TRaC Wireless Test Report	**:** 9A2786WUS1
Applicant	**:** ST Microelectronics
Apparatus	**:** DZ-ZB-S-A
Specification(s)	**:** CFR47 Part 15 C :2008 15.247
FCCID	**: YCPDZSTM32WA**
Purpose of Test	**:** Certification
Authorised by	**:** 
	: Radio Product Manager
Issue Date	**:**19th March 2010
Authorised Copy Number	**:** *PDF*

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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 :

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1.4 Apparatus Assessed

The following apparatus was assessed between: 12/04/10 to 22/04/10

DZ-ZB-S-A

The above apparatus was a.2.4GHz ZigBee radio transceiver.

1.5 Test Result Summary

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

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

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

Test Type	Regulation	Measurement standard	Result
Radiated spurious emissions (Restricted bands)	Title 47 of the CFR: Part 15 Subpart C; 15.247	ANSI C63.10	Pass
Conducted spurious emissions (Non-restricted bands)	Title 47 of the CFR: Part 15 Subpart C; 15.247	ANSI C63.10	Pass
AC Power conducted emissions	Title 47 of the CFR: Part 15 Subpart C; 15.207	ANSI C63.10	Pass
Occupied Bandwidth	Title 47 of the CFR : Part 15 Subpart C; 15.247(a)(2)	ANSI C63.10	Pass
Conducted Carrier Power	Title 47 of the CFR : Part 15 Subpart C; 15.247(b)	ANSI C63.10	Pass
Power Spectral Density	Title 47 of the CFR : Part 15 Subpart C; 15.247(d)	ANSI C63.10	Pass
Unintentional Radiated Spurious Emissions	Title 47 of the CFR: Part 15 Subpart C; 15.109	ANSI C63.10	Pass
Digital Modulation	Title 47 of the CFR: Part 15 Subpart C; 15.403	-	Pass
RF Safety	Title 47 of the CFR : Part 15 Subpart C; 15.247(b)(5)	-	Pass

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 Application of Measurement Uncertainty

The following table contains the measurement uncertainties for measurements

The following procedure is used when determining the result of a measurement :

(i) If specification limits are not exceeded by the measured result, extended by the positive component of the expanded uncertainty interval at a confidence level of 95%, then a pass result is recorded.

(ii) Where a specification limit is exceeded by the result even when the result is decreased by the negative component of the expanded uncertainty interval, a fail result is recorded.

(iii) Where a measured result is below a limit, but by a margin less than the positive measurement uncertainty component, it is not possible to record a pass based on a 95% confidence level. However, the result indicates that a pass result is more probable than a fail result.

(iv) Where a measured result is above a limit, but by a margin less than the negative measurement uncertainty component, it is not possible to record a fail based on a 95% confidence level. However the result indicates that a fail is more probable than a pass.

2.2 Measurement Uncertainty Values

For test data recorded in accordance with note (iii) of Section 2.1 the following measurement uncertainty was calculated:

Radiated Electric Field Emissions

Quantity Range	Quantity	Expanded Uncertainty
9kHz to 150 kHz	Amplitude dB(µV/m)	±1.6dB
150 kHz to 30 MHz	Amplitude dB(µV/m)	±2.1dB
30MHz to 300MHz Horizontal	Amplitude dB(µV/m)	±5.1dB
30MHz to 300MHz Vertical	Amplitude dB(µV/m)	±5.2dB
300MHz to 1GHz Horizontal	Amplitude dB(µV/m)	±5.4dB
300MHz to 1GHz Vertical	Amplitude dB(µV/m)	±5.2dB
1GHz to 18GHz Horizontal	Amplitude dB(µV/m)	±4.4dB
1GHz to 18GHz Vertical	Amplitude dB(µV/m)	±4.4dB
18GHz to 26.5GHz Horizontal	Amplitude dB(µV/m)	±4.2dB
18GHz to 26.5GHz Vertical	Amplitude dB(µV/m)	±4.2dB
26.5GHz to 40GHz Horizontal	Amplitude dB(µV/m)	±4.3dB
26.5GHz to 40GHz Vertical	Amplitude dB(µV/m)	±4.3dB

Power Line Conducted Emissions

Quantity Range	Quantity	Expanded Uncertainty
9kHz to 150kHz	Amplitude dB(µV)	±4.2dB
150kHz to 30MHz	Amplitude dB(µV)	±3.1dB

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
		ATS	: Alternative Test Site
EUT	: Equipment Under Test		
SE	: Support Equipment	Ref	: Reference
		Freq	: Frequency
L	: Live Power Line		
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 6 dB Bandwidth

Title 47 of the CFR: Part 15 Subpart (c) 15.247(a)(2) requires the measurement of the bandwidth of the transmission between the -6 dB points on the transmitted spectrum.

Test Details:	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) 15.247(a)(2)
EUT sample number	S03
Modification state	0
SE in test environment	REF112
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	$F_{lower\ (MHz)}$	$F_{Higher(MHz)}$	Measured 6dB Bandwidth (MHz)	Limit (kHz)	Result
2405	2404.206731	2405.825321	1.6185	>500	Pass
2440	2439.222756	2440.825321	1.6025	>500	Pass
2480	2479.222756	2480.817308	1.5945	>500	Pass

Plots of the 6 dB bandwidth are contained in Appendix B of this test report.

A2 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)(3)
Measurement standard	ANSI C63.10
EUT sample number	S03
Modification state	0
SE in test environment	REF112
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Peak Carrier Power (W)	Antenna Gain dBi	Radiated Power (W) (EIRP)	Limit (W)	Result
2405	0.003539973	1.0	0.004456562	1.0	Pass
2440	0.003111716	1.0	0.003917419	1.0	Pass
2480	0.002864178	1.0	0.003605786	1.0	Pass

Notes:

Conducted Measurement

Measured Peak Carrier power includes highest gain of any antenna to be used.
Highest Gain of any antenna to be used = 1 dBi
Conducted measurements were performed with a temporary antenna connector provided by the client.

A3 Transmitter Power Spectral Density

Transmitter Power Spectral Density 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(e)
Measurement standard	ANSI C63.10
EUT sample number	S03
Modification state	0
SE in test environment	REF112
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Antenna port Peak Power Spectral Density (dBm/3kHz)	Antenna Gain dBi	Peak Power Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)	Result
2405	-10.47	1.0	-9.47	8.0	Pass
2440	-11.30	1.0	-10.30	8.0	Pass
2480	-11.43	1.0	-10.43	8.0	Pass

Notes:

Conducted Measurement

Measured Power Spectral Density includes highest gain of any antenna to be used.
Highest Gain of any antenna to be used = 1dBi
Conducted measurements were performed with a temporary antenna connector provided by the client.
The resolution bandwidth on the analyser was set to 3kHz and trace set to max hold.
The span is set to 2MHz
The sweep time is 680 seconds (Span/3kHz).

A4 RF Antenna Conducted Spurious Emissions

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

Test Details: 2405 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10
Frequency range	9 kHz to 25 GHz
EUT sample number	S03
Modification state	0
SE in test environment	REF112
SE isolated from EUT	None
EUT set up	Refer to Appendix C

The worst case conducted upper band edge emission measurements at the antenna port are listed below with the transmitter at 2405MHz (CH11) :

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	9kHz to 25GHz	Pk	N	No Significant Emissions Within 20dB of the limit	87.83	Pass
2	2400.00	Pk	N	65.95	87.83	Pass
3	2399.910	Pk	N	66.86	87.83	Pass
4	2399.910	(In-band Pk)-(ΔPk Outside the band or band edge)		-40.58	54.0	Pass

No further emissions were detected within 20 dB of the test limit.

RF Antenna Conducted Spurious Emissions continued:

Test Details: 2440 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10
Frequency range	9 kHz to 25 GHz
EUT sample number	S03
Modification state	0
SE in test environment	REF112
SE isolated from EUT	None
EUT set up	Refer to Appendix C

The worst case conducted upper band edge emission measurements at the antenna port are listed below with the transmitter at 2440MHz (CH18) :

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	9kHz to 25GHz	Pk	N	No Significant Emissions Within 20dB of the limit	87.17	Pass

No further emissions were detected within 20 dB of the test limit.

RF Antenna Conducted Spurious Emissions continued:

Test Details: 2480 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10
Frequency range	9 kHz to 25 GHz
EUT sample number	S03
Modification state	0
SE in test environment	REF112
SE isolated from EUT	None
EUT set up	Refer to Appendix C

The worst case conducted upper band edge emission measurements at the antenna port are listed below with the transmitter at 2480MHz (CH26) :

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	9kHz to 25GHz	Pk	N	No Significant Emissions Within 20dB of the limit	85.81	Pass
2	2483.500	Pk	Y	60.51	85.81	Pass
3	2483.919	Pk	Y	70.70	85.81	Pass
4	2483.919	(In-band Pk)-(ΔPk Outside the band or band edge)		-36.05dB	54.0	Pass

No further emissions were detected within 20 dB of the test 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 accordance15.33 (a)(1).
3. The measurements at 2400 MHz and 2483.5 MHz were made to ensure band edge compliance.
4. The carrier level was measured whilst varying the supply voltage between 85% and 105% of the nominal supply voltage as required by 15.31(e). No variation in carrier level was observed. All other emissions were at least 20dB below the test limit

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

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

Where:

The maximum peak conducted power was measured using a spectrum analyser using a 100kHz resolution bandwidth.

Channel No.	Channel Frequency (MHz)	Measured Peak Carrier (dBμV)	Measured Peak Carrier –20dB (dBμV)	Emission Limit In a 100 kHz RBW (dBμV)
11	2405	107.83	107.83-20	87.83
19	2445	107.17	107.17-20	87.17
26	2480	105.81	105.81-20	85.81

A5 Transmit Radiated Electric Field Emissions 15.209 and within the Restricted Bands of 15.205

Preliminary scans were performed using a peak detector with the RBW = 100kHz below 1GHz and a RBW = 1MHz >1GHz. The radiated electric filed 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: 2405 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart C; 15.247 Clause 15.205 and 15.209
Measurement standard	ANSI C63.10
Frequency range	30MHz to 25 GHz
EUT sample number	S04
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photographs 1 and 2

The worst case radiated emission measurements for spurious emissions:

Ref No.	FREQ. (MHz)	DET	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	LIMIT (dBµV/m)
1.	2390.000	Pk	48.1	2.5	28.4	33.81	45.2	0	45.2	74.0
2.	2390.000	Av	38.79	2.5	28.4	33.81	35.9	0	35.9	54.0
3.	2399.919	Pk	65.2	2.7	28.4	33.81	62.5	0	62.5	83.1
4.	2399.919	Av	58.78	2.7	28.4	33.81	56.1	0	56.1	63.1
5.	2400.000	Pk	64.77	2.7	28.4	33.81	62.1	0	62.1	83.1
6.	2400.000	Av	58.19	2.7	28.4	33.81	55.5	0	55.5	63.1
7.	2404.496	Pk	71.88	2.8	28.4	N/A	103.1	0	103.1	137.0
8.	2483.500	Pk	42.81	2.6	28.5	33.84	40.1	0	40.1	74.0
9.	2483.500	Av	29.43	2.6	28.5	33.84	26.7	0	26.7	54.0
10.	4811.025	Pk	42.80	4.1	33.2	34.12	46.0	0	46.0	74.0
11	4811.025	Av	28.85	4.1	33.2	34.12	32.0	0	32.0	54.0

Test Details: 2440 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart (b) Clause 15.209
Measurement standard	ANSI C63.10
Frequency range	30MHz to 25 GHz
EUT sample number	S04
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photographs 1 and 2

The worst case radiated emission measurements for spurious emissions:

Ref No.	FREQ. (MHz)	DET	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	LIMIT (dBµV/m)
1.	2390.000	Pk	44.6	2.5	28.4	33.81	41.7	0	41.7	74.0
2.	2390.000	Av	30.4	2.5	28.4	33.81	27.5	0	27.5	54.0
3.	2400.000	Pk	44.5	2.7	28.4	33.81	41.8	0	41.8	79.9
4.	2400.000	Av	30.4	2.7	28.4	33.81	27.6	0	27.6	59.9
5.	2440.480	Pk	69.3	2.7	28.5	N/A	100.5	0	100.5	137.0
6.	2483.500	Pk	43.4	2.6	28.5	33.84	40.7	0	40.7	74.0
7.	2483.500	Av	30.7	2.6	28.5	33.84	28.0	0	28.0	54.0
8.	3664.282	Pk	43.5	3.8	31.7	34.05	45.0	0	45.0	74.0
9.	3664.282	Av	31.0	3.8	31.7	34.05	32.5	0	32.5	54.0

Test Details: 2480 MHz	
Regulation	Title 47 of the CFR: Part 15 Subpart (b) Clause 15.209
Measurement standard	ANSI C63.10
Frequency range	30MHz to 25 GHz
EUT sample number	S04
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photographs 1 and 2

The worst case radiated emission measurements for spurious emissions:

Ref No.	FREQ. (MHz)	DET	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	LIMIT (dBµV/m)
1.	2390.000	Pk	43.7	2.5	28.4	33.81	40.8	0	40.8	74.0
2.	2390.000	Av	30.43	2.5	28.4	33.81	27.5	0	27.5	54.0
3.	2400.000	Pk	43.84	2.7	28.4	33.81	41.1	0	41.1	81.4
4.	2400.000	Av	30.37	2.7	28.4	33.81	27.7	0	27.7	61.4
5.	2479.543	Pk	70.81	2.8	28.5	N/A	102.1	0	102.1	137.0
6.	2483.500	Pk	38.7	2.6	28.5	N/A	69.8	0	69.8	74.0
7.	2483.500	Av	28.6	2.6	28.5	N/A	59.7	0	59.7*	54.0
8.	2483.924	Pk	37.58	2.6	28.5	N/A	68.7	0	68.7	74.0
9.	2483.924	Av	28.3	2.6	28.5	N/A	59.4	0	59.4*	54.0
10.	4959.070	Pk	44.7	4.3	33.6	34.15	48.5	0	48.5	74.0
11	4959.070	Av	34.2	4.3	33.6	34.15	38.0	0	38.0	54.0

* Pass, refer to Note 3

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 For all the above tables, the average emissions results can be reduced by the 11.4 dB duty cycle correction factor calculated in Appendix E for comparison with the test limit.

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

The upper and lower frequency of the measurement range was decided according to 47 CFR 15:2008 Clause 15.33(a) and 15.33(a)(1).

Limits

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

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

(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:

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

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

A6 Power Line Conducted Emissions

Preview power line conducted emission measurements were performed with a peak detector in a screened room. The effect of the EUT set-up on the measurements is summarised in note (b). Where applicable formal measurements of the emissions were performed with a peak, average and/or quasi peak detector. The EUT was set to transmit on its lowest, centre and highest carrier frequency in turn. The formal measurements are detailed below:

Test Details: Transmit mode	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.207
Measurement standard	ANSI C63.10
Frequency range	150kHz to 30MHz
EUT sample number	S04 and S05
Modification state	0
SE in test environment	RFG109
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 3

The worst-case power line conducted emission measurements are listed below:

Results measured using the peak detector compared to the average limit

Ref No.	Conductor	Freq (MHz)	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
1	N	0.17770	25.1	54.6	-29.5	Pass
2	N	0.35600	33.7	48.8	-15.1	Pass
3	N	0.40100	29.4	47.8	-18.4	Pass
4	N	0.75730	27.9	46.0	-18.2	Pass
5	N	1.82680	24.7	46.0	-21.3	Pass
6	N	2.40550	32.0	46.0	-14.0	Pass
7	N	4.00900	31.4	46.0	-14.6	Pass
8	N	12.99997	33.6	50.0	-16.4	Pass
9	N	29.69700	38.0	50.0	-12.0	Pass
10	L	0.17770	25.8	54.6	-28.8	Pass
11	L	0.35667	32.6	48.8	-16.2	Pass
12	L	0.40126	29.4	47.8	-18.4	Pass
13	L	0.75796	24.2	46.0	-21.8	Pass
14	L	1.82811	31.4	46.0	-14.6	Pass
15	L	2.40779	34.7	46.0	-11.3	Pass
16	L	4.01302	33.2	46.0	-12.8	Pass
17	L	12.99997	34.2	50.0	-15.9	Pass
18	L	29.69610	37.8	50.0	-12.2	Pass

Test Details: Receive mode	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.107
Measurement standard	ANSI C63.10
Frequency range	150kHz to 30MHz
EUT sample number	S04 and S05
Modification state	0
SE in test environment	RFG109
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 3

The worst-case power line conducted emission measurements are listed below:

Results measured using the peak detector compared to the average limit

Ref No.	Conductor	Freq (MHz)	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
1	N	0.17767	24.3	54.6	-30.3	Pass
2	N	0.35544	30.9	48.8	-17.9	Pass
3	N	0.39984	32.6	47.8	-15.2	Pass
4	N	0.93313	28.5	46.0	-17.5	Pass
5	N	1.55500	27.7	46.0	-18.3	Pass
6	N	2.31030	31.6	46.0	-14.4	Pass
7	N	4.13180	31.5	46.0	-14.5	Pass
8	N	29.01000	40.9	50.0	-9.1	Pass
9	L	0.17776	25.3	54.6	-29.3	Pass
10	L	0.35560	29.4	48.8	-19.4	Pass
11	L	0.40000	31.8	47.8	-16.0	Pass
12	L	0.93329	22.2	46.0	-23.8	Pass
13	L	1.55549	28.9	46.0	-17.1	Pass
14	L	2.31133	34.7	46.0	-11.3	Pass
15	L	4.13284	34.1	46.0	-11.9	Pass
16	L	29.01320	40.9	50.0	-9.1	Pass

Specification limits :

Conducted emission limits (47 CFR 15: Clause 15.207 and 15.107):

Conducted disturbance at the mains ports.

Frequency range MHz	Limits dBμV	
	Quasi-peak	Average
0.15 to 0.5	66 to 56[2]	56 to 46[2]
0.5 to 5	56	46
5 to 30	60	50

Notes:
1. The lower limit shall apply at the transition frequency.
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15MHz to 0.5MHz.

Notes:

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

(b) The following table summarises the effect of the EUT operating mode and internal configuration 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		✓		

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

A7 Antenna Gain

The maximum antenna gain for the antenna types to be used with the EUT, as declared by the client, is 1dBi. (see Appendix D for data sheets)

A8 Unintentional Radiated Electric Field Emissions - 15.109

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

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

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

Test Details: Receive mode	
Regulation	Title 47 of the CFR: Part 15 Subpart (b) Clause 15.109
Measurement standard	ANSI C63.10
Frequency range	30MHz to 25 GHz
EUT sample number	S04
Modification state	0
SE in test environment	REF112
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photographs 1 and 2

Ref No.	FREQ. (MHz)	DET	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	LIMIT (dBµV/m)
1.	4872.076	Pk	48.16	4.4	33.3	34.13	51.7	-9.5	42.2	74.0
2.	4872.076	Av	42.45	4.4	33.3	34.13	46.0	-9.5	36.5	54.0

No further spurious emissions within 20 dB of the test limit were detected.

Specification limits :

The upper frequency of the measurement range was decided according to 47 CFR 15:2008 Clause 15.33.

Radiated emission limits (47 CFR 15:2008 Clause 15.109):

Except for a Class A digital device, the field strength of radiated emissions from unintentional radiators at a distance of 3m shall not exceed the following values:

Frequency of emission (MHz)	Field strength μV/m	Field strength dBμV/m
30-88	100	40.0 (quasi-peak)
88-216	150	43.5 (quasi-peak)
216-960	200	46.0 (quasi-peak)
960-1000	500	54.0 (quasi-peak)
Above 1000	500	54.0 (average)
Above 1000	-	74.0 (peak)

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:

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

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 1)	See 2)	See 3)	See 4)
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		✓		

1) Parameter defined by standard and / or single possible.
2) Parameter defined by client and / or single possible.
3) Parameter had a negligible effect on emission levels.
4) Worst case determined by initial measurement.

Appendix B: Supporting Graphical Data

This appendix contains graphical data obtained during testing.

Notes:

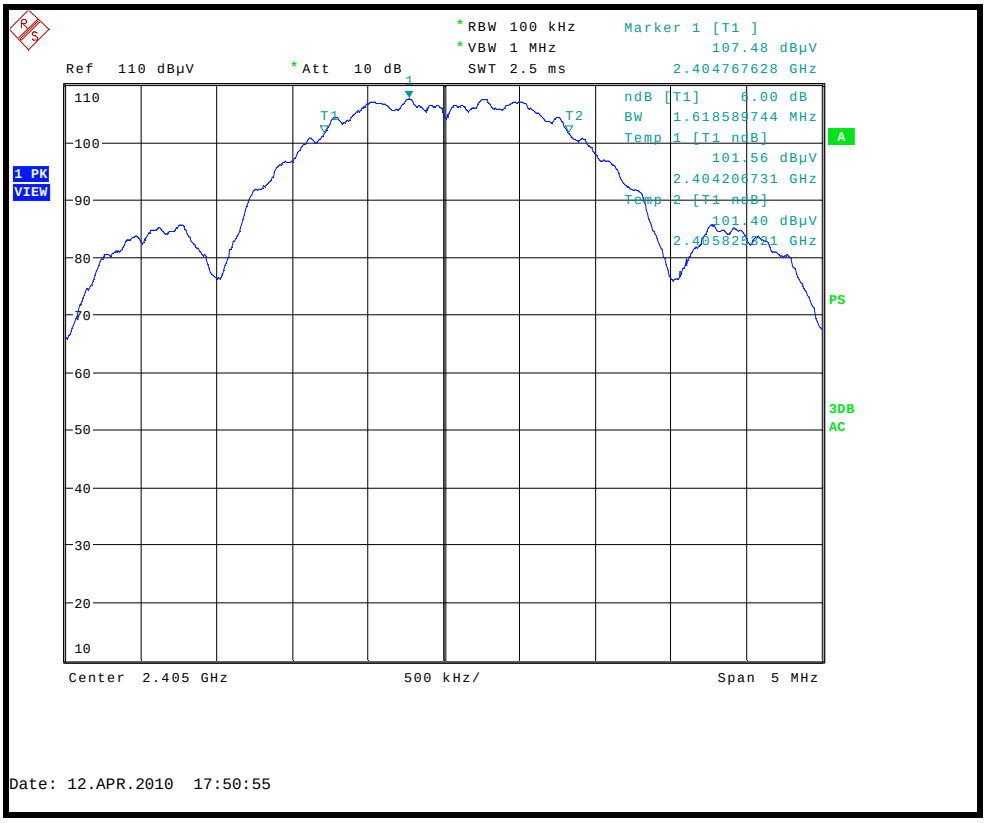
(a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.

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

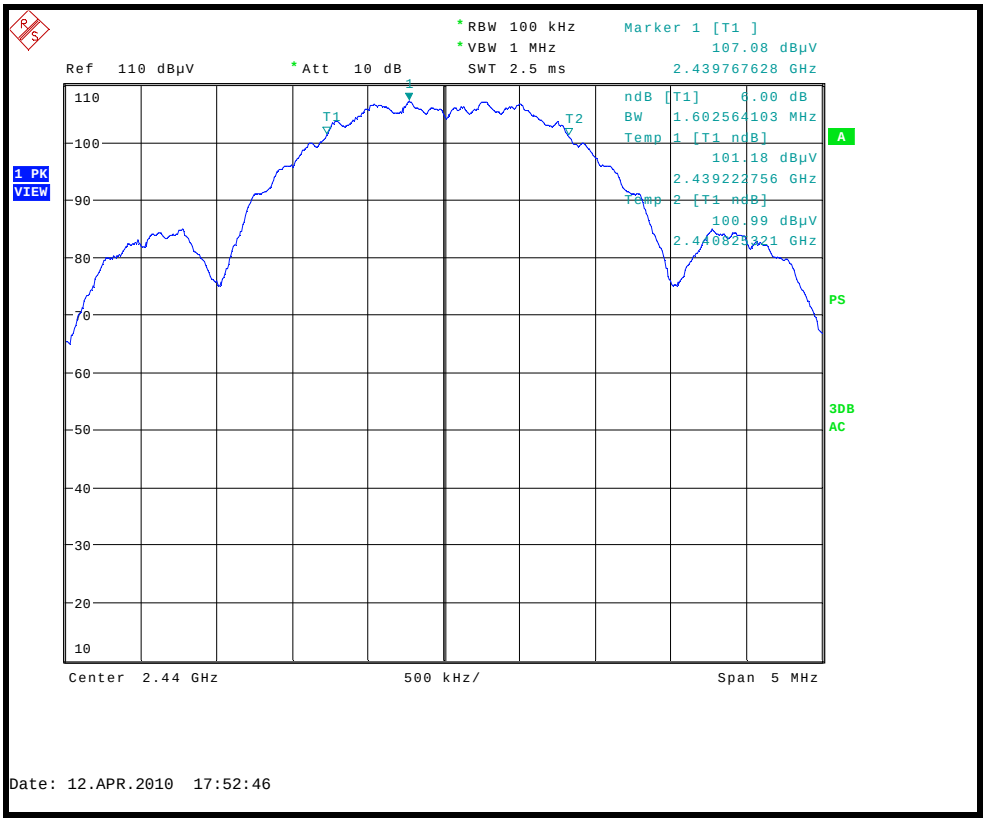
(c) Where relevant, on power line conducted emission plots, the limit displayed is the average limit, which is stricter than the quasi peak limit.

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

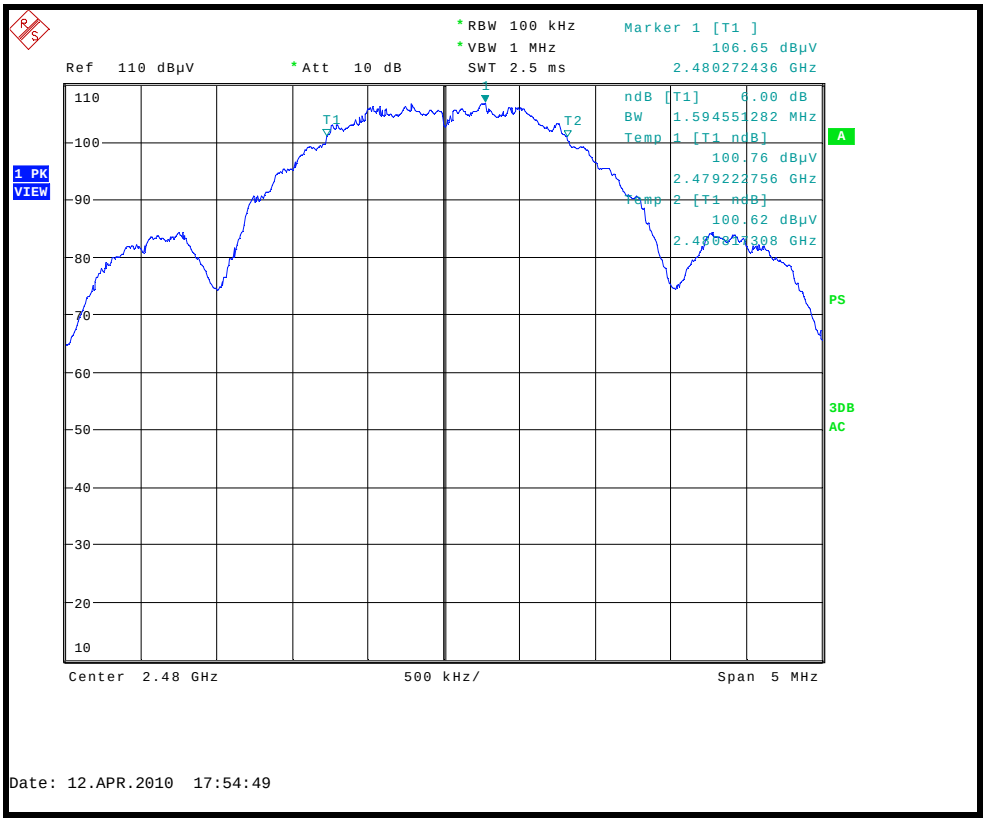
(e) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.



