TRaC Radio Test Report

for

OMG PLC

on

Autographer

DOCUMENT NO. TRA-008948-W-US-01

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TRaC Radio Test Report : TRA-008948-W-US-01

Applicant : OMG PLC

Apparatus : Autographer

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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

The testing in this report was requested by:

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1.3 Manufacturer

As Above

1.4 Apparatus Assessed

The following apparatus was assessed between 10/07/13 and 01/08/13:

Autographer

The EUT is a wearable camera designed to capture images without user intervention. The EUT uses five on board sensors and GPS capability to identify the right time to take a photograph based on changes in light and colour, motion, direction and temperature. The EUT contains a Bluetooth® transceiver for data transfer.

1.5 Results Test Summary

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

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

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

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

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
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

The following page contains the measurement uncertainties for measurements

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.

Test type	Quantity	Quantity frequency range	Uncertainty
Radiated electric field emissions 3m alternative test site Effective Radiated Power 3m alternative test site	Amplitude	30MHz to 300MHz Horizontal	±4.6dB
		30MHz to 300MHz Vertical	±5.1dB
		300MHz to 1000MHz Horizontal	±5.2dB
		300MHz to 1000MHz Vertical	±5.5dB
		1GHz to 26.5GHz Horizontal and Vertical	±4.1dB
Conducted emissions		N/A	±0.9 dB
Absolute RF power (via antenna connector)		N/A	±0.9 dB
PSD		N/A	±0.9 dB
Frequency Range	Frequency	dc to 26.5GHz	3.611kHz

Section 3: Modifications

3.1 Modifications Performed During Assessment

No modifications were performed during the assessment

Appendix A: Formal Emission Test Results

Abbreviations used in the tables in this appendix:

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

A1 Conducted Fundamental Carrier Power

The EUT transmitting on its lowest channel centre and highest carrier frequency in turn.

Test Details:	
Regulation	CFR 47 Part 15,Subpart (c) 15.247(b)(2)
Measurement standard	ANSI C63.10:2009
EUT sample number	
Modification state	0
SE in test environment	None
SE isolated from EUT	None
SE in test environment	None

Channel No	Channel Frequency (MHz)	Calculated Peak Conducted Carrier Power (dBm) (Note 2)	Measured Peak Conducted Carrier Power (mW)	Limit (W)	Result
0	2402	0.2	1.05	1.0	Pass
39	2441	0.4	1.10		Pass
79	2480	0.1	1.02		Pass

Note 1: Channel 0 is the lowest operating frequency, and channel 79 is the highest operating frequency.

Note 2: Conducted power was calculated from the measured EIRP and declared antenna gain (0.2 dBi). The Data sheet for the antenna is reproduced in Appendix D of this report

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 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 CH0/CH31/CH63	
Regulation	CFR 47 Part 15Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2009
Frequency range	30MHz to 10 GHz
EUT sample number	S28,S29 and S30
Modification state	0
SE in test environment	None
SE isolated from EUT	None
SE in test environment	None

The worst case conducted spurious emissions are listed below

Bottom Channel 2402 MHz

Frequency (MHz)	Level (dBm)	Limit (dBm)	Verdict
953.365	-69.1	-50	Pass
4807.692	-69.7	-50	Pass

Middle Channel 2441 MHz

Frequency (MHz)	Level (dBm)	Limit (dBm)	Verdict
953.365	-65.0	-49.5	Pass
1833.333	-64.5	-49.5	Pass

Top Channel 2480 MHz

Frequency (MHz)	Level (dBm)	Limit (dBm)	Verdict
953.365	-68.0	-51.2	Pass
2410.256	-61.6	-51.2	Pass

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 carrier level was measured whilst varying the supply voltage between 85% and 105% of the nominal supply voltage as required by 15.31(e). No variation in carrier level was observed. All other emissions were at least 20dB below the test limit

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

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

Channel No.	Channel Frequency (MHz)	Measured Peak Carrier Power (dBm)	Emission Limit In a 100 kHz RBW (dBm)
0	2402	-30.00	-50.00
39	2441	-29.49	-49.49
78	2480	-31.18	-51.18

A3 Radiated Electric Field Emissions 15.209 and within the Restricted Band 15.205

Transmit UHF Radio Module Only

Preliminary emission testing was performed using a peak detector with the RBW = 100kHz. The radiated electric field emission test applies to spurious emissions and harmonics that fall within the restricted bands listed in Section 15.205. The maximum permitted field strength is listed in Section 15.209. The EUT was set to transmit with its UHF radio module on its lowest, centre and highest carrier frequency in turn. The co-located Modem was not transmitting.

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

10m 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: Transmit Mode	
Regulation	CFR 47 Part 15Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.10:2009
Frequency range	30MHz to 25 GHz
EUT sample number	S28, S29 and S30
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 1 and 2

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

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	Detector	PRE AMP (dB)	ANT FACT (dB/m)	CABLE LOSS (dB)	Distance extrapolation (dB)	FIELD ST'GH (dBµV/m)	LIMIT (dBµV/m)
1.	2400.000	51.6	Pk	34.62	29.6	5.3	-9.5	42.4	94.2
2.	2400.000	49.1	Av	34.62	29.6	5.3	-9.5	39.9	74.2
3.	2483.500	55.7	Pk	34.64	29.9	4.9	-9.5	46.4	74.0
4.	2483.500	53.3	Av	34.64	29.9	4.9	-9.5	44.0	54.0

Notes:

1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.10: section 4.5, Table 1
2 In accordance with 15.35(b), above 1 GHz, emissions measured using a peak detector shall not exceed a level 20 dB above the average limit.
3 Measurements at 2400 MHz and 2483.5 MHz were made to ensure band edge compliance.

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

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

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

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

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

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

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 (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 Unintentional Radiated Electric Field Emissions - 15.109

Preliminary scans were performed using a peak detector with the RBW = 100 kHz. 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 : ☑

Test Details: Receive mode	
Regulation	CFR 47 Part 15 Subpart (b) Clause 15.109
Measurement standard	ANSI C63.10:2009
Frequency range	30MHz to 10 GHz
EUT sample number	TRA-011281S09 and S10
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 1 and 2

Worse case results listed from the middle channels in receive mode.

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	Detector	PRE AMP (dB)	ANT FACT (dB/m)	CABLE LOSS (dB)	FIELD ST'GH (dBµV/m)	LIMIT (dBµV/m)
1.	215.987	58.1	Pk	31.5	10.4	1.8	38.8	63.5
2.	215.987	46.8	Qp	31.5	10.4	1.8	27.5	43.5
3.	936.902	48.1	Pk	30.4	23	4.5	45.2	63.5
4.	936.902	37.8	Qp	30.4	23	4.5	34.9	43.5
5.	984.886	49	Pk	30	23.6	4.5	47.1	66.0
6.	984.886	36.2	Qp	30	23.6	4.5	34.3	46.0

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

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

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

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

Radiated emission limits (47 CFR 15: Clause 15.109)

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

Notes:

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

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

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

A5 ac Power Line Conducted Emissions 15.207

Power line emissions were not performed as the EUT is battery powered and transmissions are disabled whilst the battery is being charged via the USB port.

A6 ac Power Line Conducted Emissions 15.107

Preview ac power line port 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) below.
Where applicable formal measurements of the emissions were performed with a peak, average and/or quasi peak detector. The formal measurements are detailed below:

Test Details: Device in Charging Mode	
Regulation	Title 47 of the CFR:2010, Part 15 Subpart (b)
Measurement standard	ANSI C63.4:2009
Class	B – refer to specification limit table below.
Frequency range	150kHz to 30MHz
EUT sample number	S21,25 and S26
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs	Photograph 3

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

Results measured using the Quasi-Peak detector compared to the Quasi-Peak limit

Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
1	0.151	Live	38.7	65.9	-27.2	Pass
2	0.192	Live	53.0	63.9	-10.9	Pass
3	0.214	Live	34.1	63.0	-28.9	Pass
4	0.256	Live	44.9	61.5	-16.6	Pass
5	0.336	Live	38.1	59.3	-21.2	Pass
6	0.384	Live	33.5	58.1	-24.6	Pass
7	0.151	Neutral	38.8	65.9	-27.1	Pass
8	0.192	Neutral	51.9	63.9	-12.0	Pass
9	0.214	Neutral	33.4	63.0	-29.6	Pass
10	0.256	Neutral	43.7	61.5	-17.8	Pass
11	0.336	Neutral	37.3	59.3	-22.0	Pass
12	0.384	Neutral	31.1	58.1	-27.0	Pass

Results measured using the average detector compared to the average limit

Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
1	0.151	Live	26.9	55.9	-29.0	Pass
2	0.192	Live	33.4	53.9	-20.5	Pass
3	0.214	Live	28.7	53.0	-24.3	Pass
4	0.256	Live	26.3	51.5	-25.2	Pass
5	0.336	Live	22.8	49.3	-26.5	Pass
6	0.384	Live	27.0	48.1	-21.1	Pass
7	0.151	Neutral	21.8	55.9	-34.1	Pass
8	0.192	Neutral	32.2	53.9	-21.7	Pass
9	0.214	Neutral	25.6	53.0	-27.4	Pass
10	0.256	Neutral	23.1	51.5	-28.4	Pass
11	0.336	Neutral	28.8	49.3	-20.5	Pass
12	0.384	Neutral	22.9	48.1	-25.2	Pass

Specification limits :

ac power port conducted emission limits (47 CFR 15 Clause 15.107):

Conducted disturbance at the ac power line ports of Class B information technology equipment.

Frequency range MHz	Limits dBμV	
	Quasi-peak	Average
0.15 to 0.5	66 to 56	56 to 46
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 :

(c) When the average limit was met using the peak detector, the EUT was deemed to meet both the average detector and quasi-peak detector limits and measurement with the average detector and quasi-peak detector was not required

	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.				

A7 20 dB Bandwidth and Channel Spacing

Title 47 of the CFR: Part 15 Subpart (c) 15.247(a)(1)(i) requires the measurement of the bandwidth of the transmission between the -20 dB points on the transmitted spectrum. The results of this test determine the limits for channel spacing. The channel separation shall be a minimum of 25 kHz or the 20 dB bandwidth, whichever is the greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The formal measurements are detailed below:

Test Details:	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) 15.247(a)(1)(i)
EUT sample number	S19
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

2441 MHz	FL (MHz)	FH (MHz)	Measured 20 dB Bandwidth (kHz)	Result
	2440.423	2441.560	1137	N/A

Measured Channel Spacing (kHz)	Limit	Result
1000	(25kHz or ≥ 2/3 Measured 20 dB Bandwidth kHz)	Pass

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

A8 Hopping frequencies

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

Test Details:	
Regulation	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(iii)
EUT sample number	S19
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

No. of Hopping Channels	Requirement	Result
79	Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.	Pass

Plots showing the hopping channels are contained in Appendix B

A9 Channel Occupancy

Channel occupancy time was verified using a spectrum analyser in zero span mode, centred on the middle hopping channel frequency (2441MHz), while the EUT was operating in its normal frequency hopping mode. The other channels were then verified to ensure that the channel occupancy was identical for all channels.

Test Details:	
Regulation	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(iii)
EUT sample number	S19
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Dwell Time (Average Channel Occupancy/Retention Time) Calculation:

No. of utilised hopping channels (N) = 79
Measured channel repetition time (T_{rep}) = 1503ms
Measured channel occupancy time (T_{occ}) = 3.51ms
Maximum dwell time limit = 0.4s (400ms)

No. of transmission cycles in specified averaging period =

$$\frac{400 \times \mathrm{N}}{\mathrm{T_{rep}}(ms)} = \text{cycles} \qquad \therefore \frac{400 \times (79 \text{ channels})}{375(ms)} = 85 \text{ cycles}$$

∴ **The Average Channel Occupancy/Retention Time =**

Channel Occupancy Time T_{occ} x No. of transmission cycles in specified averaging period

Average Channel Occupancy Time = 3.51ms x 85 = 298.35ms

Measured Channel Occupancy Time (ms)	Measured Channel Repetition Time (ms)	Calculated Average Channel Occupancy/retention Time (ms)	Average Channel Occupancy Time Limit (ms)	Result
3.51	375	298.35	400	Pass

The calculated Average Channel Occupancy Time (Dwell Time) is less than the 0.4s (400ms) limit.

Plots showing the channel occupancy time are contained in Appendix B of this test report.

A10 Antenna Gain

The antenna gain for the Fractus FR05-S1-N-0-110 used in the EUT is 0.2 dBi max. The data sheet for the antenna is reproduced in Appendix D of this report.

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.

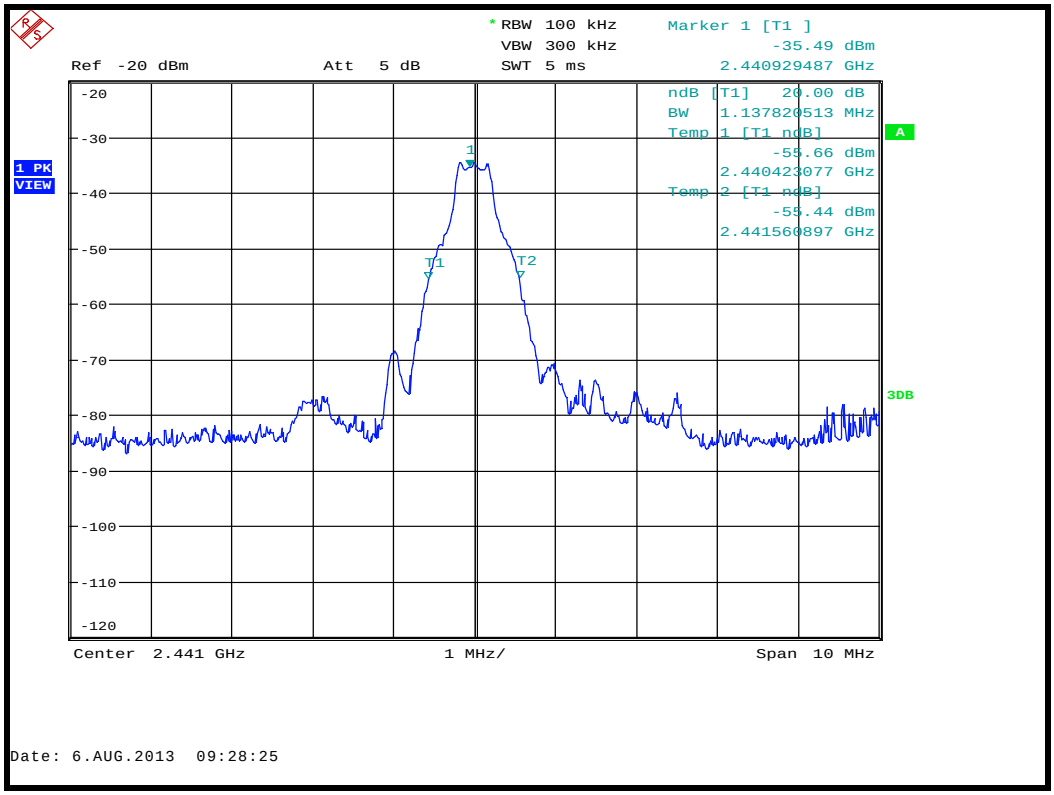
(b) The time and date on the plots do not necessarily equate to the time of the test.

(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.

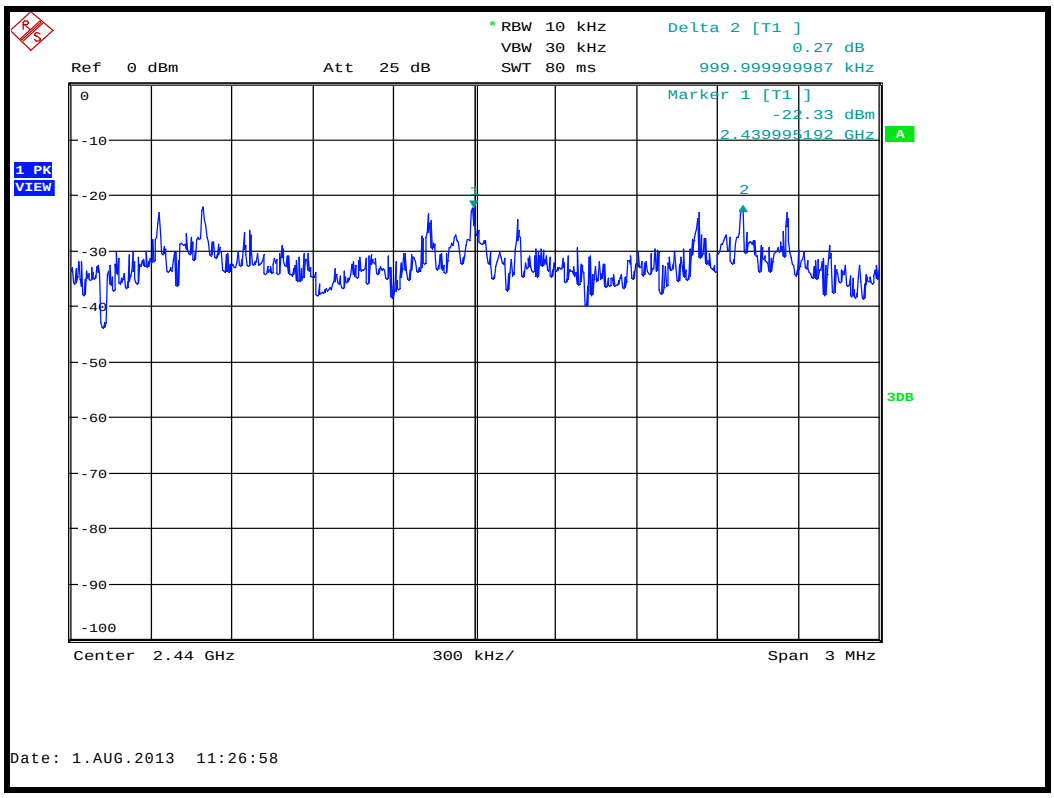
(e) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.

