



**A Radio Test Report**

**FOR**

**Renishaw Plc**

**ON**

**Primo Radio 3D Tool Setter**

**DOCUMENT NO.TRA-013623-47-03A**

**HULL**

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**TRaC Wireless Test Report** : TRA-013623-47-03A

**Applicant** : Renishaw Plc

**Apparatus** : Primo Radio 3D Tool Setter

**Specification(s)** : CFR47 Part 15.247 & RSS-210 Annex 8

**FCCID** :KQGPR3DTS

**ICID** :3928A-PR3DTS

**Purpose of Test** : **Certification**

**Authorised by** :



: Radio Product 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.

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## **1.2 Tests Requested By**

This testing in this report was requested by:

Renishaw Plc  
New Mills  
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Gloucestershire  
GL12 8JR

## **1.3 Manufacturer**

As above

## **1.4 Apparatus Assessed**

The following apparatus was assessed between 09<sup>th</sup> January 2014 and 20<sup>th</sup> January 2014.

Primo Radio 3D Tool Setter

The above device operates in the license free 2.4GHz radio 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
	Title 47 of the CFR: Part 15 Subpart (c)	RSS – 210 Issue 8, December 2010		
Radiated spurious emissions (Restricted bands)	15.247	Annex 8, A8.5	ANSI C63.10:2009	Pass
Conducted spurious emissions (Non-restricted bands)	15.247	Annex 8, A8.5	ANSI C63.10:2009	Pass
AC Power conducted emissions	15.207	Section 7.2.2	ANSI C63.10:2009	N/A
20dB Bandwidth and Channel Spacing	15.247(a)(1)(i)	Annex 8, A8.1(b)	ANSI C63.10:2009	Pass
Conducted Carrier Power	15.247(b)(2)	Annex 8, A8.4(2)	ANSI C63.10:2009	Pass
Hopping Frequencies	15.247(a)(1)	Annex 8, A8.1(d)	ANSI C63.10:2009	Pass
Channel Occupancy	15.247(a)(1)(i)	Annex 8, A8.1(d)	ANSI C63.10:2009	Pass
Unintentional Radiated Spurious Emissions	15.109	Section 7.2.3	ANSI C63.10:2009	Pass
Extrapolation Factor:	15.31(f)	RSS-Gen Issue 3 7.2.7	-	-
Maximum Frequency of Search:	15.33	RSS-Gen Issue 3 4.9	-	-
Antenna Arrangements Integral:	15.203	RSS-Gen Issue 3 7.1.2	-	-
Antenna Arrangements External Connector:	15.204	RSS-Gen Issue 3 7.1.2	-	-
Restricted Bands:	15.205	RSS-Gen Issue 3 7.2.2	-	-

Abbreviations used in the above table:

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

Mod : Modification  
CFR : Code of Federal Regulations  
REFE : Radiated Electric Field Emissions

RSS : Radio Standards Specification  
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 (Frequency Counter) = **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.

<b>Test Details:</b>	
Regulation	Part 15.247(b)(1) RSS – 210, Annex 8, A8.4(2)
Measurement standard	ANSI C63.10:2009, RSS-GEN
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	24.8°C

Channel Frequency (MHz)	Peak Carrier Power (W)	Limit (W)	Result
2402	0.00088	1	Pass
2441	0.00104		Pass
2480	0.00115		Pass

**Notes:**

Number of hopping channels employed is 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.

<b>Test Details: 2402 MHz</b>	
Regulation	Part 15.247(d) and Clause 15.205, RSS-210 Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	9 kHz 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
Temperature	24.8°C

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 20dB of the limit					Pass

**RF Antenna Conducted Spurious Emissions continued:**

<b>Test Details: 2441 MHz</b>	
Regulation	Part 15.247(d) and Clause 15.205, RSS-210 Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	9 kHz 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
Temperature	24.8°C

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 20dB of the limit					Pass

**RF Antenna Conducted Spurious Emissions continued:**

<b>Test Details: 2480 MHz</b>	
Regulation	Part 15.247(d) and Clause 15.205, RSS-210 Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	9 kHz 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
Temperature	24.8°C

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 20dB of the limit					Pass

**Notes:**

1. The conducted emission limit for emissions are based on a transmitted carrier level of 15.247(b) and Annex 8, A8.4(2).. 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) and Annex 8, A8.5 using a peak detector.
2. The RBW = 100 kHz, Video bandwidth (VBW) > RBW and the radio spectrum was investigated in accordance with 15.33 (a)(1) and RSS – GEN 4.9.
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.
5. The measurements at 2400 MHz and 2483.5 MHz were made to ensure band edge compliance. 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) and Annex 8, A8.5:

$$\text{The limit in 100 kHz RBW} = (\text{Maximum Peak Conducted Carrier}) - 20\text{dB}$$

Where:

Channel No.	Channel Frequency (MHz)	Measured Peak Carrier Power (W)	Measured Peak Carrier (dBm)	Measured Peak Carrier -20dB (dBm)	Emission Limit In a 100 kHz RBW (dBm)
Bottom	2402	0.00088	-0.56	-20.56	-20.56
Middle	2441	0.00104	0.17	-19.83	-19.83
Top	2480	0.00115	0.59	-19.41	-19.41



**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. 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.

<b>Test Details: 2402 MHz</b>	
Regulation	Part 15.247(d) and 15.205, RSS – 210, Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz – 25GHz
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25.4°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:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HPF Loss (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4803.95pk	58.22	3.6	32.7	35.6	0.3	59.22	914.11	5000
2.	4803.95av	49.89	3.6	32.7	35.6	0.3	50.89	350.35	500
3.	7206.29pk	50.77	4.4	36.2	36	0.3	55.67	607.44	5000
4.	7206.29av	40.04	4.4	36.2	36	0.3	44.94	176.60	500

**Radiated Electric Field Emissions:**

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

<b>Test Details: 2441 MHz</b>	
Regulation	Part 15.247(d) and 15.205, RSS – 210, Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz to 25 GHz
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25.4°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:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HPF Loss (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4881.98pk	59.06	3.6	33	35.6	0.3	60.36	1042.32	5000
2.	4881.98av	50.39	3.6	33	35.6	0.3	51.69	384.15	500
3.	7322.98pk	53.26	4.4	36.6	36.1	0.3	58.46	837.53	5000
4.	7322.98av	43.86	4.4	36.6	36.1	0.3	49.06	283.79	500

**Radiated Electric Field Emissions:**

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

<b>Test Details: 2480 MHz</b>	
Regulation	Part 15.247(d) and 15.205, RSS – 210, Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz to 25 GHz
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25.4°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:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HPF Loss (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4960pk	58.5	3.6	33.2	35.7	0.2	59.80	977.24	5000
2.	4960av	50.2	3.6	33.2	35.7	0.2	51.50	375.84	500
3.	7440pk	50.83	4.3	36.7	36.1	0.3	56.03	633.14	5000
4.	7440av	39.95	4.3	36.7	36.1	0.3	45.15	180.93	500

**Notes:**

- 1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.10:2009: section 4.5, Table 1 and ANSI C63.4: 2003 section 8.2.1
- 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 C63.10:2009 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

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

The upper and lower frequency of the measurement range was decided according to Part 15: Clause 15.33(a) and 15.33(a)(1) and RSS-GEN 4.9

Radiated emission limits for emissions falling within the restricted bands.

Frequency of emission (MHz)	Field strength ( $\mu\text{V}/\text{m}$ )	Measurement Distance (m)	Field strength ( $\text{dB}\mu\text{V}/\text{m}$ )
30-88	100	3	40.0
88-216	150	3	43.5
216-960	200	3	46.0
Above 960	500	3	54.0

- (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 20 dB Bandwidth and Carrier Frequency Separation**

Title 47 of the CFR: Part 15 Subpart (c) 15.247(a)(1)(i) and RSS-210 Annex 8, A8.1(b) 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 the 2/3 of 20 dB bandwidth, whichever is the greater. The formal measurements are detailed below:

Test Details:	
Regulation	Part 15.247(a)(1)(i). RSS-210 Annex 8, A8.1(b)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
Temperature	24.1°C
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Measured 20 dB Bandwidth (kHz)
2402	1141.827
2441	1089.744
2480	1089.744

Measured Channel Spacing (kHz)	Limit	Result
996.795	(25kHz or $\geq 2/3$ of Measured 20 dB Bandwidth kHz), whichever is greater	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	Part 15.247(a)(1)(i), RSS – 210, Annex 8, A8.1(d)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
Temperature	24.1°C
EUT set up	Refer to Appendix C

No. of Hopping Channels	Requirement	Result
79	$\geq 15$	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 (2441 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	Part 15.247(a)(1), RSS – 210, Annex 8, A8.1(d)
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	None
Temperature	24.1°C
EUT set up	Refer to Appendix C

Channel Occupancy Time (µs)	Channel Repetition Time (ms)	Calculated Average Channel retention Time (ms)	Average Channel Occupancy Time Limit (ms)	Result
170.9	1.024	5.274	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 ( $T_{rep}$ ) = 1.024ms  
 Measured channel occupancy time ( $T_{occ}$ ) = 170.9µs

No. of transmission cycles in specified averaging period =

$$\frac{0.4 \times N}{T_{rep}(ms)} = \text{cycles} \quad \therefore \frac{0.4 \times 79}{1.024(ms)} = 30.859 \text{ cycles}$$

**∴ The Average Retention Time =**

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

Average Channel Occupancy Time = 170.9 µs x 30.859 = 5.274 ms



**A7 Antenna Gain**

The maximum antenna gain for the antenna types to be used with the EUT, as declared by the client, is 5 dBi.