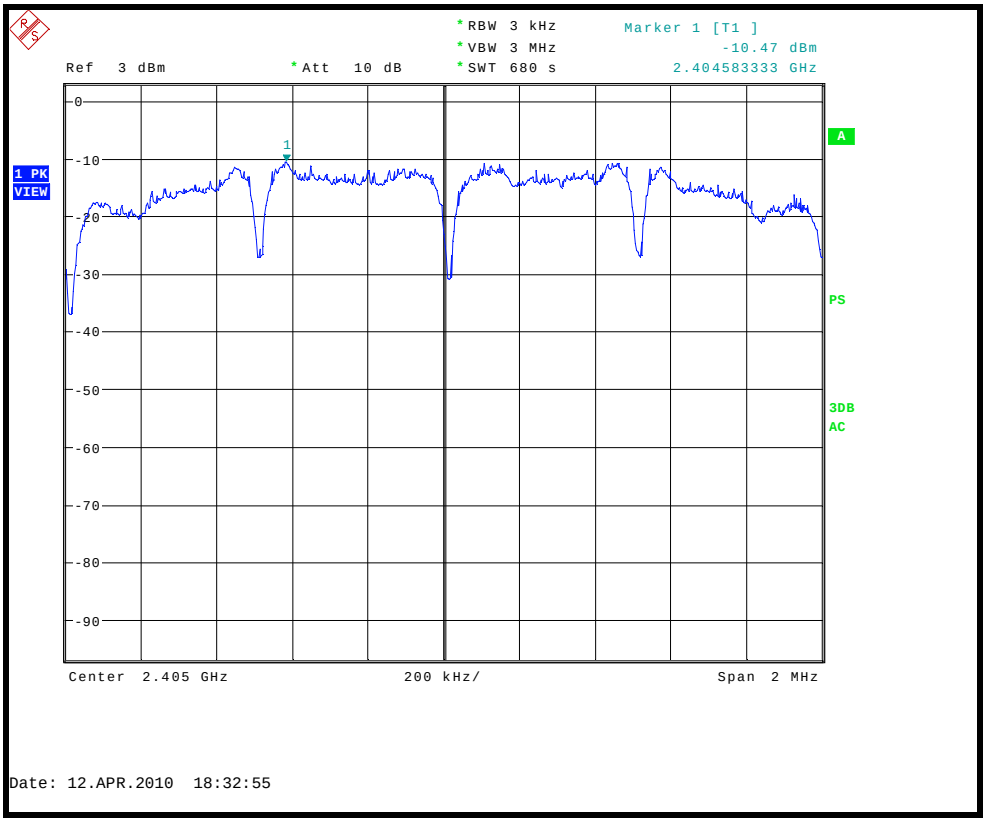
6dB Bandwidth: Channel 11 2405MHz



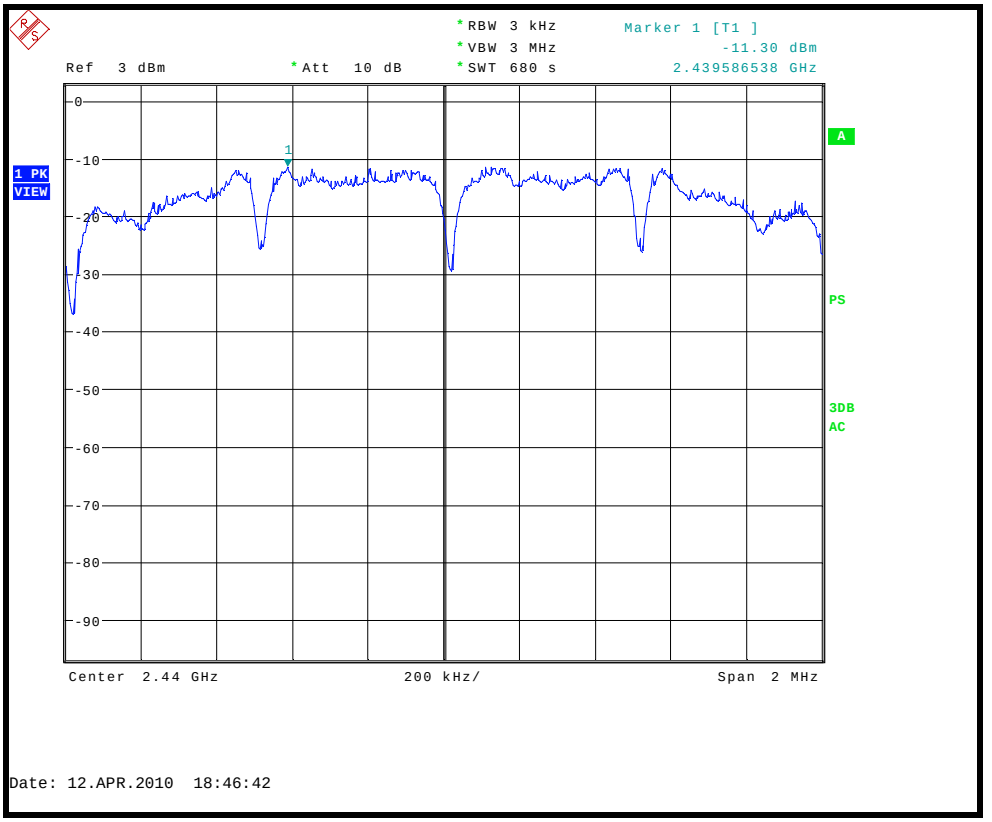
6dB Bandwidth: Channel 18 2440MHz



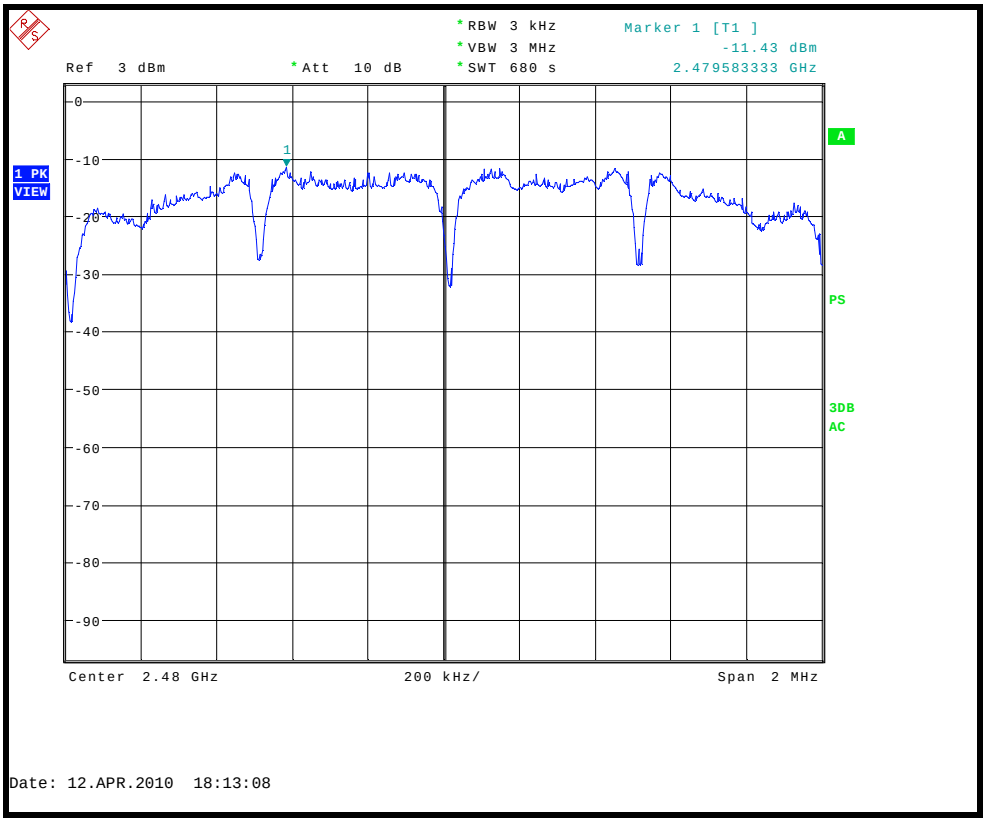
6dB Bandwidth: Channel 26 2480MHz



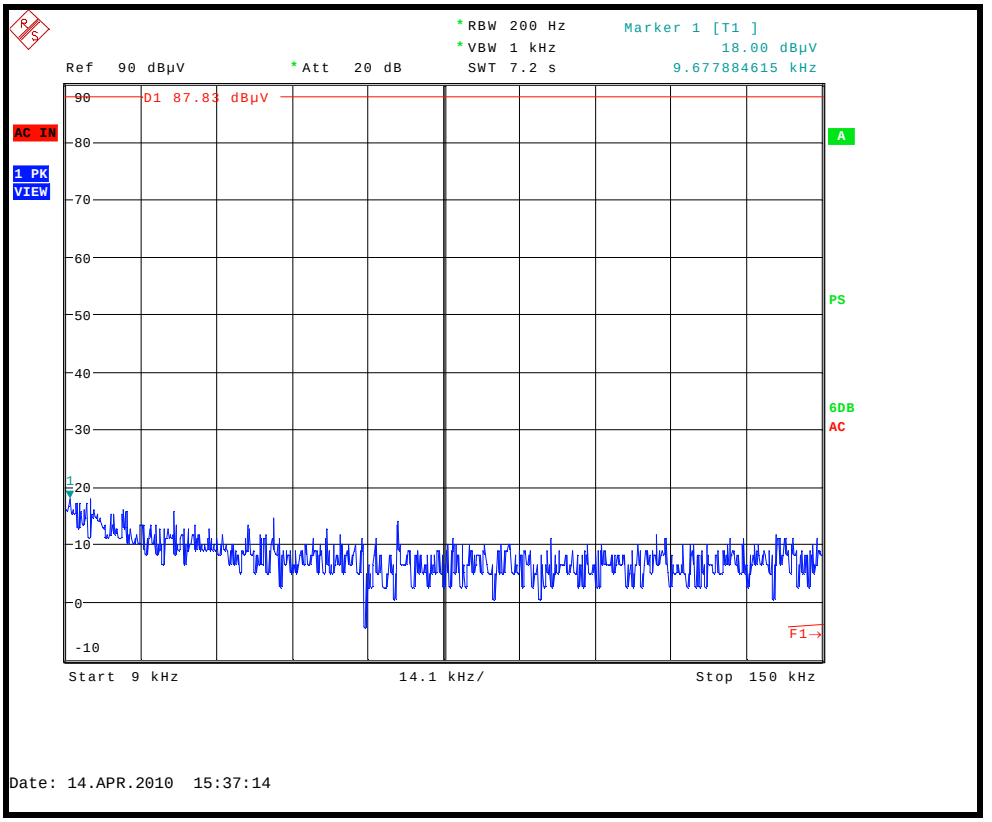
Power Spectral Density: Channel 11 2405MHz



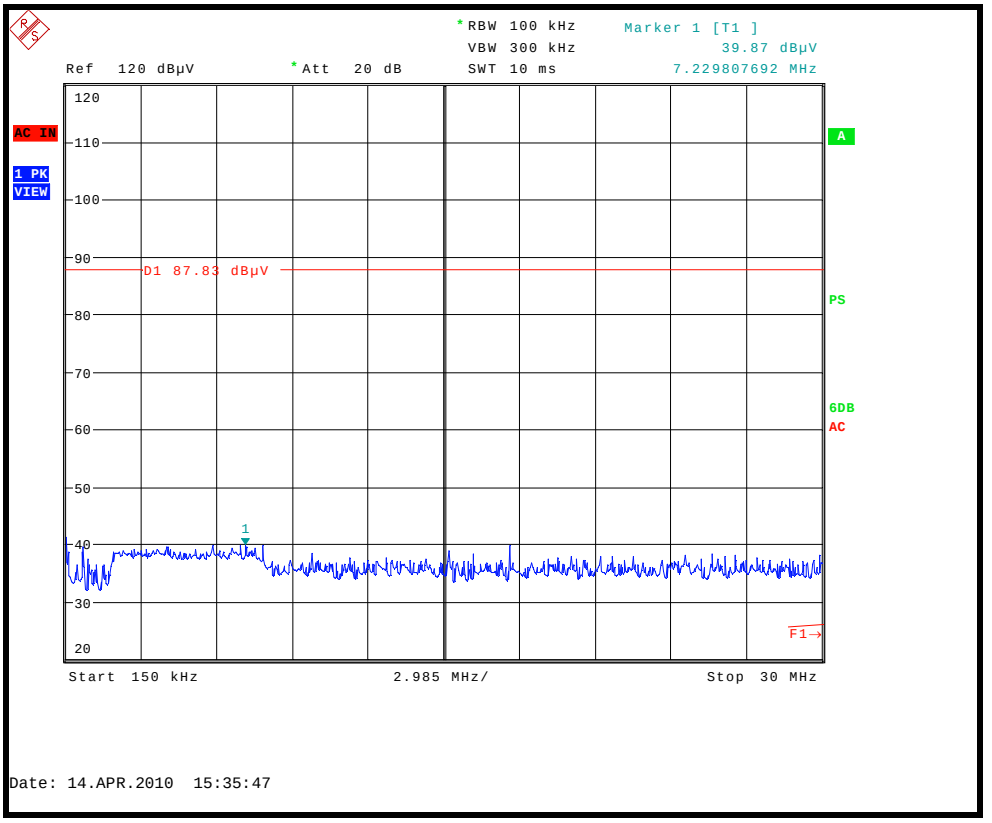
Power Spectral Density: Channel 18 2440MHz



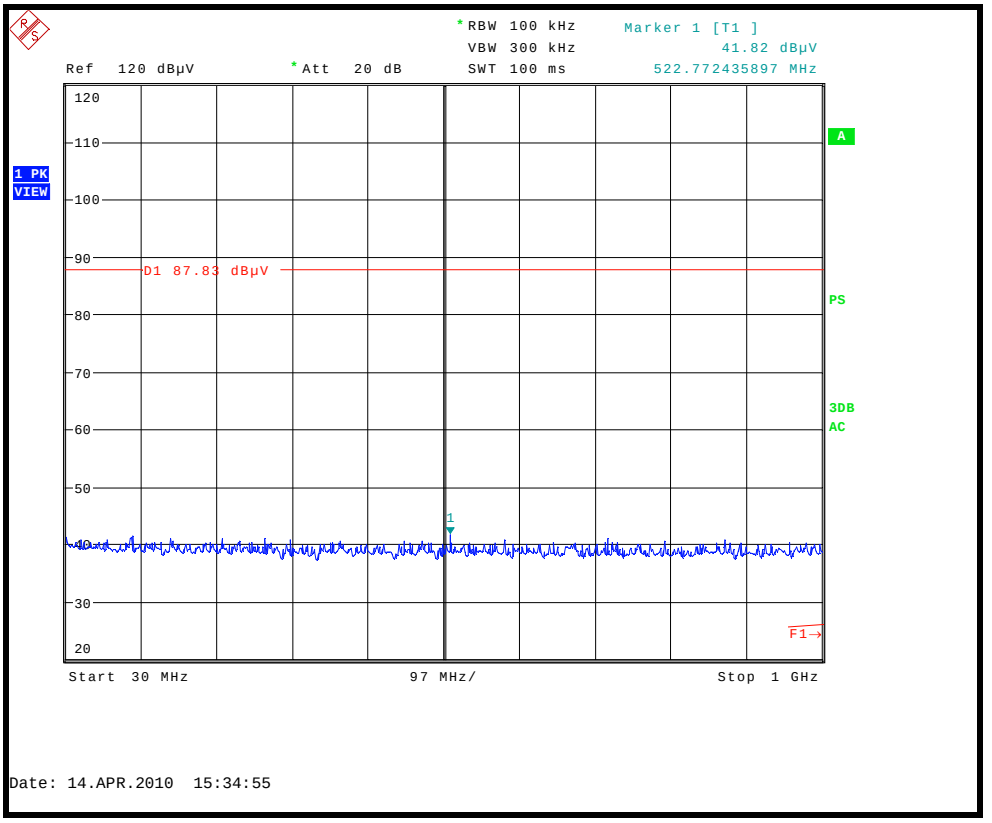
Power Spectral Density: Channel 26 2480MHz