20dB Bandwidth Plot



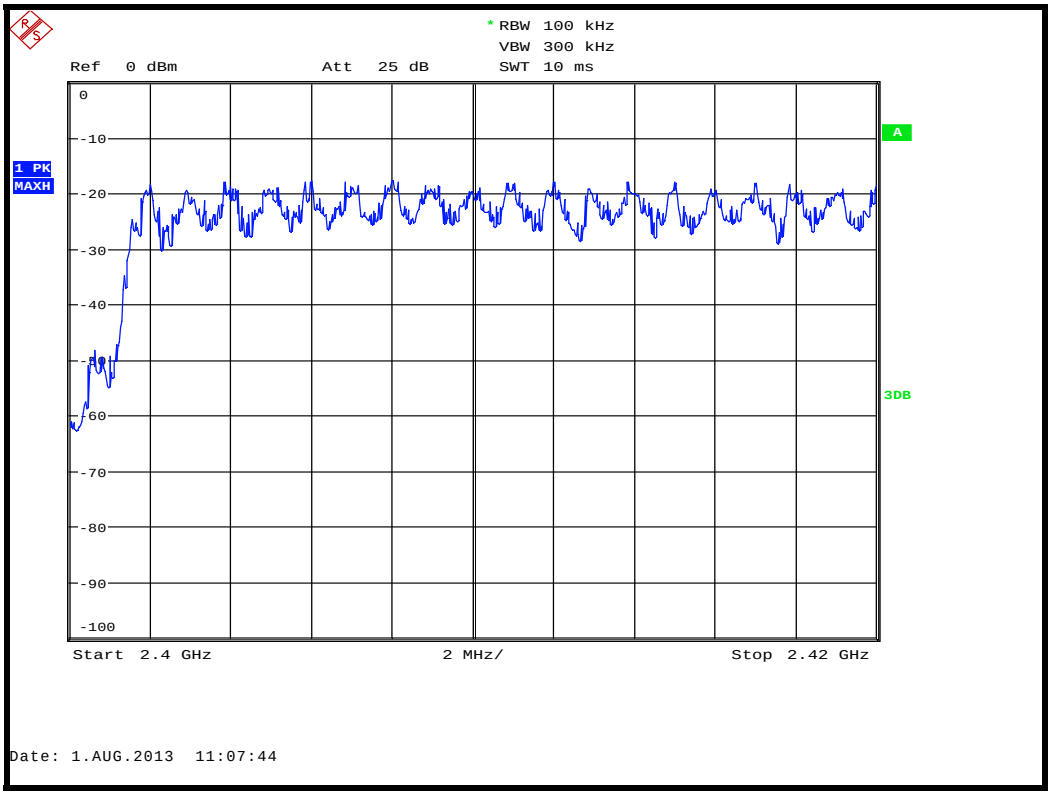
20dB Bandwidth

Channel Spacing Plot

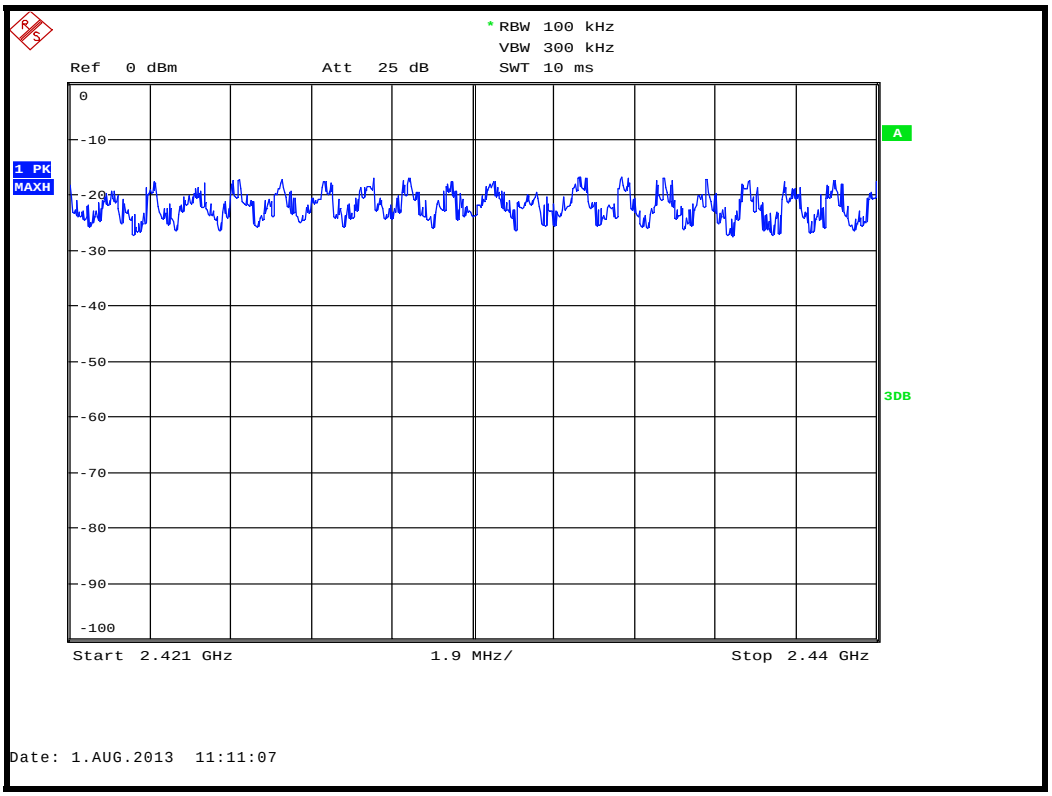


Channel Spacing

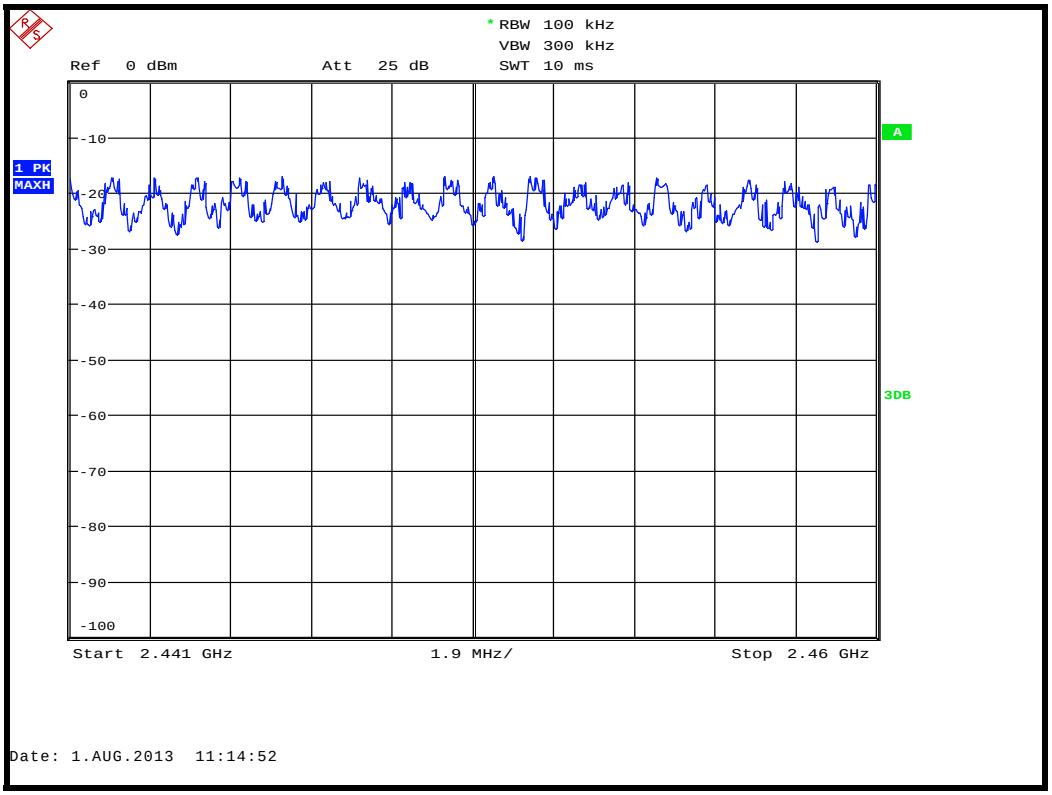
Hopping Channels Plots



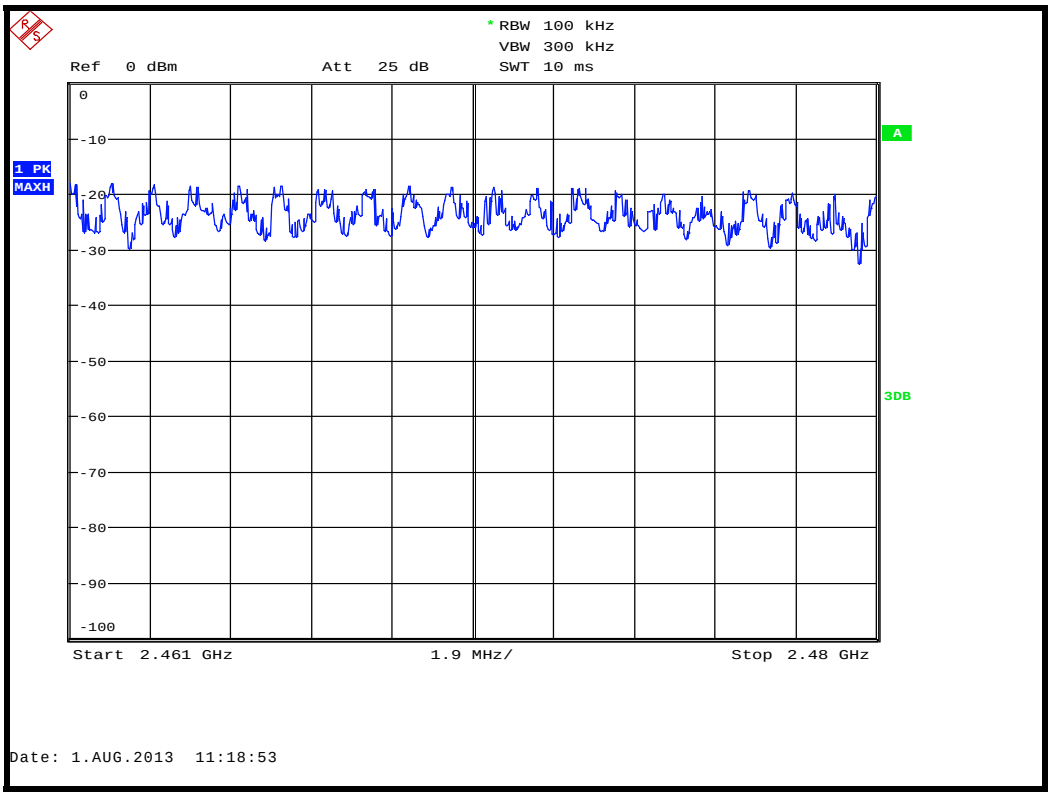
Channels 0-19:



Channels 20-39:

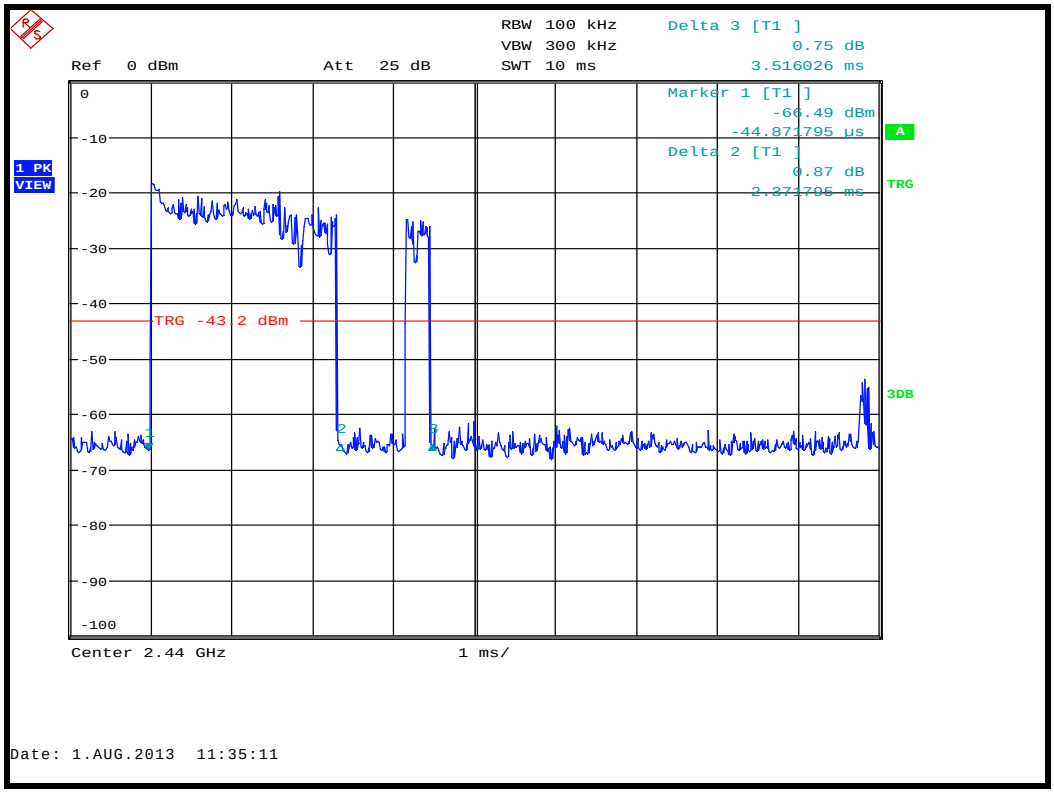


Channels 40-59:



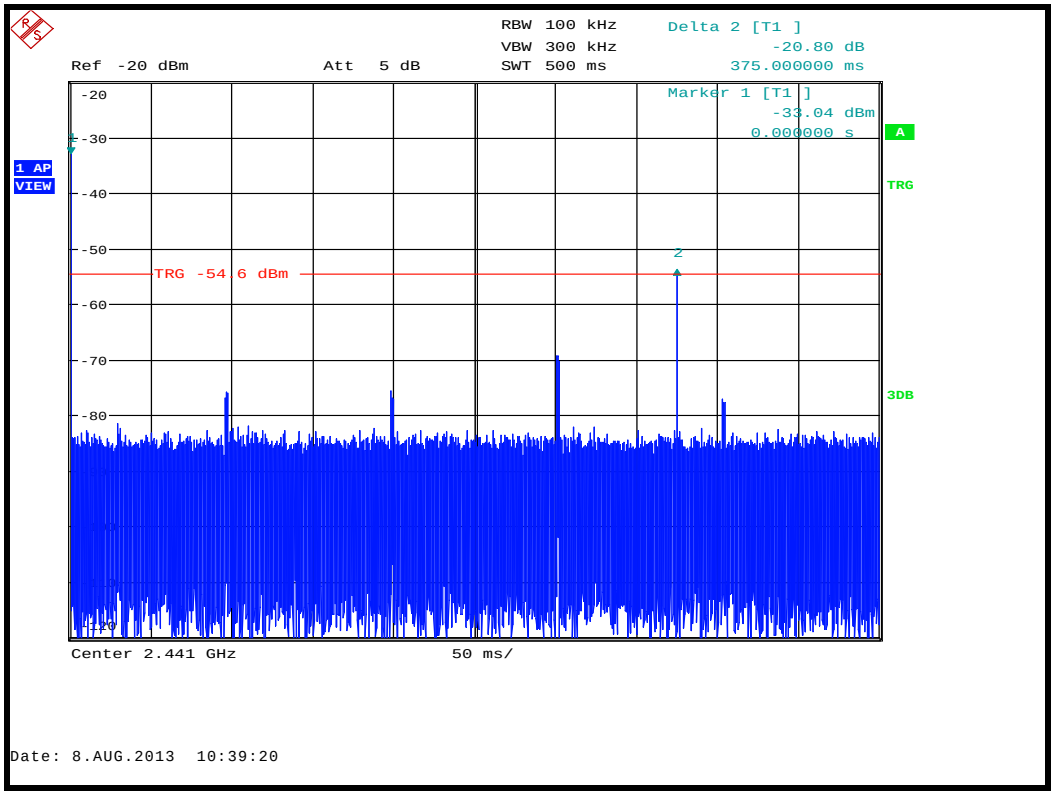
Channels 60-78:

Channel Occupancy Time Plot



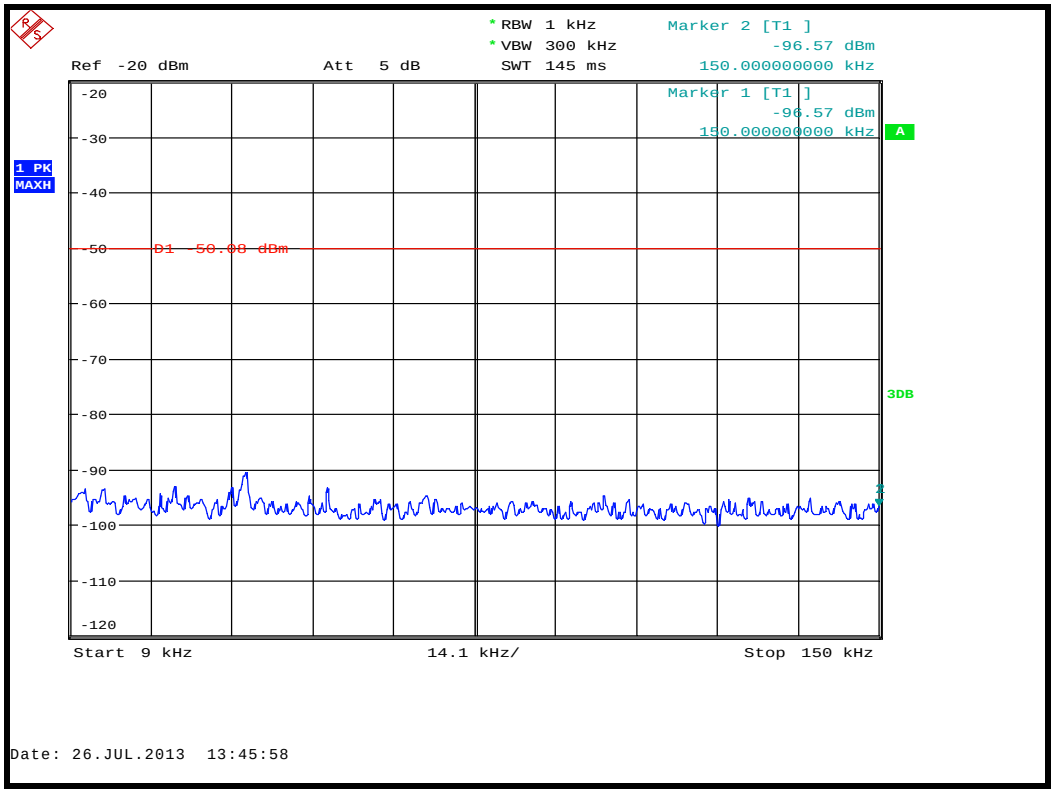
Channel Occupancy Time

Channel Repetition Time Plot

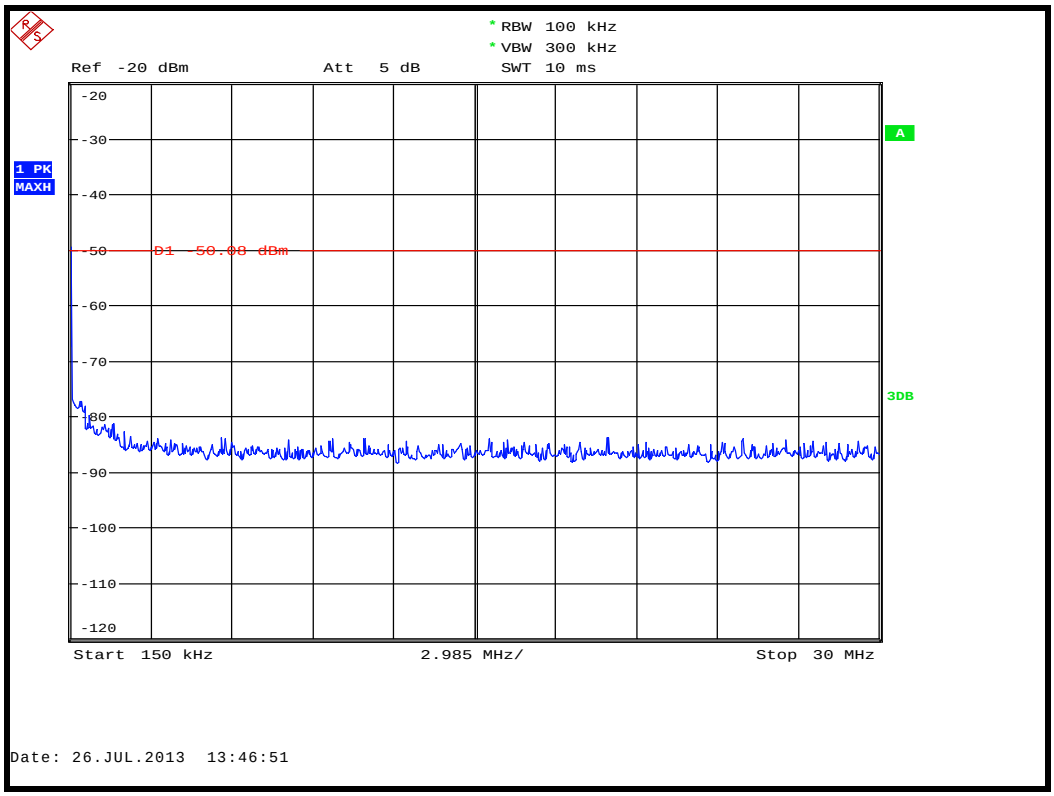


Repetition time

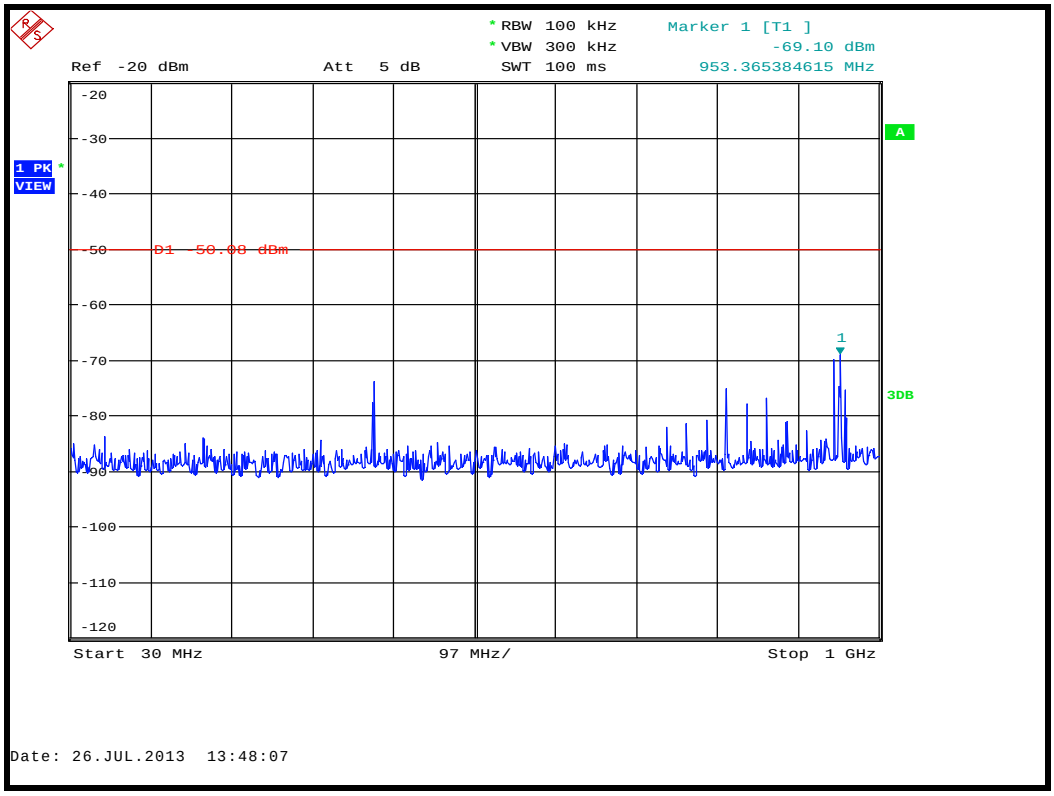
Conducted Emissions Plots



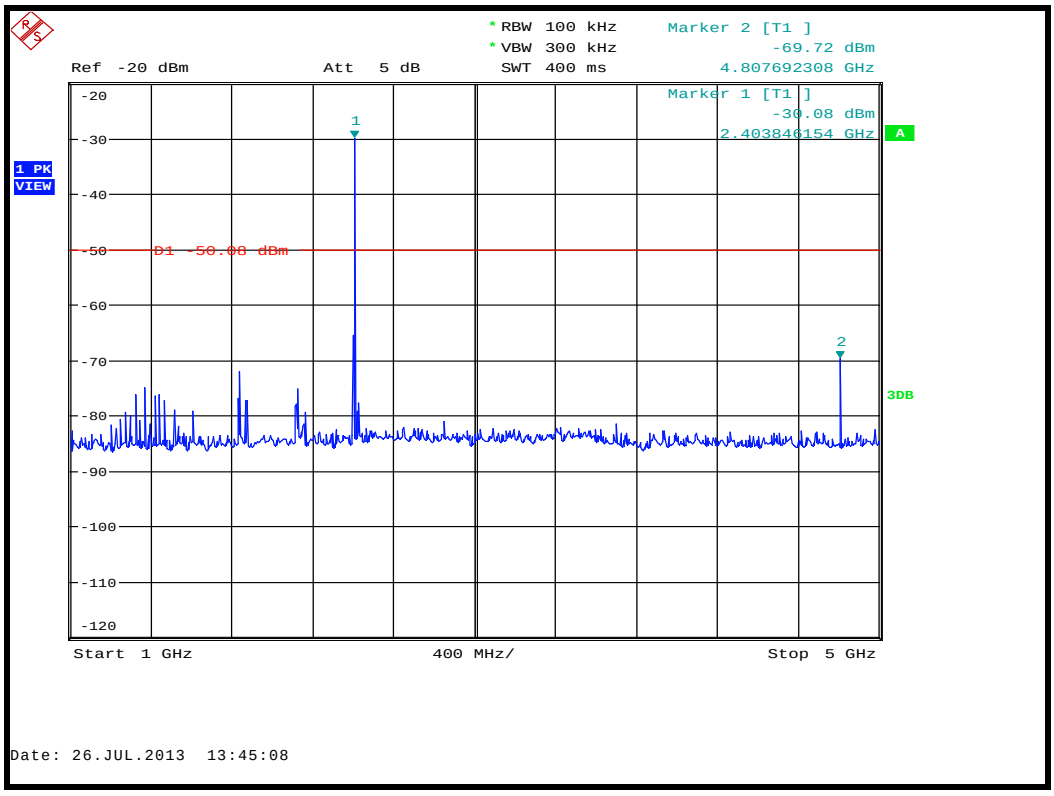
Conducted Emissions: 9kHz to 150kHz Bottom Channel 0 2402 MHz



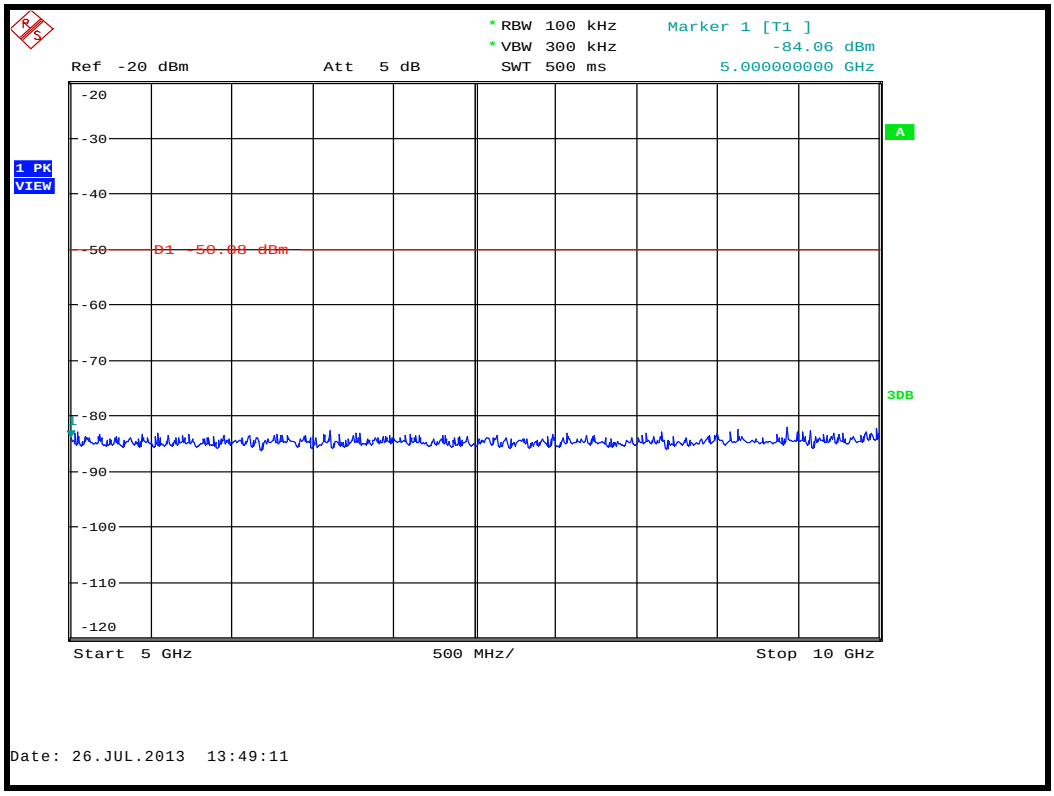
Conducted Emissions: 150kHz to 30MHz Bottom Channel 0 2402 MHz