**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 and RSS- GEN Section 7.2.3. 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 :

<b>Test Details: 2402 MHz</b>	
Regulation	Part 15.109, RSS – GEN, Section 7.2.3
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz to 25 GHz
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25.4°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:

Ref No.	FREQ. (MHz)	MEAS Rx (dBμV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBμV/m)	FIELD ST'GH (μV/m)	LIMIT (μV/m)
1.	2747.43pk	52.26	3.1	29.1	36	48.46	264.85	5000
2.	2747.43av	46.67	3.1	29.1	36	42.87	139.16	500

**Unintentional Radiated Electric Field Emissions continued:**

<b>Test Details: 2441 MHz</b>	
Regulation	Part 15.109, RSS – GEN, Section 7.2.3
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz to 25 GHz
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25.4°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:

Ref No.	FREQ. (MHz)	MEAS Rx (dBμV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBμV/m)	FIELD ST'GH (μV/m)	LIMIT (μV/m)
1.	2792.03pk	53.2	3.2	29.1	36	49.50	298.54	5000
2.	2792.03av	48.9	3.2	29.1	36	45.20	181.97	500

**Unintentional Radiated Electric Field Emissions continued:**

<b>Test Details: 2480 MHz</b>	
Regulation	Part 15.109, RSS – GEN, Section 7.2.3
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz to 25 GHz
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25.4°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:

Ref No.	FREQ. (MHz)	MEAS Rx (dB $\mu$ V)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dB $\mu$ V/m)	FIELD ST'GH ( $\mu$ V/m)	LIMIT ( $\mu$ V/m)
1.	2836.54pk	54.33	3.2	29.2	36	50.73	343.95	5000
2.	2836.54av	49.31	3.2	29.2	36	45.71	192.97	500

**Appendix B:**

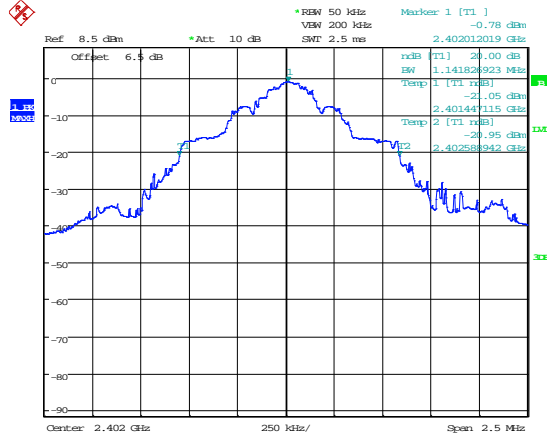
**Supporting Graphical Data**

This appendix contains graphical data obtained during testing.

Notes:

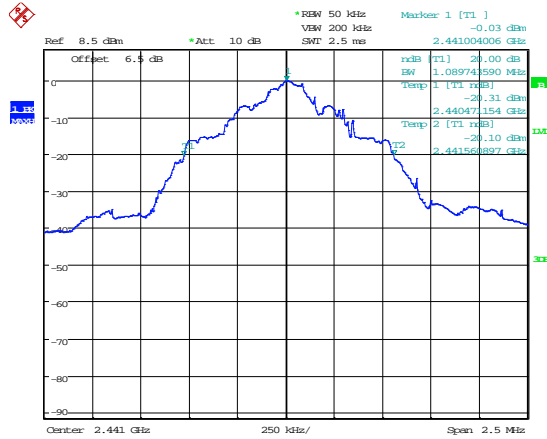
- (a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.
- (b) The time and date on the plots do not necessarily equate to the time of the test.
- (c) Where relevant, on power 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 - 2402 MHz



