TRaC Test Report : 8F1800WUS1

Applicant : Landis + Gyr

Apparatus : 5276 ZigBee Transceiver Module

Summary:

The apparatus detailed above is compliant with the above standard as tested
(see section 1.5 of this report for full details)

Authorised by : 

: , Authorised Signatory

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Contents

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 :

Landis + Gyr
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1.3 Manufacturer

Jabil Circuit [GuangZhou] Ltd
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Guangdong Providence
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1.4 Apparatus Assessed

The following apparatus was assessed between 08/06/09and 12/06/09:

5276 ZigBee Transceiver Module

The above equipment was a 2.4GHz ZigBee transceiver module

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
CFCP	Title 47 of the CFR :2008, Part 15 Subpart (c) 15.247(b)(3)	ANSI C63.4: 2003	Pass
RF Antenna Port Conducted Spurious Emissions	Title 47 of the CFR: 2008, Part 15 Subpart (c) 15.247(d)	ANSI C63.4: 2003	Pass
REFE (Digital devices)	Title 47 of the CFR: 2008, Part 15 Subpart (b) 15.109 (a)	ANSI C63.4: 2003	Pass
REFE (Within the restricted band)	Title 47 of the CFR: 2008, Part 15 Subpart (c) 15.247(d) and 15.205	ANSI C63.4: 2003	Pass
PLCE	Title 47 of the CFR: 2008, Part 15 Subpart (c) 15.207	ANSI C63.4: 2003	N/A
6dB Bandwidth	Title 47 of the CFR :2008, Part 15 Subpart (c) 15.247(a)(2)	ANSI C63.4: 2003	Pass
Antenna Gain	Title 47 of the CFR :2008, Part 15 Subpart (c) 15.247(b)(4)	ANSI C63.4: 2003	N/A
Power Spectral Density	Title 47 of the CFR :2008, Part 15 Subpart (c) 15.247(e)	ANSI C63.4: 2003	Pass

Abbreviations used in the above table:

Mod : Modification
CFR : Code of Federal Regulations
REFE : Radiated Electric Field Emissions
CFCP : Conducted Fundamental Carrier Power
ANSI : American National Standards Institution
PLCE : Power Line Conducted Emissions
N/A Not Applicable

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.

TRaC Telecoms & Radio is a listed electromagnetic compatibility Conformance Assessment Body (CAB) for EC access to the US market. (Decision No 3/2000 of the Joint Committee established under the Agreement on Mutual Recognition between the European Community and the United States of America. This decision was effective from 16th January 2001).

FCC Facility Registration number (3m semi anechoic chamber) : 90743

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 TRaC Telecoms & Radio 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 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 TRaC Telecoms & Radio Measurement Uncertainty Values

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

Test type	Quantity	Quantity frequency range	TRaC Telecoms & Radio Uncertainty
Radiated electric field emissions 3m alternative test site	Amplitude	30MHz to 300MHz Horizontal	±4.9dB
		30MHz to 300MHz Vertical	±5.1dB
		300MHz to 1000MHz Horizontal	±5.3dB
		300MHz to 1000MHz Vertical	±5.1dB
		1GHz to 26.5GHz Horizontal and Vertical	±4.1dB
Power line conducted emissions using a V mode lisn		150kHz to 30MHz	±3.9dB
Conducted emissions		N/A	±0.9 dB
Absolute RF power (via antenna connector)		N/A	±0.9 dB
PSD		N/A	±0.9 dB
6dB Bandwidth	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

Conducted carrier power was verified using a peak power meter, the EUT transmitting on its lowest, centre and highest carrier frequency in turn.

Test Details:	
Regulation	Title 47 of the CFR 2008, Part15 Subpart (c) 15.247(b)(3)
EUT sample number	S02
Modification state	0
SE in test environment	RFG389
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Channel No	Channel Frequency (MHz)	Measured Peak Conducted Carrier Power (mW)	Limit (mW)	Result
11	2405	75.16	427.56[#]	Pass
18	2440	84.14		Pass
24	2470	90.78		Pass
25	2475	23.23		Pass
26	2480	0.571		Pass

Note

[#]The Antenna gain has been calculated to be greater than 6dBi (9.69dBi). Please refer to Section A7 of this test report. The conducted output power limit specified in 47 CFR Part 15 Subpart (c) Clause 15.247(b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

Except as shown in paragraph 47 CFR Part 15 Subpart (c) Clause 15.247(b) (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in 47 CFR Part 15 Subpart (c) clause 15.247 paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Therefore under section 15.247 (b)(4) the conducted power limit shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi. This equates to 3.69dB

Limit 1W or (30dBm-3.69dB) = 26.31dBm

26.31dBm = 427.56mW

A2 RF Antenna Conducted Spurious Emissions

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

Test Details CH11	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.4:2003
Frequency range	9 kHz to 25 GHz
EUT sample number	S02
Modification state	0
SE in test environment	RFG389
SE isolated from EUT	None
EUT set up	Refer to Appendix C

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

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 1GHz	Pk	N	No Significant Emissions Within 20dB of the limit	100.47	Pass
2	2399.867	Pk	N	80.96	100.47	Pass
3	2400.000	Pk	Y	79.57	100.47	See Section A3
4	4814.102	Pk	Y	66.89	N/A	See Section A3
5	7219.551	Pk	Y	52.91	N/A	See Section A3
6	9623.397	Pk	N	53.88	100.47	Pass
7	10GHz to 25GHz	Pk	N	No Significant Emissions Within 20dB of the limit	100.47	Pass

RF Antenna Conducted Spurious Emissions continued:

Test Details CH18	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.4:2003
Frequency range	9 kHz to 25 GHz
EUT sample number	S02
Modification state	0
SE in test environment	RFG389
SE isolated from EUT	None
EUT set up	Refer to Appendix C

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

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 1GHz	Pk	N	No Significant Emissions Within 20dB of the limit	101.74	Pass
2	4884.615	Pk	Y	67.44	N/A	See Section A3
3	5GHz to 25GHz	Pk	N	No Significant Emissions Within 20dB of the limit	101.74	Pass

RF Antenna Conducted Spurious Emissions continued:

Test Details CH24 and CH25	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.4:2003
Frequency range	Upper Band Edge 2.4835GHz only.
EUT sample number	S02
Modification state	0
SE in test environment	RFG389
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 2470MHz (CH24) :

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	2483.500	Pk	Y	64.16	N/A	See Section A3
2	2484.097	Pk	Y	52.11	N/A	See Section A3

The worst case conducted upper band edge emission measurements at the antenna port are listed below with the transmitter at 2475MHz (CH25) :

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	2483.500	Pk	Y	55.42	N/A	See Section A3
2	2483.888	Pk	Y	65.86	N/A	See Section A3

RF Antenna Conducted Spurious Emissions continued:

Test Details CH26	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.4:2003
Frequency range	9 kHz to 25 GHz
EUT sample number	S02
Modification state	0
SE in test environment	RFG389
SE isolated from EUT	None
EUT set up	Refer to Appendix C

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

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 2.4835GHz	Pk	N	No Significant Emissions Within 20dB of the limit	77.75	Pass
2	2483.500	Pk	Y	52.11	N/A	See Section A3
3	2483.901	Pk	Y	64.23	N/A	See Section A3
4	2.483901GHz to 25GHz	Pk	N	No Significant Emissions Within 20dB of the limit	77.75	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)(3). 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 was made to ensure band edge compliance.

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

Where:

The maximum peak conducted power was measured using a peak power meter or spectrum analyser. Please refer to section A1 of this test report.

dc mode: Non restricted band conducted emissions Limit					
Channel No.	Channel Frequency (MHz)	Measured Peak Conducted Carrier Power (in 100kHz) (mW)	Measured Peak Conducted Carrier (dBμV)	Measured Peak Conducted Carrier – 20dB (dBμV)	Emission Limit 15.247(d) Outside the restricted band in 100 kHz RBW (dBμV)
11	2405	22.23	120.47	120.47-20	100.47
18	2440	29.79	121.74	121.74-20	101.74
24	2470	31.69	122.01	122.01-20	102.01
25	2475	8.55	116.32	116.32-20	96.32
26	2480	0.119	97.75	97.75-20	77.75

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

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

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 CH11	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.4:2003
Frequency range	30MHz to 25GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	RFG389
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)	Det.	Angle. Deg.	Height (cm)	Pol.	Result (dBμV/m)	Spec. Limit (dBμV/m)	Margin (dB)	Summary
1	120.448	Pk	0	104	V	24.6	74.0	-49.4	Pass
2	120.448	Qp	0	104	V	19.6	54.0	-34.4	Pass
3	164.280	Pk	225	102	V	28.8	74.0	-45.2	Pass
4	164.280	Qp	225	102	V	23.3	54.0	-30.7	Pass
5	168.012	Pk	200	100	V	27.0	74.0	-47.0	Pass
6	168.012	Qp	200	100	V	22.1	54.0	-31.9	Pass
7	240.009	Pk	358	100	V	23.6	74.0	-50.4	Pass
8	240.009	Qp	358	100	V	21.7	54.0	-32.3	Pass
9	263.990	Pk	77	102	H	24.3	74.0	-49.7	Pass
10	263.990	Qp	77	102	H	21.9	54.0	-32.1	Pass
11	2390.000	Pk	120	100	H	68.3	74.0	-5.7	Pass
12	2390.000	Av	120	100	H	58.1	54.0	4.1	Pass (Note 7)
13	2400.000	Pk	120	100	H	84.6	103.3	-18.7	Pass
14	2400.000	Av	120	100	H	77.0	83.3	-6.3	Pass
15	2483.500	Pk	0	100	H	58.4	74.0	-15.6	Pass
16	2483.500	Av	0	100	H	45.6	54.0	-8.4	Pass

Radiated Electric Field Emissions Within The Restricted Band 15.205/15.209 continued:

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

Ref No.	Freq (MHz)	Det.	Angle. Deg.	Height (cm)	Pol.	Result (dBμV/m)	Spec. Limit (dBμV/m)	Margin (dB)	Summary
17	4808.926	Pk	124	100	H	63.0	74.0	-11.0	Pass
18	4808.926	Av	124	100	H	54.0	54.0	0	Pass (Note 7)
19	12027.355	Pk	220	100	V	67.3	74.0	-6.7	Pass
20	12027.355	Av	220	100	V	59.1	54.0	5.1	Pass (Note 7)

Radiated Electric Field Emissions Within The Restricted Band 15.205/15.209 continued:

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

Test Details CH18	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.4:2003
Frequency range	30MHz to 25GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	RFG389
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)	Det.	Angle. Deg.	Height (cm)	Pol.	Result (dBμV/m)	Spec. Limit (dBμV/m)	Margin (dB)	Summary
1	1202.409	Pk	236	100	V	59.8	74.0	-14.2	Pass
2	1202.409	Av	236	100	V	42.4	54.0	-11.6	Pass
3	2390.000	Pk	120	100	H	58.5	74.0	-15.5	Pass
4	2390.000	Av	120	100	H	45.7	54.0	-8.3	Pass
5	2400.000	Pk	120	100	H	58.2	104.2	-46.0	Pass
6	2400.000	Av	120	100	H	45.0	84.2	-39.2	Pass
7	2483.500	Pk	120	134	H	59.1	74.0	-14.9	Pass
8	2483.500	Av	120	134	H	45.7	54.0	-8.3	Pass
9	4878.785	Pk	56	100	V	62.5	74.0	-11.5	Pass
10	4878.785	Av	56	100	V	51.8	54.0	-2.2	Pass (Note 7)
11	12202.409	Pk	236	100	V	68.2	74.0	-5.8	Pass
12	12202.409	Av	236	100	V	59.5	54.0	5.5	Pass (Note 7)

Radiated Electric Field Emissions Within The Restricted Band 15.205/15.209 continued:

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

Test Details CH26	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.4:2003
Frequency range	30MHz to 25GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	RFG389
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)	Det.	Angle. Deg.	Height (cm)	Pol.	Result (dBμV/m)	Spec. Limit (dBμV/m)	Margin (dB)	Summary
1	2390.000	Pk	120	100	H	47.2	74.0	-26.8	Pass
2	2390.000	Av	120	100	H	34.2	54.0	-19.8	Pass
3	2400.000	Pk	120	100	H	47.4	84.9	-37.5	Pass
4	2400.000	Av	120	100	H	34.3	64.9	-30.6	Pass
5	2483.500	Pk	120	135	H	72.7	74.0	-1.3	Pass[1]
6	2483.500	Av	120	135	H	62.3	54.0	8.3	Pass (Note 7)
7	2483.901	Pk	120	135	H	71.9	74.0	-2.1	Pass[1]
8	2483.901	Av	120	135	H	62.9	54.0	8.9	Pass (Note 7)
9	4960.955	Pk	124	100	H	56.7	74.0	-17.3	Pass
10	4960.955	Av	124	100	H	48.0	54.0	-6.0	Pass

[1]See section 2.2 Note (iii).

Radiated Electric Field Emissions Within The Restricted Band 15.205/15.209 continued:

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

Test Details CH24/CH25 Band-Edge Only	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) Clause 15.247(d) and Clause 15.205
Measurement standard	ANSI C63.4:2003
Frequency range	30MHz to 25GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	RFG389
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 1 and 2

The worst case radiated emission measurements for restricted band edge spurious emissions when the EUT is transmitting on channel 24 (2470MHz):

Ref No.	Freq (MHz)	Det.	Angle. Deg.	Height (cm)	Pol.	Result (dB V/m)	Spec. Limit (dB V/m)	Margin (dB)	Summary
1	2390.000	Pk	0	100	H	58.2	74.0	-15.8	Pass
2	2390.000	Av	120	135	H	44.8	54.0	-9.2	Pass
3	2400.000	Pk	120	135	H	58.7	105.2	-46.5	Pass
4	2400.000	Av	120	135	H	45.4	85.2	-39.8	Pass
5	2483.500	Pk	120	133	H	69.5	74.0	-4.5	Pass[1]
6	2483.500	Av	120	133	H	58.2	54.0	4.2	Pass (Note 7)
7	2484.097	Pk	120	133	H	71.0	74.0	-3.0	Pass
8	2484.097	Av	120	133	H	59.2	54.0	5.2	Pass (Note 7)

The worst case radiated emission measurements for restricted band edge spurious emissions when the EUT is transmitting on channel 25 (2475MHz):

Ref No.	Freq (MHz)	Det.	Angle. Deg.	Height (cm)	Pol.	Result (dB V/m)	Spec. Limit (dB V/m)	Margin (dB)	Summary
1	2390.000	Pk	0	100	H	58.2	74.0	-15.8	Pass
2	2390.000	Av	0	100	H	44.7	54.0	-9.3	Pass
3	2400.000	Pk	0	100	H	58.8	100.0	-41.2	Pass
4	2400.000	Av	0	100	H	45.4	80.0	-34.6	Pass
5	2483.500	Pk	120	135	H	72.8	74.0	-1.2	Pass[1]
6	2483.500	Av	120	135	H	61.9	54.0	7.9	Pass (Note 7)
7	2483.888	Pk	120	135	H	63.2	74.0	-10.8	Pass
8	2483.888	Av	120	135	H	58.7	54.0	4.7	Pass (Note 7)

[1]See section 2.2 Note (iii).

Notes:

1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.4: 2003 section 8.2.1.

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

3 The measurements 2483.5 MHz was made to ensure band edge compliance.

4 Demonstration of band edge compliance at 2.4GHz (which lies outside the restricted bands as defined in section 47CFR15.205(a) is contained in section A2, RF Antenna Conducted Spurious Emissions and Appendix B of this test report.

5 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.

6 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= 1 MHz, VBW = 10 Hz

These settings are as per ANSI C63.4.

7 In accordance with 47CFR 15.35(c) the emissions may be reduced by the duty cycle correction factor. The duty cycle factor was determined by the on-time of the transmitter/100 milliseconds or period, whichever is less See Appendix E for further details.

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).

Radiated emission limits (47 CFR 15:2008 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	210	3	46.4
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 Radiated Electric Field Emissions 15.109 (Receiver/Digital circuitry)

Preliminary radiated electric field emissions testing was performed using a peak detector in an absorber lined screened room.

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	
Regulation	Title 47 of the CFR:2008, Part 15 Subpart (b)
Measurement standard	ANSI C63.4:2003
Class	B – refer to specification limit table below.
Frequency range	30MHz to 25GHz
EUT sample number	S01
Modification state	0
SE in test environment	None
SE isolated from EUT	RFG389
EUT set up	Refer to Appendix C
Photographs	Photographs 1 and 2

The worst case radiated emission measurements are listed below:

Ref No	Freq (MHz)	Det	Ang Deg	Hgt (cm)	Pol	MD (m)	Res at MD (dBuV/m)	SD (m)	Res at SD (dBuV/m)	Spec Limit (dBuV/m)	Margin (dB)	Res Sum
1	55.288	QP	35	100	V	3	18.7	3	18.7	40.0	-21.3	Pass
2	99.787	QP	0	100	V	3	31.8	3	31.8	43.5	-11.7	Pass
3	105.813	QP	0	100	V	3	30.3	3	30.3	43.5	-13.2	Pass
4	120.000	QP	0	100	V	3	25.6	3	25.6	43.5	-17.9	Pass
5	153.317	QP	163	100	V	3	24.8	3	24.8	43.5	-18.7	Pass
6	191.998	QP	220	100	V	3	22.2	3	22.2	43.5	-21.3	Pass
7	216.001	QP	271	100	V	3	24.3	3	24.3	46.0	-21.7	Pass
8	312.000	QP	296	100	H	3	28.8	3	28.8	46.0	-17.2	Pass
9	360.000	QP	180	100	V	3	25.4	3	25.4	46.0	-20.6	Pass

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
88-216	150	43.5
216-960	200	46.0
Above 960	500	54.0

Notes:

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

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

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

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

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

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

(i) Parameter defined by standard and / or single possible, refer to Appendix 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

A5 Power Line Conducted Emissions

The EUT is a dc powered RF module, for modular approval. No assessment to the 47 CFR 15:2008 Clause 15.207 has been made.

A6 6 dB Bandwidth

Measurement of the bandwidth of the transmission between the -6 dB points on the transmitted modulated spectrum was verified using a spectrum analyser. To determine the occupied bandwidth a RBW of 100 kHz and a minimum VBW three times greater than the RBW (1 MHz) was used. The spectrum analyser was then set to take a peak hold measurement. The peak level was found and set to a 0dB reference point and markers offset by -6dB determined the bandwidth. The EUT was set to transmit on its lowest, centre and highest carrier frequency in turn. The formal measurements are detailed below:

Test Details:	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) 15.247(a)(2)
EUT sample number	S02
Modification state	0
SE in test environment	RFG389
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Channel No	Channel Frequency (MHz)	Measured 6 dB Bandwidth (MHz)	Limit	Result
11	2405	1.5705	>500 kHz	Pass
18	2440	1.5625		Pass
26	2480	1.5705		Pass

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

A7 Antenna Gain

The conducted output power limit specified in paragraph (b) is based on the use of antennas with directional gains that do not exceed 6dBi

Calculated Antenna Gain

Maximum Antenna Gain dBi	Limit dBi
9.69	6

The conducted output power limit specified in 47 CFR Part 15 Subpart (c) Clause 15.247(b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

Except as shown in paragraph 47 CFR Part 15 Subpart (c) Clause 15.247(b) (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in 47 CFR Part 15 Subpart (c) clause 15.247 paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

A8 Power Spectral Density

Power spectral density was verified using a spectrum analyser. Testing was performed with the EUT transmitting a modulated carrier on its lowest, centre and highest carrier frequency in turn.

Test Details:	
Regulation	Title 47 of the CFR 2008, Part 15 Subpart (c) 15.247(e)
EUT sample number	S02
Modification state	0
SE in test environment	RFG389
SE isolated from EUT	None
EUT set up	Refer to Appendix C

Channel No	Channel Frequency (MHz)	Measured Power Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)	Result
11	2405	4.00	8.0	Pass
18	2440	4.64		Pass
26	2480	-16.88		Pass

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) Any conducted emissions detected within the restricted band were formally assessed against the 47 CFR Part 15 Subpart (c) Clause 15.209 radiated electric field emissions limits. For details of formal results, refer to Appendix A and Appendix B.

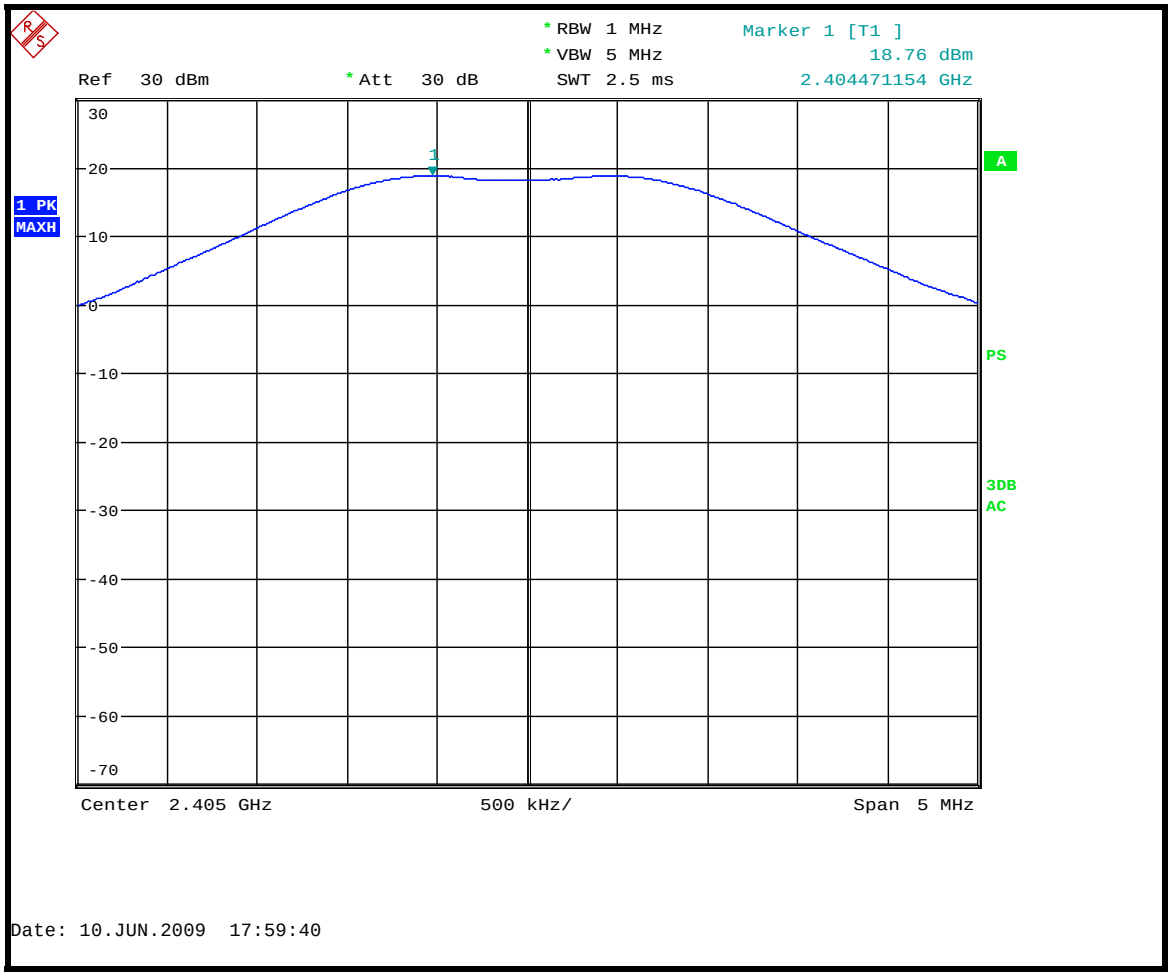
(c) The limit line on the radiated emission plots is the 15.109 & 15.209 limits that corresponds to emissions digital circuitry and emissions within the restricted bands and . Any emissions detected within the restricted band were formally assessed against the limits in 47 CFR Part 15 Subpart (c) Clause 15.209.