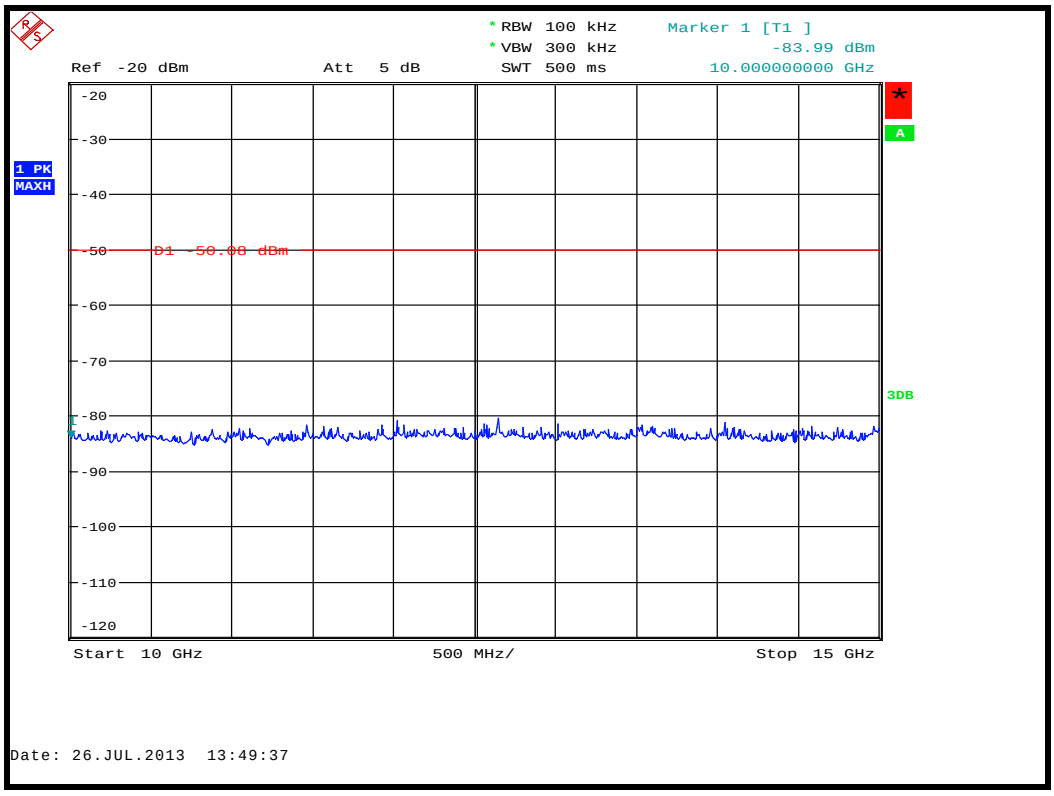
Conducted Emissions: 30MHz to 1GHz Bottom Channel 0 2402 MHz



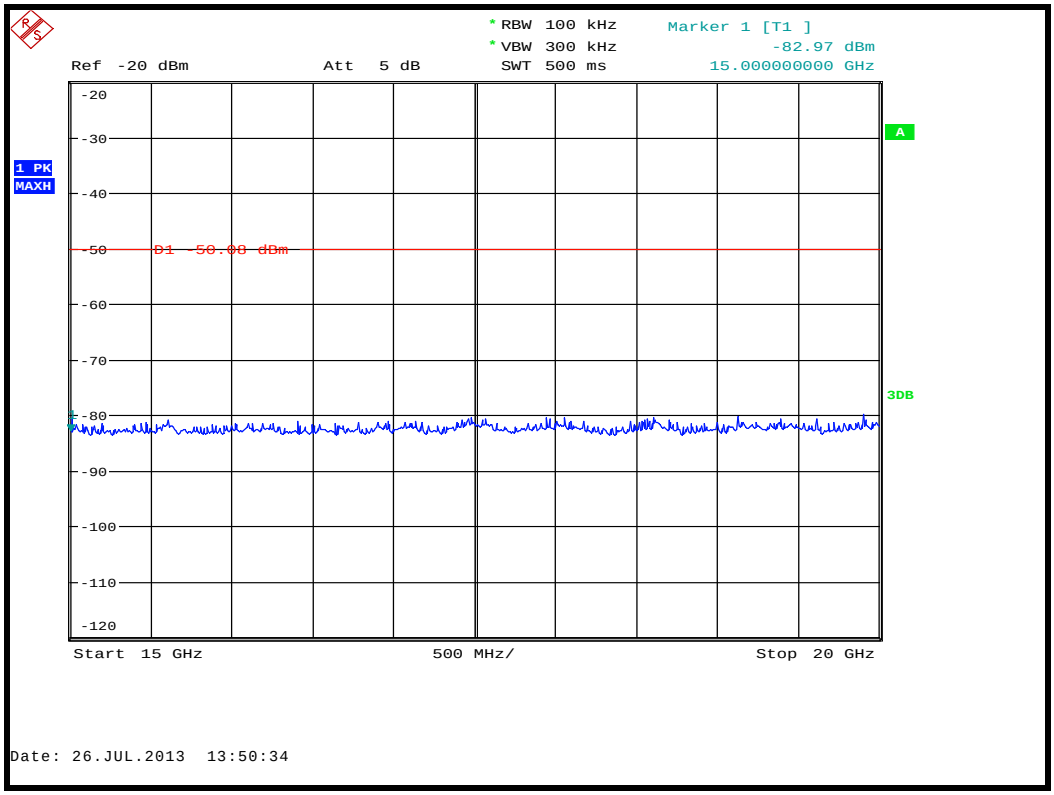
Conducted Emissions: 1GHz to 5GHz Bottom Channel 0 2402 MHz



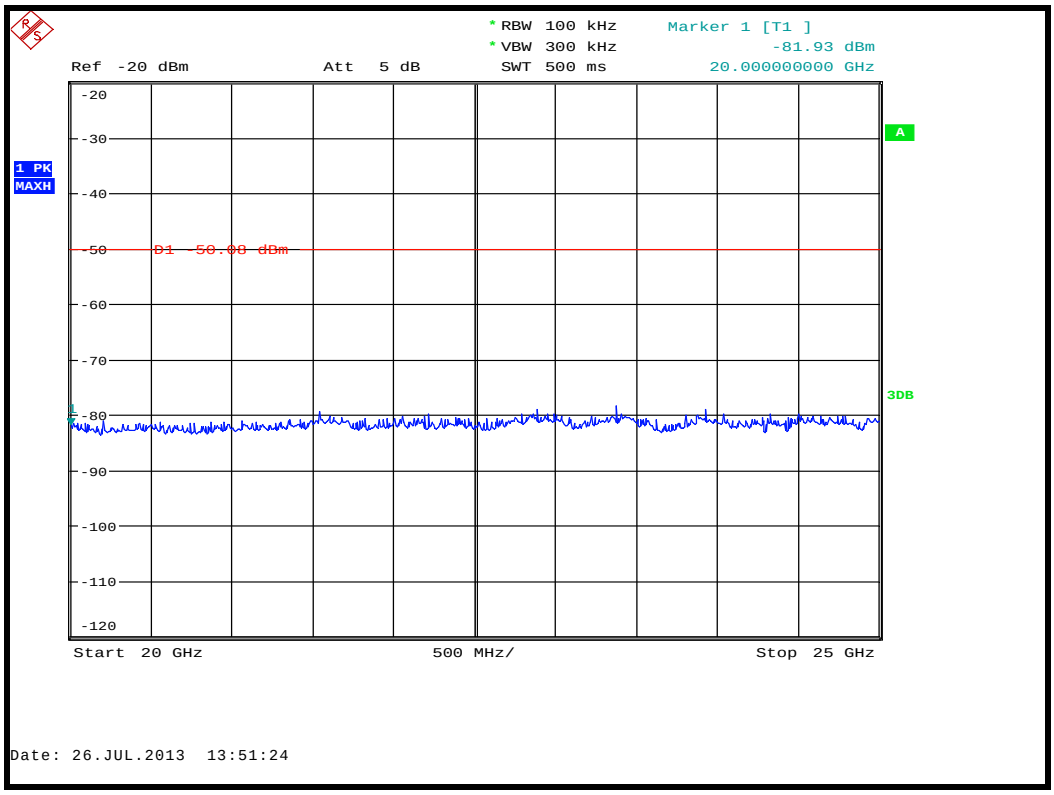
Conducted Emissions: 5GHz to 10GHz Bottom Channel 0 2402 MHz



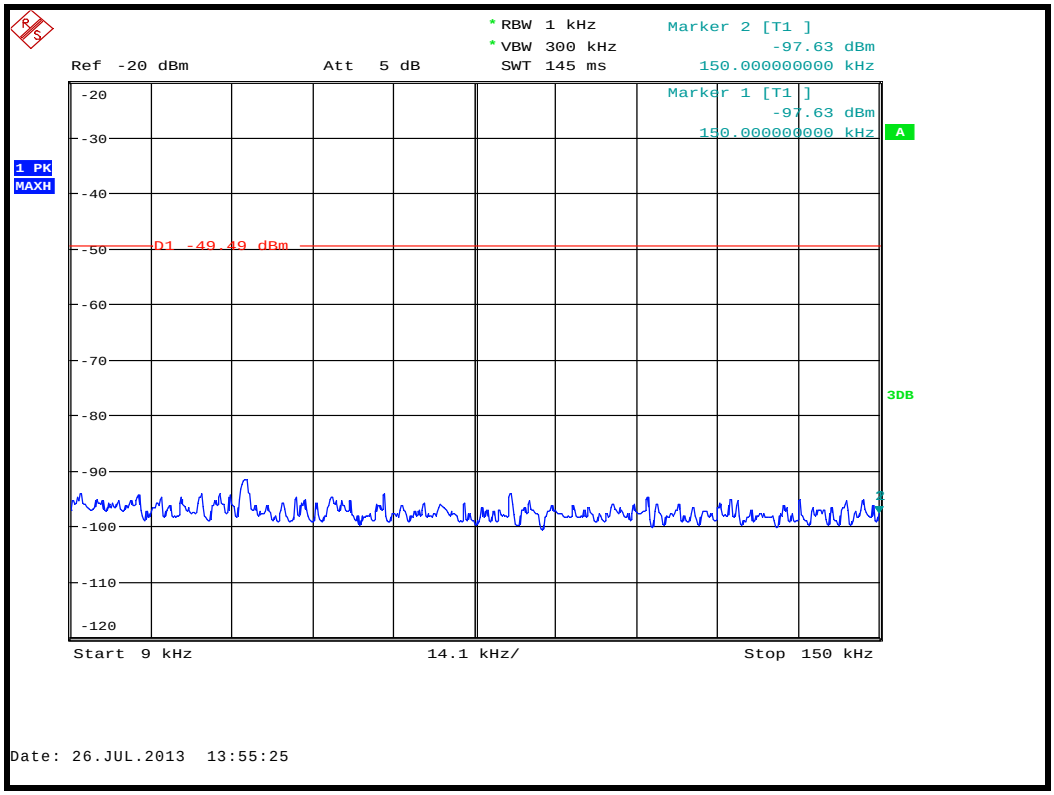
Conducted Emissions: 10 GHz to 15GHz Bottom Channel 0 2402 MHz



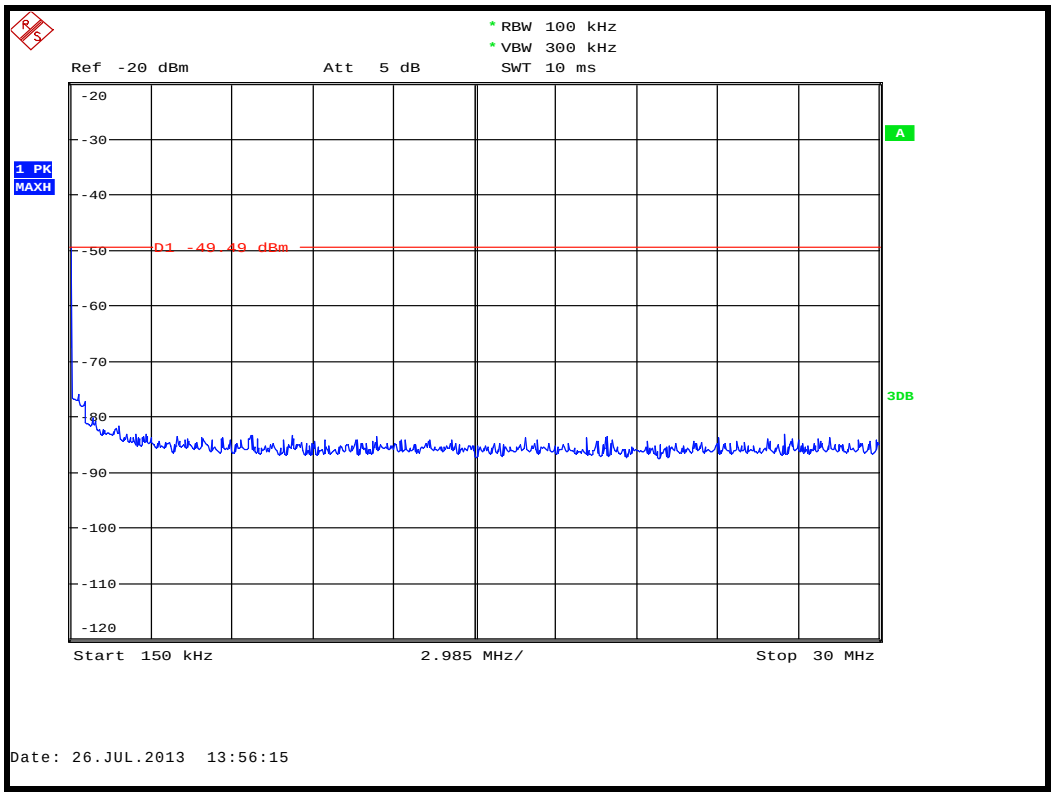
Conducted Emissions: 15GHz to 20GHz Bottom Channel 0 2402 MHz



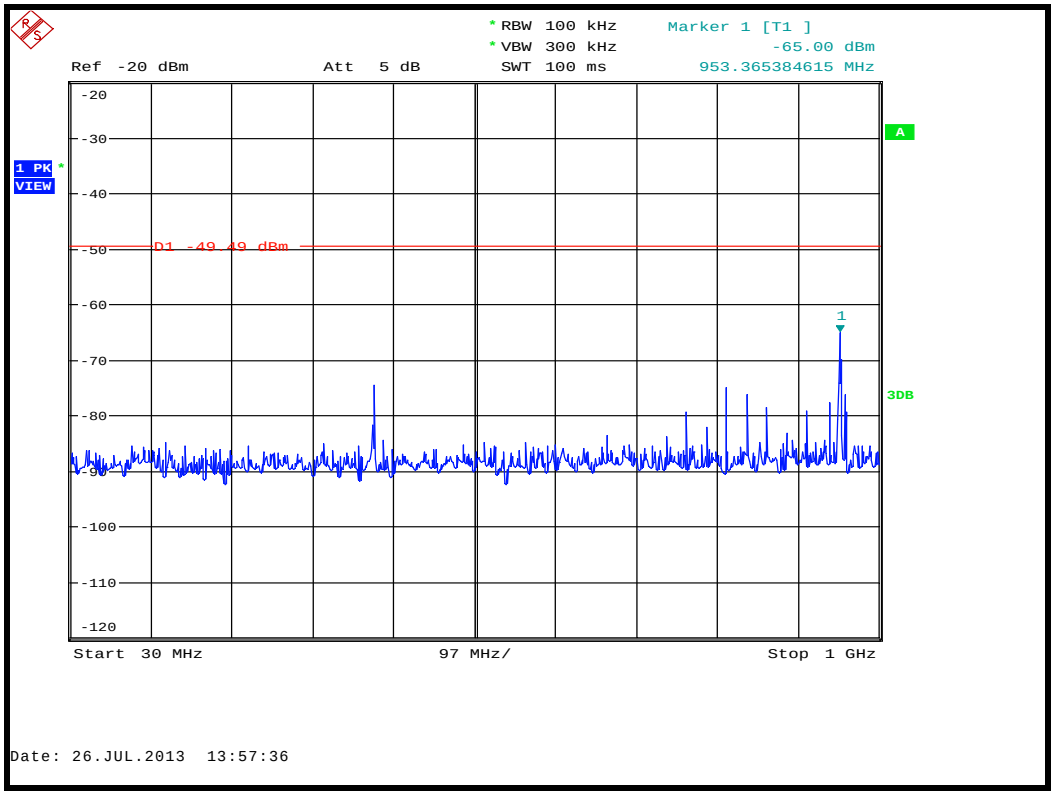
Conducted Emissions: 20GHz to 25GHz Bottom Channel 0 2402 MHz



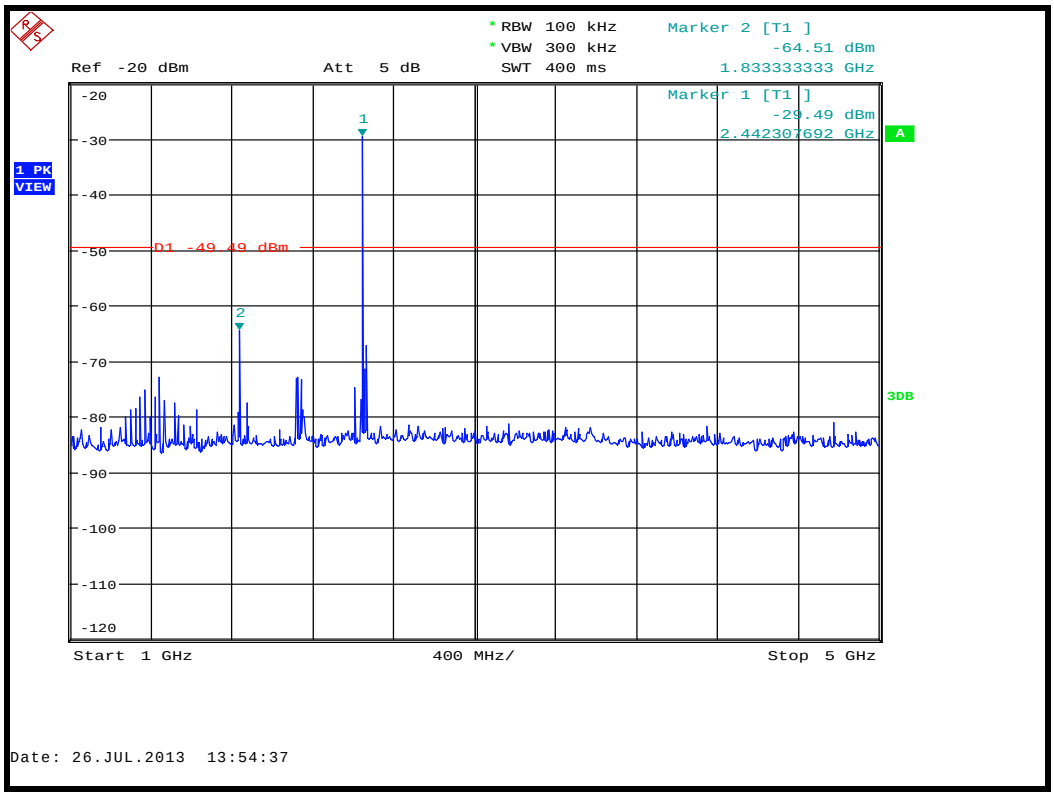
Conducted Emissions: 9kHz to 150kHz Middle Channel 39 2441MHz



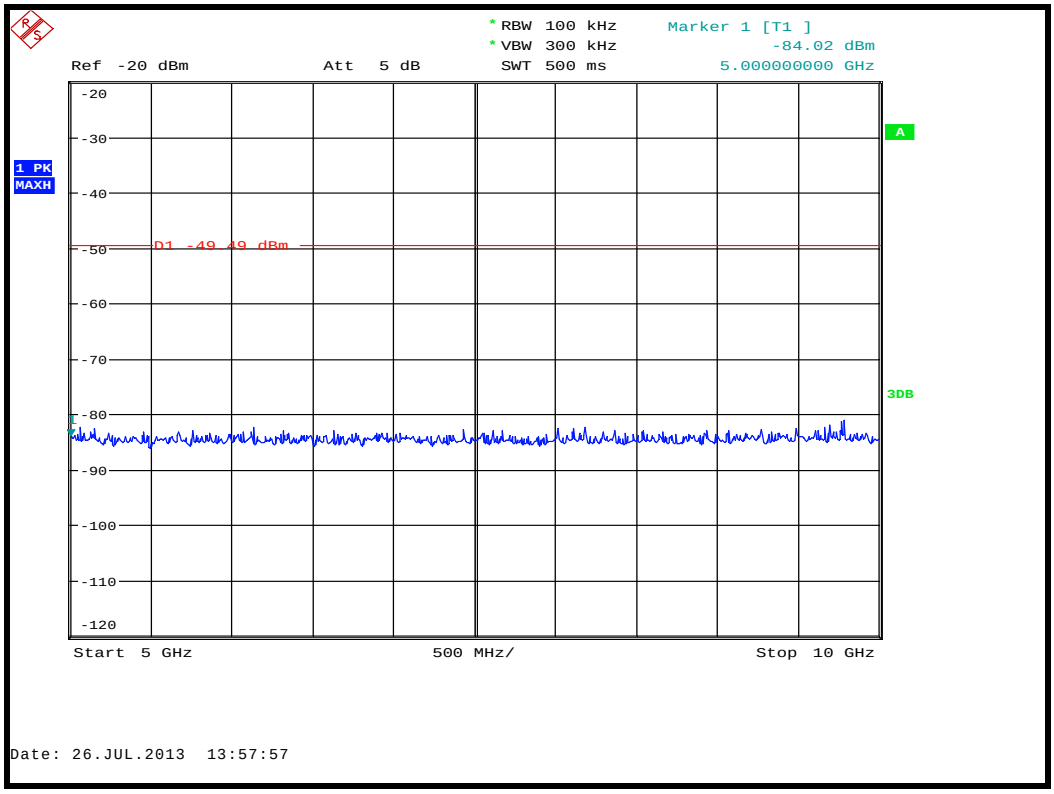
Conducted Emissions: 150kHz to 30MHz Middle Channel 39 2441MHz



