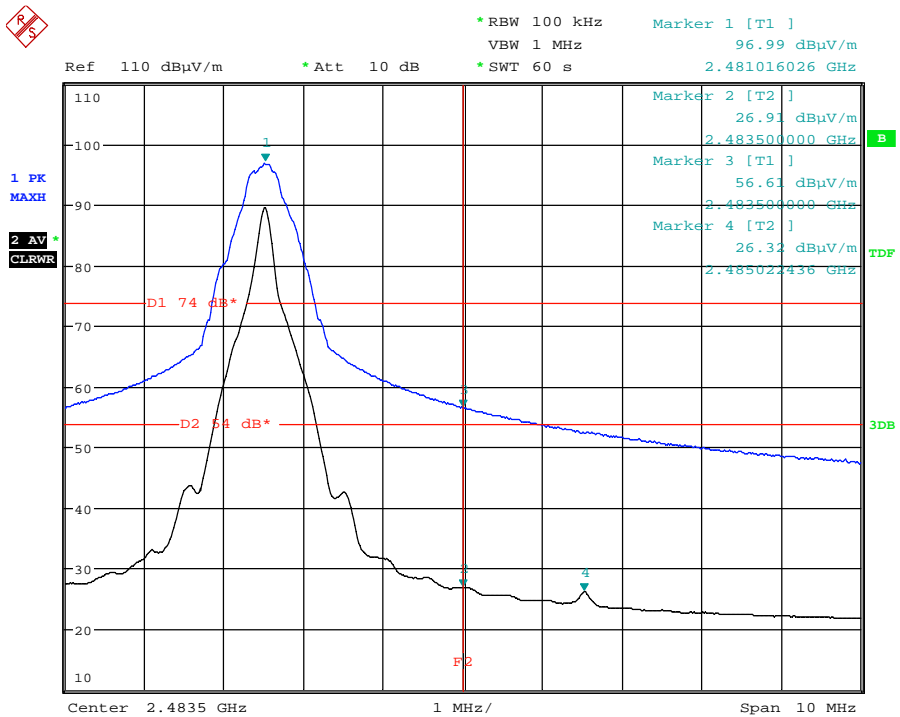
Date: 3.AUG.2012 14:53:33

RMP60M Radiated Lower Band-edge Compliance – Hopping mode



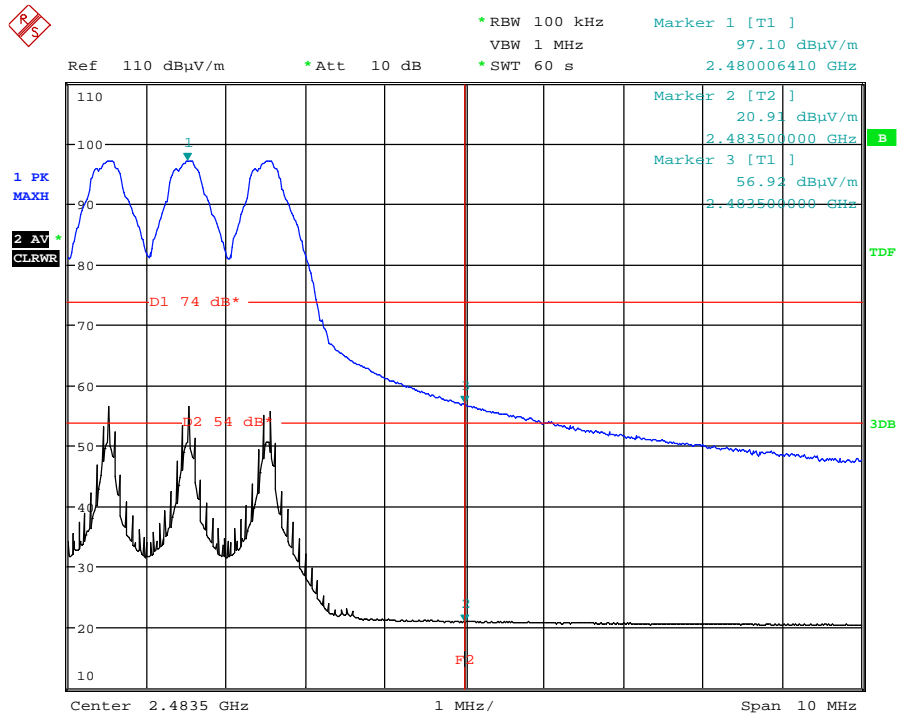
Date: 3.AUG.2012 15:08:17

RMP60M Radiated Upper Band-edge Compliance



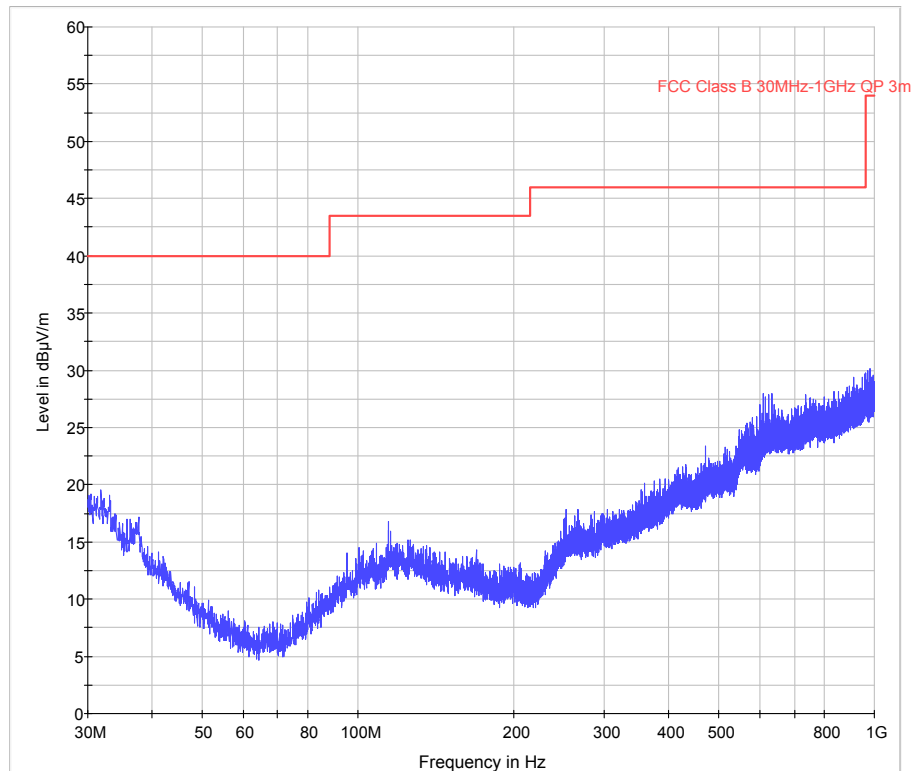
Date: 3.AUG.2012 14:59:55

RMP60M Radiated Upper Band-edge Compliance – Hopping mode

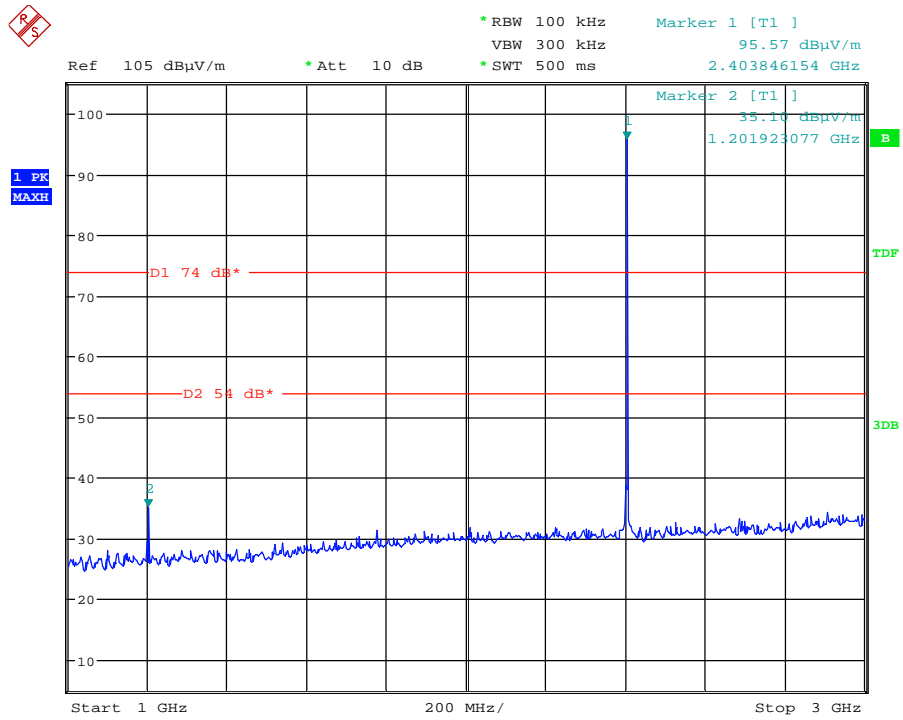


Date: 3.AUG.2012 15:03:45

RMP60M Radiated Spurious Emissions 30MHz to 1GHz – 2403MHz

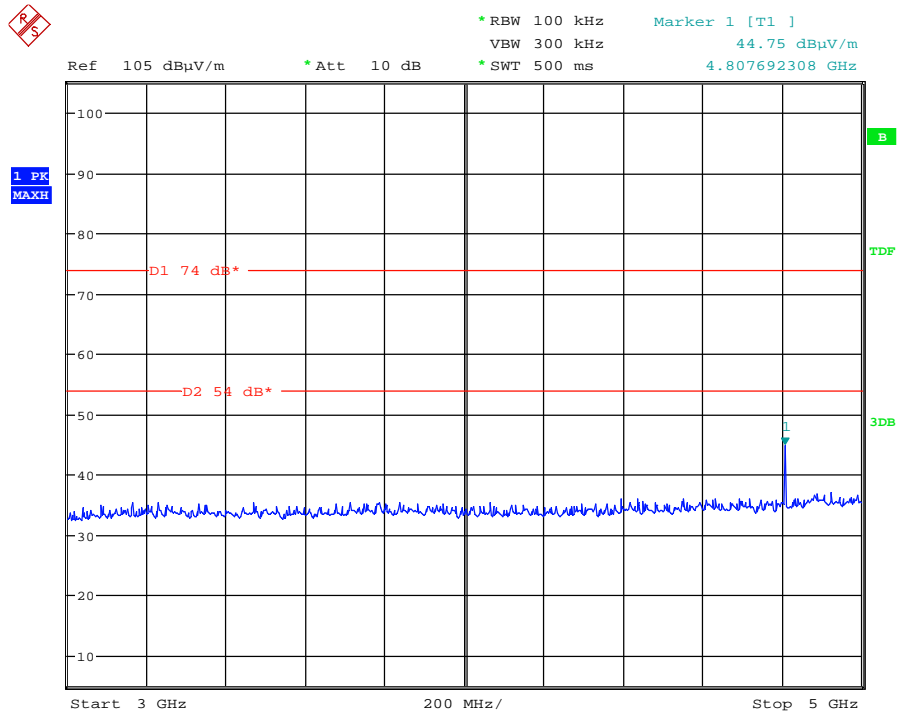


RMP60M Radiated Spurious Emissions 1GHz to 3GHz – 2403MHz



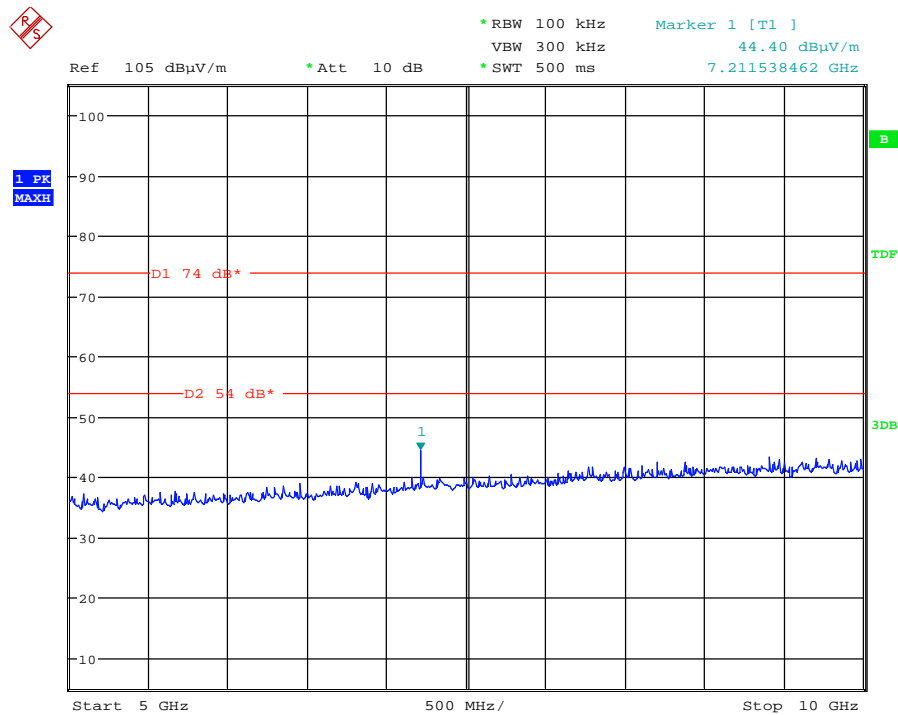
Date: 30.JUL.2012 11:55:25

RMP60M Radiated Spurious Emissions 3GHz to 5GHz – 2403MHz



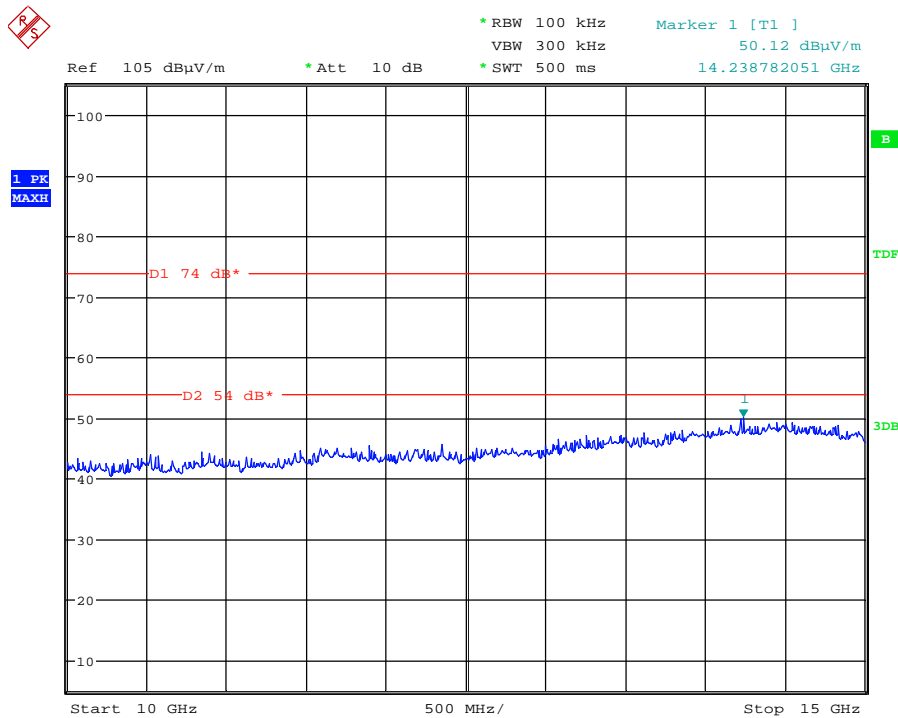