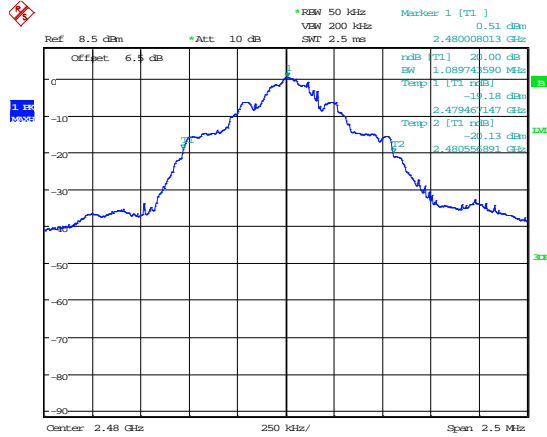
Date: 15.JAN.2014 17:08:55

### 20dB Bandwidth - 2441 MHz



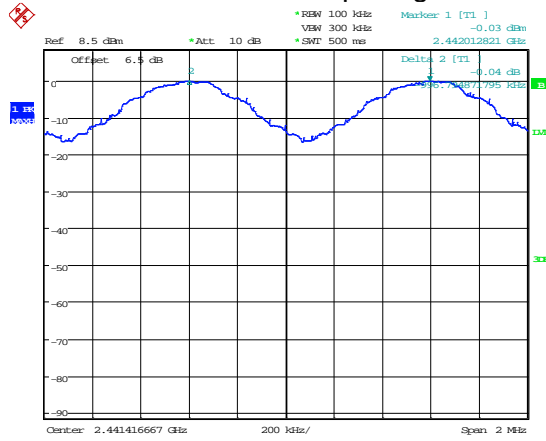
Date: 15.JAN.2014 17:09:52

### 20dB Bandwidth - 2480 MHz



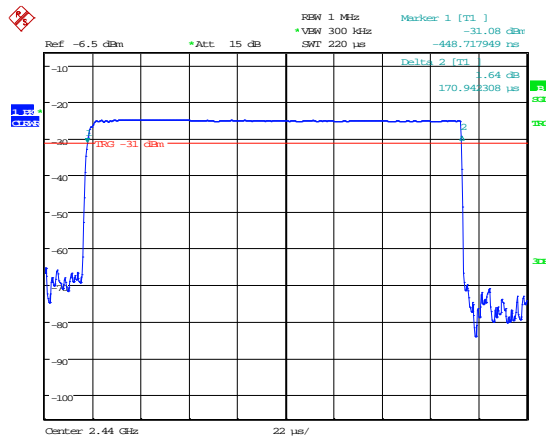
Date: 15.JAN.2014 17:10:31

### Channel Spacing



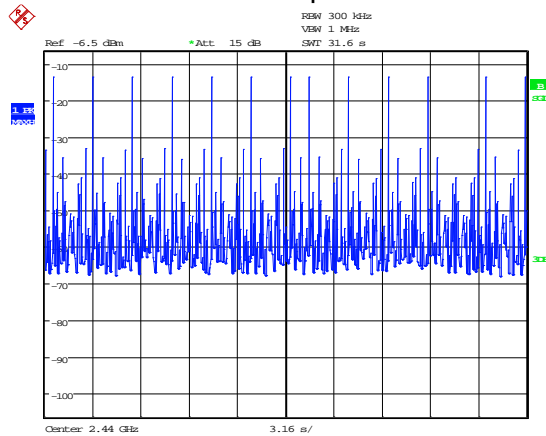
Date: 15.JAN.2014 16:54:41

### Channel Occupancy Time



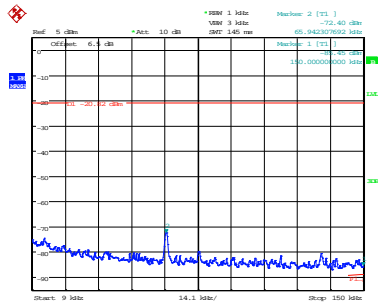
Date: 17.JAN.2014 09:41:52

### Channel repetition time



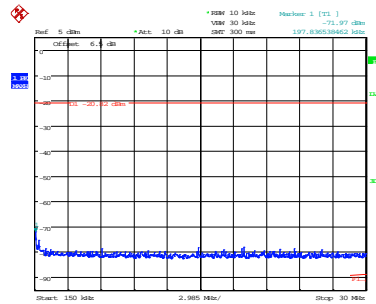
Date: 17.JAN.2014 11:02:03

### Conducted Spurious emissions– 2402 MHz



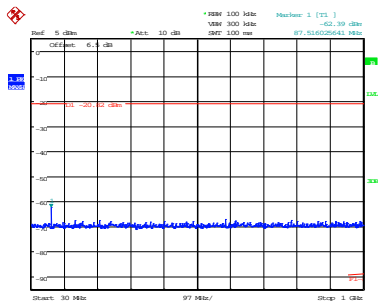
Date: 16\_JAN\_2014 10:12:01

#### 9kHz to 150kHz



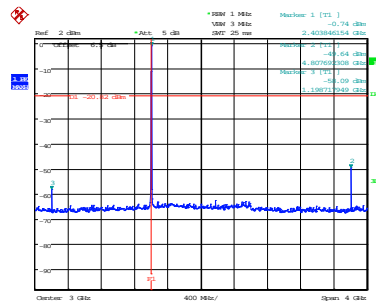
Date: 16\_JAN\_2014 10:12:09

#### 150kHz to 30MHz



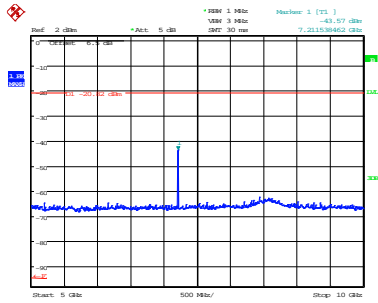
Date: 16\_JAN\_2014 10:12:15

#### 30 MHz to 1 GHz



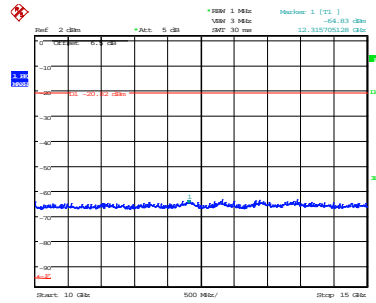
Date: 16\_JAN\_2014 10:12:48

#### 1 GHz to 5 GHz



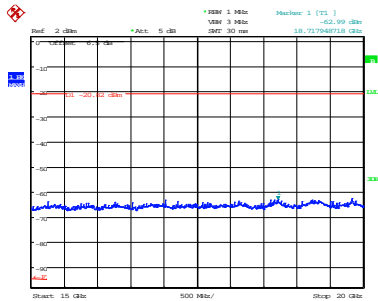
Date: 16\_JAN\_2014 10:13:12

#### 5 GHz to 10GHz



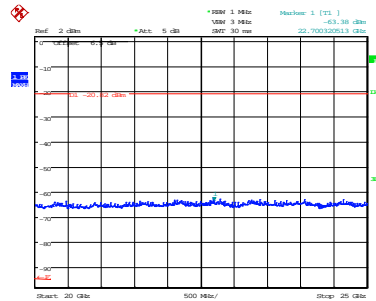
Date: 16\_JAN\_2014 10:13:19

#### 10 GHz to 15 GHz



Date: 16\_JAN\_2014 10:13:43

#### 15 GHz to 20GHz

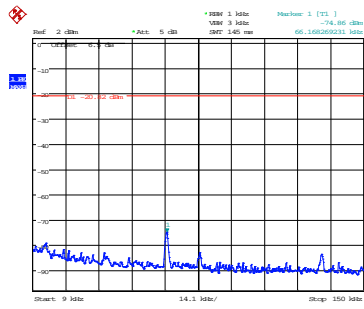


Date: 16\_JAN\_2014 10:13:16

#### 20 GHz to 25 GHz

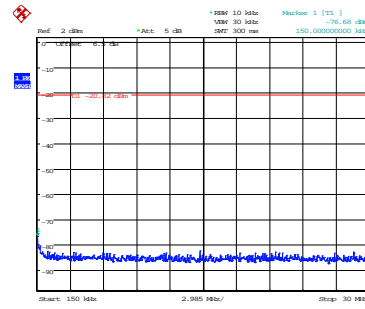


Conducted Spurious emissions– 2441 MHz



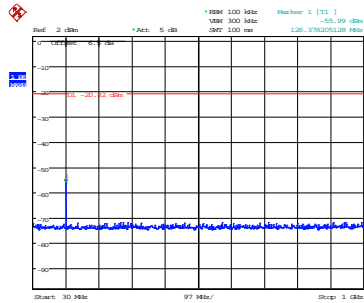
Date: 16\_JAN\_2014 10:56:45

9kHz to 150kHz



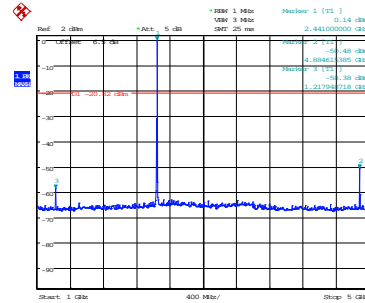
Date: 16\_JAN\_2014 10:57:15

150kHz to 30MHz



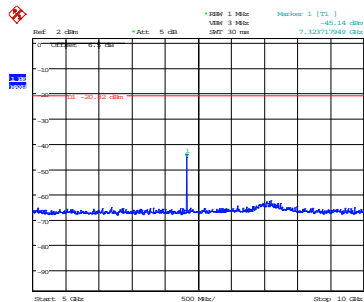
Date: 16\_JAN\_2014 10:57:49

30 MHz to 1 GHz



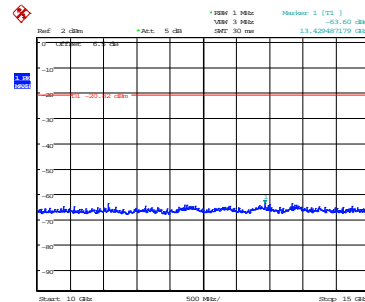
Date: 16\_JAN\_2014 10:54:34

1 GHz to 5 GHz



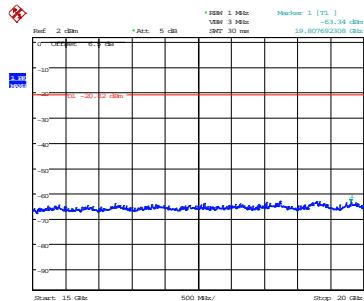
Date: 16\_JAN\_2014 10:54:58

5 GHz to 10GHz



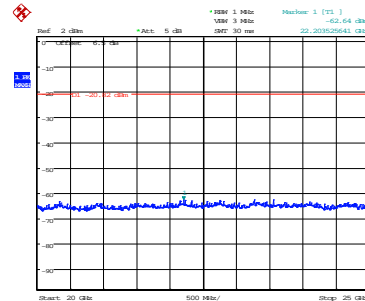