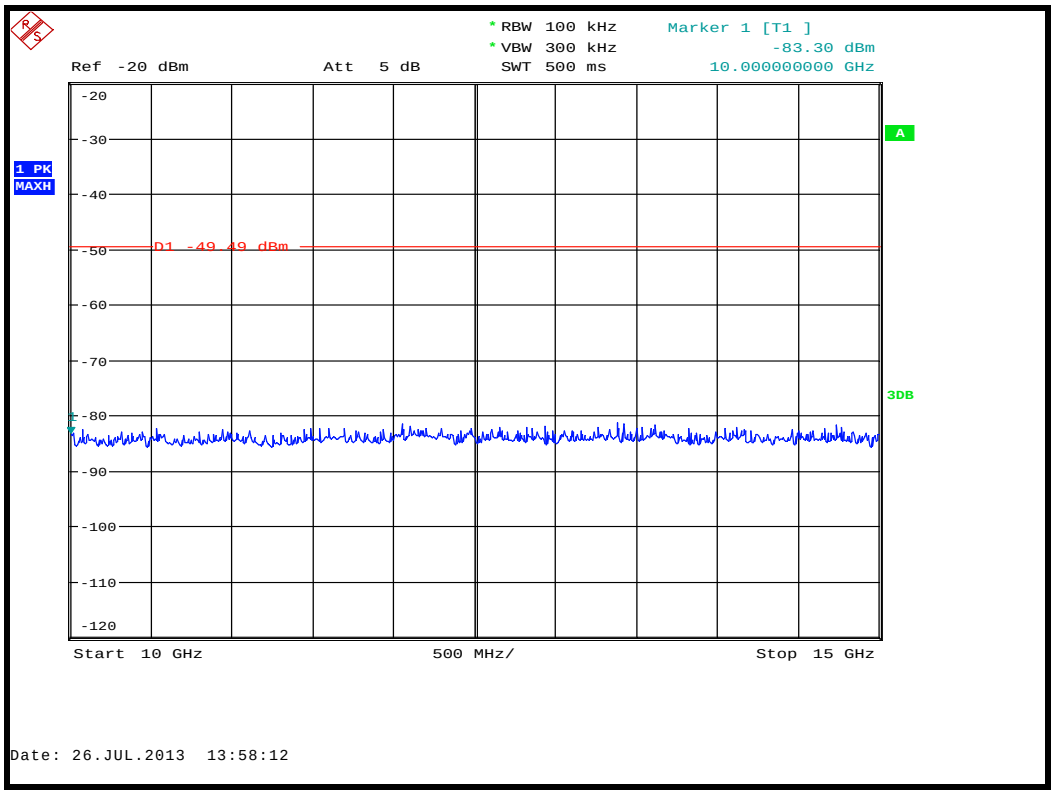
Conducted Emissions: 30MHz to 1GHz Middle Channel 39 2441MHz



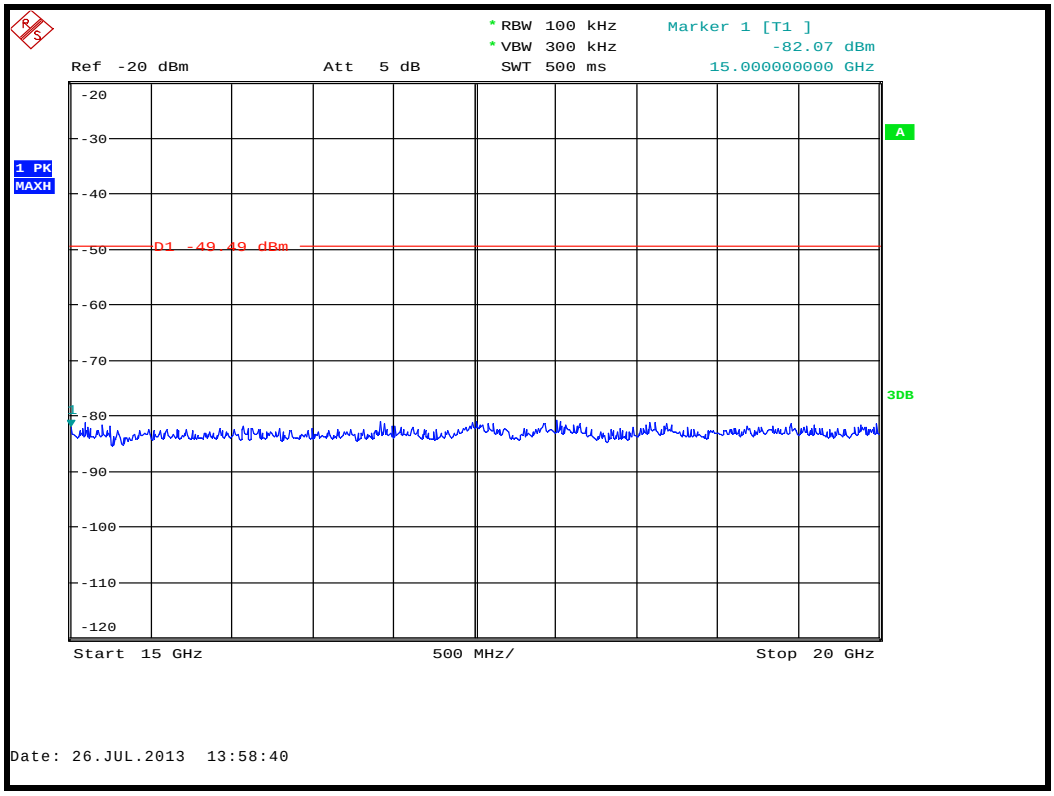
Conducted Emissions: 1GHz to 5GHz Middle Channel 39 2441MHz



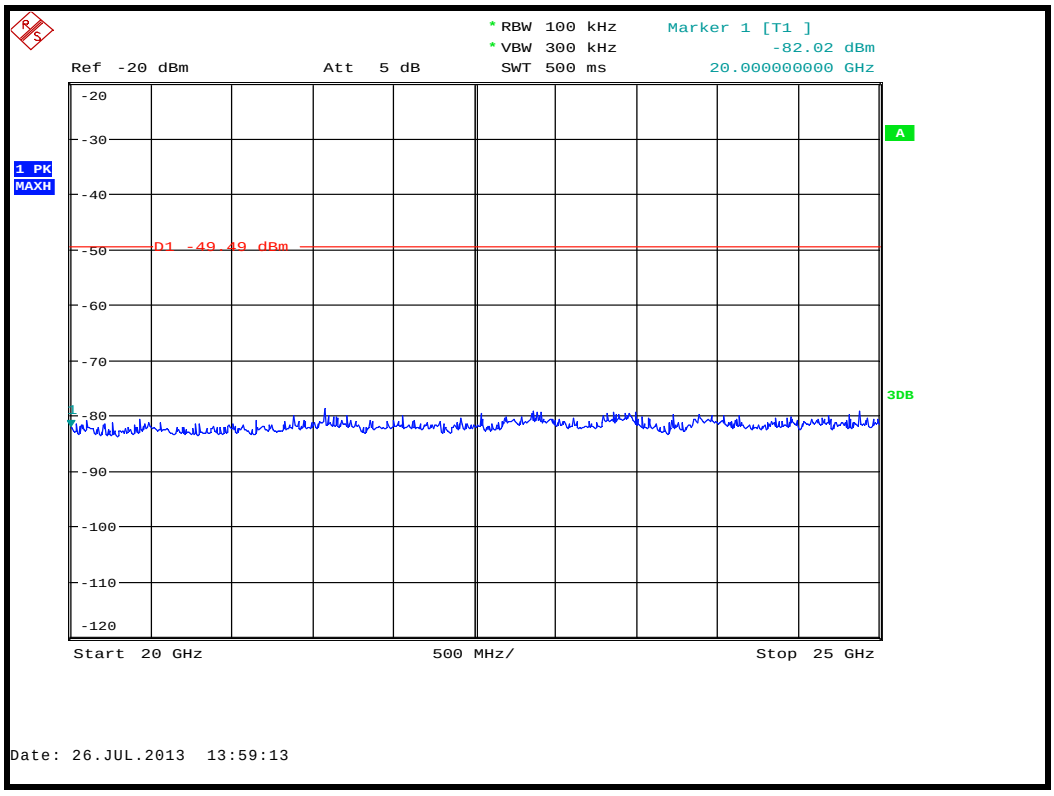
Conducted Emissions: 5GHz to 10GHz Middle Channel 39 2441MHz



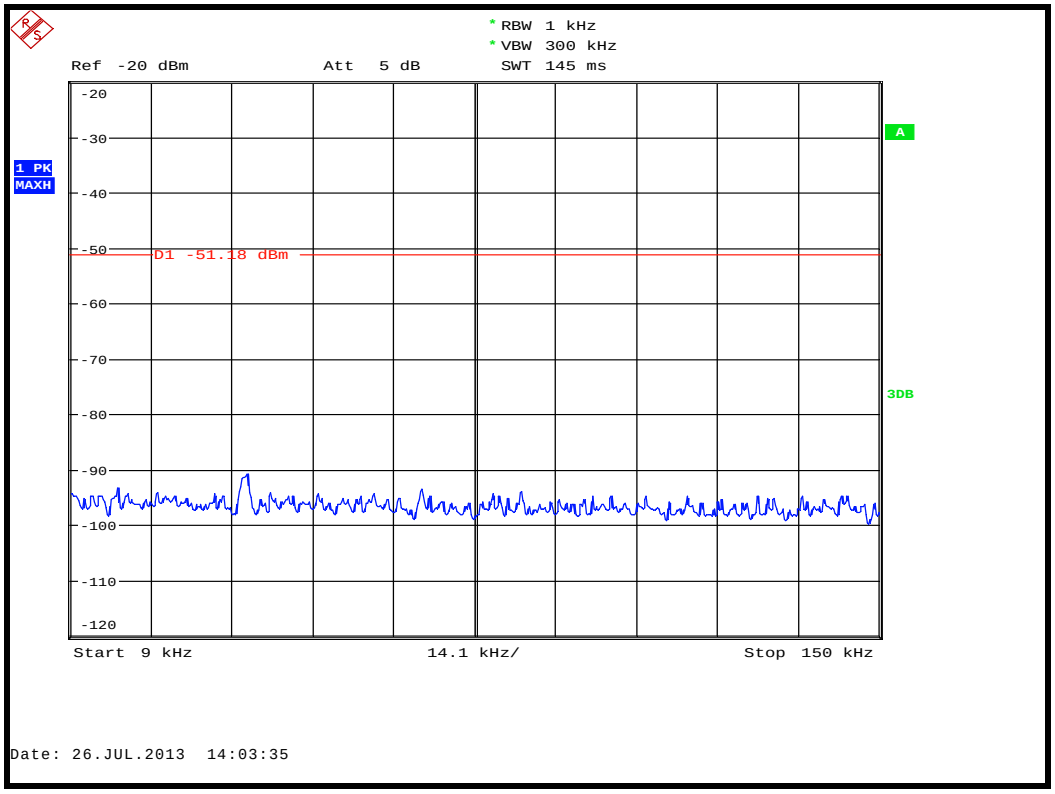
Conducted Emissions: 10GHz to 15GHz Middle Channel 39 2441MHz



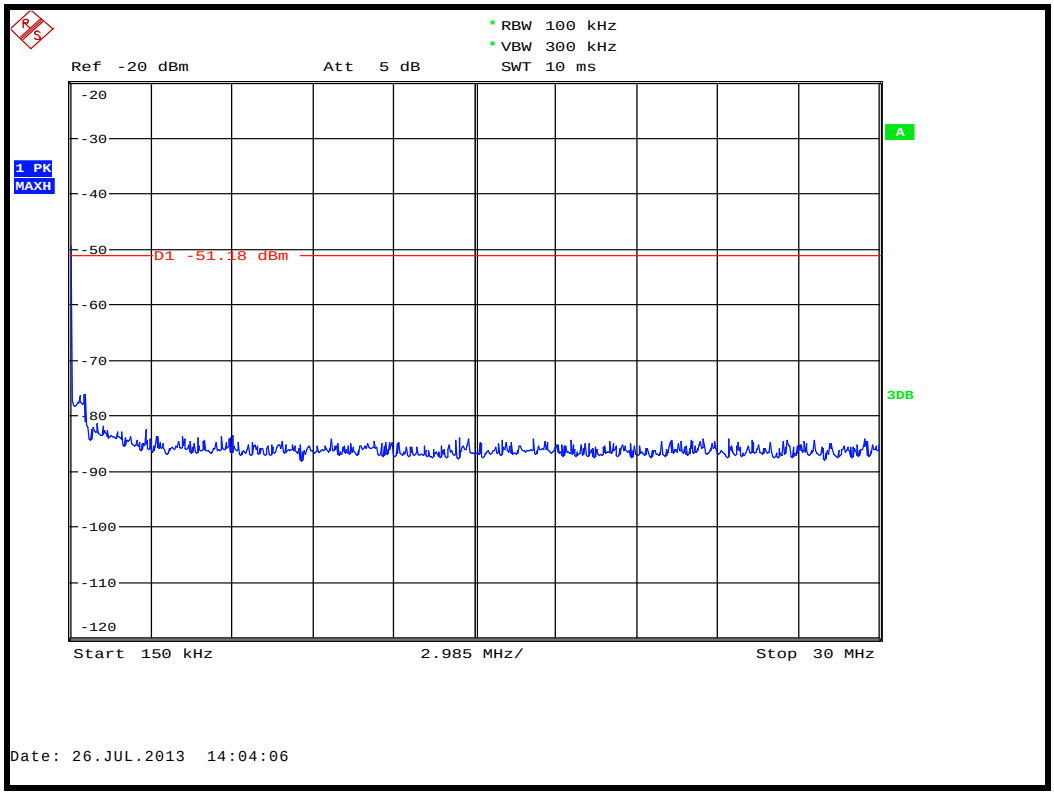
Conducted Emissions: 15GHz to 20GHz Middle Channel 39 2441MHz



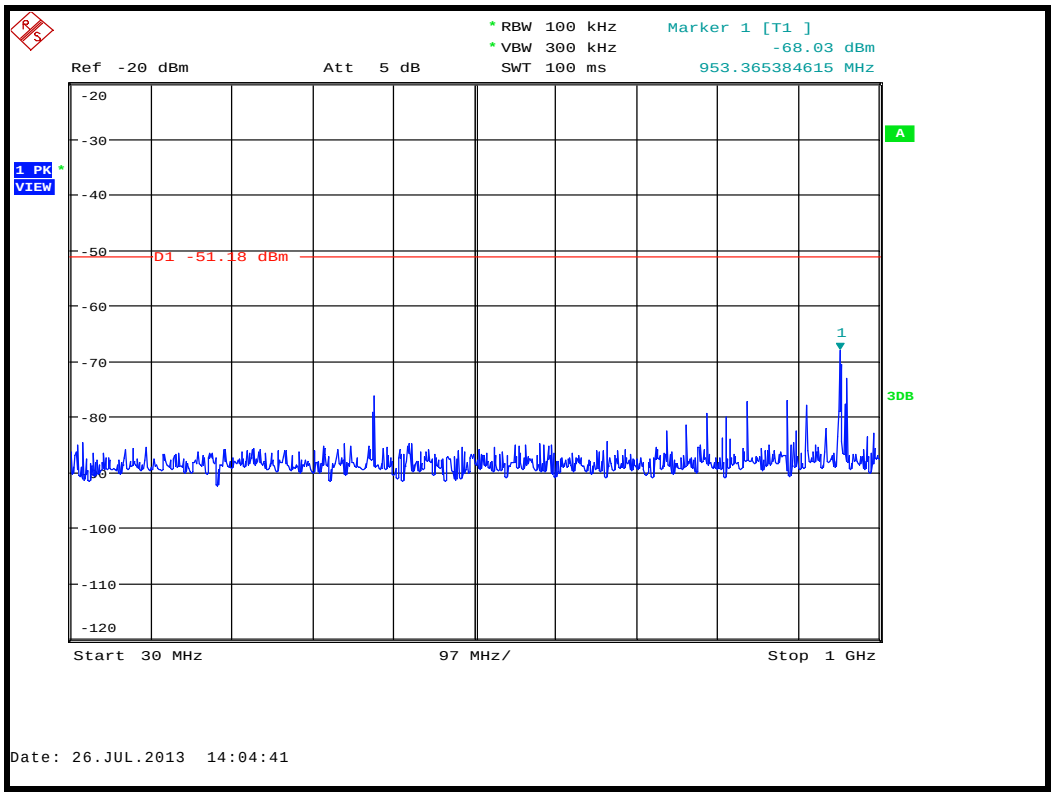
Conducted Emissions: 20GHz to 25 GHz Middle Channel 39 2441MHz



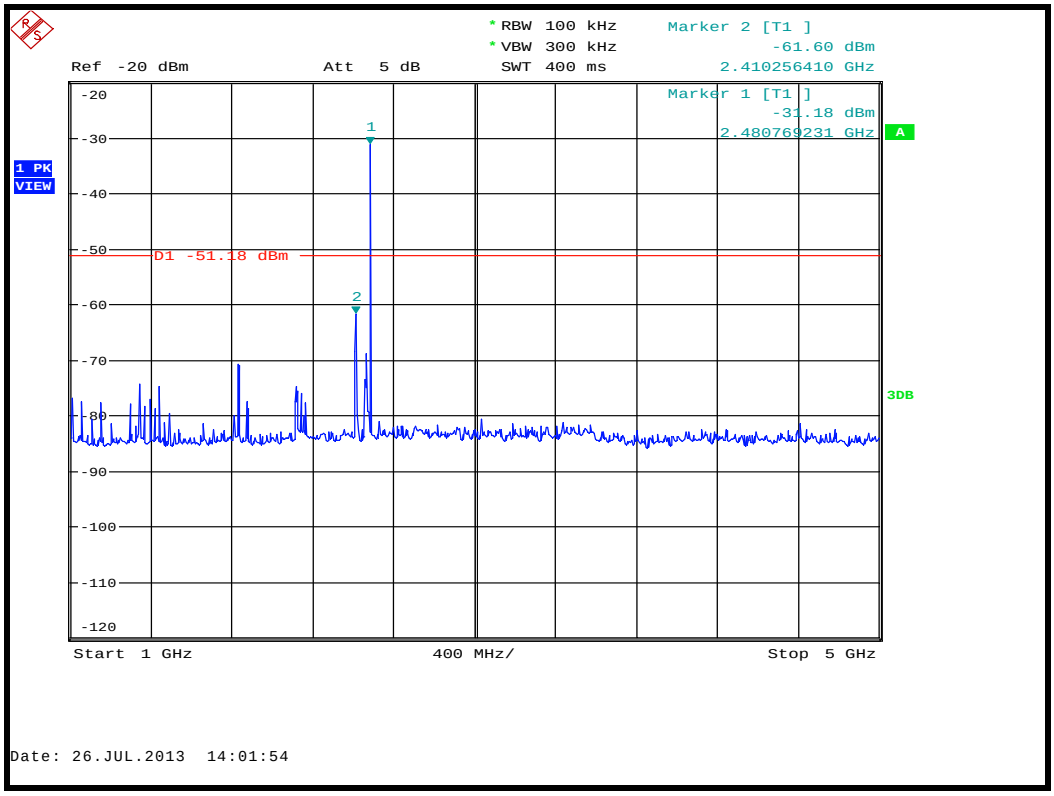
Conducted Emissions: 9kHz to 150kHz Top Channel 39 2441MHz



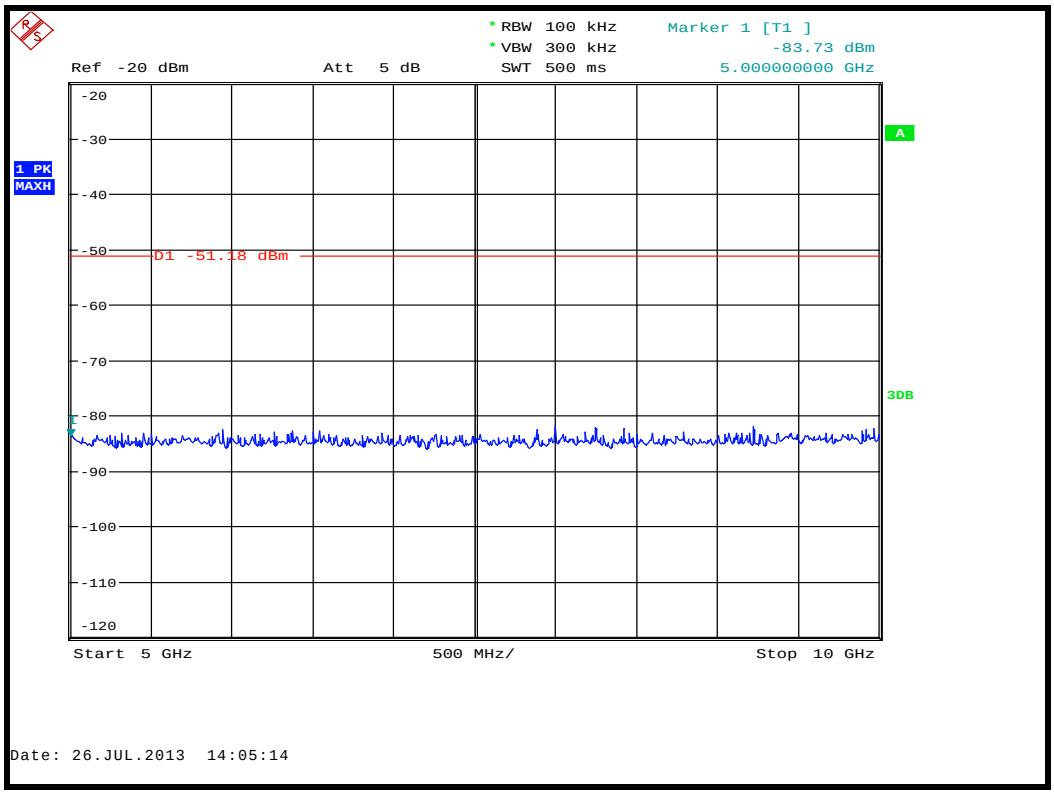
Conducted Emissions: 150kHz to 30MHz Top Channel 78 2480MHz



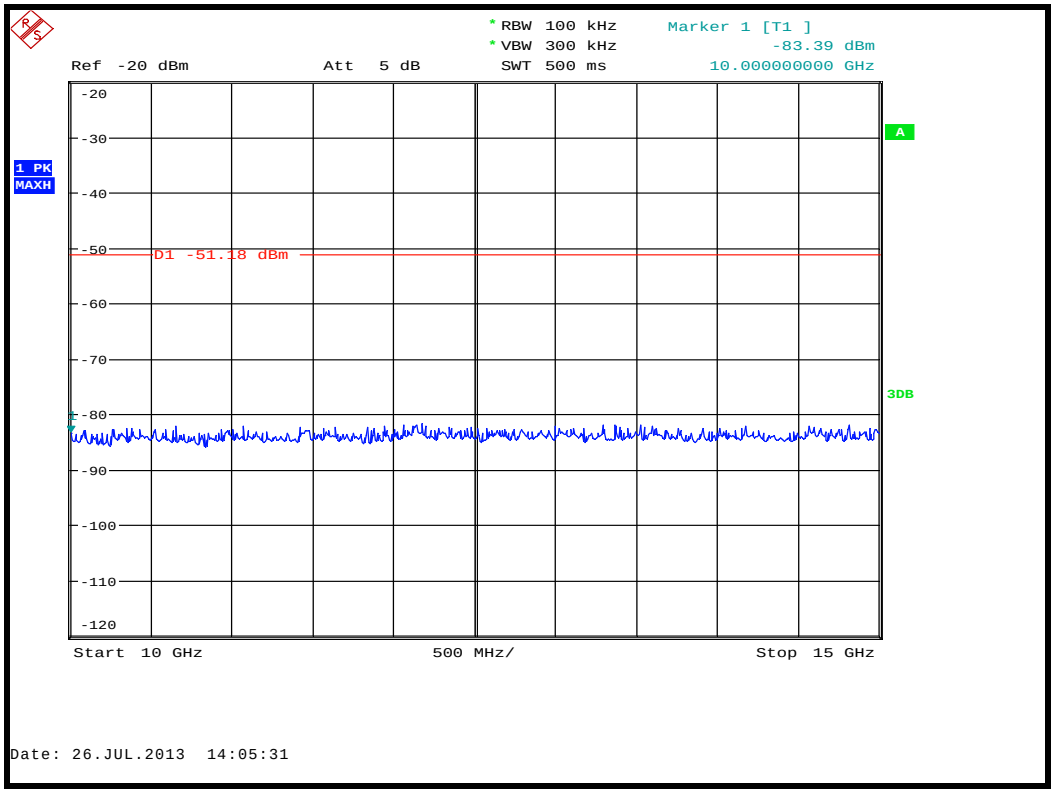
Conducted Emissions: 30MHz to 1GHz Top Channel 78 2480MHz