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

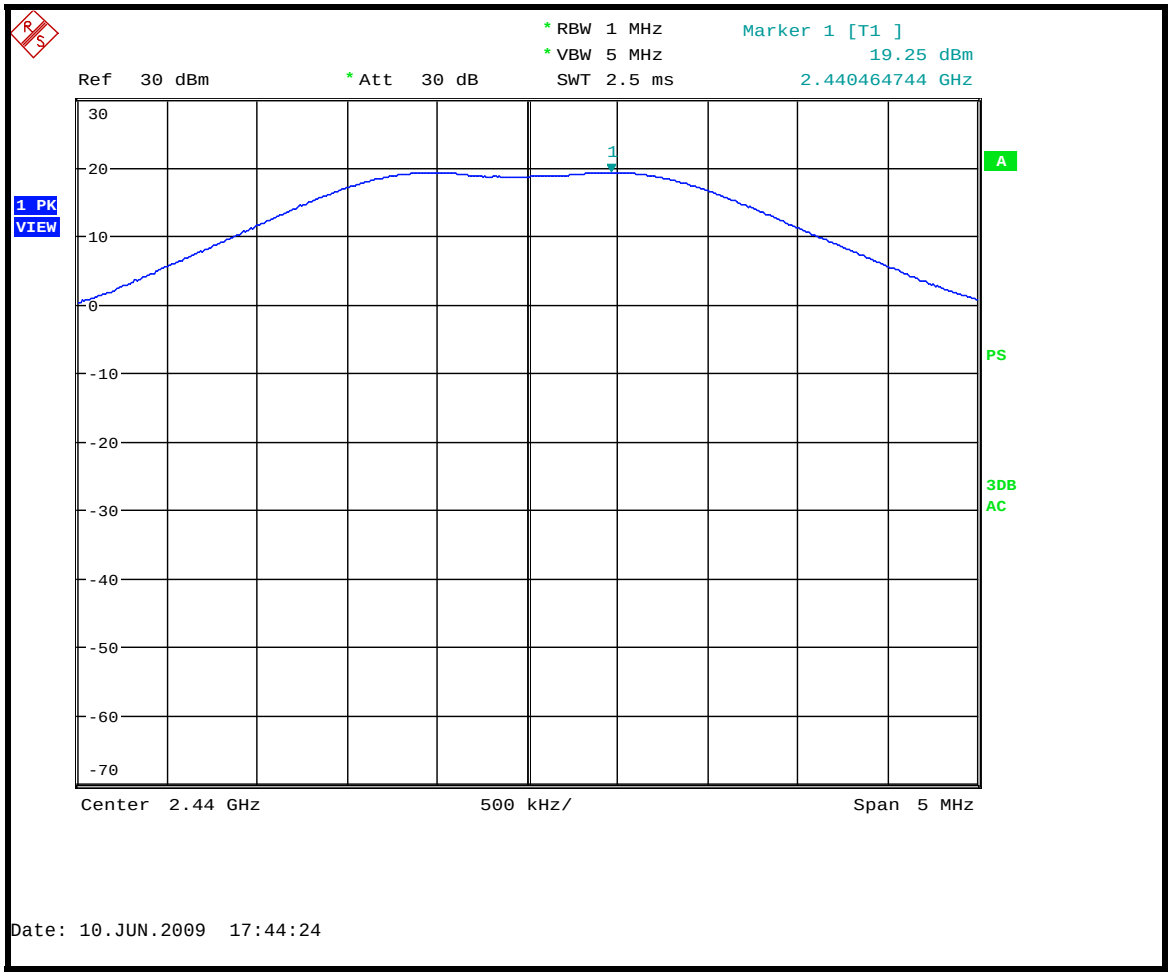
(e) Where relevant, on power line conducted emission plots, the limit displayed is the average limit, which is stricter than the quasi peak limit.

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

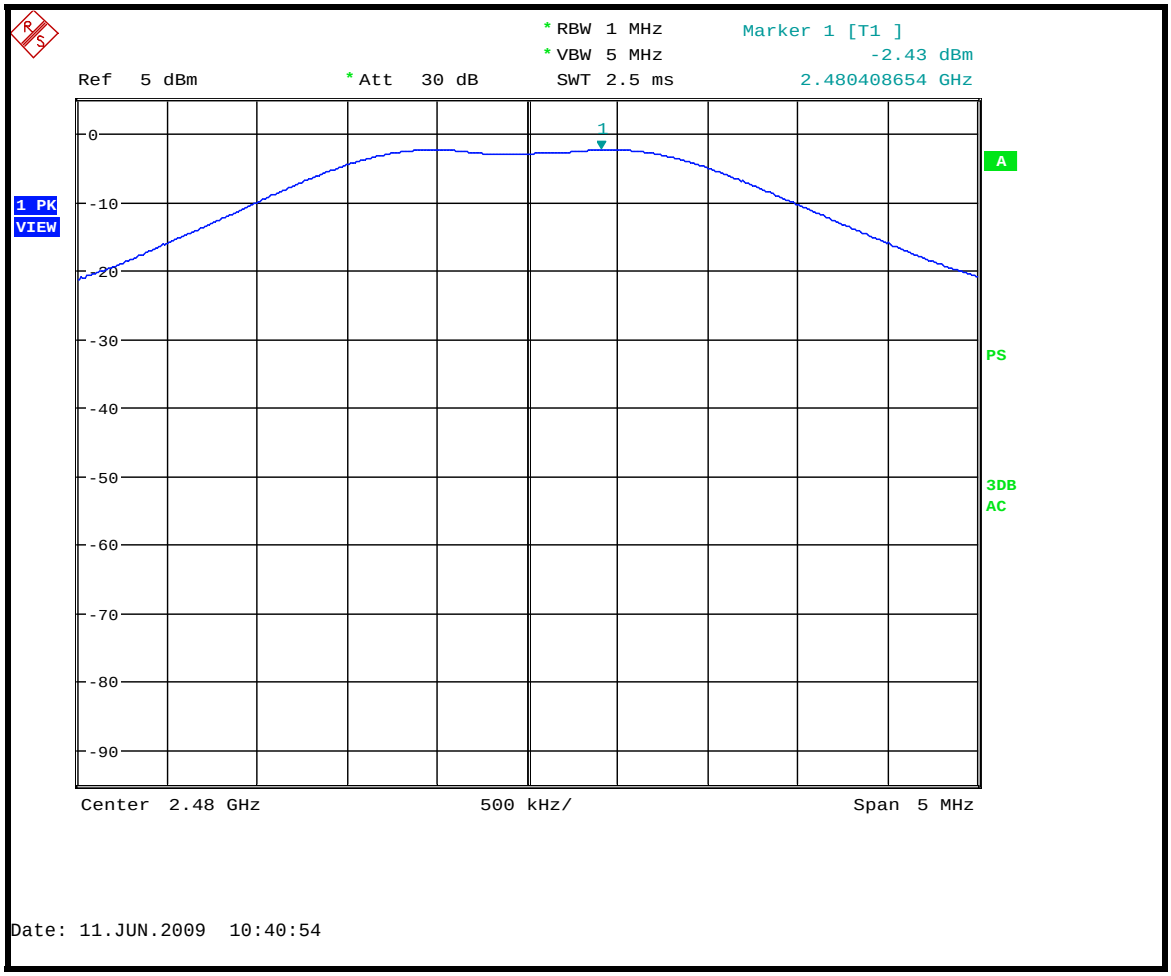
(g) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.



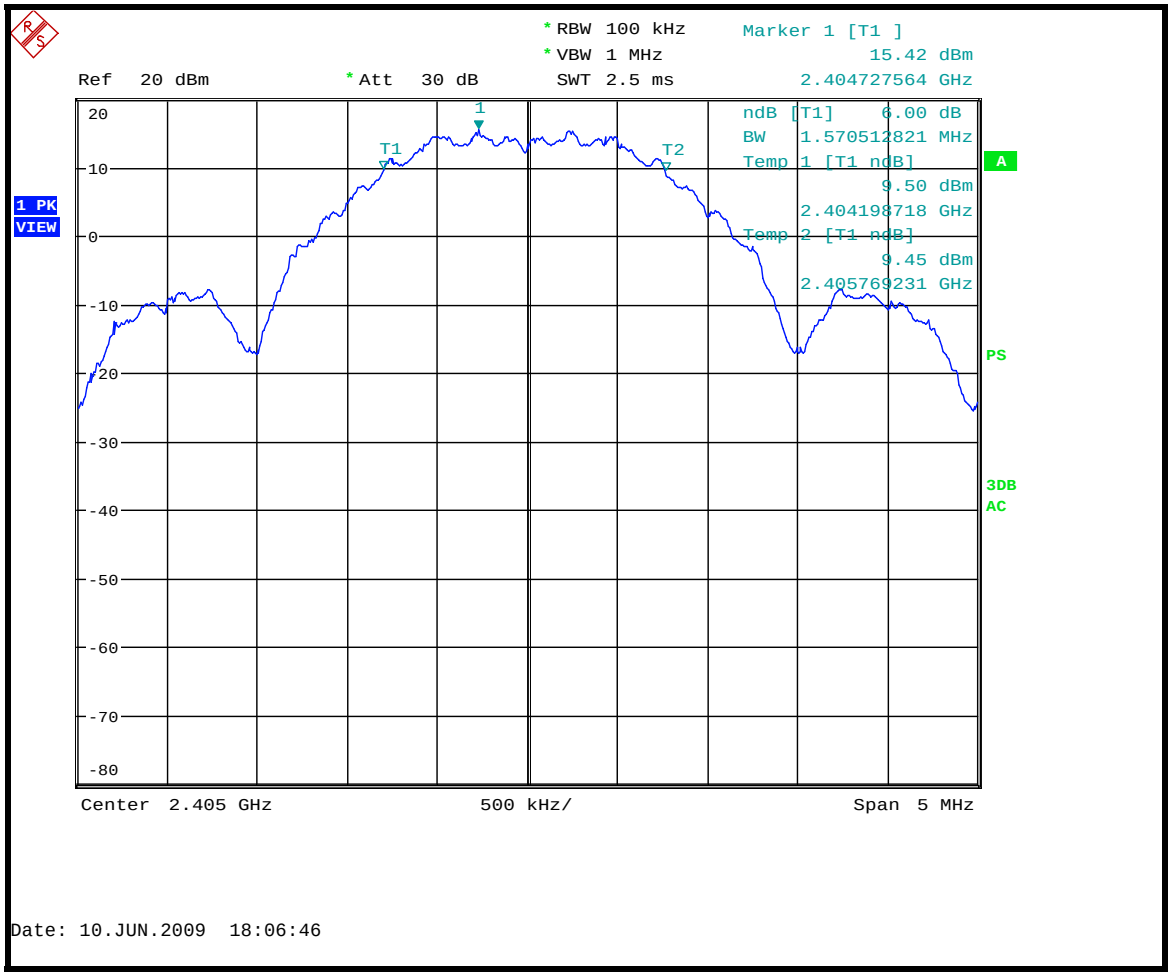
Conducted Carrier Power: Channel 11 2405MHz



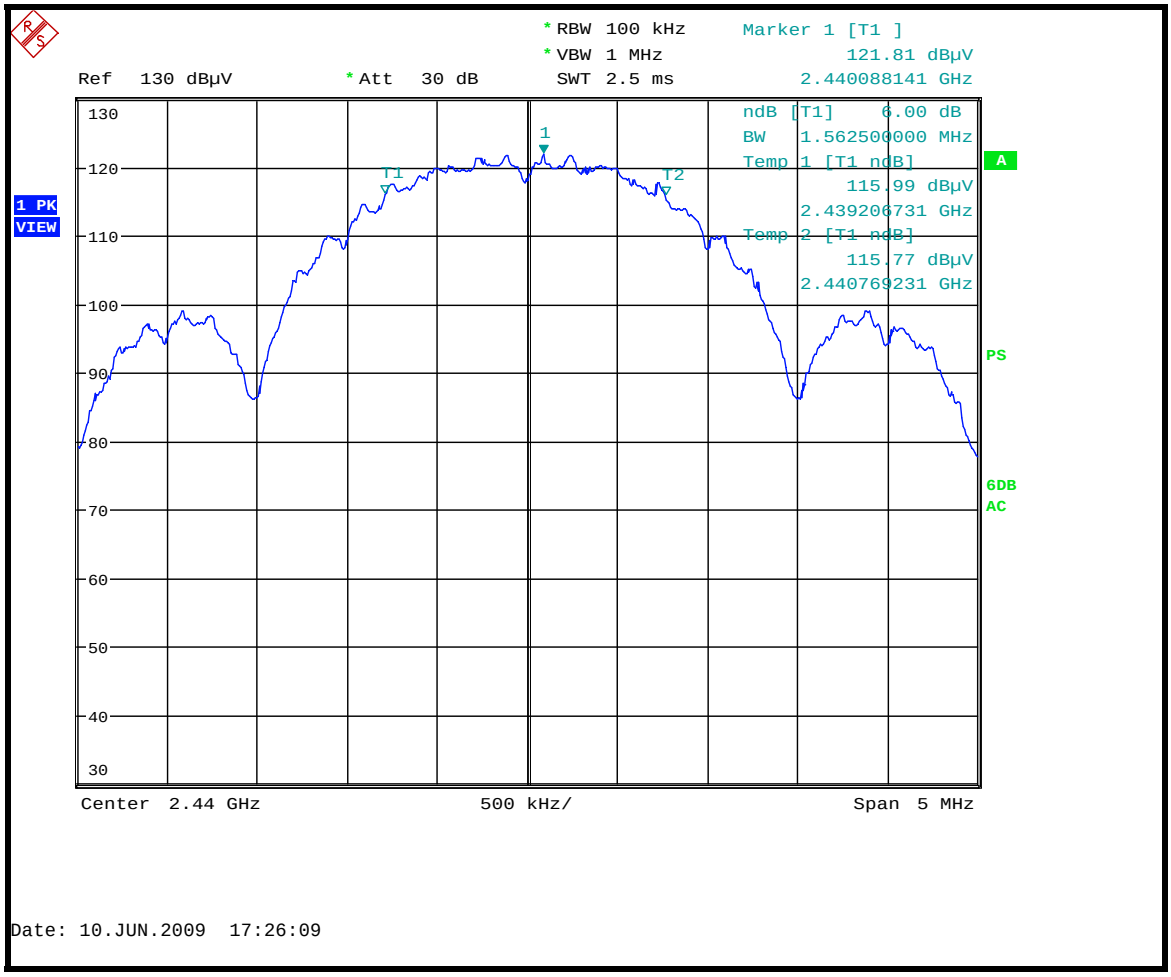
Conducted Carrier Power: Channel 18 2440MHz



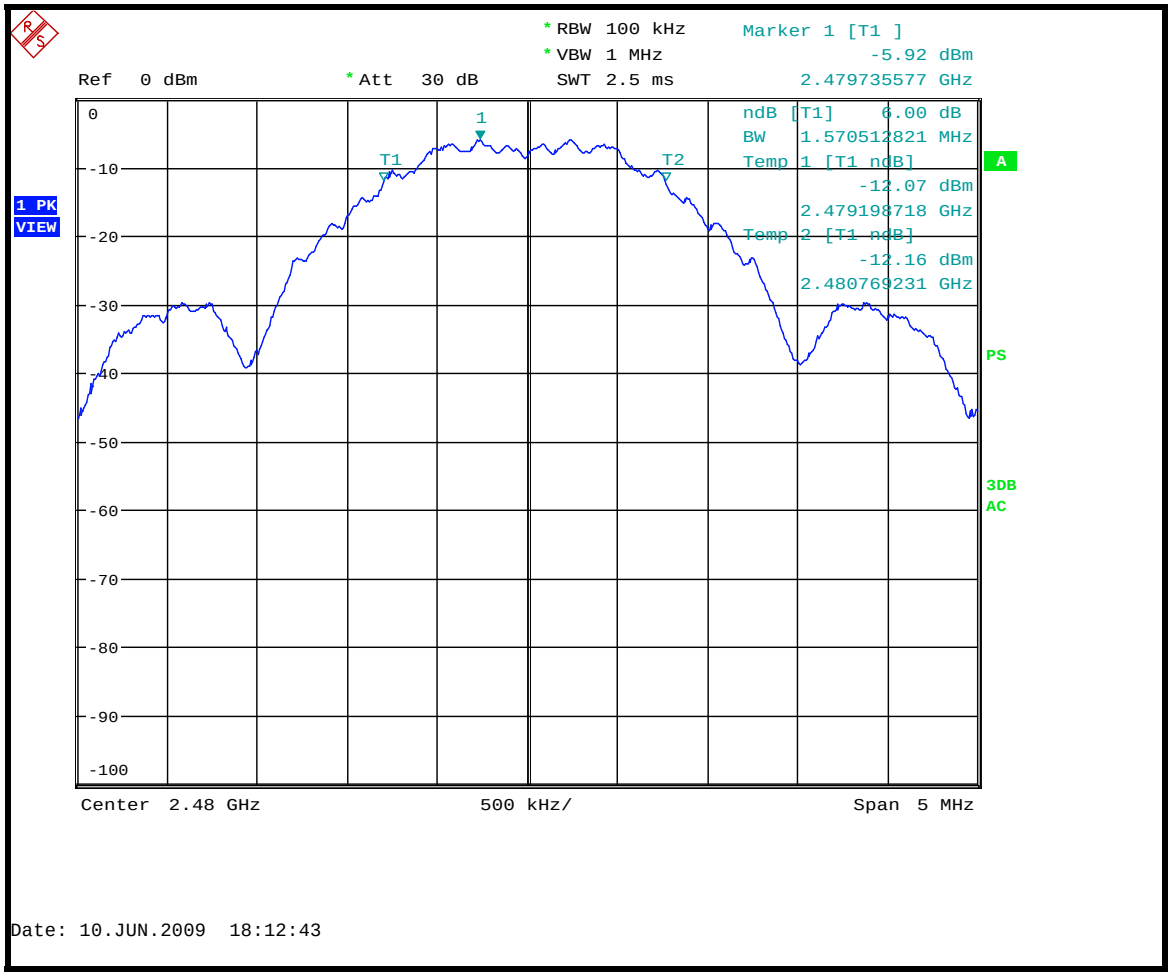
Conducted Carrier Power: Channel 26 2480MHz