Date: 16\_JAN\_2014 10:55:25

10 GHz to 15 GHz



Date: 16\_JAN\_2014 10:55:48

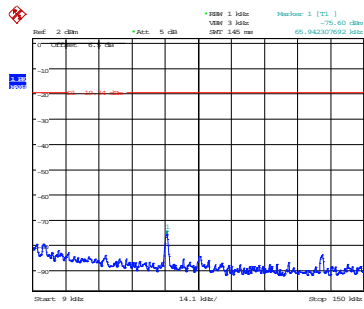
15 GHz to 20GHz



Date: 16\_JAN\_2014 10:56:13

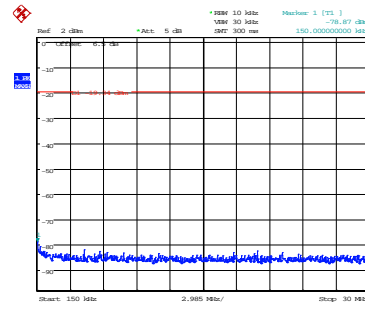
20 GHz to 25 GHz

Conducted Spurious emissions– 2480 MHz



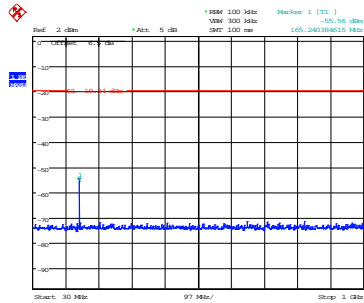
Date: 16\_JAN.2014 11:24:01

9kHz to 150kHz



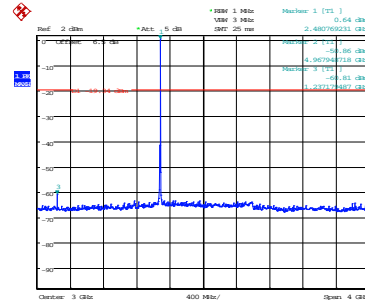
Date: 16\_JAN.2014 11:24:25

150kHz to 30MHz



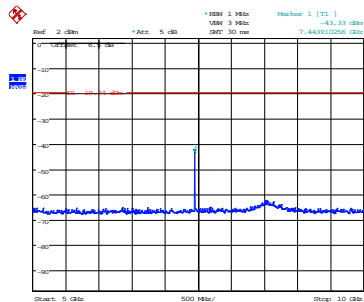
Date: 16\_JAN.2014 11:24:54

30 MHz to 1 GHz



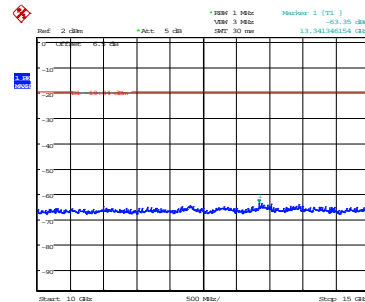
Date: 16\_JAN.2014 11:22:01

1 GHz to 5 GHz



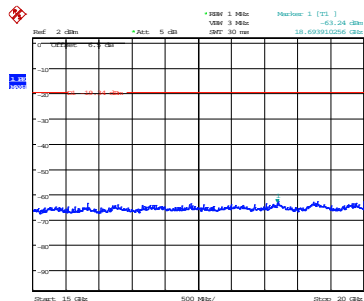
Date: 16\_JAN.2014 11:22:32

5 GHz to 10GHz



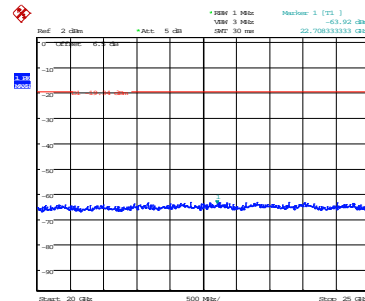
Date: 16\_JAN.2014 11:22:55

10 GHz to 15 GHz



Date: 16\_JAN.2014 11:23:17

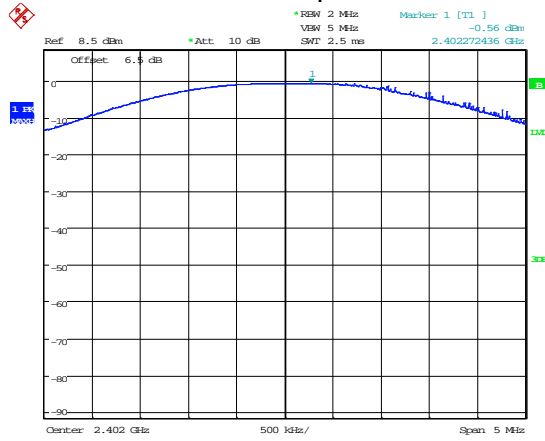
15 GHz to 20GHz



Date: 16\_JAN.2014 11:23:37

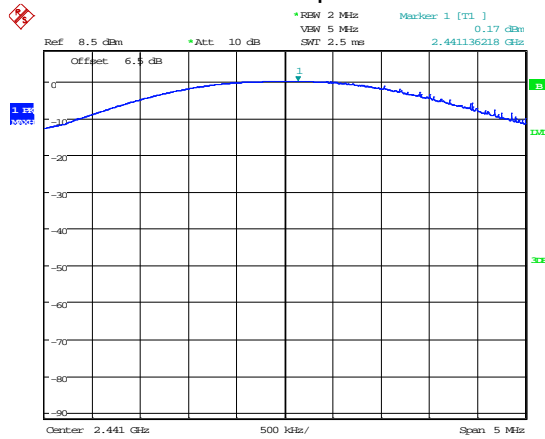
20 GHz to 25 GHz

### Conducted carrier power - 2402 MHz



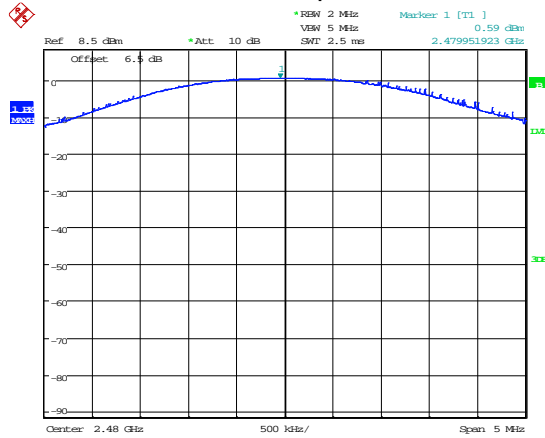
Date: 15.JAN.2014 17:22:41

### Conducted carrier power - 2441 MHz



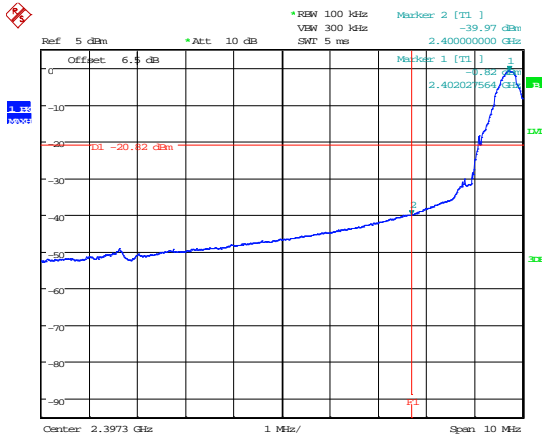
Date: 15.JAN.2014 17:23:21

### Conducted carrier power - 2408 MHz

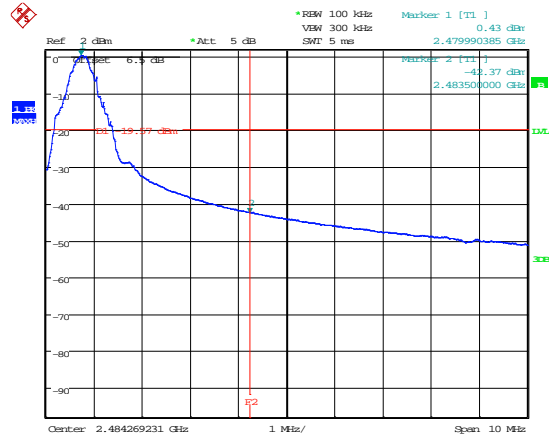


Date: 15.JAN.2014 17:24:03

### Bandedge Compliance

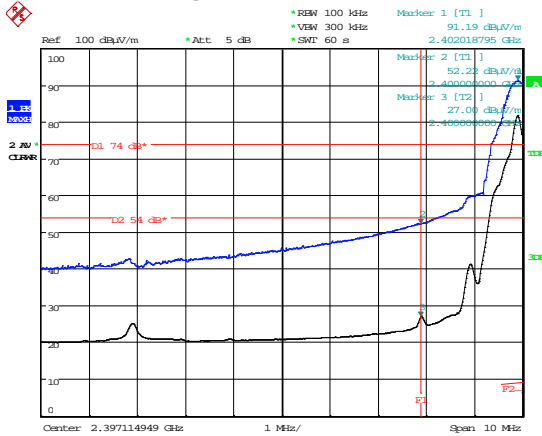


Date: 16.JAN.2014 10:27:43



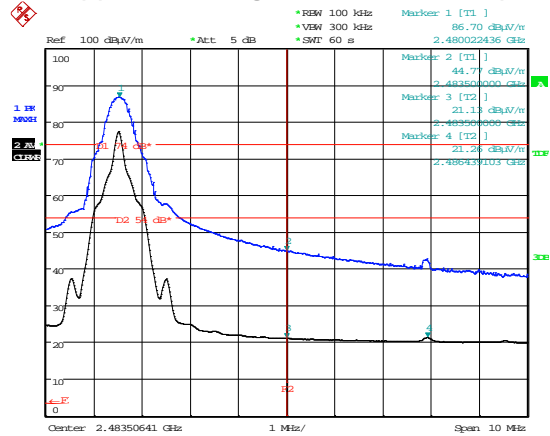
Date: 16.JAN.2014 11:02:20

### Lower Bandedge Conducted – Bottom Channel



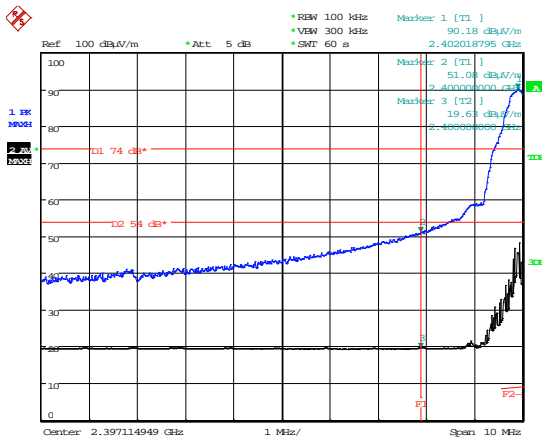
Date: 14.JAN.2014 13:28:02

### Upper Bandedge Conducted – Top Channel



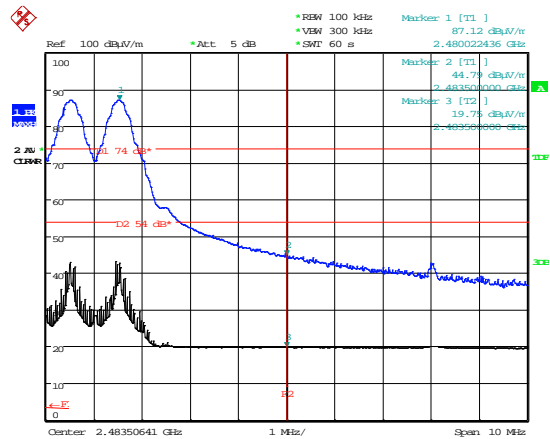
Date: 14.JAN.2014 13:51:19

### Lower Bandedge Radiated – Bottom Channel



Date: 14.JAN.2014 13:31:19

### Upper Bandedge Radiated – Top Channel

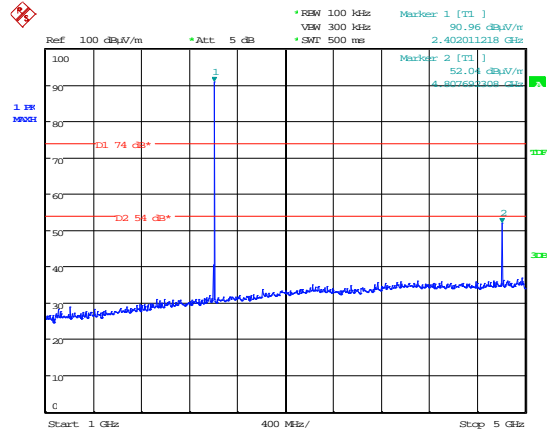
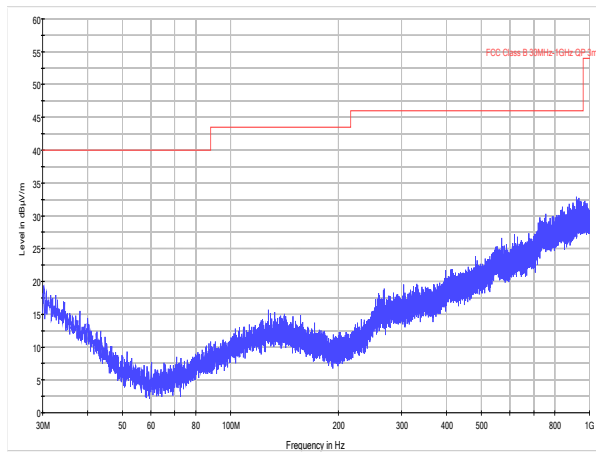