Date: 30.JUL.2012 11:56:04

RMP60M Radiated Spurious Emissions 5GHz to 10GHz – 2403MHz



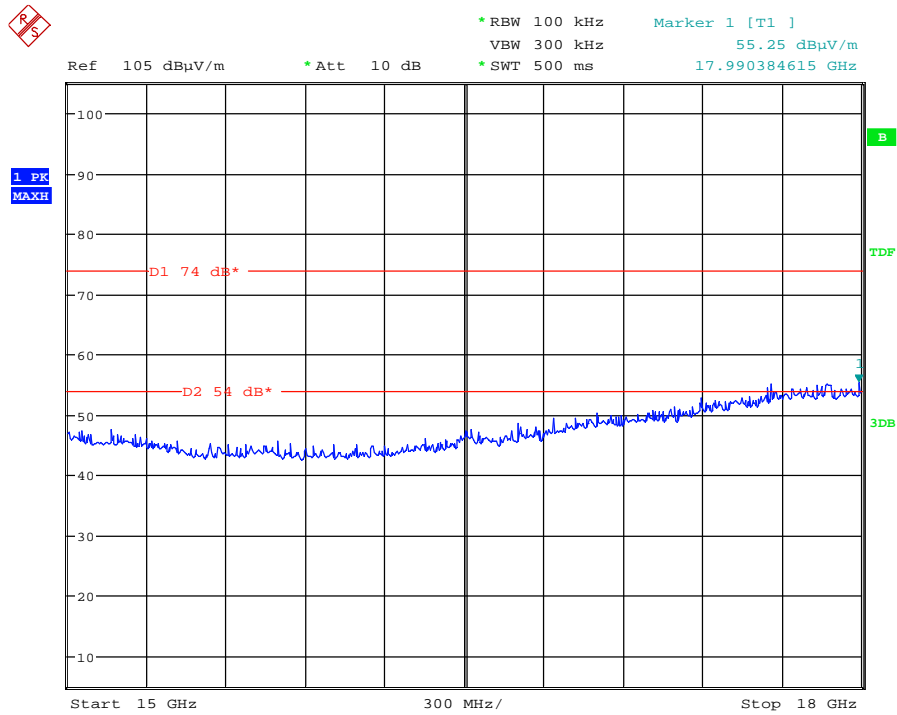
Date: 30.JUL.2012 11:56:37

RMP60M Radiated Spurious Emissions 10GHz to 15GHz – 2403MHz



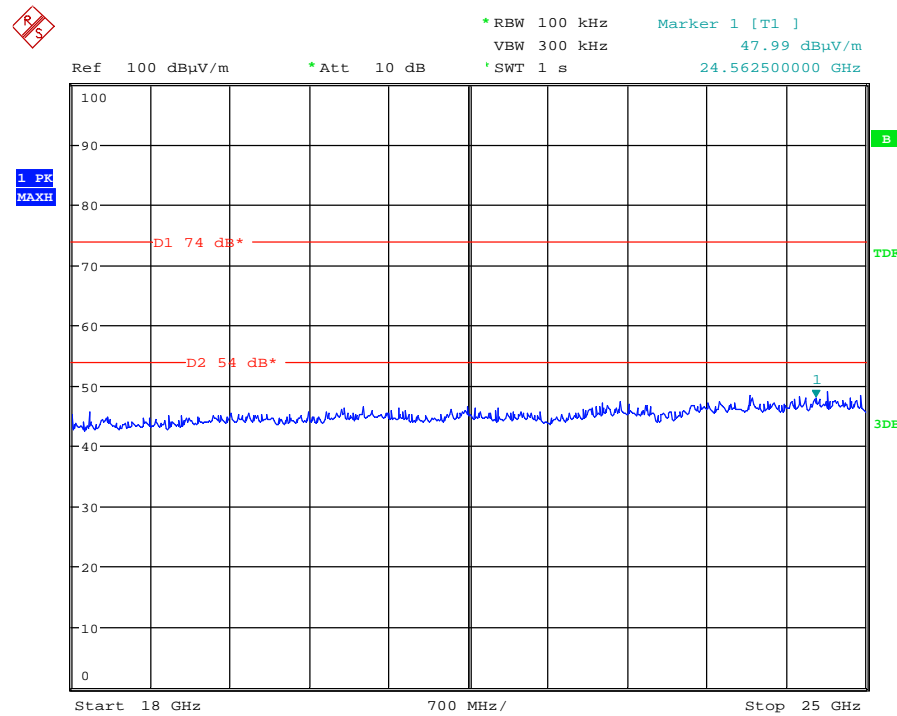
Date: 30.JUL.2012 11:57:16

RMP60M Radiated Spurious Emissions 15GHz to 18GHz – 2403MHz



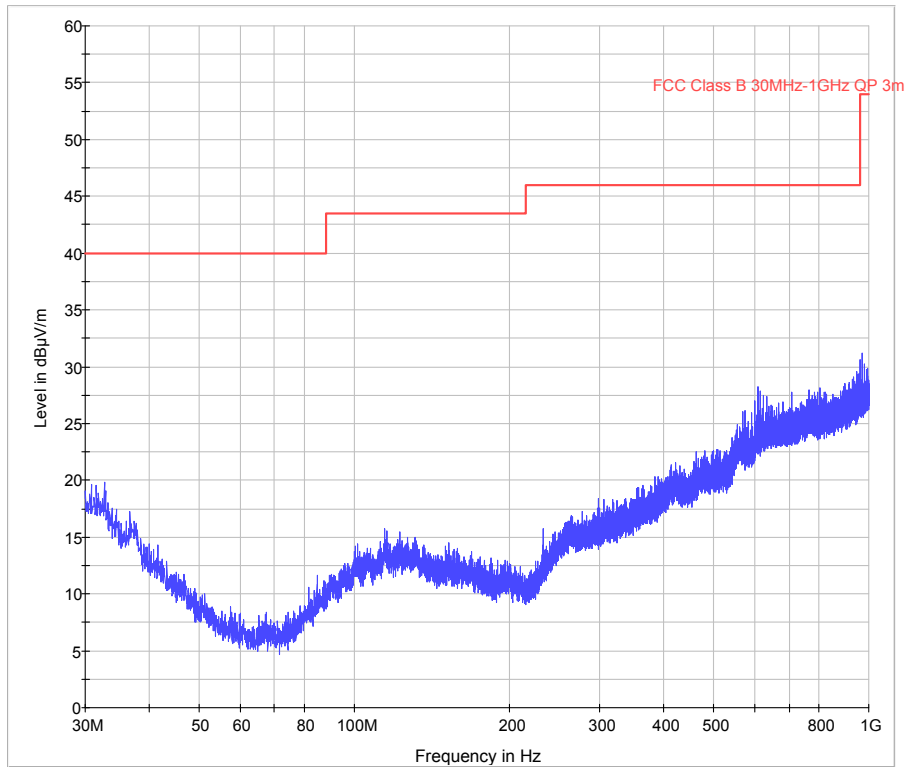
Date: 30.JUL.2012 11:58:02

RMP60M Radiated Spurious Emissions 18GHz to 25GHz – 2403MHz

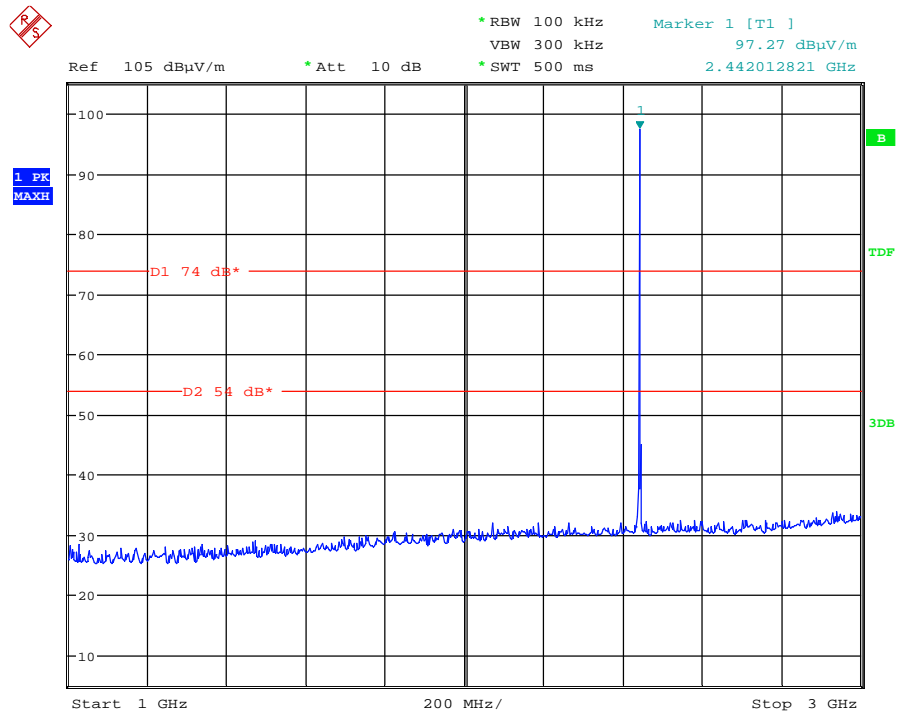


Date: 30.JUL.2012 11:40:57

RMP60M Radiated Spurious Emissions 30MHz to 1GHz – 2442MHz

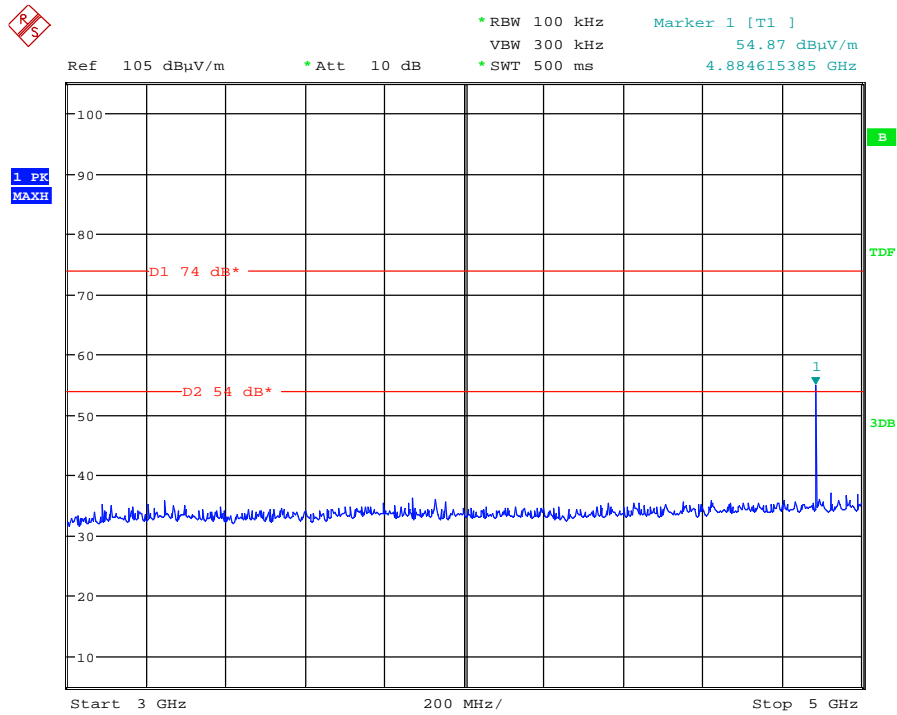


RMP60M Radiated Spurious Emissions 1GHz to 3GHz – 2442MHz



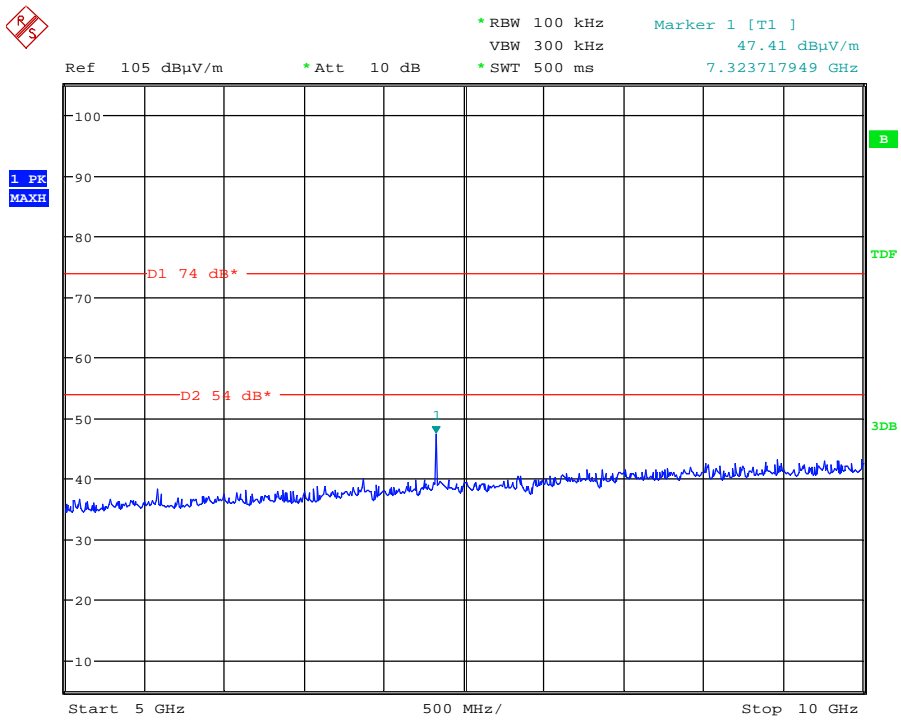