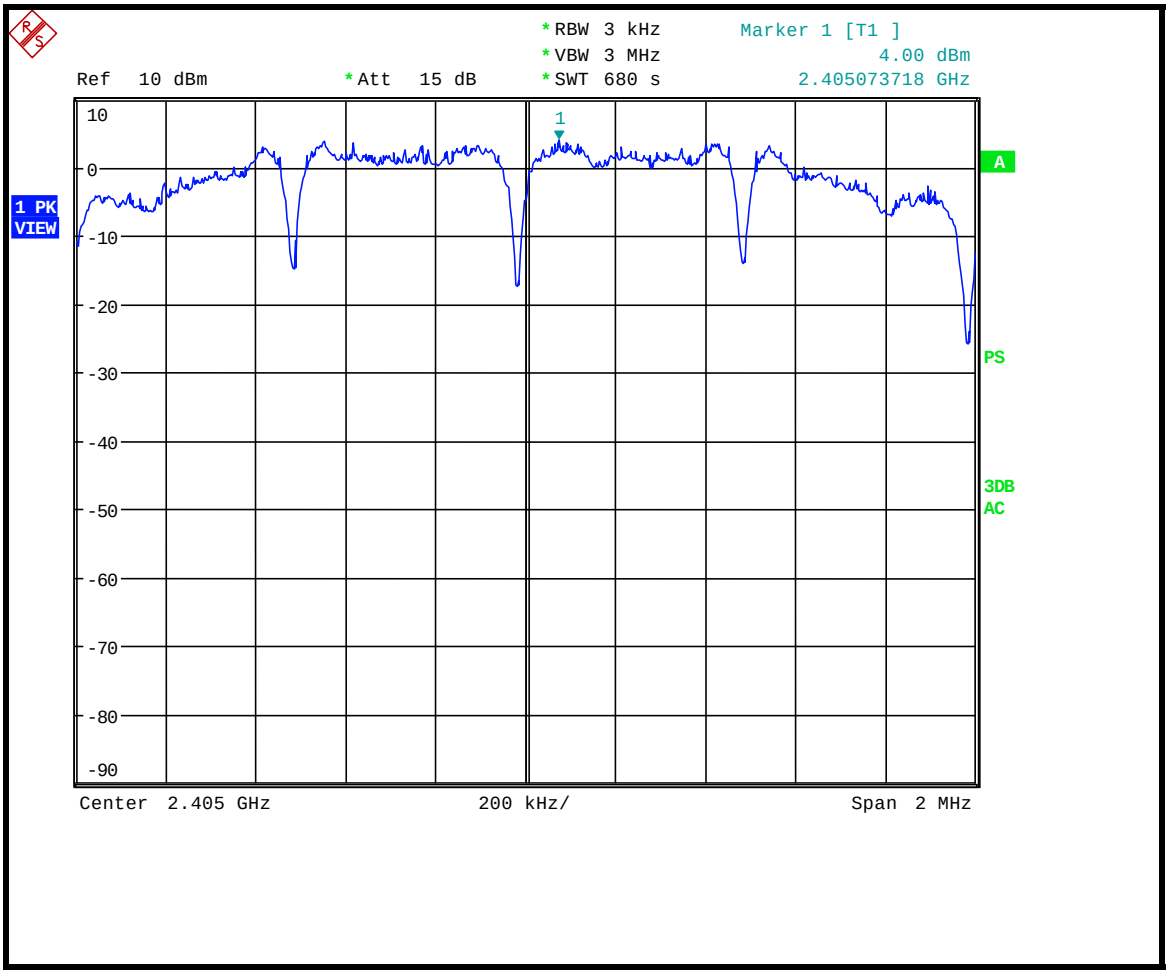
6dB Bandwidth: Channel 11 2405MHz



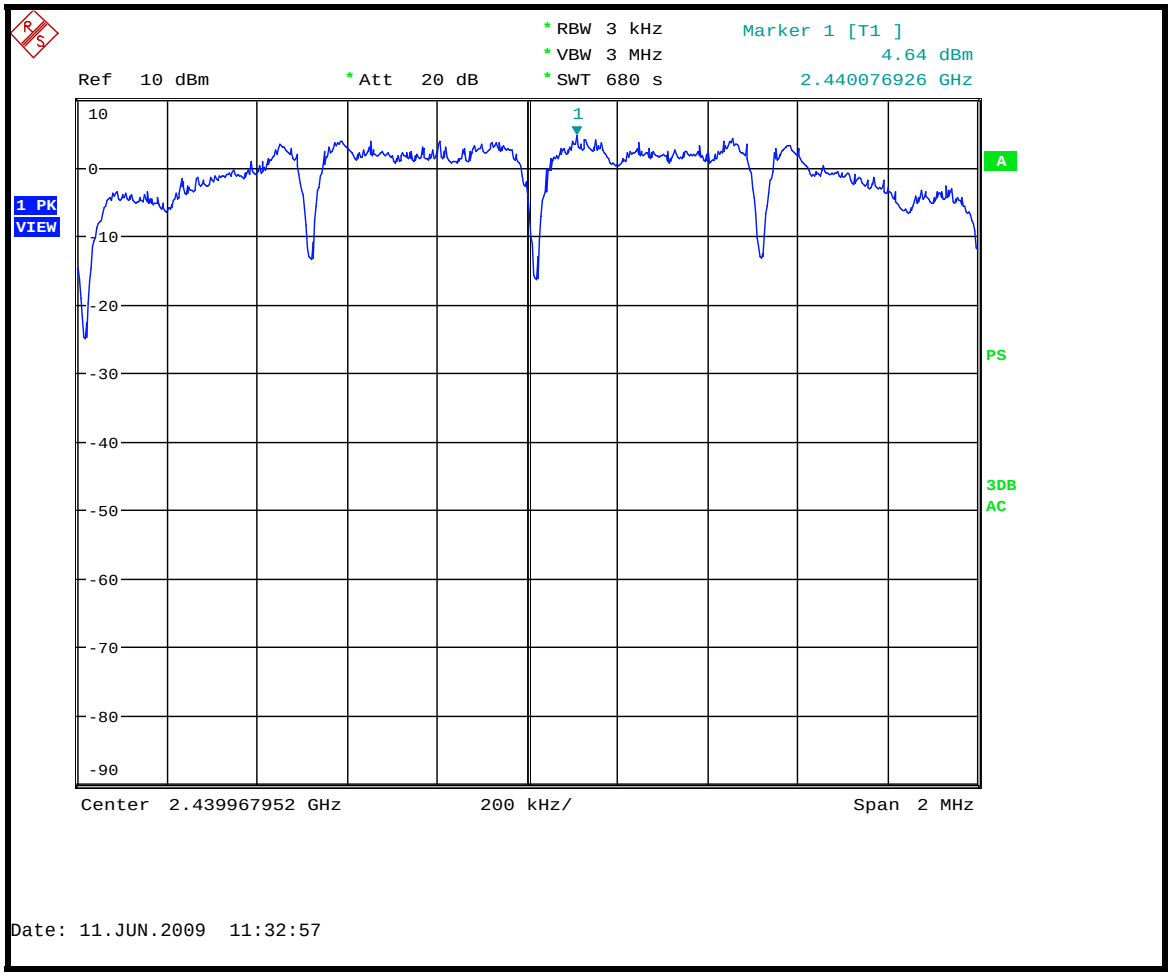
6dB Bandwidth: Channel 18 2440MHz



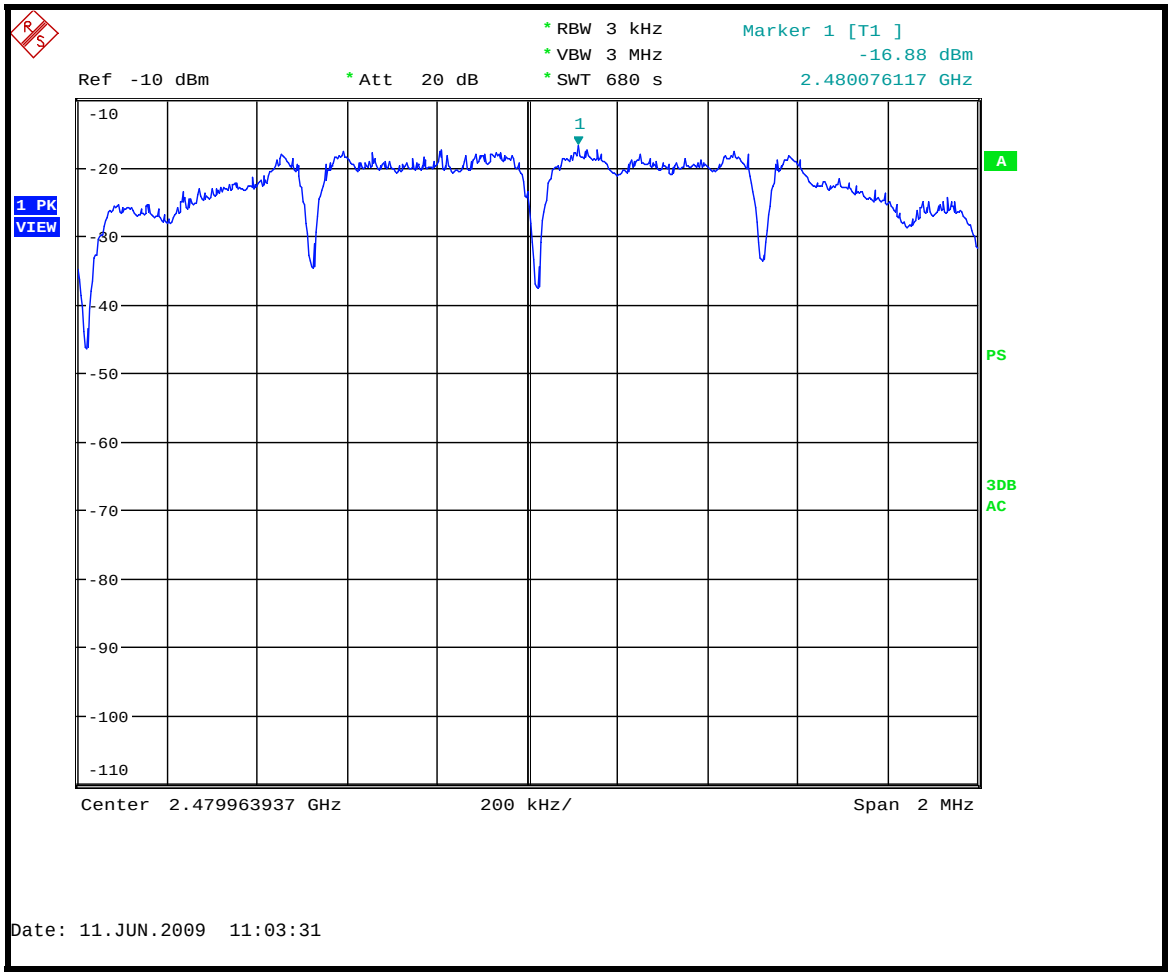
6dB Bandwidth: Channel 26 2480MHz



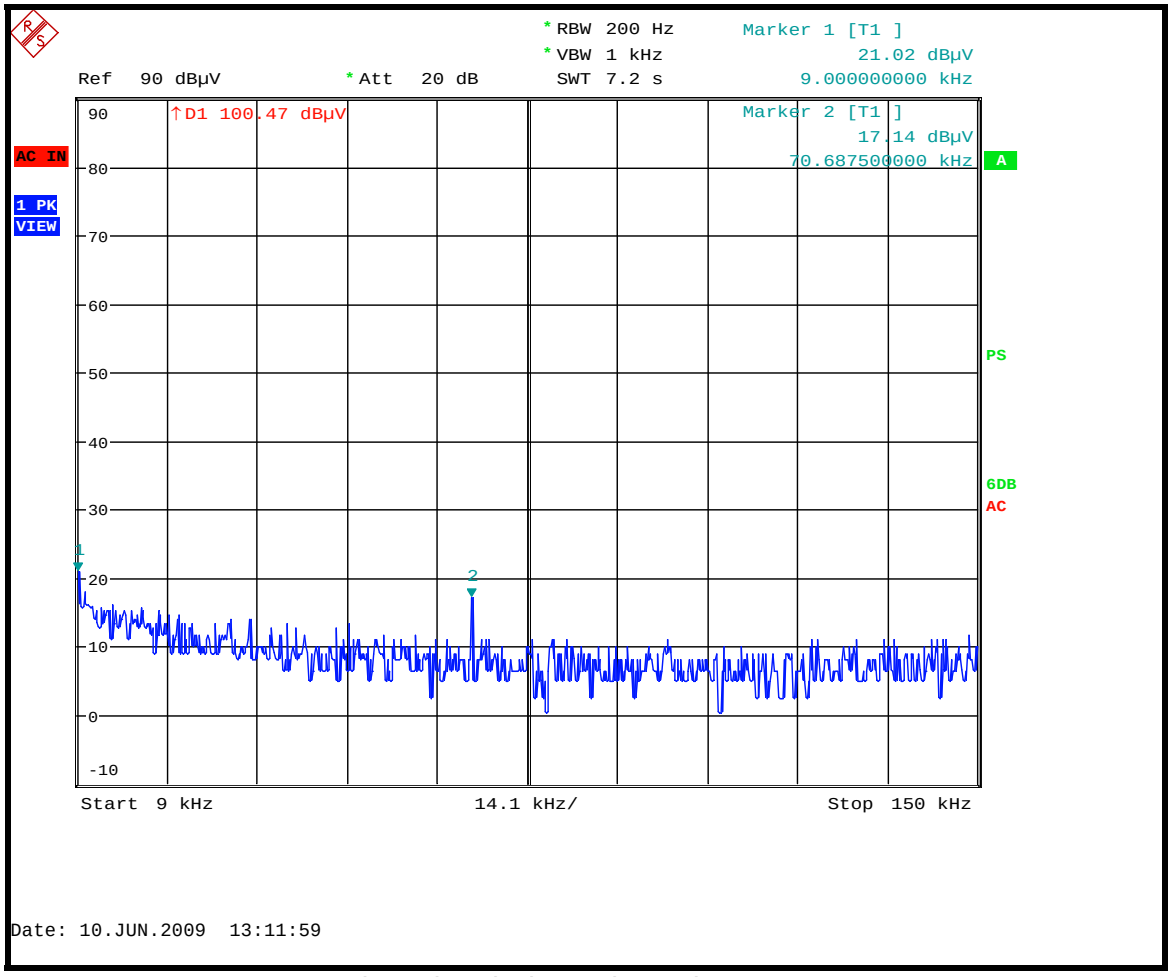
Power Spectral Density: Channel 11 2405MHz



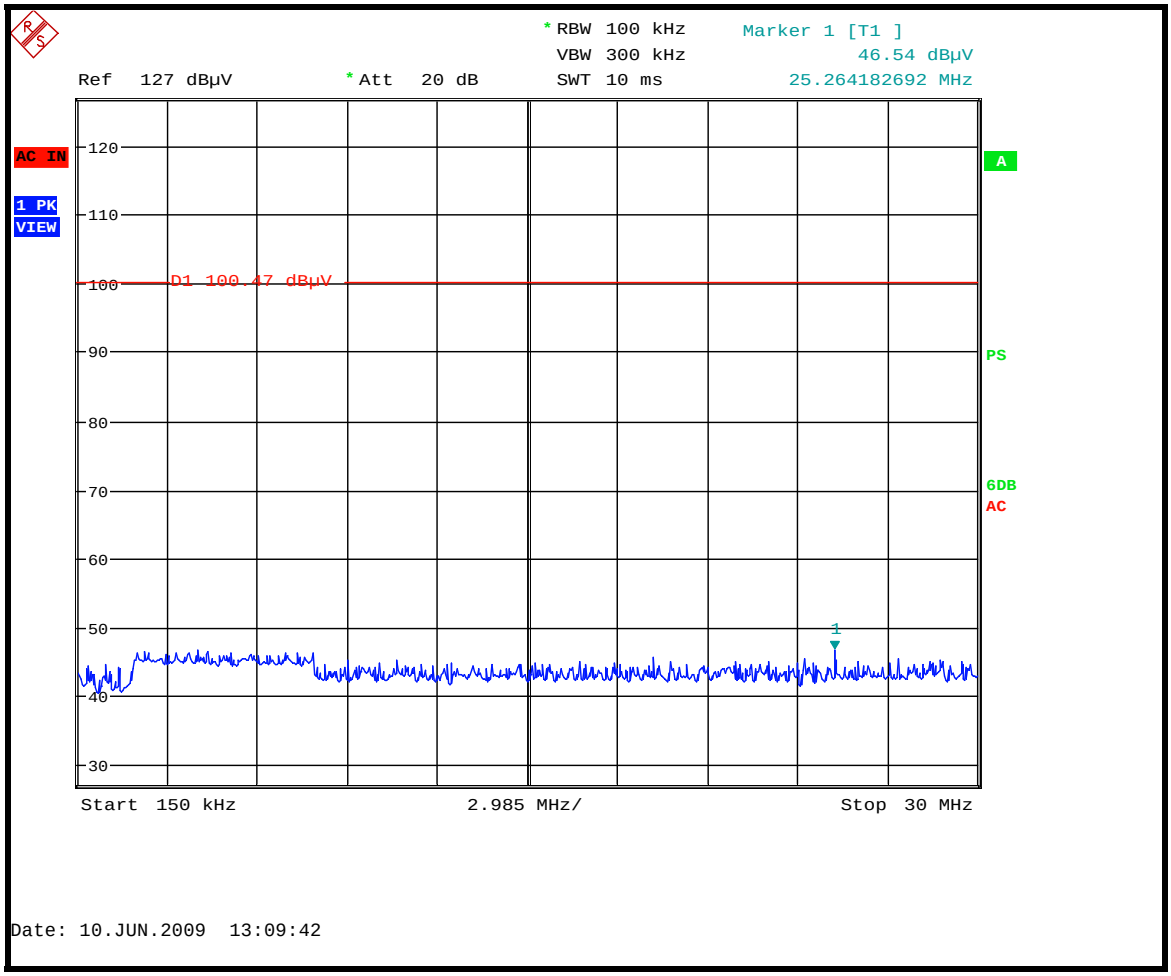
Power Spectral Density: Channel 18 2440MHz



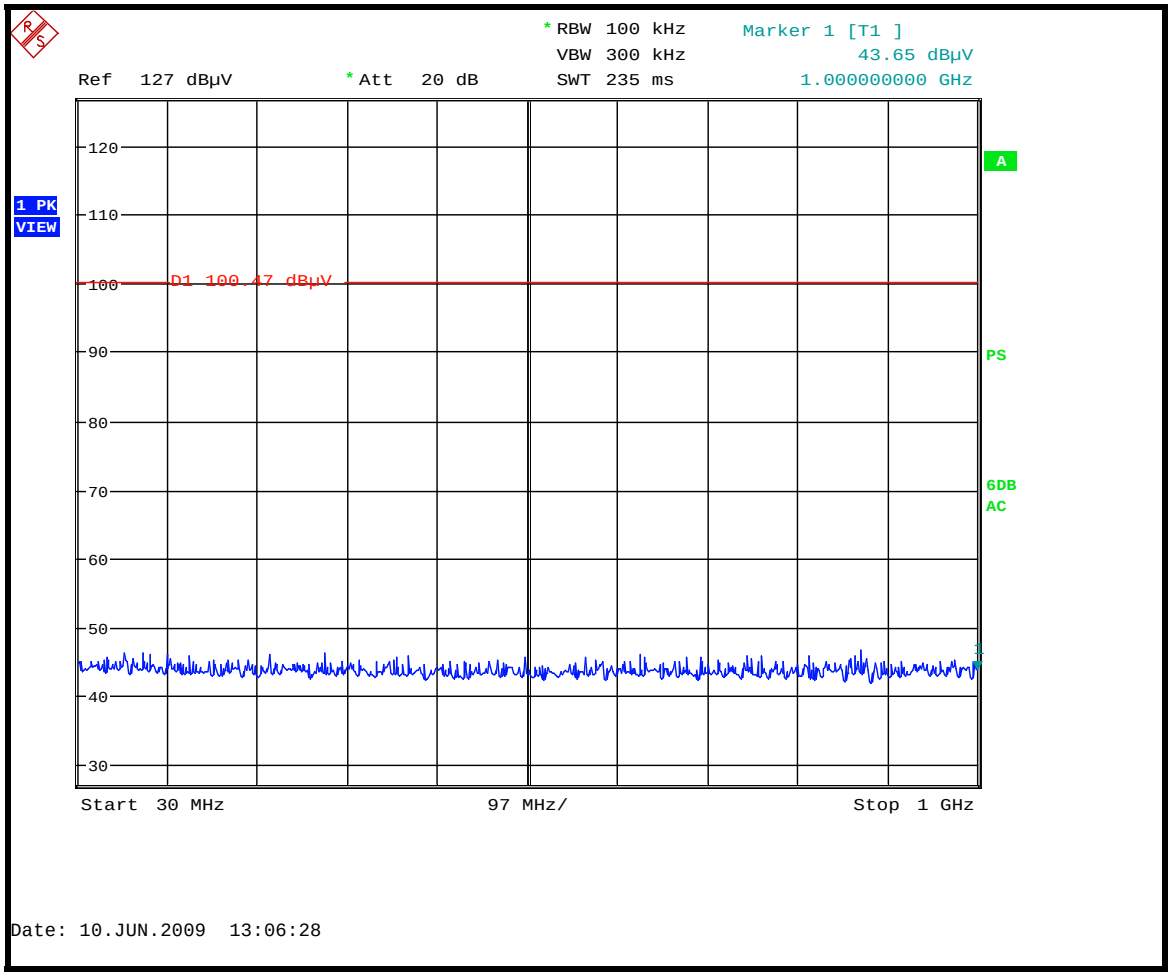
Power Spectral Density: Channel 26 2480MHz