Date: 14.JAN.2014 14:01:40

### Lower Bandedge Radiated – Hopping

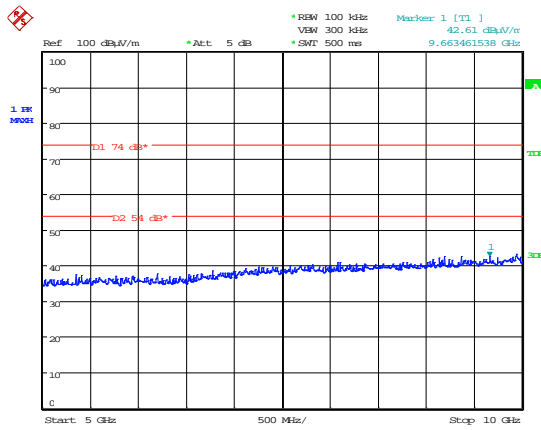
### Upper Bandedge Radiated – Hopping

### Radiated Spurious Emissions – 2402 MHz



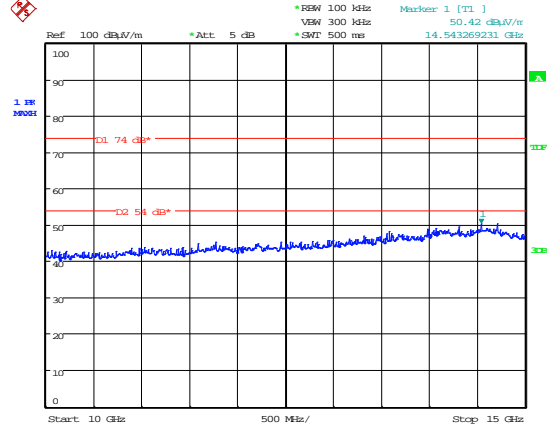
Date: 9.JAN.2014 13:13:02

### 30 MHz to 1 GHz



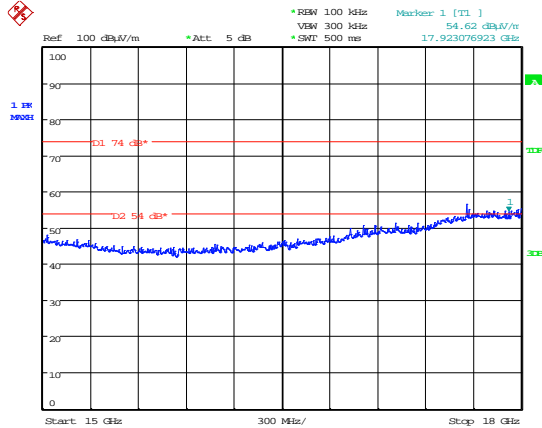
Date: 9.JAN.2014 13:13:44

### 1 GHz to 5 GHz



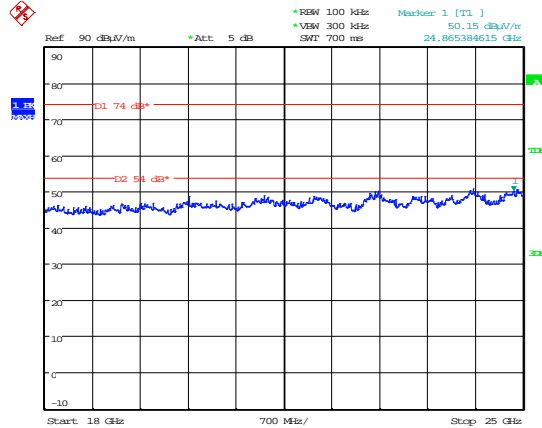
Date: 9.JAN.2014 13:14:36

### 5GHz to 10 GHz



Date: 9.JAN.2014 13:15:07

### 10 GHz to 15 GHz

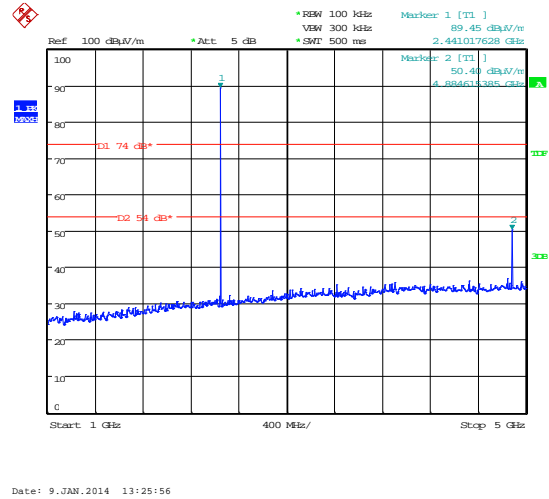
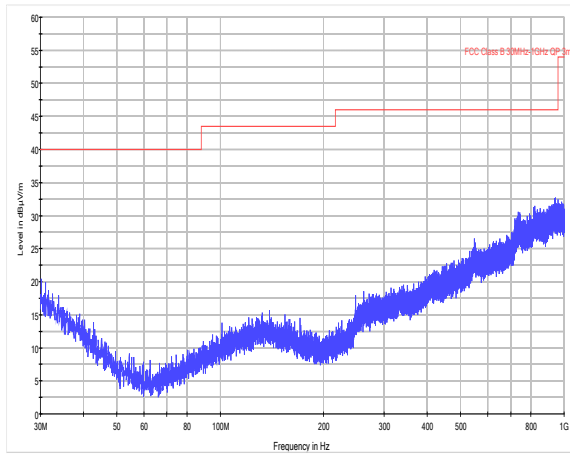


Date: 14.JAN.2014 11:12:31

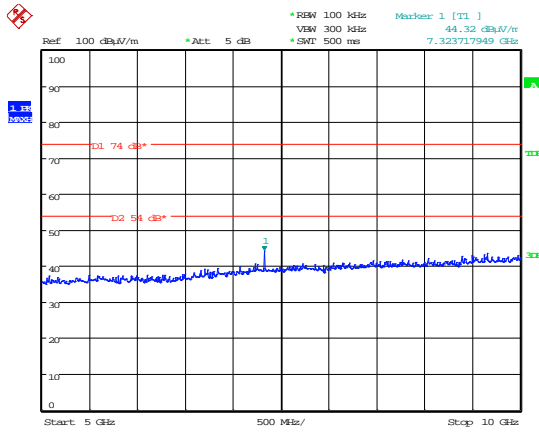
### 15 GHz to 18 GHz

### 18 GHz to 25 GHz

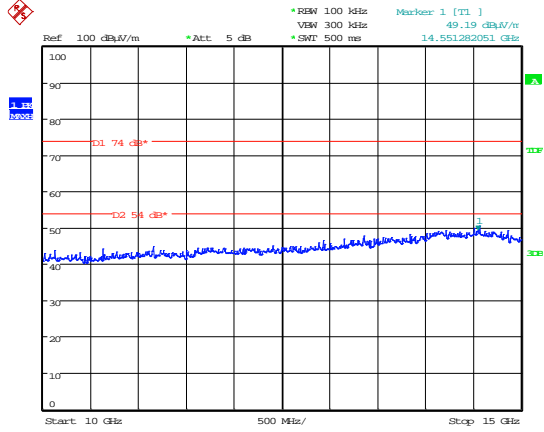
### Radiated Spurious Emissions – 2441 MHz



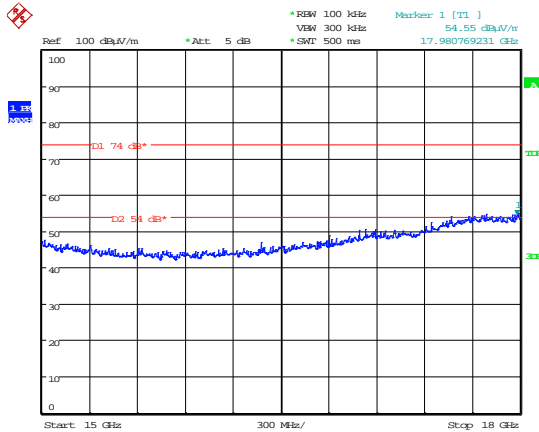
#### 30 MHz to 1 GHz



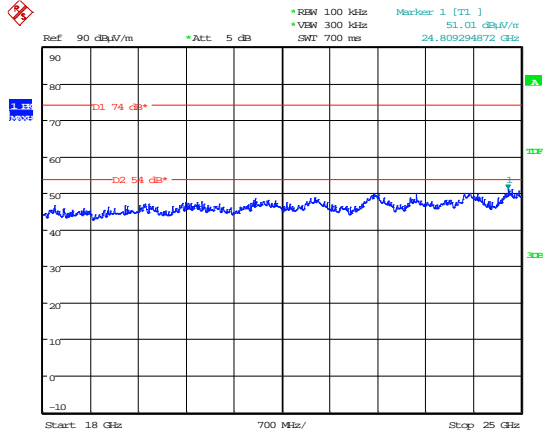
#### 1 GHz to 5 GHz



#### 5GHz to 10 GHz



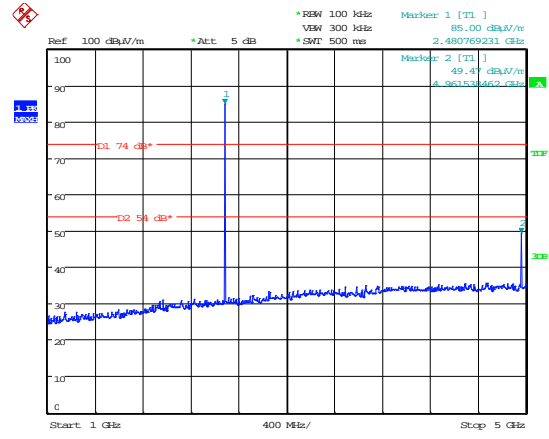
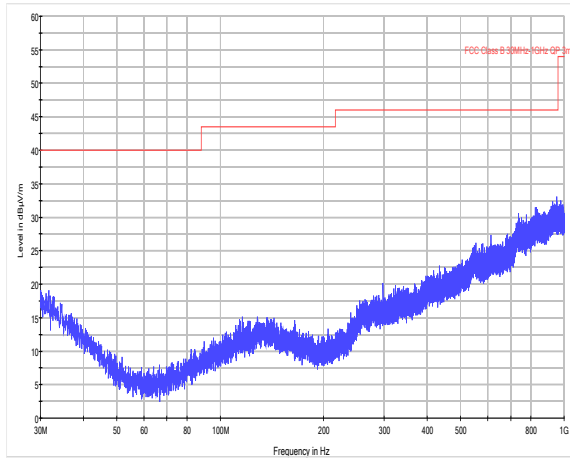
#### 10 GHz to 15 GHz