Date: 30.JUL.2012 12:07:22

RMP60M Radiated Spurious Emissions 3GHz to 5GHz – 2442MHz



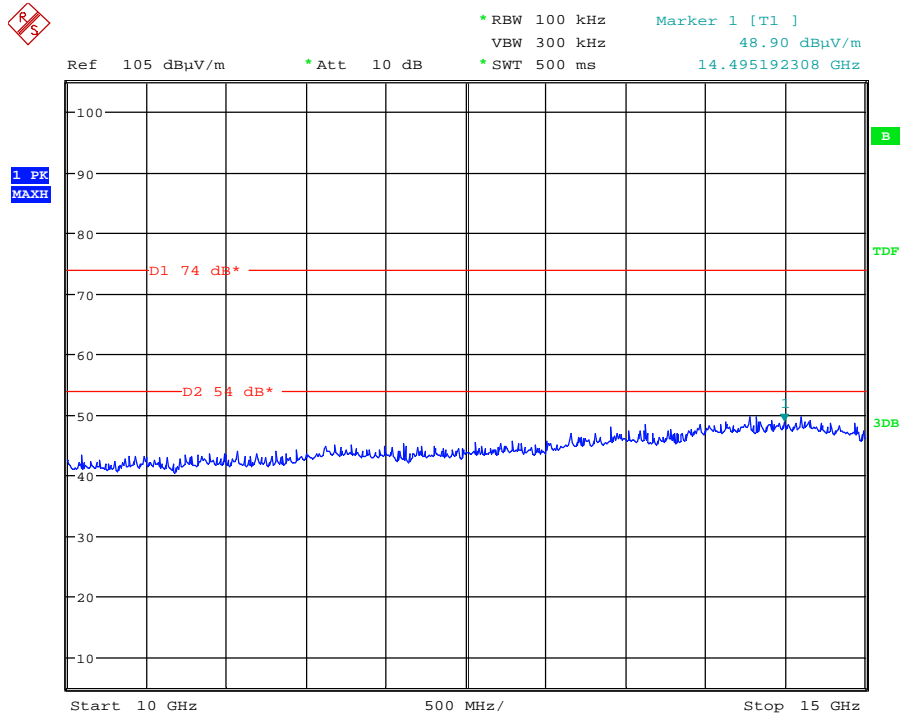
Date: 30.JUL.2012 12:07:45

RMP60M Radiated Spurious Emissions 5GHz to 10GHz – 2442MHz



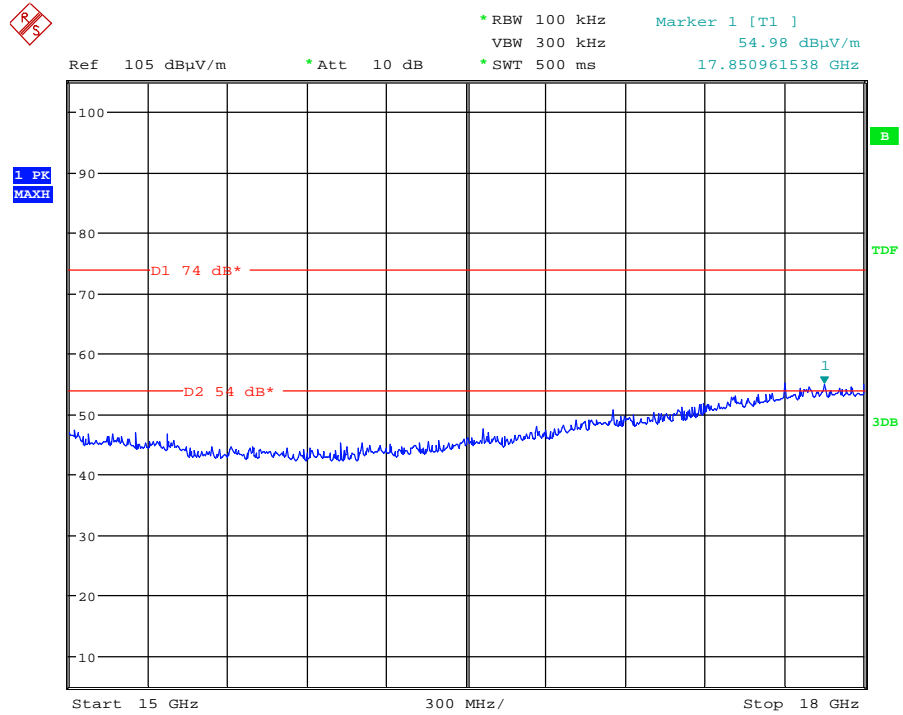
Date: 30.JUL.2012 12:08:15

RMP60M Radiated Spurious Emissions 10GHz to 15GHz – 2442MHz



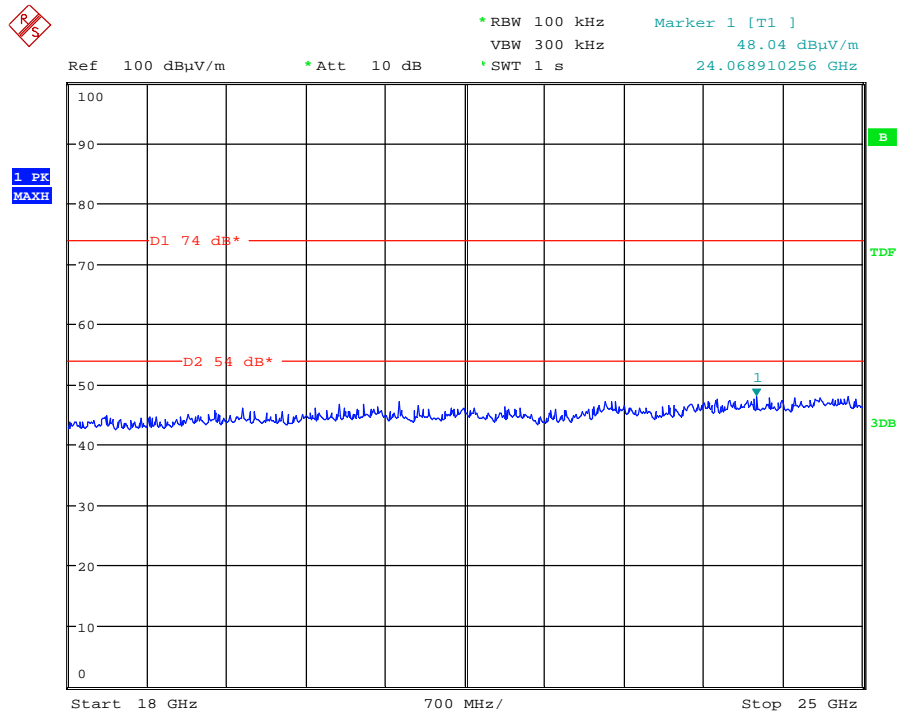
Date: 30.JUL.2012 12:08:39

RMP60M Radiated Spurious Emissions 15GHz to 18GHz – 2442MHz



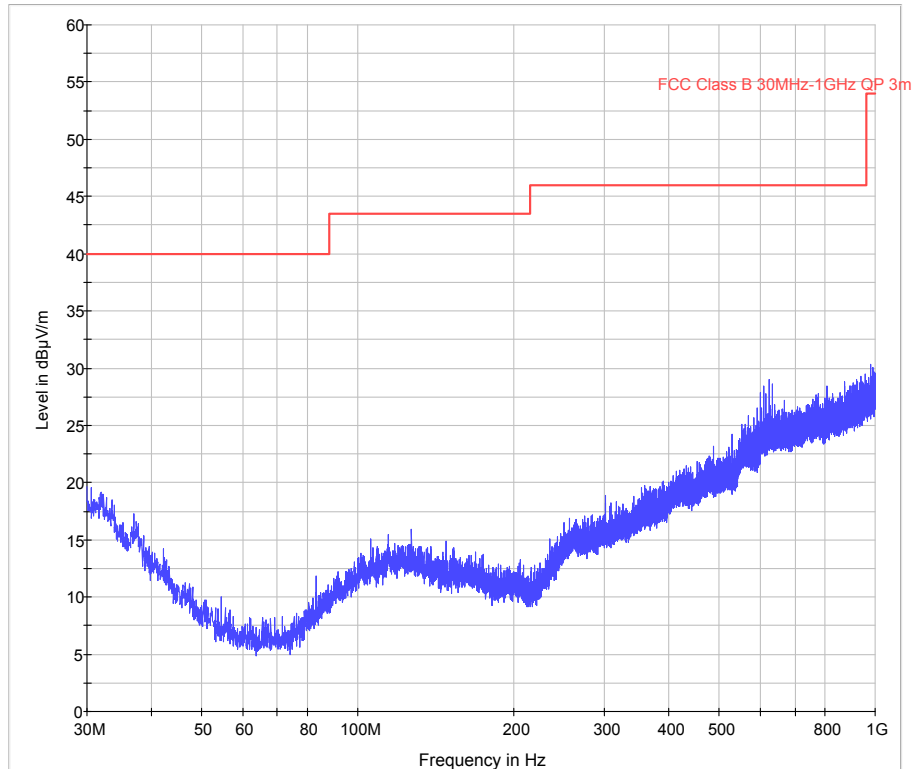
Date: 30.JUL.2012 12:09:10

RMP60M Radiated Spurious Emissions 18GHz to 25GHz – 2442MHz

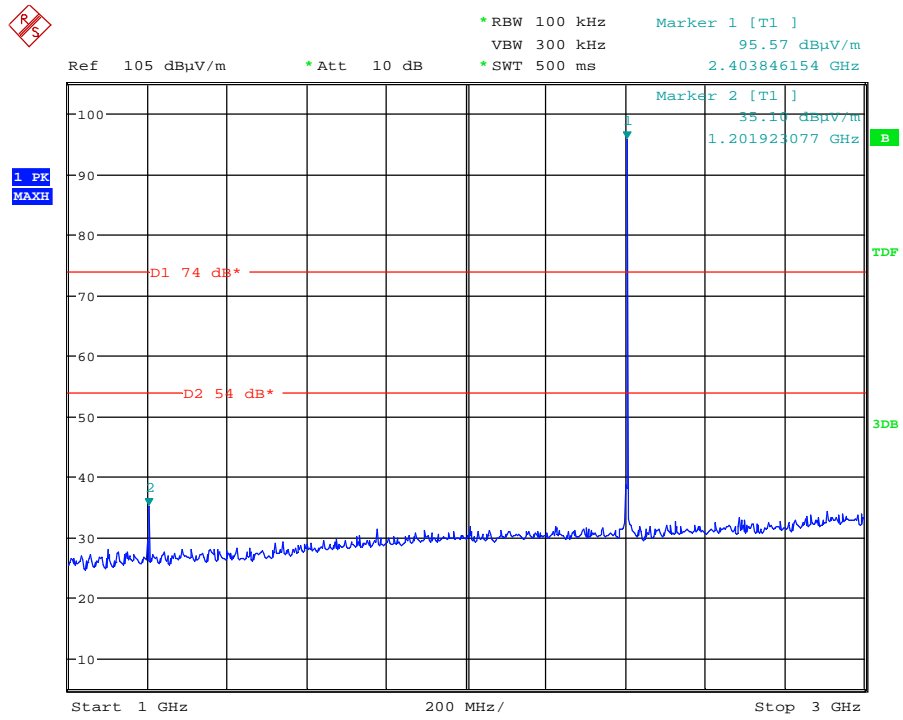


Date: 30.JUL.2012 11:42:31

RMP60M Radiated Spurious Emissions 30MHz to 1GHz – 2481MHz