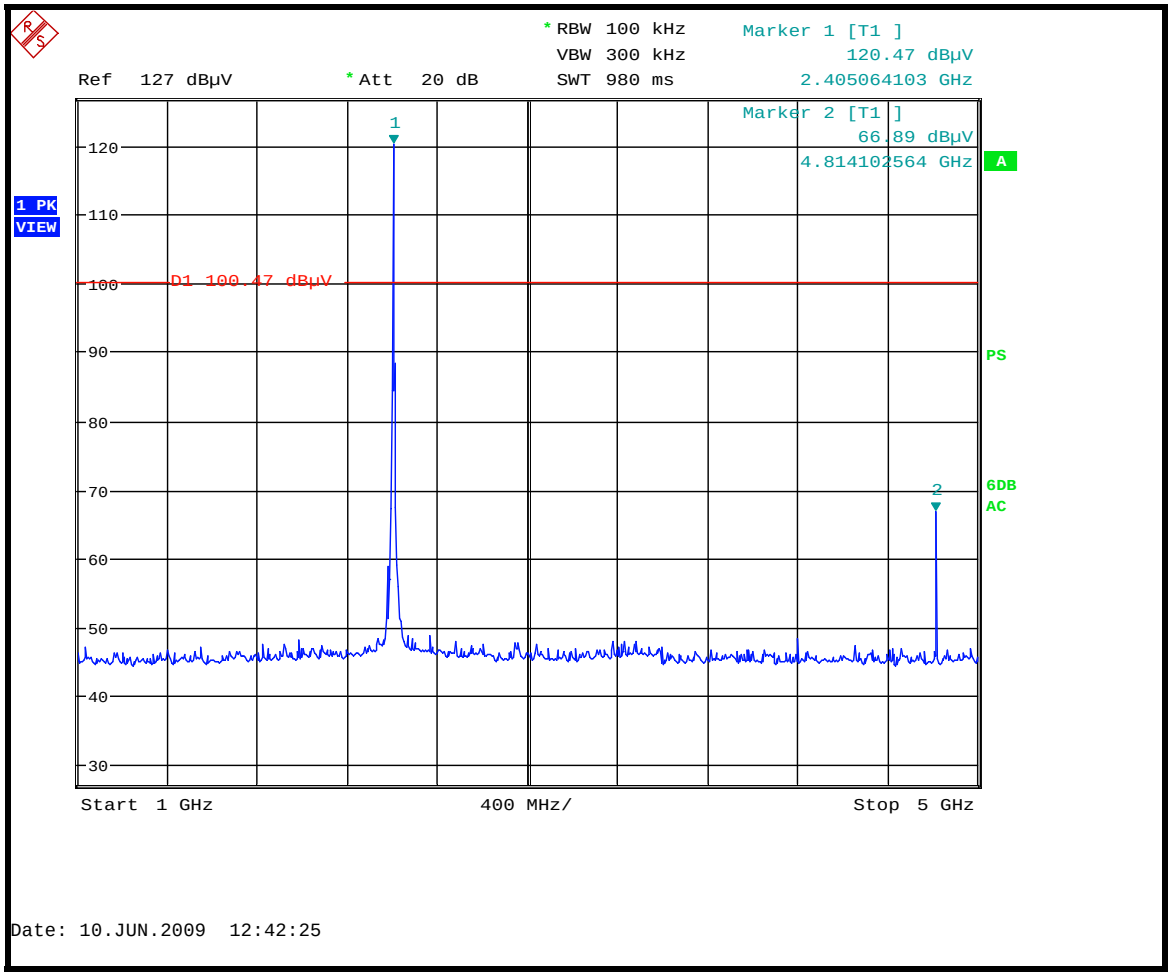
Conducted Emissions Channel 11 2405MHz



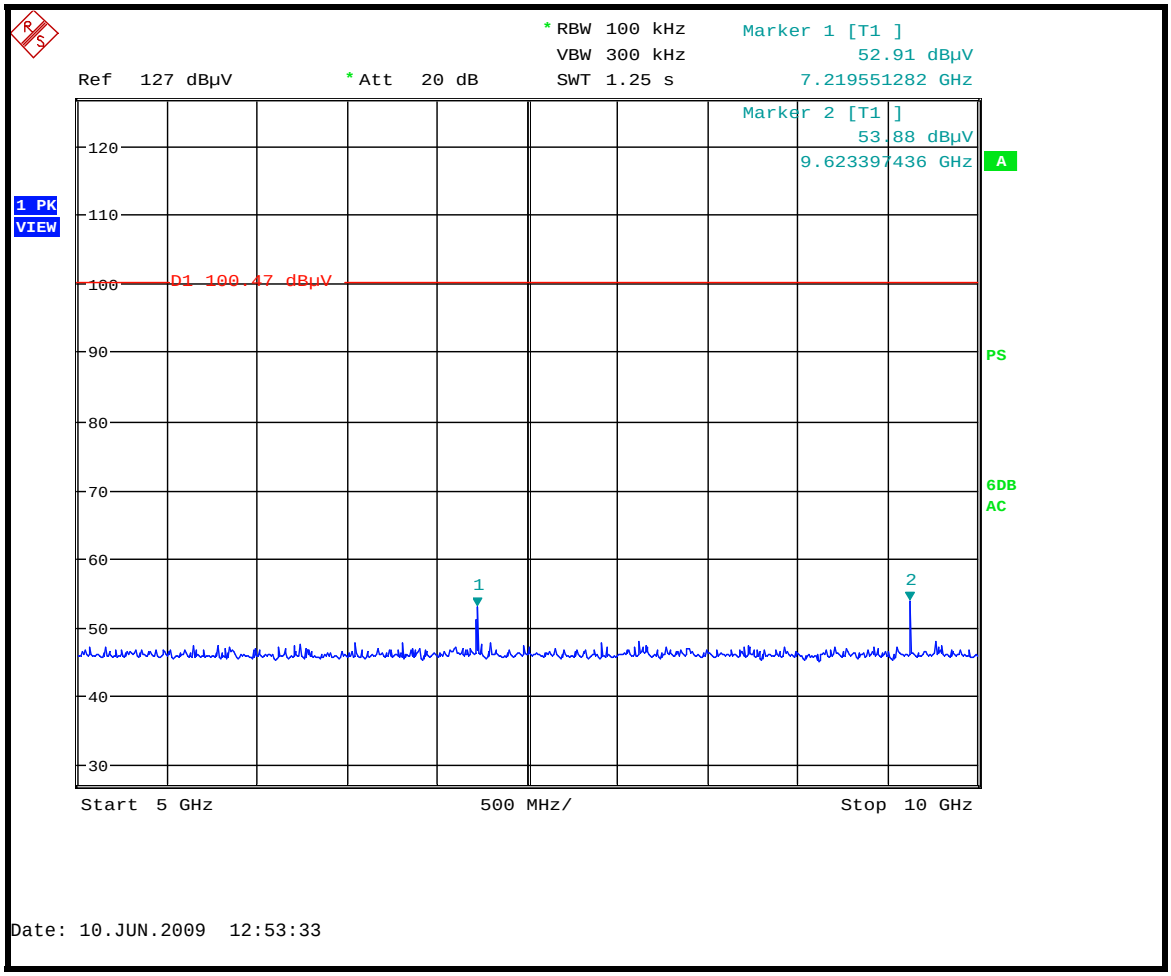
Conducted Emissions Channel 11 2405MHz



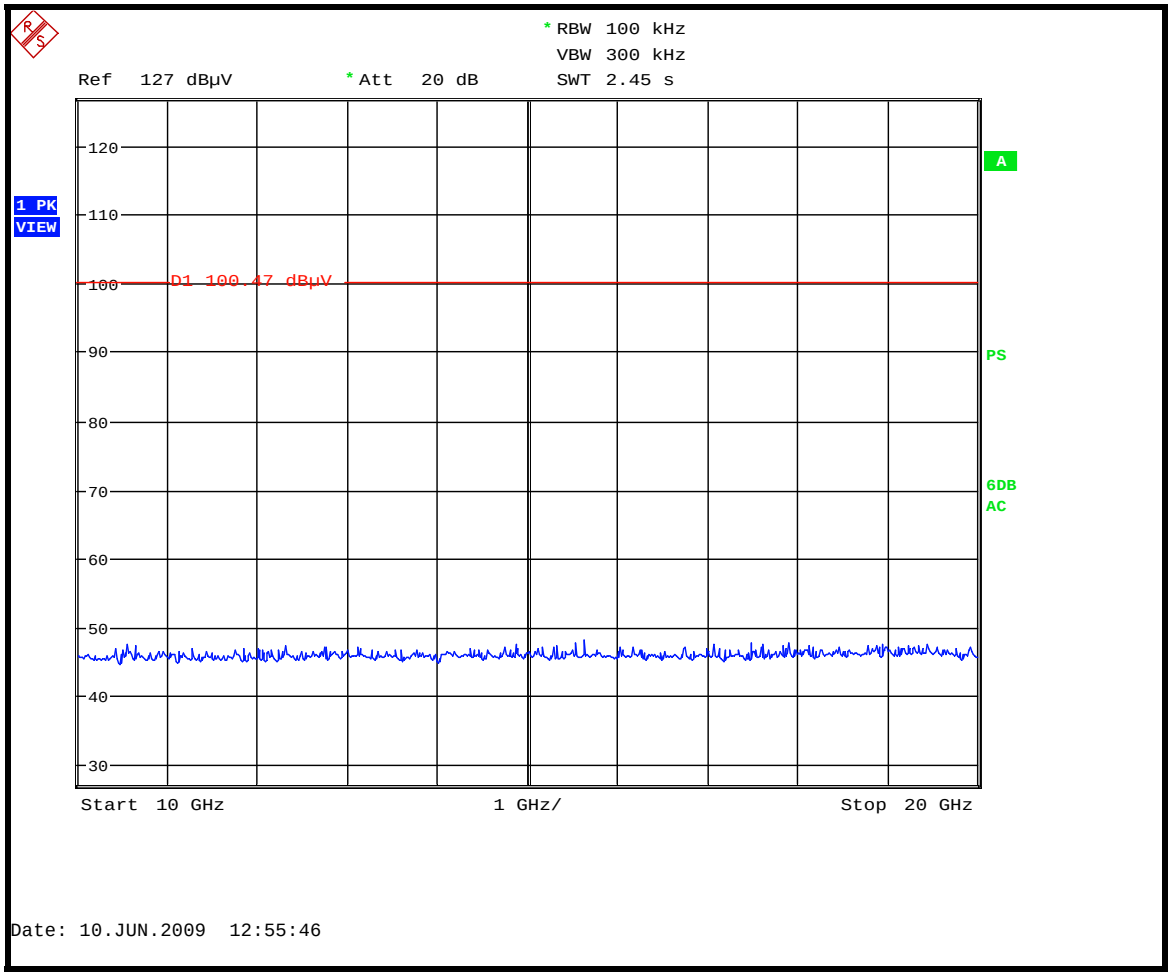
Conducted Emissions Channel 11 2405MHz



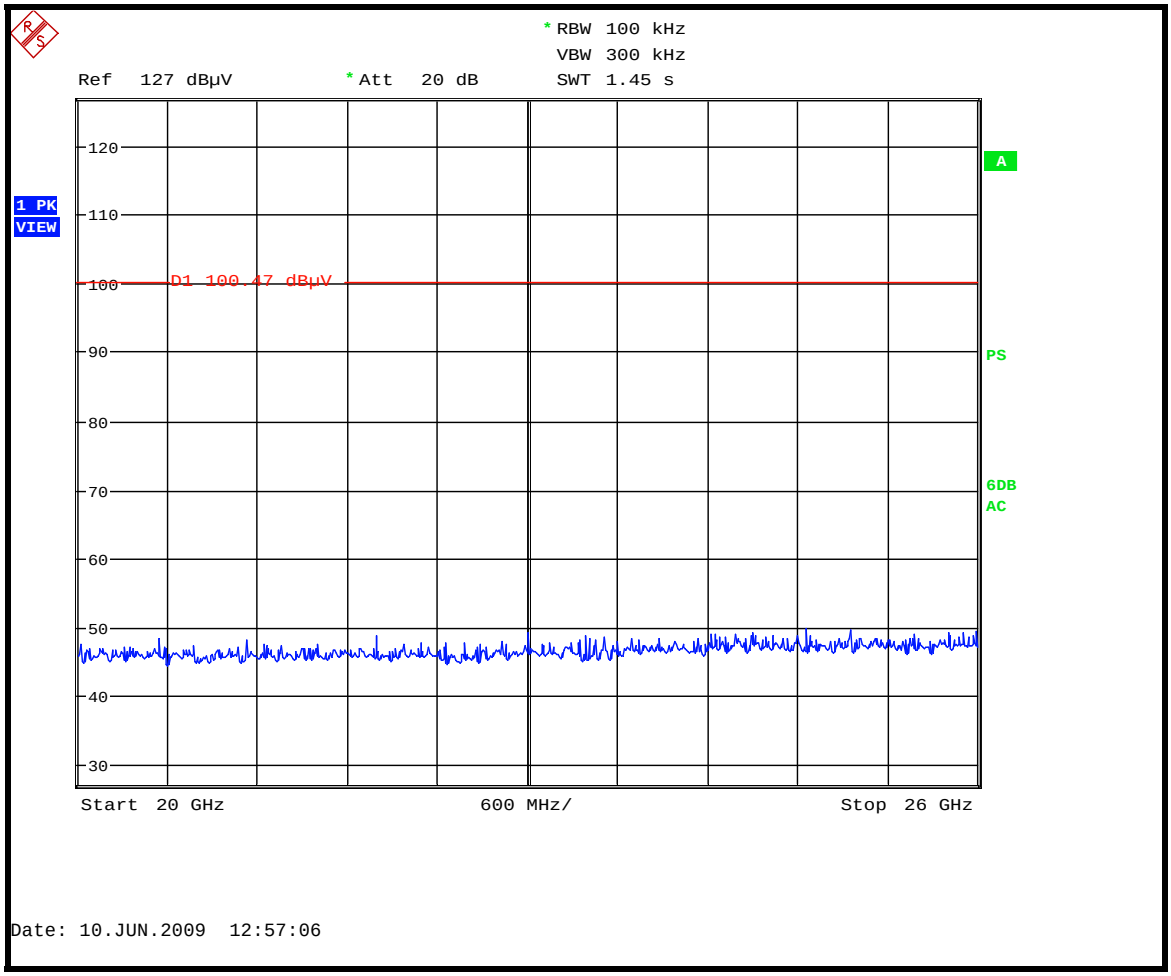
Conducted Emissions Channel 11 2405MHz



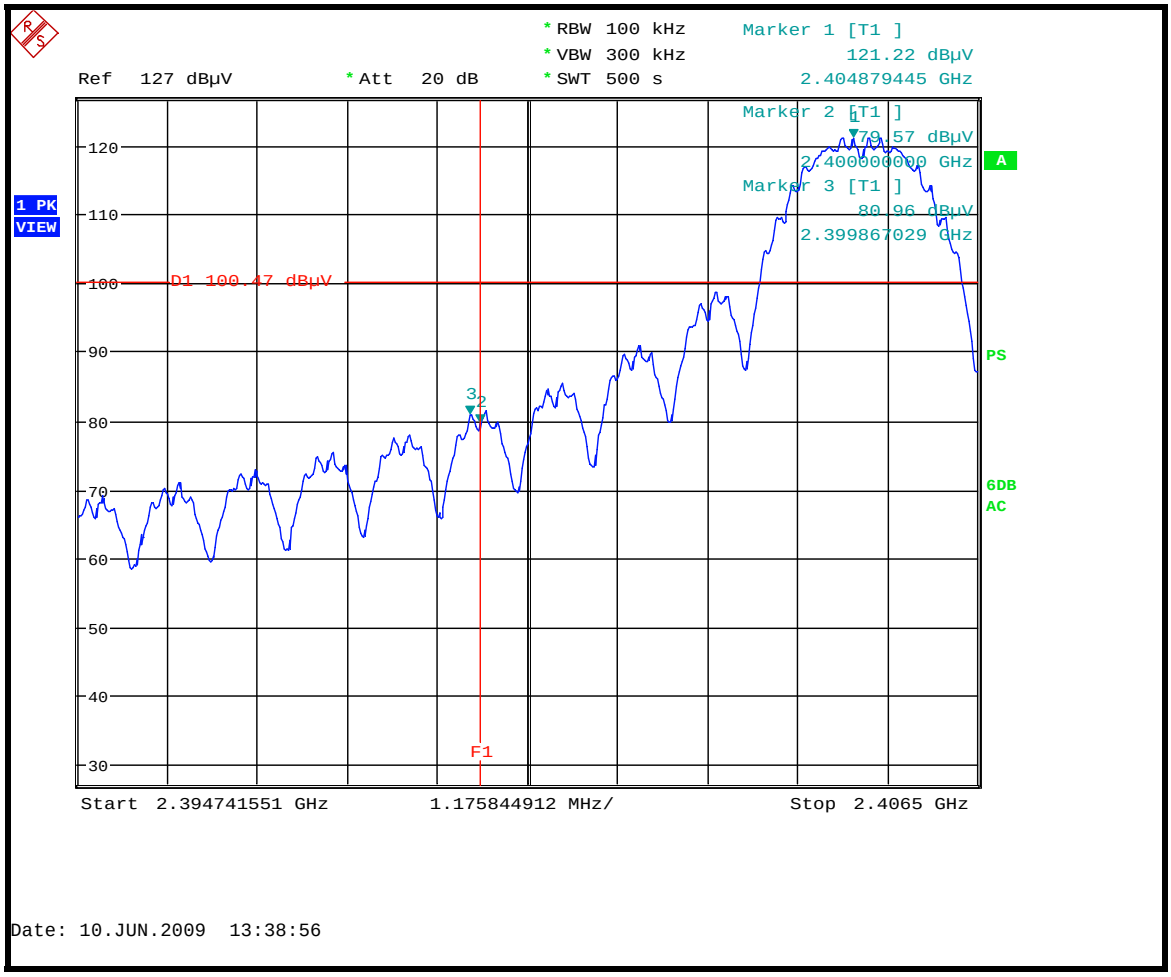
Conducted Emissions Channel 11 2405MHz



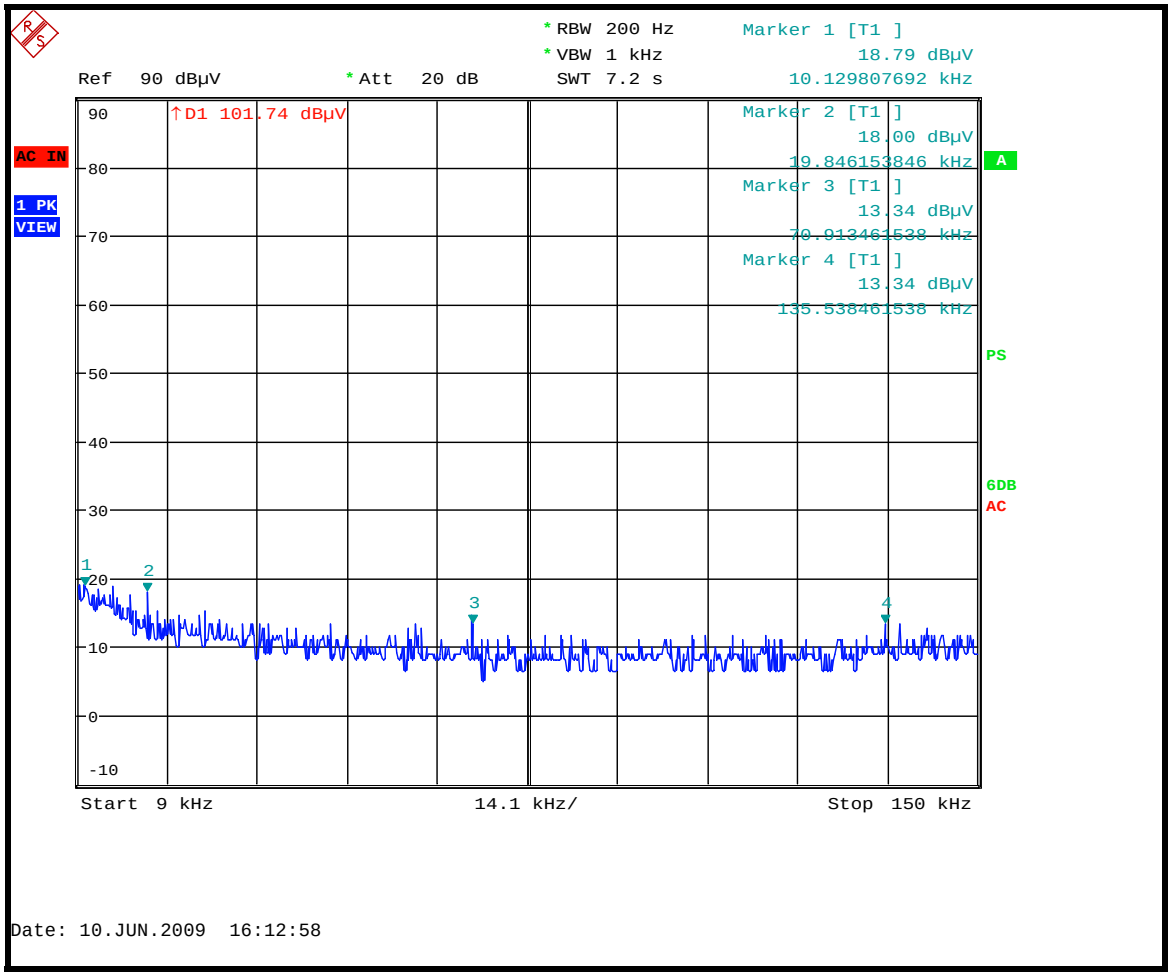
Conducted Emissions Channel 11 2405MHz



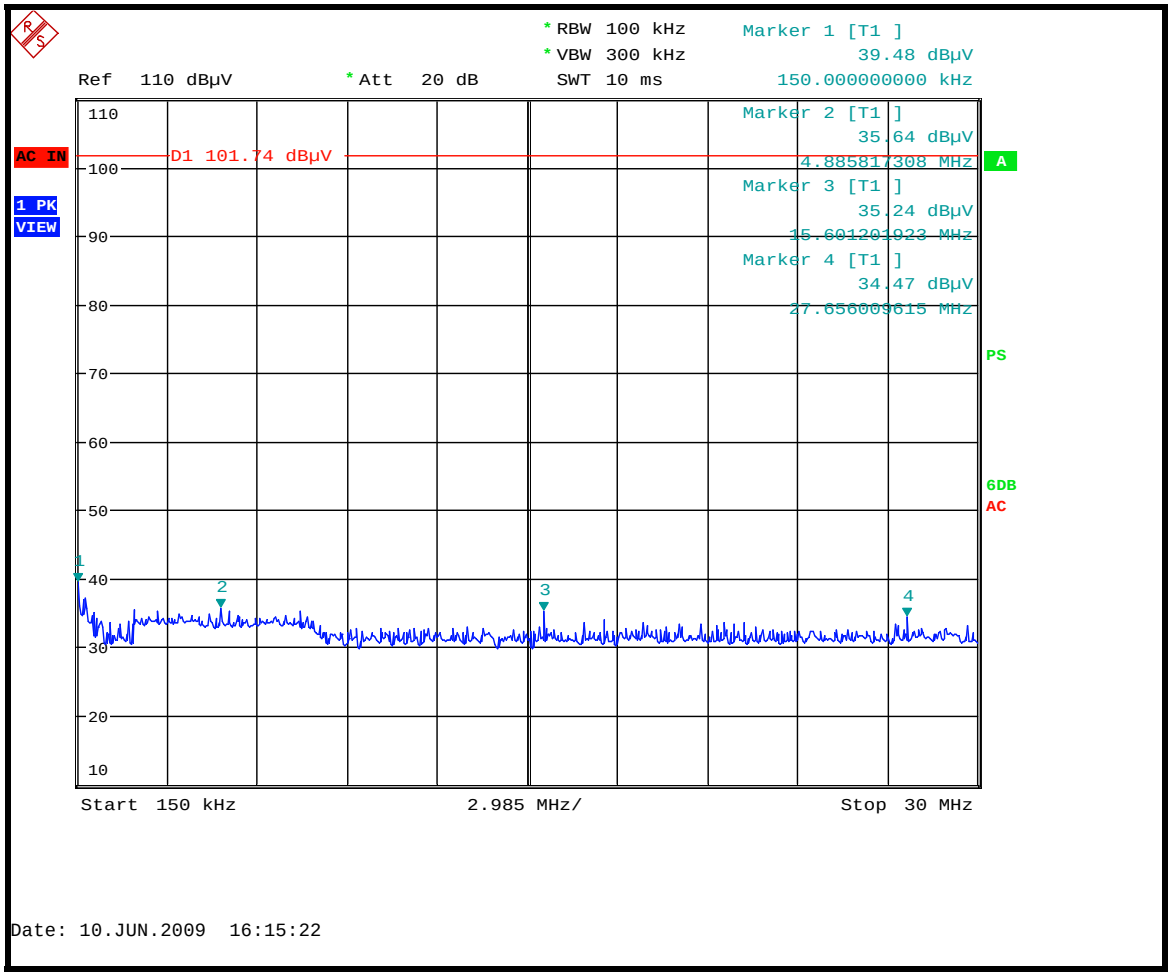
Conducted Emissions Channel 11 2405MHz



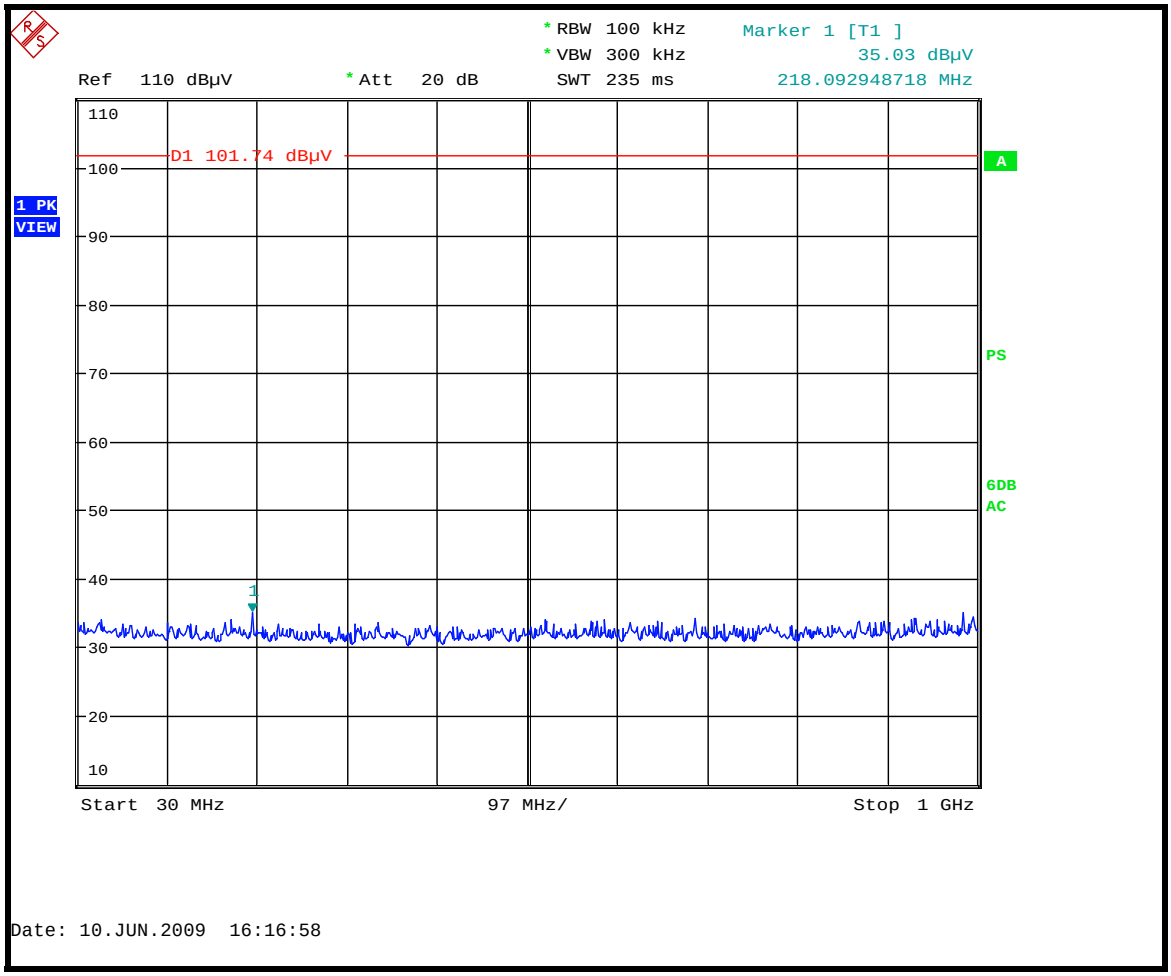
Conducted Emissions Channel 11 2405MHz: Lower-Band edge