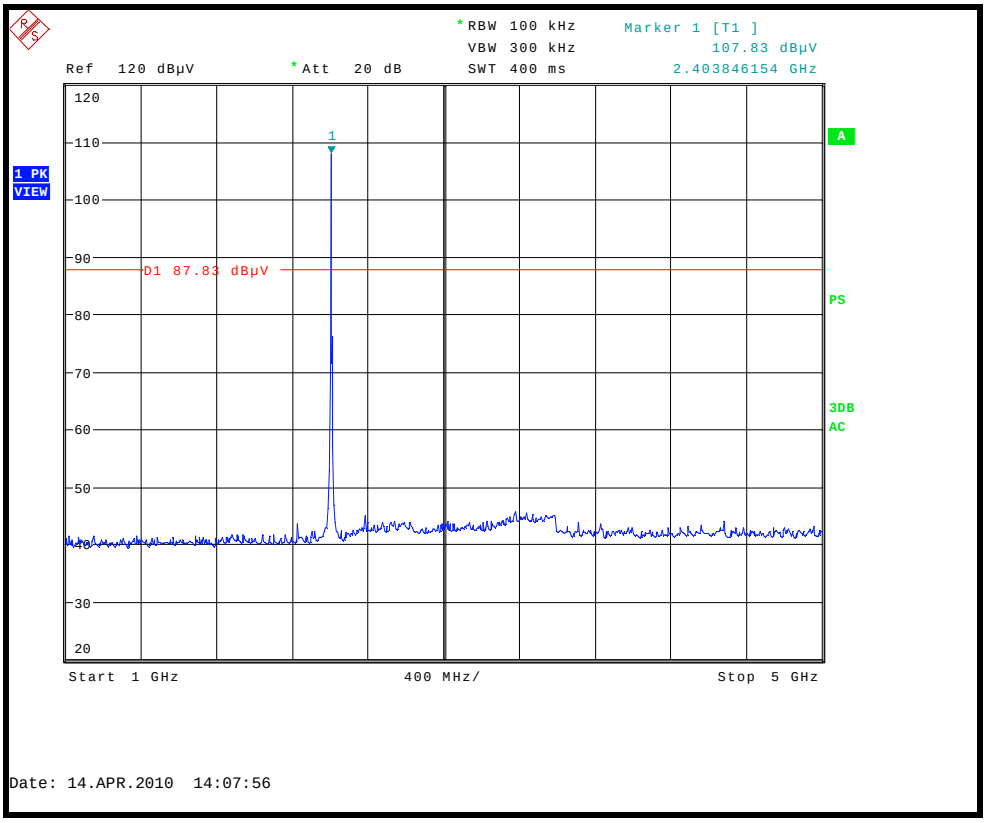
Conducted Emissions Channel 11 2405MHz



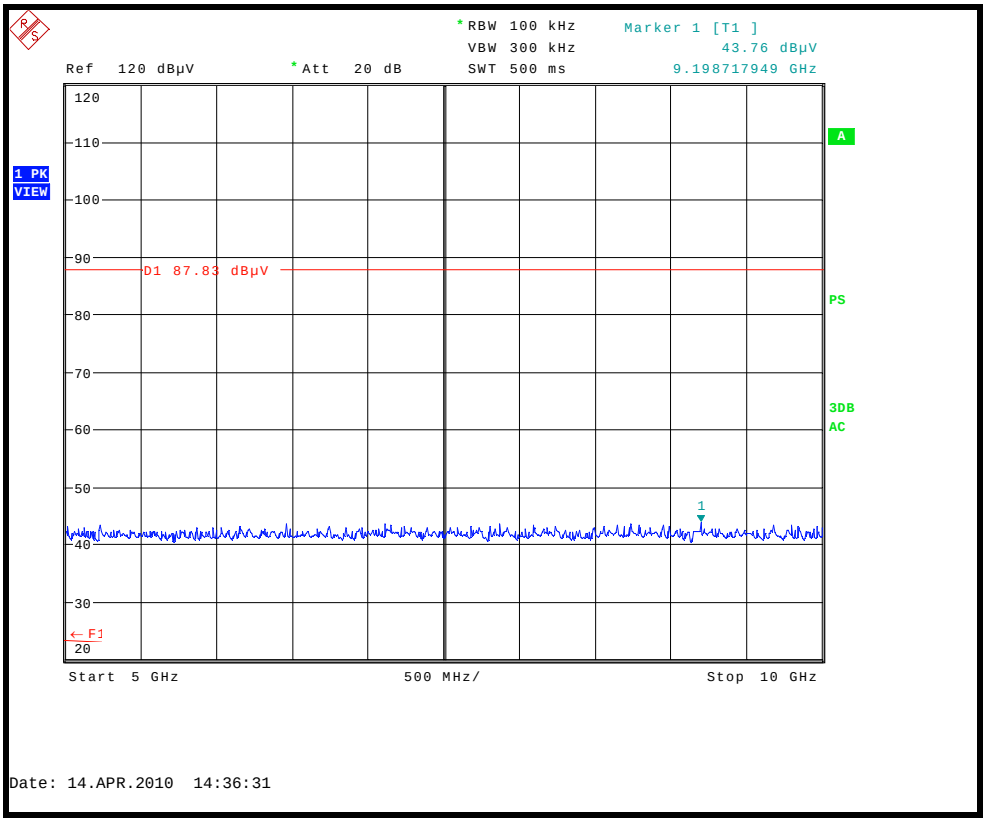
Conducted Emissions Channel 11 2405MHz



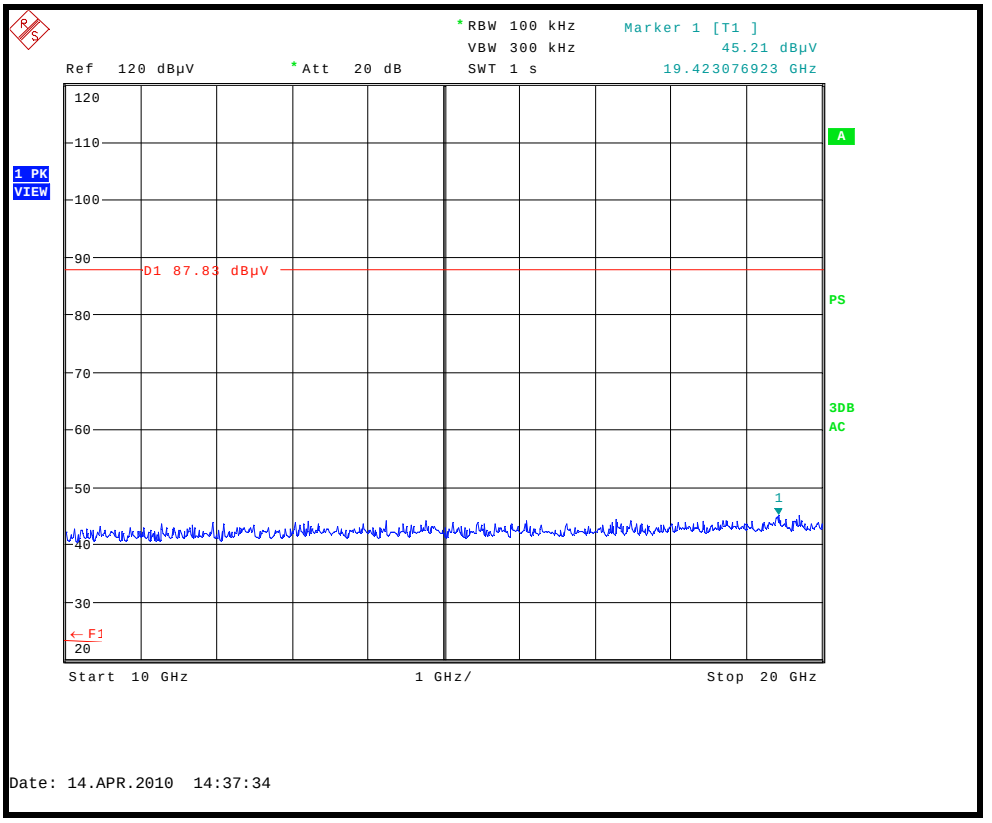
Conducted Emissions Channel 11 2405MHz



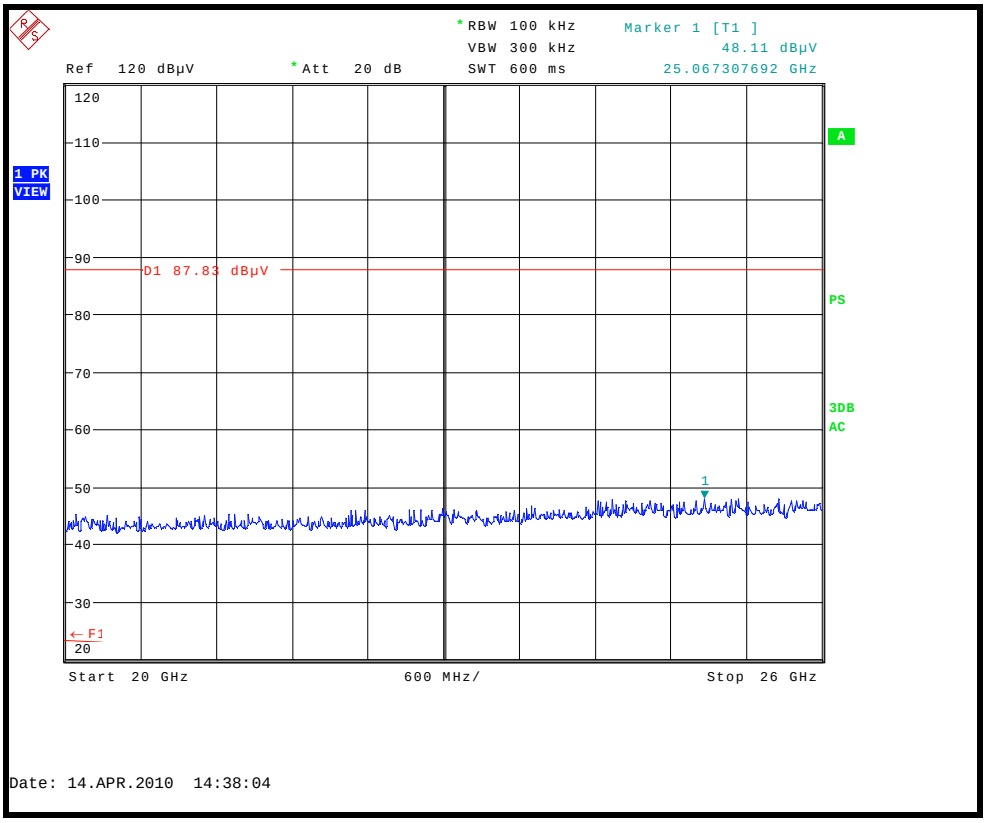
Conducted Emissions Channel 11 2405MHz



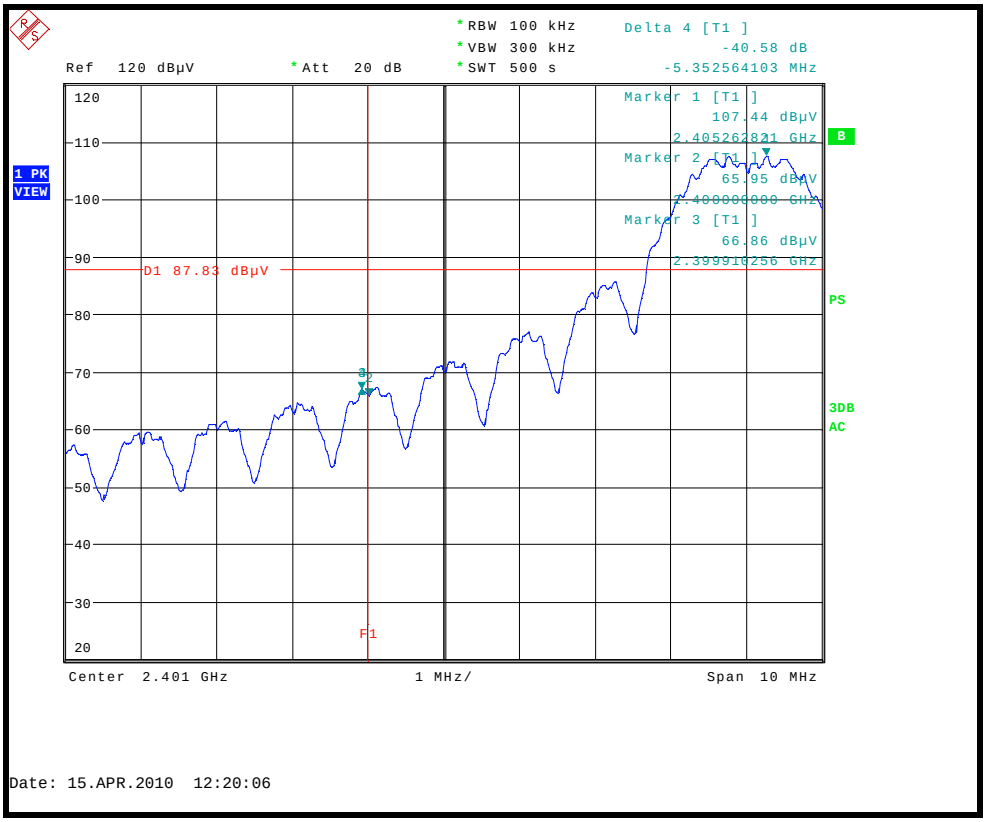
Conducted Emissions Channel 11 2405MHz



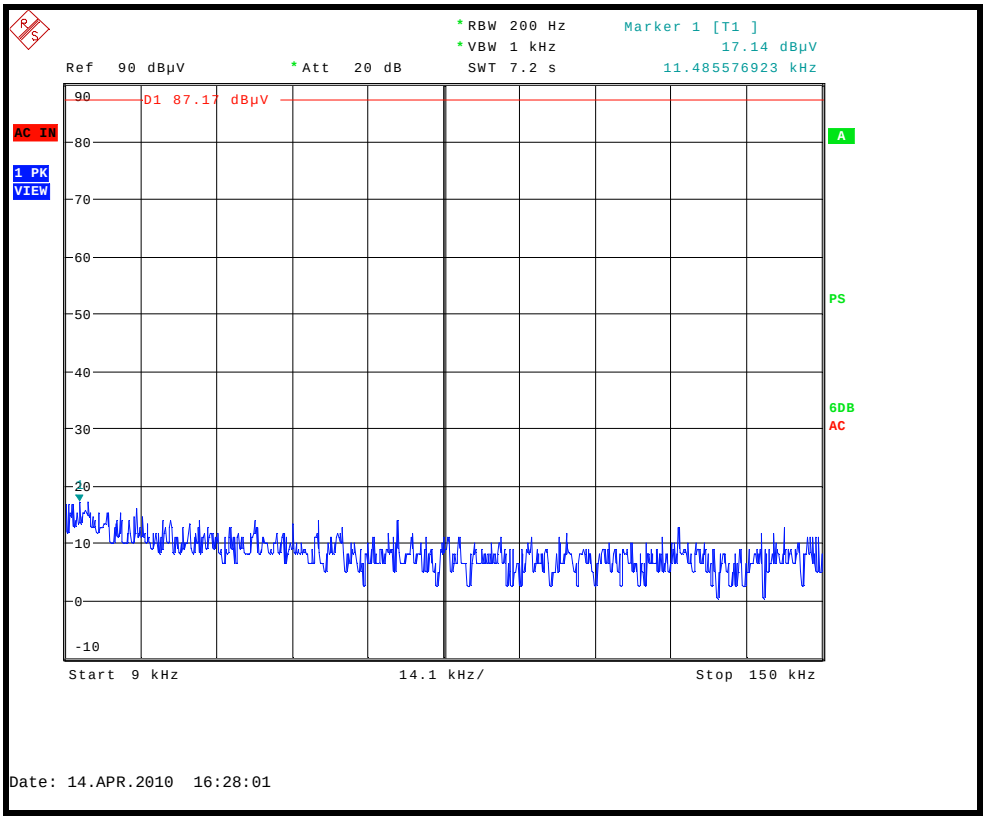
Conducted Emissions Channel 11 2405MHz



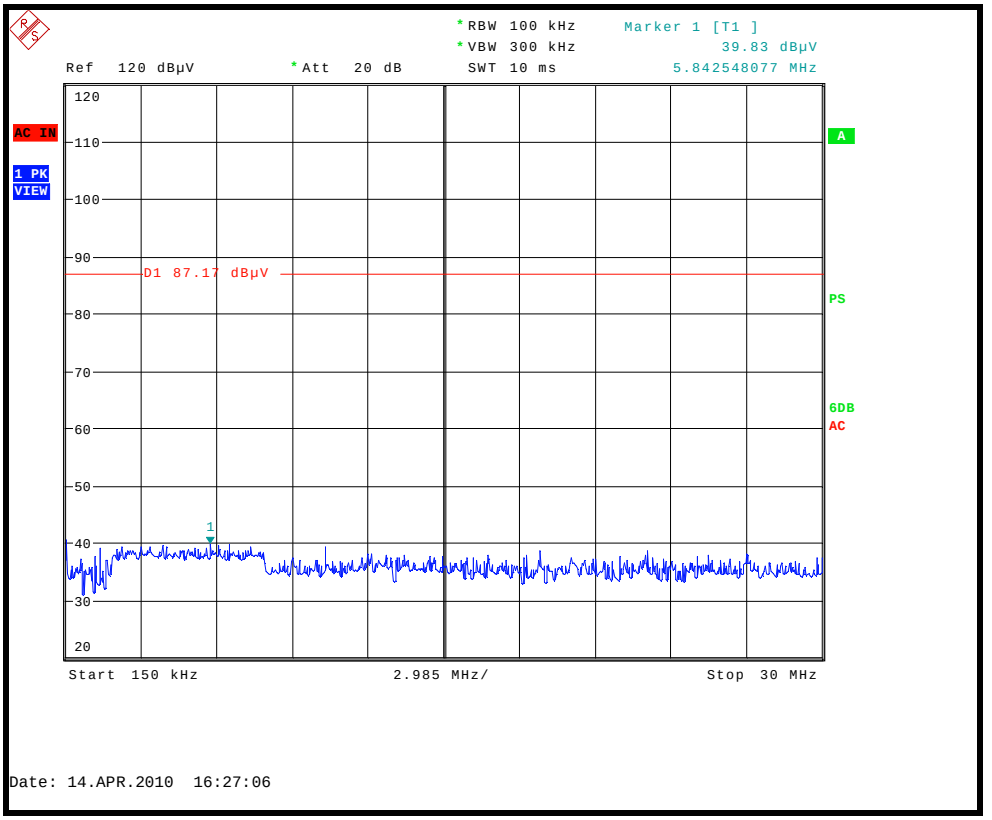
Conducted Emissions Channel 11 2405MHz



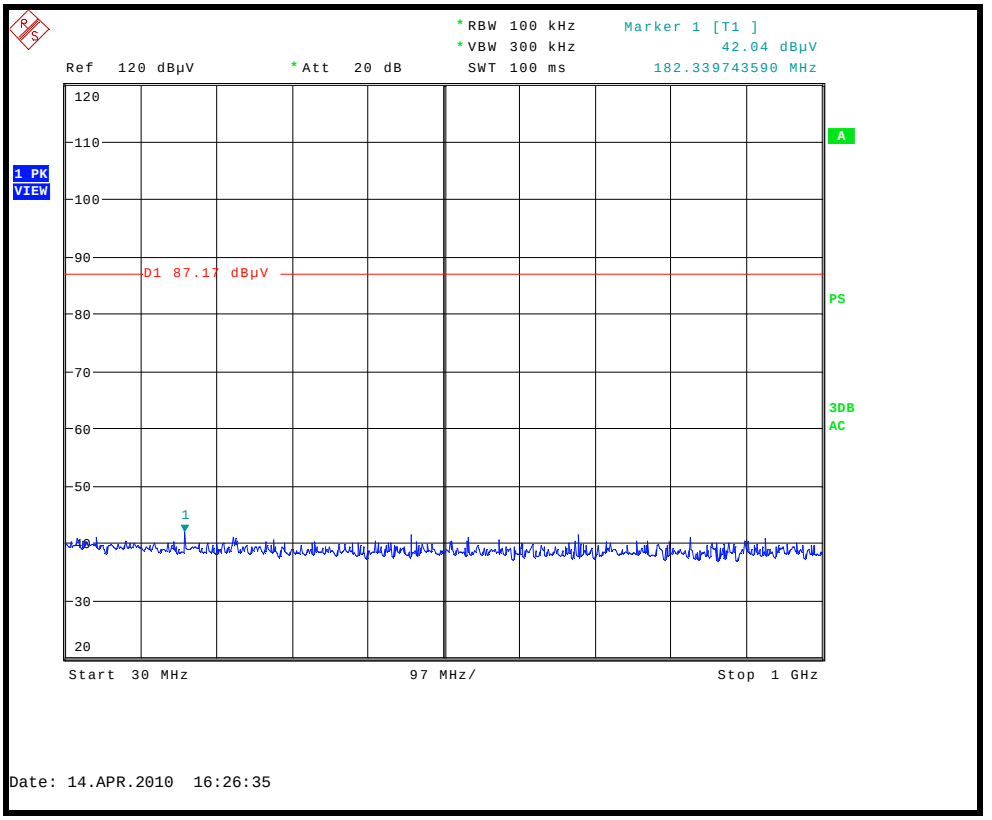
Conducted Emissions Channel 11 2405MHz: Lower-Band edge