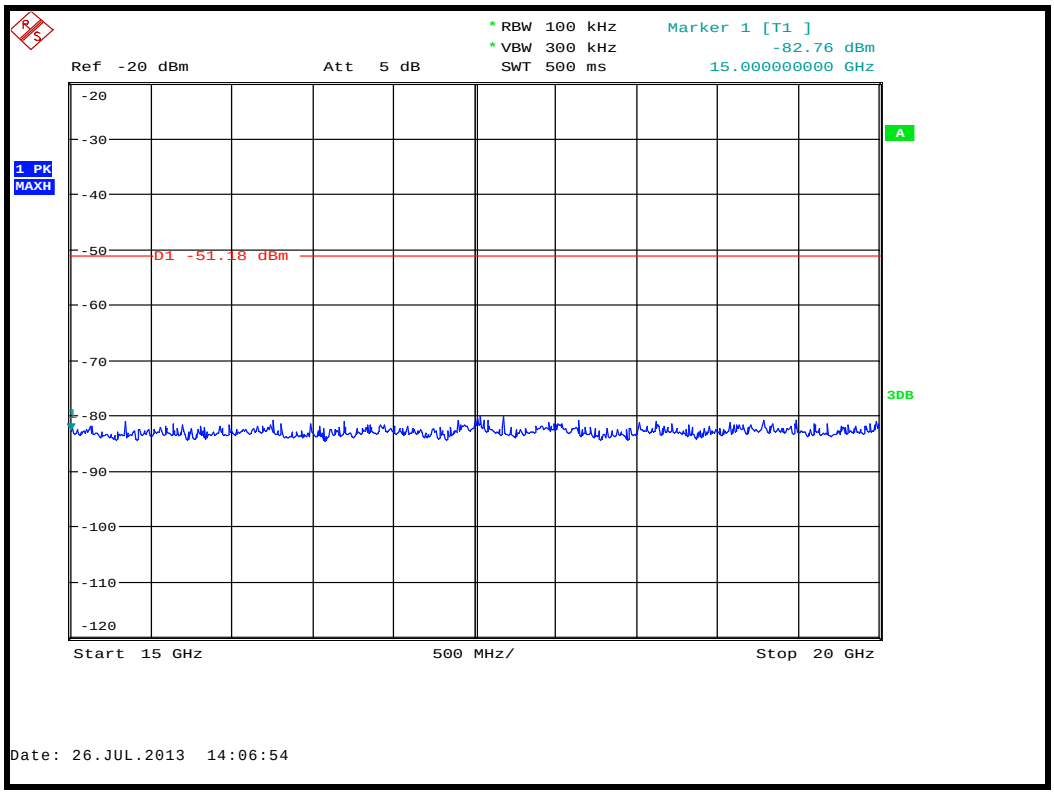
Conducted Emissions: 1GHz to 5GHz Top Channel 78 2480MHz



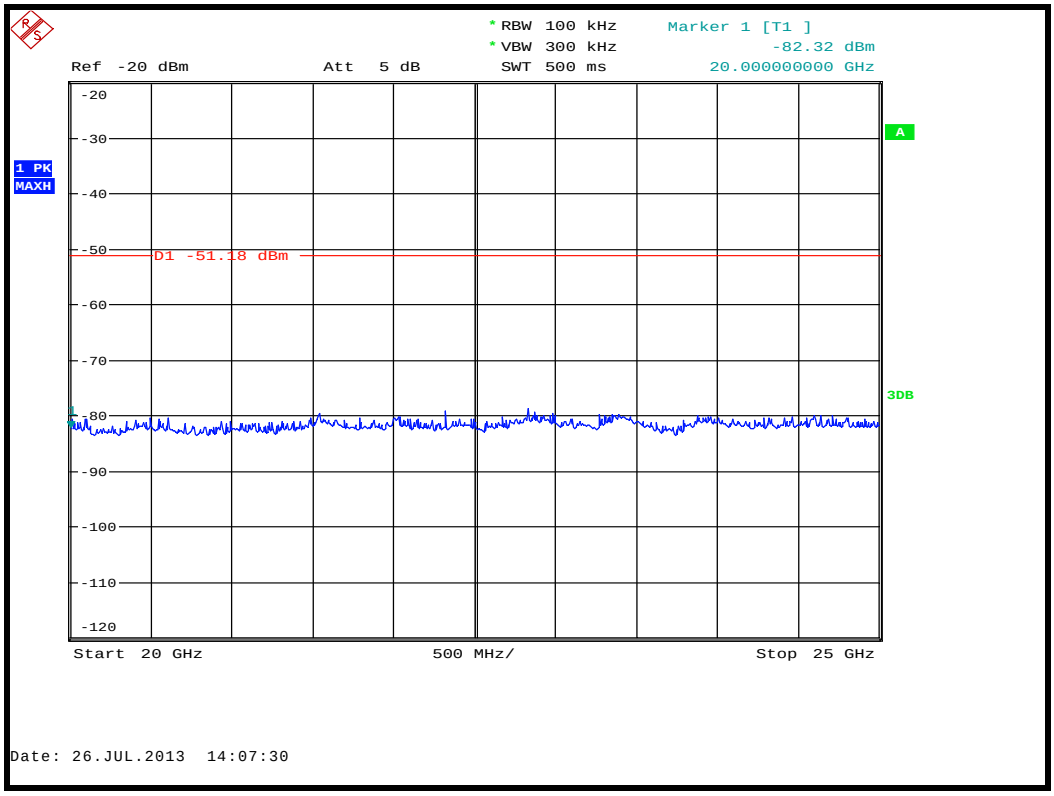
Conducted Emissions: 5GHz to 10GHz Top Channel 78 2480MHz



Conducted Emissions: 10GHz to 15GHz Top Channel 78 2480MHz

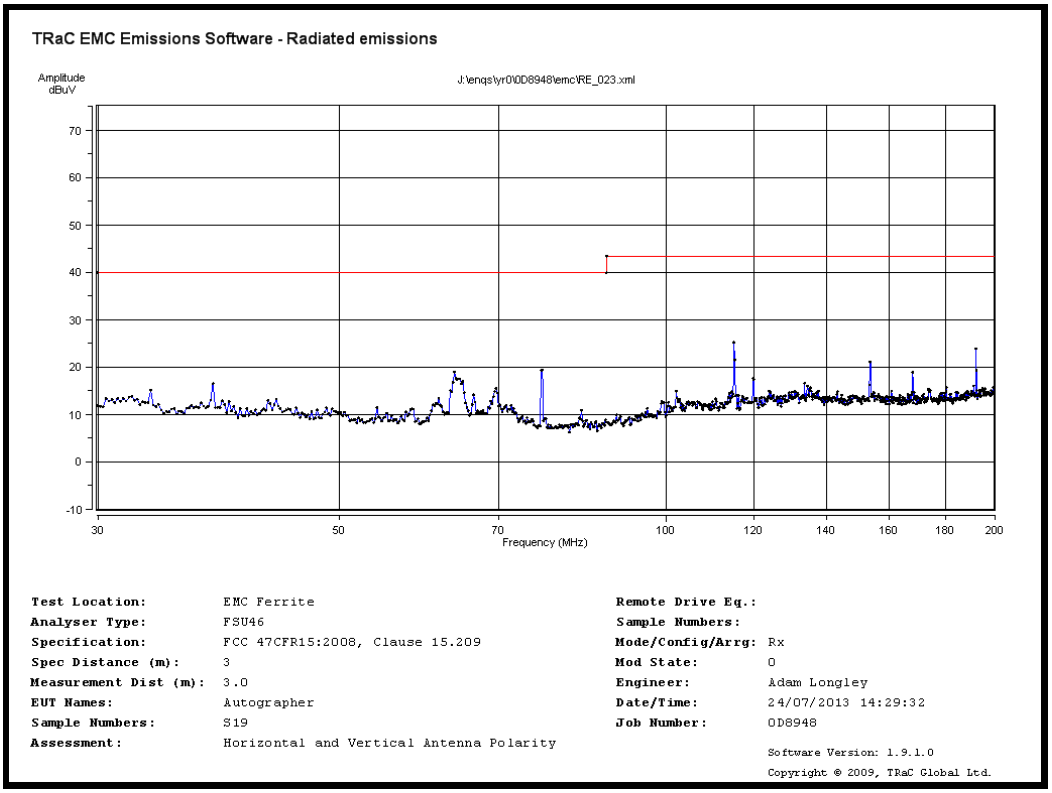


Conducted Emissions: 15GHz to 20GHz Top Channel 78 2480MHz

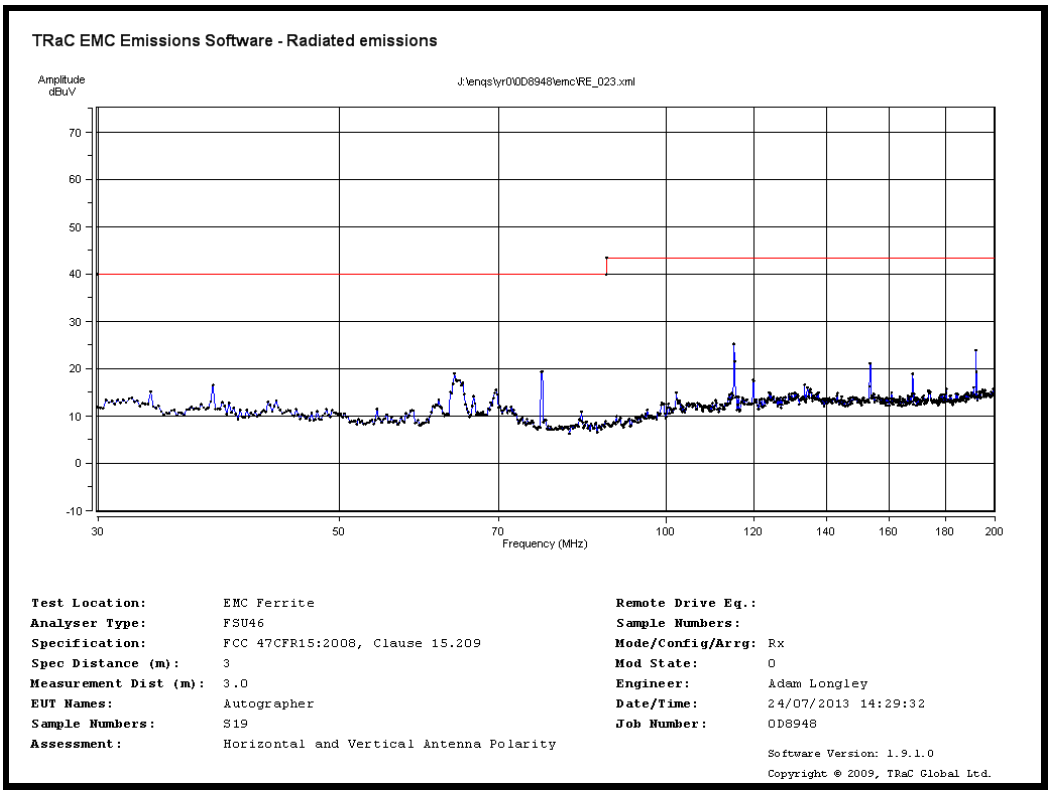


Conducted Emissions: 20GHz to 25GHz Top Channel 78 2480MHz

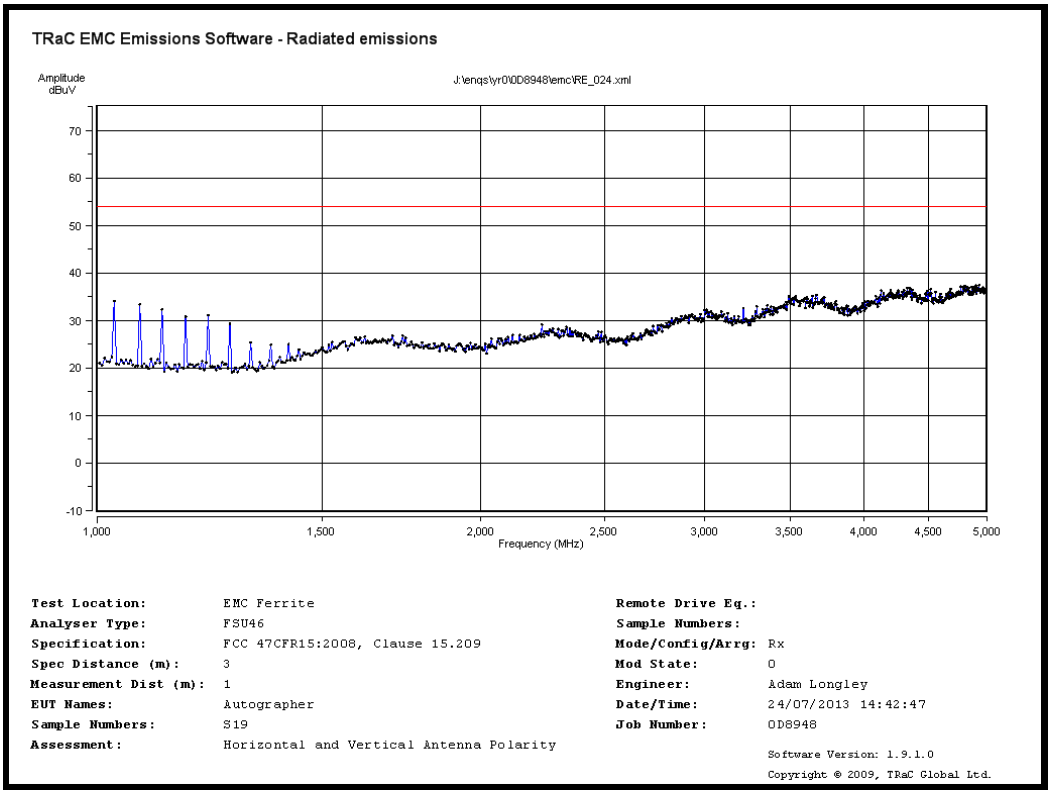
Preview Radiated Spurious emissions/receive mode (15.109)



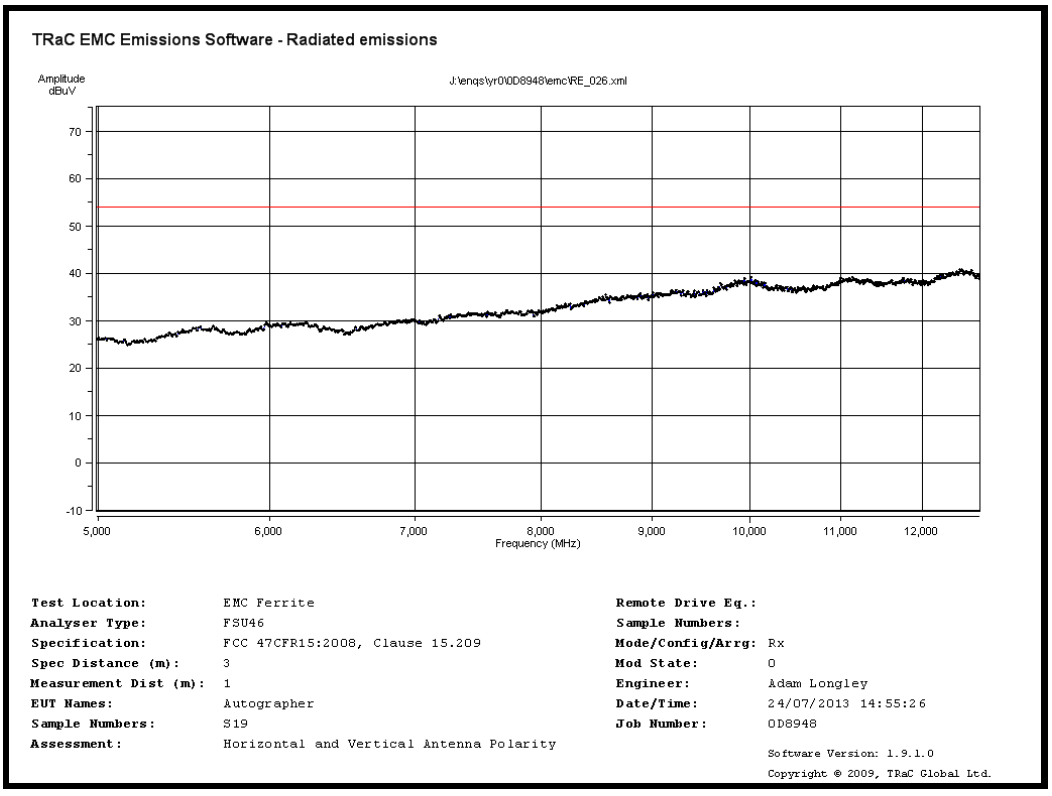
Radiated RX Mode Emissions (15.109)



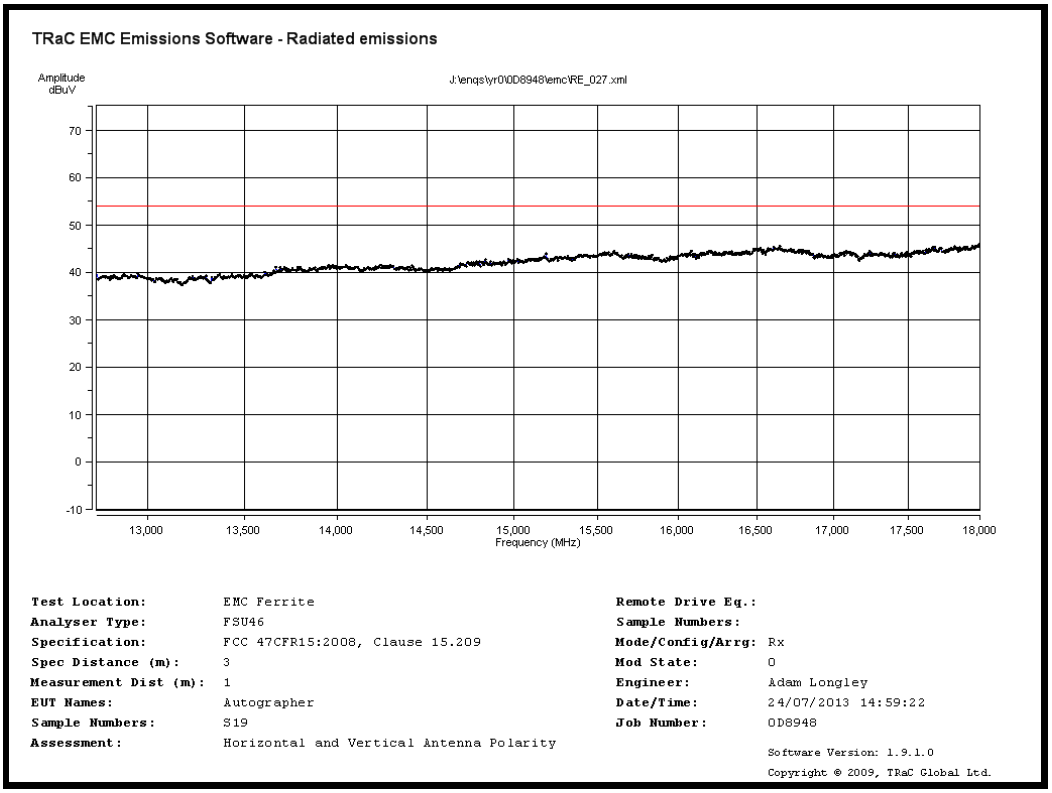
Radiated RX Mode Emissions (15.109)



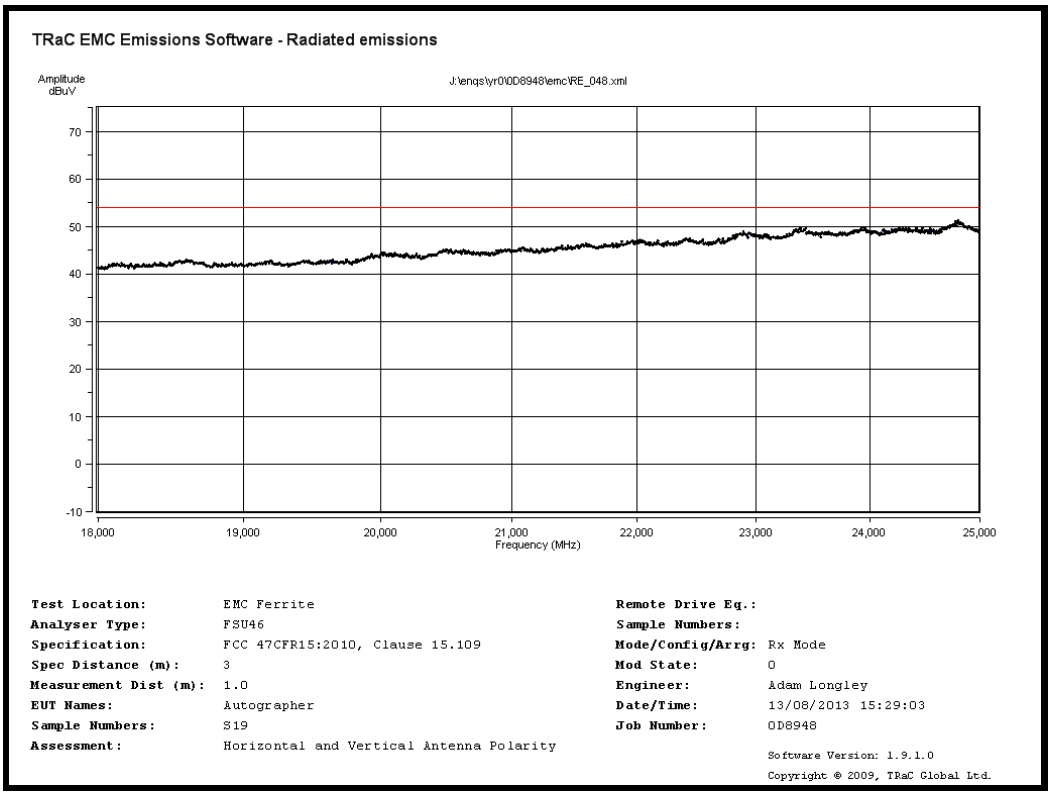
Radiated RX Mode Emissions (15.109)



Radiated RX Mode Emissions (15.109)

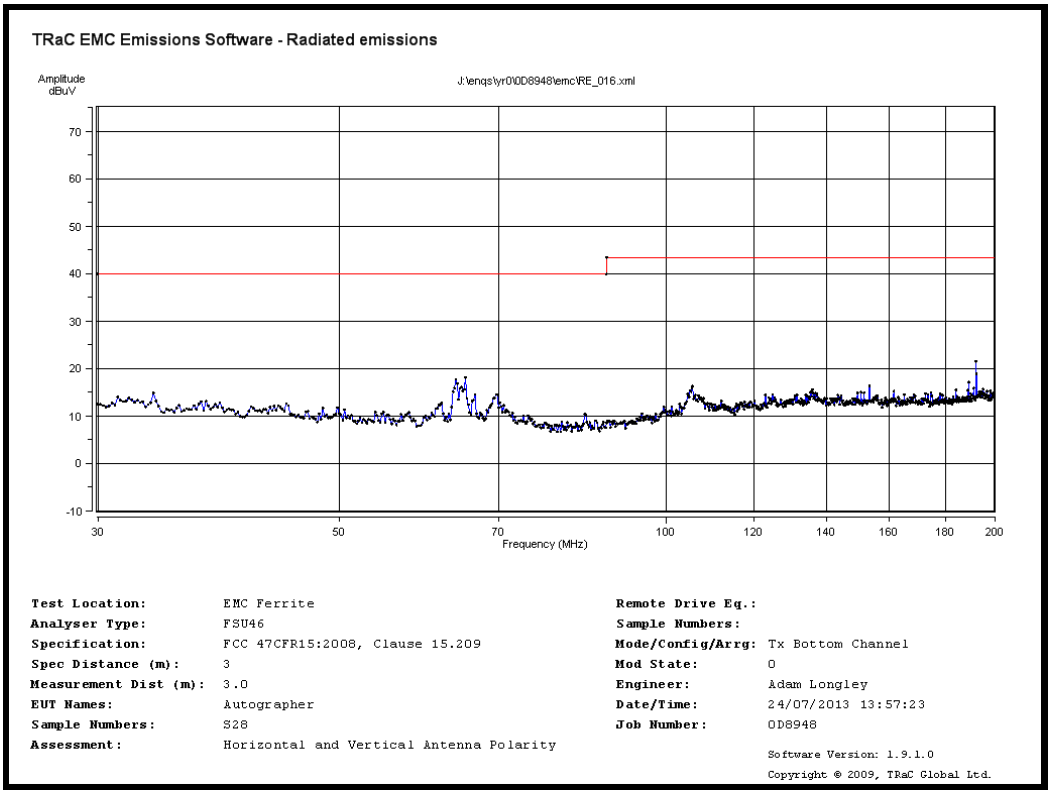


Radiated RX Mode Emissions (15.109)