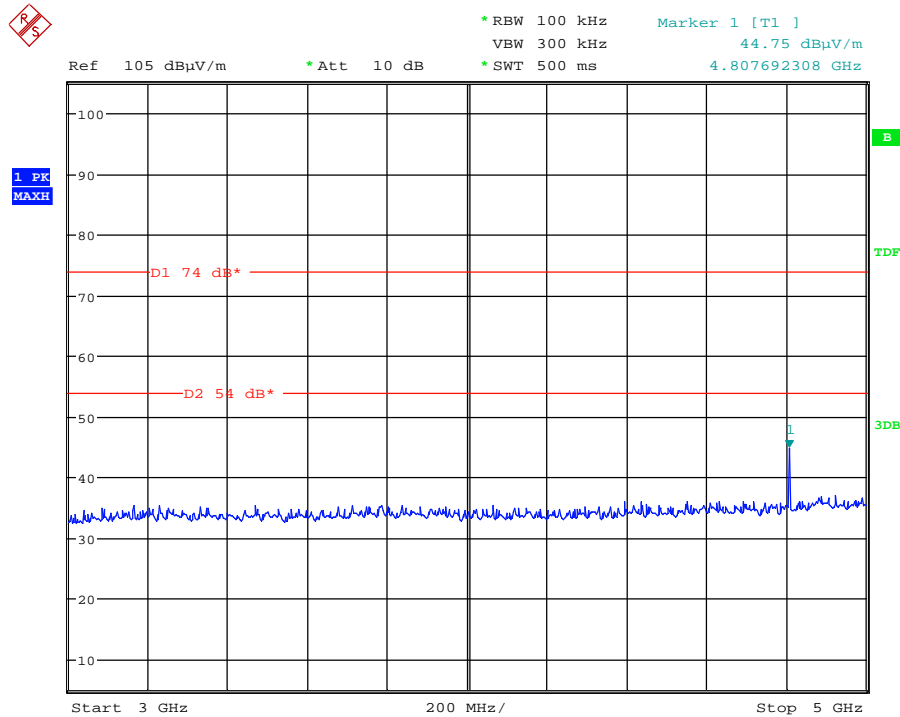


RMP60M Radiated Spurious Emissions 1GHz to 3GHz – 2481MHz



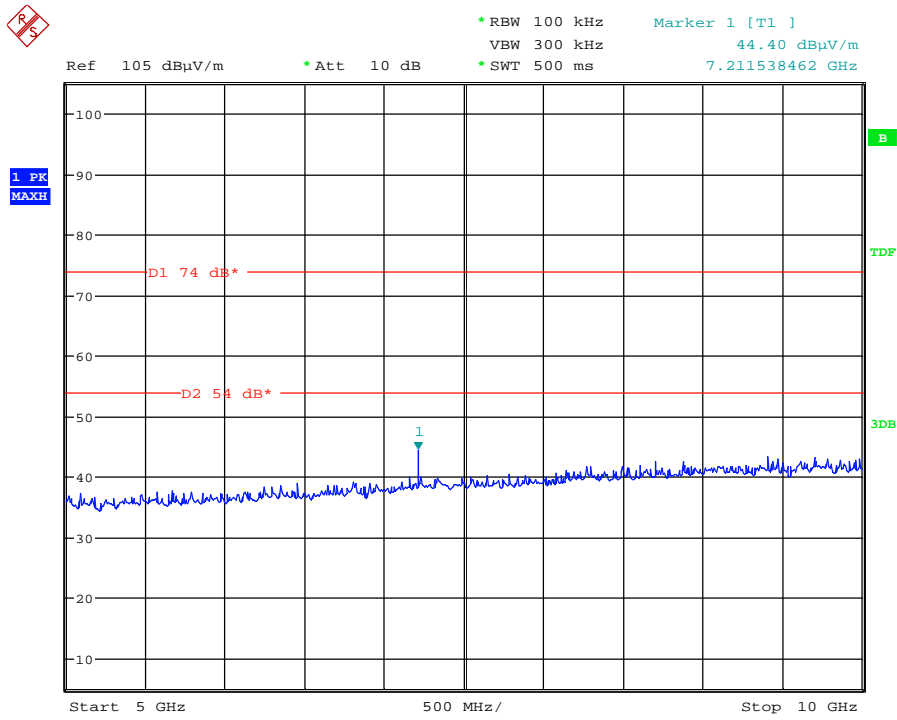
Date: 30.JUL.2012 11:55:25

RMP60M Radiated Spurious Emissions 3GHz to 5GHz – 2481MHz



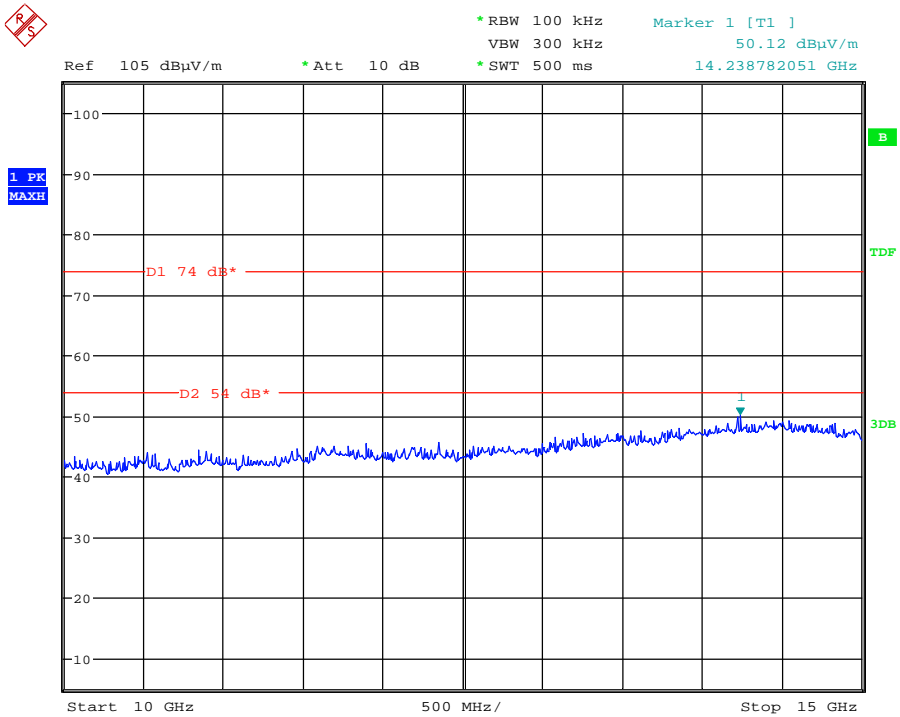
Date: 30.JUL.2012 11:56:04

RMP60M Radiated Spurious Emissions 5GHz to 10GHz – 2481MHz



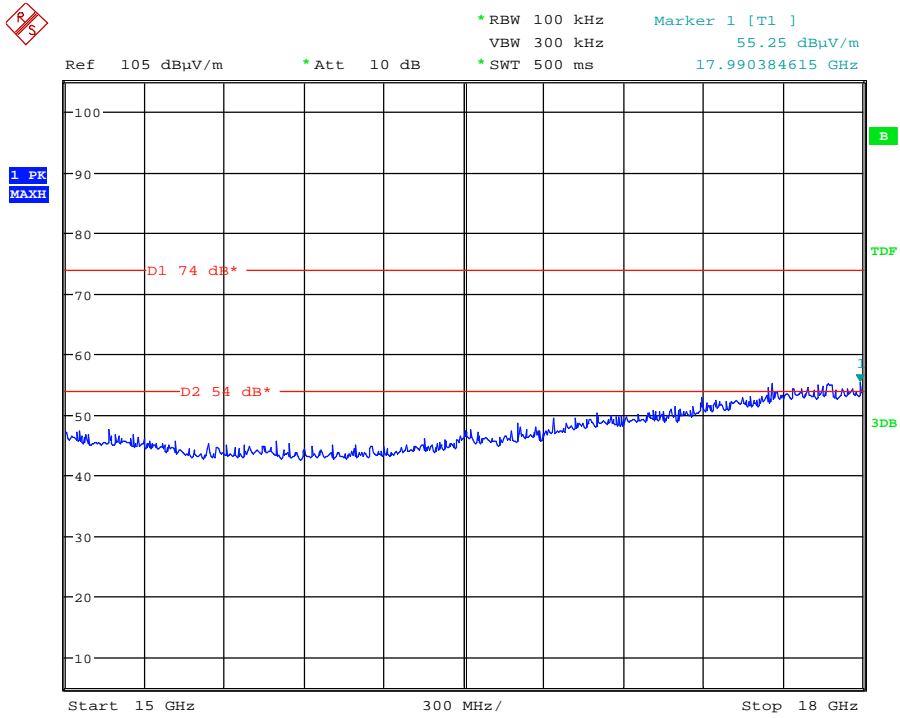
Date: 30.JUL.2012 11:56:37

RMP60M Radiated Spurious Emissions 10GHz to 15GHz – 2481MHz



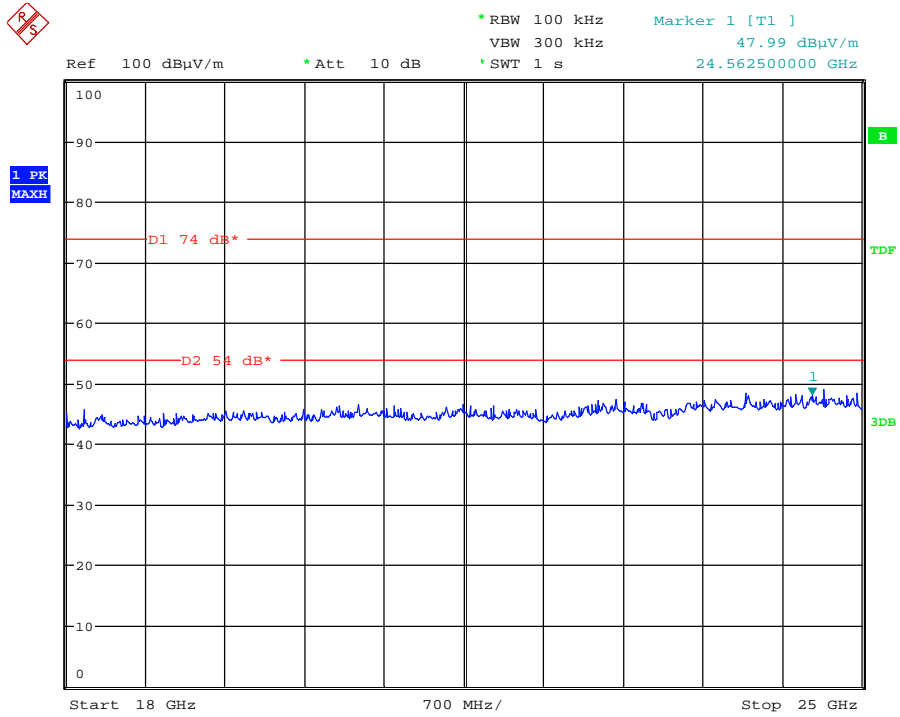
Date: 30.JUL.2012 11:57:16

RMP60M Radiated Spurious Emissions 15GHz to 18GHz – 2481MHz



Date: 30.JUL.2012 11:58:02

RMP60M Radiated Spurious Emissions 18GHz to 25GHz – 2481MHz



Date: 30.JUL.2012 11:40:57