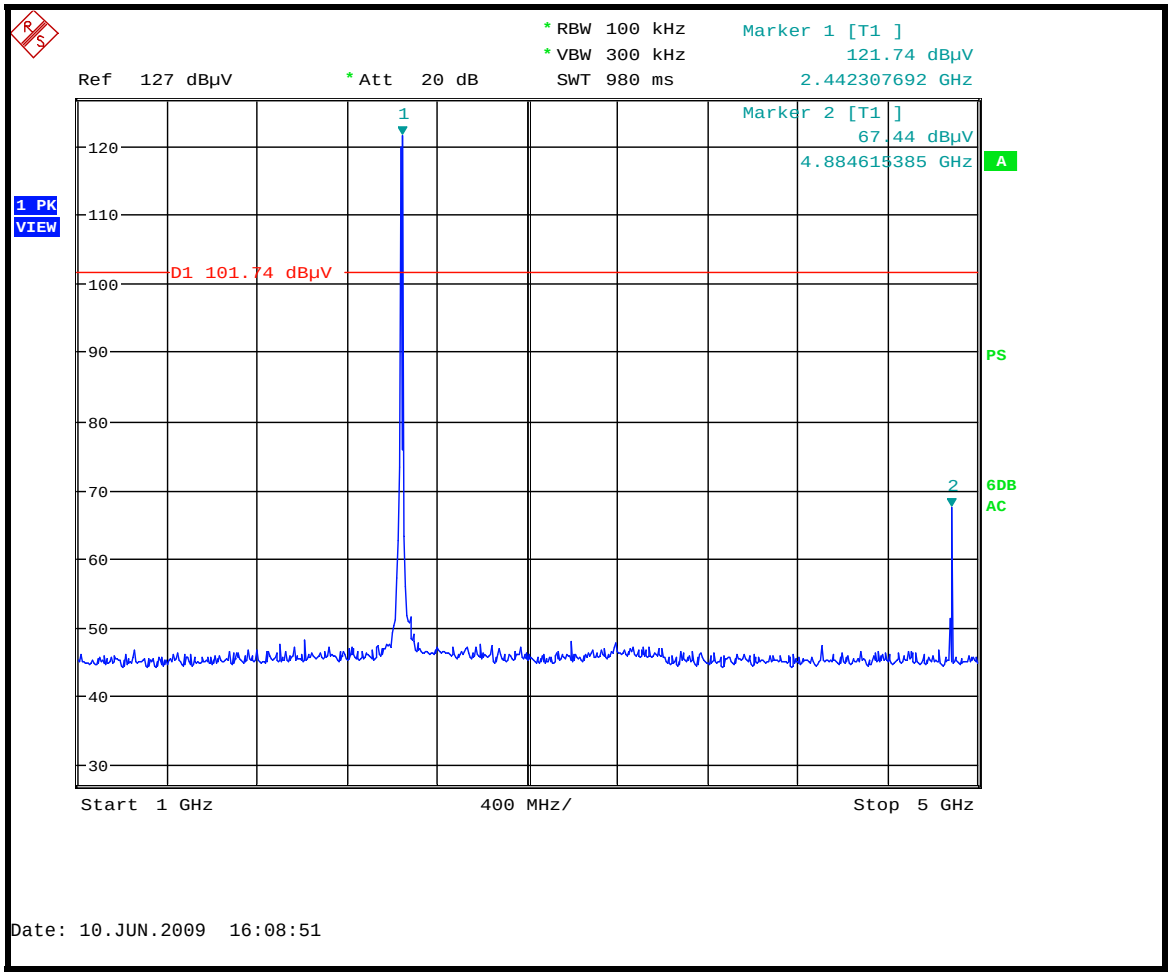
Conducted Emissions Channel 18 2440MHz



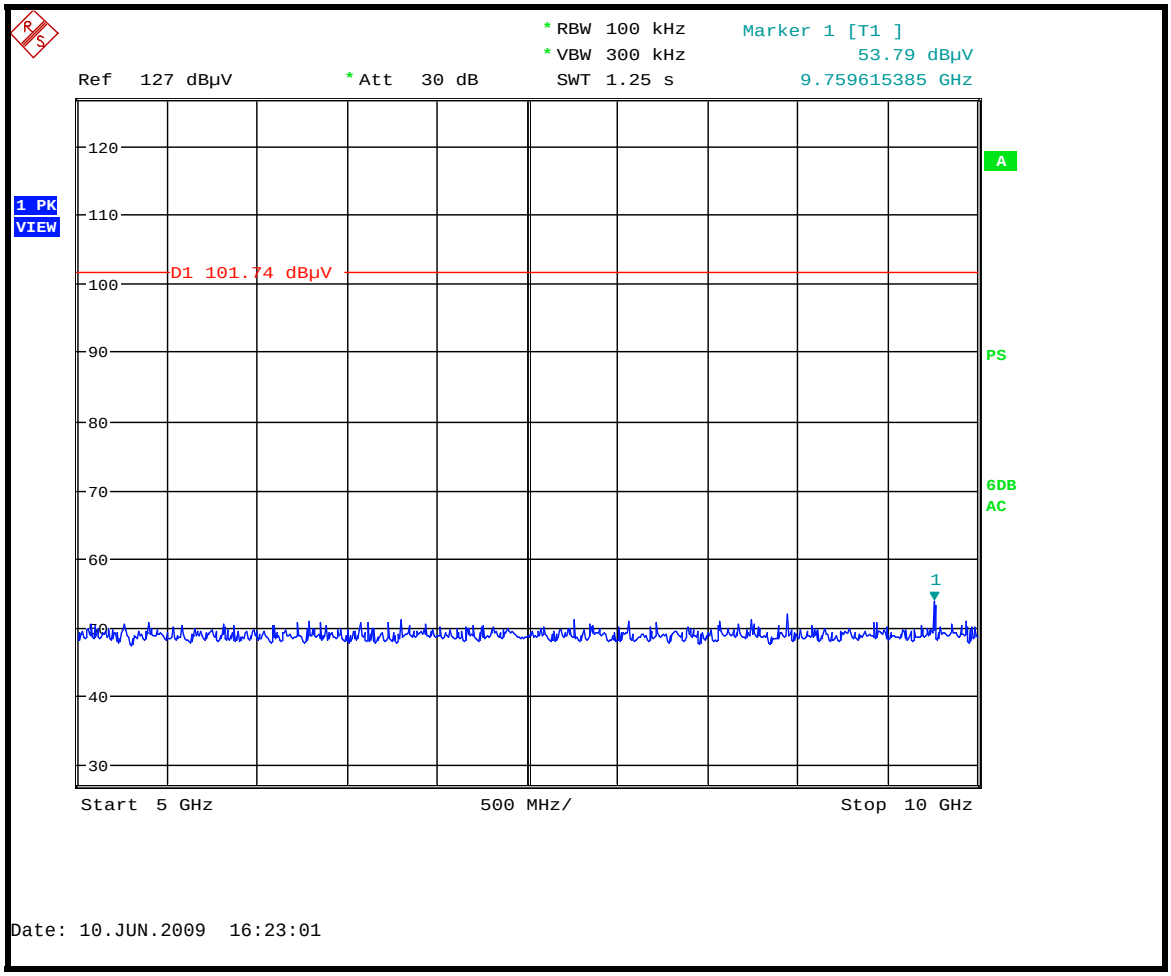
Conducted Emissions Channel 18 2440MHz



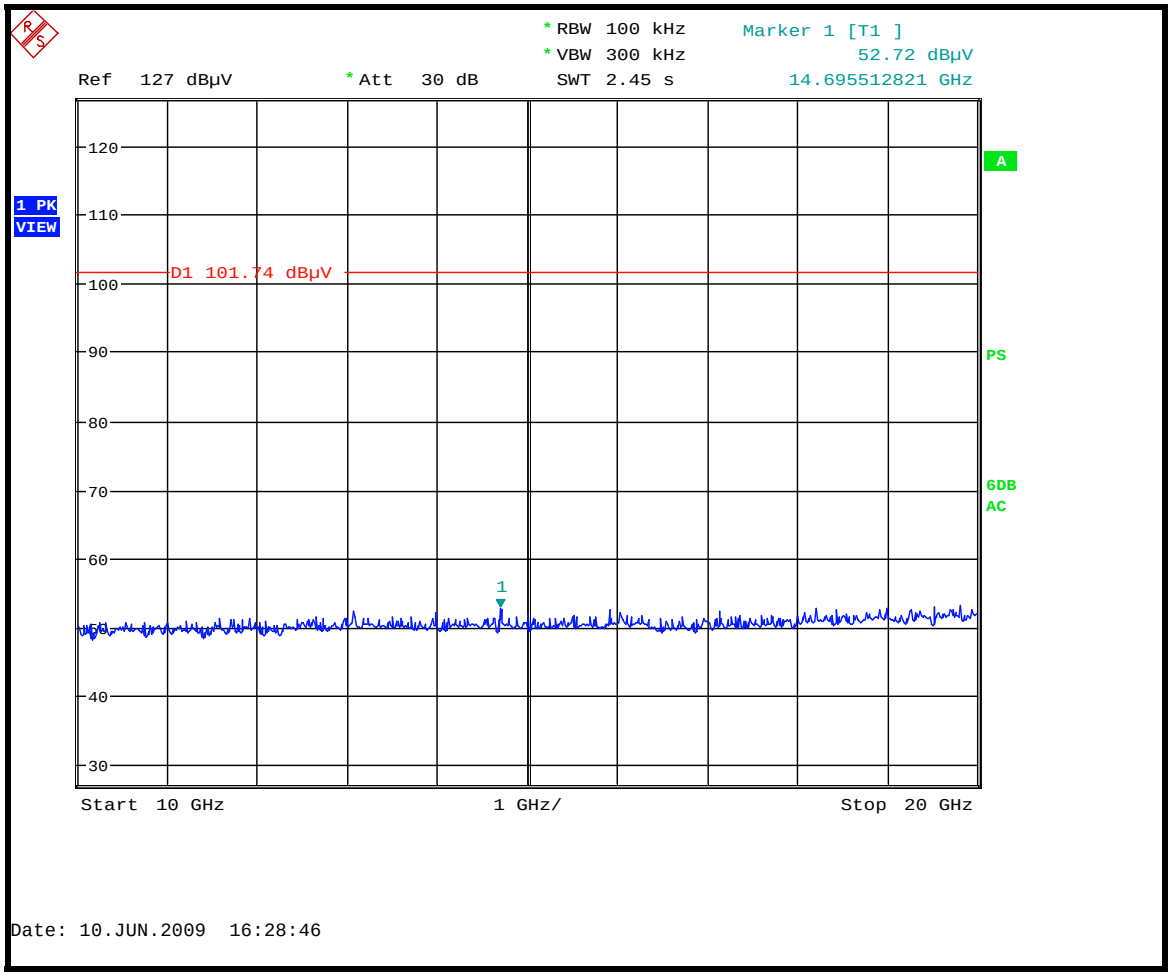
Conducted Emissions Channel 18 2440MHz



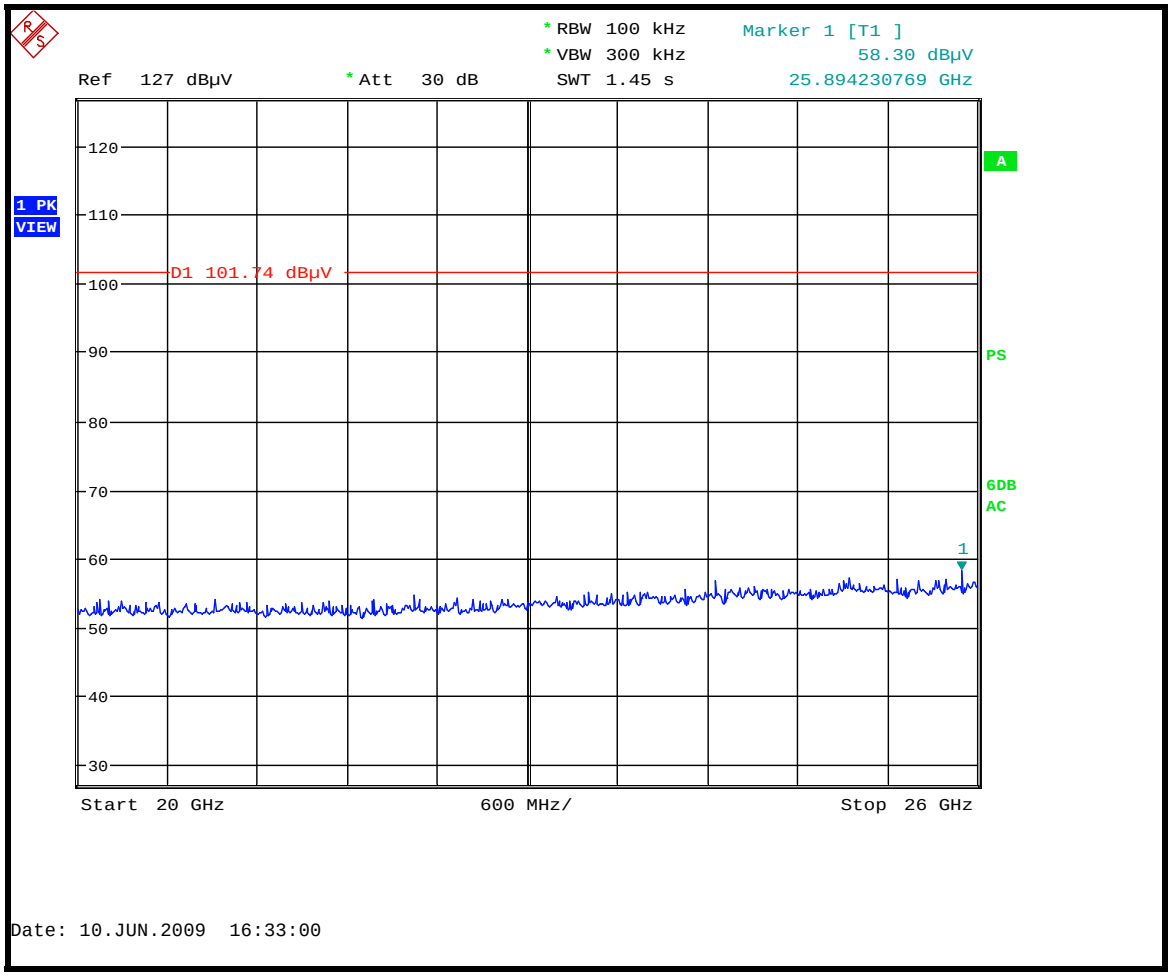
Conducted Emissions Channel 18 2440MHz



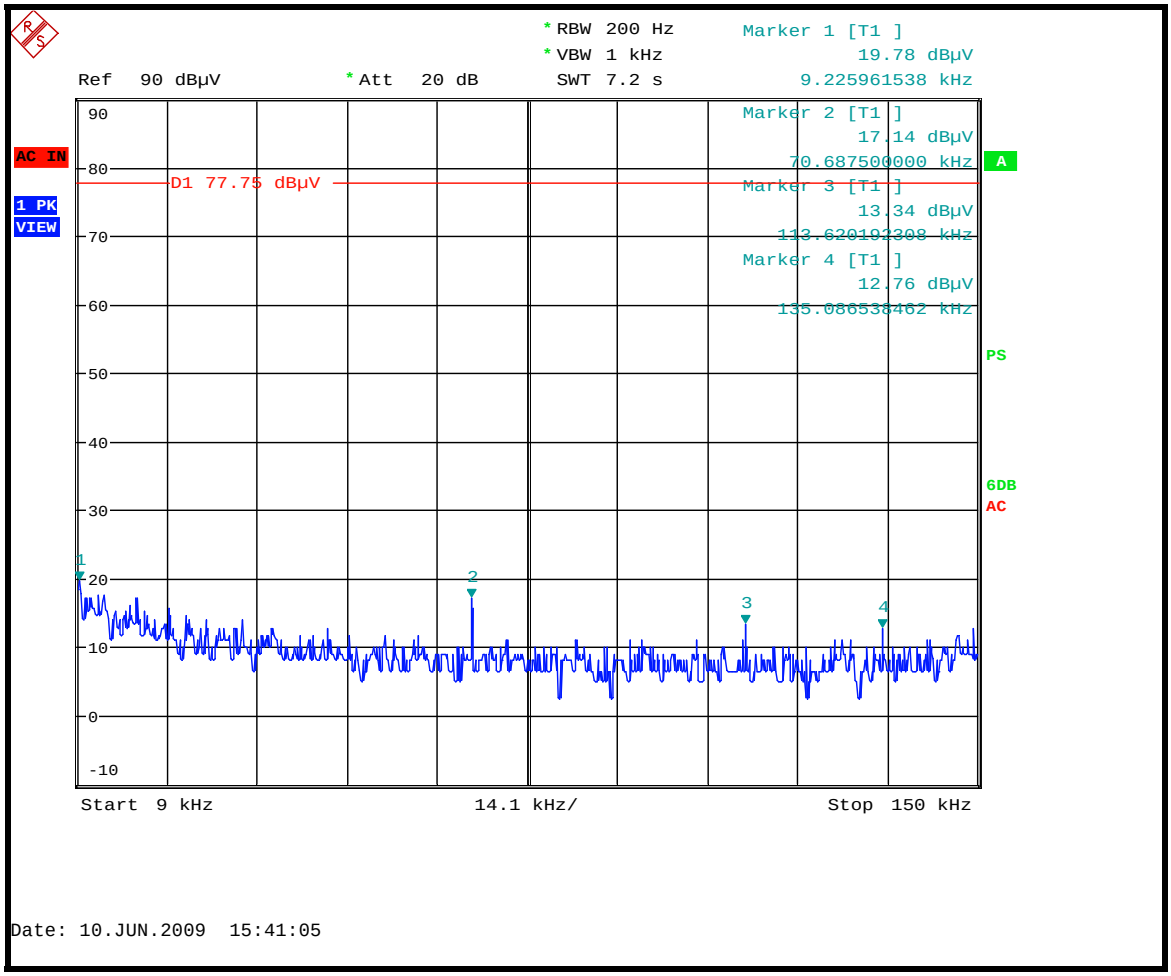
Conducted Emissions Channel 18 2440MHz



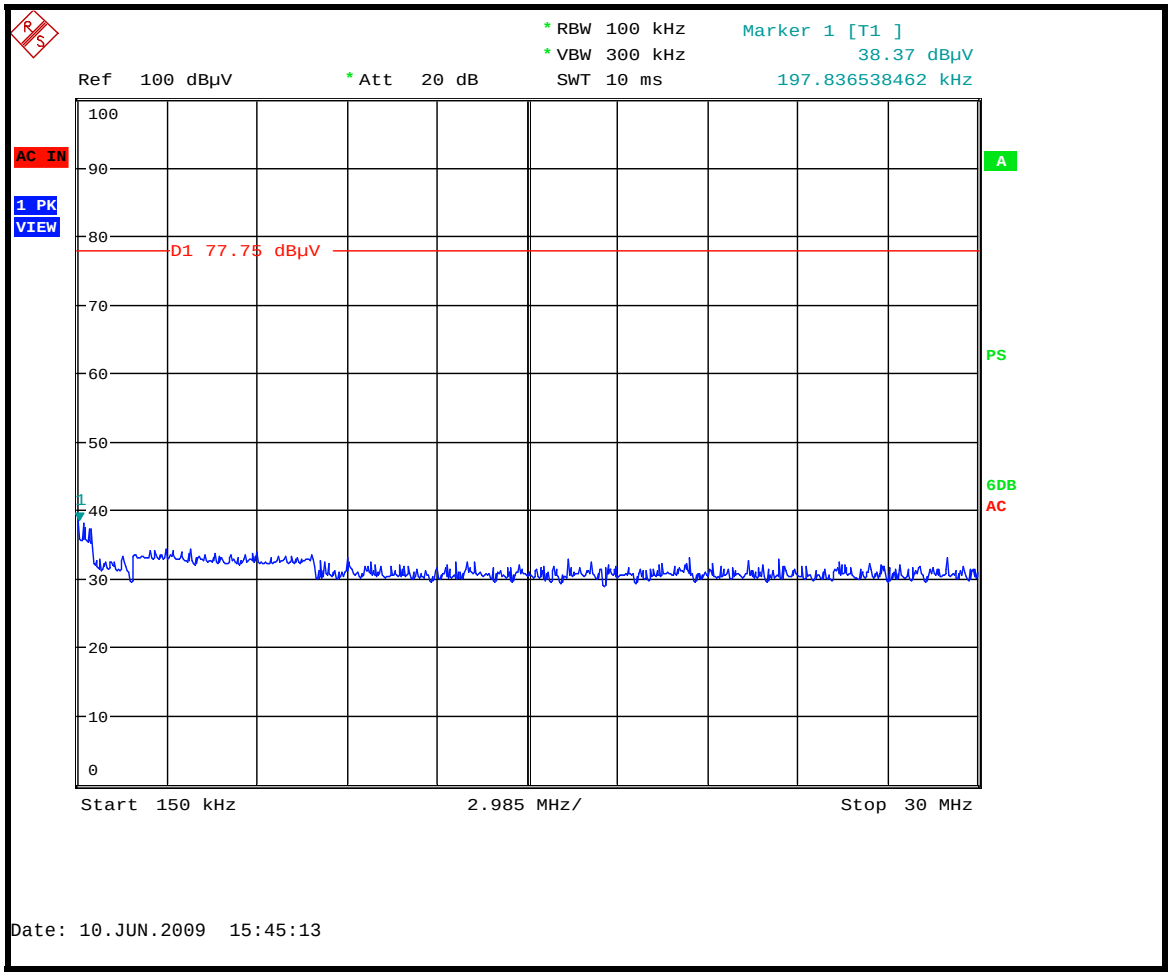
Conducted Emissions Channel 18 2440MHz



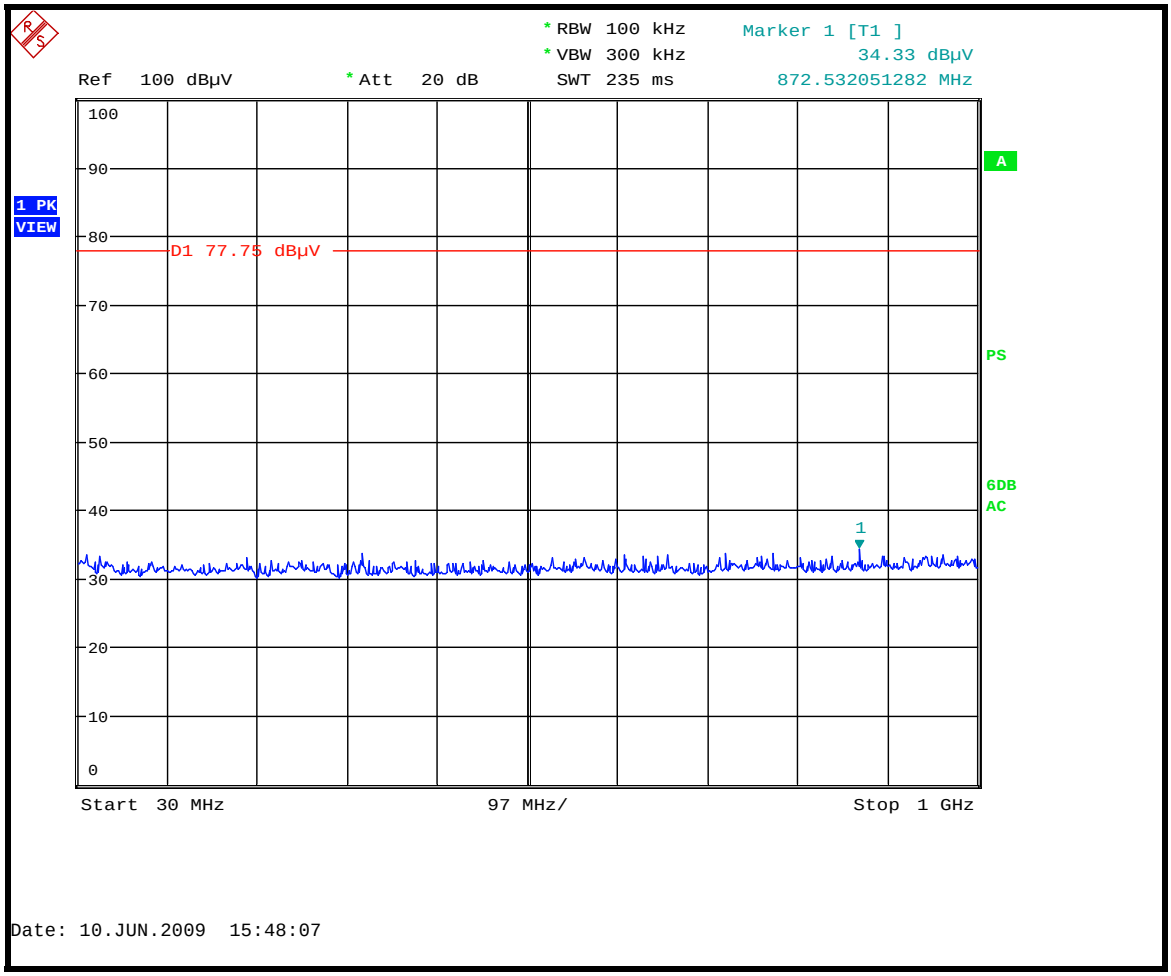
Conducted Emissions Channel 18 2440MHz



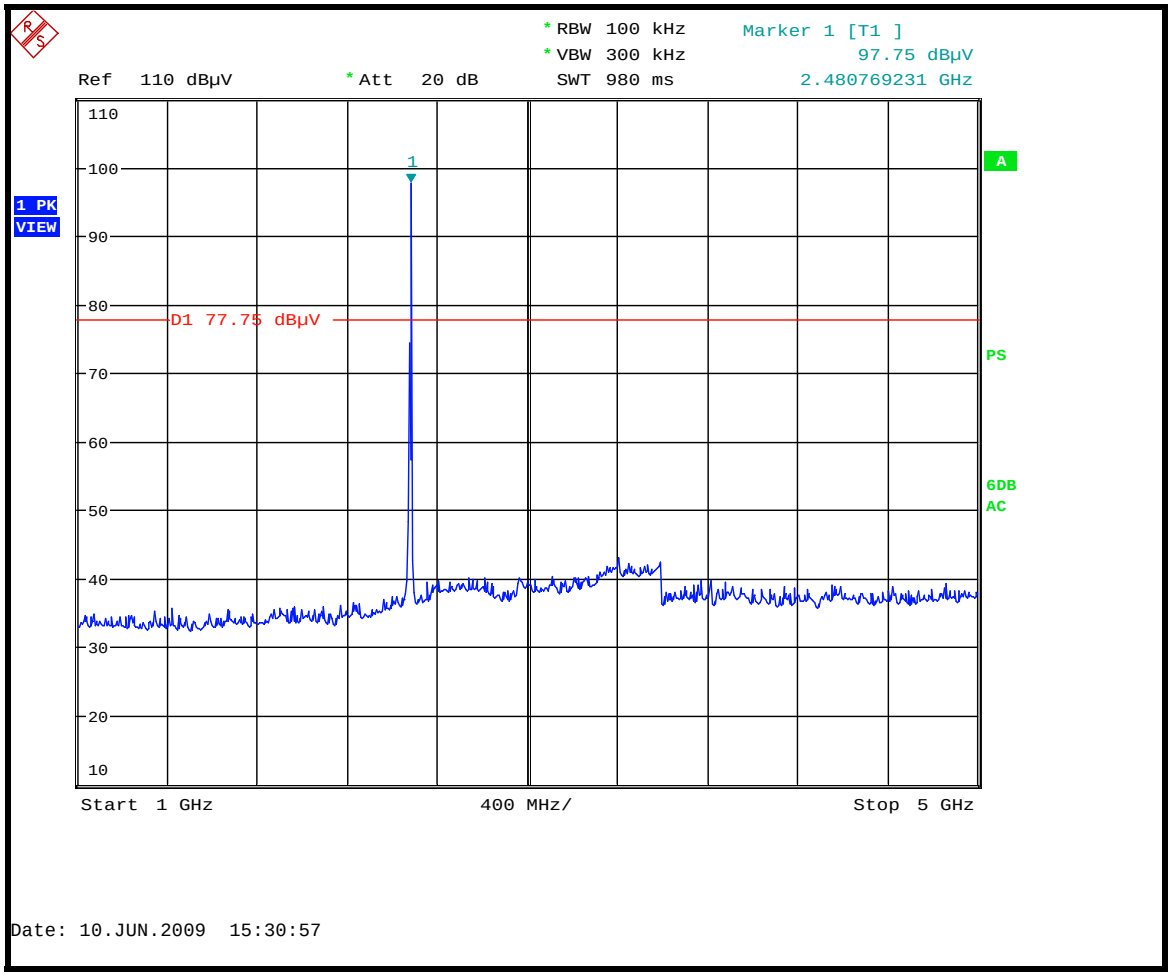