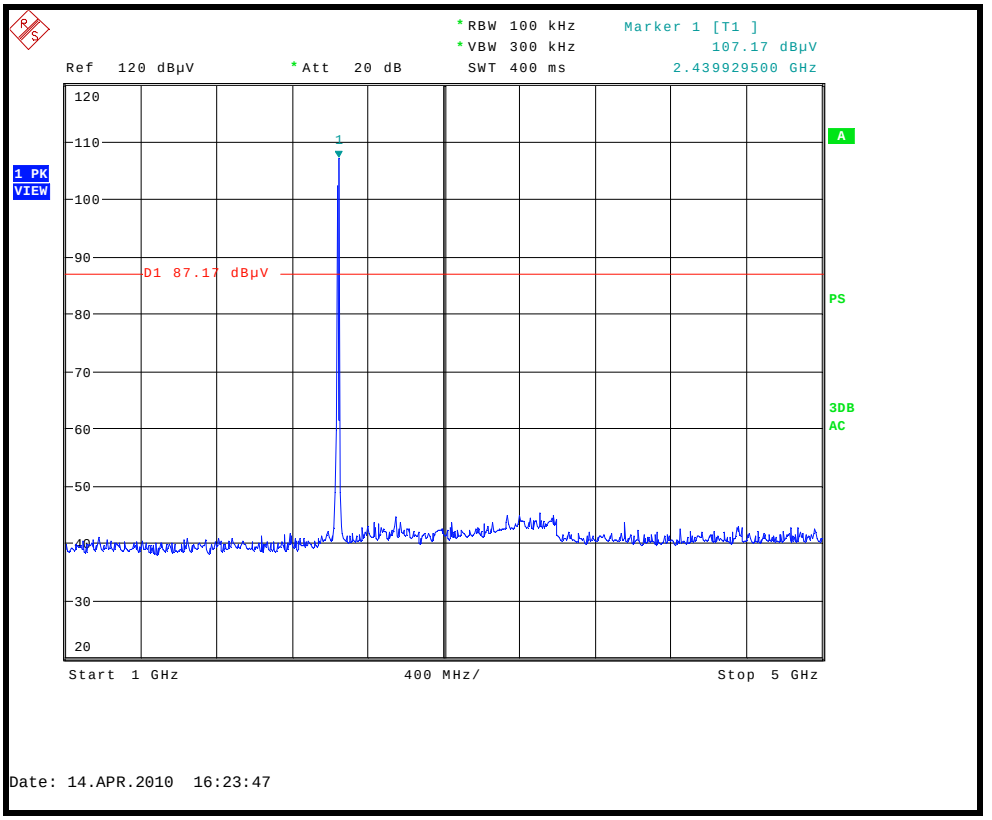
Conducted Emissions Channel 18 2440MHz



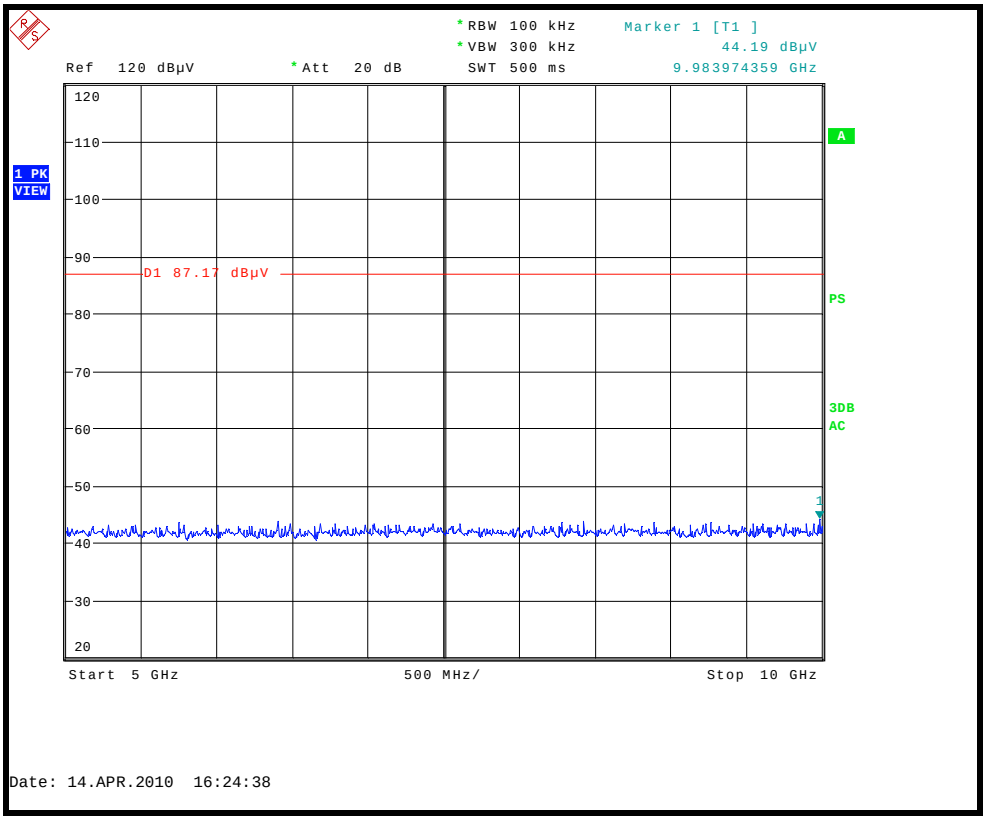
Conducted Emissions Channel 18 2440MHz



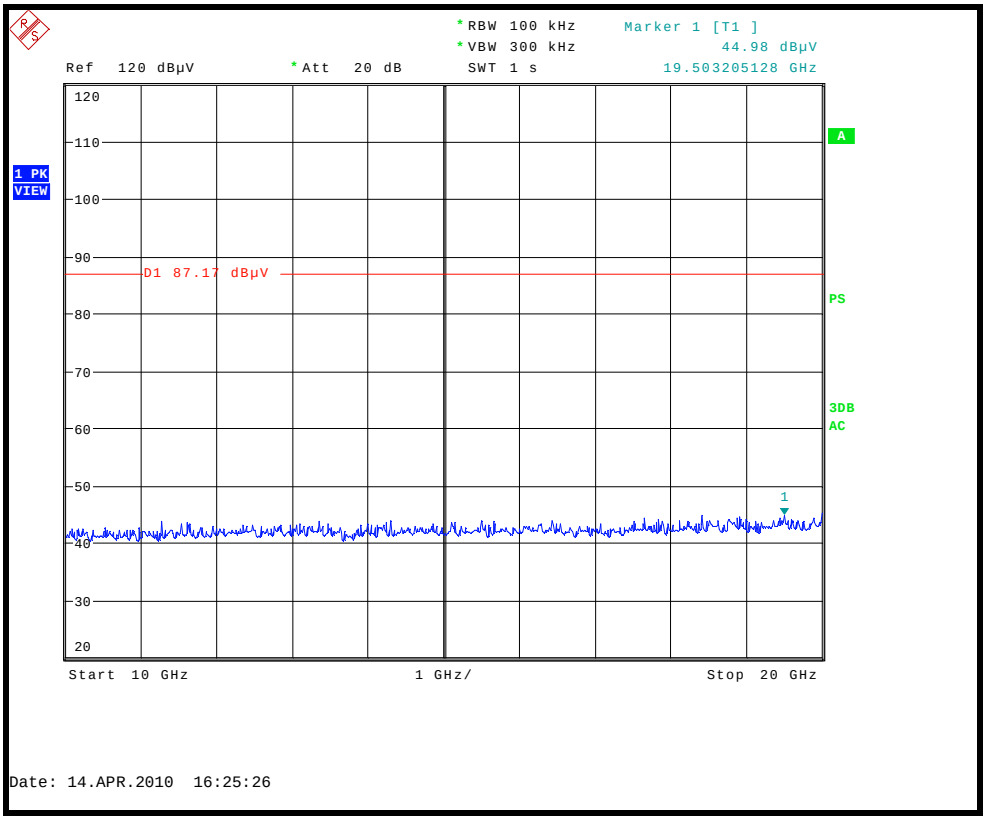
Conducted Emissions Channel 18 2440MHz



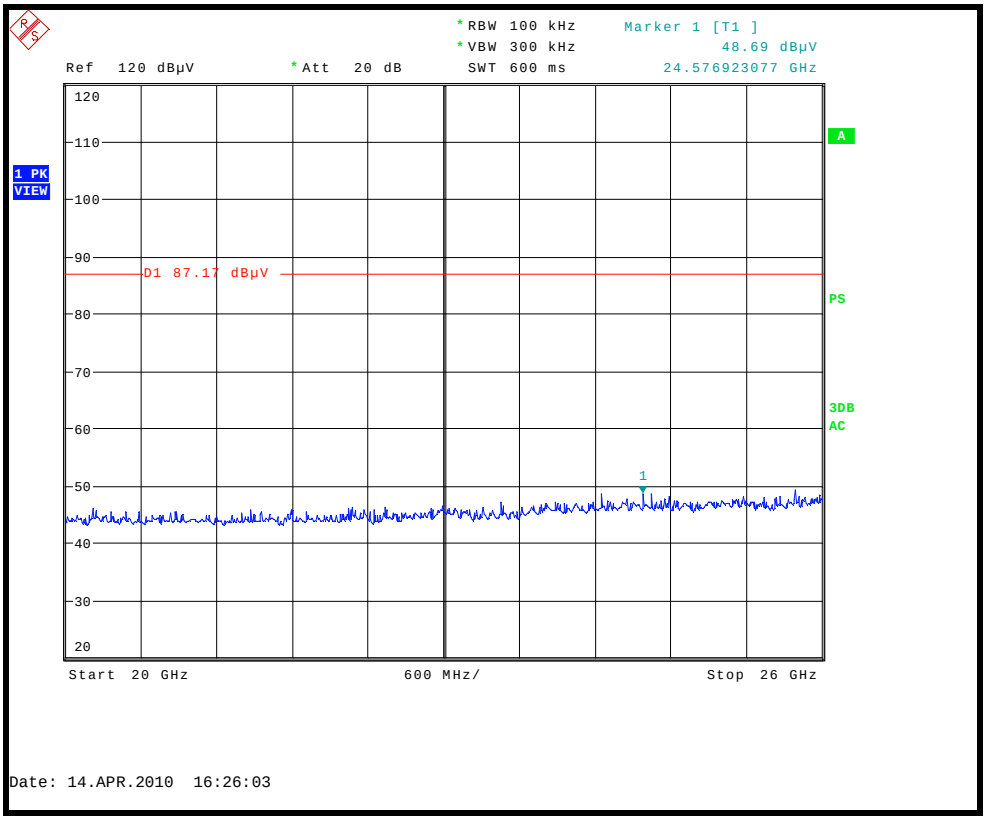
Conducted Emissions Channel 18 2440MHz



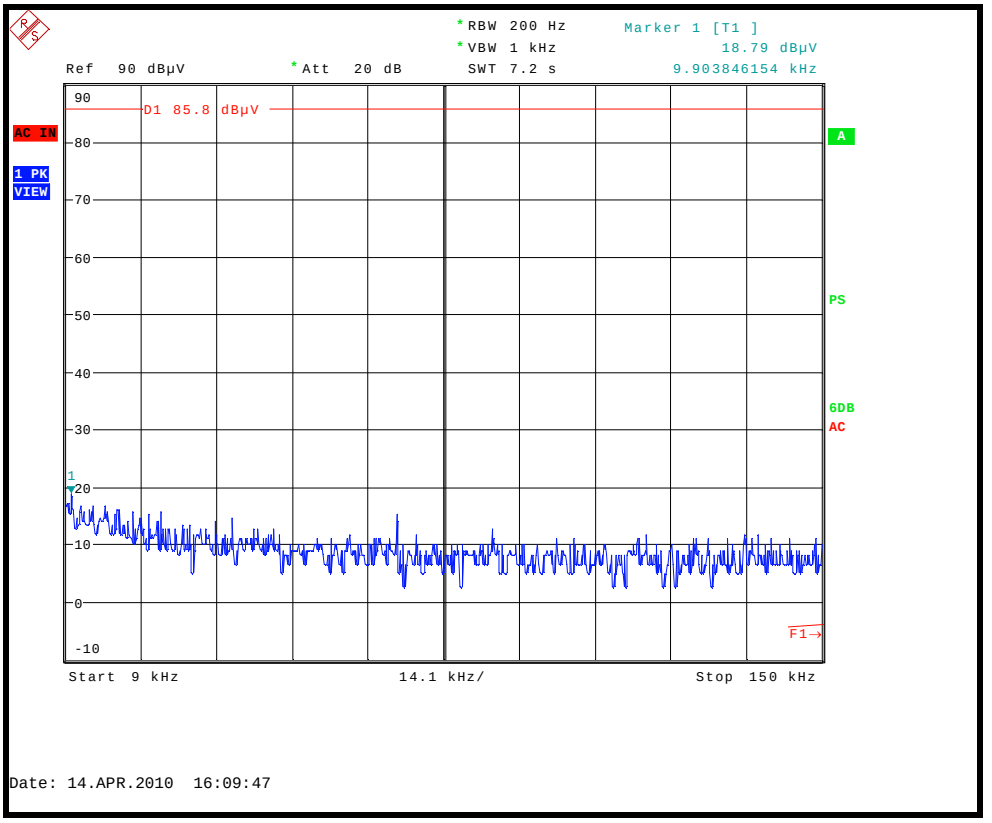
Conducted Emissions Channel 18 2440MHz



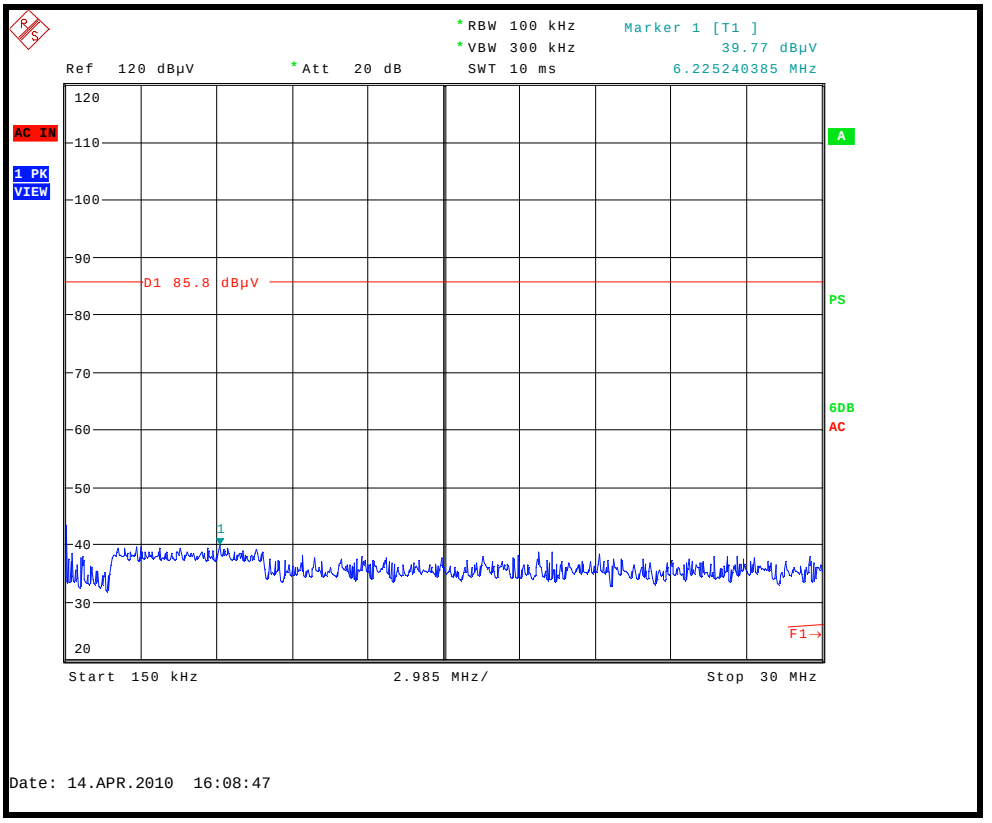
Conducted Emissions Channel 18 2440MHz



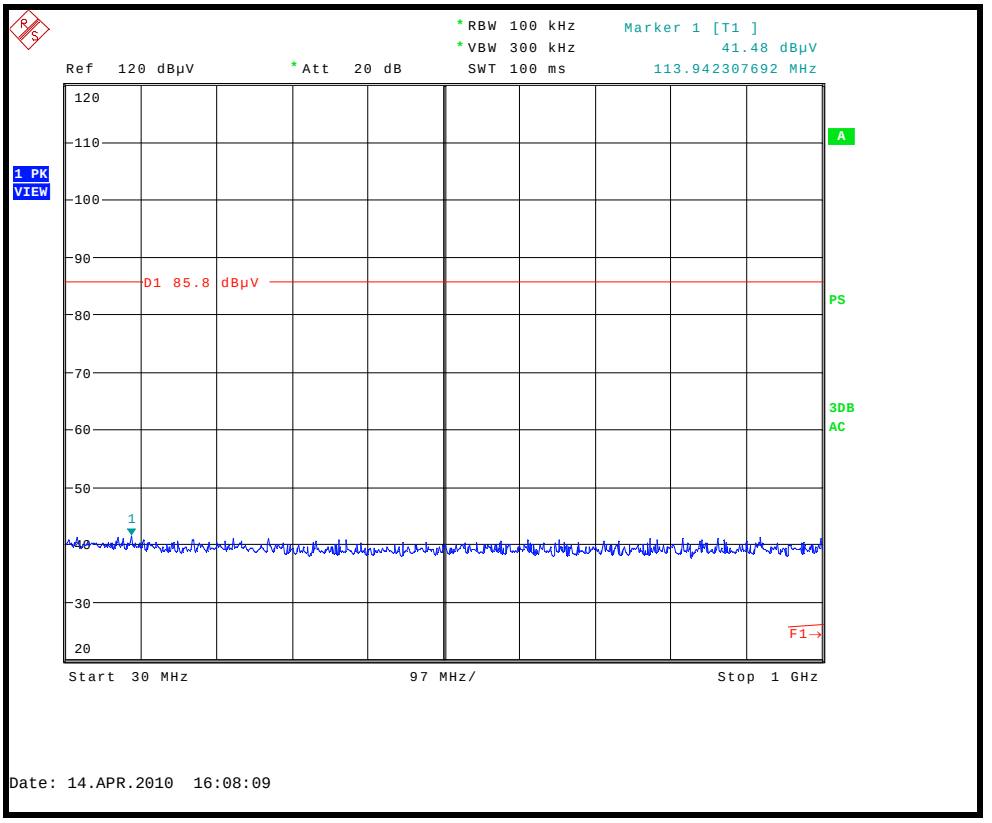
Conducted Emissions Channel 18 2440MHz



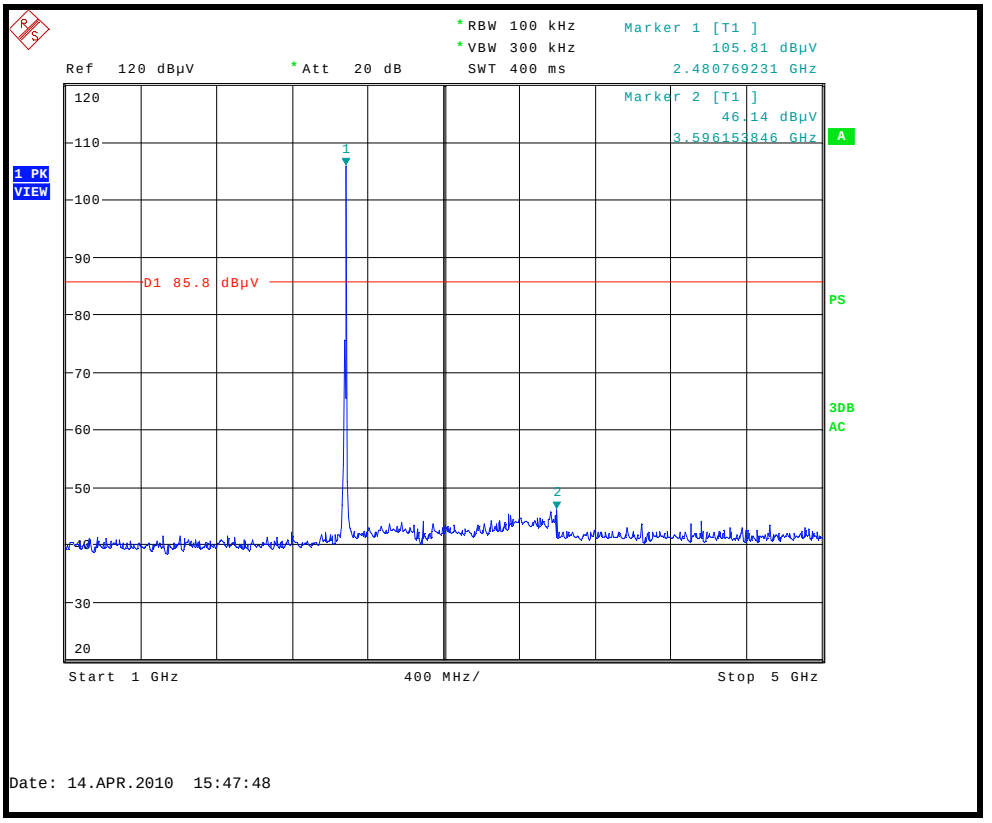
Conducted Emissions Channel 26 2480MHz



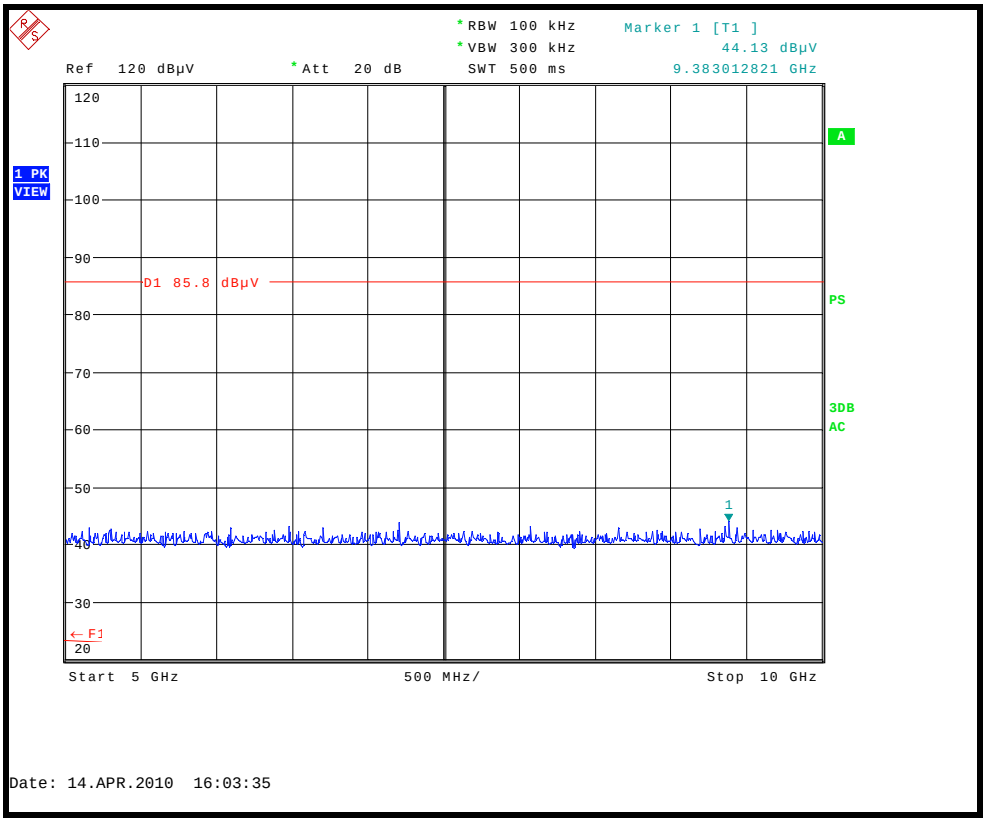
Conducted Emissions Channel 26 2480MHz



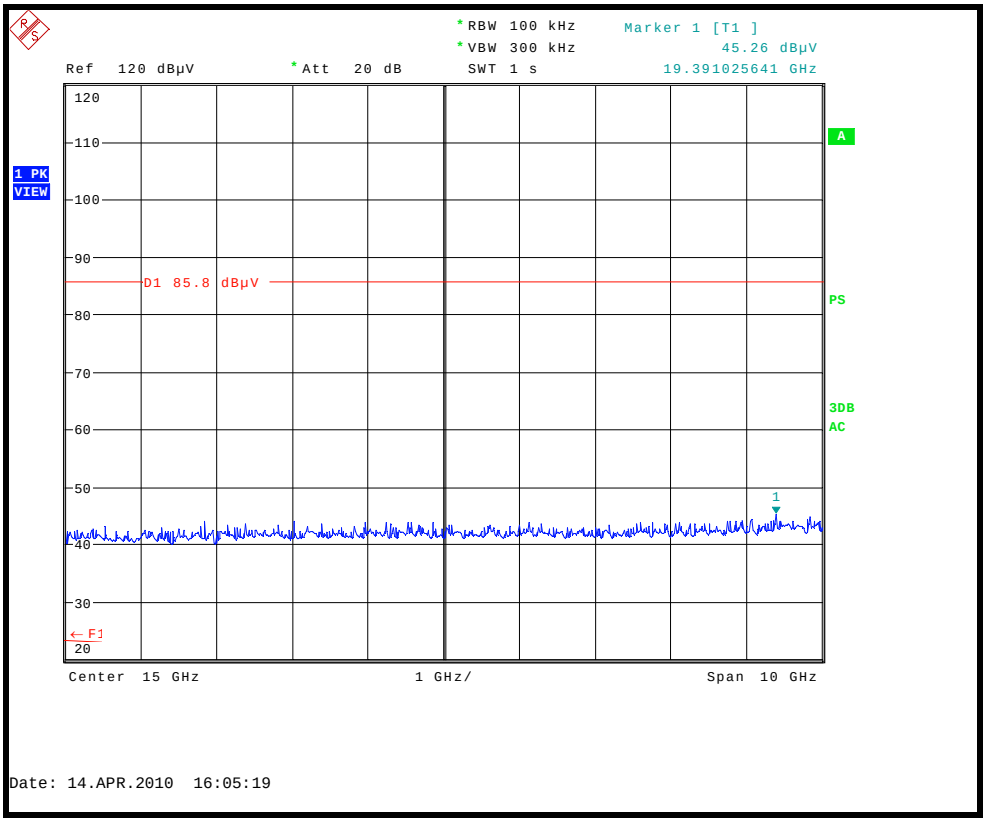
Conducted Emissions Channel 26 2480MHz



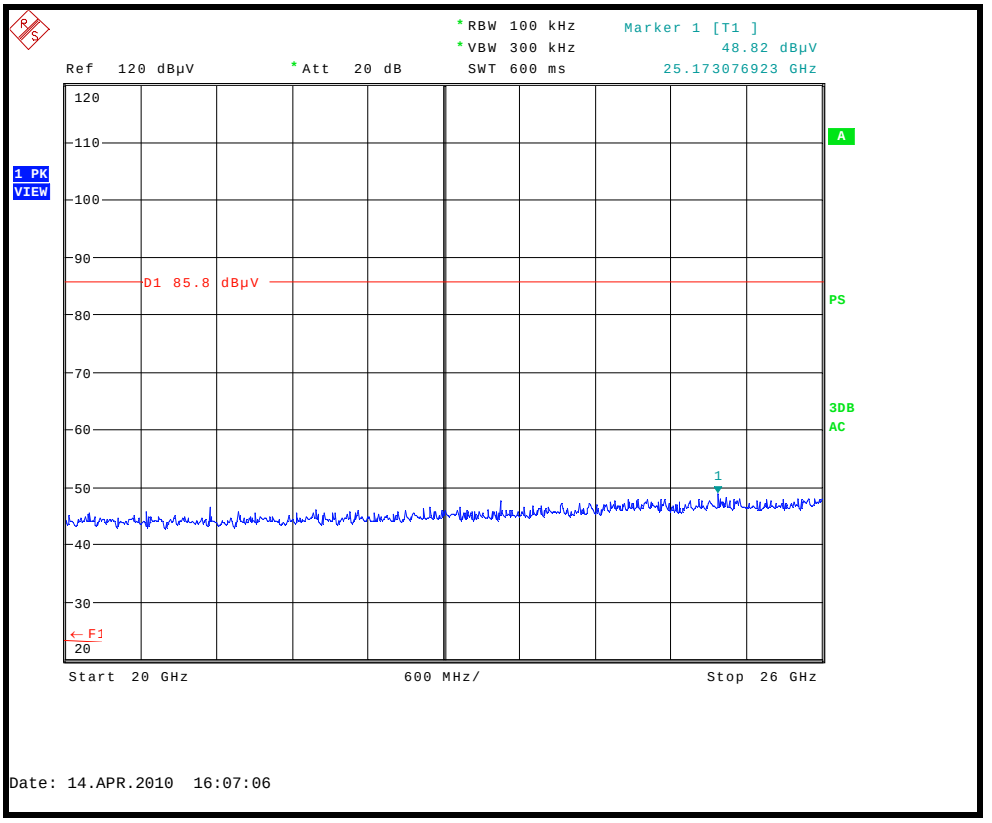
Conducted Emissions Channel 26 2480MHz



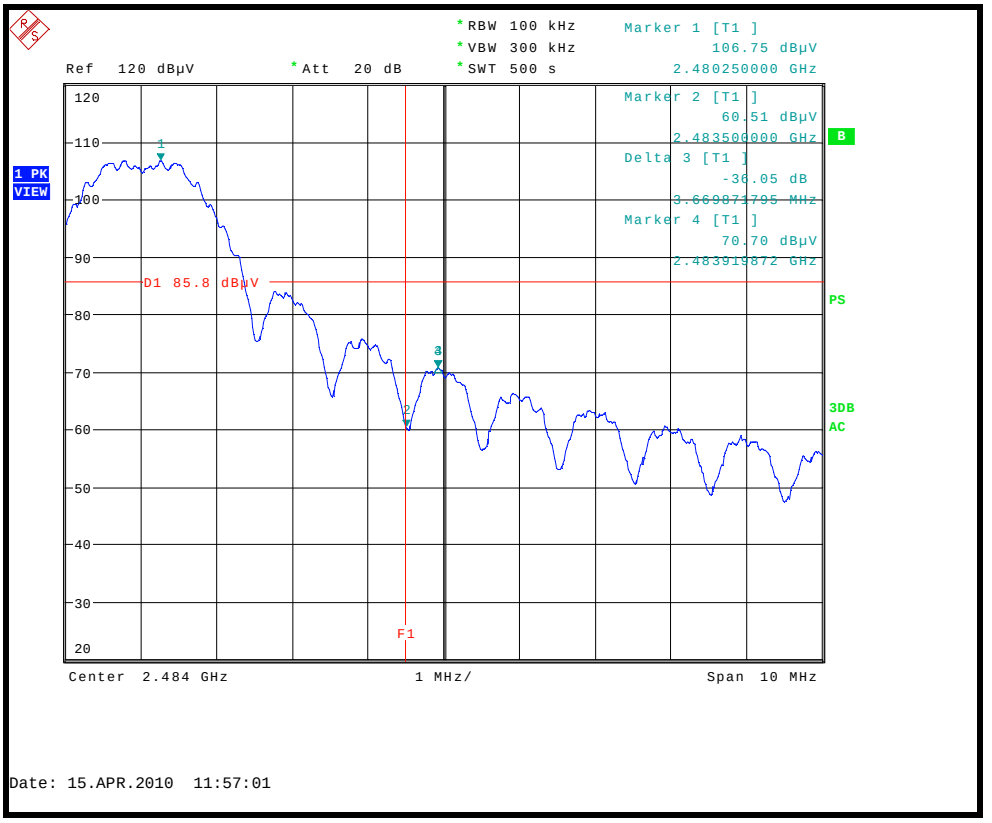
Conducted Emissions Channel 26 2480MHz



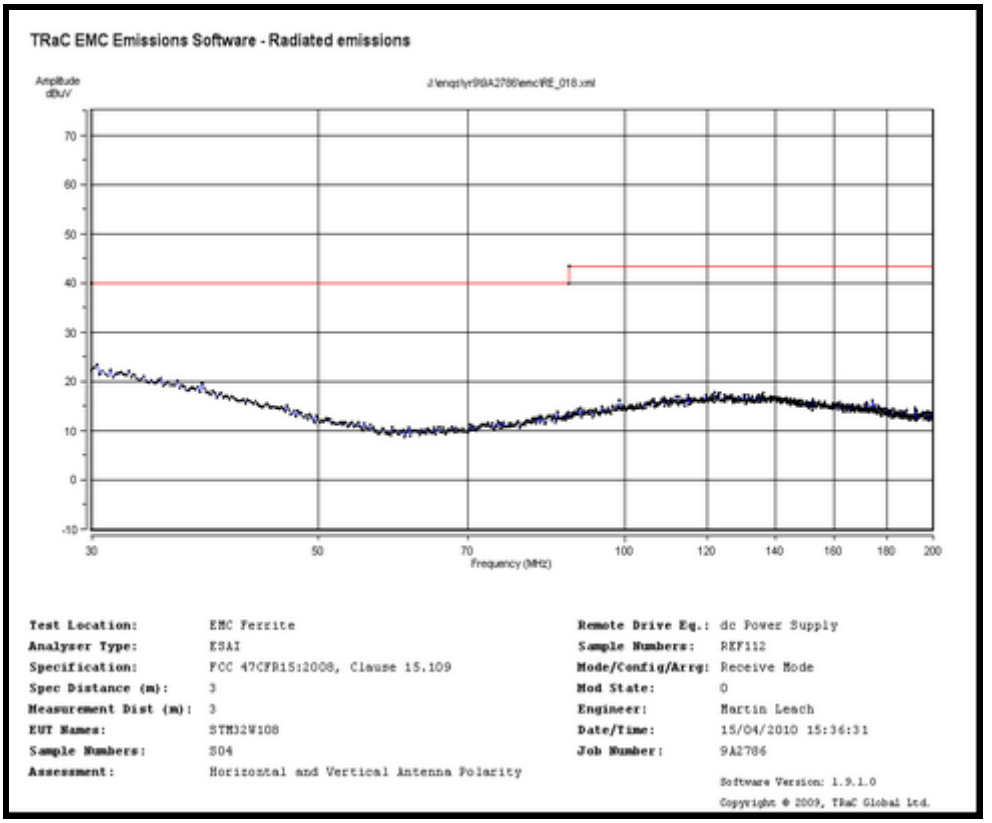
Conducted Emissions Channel 26 2480MHz



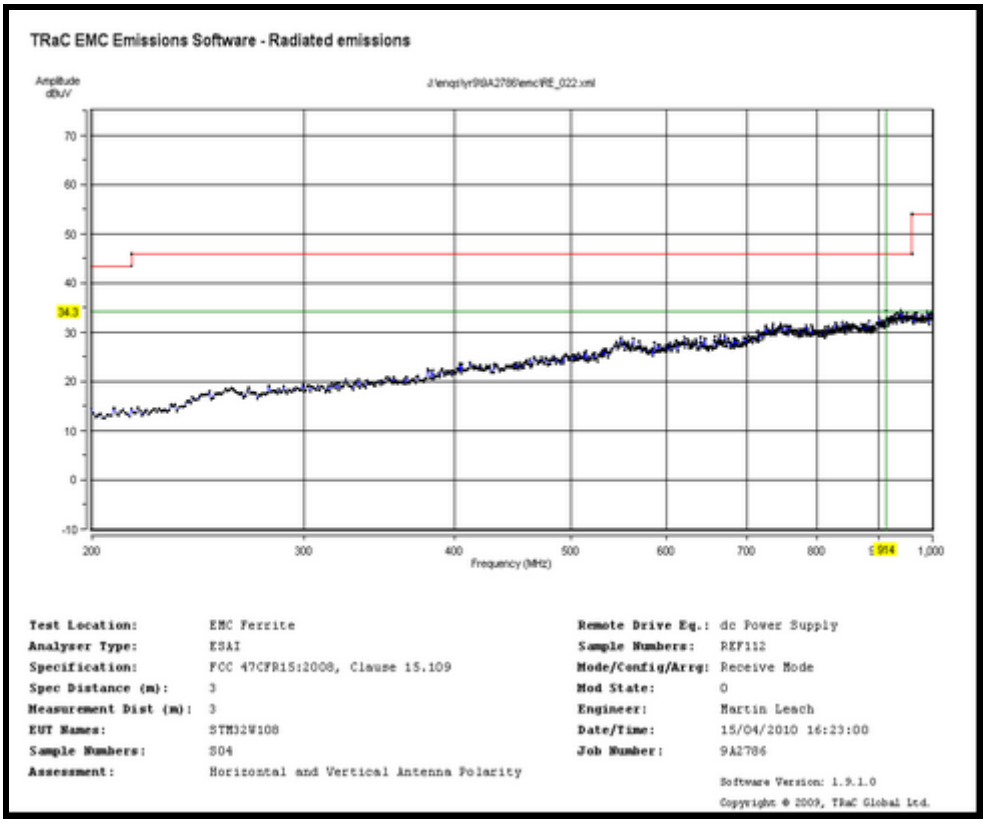
Conducted Emissions Channel 26 2480MHz



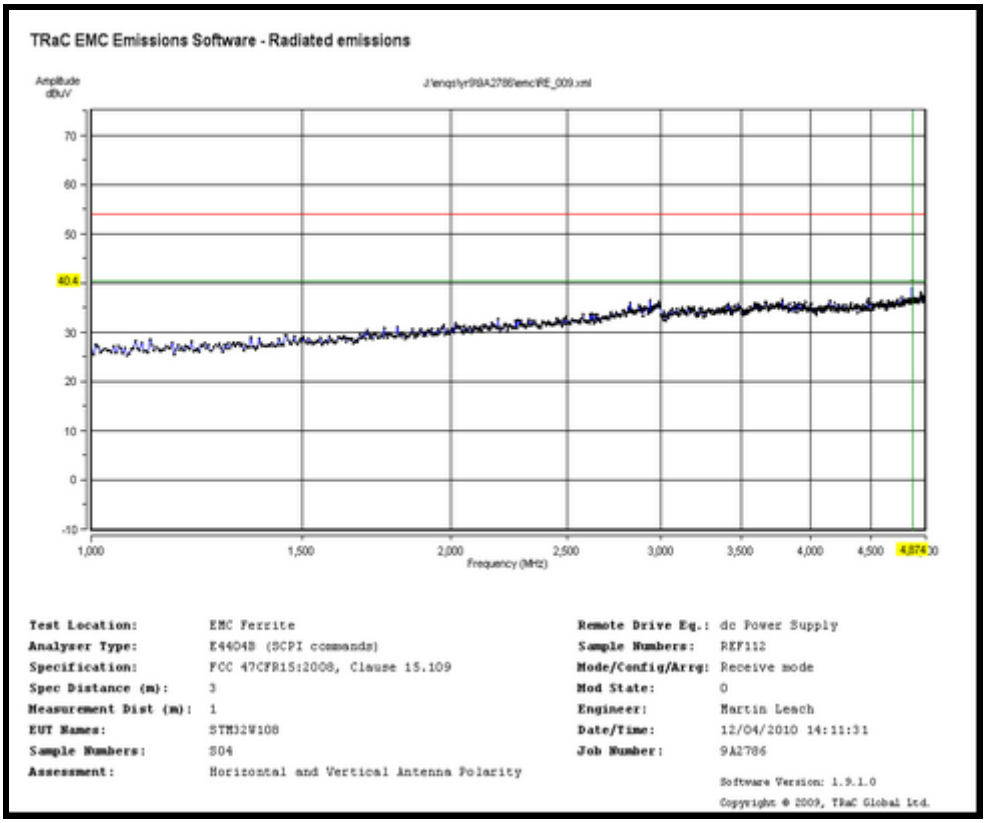
Conducted Emissions Channel 26 2480MHz: Upper-Band edge



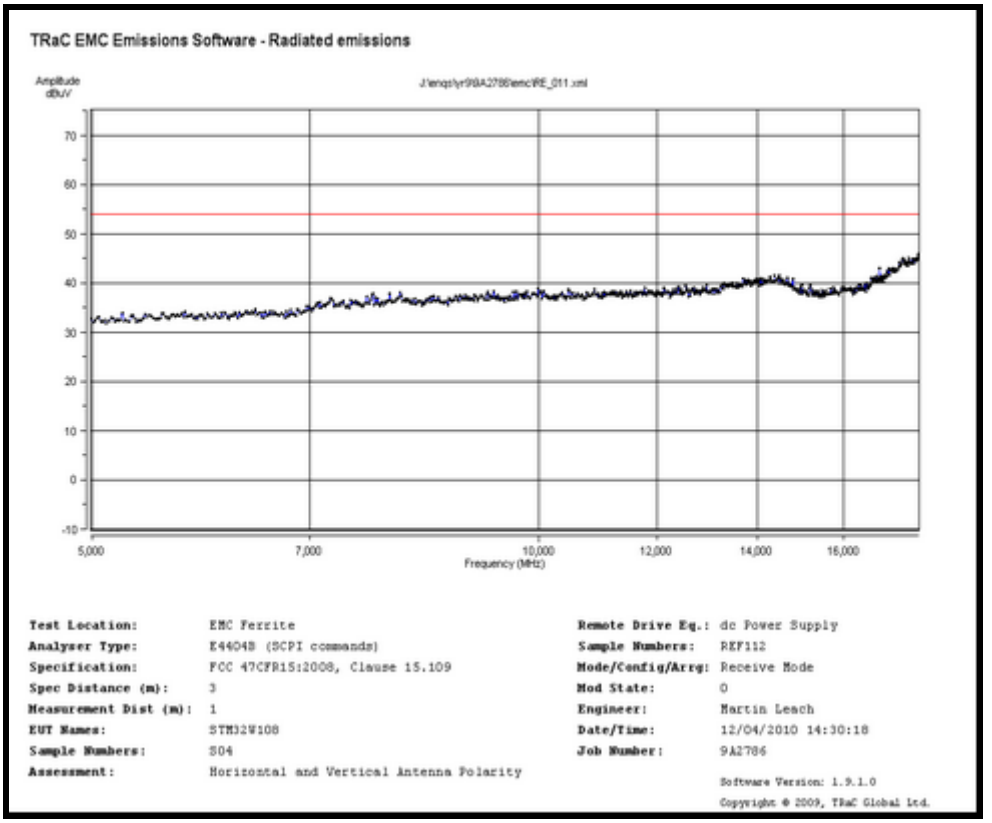
Radiated RX Mode Emissions (15.109)



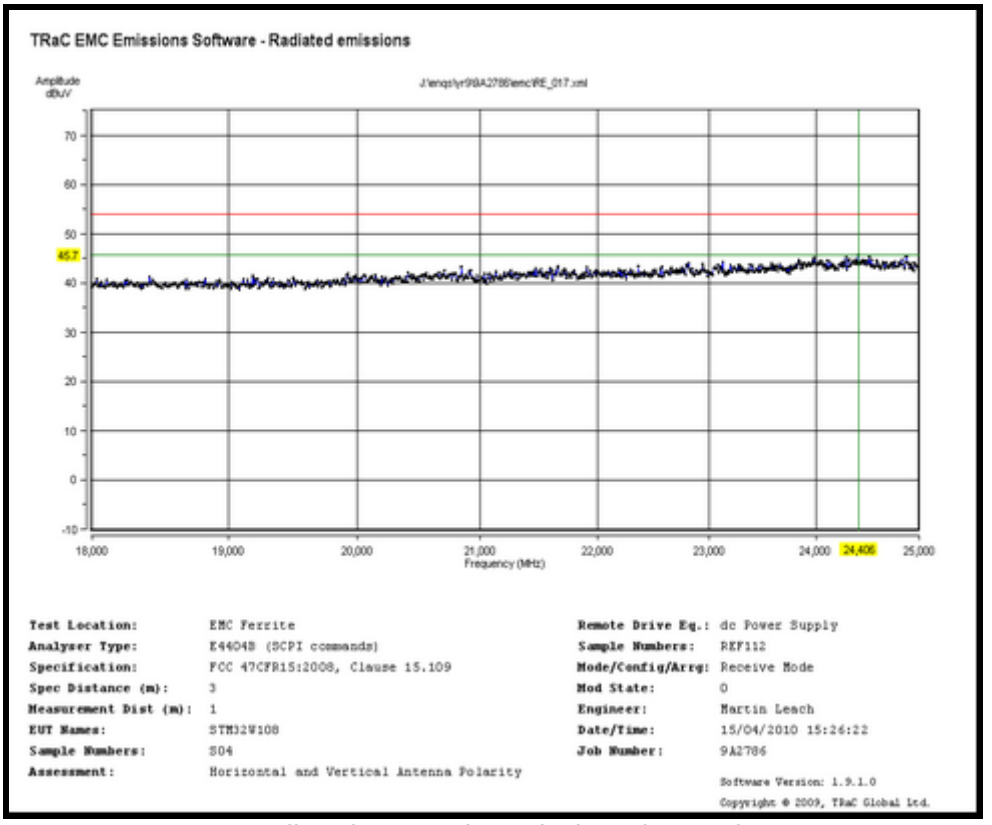
Radiated RX Mode Emissions (15.109)



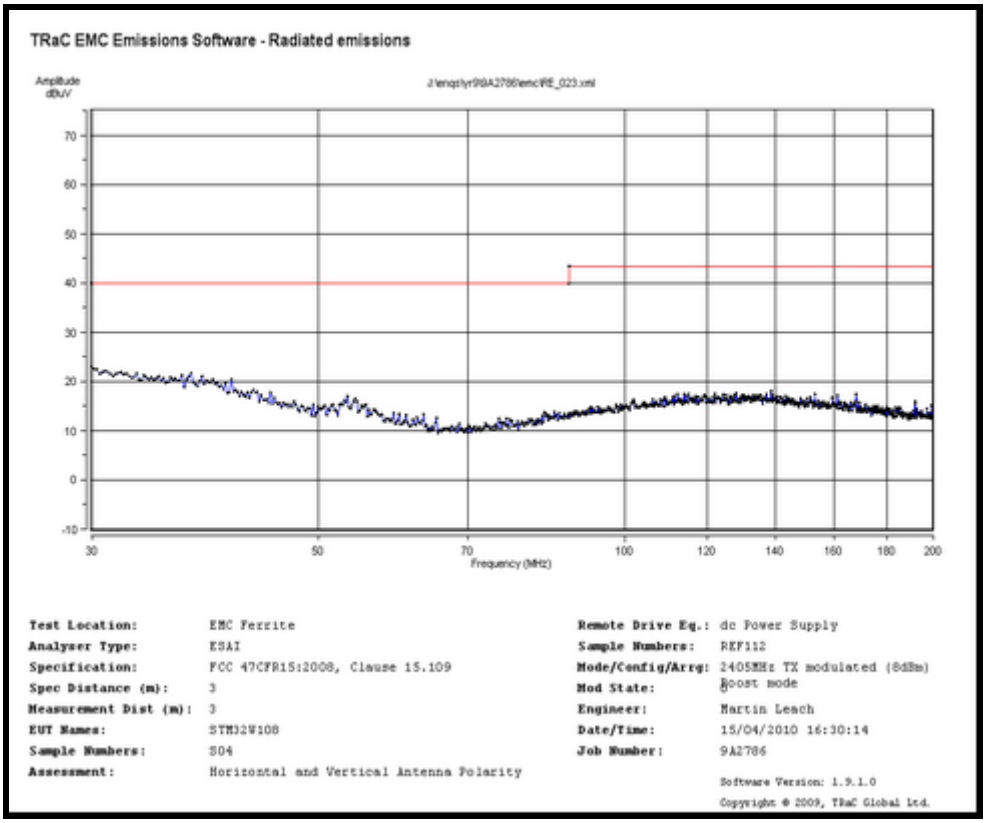
Radiated RX Mode Emissions (15.109)