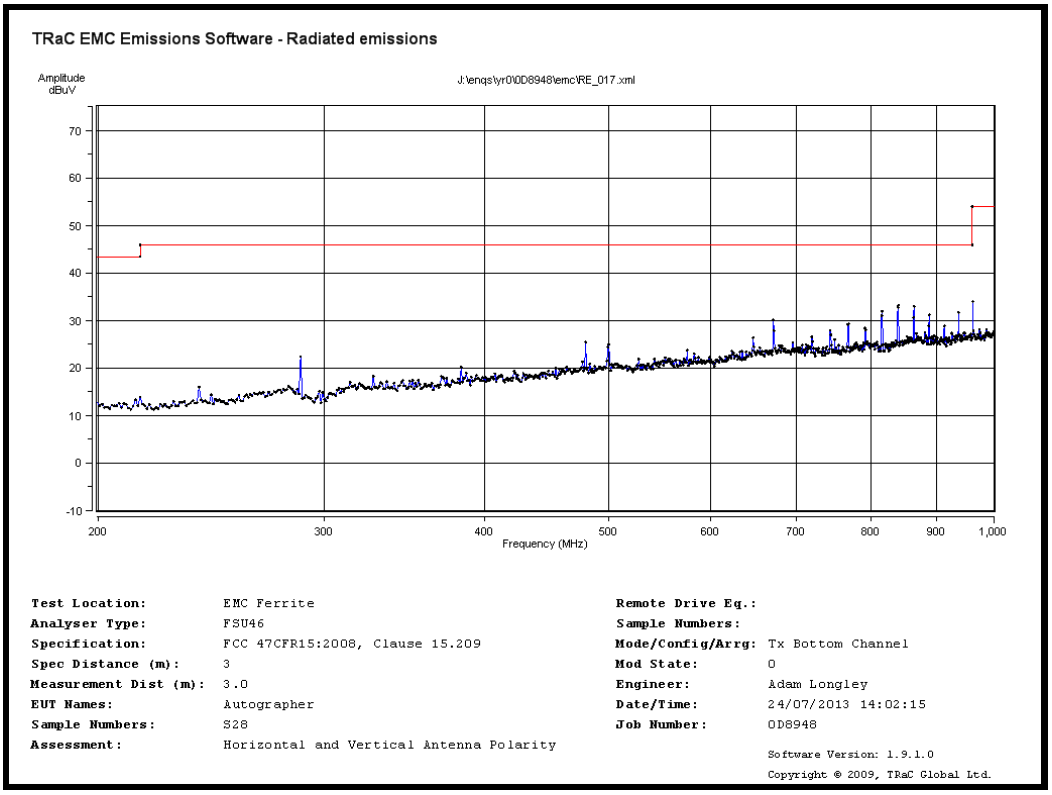


Radiated RX Mode Emissions (15.109)

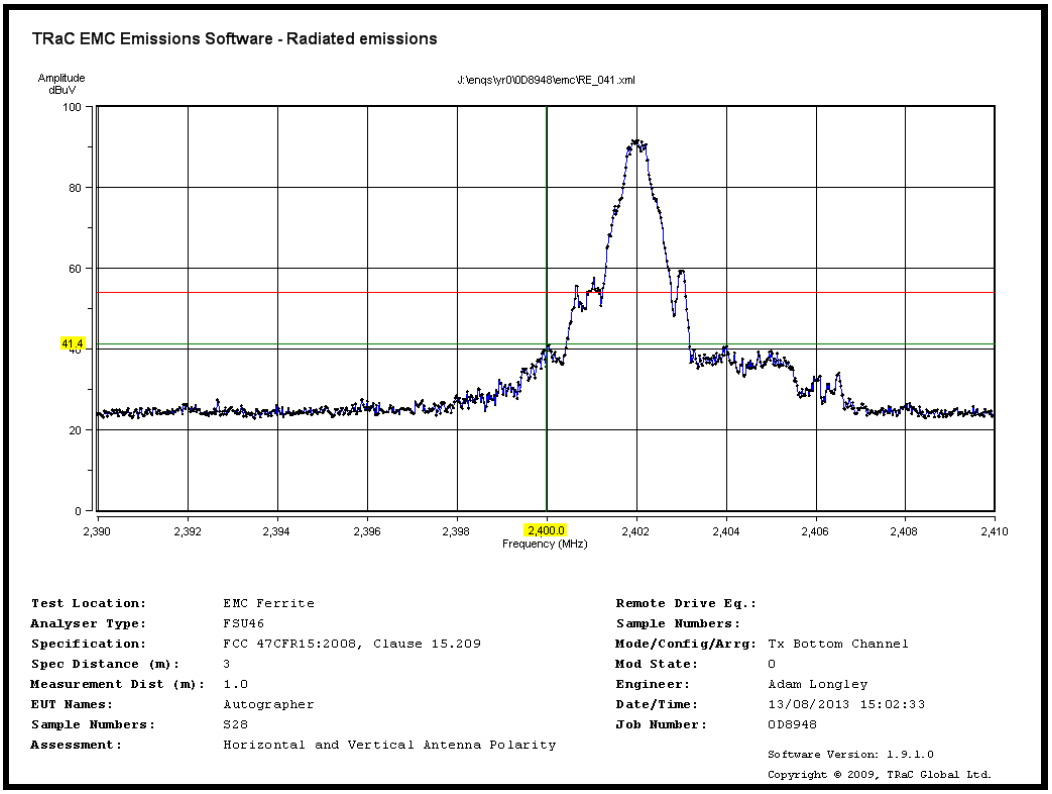
Preview Radiated Transmitter Spurious emissions (15.209)



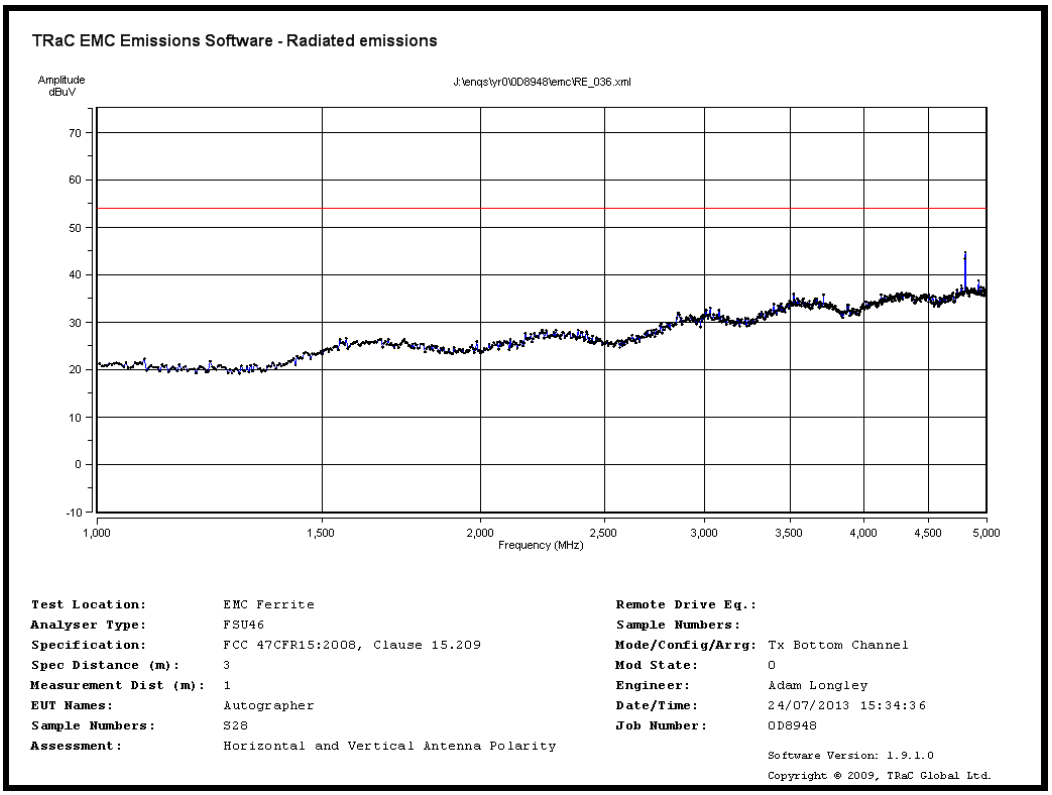
Radiated Transmitter Emissions Channel 0 2402 MHz (15.209)



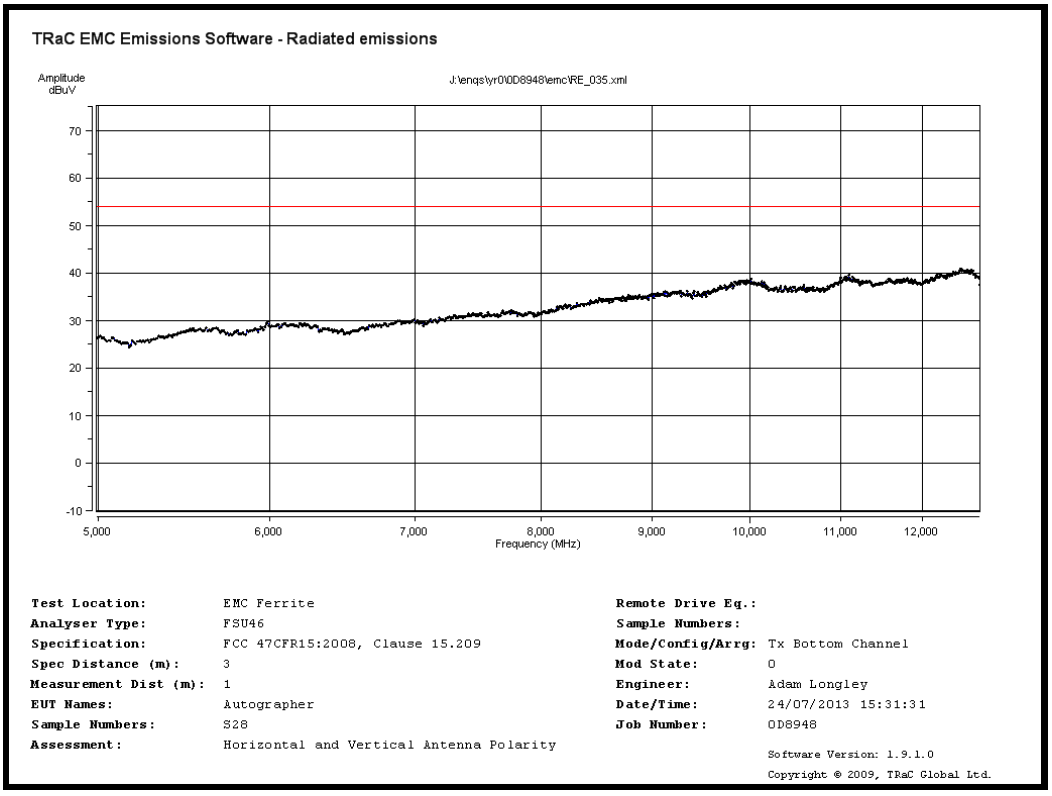
Radiated Transmitter Emissions Channel 0 2402 MHz (15.209)



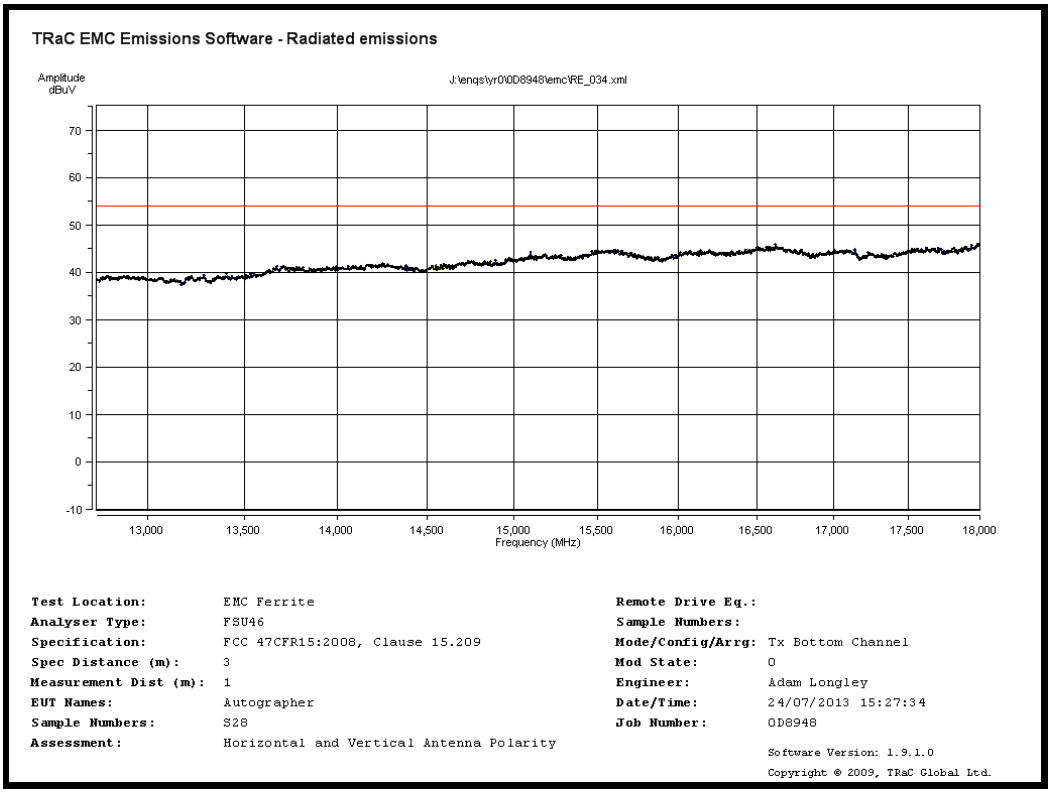
Radiated Transmitter Emissions Channel 0 2402 MHz (15.209)
Lower Band Edge Compliance RBW 100kHz



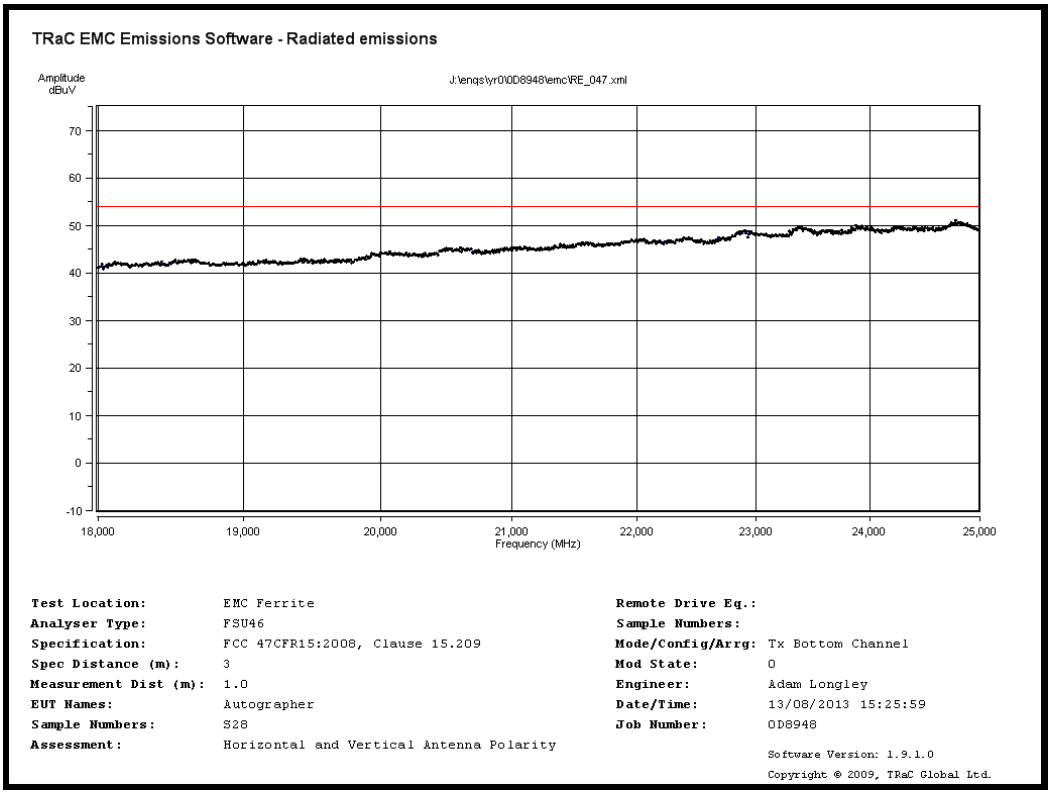
Radiated Transmitter Emissions Channel 0 2402 MHz (15.209)



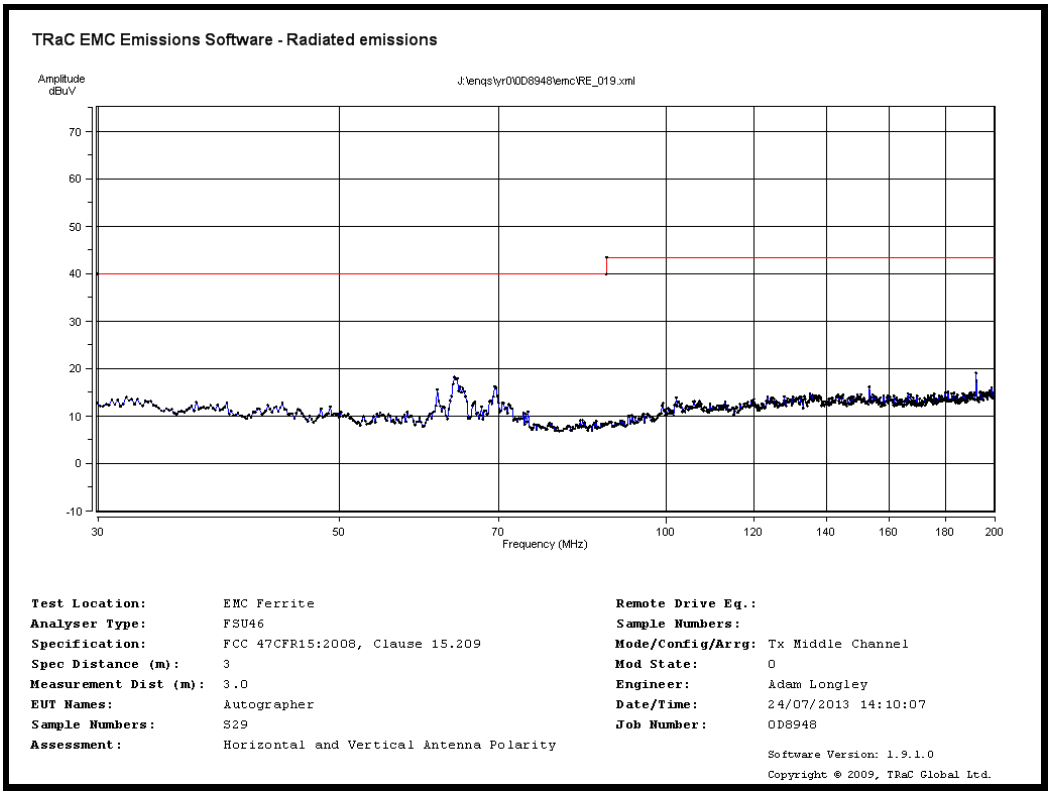
Radiated Transmitter Emissions Channel 0 2402 MHz (15.209)



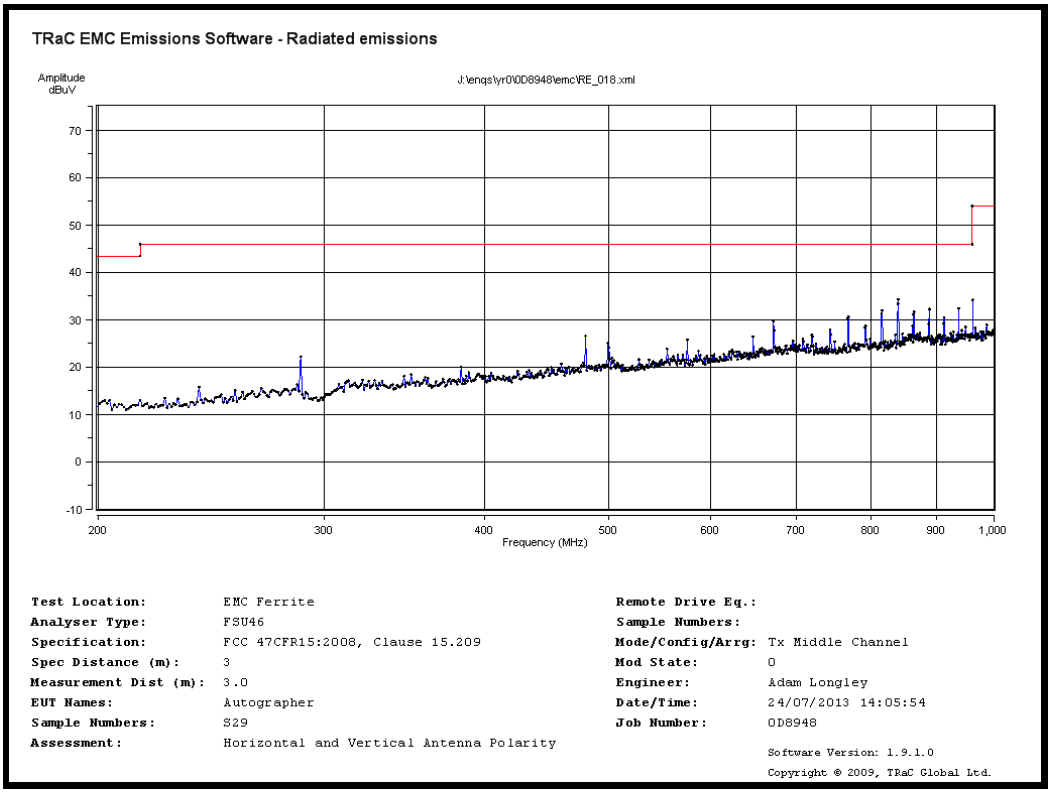
Radiated Transmitter Emissions Channel 0 2402 MHz (15.209)