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
S01	RMP60 (Radiated Sample)	None
S02	RMP60M (Radiated Sample)	None
S03	RMP60 (Radiated Sample)	None
S04	RMP60M (Radiated Sample)	None
S05	RMP60 (Conducted Sample)	None
S06	RMP60M (Conducted Sample)	None

The following samples of apparatus were submitted by the client as host, support or drive equipment (auxiliary equipment):

Sample No.	Description	Identification
S07	RMI	None

C2 EUT operating mode during testing

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

Test	Description of Operating Mode
Unintentional radiated emissions	EUT in receive mode
All other tests in this report	EUT actively transmitting

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 : S05
Tests : All conducted tests

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

Sample : S01 & S02
Tests : Radiated Emissions

Port	Description of Cable Attached	Cable length	Equipment Connected
No External Ports			


C5 Details of Equipment Used

TRaC Ref	Equipment Type	Description	Brand	Last Calibrated
UH004	ESVS10	Receiver	R&S	12/01/2012
UH093	CBL6112B	30MHz – 2GHz Bilog	Chase	20/06/2011
UH281	FSU46	Spectrum Analyser	R&S	09/02/2012
TRL572	8449B	Pre Amp	Agilent	24/11/2010
TRL138	3115	1GHz-18GHz Horn	Emco	08/11/2011
TRL300	20240-20	18GHz-26GHz Horn	Flann	17/11/2011

Appendix D:

Additional Information

The duty cycle declaration letter, as submitted by the manufacturer is enclosed below.