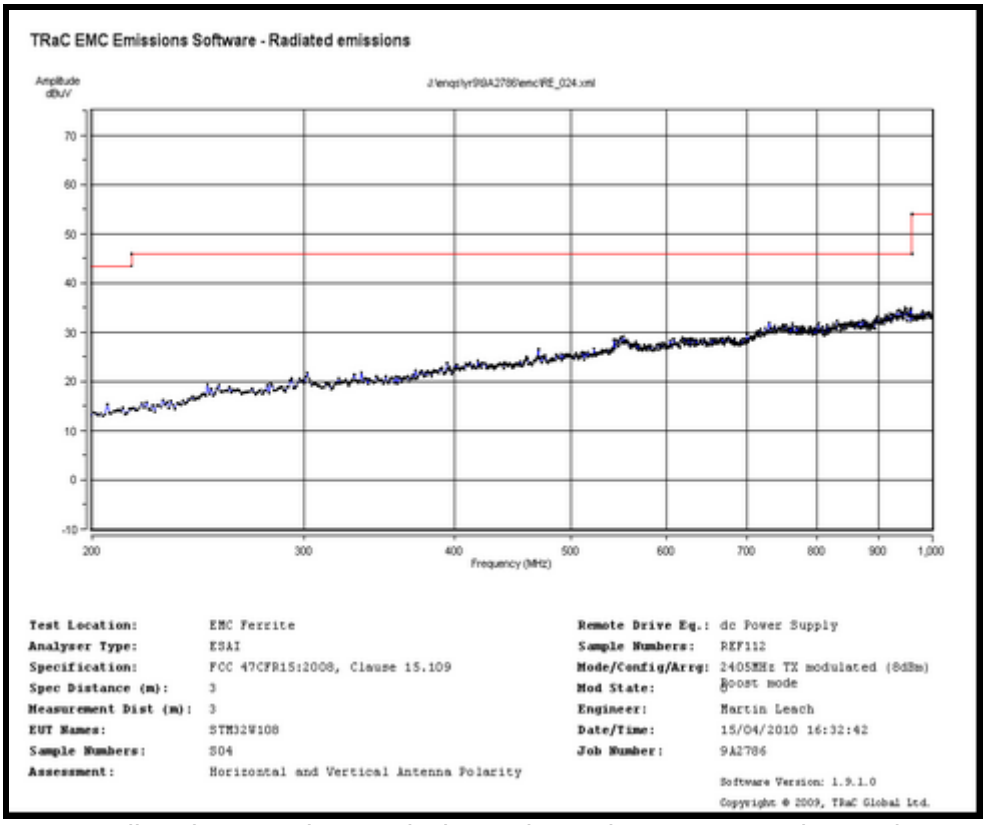
Radiated RX Mode Emissions (15.109)



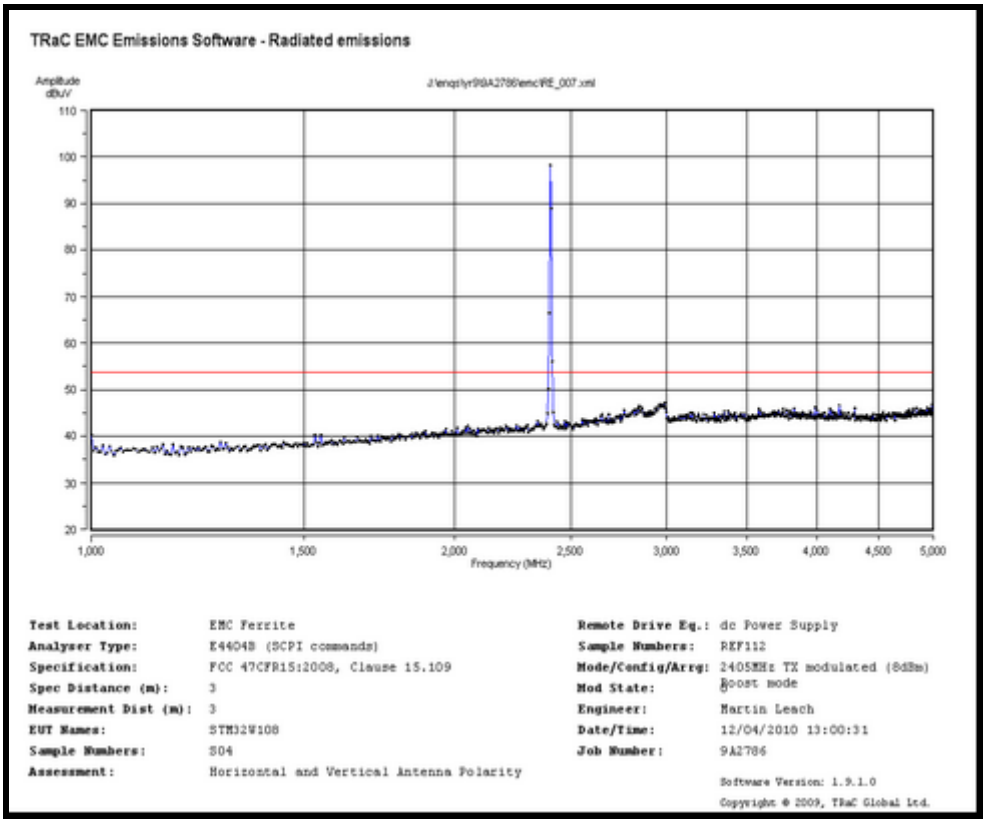
Radiated RX Mode Emissions (15.109)



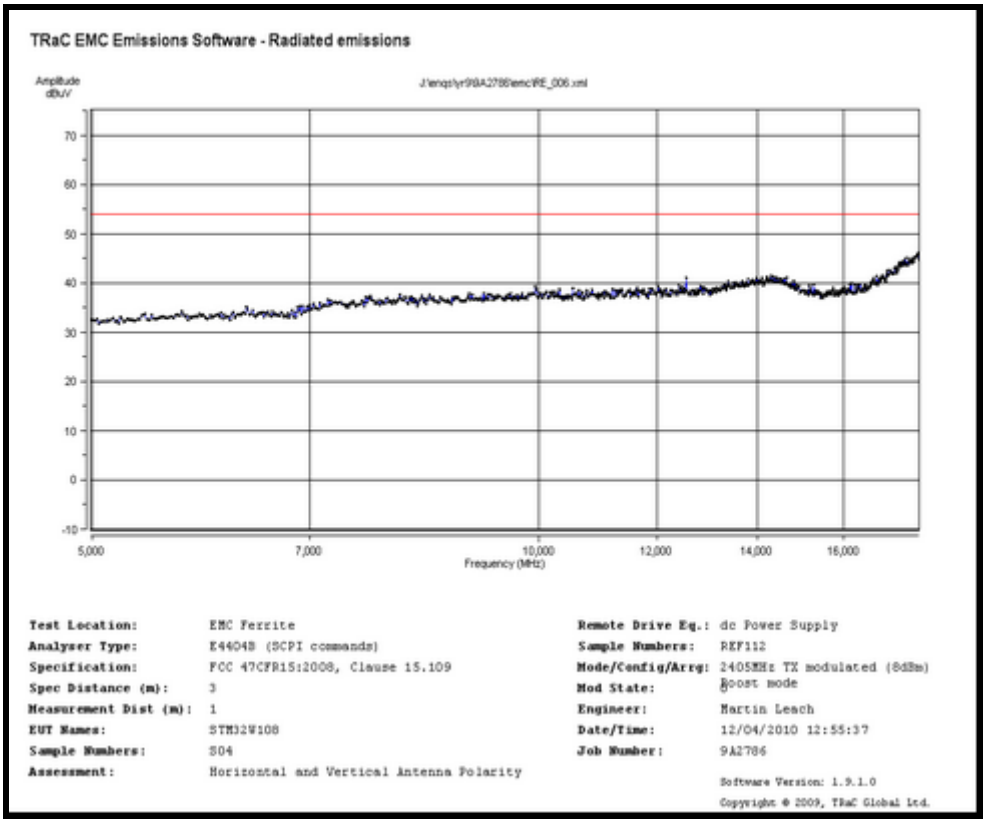
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



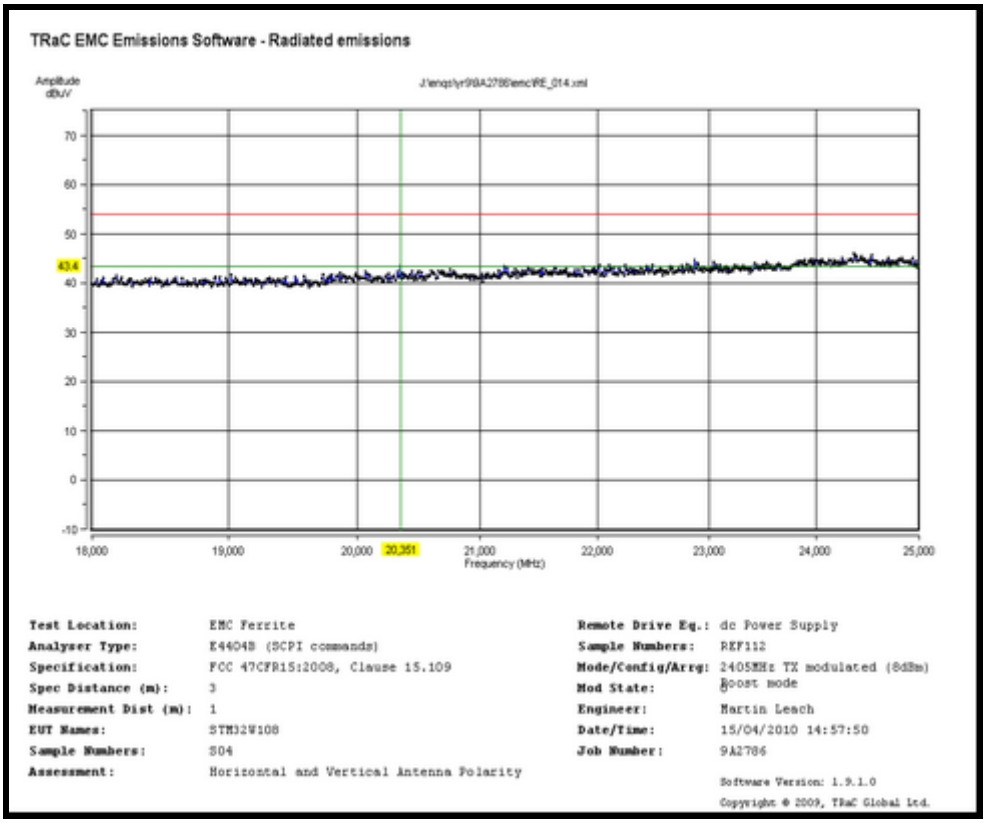
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



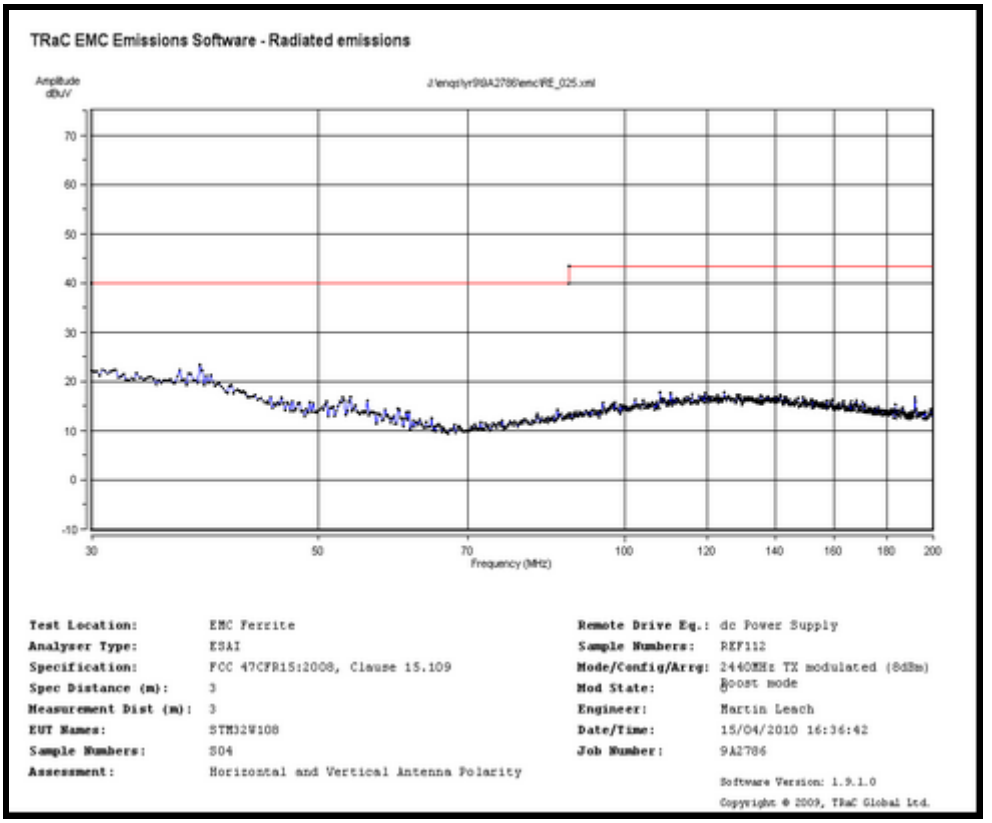
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



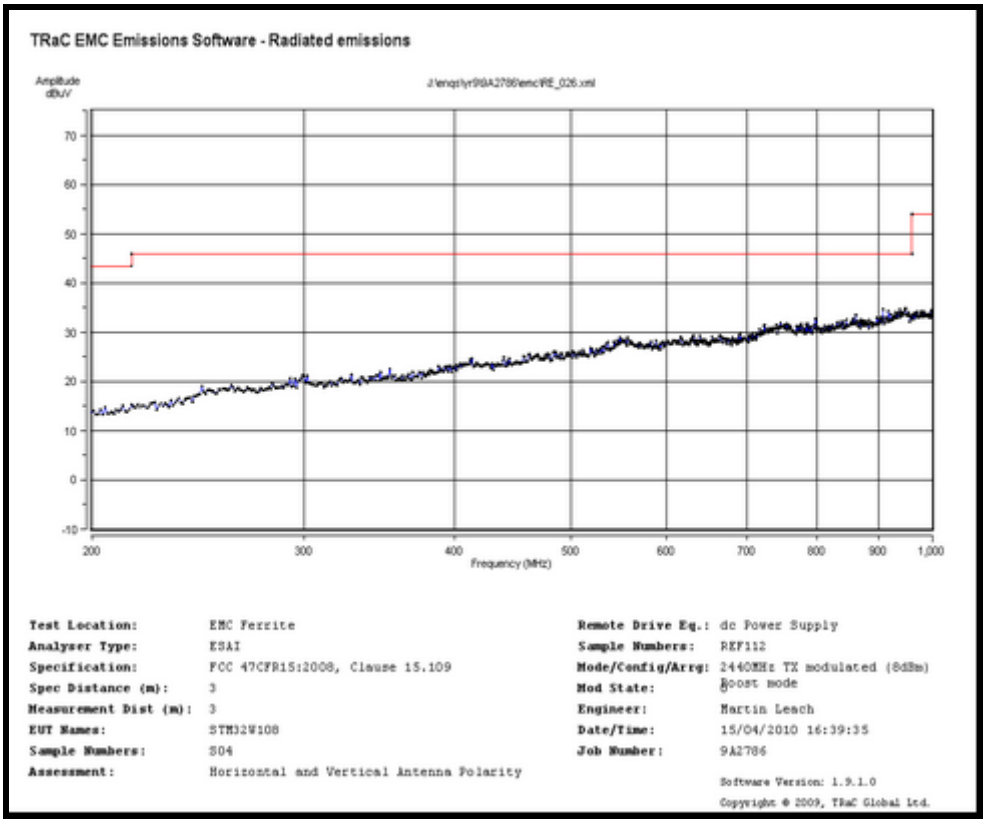
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



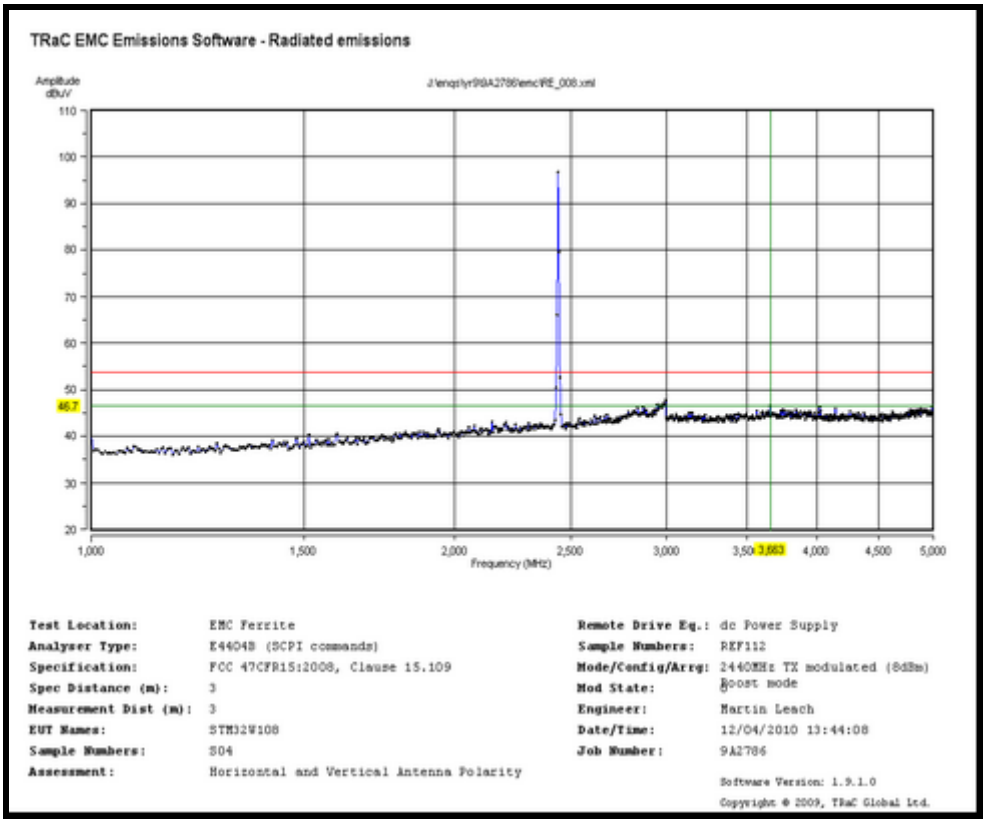
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



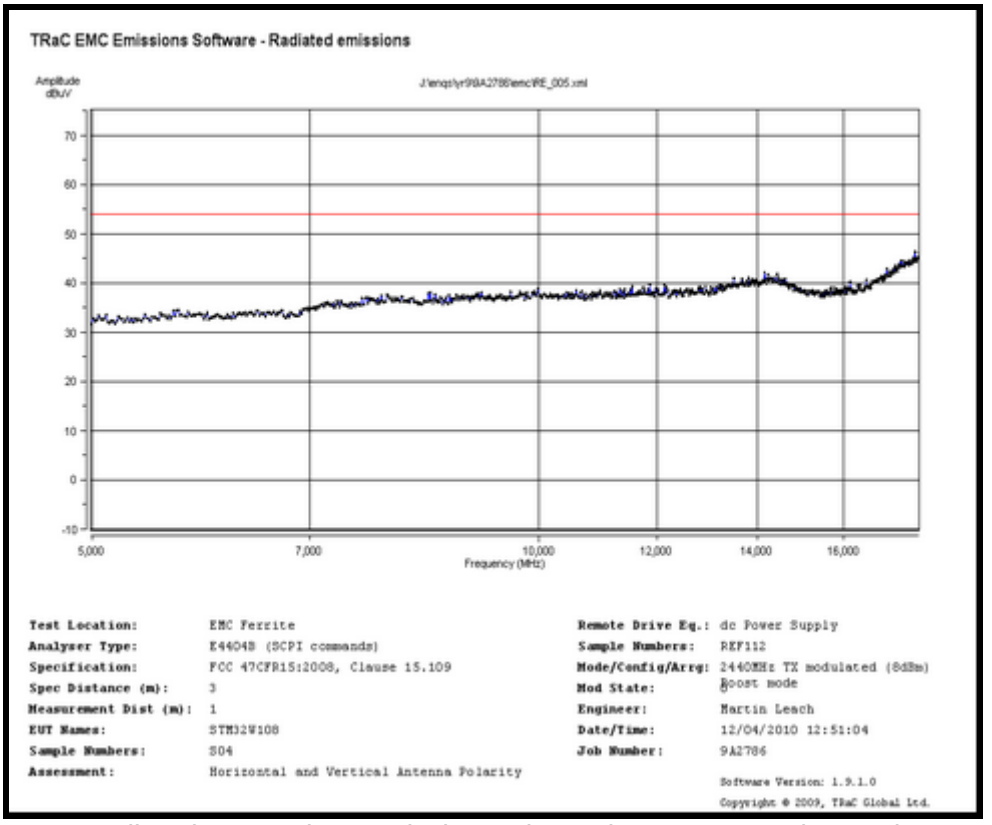
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



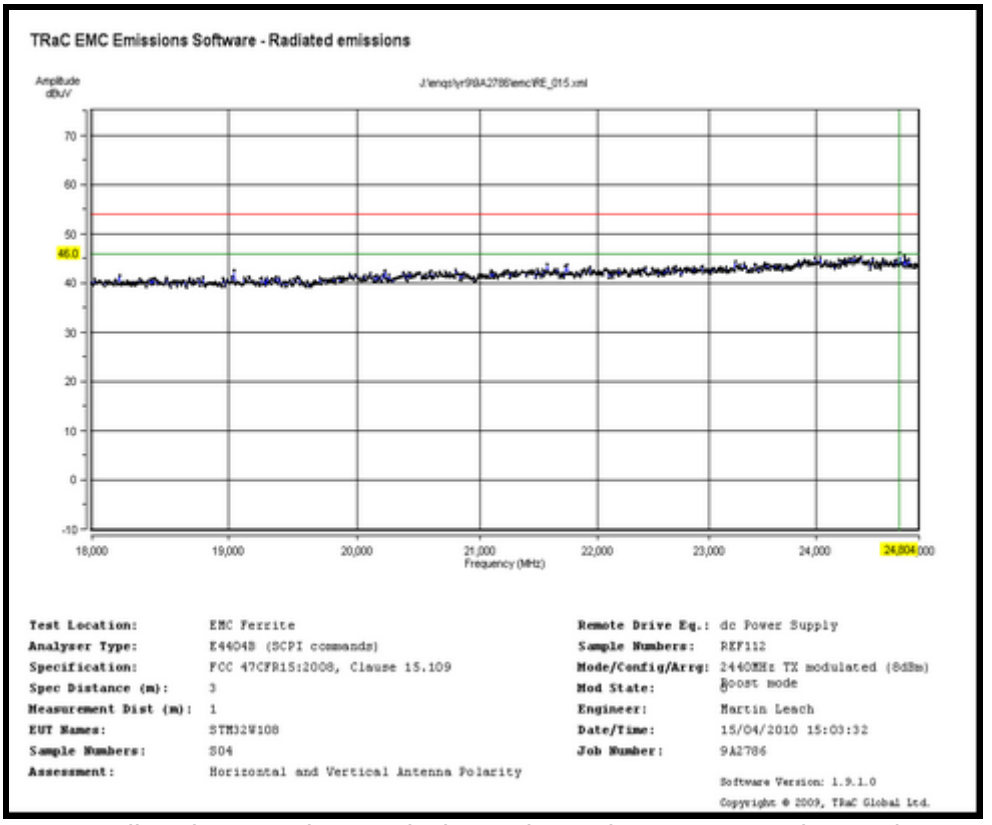
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



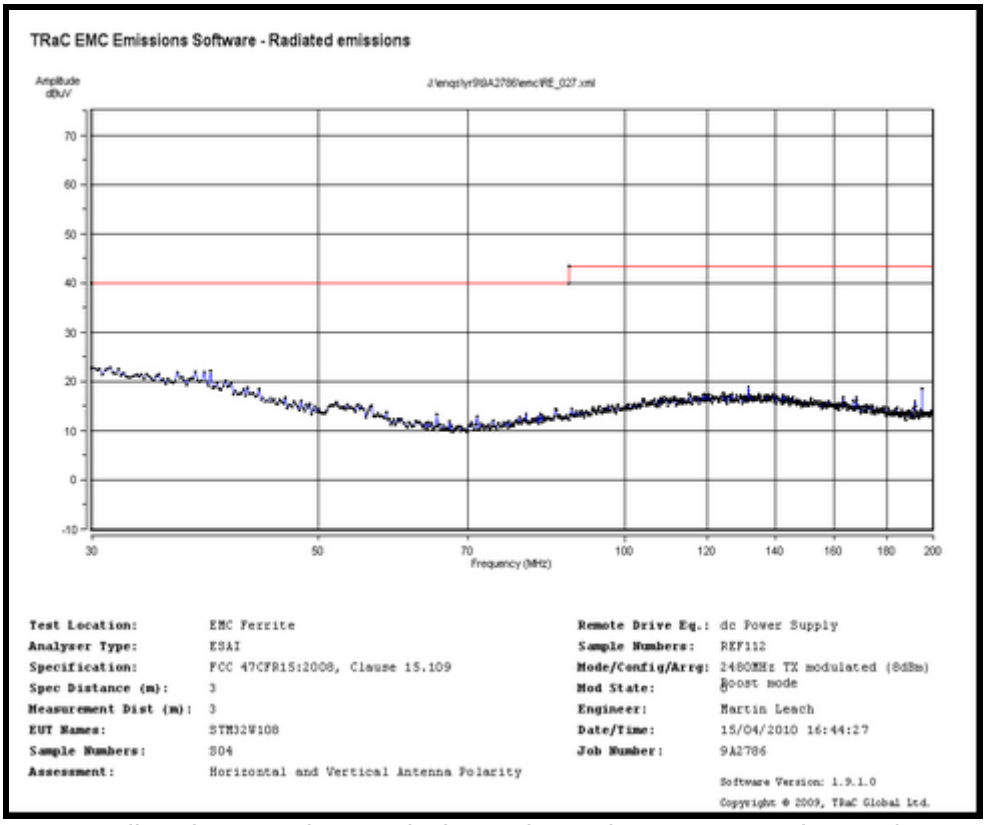
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