#### 15GHz to 18 GHz

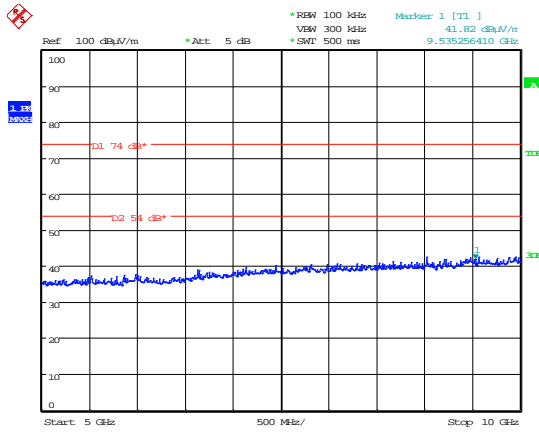
#### 18 GHz to 25 GHz

### Radiated Spurious Emissions – 2480 MHz



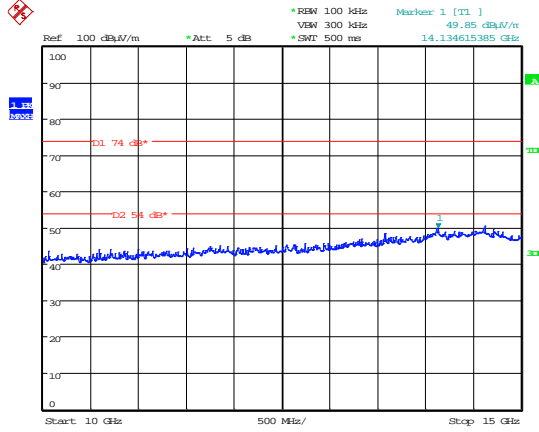
Date: 9.JAN.2014 13:38:01

#### 30 MHz to 1 GHz



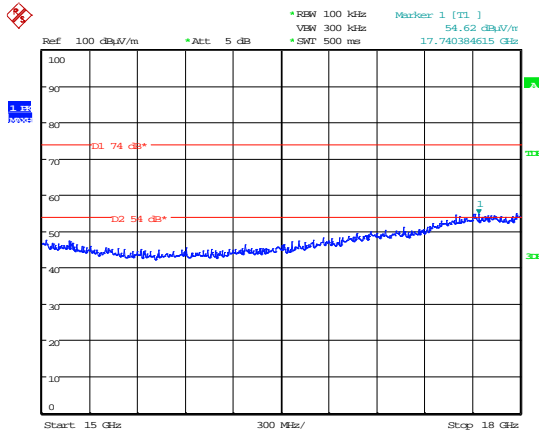
Date: 9.JAN.2014 13:38:39

#### 1 GHz to 5 GHz



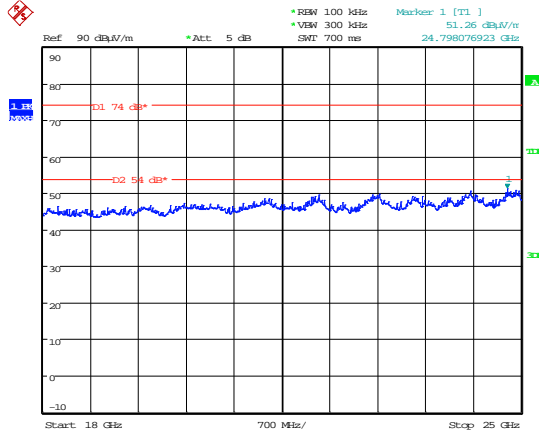
Date: 9.JAN.2014 13:39:55

#### 5GHz to 10 GHz



Date: 9.JAN.2014 13:40:26

#### 10 GHz to 15 GHz

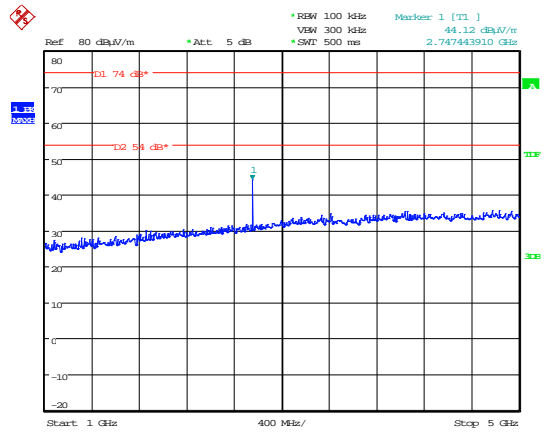
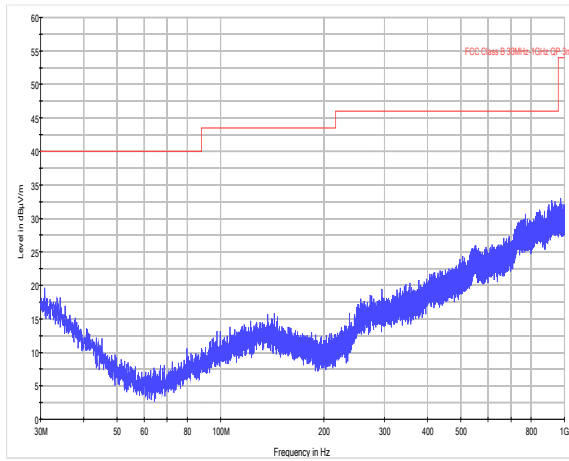