Conducted Emissions Channel 26 2480MHz



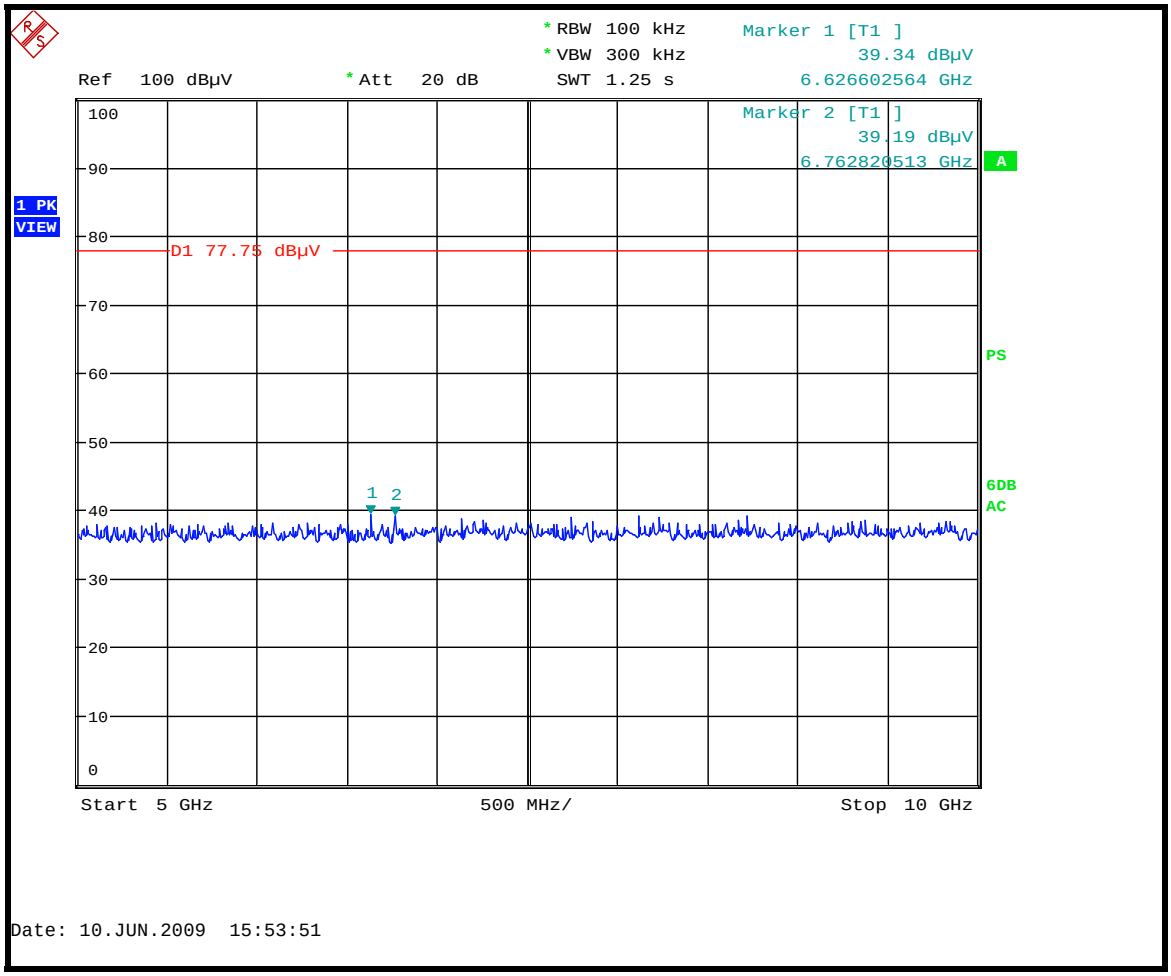
Conducted Emissions Channel 26 2480MHz



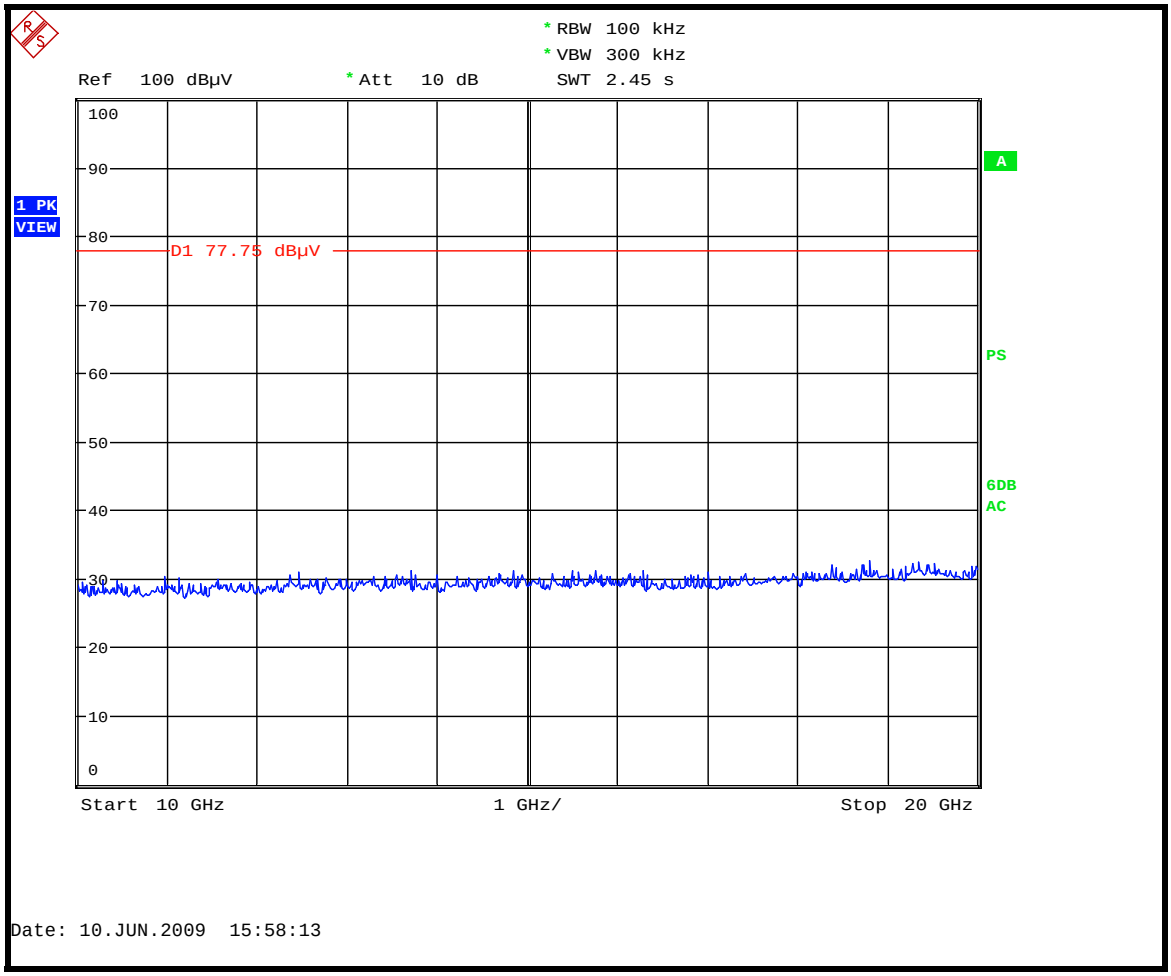
Conducted Emissions Channel 26 2480MHz



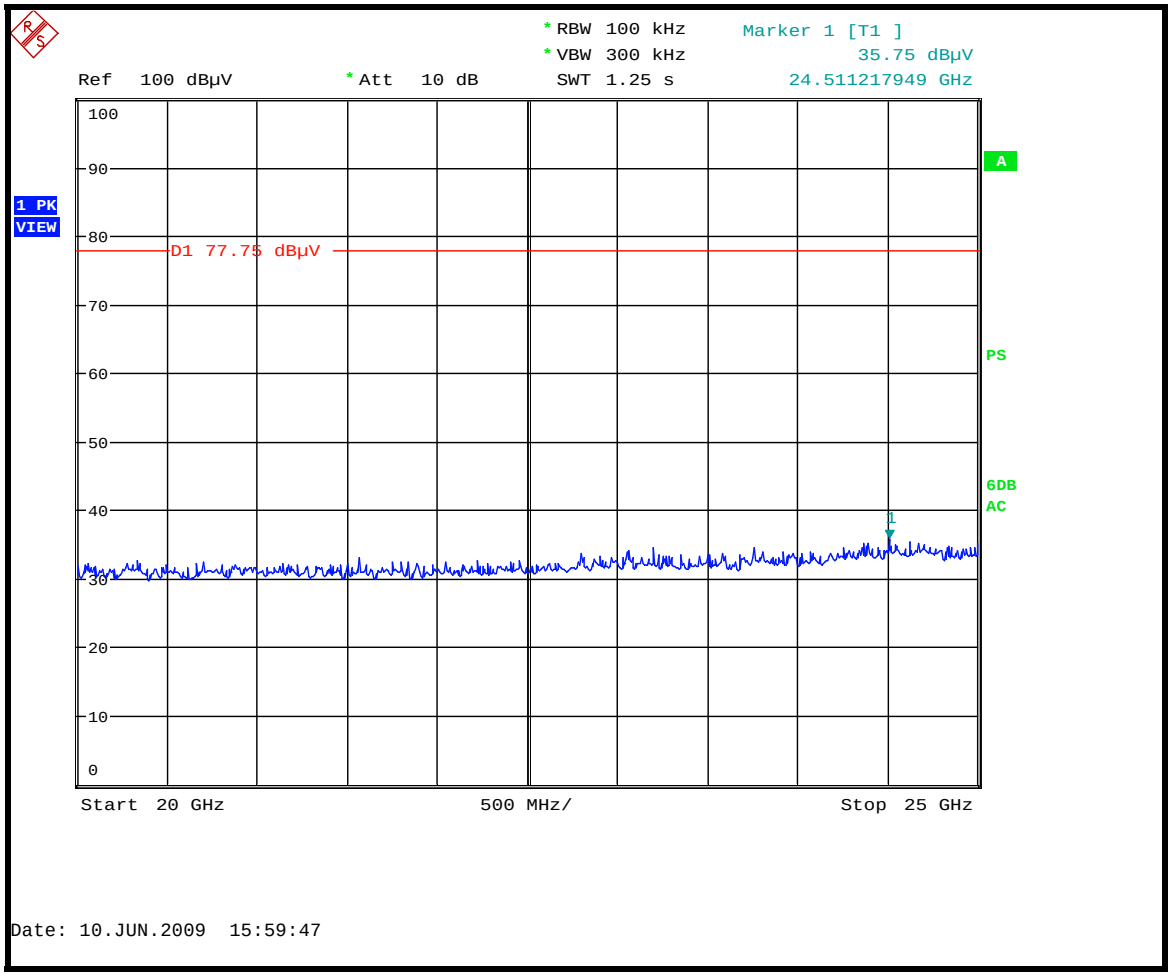
Conducted Emissions Channel 26 2480MHz



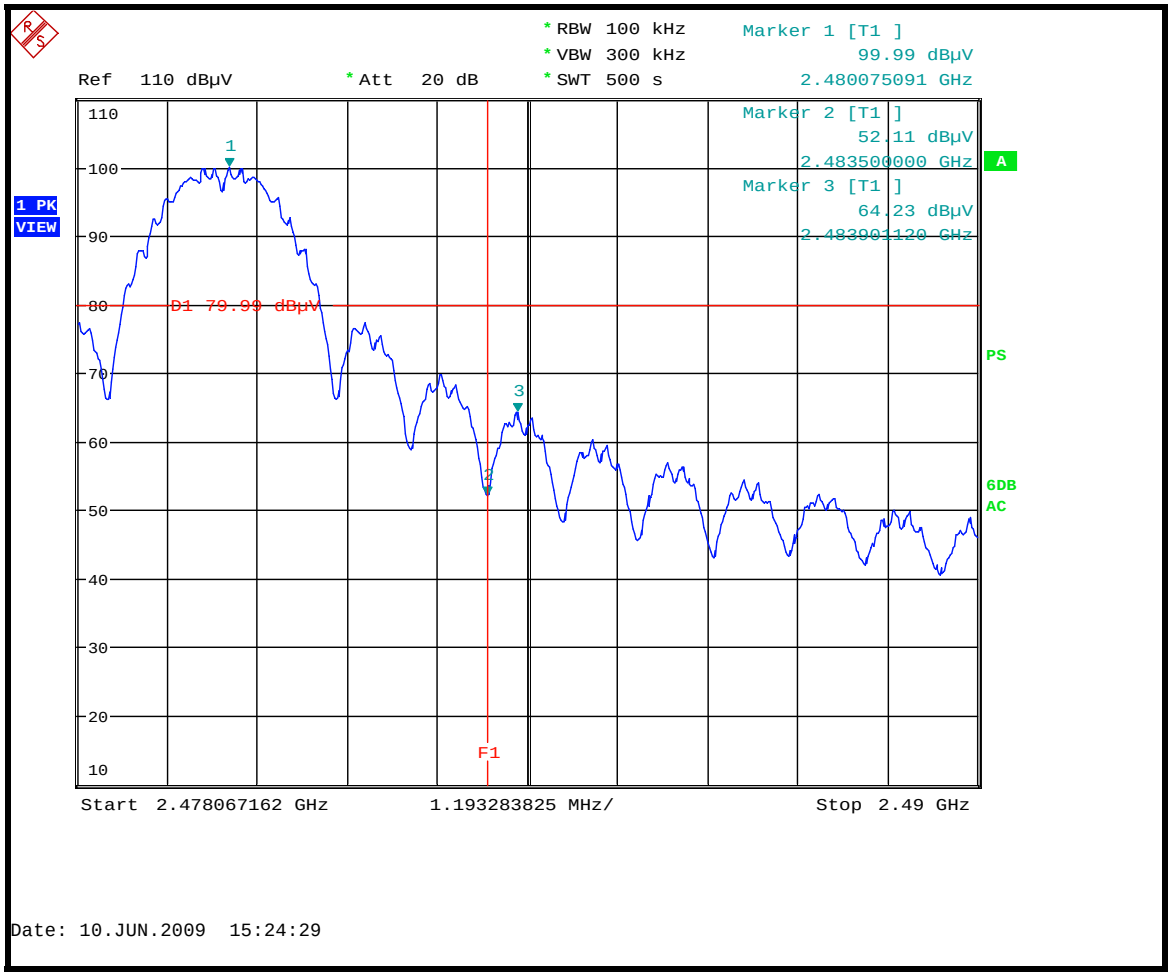
Conducted Emissions Channel 26 2480MHz



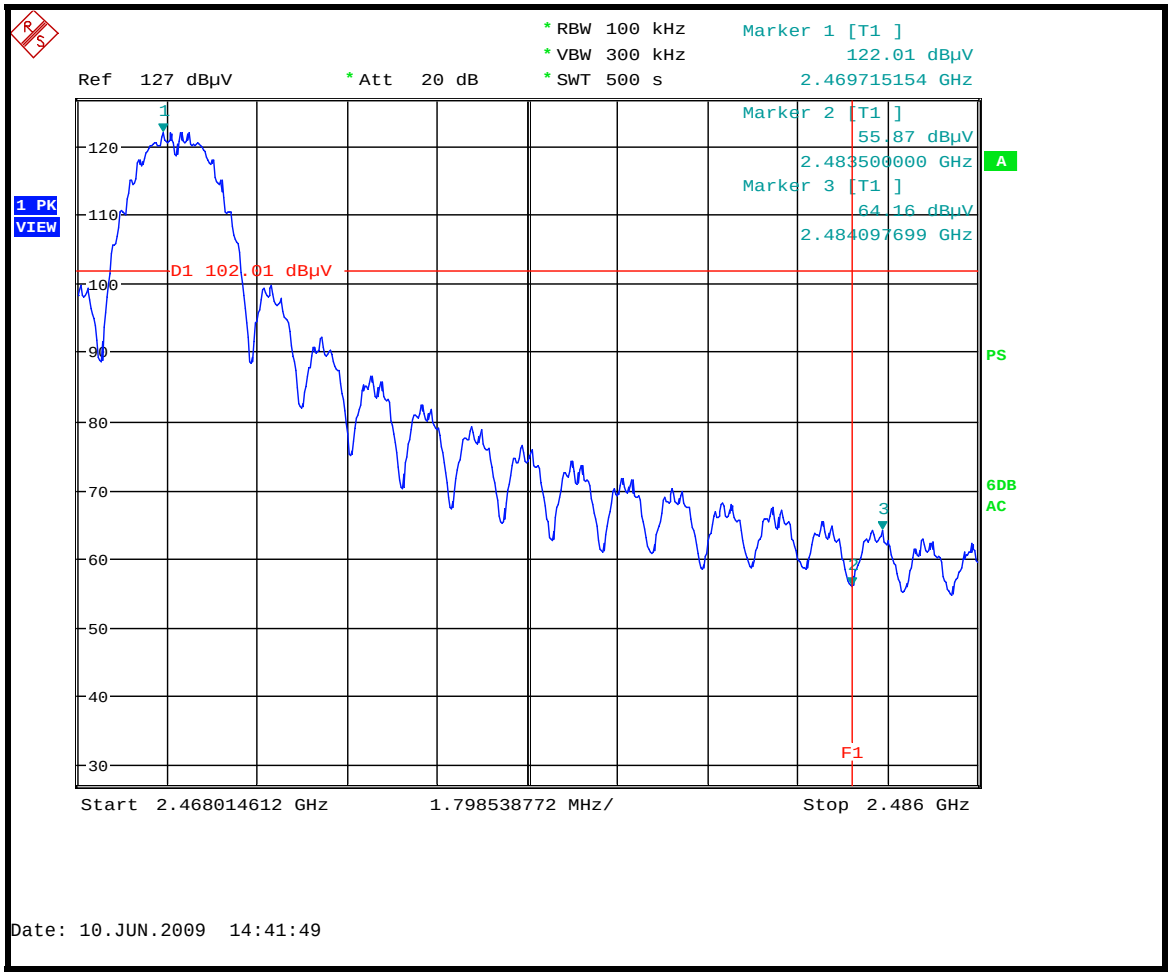
Conducted Emissions Channel 26 2480MHz



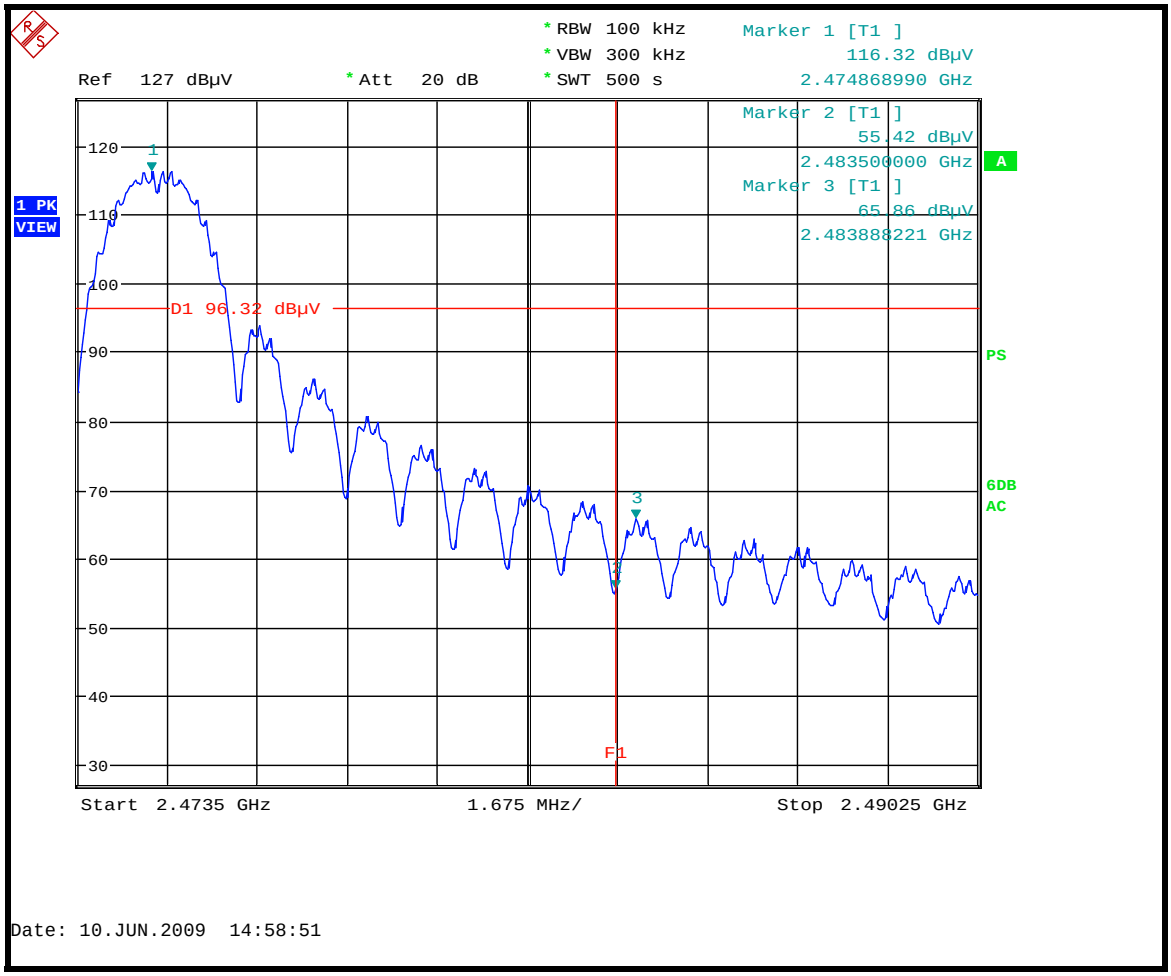
Conducted Emissions Channel 26 2480MHz



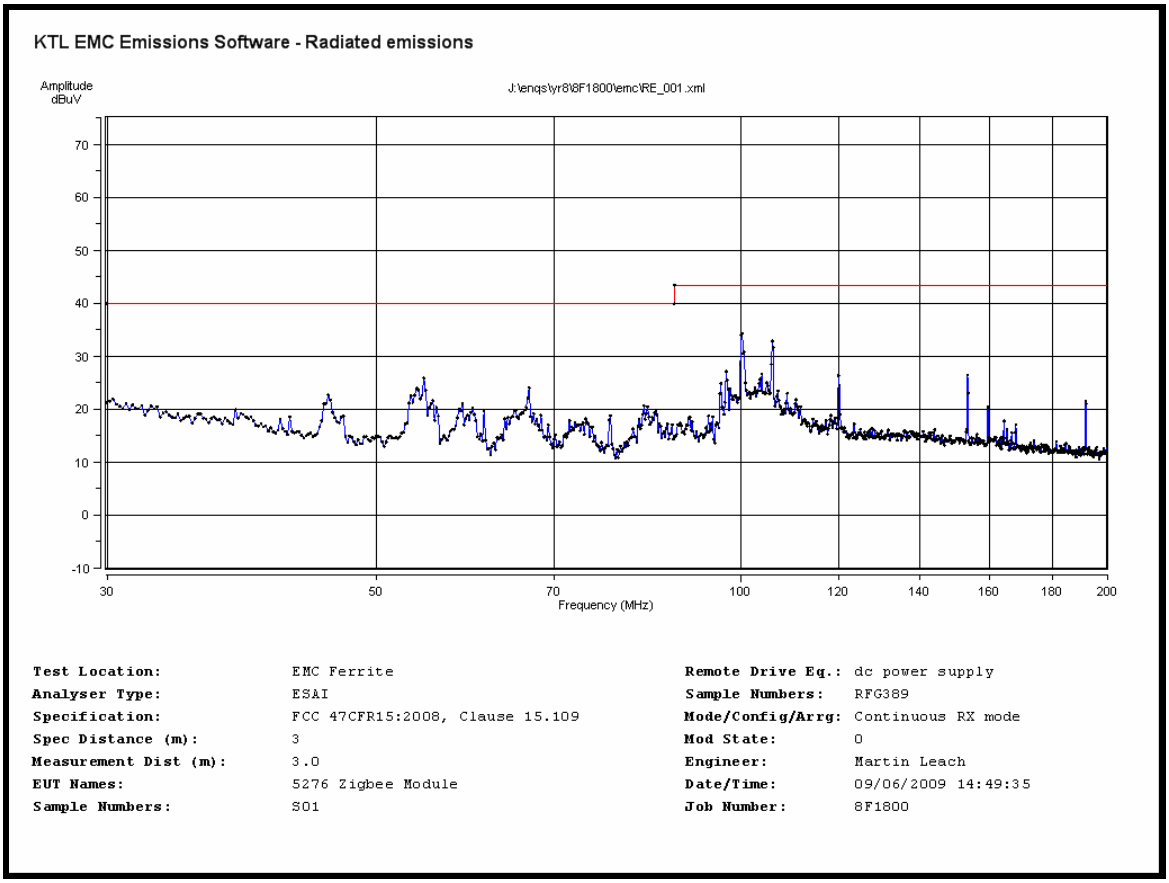
Conducted Emissions Channel 26 2480MHz: Upper-Band edge