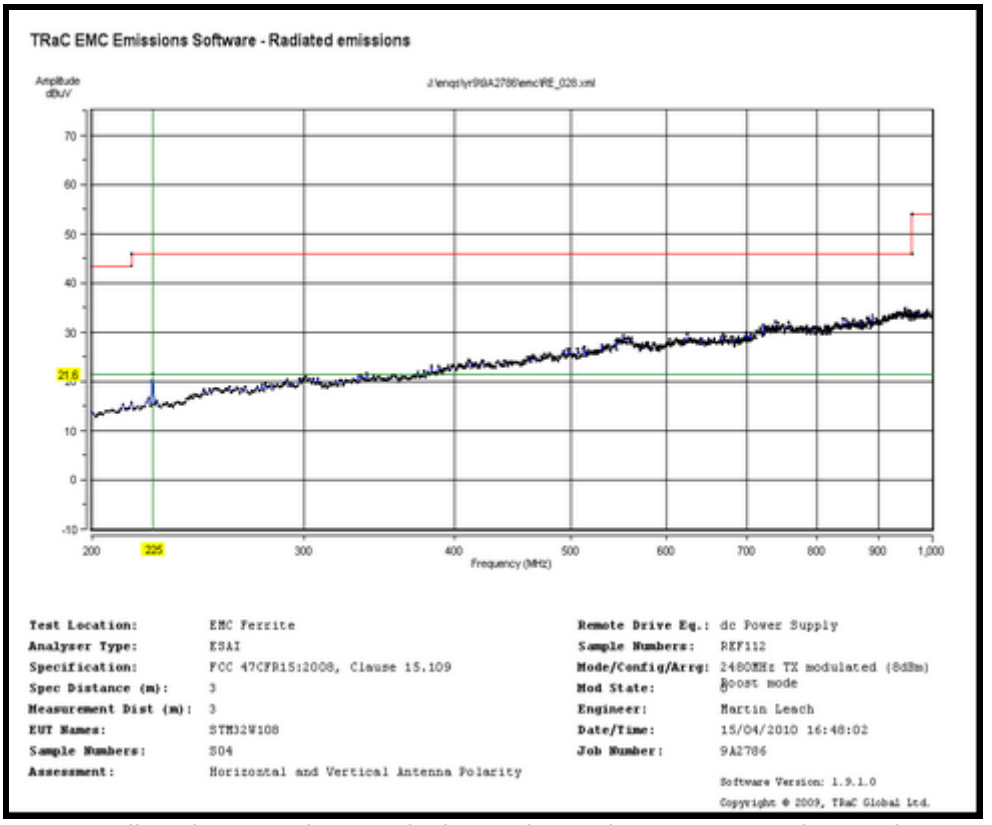
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



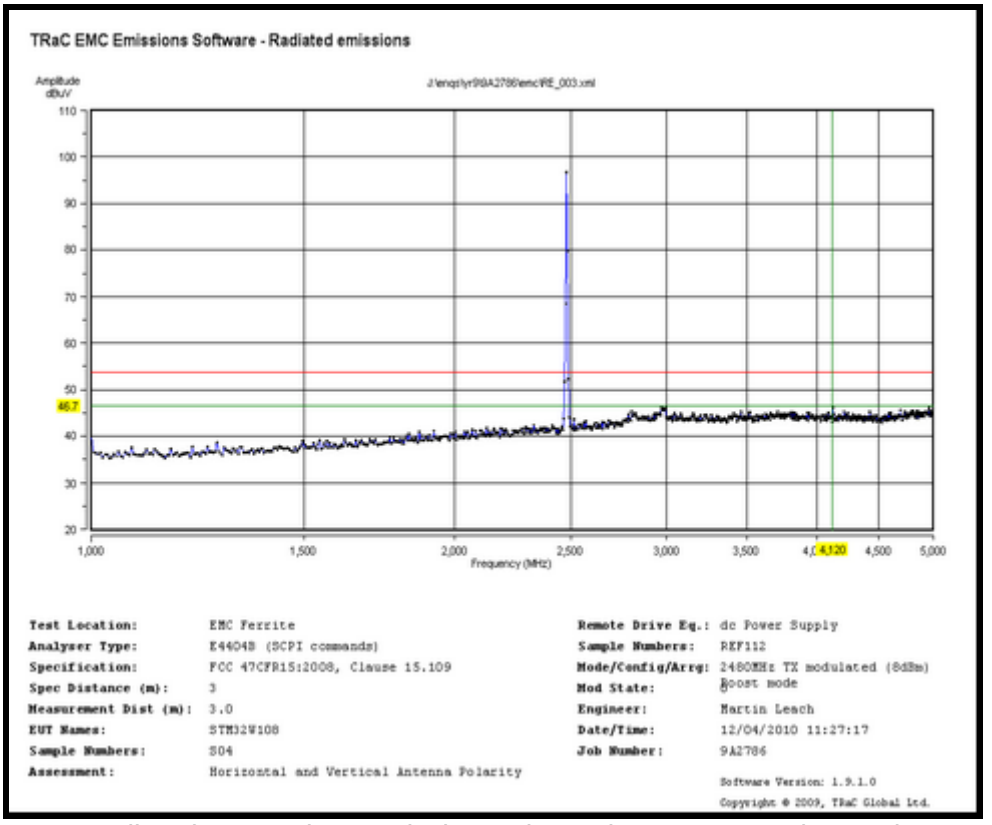
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



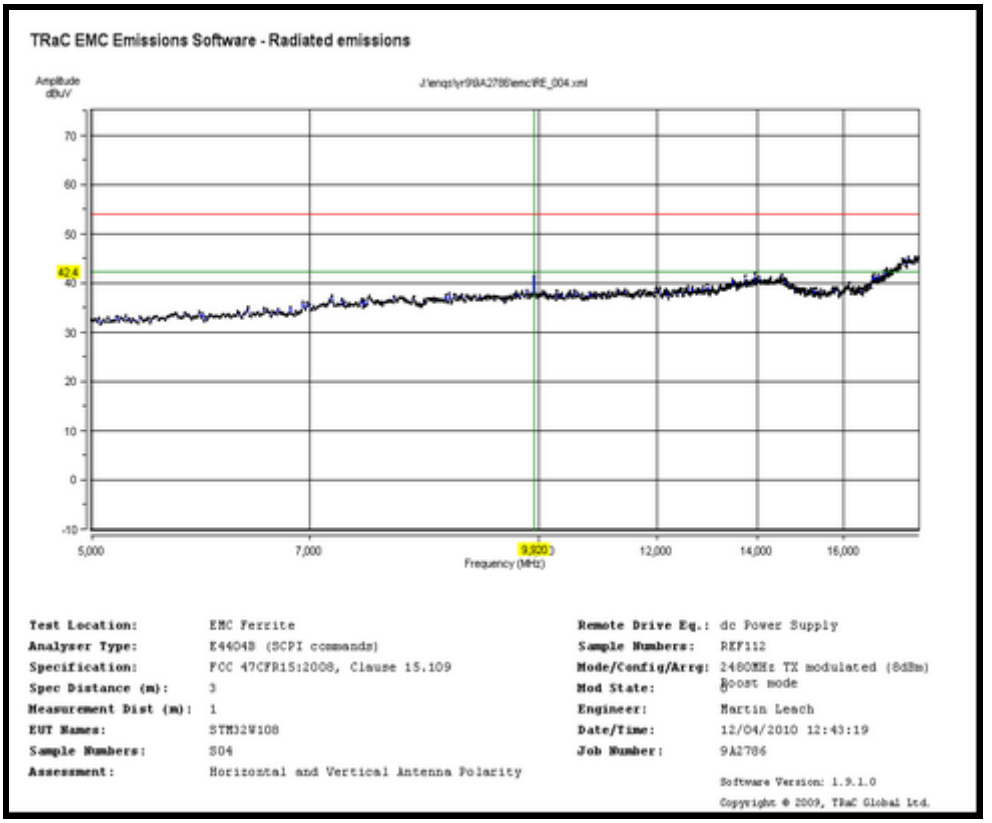
Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



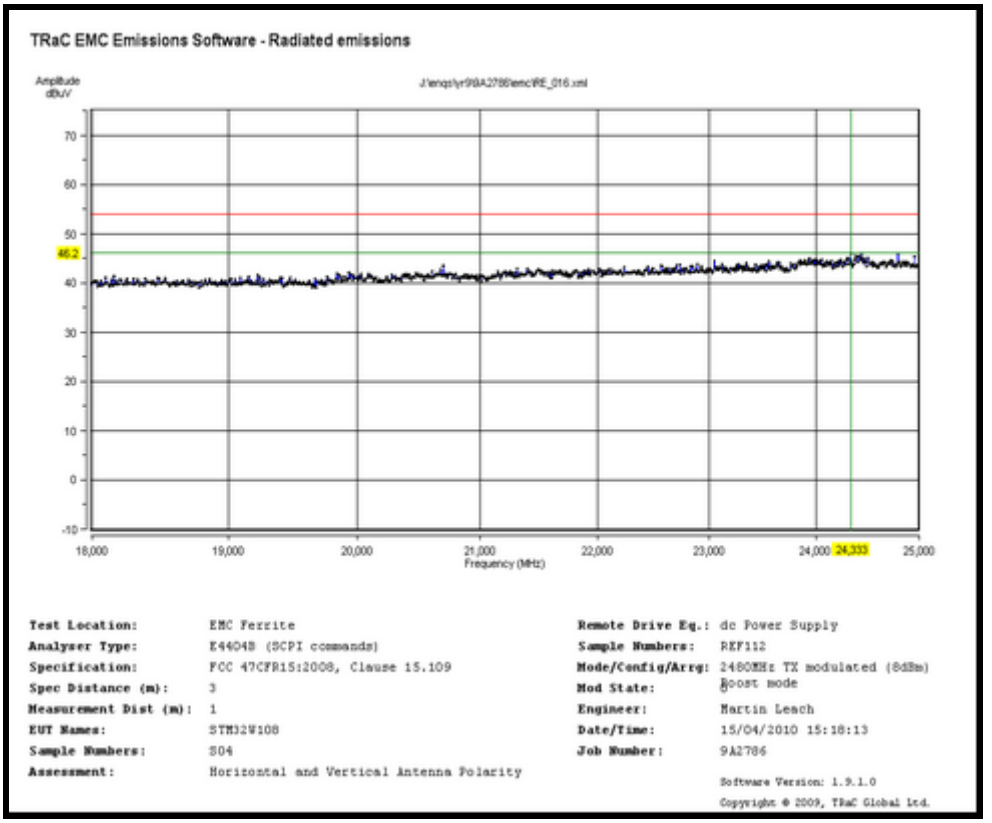
Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



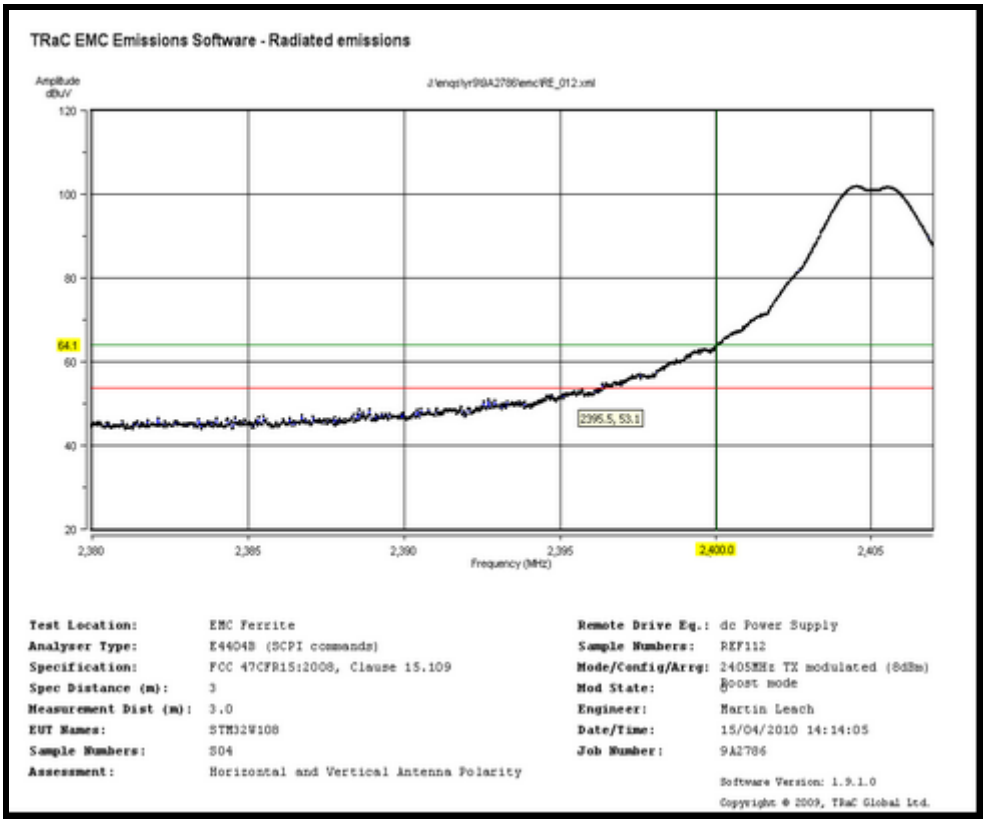
Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



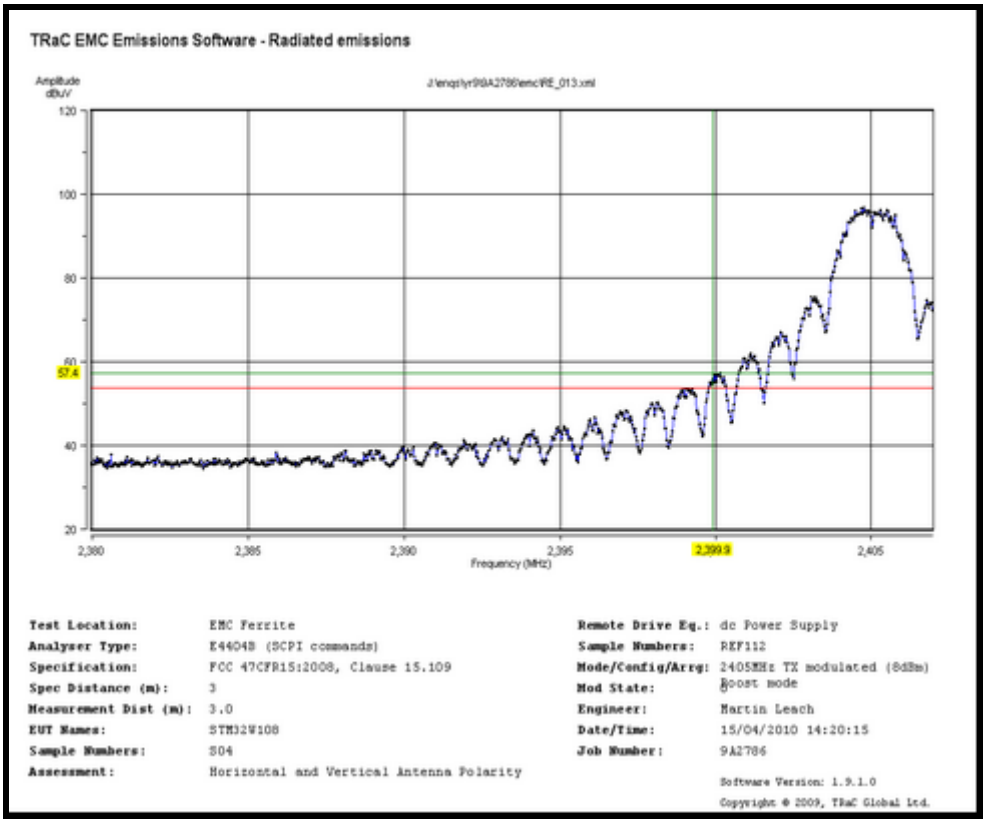
Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



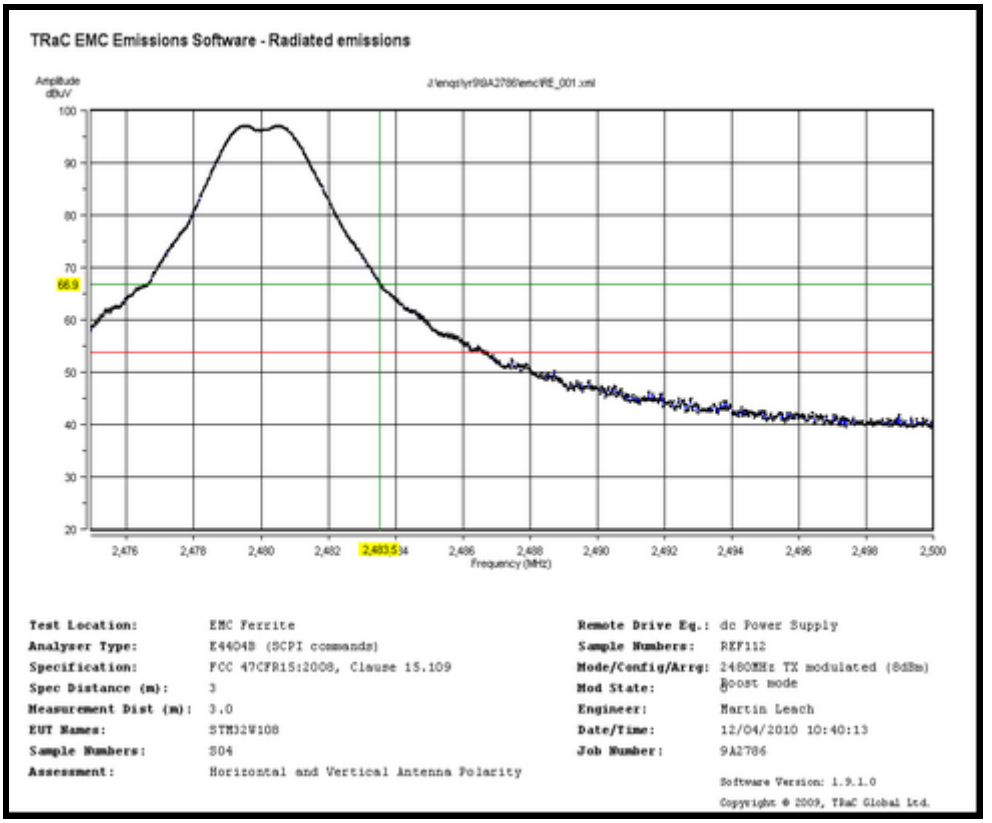
Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



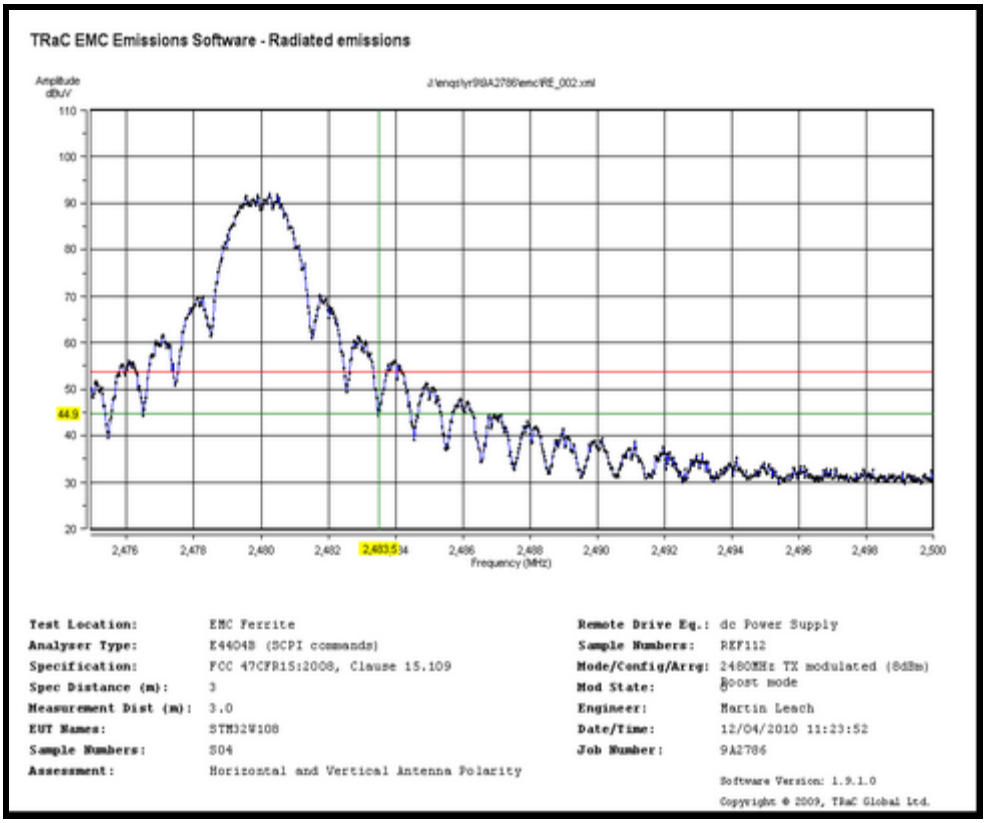
Radiated Transmitter Emissions Channel 11 2405MHz (15.209) Band Edge Compliance RBW 1MHz



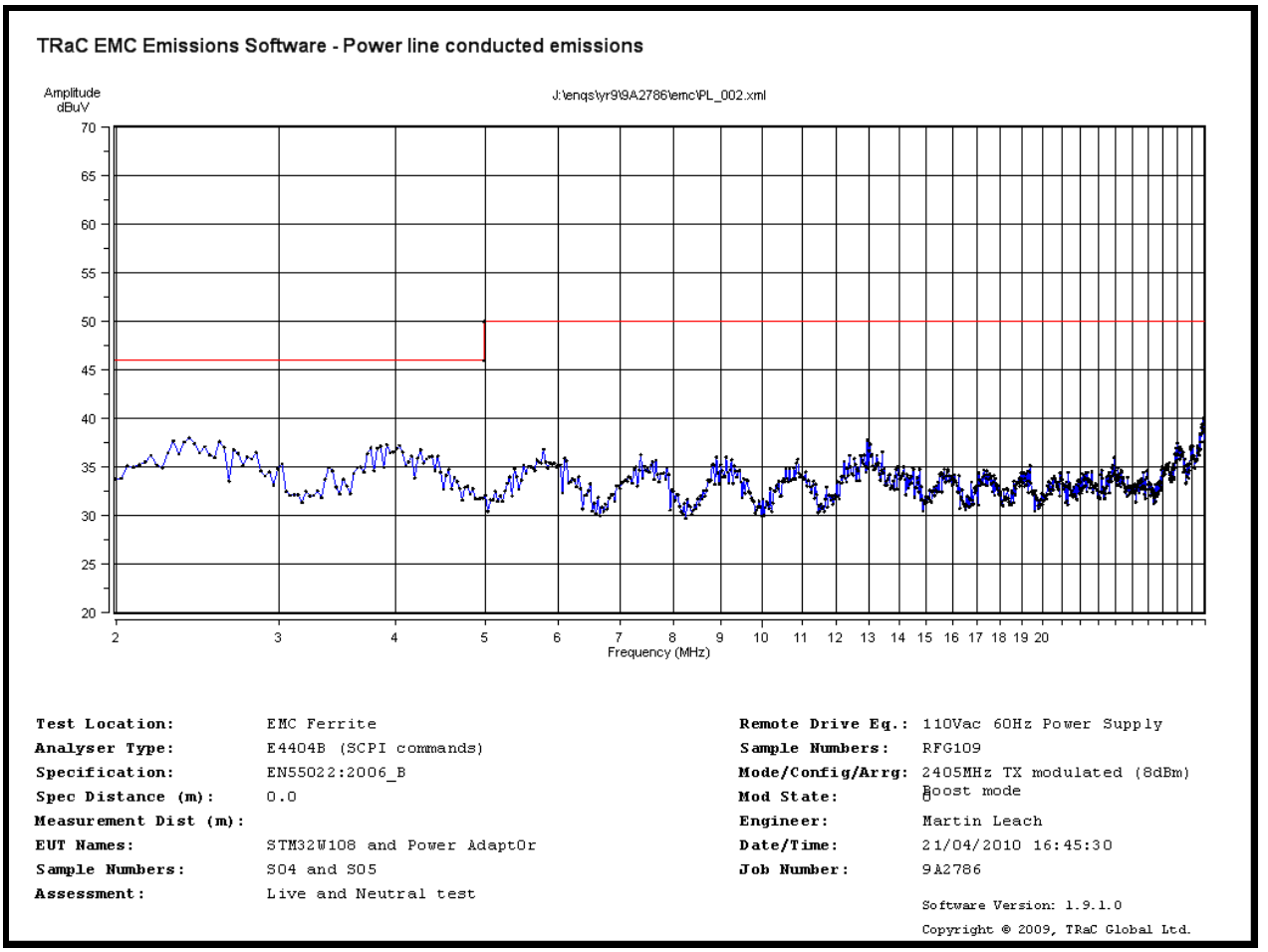
Radiated Transmitter Emissions Channel 11 2405MHz (15.209) Band Edge Compliance RBW 100kHz



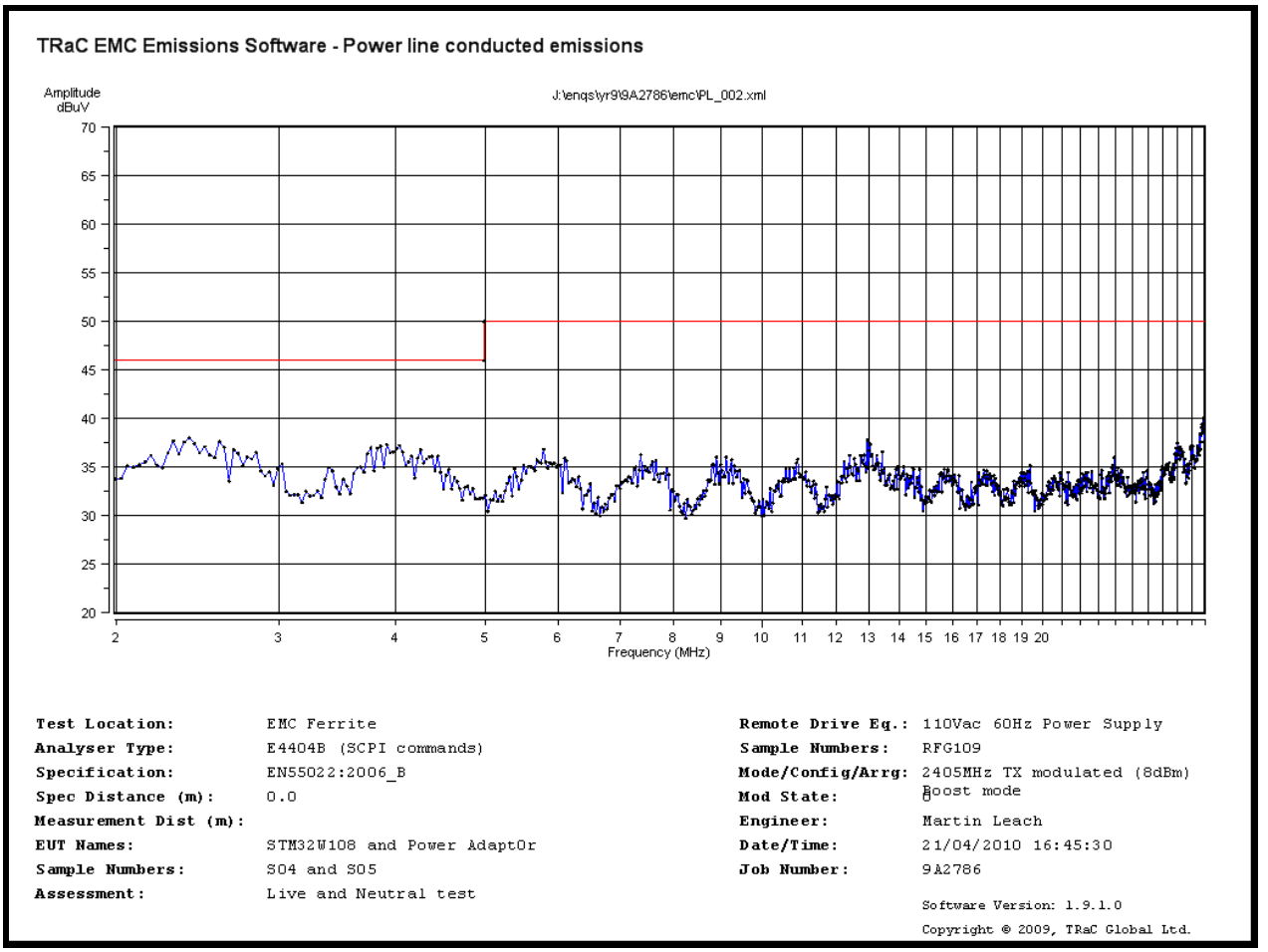
Radiated Transmitter Emissions Channel 26 2480MHz (15.209) Band Edge Compliance
RBW 1MHz