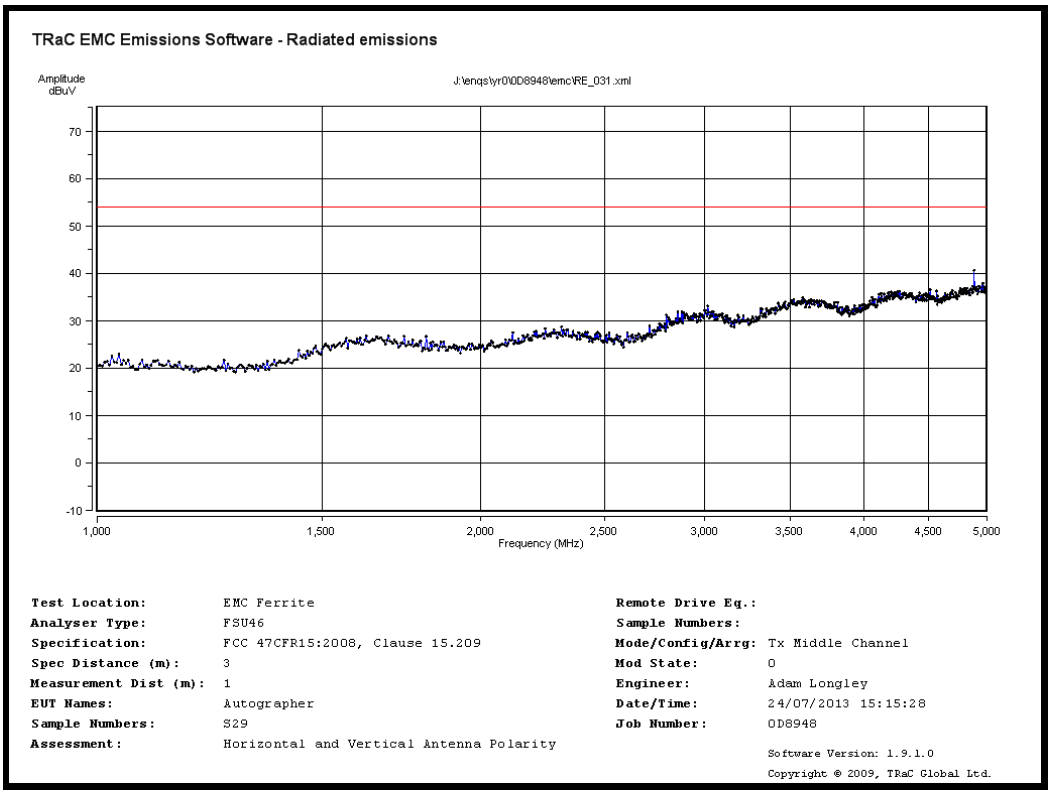
Radiated Transmitter Emissions Channel 0 2402 MHz (15.209)



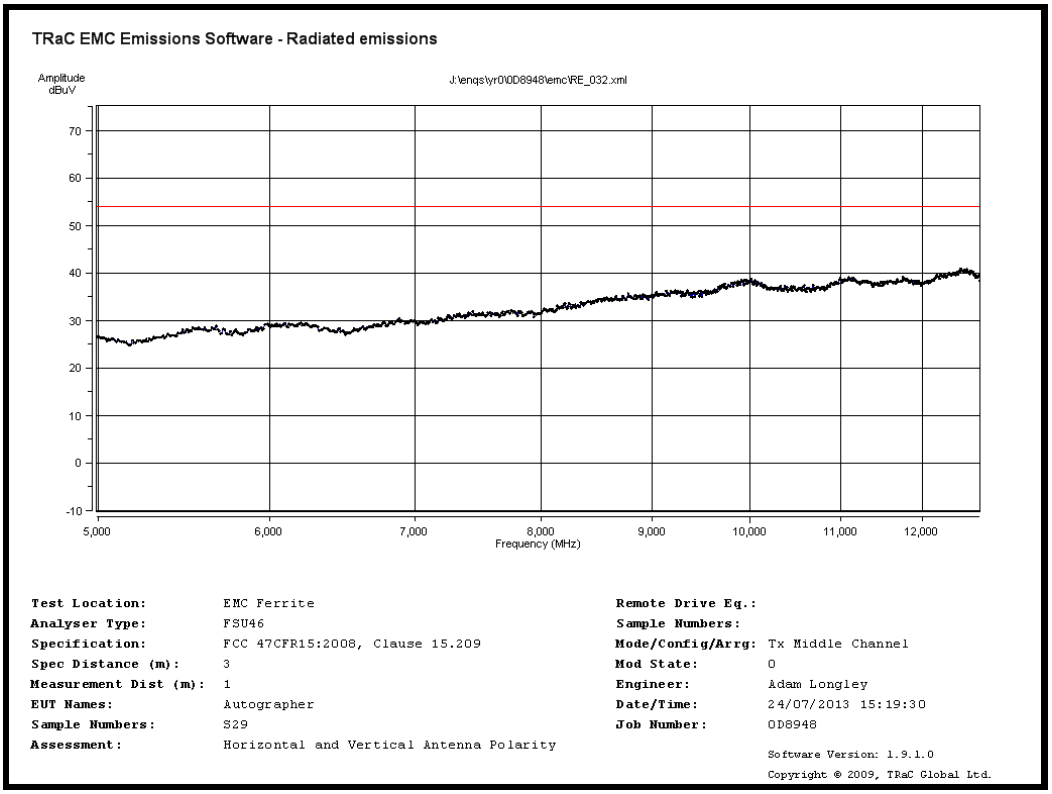
Radiated Transmitter Emissions Channel 39 2441 MHz (15.209)



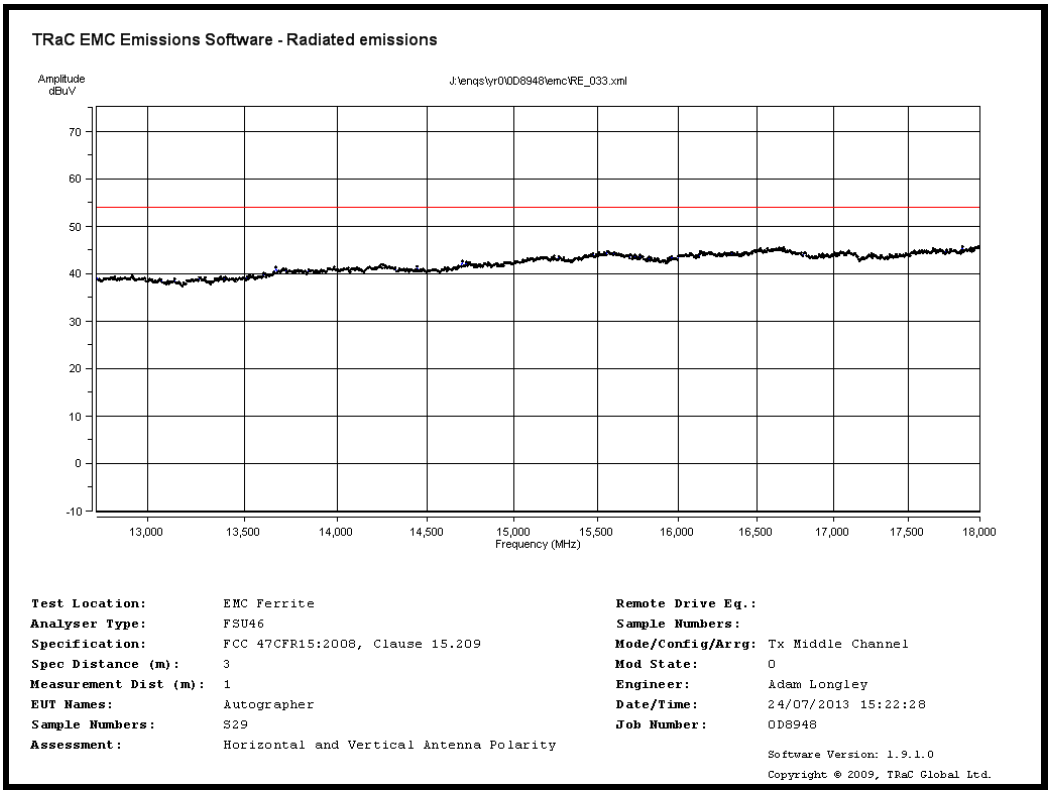
Radiated Transmitter Emissions Channel 39 2441 MHz (15.209)



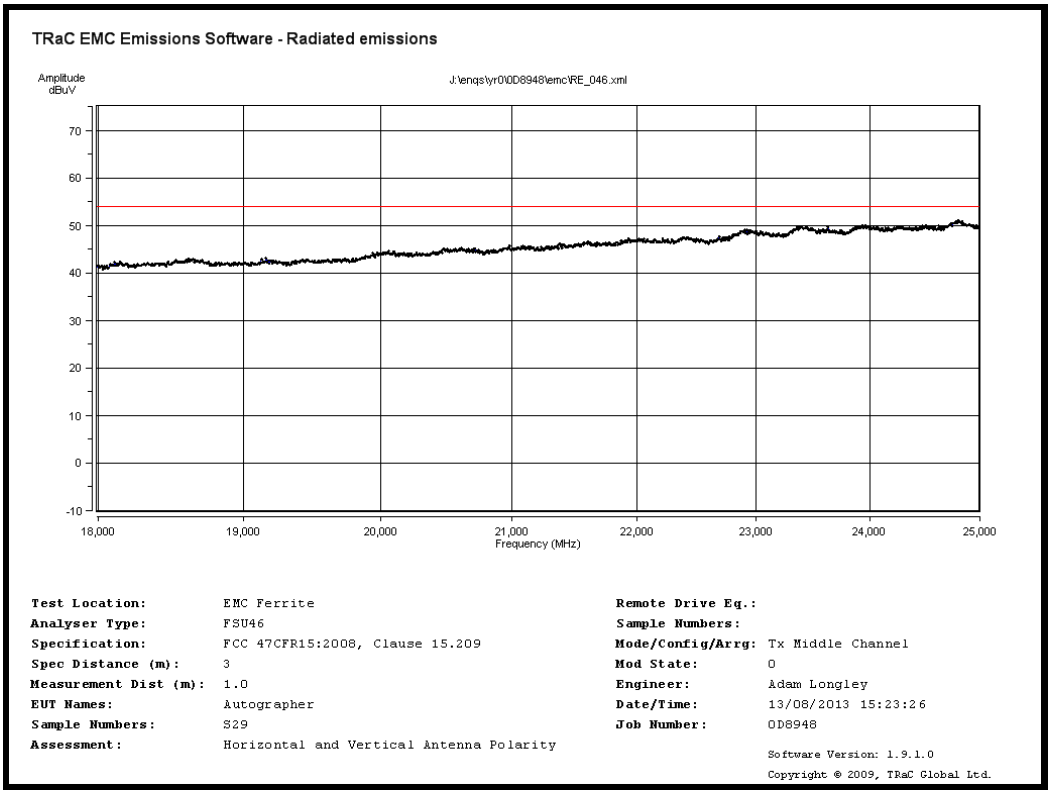
Radiated Transmitter Emissions Channel 39 2441 MHz (15.209)



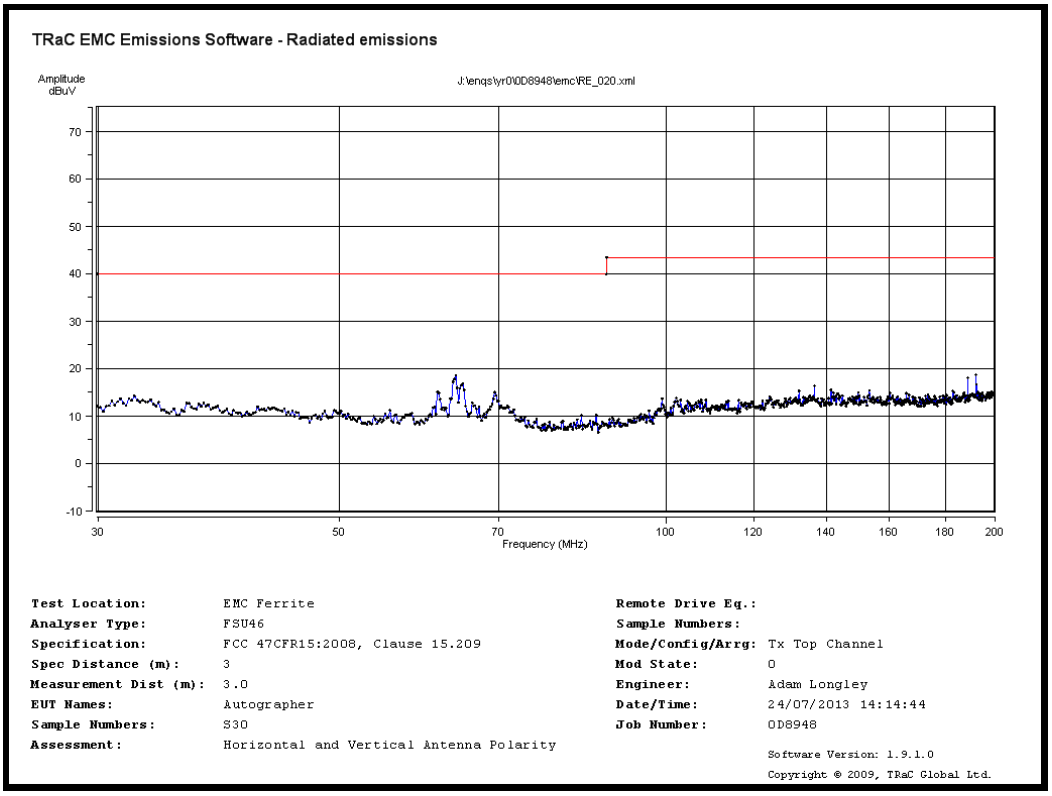
Radiated Transmitter Emissions Channel 39 2441 MHz (15.209)



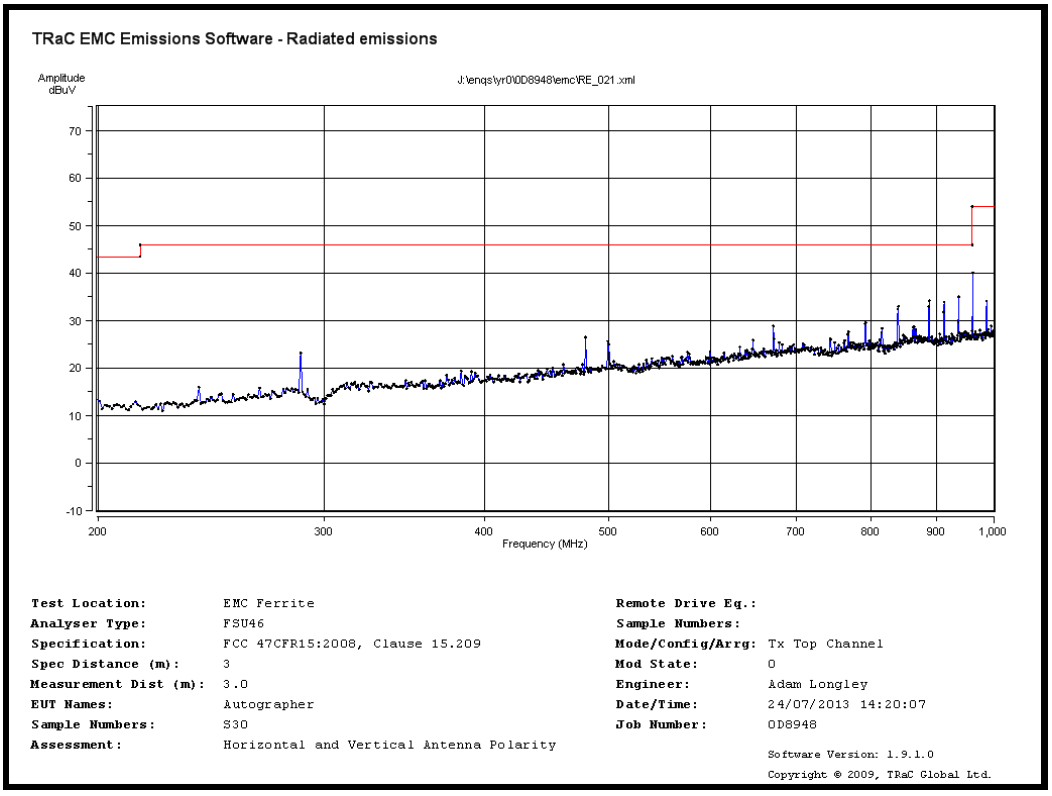
Radiated Transmitter Emissions Channel 39 2441 MHz (15.209)



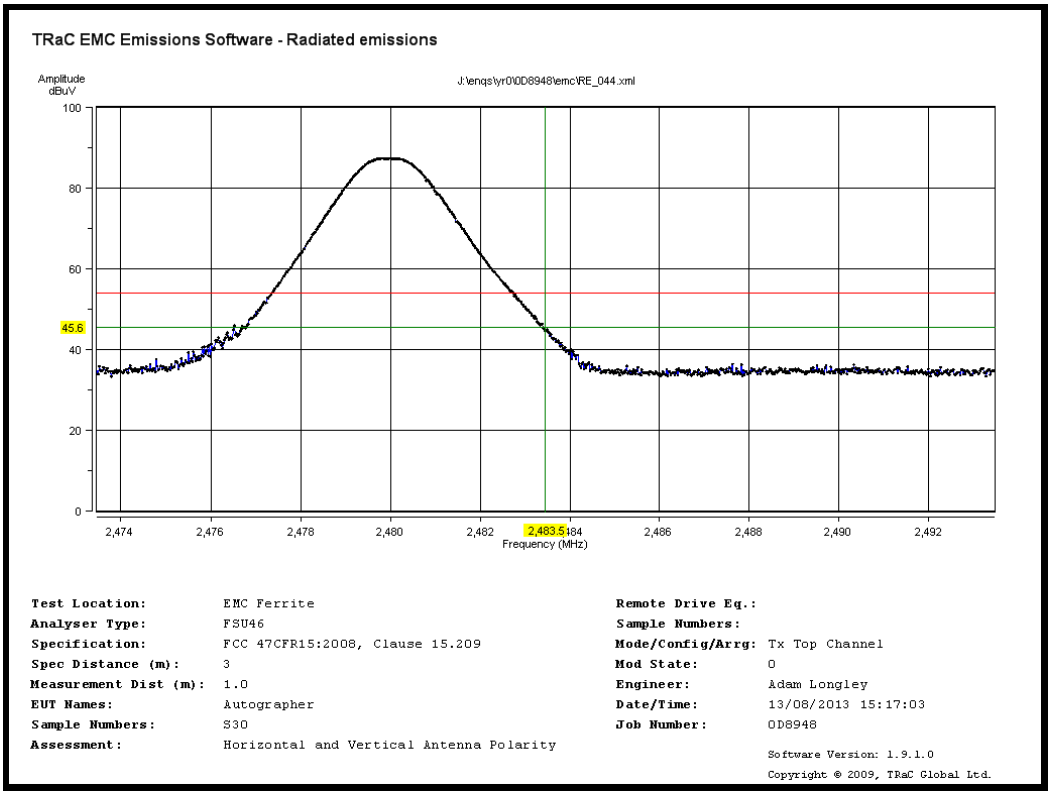
Radiated Transmitter Emissions Channel 39 2441 MHz (15.209)



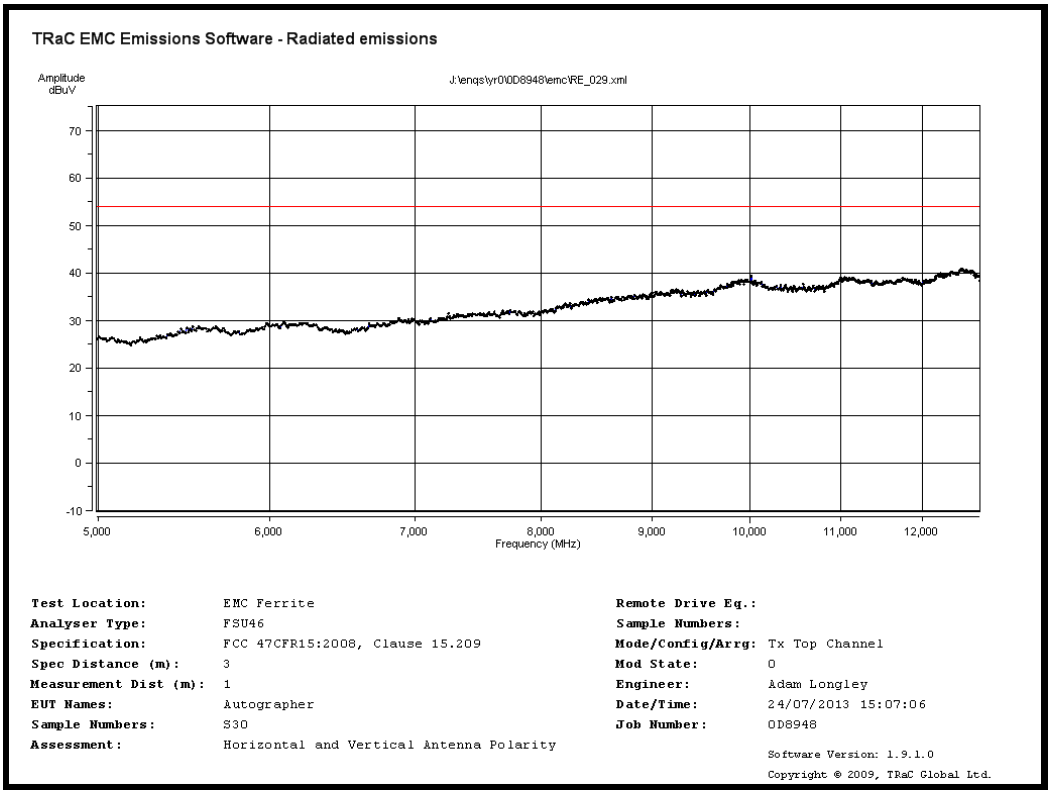
Radiated Transmitter Emissions Channel 78 2480 MHz (15.209)



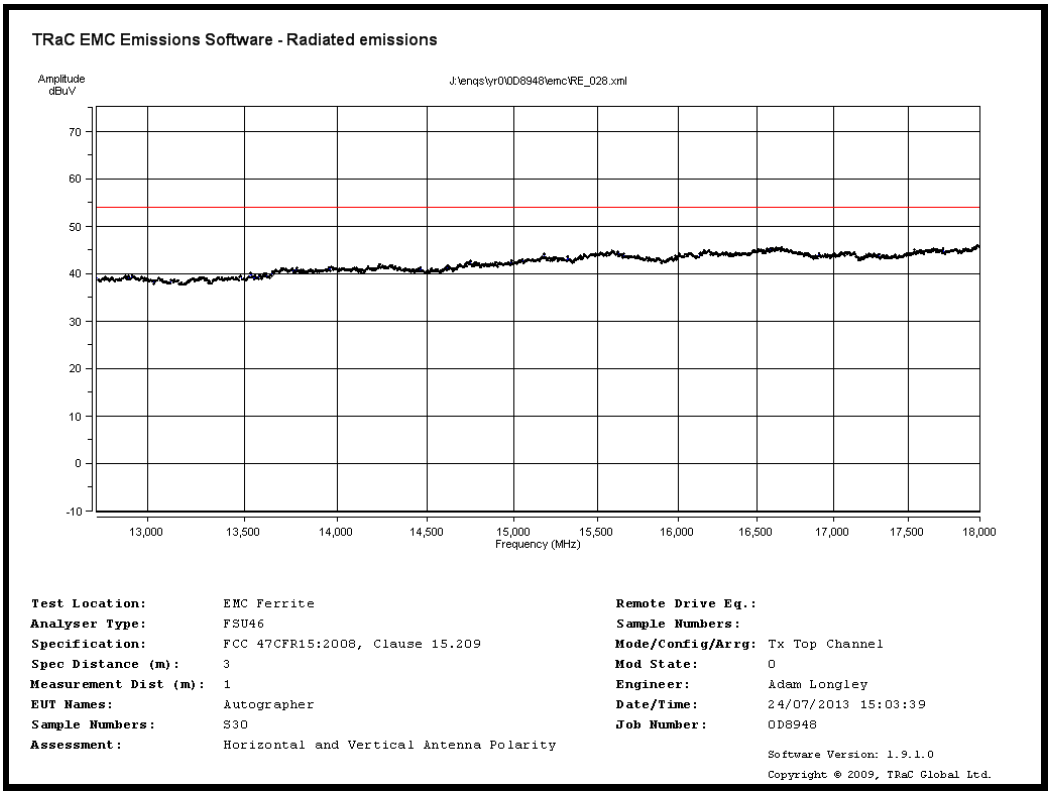
Radiated Transmitter Emissions Channel 78 2480 MHz (15.209)