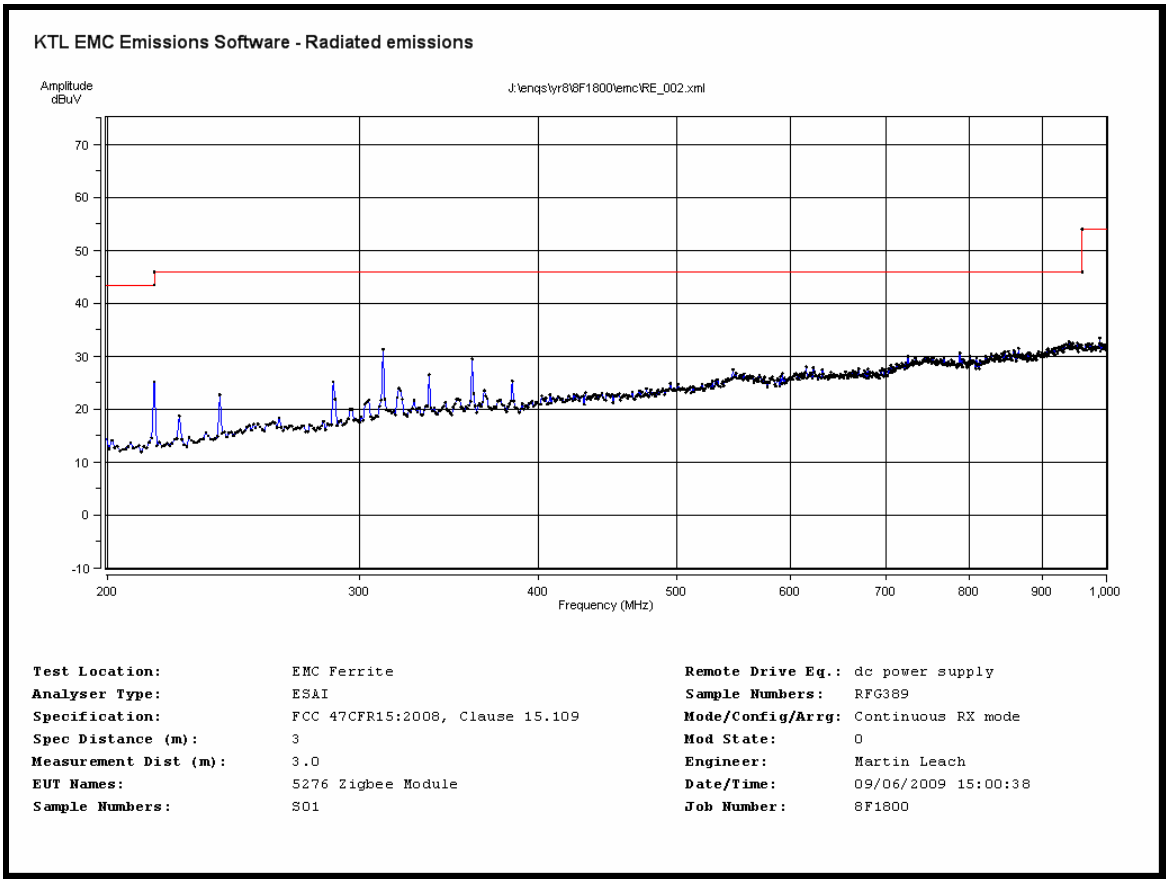
Conducted Emissions Channel 24 2470MHz: Upper-Band edge



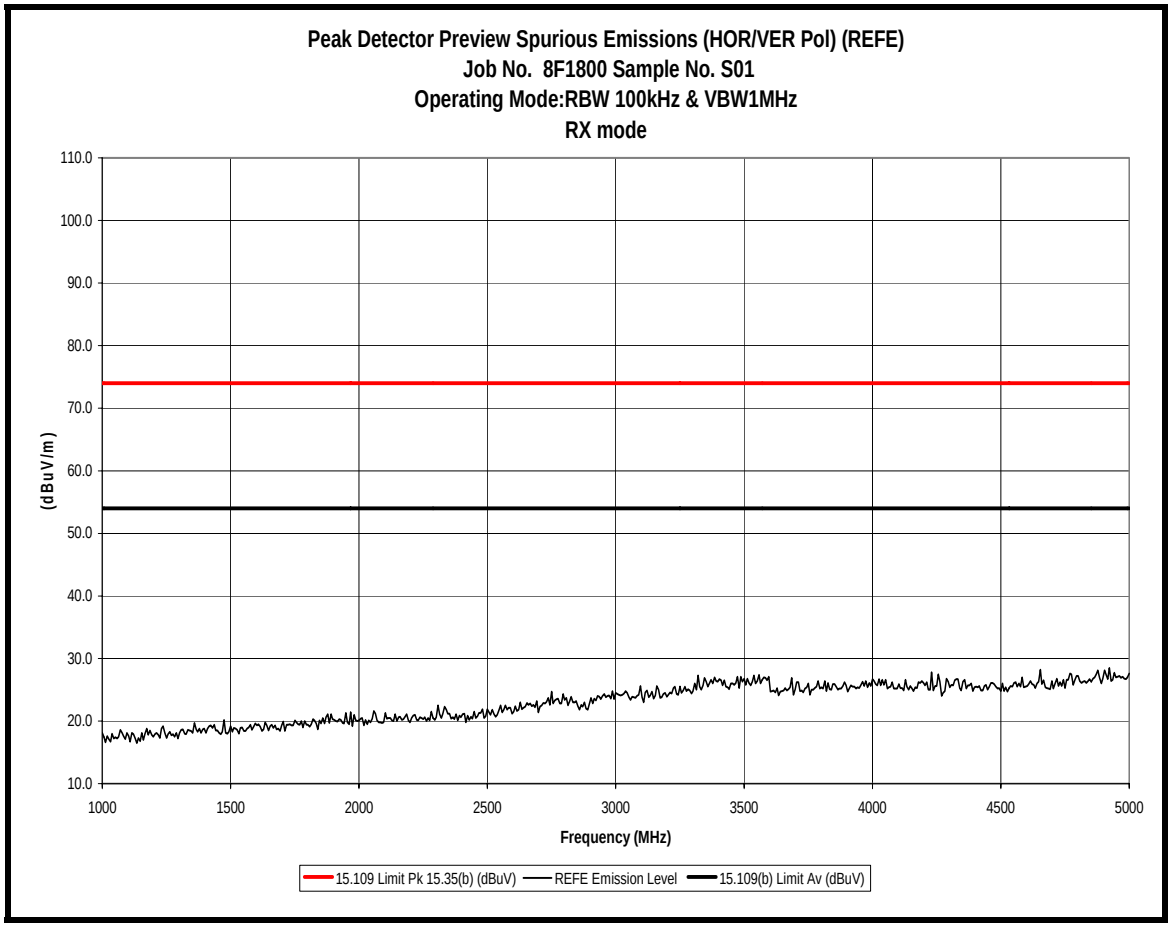
Conducted Emissions Channel 25 2475MHz: Upper-Band edge



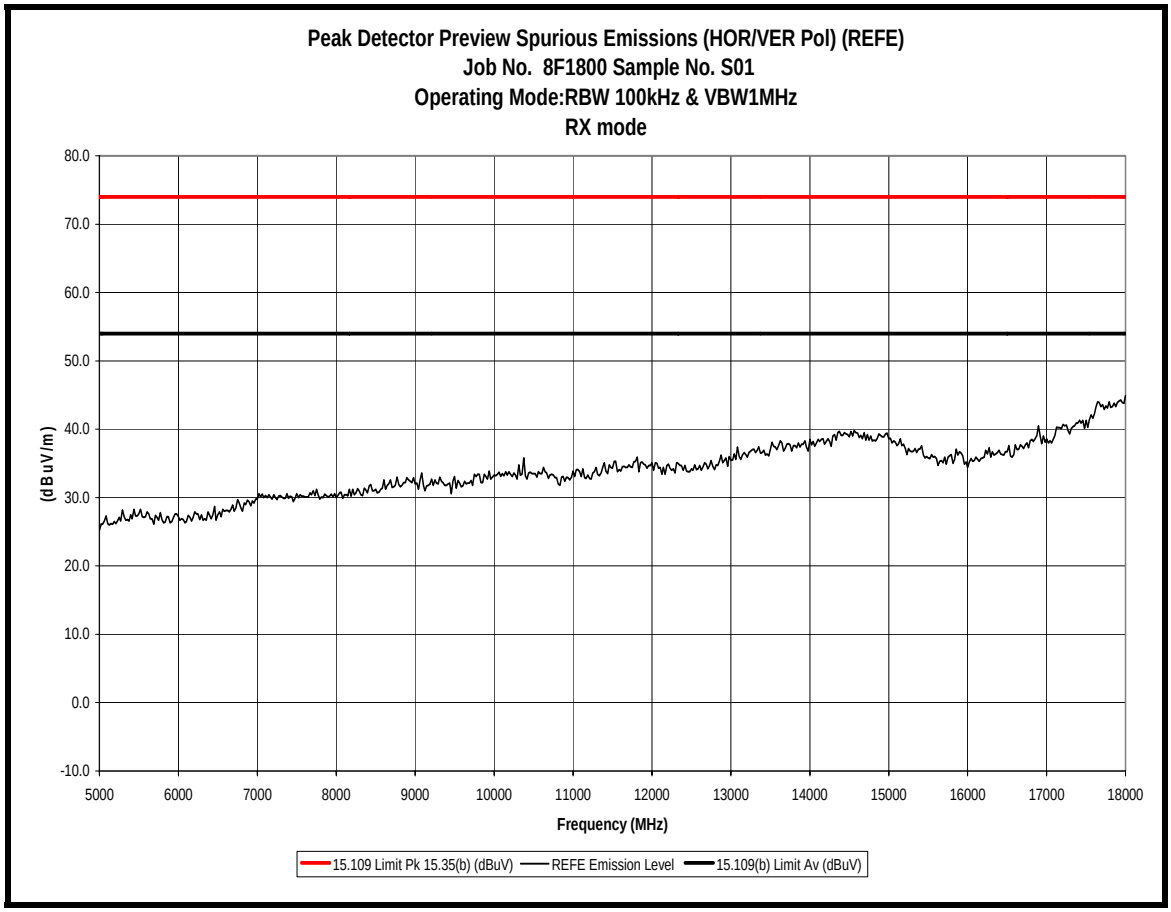
Radiated RX Mode Emissions (15.109)



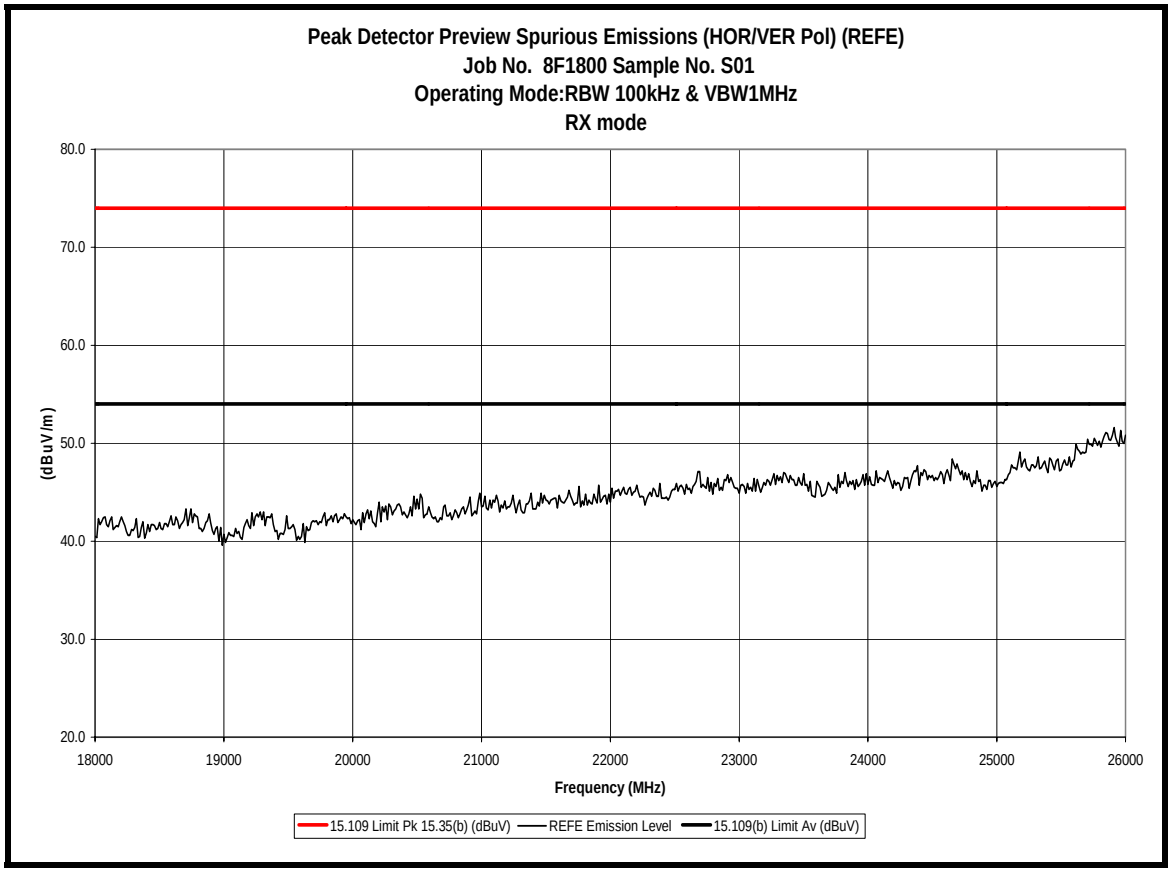
Radiated RX Mode Emissions (15.109)



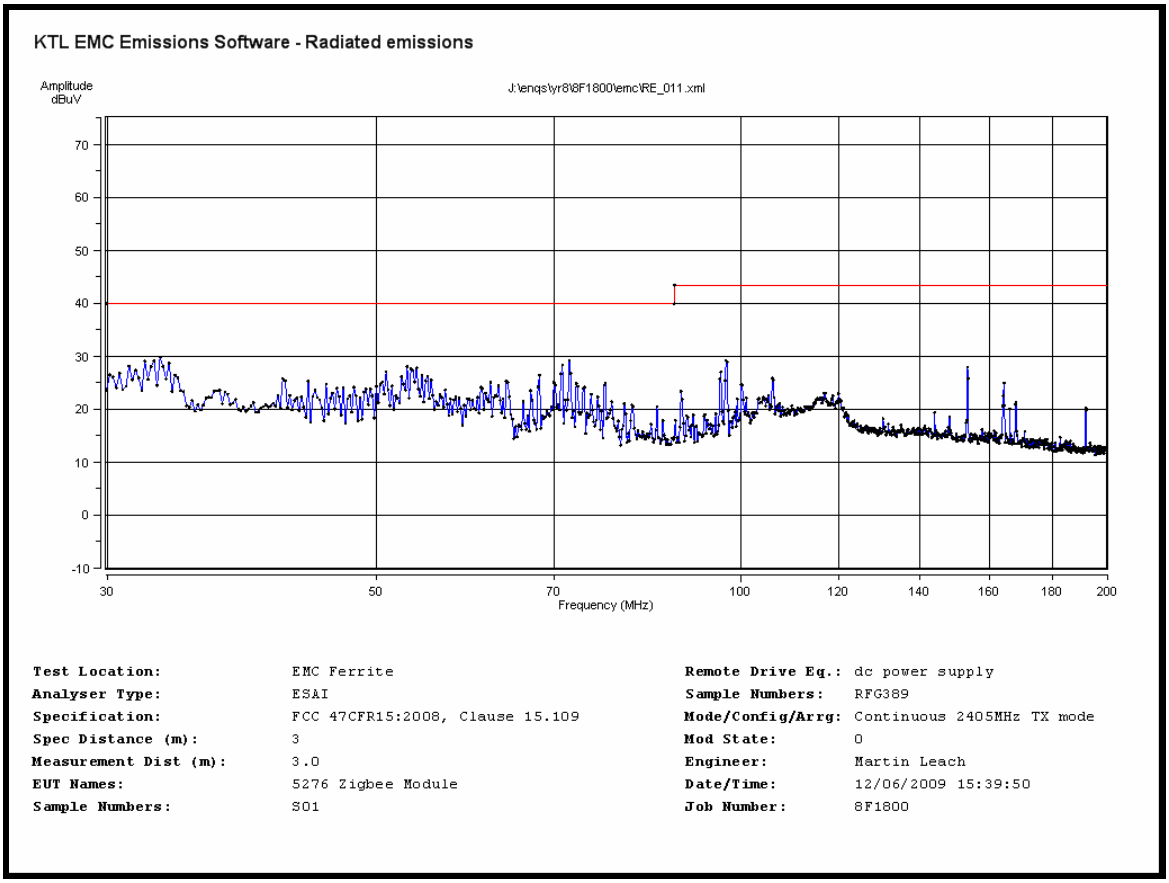
Radiated RX Mode Emissions (15.109)



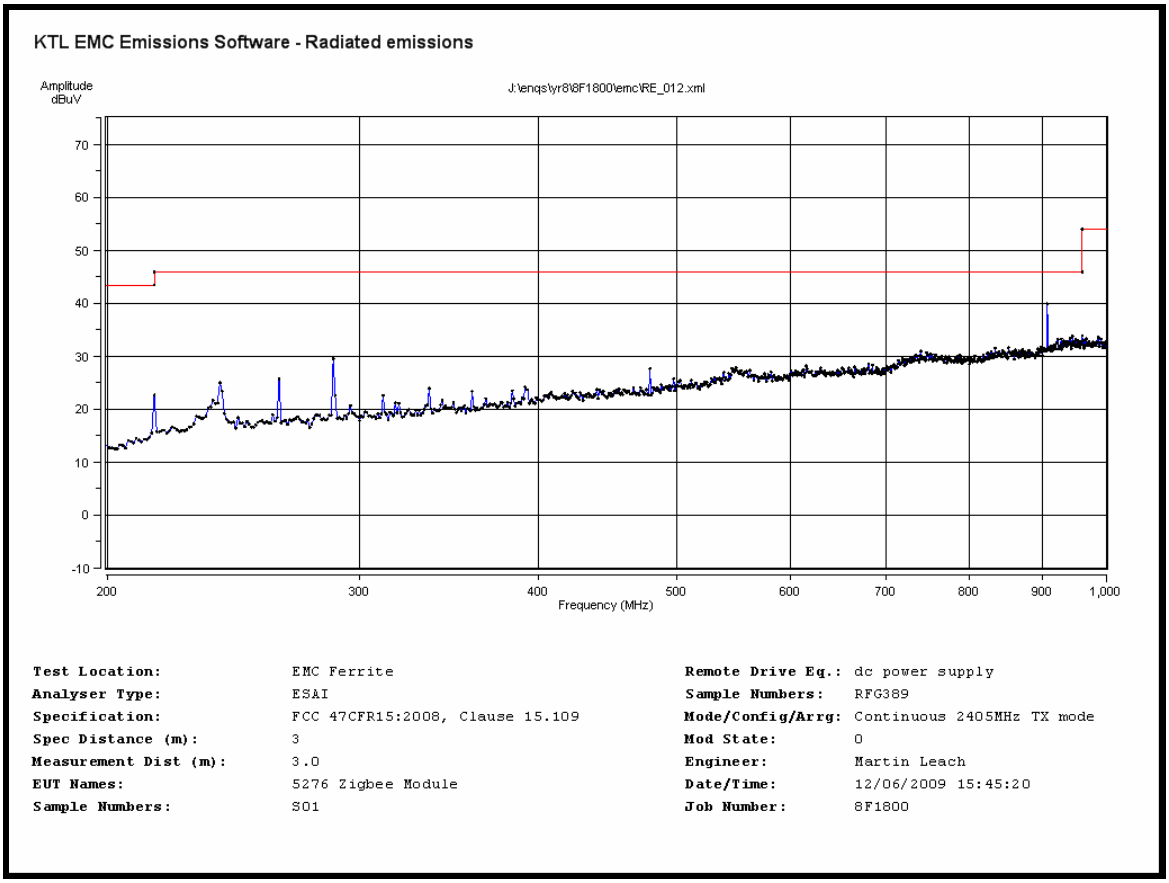
Radiated RX Mode Emissions (15.109)



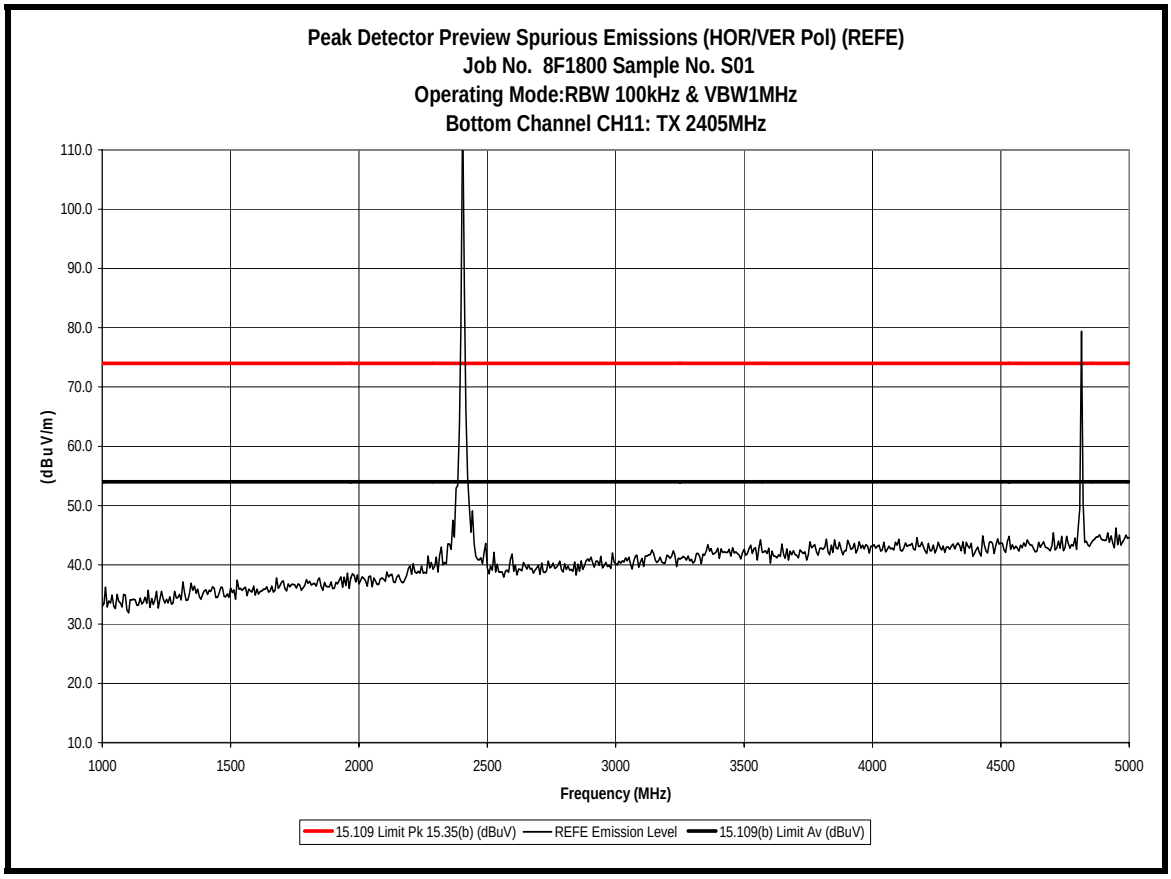
Radiated RX Mode Emissions (15.109)



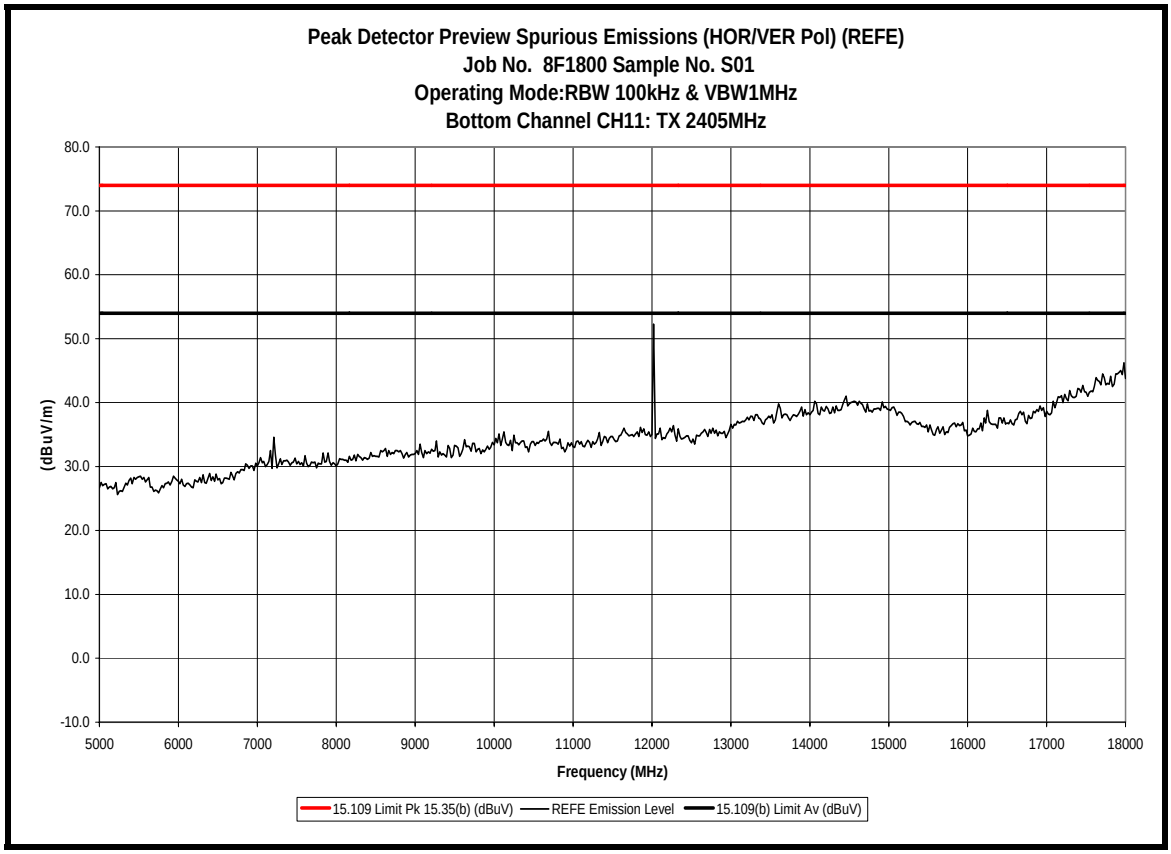
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