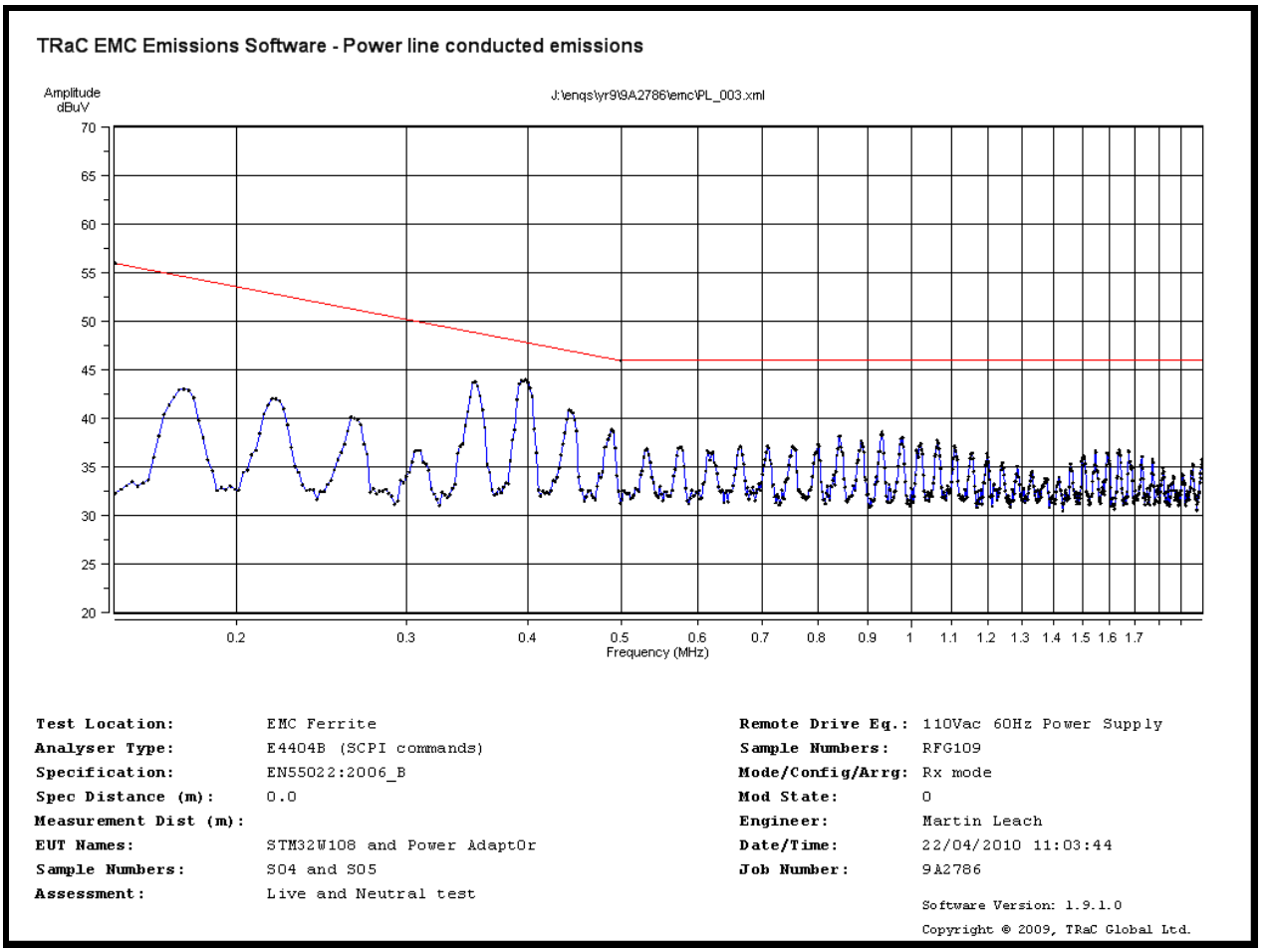
Radiated Transmitter Emissions Channel 26 2480MHz (15.209) Band Edge Compliance
RBW 100kHz



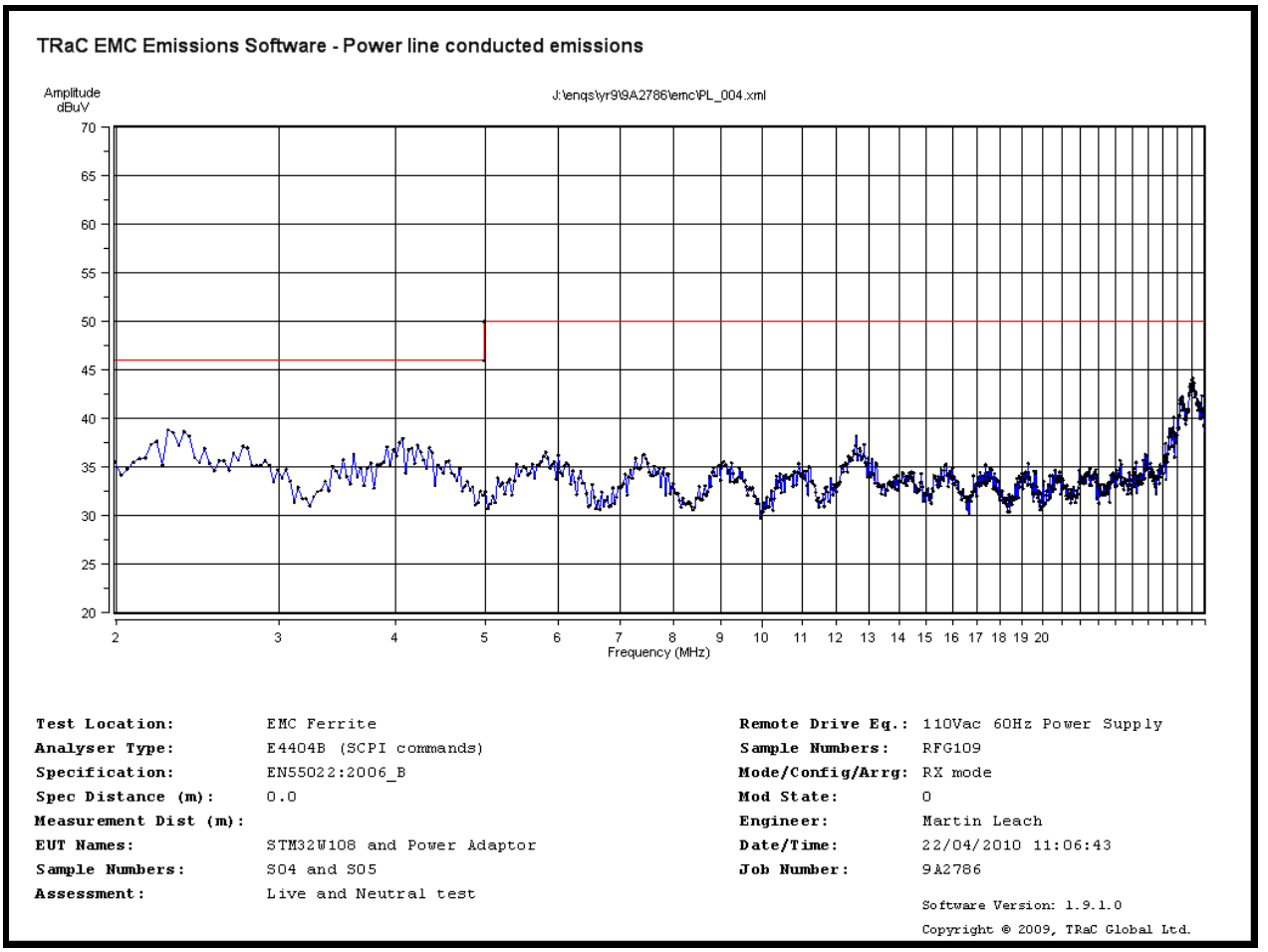
PLCE- EUT transmitting Live and Neutral Lines



PLCE- EUT transmitting Live and Neutral Lines



PLCE - EUT Receiving Live and Neutral Lines



PLCE - EUT Receiving Live and Neutral Lines

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 Telecoms & Radio upon request.

C1) Test samples

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

Sample No.	Description	Identification
S03	DZ-ZB-S-A ZigBee module (conducted)	None
S04	DZ-ZB-S-A ZigBee module (radiated)	None
S05	ac-dc plug top power supply	P/NDMS120085-P5-IC

The following samples of apparatus were supplied by TRaC as support or drive equipment (auxiliary equipment):

TRaC Identification	Description
REF112	Thurlby 30V-2A dc power supply
RFG109	110Vac 60Hz power supply

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, except as described below	The EUT was powered via REF112 dc power supply. The EUT was transmitting on maximum power, 100% duty cycle using O-QPSK with half-sine pulse-shaping - 8-symbol listen-before send for CSMA-CA - Bit rate 250kb/s, symbol rate 62.5ksymbol/s with 4-bit 16-ary orthogonal symbols, chip rate 2000kchip/s) modulation at centre frequencies Fc = 2405 + (5x(k – 11) in MHz, where k = 11, 18 and 26

Test	Description of Operating Mode: Transmit (15.207)
PLCE	The EUT was powered via S05 and RFG109. The EUT was transmitting on maximum power, 100% duty cycle using O-QPSK with half-sine pulse-shaping - 8-symbol listen-before send for CSMA-CA - Bit rate 250kb/s, symbol rate 62.5ksymbol/s with 4-bit 16-ary orthogonal symbols, chip rate 2000kchip/s) modulation at centre frequencies.

Test	Description of Operating Mode: Receive
Radiated Electric Field Emissions Restricted band 15.109 digital circuitry	The EUT was placed in continuous receive mode during the test was powered via REF112.

Test	Description of Operating Mode Receive (15.107)
PLCE	The EUT was powered via S05 and RFG109. The EUT was in continuous Receive mode

C3) EUT Configuration Information.

Sample	Internal Configuration Details
S03	Single possible internal configuration
S04	Single possible internal configuration
S05	Single possible internal configuration

C4) List of EUT Ports

Sample : S03
Tests : RF Antenna Port Conducted Spurious Emissions, 6dB Bandwidth, Power Spectral Density and Conducted Fundamental Carrier Power.

Port	Description of Cable Attached	Cable length	Equipment Connected
Antenna port	50Ohm coax	7cm	REF847/REF835
dc power port	2 core unscreened	1m	REF112

Sample : S04
Tests : Radiated Electric Field Emissions Restricted band 15.205 and 15.109 digital circuitry

Port	Description of Cable Attached	Cable length	Equipment Connected
dc power port	2 core unscreened	>1m	REF112

Sample : S04
Tests : Power Line Conducted Emissions 15.207 and 15.107

Port	Description of Cable Attached	Cable length	Equipment Connected
dc power port	2 core unscreened	1.8m	S05

Sample : S05
Tests : Power Line Conducted Emissions 15.207 and 15.107

Port	Description of Cable Attached	Cable length	Equipment Connected
ac power port	Plug top ac –dc power supply	N/A	RFG109
dc power port	2 core unscreened	1.8m	S04

C5 Details of Equipment Used

For Radiated Measurements:

TRAC REF/RFG No.	Type	Description	Manufacturer	Date Calibrated.
274	Lab 10	Large anechoic chamber	TRaC	29/02/08
231	CBL6111	BILOG Antenna	Chase	12/08/08
129	3115	1-18GHz Horn Antenna	EMCO	11/08/08
630	QSH20S20S	18-26GHz Horn antenna	Q-PAR	02/11/06
008	8447D	Pre Amp (30 to 1000MHz)	HP	16/02/10
307	8449B	Microwave pre amp (1 to 26.5GHz)	HP	01/03/10
214	ESAI	Spec Analyser/Test Receiver (LF/HF)	R & S	22/03/10
RFG404	ESA-E	E4407B Spectrum Analyser	Agilent	10/05/10
REF847	ESU40	Spectrum Analyser/Receiver	Rhode & Schwarz	08/05/09
REF112	PL320	dc power supply	Thurlby	CAL date N/A
246	07212BD	4.5m N-Type cable	TRaC	22/09/09
270	30-05151-10	3m N-Type cable	TRaC	22/09/09
278	30-05156-10	1m N-Type cable	TRaC	22/09/09
643	ST18/Nm/Nm/48	48 inch Sucoflex cable	Huber & Suhner	22/09/09
650	N-106	3 meter HF Sucoflex cable	Huber & Suhner	22/09/09
651	N-106	7 meter HF Sucoflex cable	Huber & Suhner	22/09/09
REF831		5m K-Type M-M	Teleydyne Reynolds	22/04/09
REF833		2m K-Type M-M	Teleydyne Reynolds	09/07/10

For Conducted Measurements

TRAC REF/RFG No.	Type	Description	Manufacturer	Date Calibrated.
REF847	ESU40	Spectrum Analyser/Receiver	Rhode & Schwarz	08/05/09
REF112	PL320	dc power supply	Thurlby	CAL date N/A
835/836	N10149 N1911A	Power head and meter	Agilent	03/08/09
REF833		2m K-Type M-M	Teleydyne Reynolds	09/07/10

For Power Line Conducted Emissions

TRAC REF/RFG No.	Type	Description	Manufacturer	Date Calibrated.
REF847	ESU40	Spectrum Analyser/Receiver	Rhode & Schwarz	08/05/09
n/a	Lab 7	Screened room 1	TRaC	CAL date N/A
189	ESH3-Z5	2-phase LISN	Rhode & Schwarz	20/05/09
232	ESH3-Z2	Pulse Limiter	Rhode & Schwarz	16/02/10
404	E4407B	Spectrum Analyser	Agilent	10/05/10
REF109		110Vac/60Hz supply	Farnell	CAL date N/A

Appendix D: Additional Information

The following additional information is included within this test report.

D.1 Data sheet for Antenna

RAINSUN GROUP RainSun

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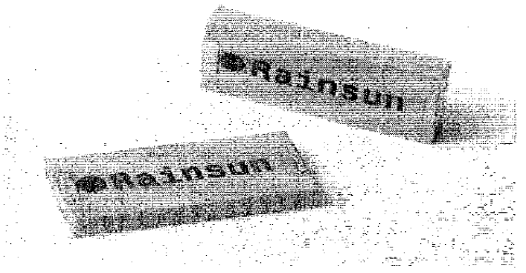
AN0835

Multilayer Chip Antenna for

2.4GHz Wireless Communication



RainSun Corporation
http://www.rainsun.com

1 of 9

Aug, 2006
Ver.1.1

AN0835 Multilayer Chip Antenna

◆ Features

- Light weight and low profile 8.0mm(L) x 3.5mm(W) x 1.0mm(H)
- Omni-directional in azimuth
- Lead (Pb) Free

◆ Applications

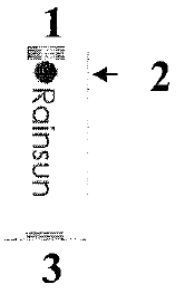
- 2.4GHz wireless communications
- 2.4GHz Modules
- Bluetooth System
- 802.11b/g Wireless LAN System

Specifications

Center frequency	2.45 GHz
Peak gain	1 dBi
Operation temperature	-40 ˚C ~ +85 ˚C
Storage temperature	-40 ˚C ~ +85 ˚C
VSWR	2.0 (max)
Input Impedance	50 Ohm
Power handling	3W (max)
Bandwidth	180 MHz
Azimuth beamwidth	Omni-directional
Polarization	Linear

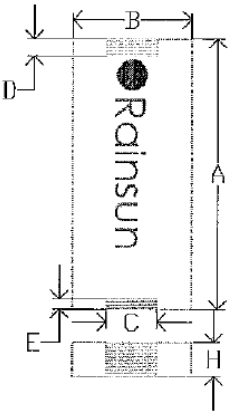
Pin configuration

Top view



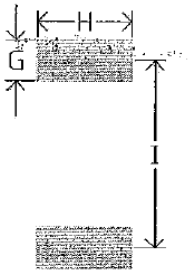
Pin No	Pin assignment
1	Feed termination
2	Feed point mark
3	Solder termination

Dimensions



Symbol	Dimensions(mm)
A	8.00 ± 0.10
B	3.50 ± 0.10
C	1.50 ± 0.02
D	0.50 ± 0.05
E	0.30 ± 0.05
H	1.00 ± 0.20

PCB Foot Print



Symbol	Dimensions(mm)
G	1.0
H	1.9
I	8.0

Recommended Test Board Pattern

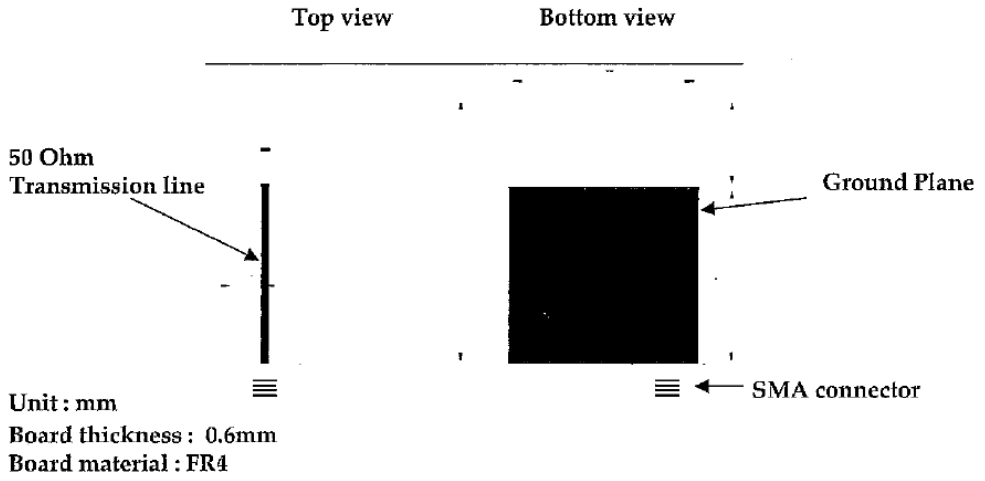
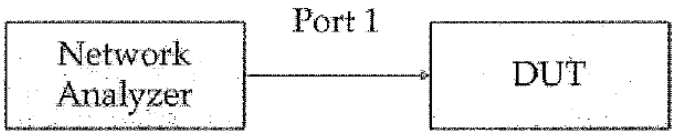
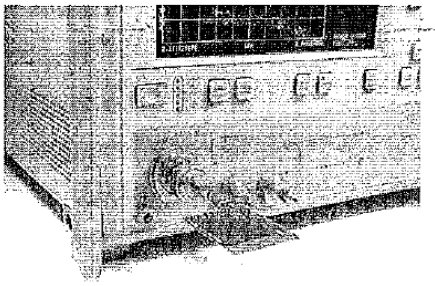


Fig-1

Testing Setup



Measurement



Testing Instrument:
Anritsu 37369C VNA(Vector Network Analyzer)

VNA calibrate with 1 path reflection only calibration sequence on test board feed point.

The test board dimension and it's layout is the same as Fig-1.

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RainSun

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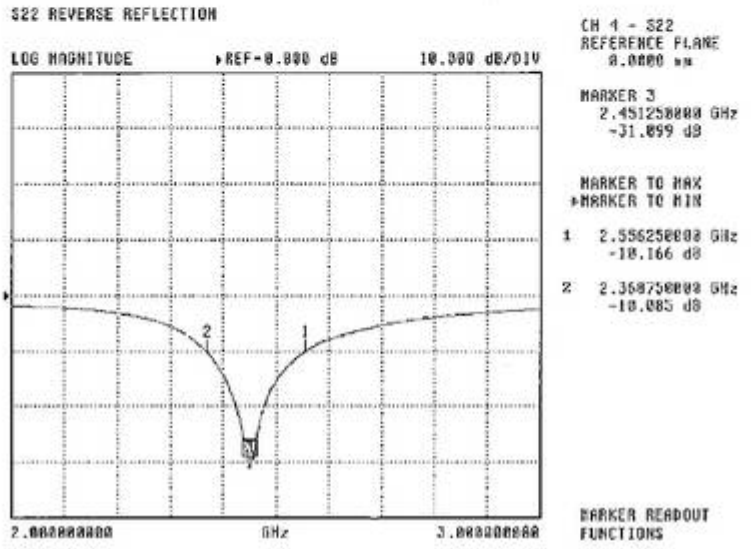
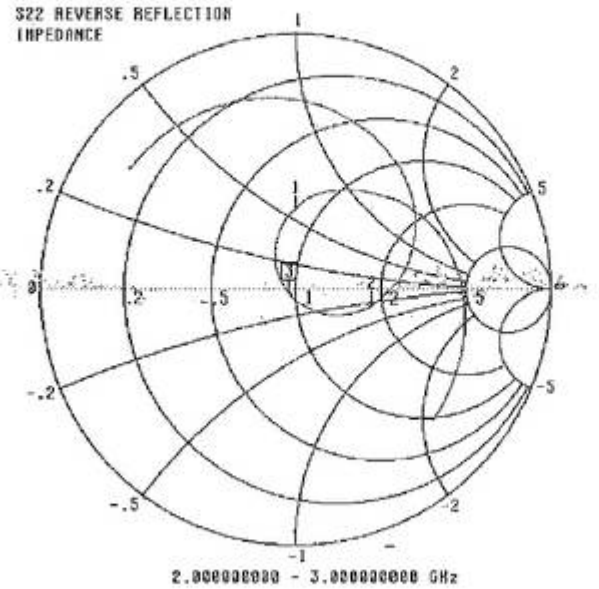
Typical Electrical Characteristics

Return loss



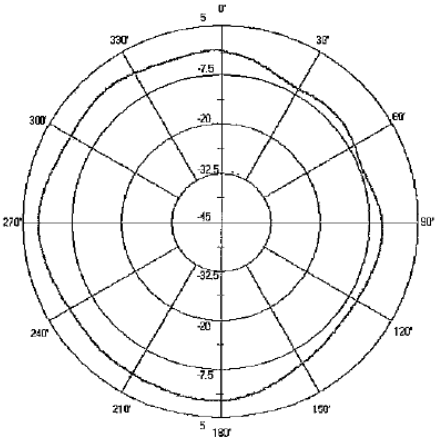
Smith Chart



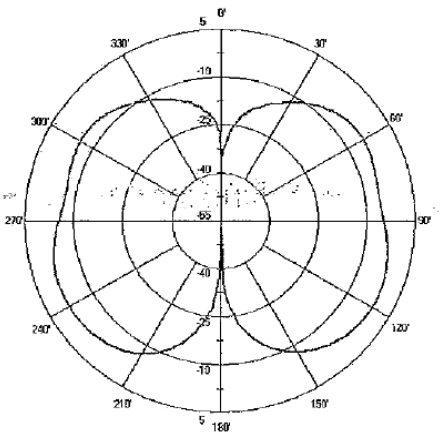
Marker data:
1 : f=2.556 GHz
2 : f=2.368 GHz
3 : f=2.451 GHz

Typical Radiation Patterns

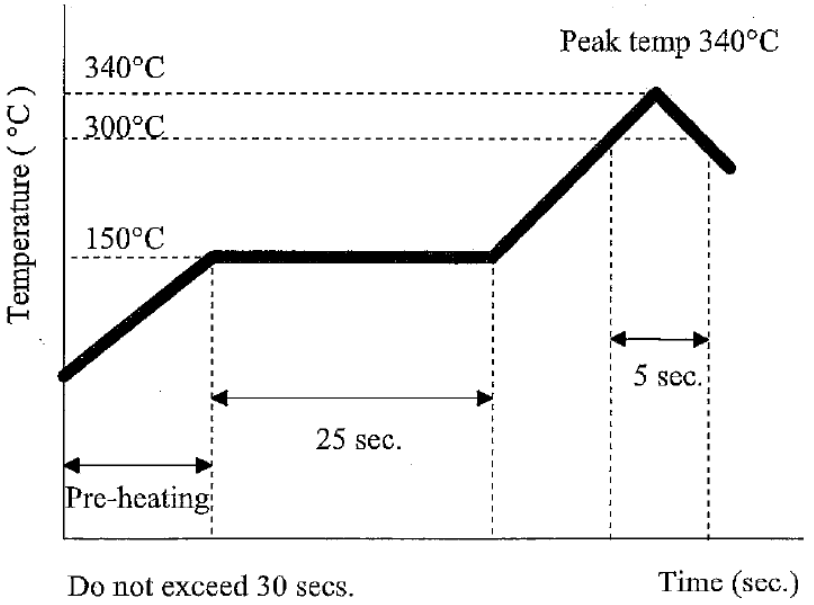
2.45 GHz H-Plane



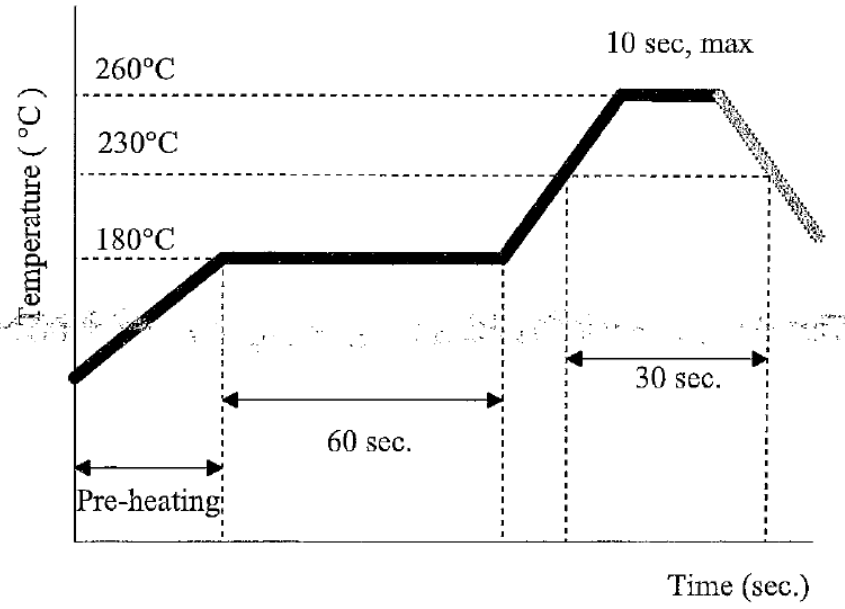
2.45 GHz E-Plane



Typical Soldering Profile for Lead-free Process

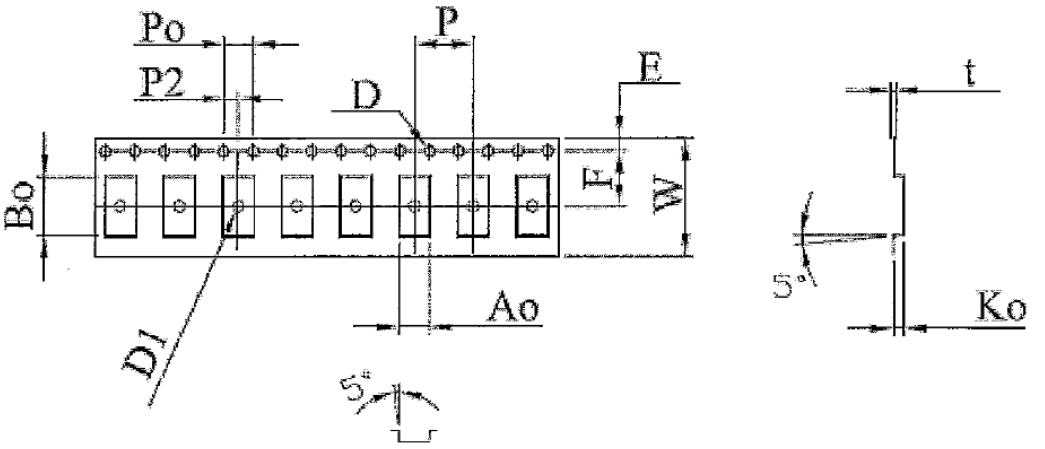


Reflow Soldering



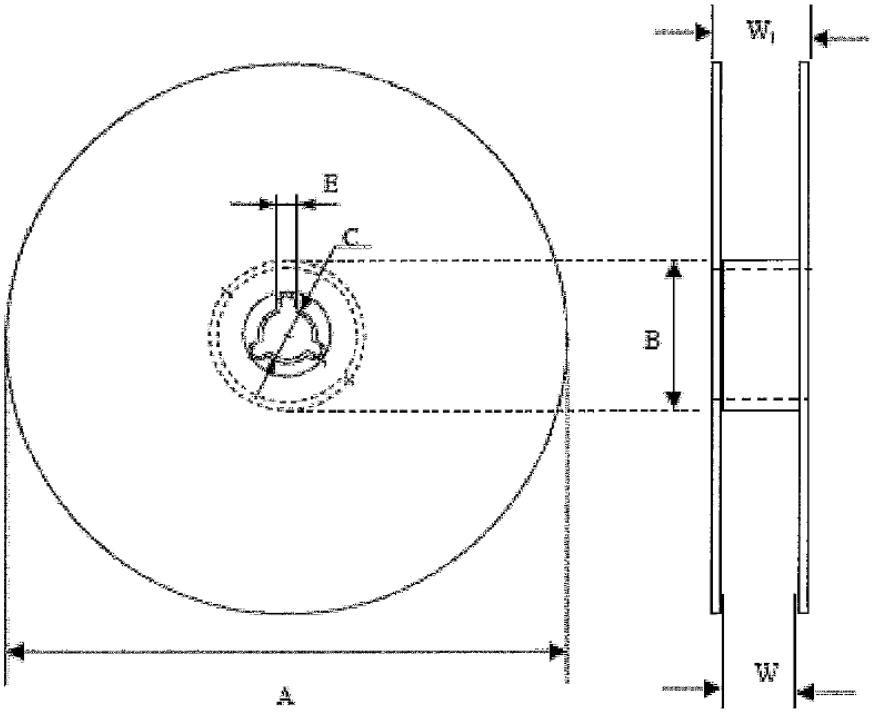
Packing

Blister Tape Specifications



Symbol	Dimension	Tolerance	Unit
W	16.00	± 0.30	mm
E	1.75	± 0.10	mm
F	7.50	± 0.10	mm
D	1.50	± 0.10	mm
D_1	1.50	+0.25 -0.00	mm
P_0	4.00	± 0.10	mm
P	8.00	± 0.10	mm
P_2	2.00	± 0.10	mm
A_0	3.70	± 0.10	mm
B_0	8.20	± 0.10	mm
K_0	1.40	± 0. 10	mm
T	0.30	± 0.05	mm

Reel Specifications



Quantity Per Reel	Tape Width (mm)	A (mm)	C (mm)	B (mm)	E (mm)	W (mm)	W_1 (mm)
1,000	16	178±1	13±0.2	60±0.5	2.2±0.5	16.7±0.3	19.5±1.0

Appendix E: Calculation of the duty cycle correction factor

The following information was supplied by the client to support this assessment:

MMS GROUP

MCD Division

DUTY CYCLE DECLARATION

May 3rd 2010

STMicroelectronics SAS
190 Avenue Celestin Coq
Zone Industrielle
Rousset Cedex
13106
France

RE: Duty cycle declaration

FCC ID: YCPDZSTM32WA
IC ID: 8976A-DZSTM32WA

To Whom It May Concern:

Please be advised that STMicroelectronics SAS declare that the maximum duty cycle for the RF 802.15.4 Zig-Bee module on channel 26 is 50%.