Date: 14.JAN.2014 11:15:56

#### 15GHz to 18 GHz

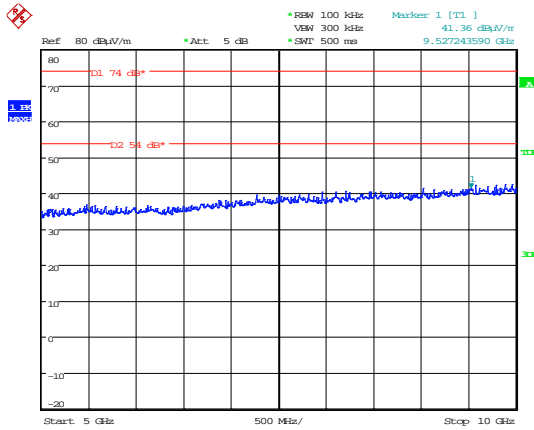
#### 18 GHz to 25 GHz

### Unintentional Radiated Spurious Emissions – 2402 MHz



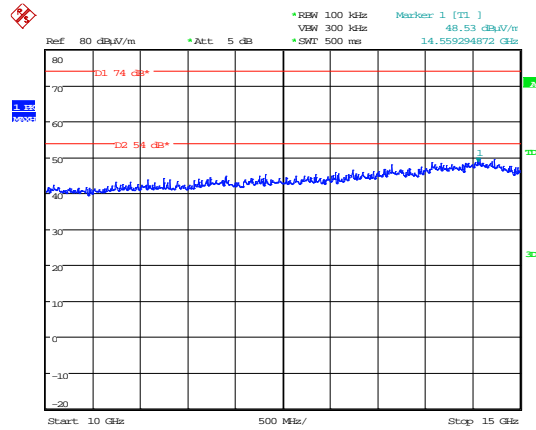
Date: 9.JAN.2014 14:01:27

#### 30 MHz to 1 GHz



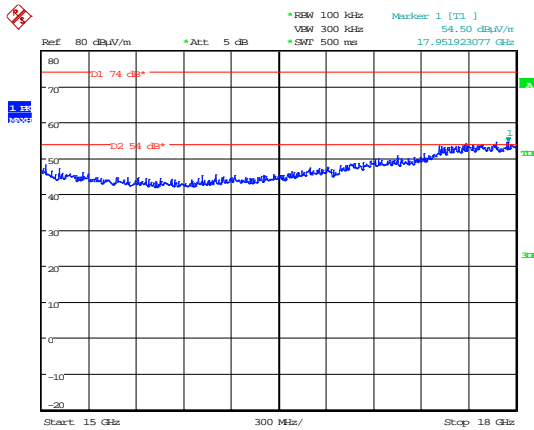
Date: 9.JAN.2014 14:02:04

#### 1 GHz to 5 GHz



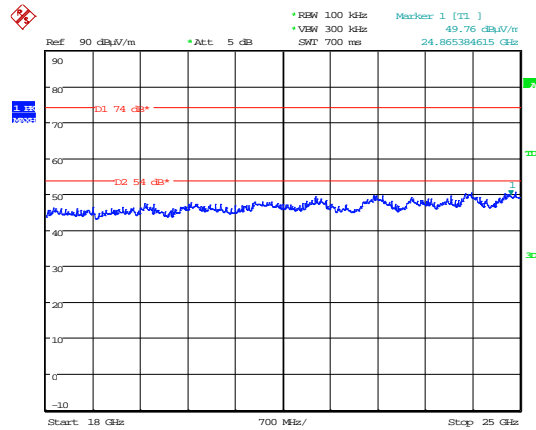
Date: 9.JAN.2014 14:02:36

#### 5GHz to 10 GHz



Date: 9.JAN.2014 14:03:06

#### 10 GHz to 15 GHz



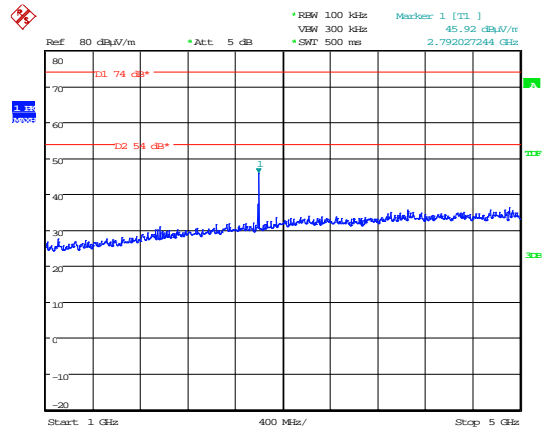
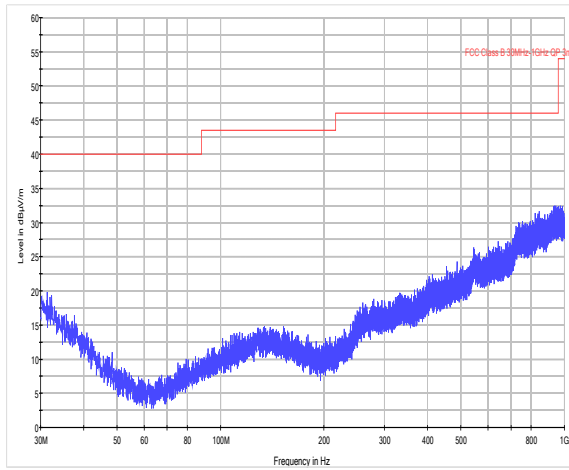
Date: 14.JAN.2014 11:17:31

#### 15 GHz to 18 GHz

#### 18 GHz to 25 GHz

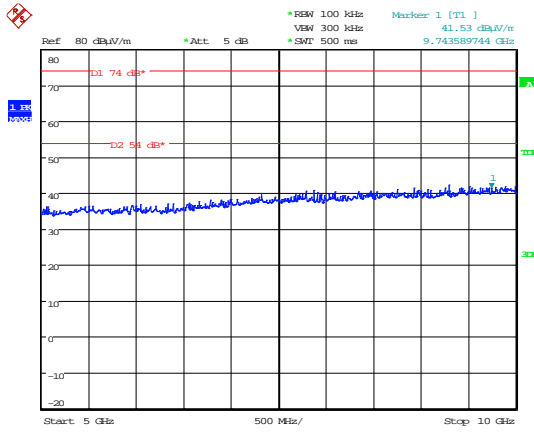


Unintentional Radiated Spurious Emissions – 2441 MHz



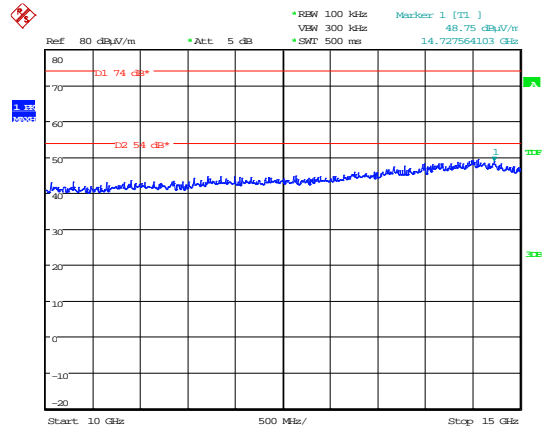
Date: 9.JAN.2014 14:33:18

30 MHz to 1 GHz



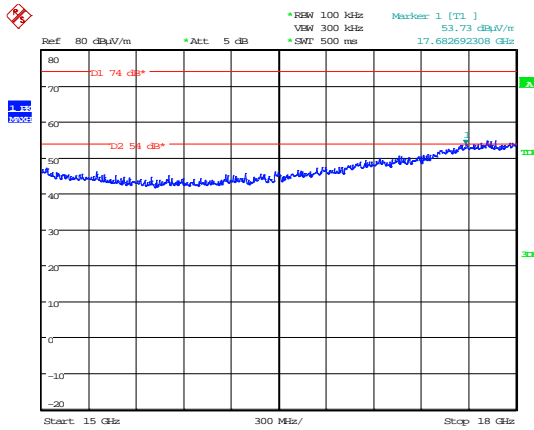
Date: 9.JAN.2014 14:33:53

1 GHz to 5 GHz



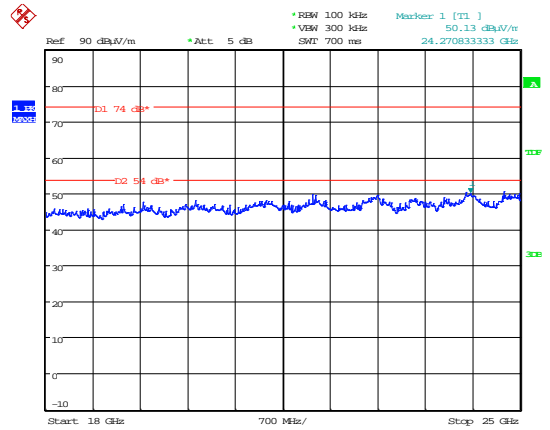
Date: 9.JAN.2014 14:34:27

5GHz to 10 GHz



Date: 9.JAN.2014 14:34:56

10 GHz to 15 GHz

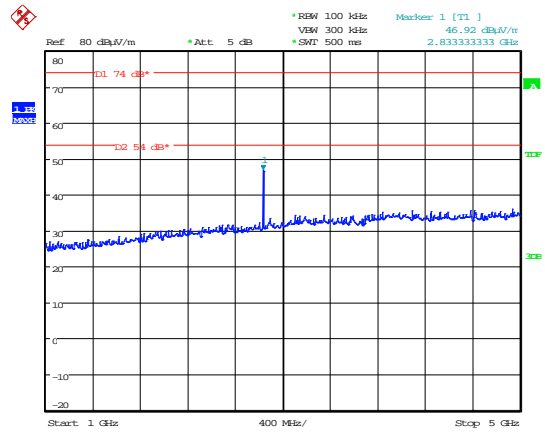
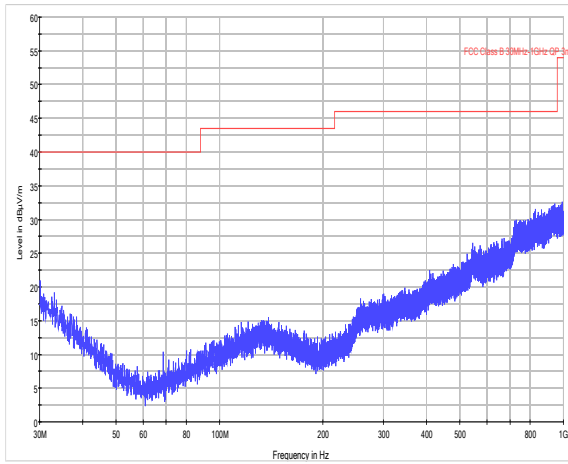