<p>Renishaw plc New Mills, Wotton-under-Edge, Gloucestershire GL12 8JR United Kingdom</p>	<p>Tel +44 (0) 1453 524524 Fax +44 (0) 1453 524901 Email uk@renishaw.com www.renishaw.com</p>	<p>RENISHAW  apply innovation™</p>
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21 August 2012


DECLARATION

RMP60 Operating details


The RMP60 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 RMP60 receives an acknowledgement message from the RMI.

It should be noted that the test modes used within the RMP60 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



John Styles CEng MIET
Principal Design Engineer

<p>Registered office New Mills, Wotton-under-Edge, Gloucestershire GL12 8JR</p>	<p>Registered number 1106260, England</p>	
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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 plots 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 = $20 \times \text{Log}_{10} (1/\text{Calculated Duty Cycle})$

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

e.g

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

0.07459 or 7.459%

Correction factor (dB) = $20 \times \text{Log}_{10} (1/0.07459) = 22.54\text{dB}$

Appendix F:

Photographs and Figures

The following photographs were taken of the test samples:

1. Radiated electric field emissions arrangement: RMP60 Overview.
2. Radiated electric field emissions arrangement: RMP60 close up.
3. Radiated electric field emissions arrangement: RMP60M Overview.
4. Radiated electric field emissions arrangement: RMP60M close up.



Photograph 1



Photograph 2



Photograph 3



Photograph 4