Thank you for your attention to this matter.

Yours faithfully

STMicroelectronics SAS

Signature

Francis Dell'ova

MMS GROUP

MCD Division

Transmit Power Duty Cycle

Goal:
Calculate the worse case time a 802.15.4 Node will be in TX Mode in any 100ms Time Window.

Correction Factor is: 20*Log10(Duty Cycle)

Procedure:
In order to calculate the worse case TX on time.
IEEE 802.15.4 MAC and PHY constants are used and slotted ACK
LIFS and SIFS scenarios. Each scenario is described below.

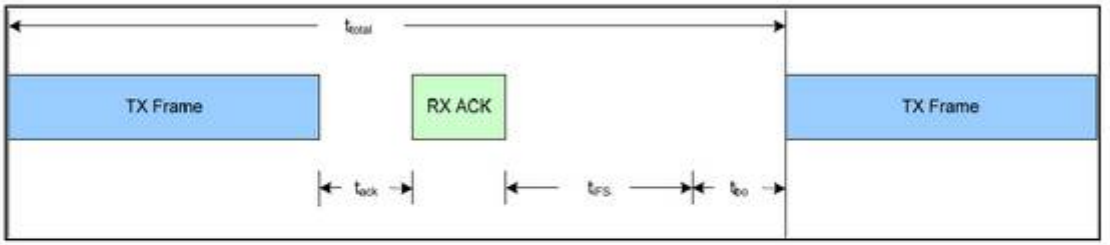
IEEE 802.15.4-2003 2.4 GHz PHY Constants

Data Rate	250000	bits / sec
	31250	bytes / sec
Symbols/byte	2	sym / bytes
Symbol Timing	62500	sym / sec
	0,000016	sec / sym
Byte Timing	0,000032	sec / byte
PHY PSDU	6	bytes 4 Preamble, SPD, Length
Max Length	127	bytes
Total Packet Length	133	bytes
Maximum Time TX PKT	0,004256	sec

IEEE 802.15.4-2003 MAC Constants

maxBE	5	
aMaxFrameResponseTime	1220	symbols
aMaxFrameRetries	3	
aUnitBackoffPeriod	20	symbols
macAckWaitDuration	54	symbols
macBattLifeExtPeriods	6	Backoff periods
macMaxCSMABackoffs	4	
macMinBE	3	
aMinLIFSPeriod	40	symbols
aMinSIFSPeriod	12	symbols
aMinCAPLength	440	symbols
NB	0	
CW	2	
BE	3	

2) Wait for ACK
3) RX ACK
4) Wait for LIFS
5) Wait for Backoff
6) Repeat 1)



MAC-Level Calculation (LIFS)

Long InterFrame Spacing (Slotted w/ ACK)		
Long Frame	127	bytes
Data Frame Payload	102	bytes
ACK Frame	5	bytes
tack	12	sym
LIFS	40	sym
Backoff Period	20	sym
Maximum Backoff	7	Random between 0 and 7
Backoff Required	2	
Backoff Time	60	sym

Transmit Time	
TX Time (Packet)	0,004256
Total TX Time (sec)	0,004256

NOT Transmit time (RX or Idle)	
Backoff Time	0,00192
tack(minimum)	0,000192
RX Time (ACK)	0,000352
LIFS	0,00064
Total Off Time (sec)	0,003104

Total Time (ttotal)	0,00736
Number of periods in 100ms Window	13,58695652
Worse Case (100ms window)	
TX Frame 14 times	0,059584
RX or IDLE 13 Times	0,040352
Sum	0,099936

MAC TX Duty Cycle (On /total)	59,62%	Represents MAC only performance

Short Frame Scenario:

1) TX Frame — Assume Frame is Data Frame

2) Wait for ACK
3) RX ACK
4) Wait for SIFS
5) Wait for Backoff
6) Repeat 1)

MAC-Level Calculation (SIFS)

Short InterFrame Spacing (Slotted w/ ACK)		
Short Frame	18	bytes
Data Frame Payload	18	bytes
ACK Frame	5	bytes
tack	12	sym
SIFS	12	sym
Backoff Period	20	sym
Maximum Backoff	7	Random between 0 and 7
Backoff Required	2	
Backoff Time	60	sym

Transmit Time	
TX Time (Packet)	0,000768
Total TX Time (sec)	0,000768

NOT Transmit time (RX or Idle)	
Backoff Time	0,00192
tack(minimum)	0,000192
RX Time (ACK)	0,000352
SIFS	0,000192
Total Off Time (sec)	0,002656

Total Time (ttotal)	0,003424
Number of periods in 100ms Window	29,20560748
Worse Case (100ms window)	
TX Frame 29 times	0,022272
RX or IDLE 29 Times	0,077024
Sum	0,099296

MAC TX Duty Cycle (On /total)	22,43%

Use for FCC Calculations	23%	
	In TX Mode 23ms worst case in any 100ms window.	

Therefore worst case being 59.62% of MAC duty cycle corresponding to 4.5dB of reduction, we need to add an additional reduction of 1.5dB to be below 5.9dB. Duty cycle is then D = 10(-1.5/20) = 0.841 = 84.1%, say 84% which gives a total duty cycle of 50%.

$$= \frac{23ms}{100ms} = 0.23$$

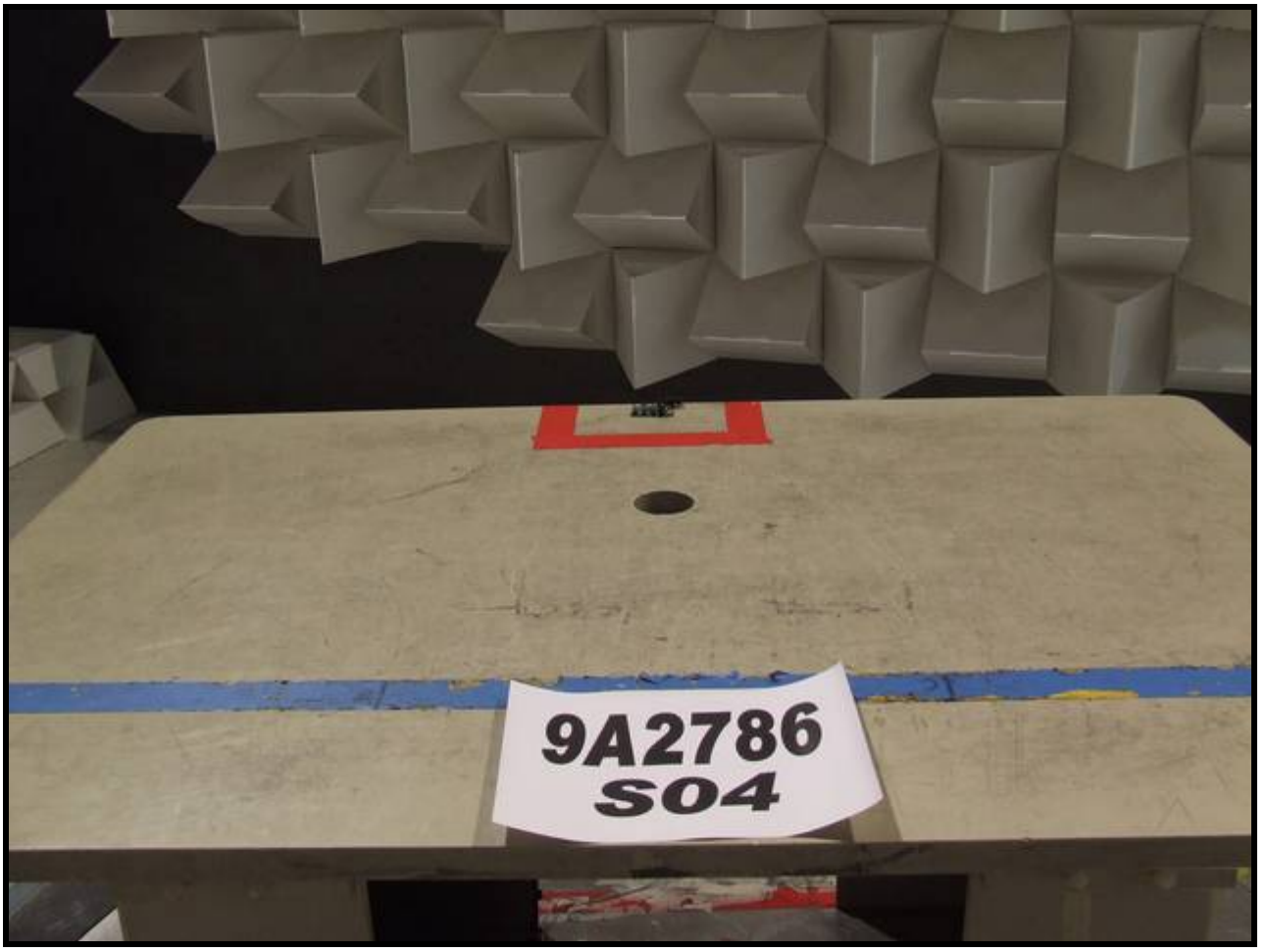
0.23 or 23%

The calculated Correction factor (dB) = 20 x (Log_{10} 0.23) = -12.76dB

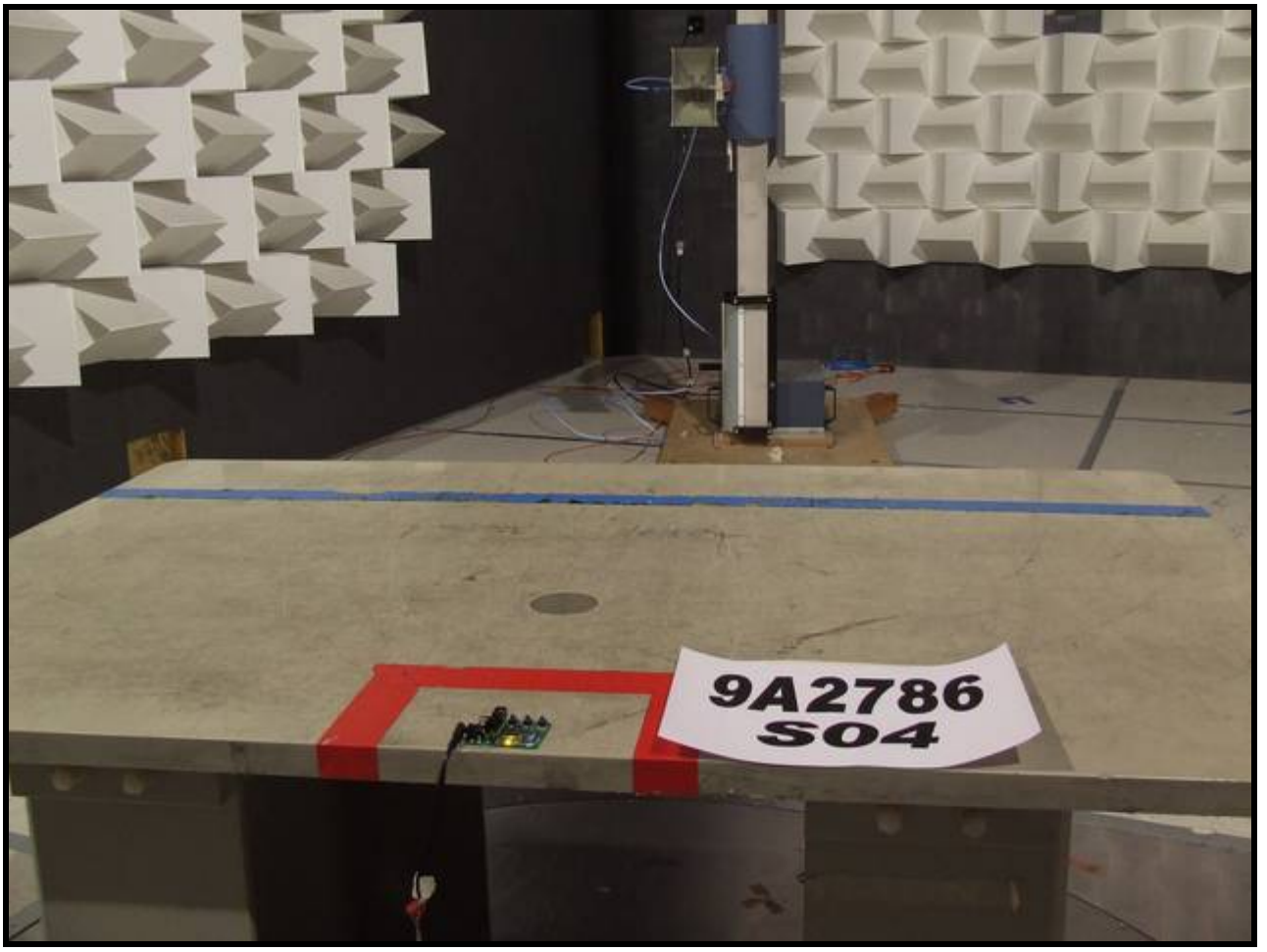
Appendix F: Photographs and Figures

The following photographs were taken of the test samples:

1. Radiated electric field emissions arrangement: front view.
2. Radiated electric field emissions arrangement: rear view.
3. Radiated electric field emissions arrangement: rear view close up.
4. Power line conducted emissions
5. PCB Photo: Front
6. PCB Photo: Front with screen can removed
7. PCB Photo: Rear



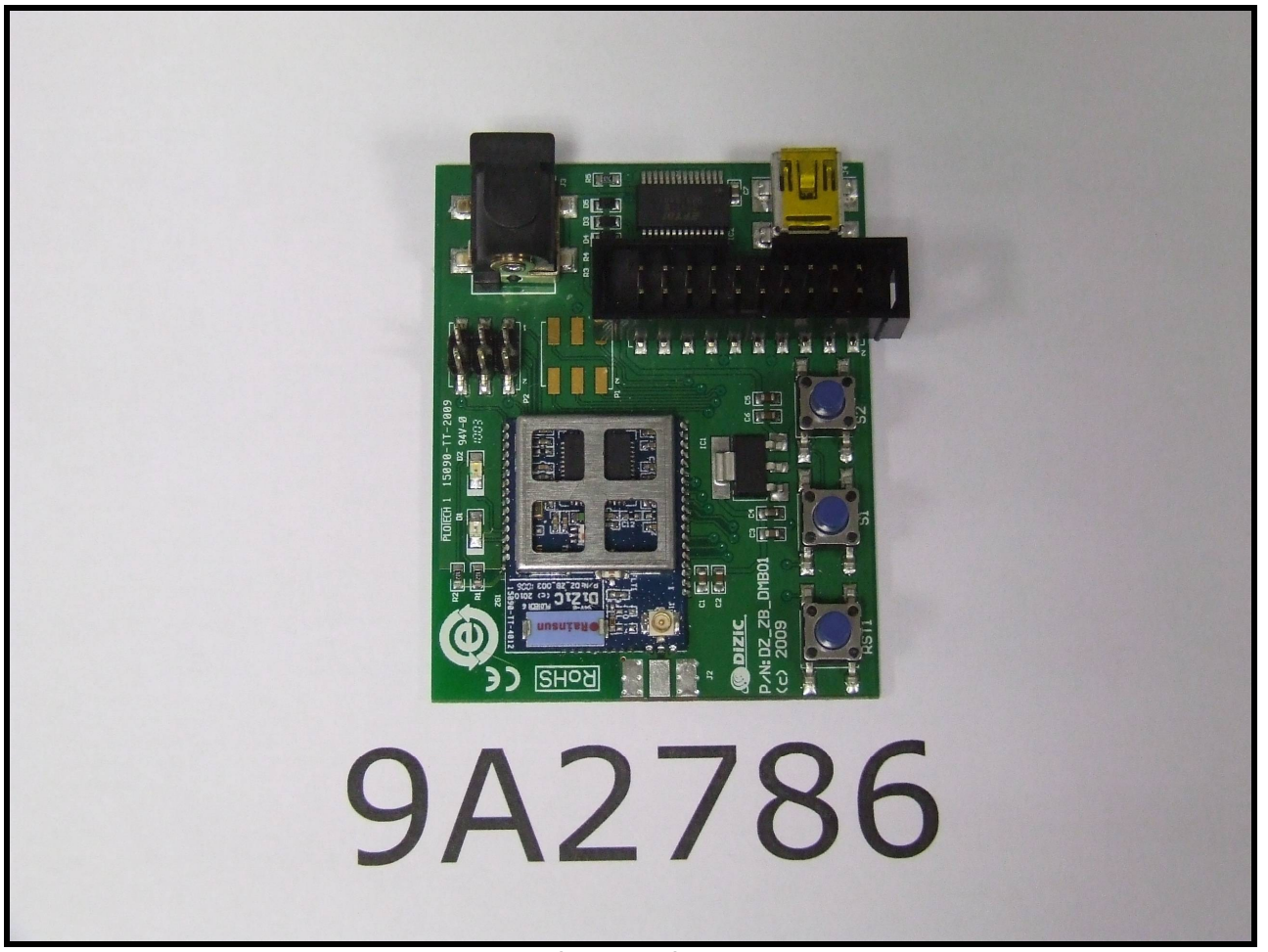
Photograph 1



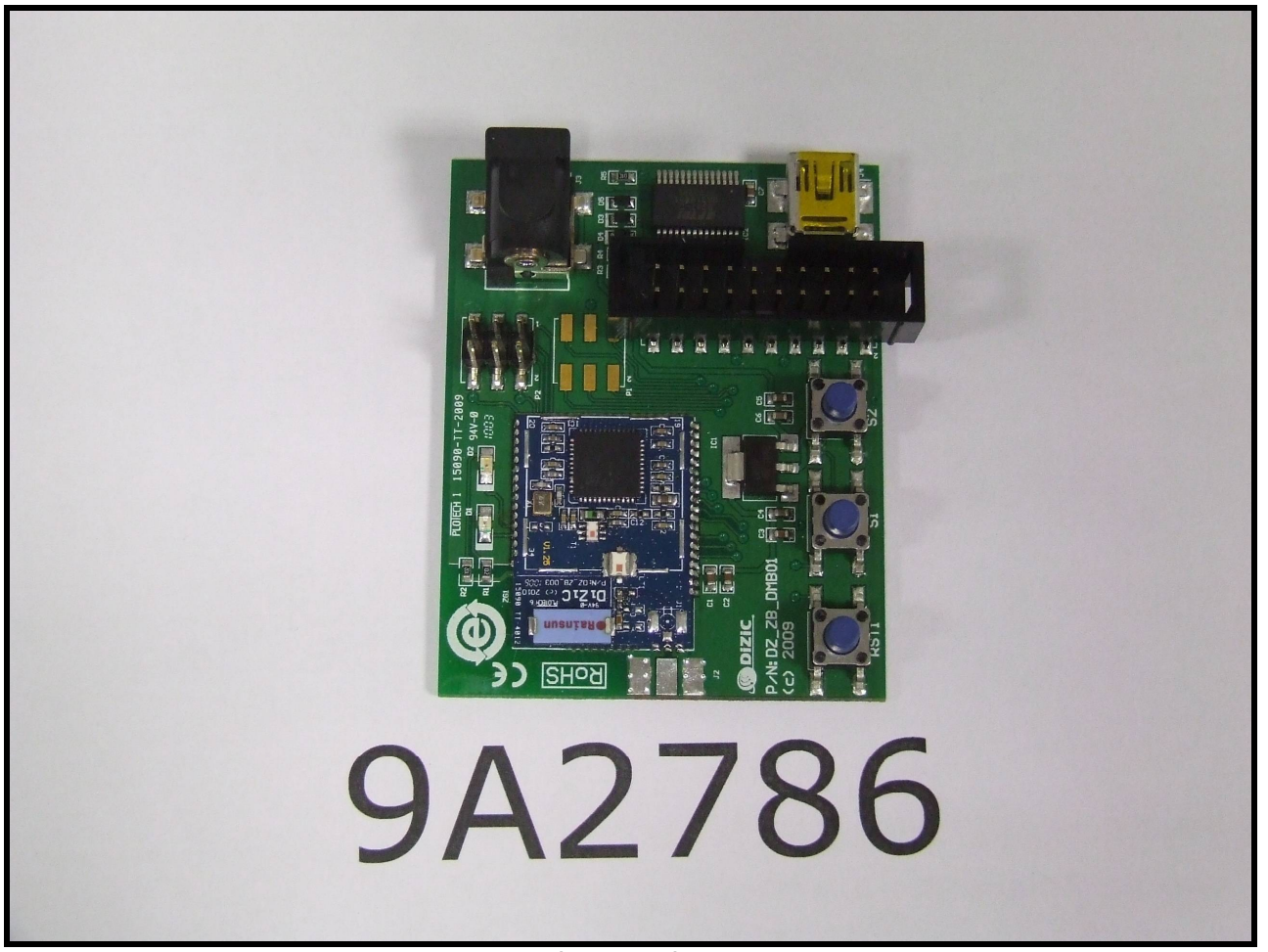
Photograph 2

Photograph 3

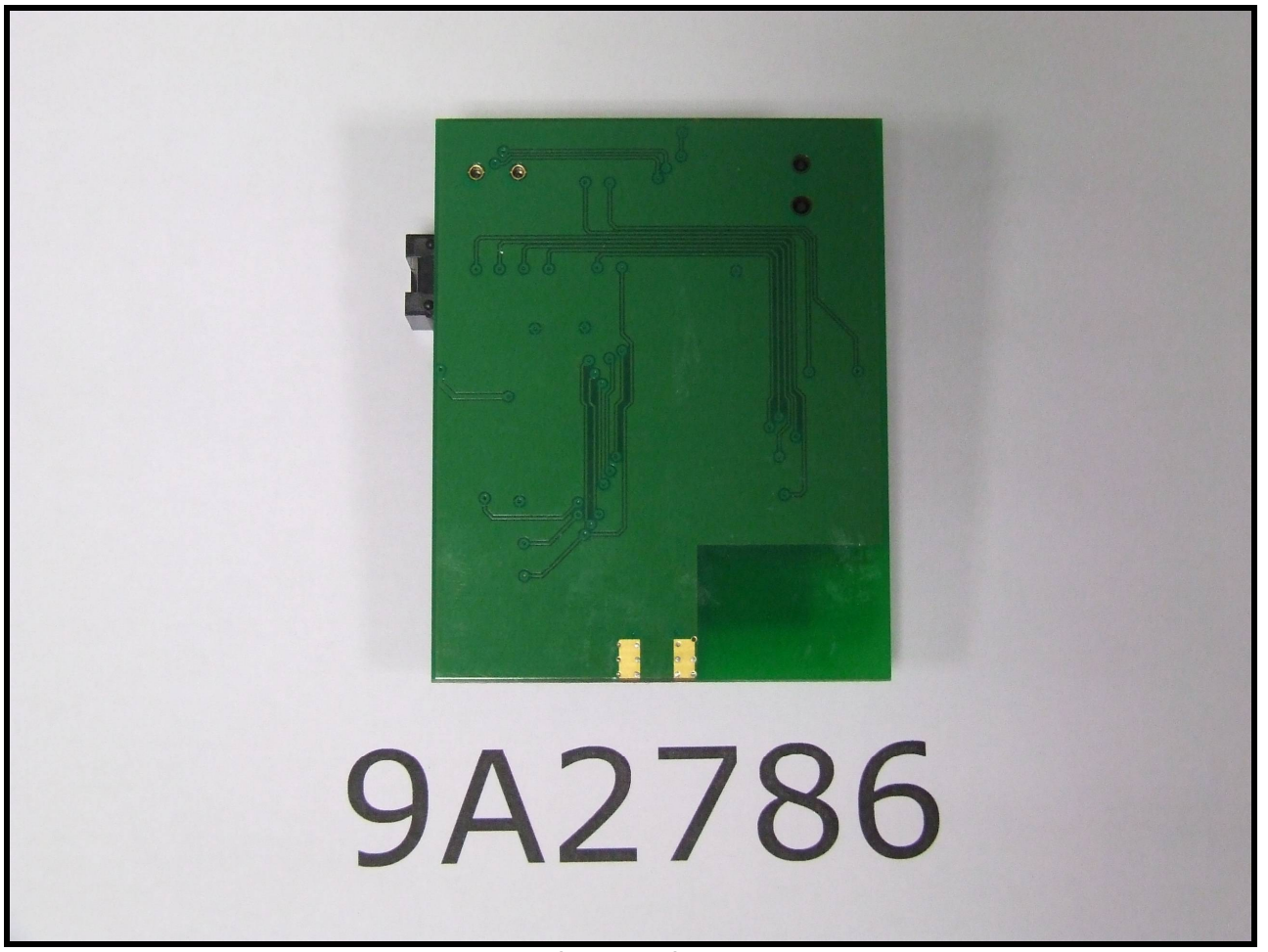
Photograph 4



Photograph 5



Photograph 6



Photograph 7

Appendix G: MPE Calculation

OET Bulletin No. 65, Supplement C 01-01

47 CFR §§1.1307 and 2.1091

2.1091 Radio frequency radiation exposure evaluation: mobile devices.

For purposes of these requirements mobile devices are defined by the FCC 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 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 1mW/cm^2 power density limit, as required under FCC rules.

Prediction of MPE limit at a given distance

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

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

where:
S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the centre of radiation of the antenna

Sample No.	S03	
Maximum peak output power at the antenna terminal:	5.49	dBm
Maximum peak output power at the antenna terminal:	3.53997341	mW
Power density	1.00000000	mW/cm^2
Antenna gain (typical):	1	dBi
Maximum antenna gain:	1.258925412	numeric
Prediction frequency:	2405	MHz

Result

Prediction Frequency (MHz)	Maximum allowable antenna gain: (dBi)	Power density limit (S) (mW/cm^2)	Distance (R) cm required to be less than 1mW/cm^2
2405	1	1.000000	**0.59551824**