Date: 14.JAN.2014 11:19:10

15 GHz to 18 GHz

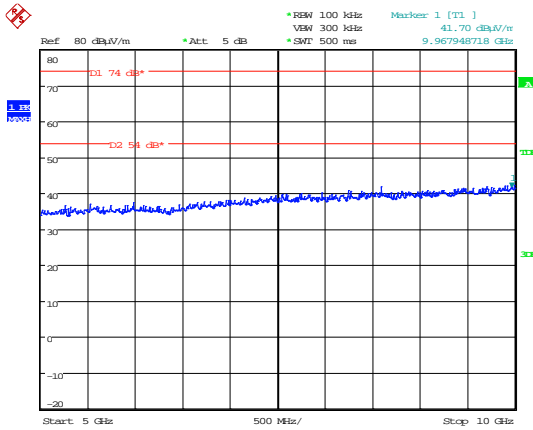
18 GHz to 25 GHz

### Unintentional Radiated Spurious Emissions – 2480 MHz



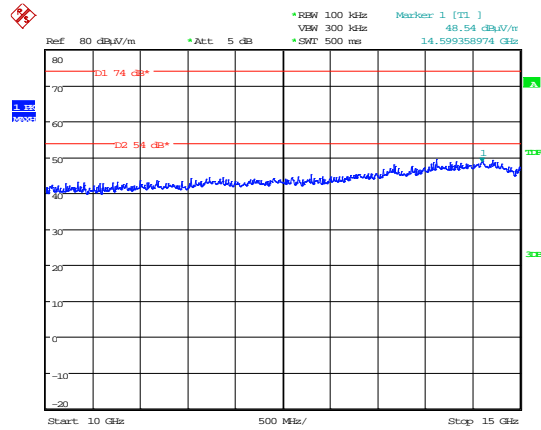
Date: 9.JAN.2014 14:49:10

### 30 MHz to 1 GHz



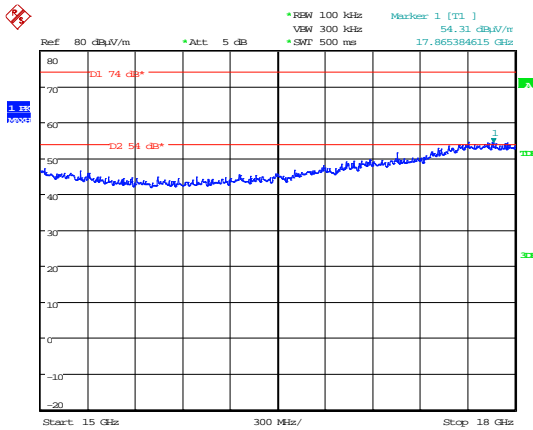
Date: 9.JAN.2014 14:49:57

### 1 GHz to 5 GHz



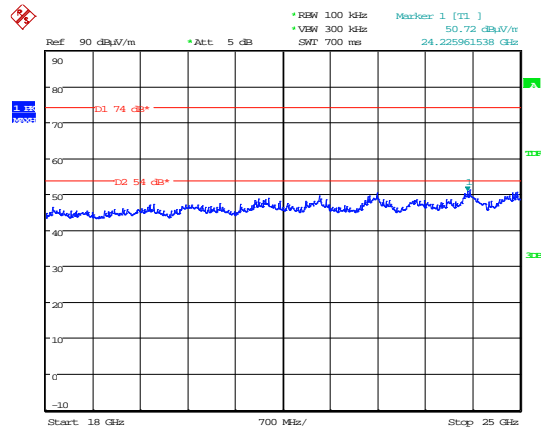
Date: 9.JAN.2014 14:50:43

### 5GHz to 10 GHz



Date: 9.JAN.2014 14:51:24

### 10 GHz to 15 GHz



Date: 14.JAN.2014 11:20:38

### 15 GHz to 18 GHz

### 18 GHz to 25 GHz

**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	Primo Radio 3D Tool Setter	232C93
S06	Primo Radio 3D Tool Setter	232C90

**C2) EUT Operating Mode During Testing.**

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

Test	Description of Operating Mode : Transmit
All tests detailed in this report	Unless Specified as set to a specific frequency the EUT transmitting on maximum power using FHSS over 79 channels

Test	Description of Operating Mode: Receive
Receiver conducted and radiated (ERP) spurious emissions	EUT active but non-transmitting.

**C3) EUT Configuration Information.**

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

**C4) List of EUT Ports**

EUT is battery powered equipment with no external ports.

**C5 Details of Equipment Used**

<b>TRAC Ref</b>	<b>Type</b>	<b>Description</b>	<b>Manufacturer</b>	<b>Date Calibrated.</b>
UH004	ESVS10	Receiver	R&S	11/02/2013
UH191	CBL611/A	Bilog	Chase	13/12/2012
UH281	FSU46	Spectrum Analyser	R&S	06/03/2013
UH405	FSU26	Spectrum Analyser	R&S	20/03/2013
L138	3115	1-18GHz Horn	EMCO	17/10/2013
L572	8449B	Pre Amp	Agilent	12/12/2012
REF940	ATS	Radio Chamber - PP	Rainford EMC	09/07/2013
REF977	SH4141	High Pass Filter	BSC	25/02/2013



## Appendix D:

## Additional Information

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15 January 2014

### DECLARATION

#### Primo system details

The Primo products (Interface, Part Setter and 3D Tool Setter) all use a Nordic Semiconductor nRF24L01+ transceiver. This transceiver provides automatic packet handling with an on-air transmission rate of 1Mbps. In addition to the payload, each transmission consists of 8 bits of preamble, 40 bits of address header, 9 bits of packet control data and finally 16 bits of CRC (covering the entire packet). The data payload can vary in length (depending on mode) from 48 bits to 144 bits for the probes and from 32 bits to 208 bits for the interface. The transceiver has a synthesiser settling time of approximately 130µs before it is ready to send the data over the air. The repetition rate under normal circumstances varies from between 1.024ms and 32.768ms (i.e. 976 transmissions per second to 30 transmissions per second) depending on whether the probe (Part Setter or 3D Tool Setter) receives an acknowledgement from the Primo Interface.

It should be noted that the test modes used within the individual Primo elements use Pseudorandom Noise modulated data (256µs) with a repetition rate of 1.024ms. The actual 'on-air' period starts 57µs before the PN data is transmitted and finishes 18µs after it, therefore giving a total time of 329µs.

Signed by

A handwritten signature in blue ink that reads "John Styles".

John Styles CEng MIET

Principal Design Engineer

**Appendix E:**

**Photographs and Figures**

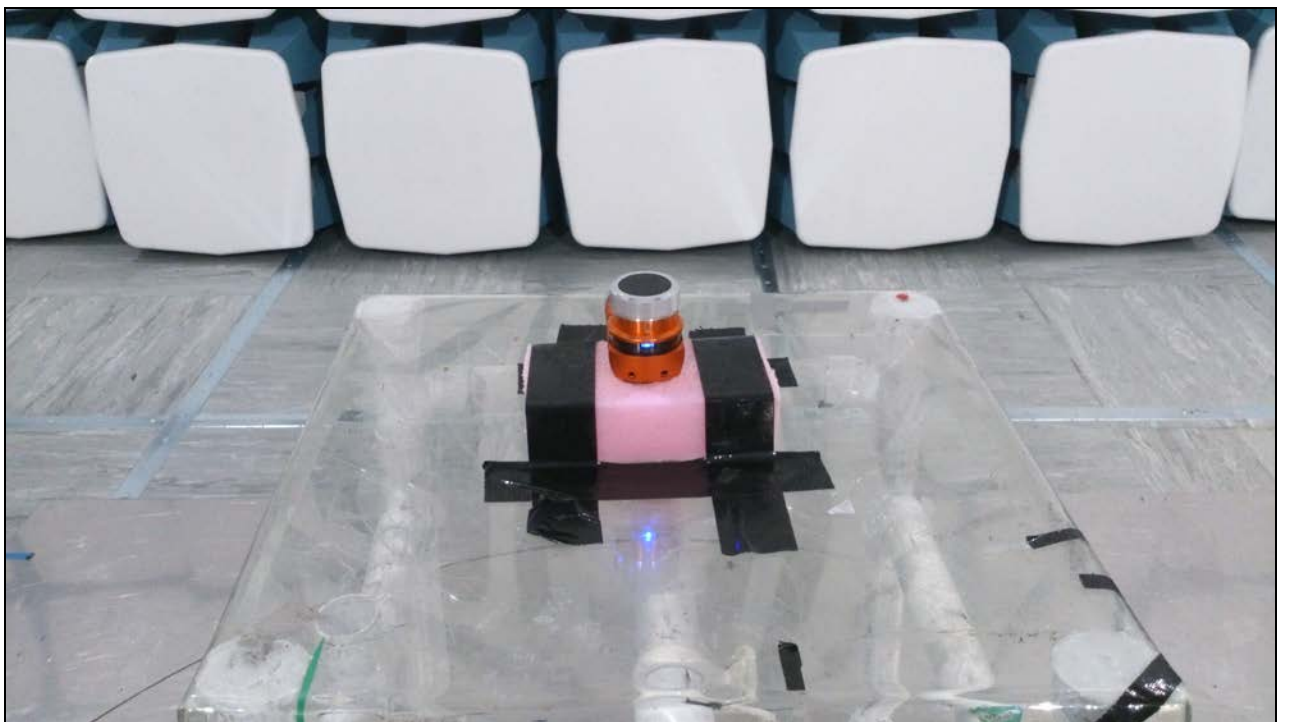
The following photographs were taken of the test samples:

1. Radiated electric field emissions arrangement: Overview.
2. Radiated electric field emissions arrangement: close up.

Photograph 1



Photograph 2



**Appendix F:****MPE Calculation**

OET Bulletin No. 65, Supplement C 01-01, RSS-102

**47 CFR §§1.1307 and 2.1091**

Radio frequency radiation exposure evaluation: mobile devices.

For purposes of these requirements mobile devices are defined by the FCC and IC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimetres is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits. As the 20cm separation specified under FCC and IC rules may not be achievable under normal operation of the EUT, an RF exposure calculation is needed to show the minimum distance required to be less than power the density limit, as required.

**Prediction of MPE limit at a given distance**

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{EIRP}{4\pi R^2} \text{ re - arranged } R = \sqrt{\frac{EIRP}{S4\pi}}$$

where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Note:

The EIRP measurement was calculated from the peak conducted carrier power plus the antenna gain.

Result:

Prediction Frequency (MHz)	Maximum EIRP (mW)	Power density limit (S) (mW/m <sup>2</sup> )	Distance (R) required to be less than (S)
2480	3.62	1	0.54

IC limit: 10mW/m<sup>2</sup>1mW/cm<sup>2</sup> ≡ 10W/m<sup>2</sup>