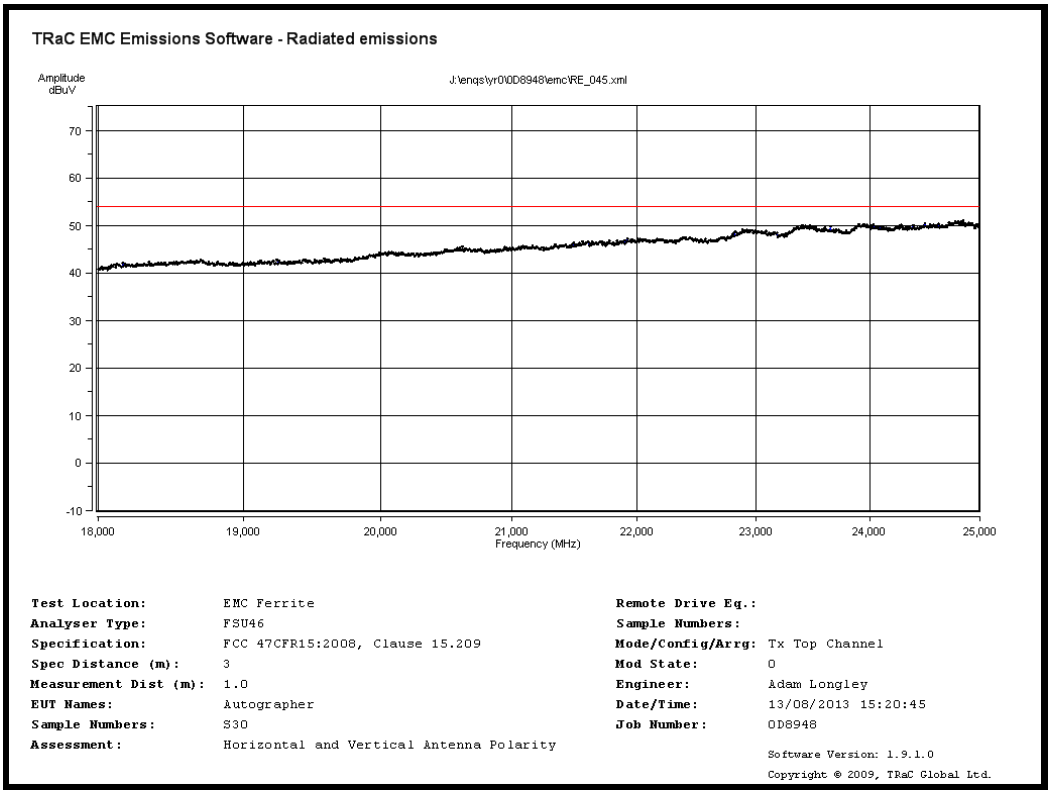
Radiated Transmitter Emissions Channel 78 2480 MHz (15.209)
Upper Band Edge Compliance RBW 1 MHz



Radiated Transmitter Emissions Channel 78 2480 MHz (15.209)

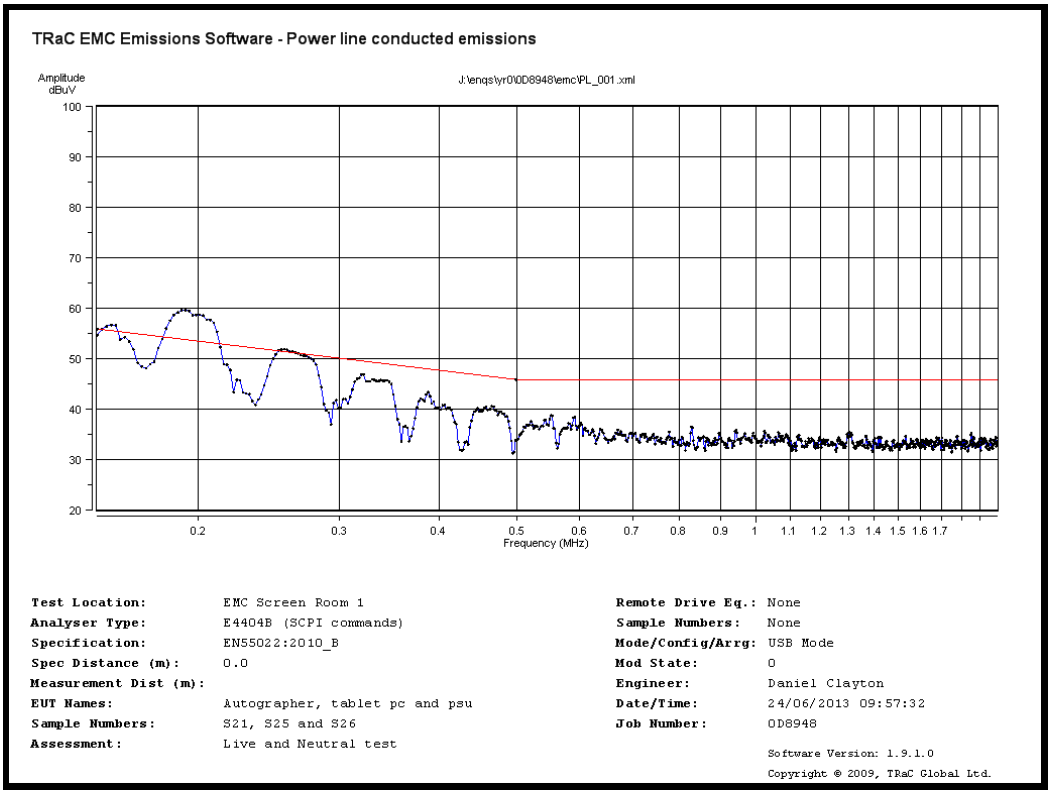


Radiated Transmitter Emissions Channel 78 2480 MHz (15.209)

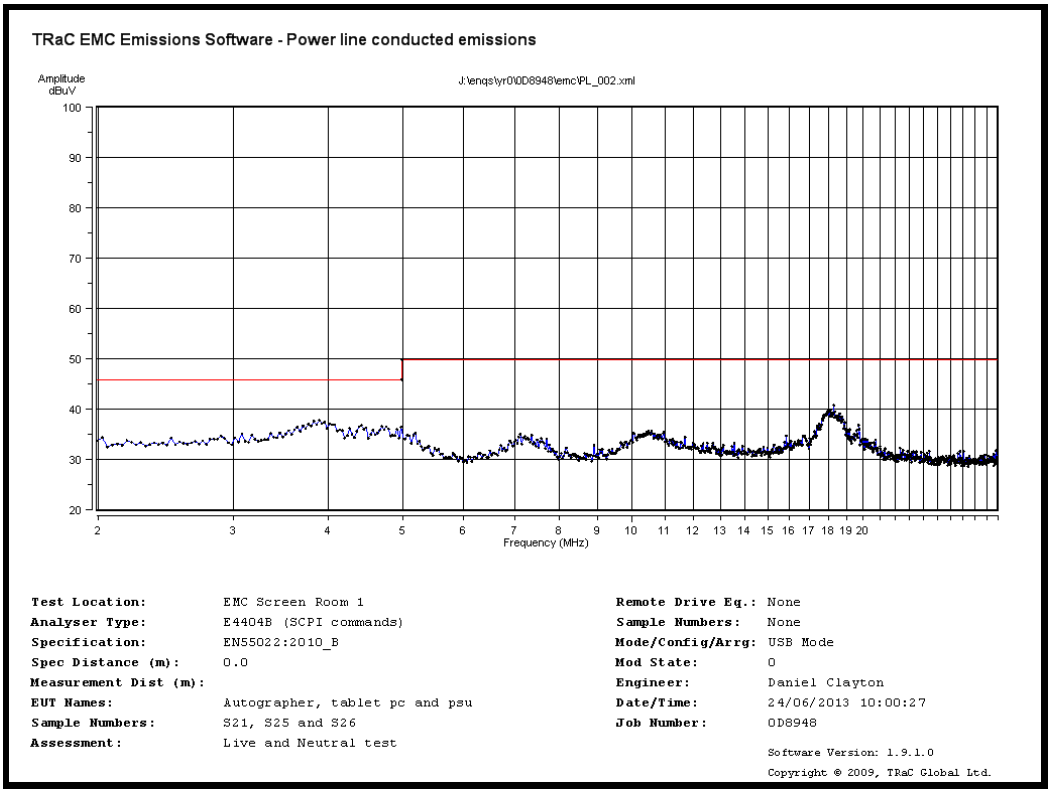


Radiated Transmitter Emissions Channel 78 2480 MHz (15.209)

Preview Power Line emissions (15.107)



Power Line emissions (15.107)



Power Line emissions (15.107)

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.

C1) Test samples

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

Sample No.	Description	Identification
S19	Autographer (Normal operating sample)	PK13E123457031
S28	Autographer (Bottom Channel Tx sample)	PK13F123457104
S29	Autographer (Middle Channel Tx sample)	PK13F123457046
S30	Autographer (Top Channel Tx sample)	None

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

Identification	Description
None	TRaC PC

C2) EUT Operating Mode During Testing.

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

Test	Description of Operating Mode: None-Hopping Mode
Radiated Electric Field Emissions Restricted band 15.209 and conducted spurious emissions.	The EUT (S28, S29 and S30) were set to transmit on maximum power with 1Mbps/GFSK modulation, and was set to transmit on the lowest (2402MHz), middle (2441MHz) and highest (2480MHz) operating frequency

Test	Description of Operating Mode: Transmit UHF radio only (None-Hopping radiated testing)
Radiated Electric Field Emissions Receive Mode 15.109 and PLCE 15.107)	The EUT (S19) was powered on but set to not transmit .

Test	Description of Operating Mode: None-Hopping Mode
All other tests	The EUT (S28, S29 and S30) were set to transmit on maximum power with 1Mbps/GFSK modulation, and was set to transmit on the lowest (2402MHz), middle (2441MHz) and highest (2480MHz) operating frequency

C3) EUT Configuration Information.

Sample	Internal Configuration Details
All	Single possible internal configuration

C4)List of EUT Ports

The table below describes the termination of EUT ports:

Sample : All
Tests : All

Port	Description of Cable Attached	Cable length	Equipment Connected
USB	None	N/A	None

Note: USB port only used for charging purposes, transmitter is disabled whilst charging.

C5 Details of Equipment Used

For Conducted Measurements

TRaC REF/RFG No	Type	Description	Manufacturer	Date Calibrated
636	NSG 1007	110Vac/60Hz supply	Schaffner	Cal before use
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R & S	21/11/12

For Power Line Conducted Emissions

TRaC REF/RFG No	Type	Description	Manufacturer	Date Calibrated
n/a	Lab 7	Small Screened Chamber	TRaC	-
189	ESH3-Z5	Single-phase LISN	R & S	27/06/12
680	ESH3-Z2	Pulse Limiter	R & S	21/06/12
657	E4404B	Spectrum Analyser	Agilent	01/05/12
636	NSG 1007	110Vac/60Hz supply	Schaffner	Cal before use
REF1270		Variac	TRaC	Cal before use
REF528	34401A	Digital multimeter	HP	11/07/12
295	BNC	RF coaxial cable (Lab 7)	TRaC	22/10/12
299	BNC	RF coaxial cable (Lab 7)	TRaC	22/10/12
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R & S	21/11/12

For Radiated Measurements:

TRaC REF/RFG No	Type	Description	Manufacturer	Date Calibrated
274	Lab 10	Ferrite Lined Chamber	TRaC	01/08/12
679	CBL6111	BILOG Antenna	Chase	05/05/11
682	HL050	Log P Antenna 0.85 to 26.5GHz	R & S	16/07/12
629	QSH20S20S	Horn antenna 18 to 26.5GHz	Q-Par	18/11/11
008	8447D	Pre Amp	HP	16/02/12
307	8449B	HF Pre Amp (1 to 26.5GHz)	HP	29/02/12
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R & S	21/11/12
REF831	-	HF RF coaxial cable 3.0m	Teledyne & Reynolds	02/07/12
REF832	-	HF RF coaxial cable x.0m	Teledyne & Reynolds	02/07/12
643	-	48 inch HF coaxial cable	Sucoflex	22/10/12
651	-	7m HF coaxial cable	Sucoflex	
678	-	8m HF coaxial cable	Sucoflex	22/10/12
687	VHF1500+	High Pass Filter	Mini Circuits	22/10/12
445	-	High Pass Filter	BSC	15/05/12
REF528	34401A	Digital multimeter	HP	11/07/12
636	NSG 1007	110Vac/60Hz supply	Schaffner	Cal before use

Appendix D: Additional Information

Antenna Data Sheet

fractus
Optimised Antennas for Wireless Devices

DATA SHEET · PRODUCTS & SERVICES

Small SMD Chip antenna for miniature wireless products

Fractus specialises in enabling effective mobile communications. Using fractal technology, we design and manufacture optimised antennas to make your wireless devices more competitive. Our mission is to help our clients develop innovative products and accelerate their time to market through our expertise in antenna design, testing and manufacturing.

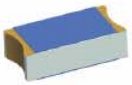
Fractus® Micro Reach Xtend™ 2.4GHz Chip Antenna P/N: FR05-S1-N-0-110

Fractus® Micro Reach Xtend™ Chip Antenna is a very small size and low cost antenna that combines reduced clearance area required within the customer PCB with its high performance and integration flexibility. This makes it ideal for small consumer electronics devices such as small wireless headsets and highly integrated multifunction mobile handsets.

Taking advantage of the space-filling properties of fractals, this small monopole antenna is perfect to use within indoor (highly scattered) environment.

4.1 mm x 2 mm x 1 mm (image larger than real size)

TOP

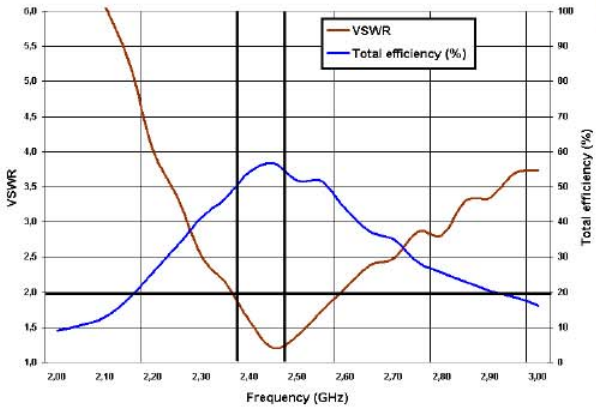


BOTTOM

PAT. US 7,148,850, US 7,202,822

Product Benefits

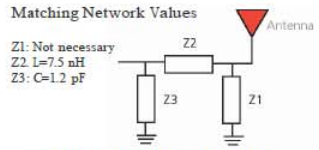
- **Small form factor**
  Allows integration into space limited areas easily and efficiently with minimum clearance area.
- **Low cost**
  Enables product developers to reduce BoM cost increasing device competitiveness.
- **Omnidirectional pattern**
  Optimises device usage due to a uniform radiation pattern.
- **Broad bandwidth**
  Ensures robust performance when considering different plastic housing and close body proximity.



Technical Features	
Frequency range	2.4 GHz - 2.5 GHz
Average Efficiency	54.2 %
Peak Gain	0.2 dB
Radiation Pattern	Omnidirectional
VSWR	< 2:1
Polarization	Linear
Weight (aprox.)	0.01 g
Temperature	-40 to + 85°C
Impedance	50Ω
Dimensions (L x W x H)	4.1 mm x 2 mm x 1 mm

Measures from the evaluation board (40 mm x20 mm x 1 mm PCB) with 2 element matching network

Matching Network Values



Optimal matching network values may vary depending on the antenna environment.

For additional information, please download the user manual from http://www.fractus.com/main/fractus/documentation or contact info@fractus.com.

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Appendix E: Calculation of the duty cycle correction factor

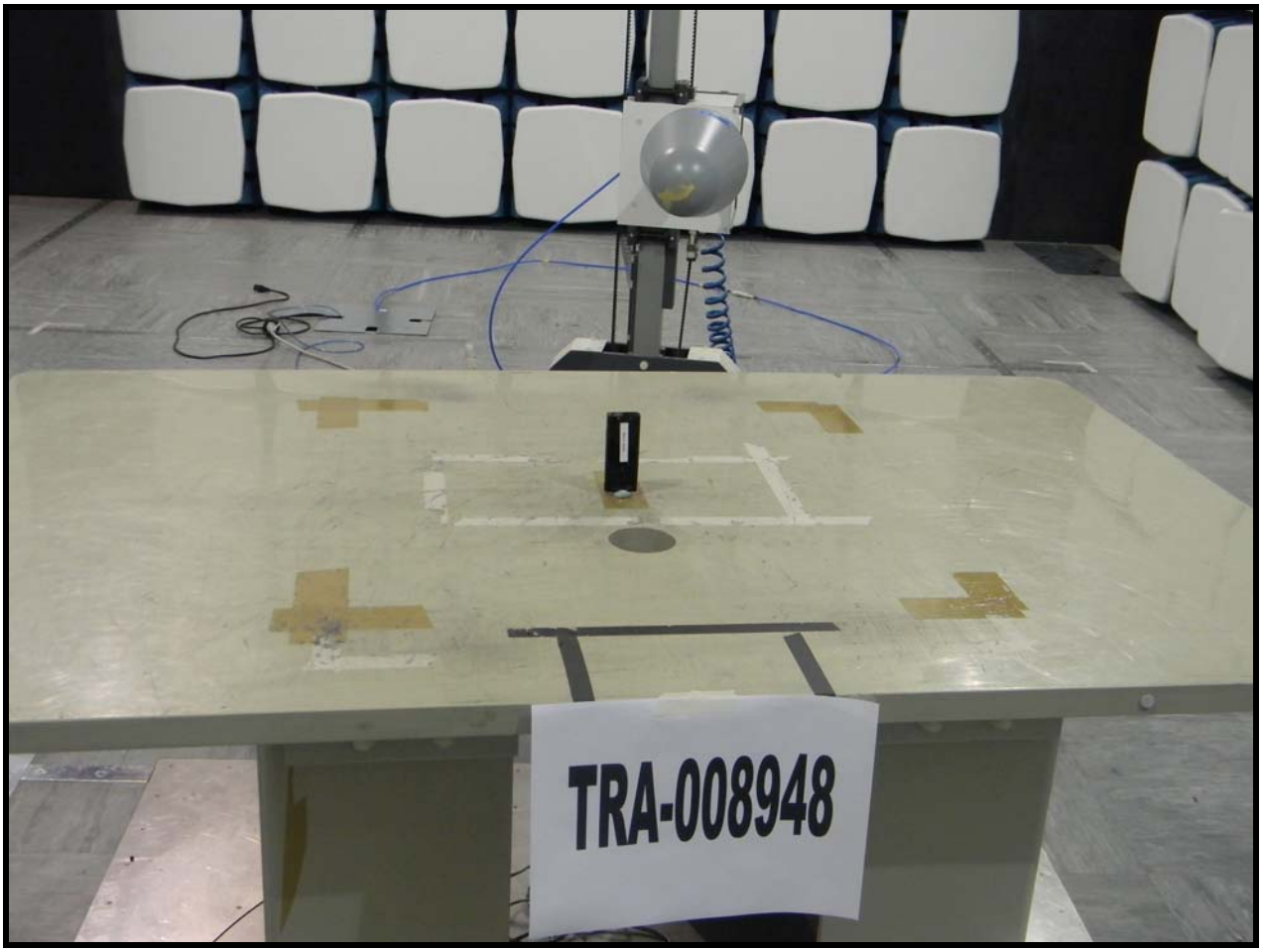
No Duty cycle correction has been determined within this test report.

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.

Photograph 1



Photograph 2

Appendix G: MPE Calculation

MPE calculation for the Autographer

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 19 of OET Bulletin 65, Edition 97-01

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

where:

S = power density (Limit) (in appropriate units, e.g. mW/cm^2)
EIRP = equivalent (or effective) isotropically radiated power (mW)
R = distance to the center of radiation of the antenna (cm)
P = power input to the antenna (mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
(***numeric*** gain. = $G = 10^{\frac{dB}{10}}$

Sample No.	S29	
Maximum peak output power at the antenna terminal:	0.4	dBm
Maximum peak output power at the antenna terminal:	1.1	mW
Antenna gain (typical):	0.2	dBi
Maximum antenna gain:	1.05	numeric
Prediction distance:	N/A	cm
Prediction frequency:	2441	MHz

Result

Prediction Frequency (MHz)	Maximum EIRP (mW)	Power density limit (mW/cm^2)	Distance (R) cm required to be less than 1 mW/cm^2
2441	1.2	1	0.3

RSS-102 Issue 4 March 2010

MPE calculation for the Autographer

Radio frequency radiation exposure evaluation:

For purposes of these requirements mobile devices are defined 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 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 10W/m^2 power density limit of Section 4.2 RSS102 Issue 4 March 2010.

Prediction of MPE limit at a given distance

Equation from page 19 of OET Bulletin 65, Edition 97-01

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

where:

S = power density (Limit) (in appropriate units, e.g. W/m^2)
EIRP = equivalent (or effective) isotropically radiated power (W)
R = distance to the centre of radiation of the antenna (m)
P = power input to the antenna (W)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
(***numeric*** gain. = $G = 10^{\frac{dB}{10}}$

Sample No.	S29	
Maximum peak output power at the antenna terminal:	0.4	(dBm)
Maximum peak output power at the antenna terminal:	0.0011	(W)
Antenna gain (typical):	0.2	(dBi)
Maximum antenna gain:	1.05	(numeric)
Prediction distance:	N/A	(m)
Prediction frequency:	2441	(MHz)

Prediction Frequency (MHz)	Maximum EIRP (Watts)	Power density limit (S) W/m^2	Distance (R) in meters required to be less than10 W/m^2
2441	0.0012	10	0.003

Appendix H: FCC CFR47 Part 15(c) / IC RSS-210 Comparison Table

The following table summarises the results of the assessment to RSS-210:

Test Type	Regulation	Regulation	Measurement standard	Result
Radiated spurious emissions	Title 47 of the CFR: Part 15 Subpart (c) 15.247	RSS – 210 Issue 8, December 2010 Annex 8, A8.5	RSS- GEN Issue 3, December 2010 ANSI C63.10	Pass
Conducted spurious emissions	Title 47 of the CFR: Part 15 Subpart (c) 15.247	RSS – 210 Issue 8, December 2010 Annex 8, A8.5	RSS- GEN Issue 3, December 2010 ANSI C63.10	Pass
ac Power Lines conducted emissions	Title 47 of the CFR: Part 15 Subpart (c) 15.207	RSS – 210 Issue 8, December 2010 Section 7.2.2	RSS- GEN Issue 3, December 2010 ANSI C63.10	Pass
20dB Bandwidth and Channel Spacing	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(i)	RSS – 210 Issue 8, December 2010 Annex 8, A8.1(b)	RSS- GEN Issue 3, December 2010 ANSI C63.10	Pass
Conducted Carrier Power	Title 47 of the CFR : Part 15 Subpart (c) 15.247(b)(2)	RSS – 210 Issue 8, December 2010 Annex 8, A8.4(2)	RSS- GEN Issue 3, December 2010 ANSI C63.10	Pass
Hopping Frequencies	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)	RSS – 210 Issue 8, December 2010 Annex 8, A8.1(d)	ANSI C63.10	Pass
Channel Occupancy	Title 47 of the CFR : Part 15 Subpart (c) 15.247(a)(1)(i)	RSS – 210 Issue 8, December 2010 Annex 8, A8.1(d)	ANSI C63.10	Pass
Unintentional Radiated Spurious Emissions	Title 47 of the CFR: Part 15 Subpart (b) 15.109	RSS – 210 Issue 8, December 2010 Section 7.2.3	RSS- GEN Issue 3, December 2010 ANSI C63.10	Pass

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