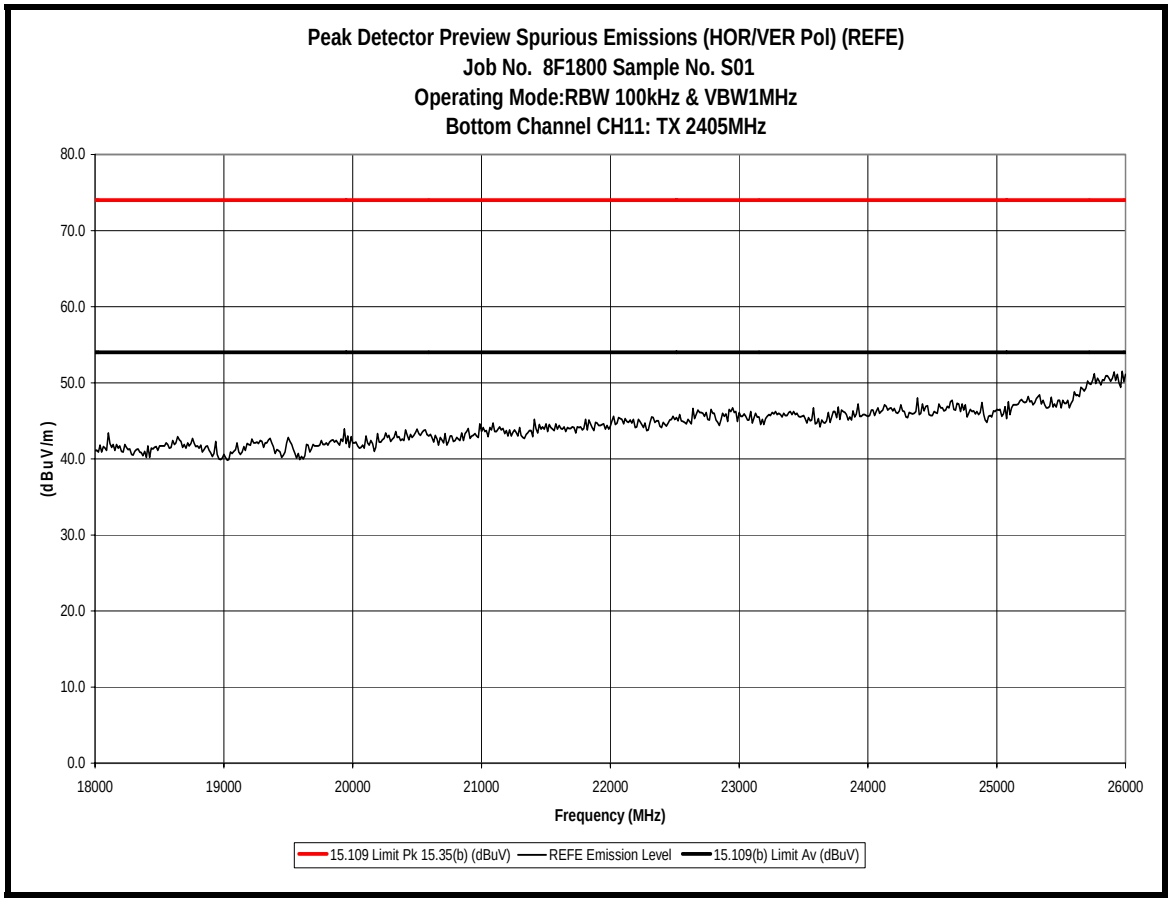
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



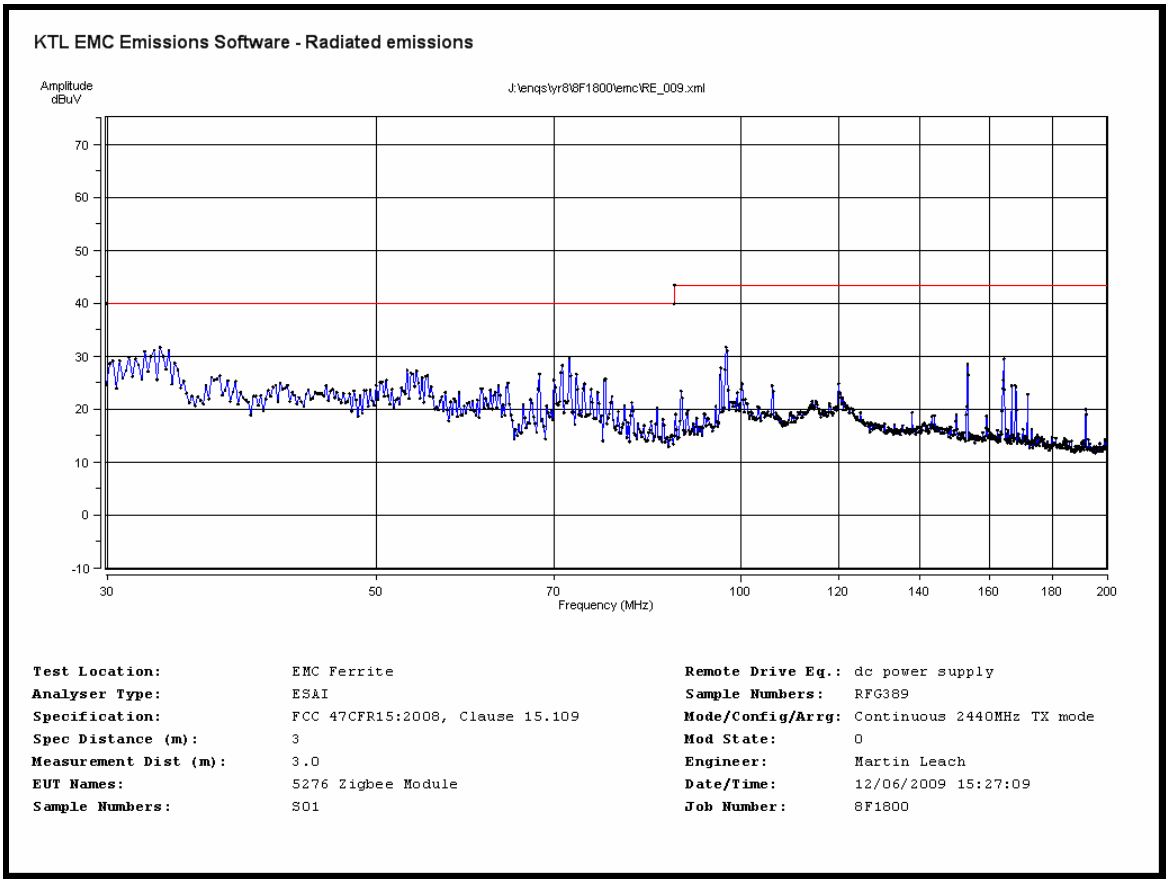
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



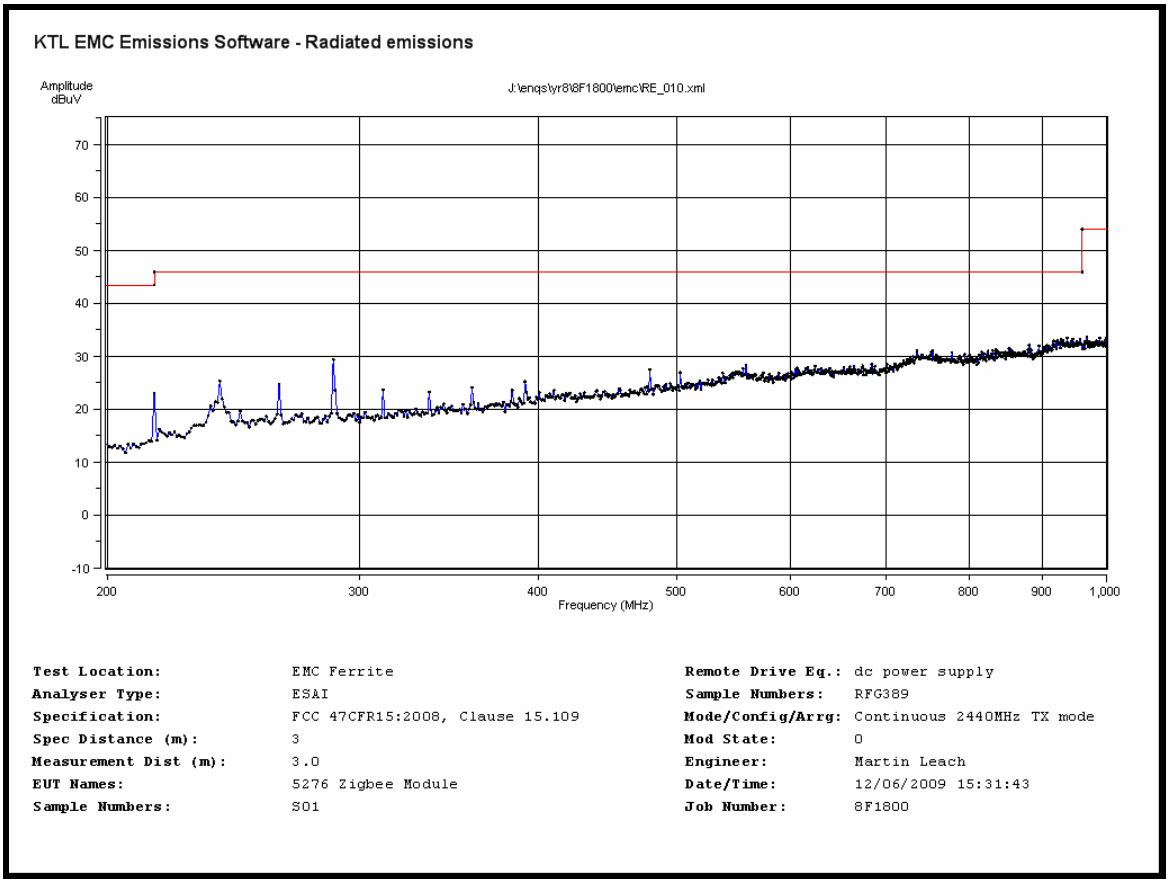
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



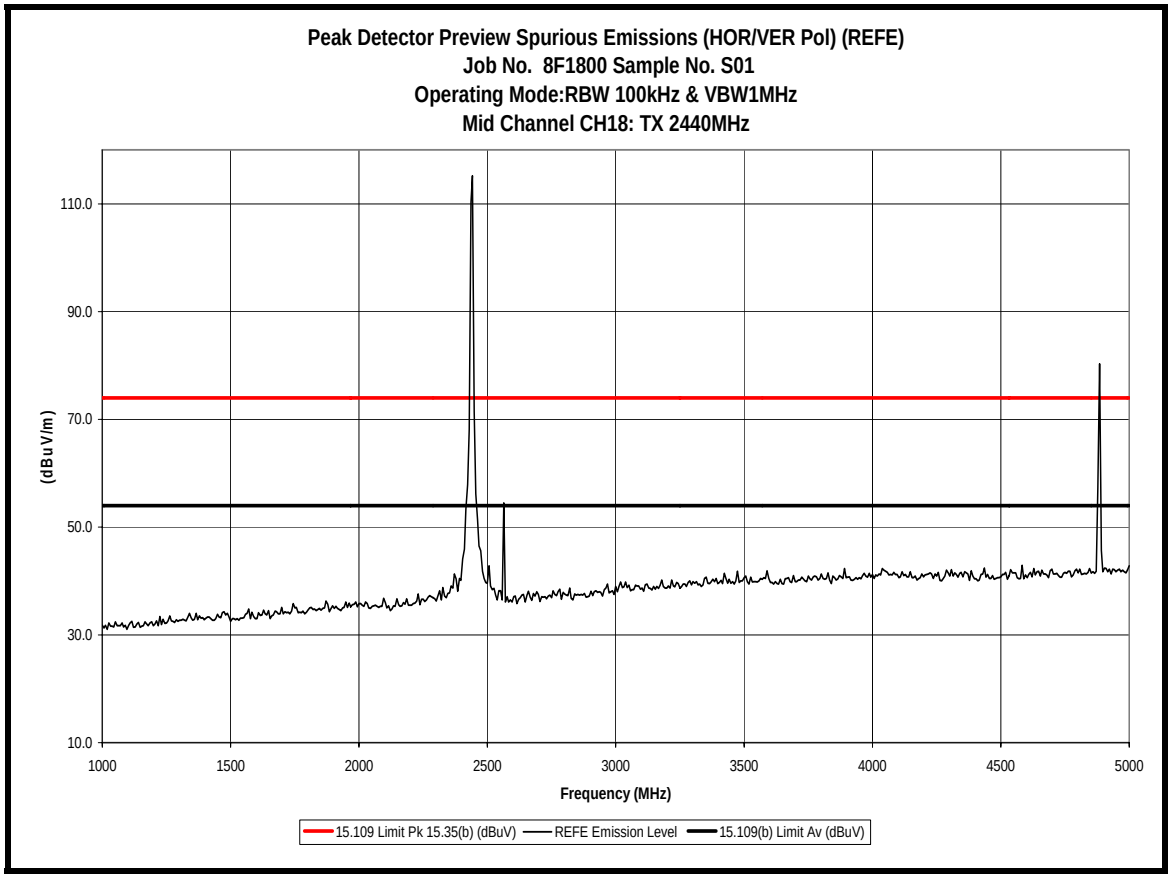
Radiated Transmitter Emissions Channel 11 2405MHz (15.209)



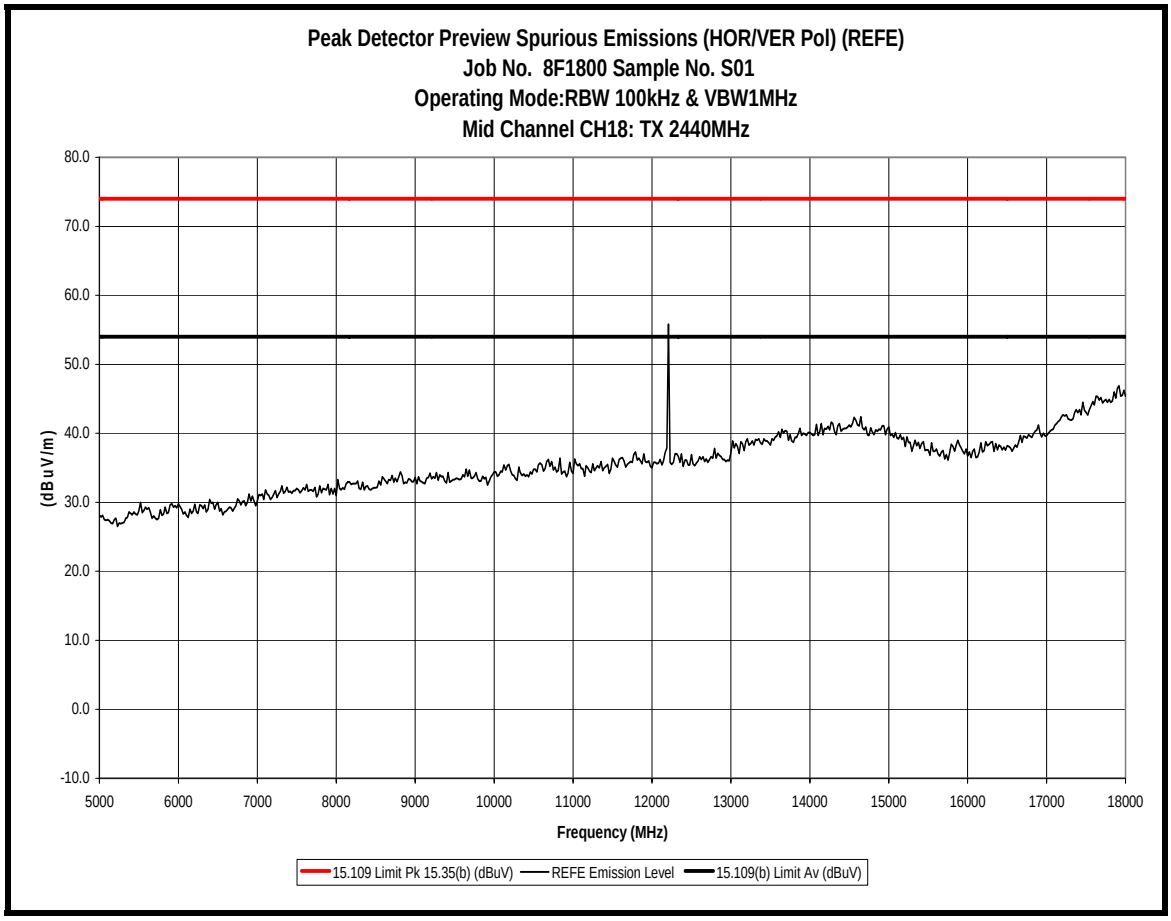
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



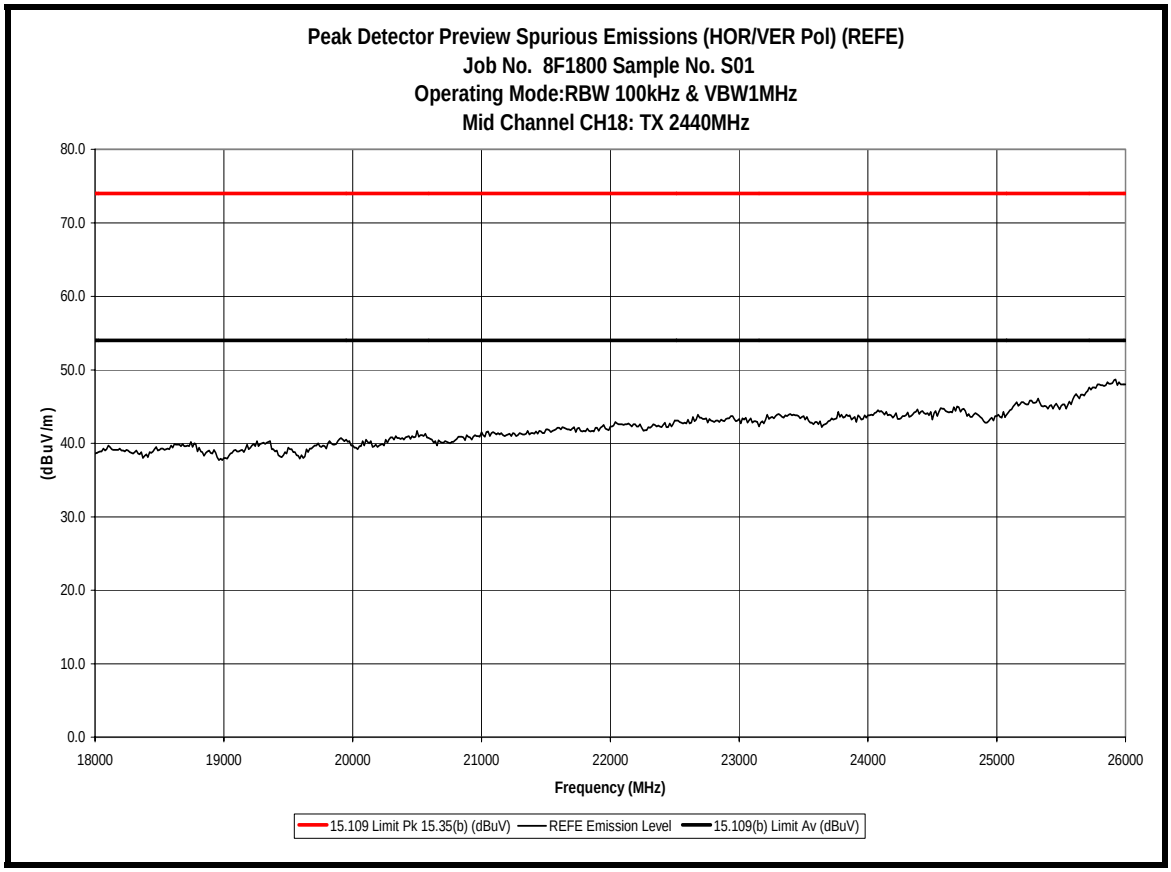
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



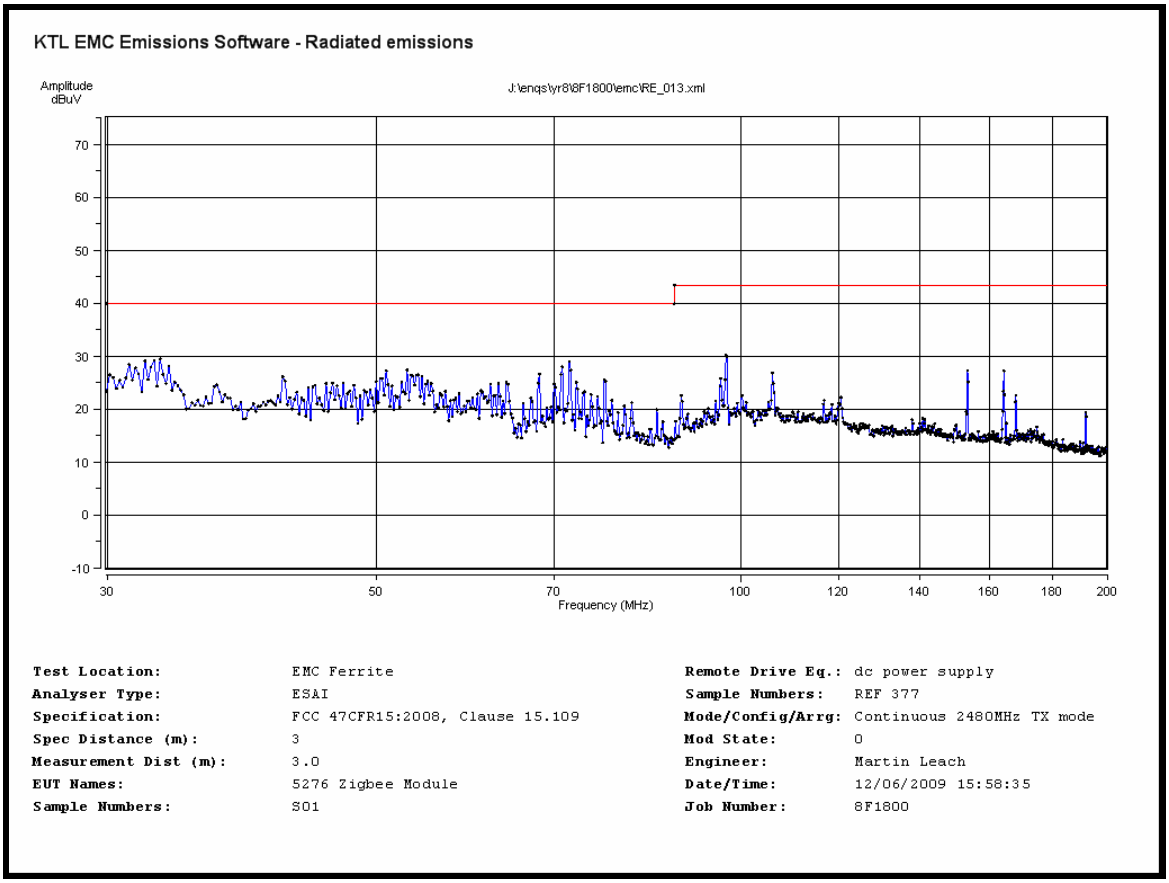
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



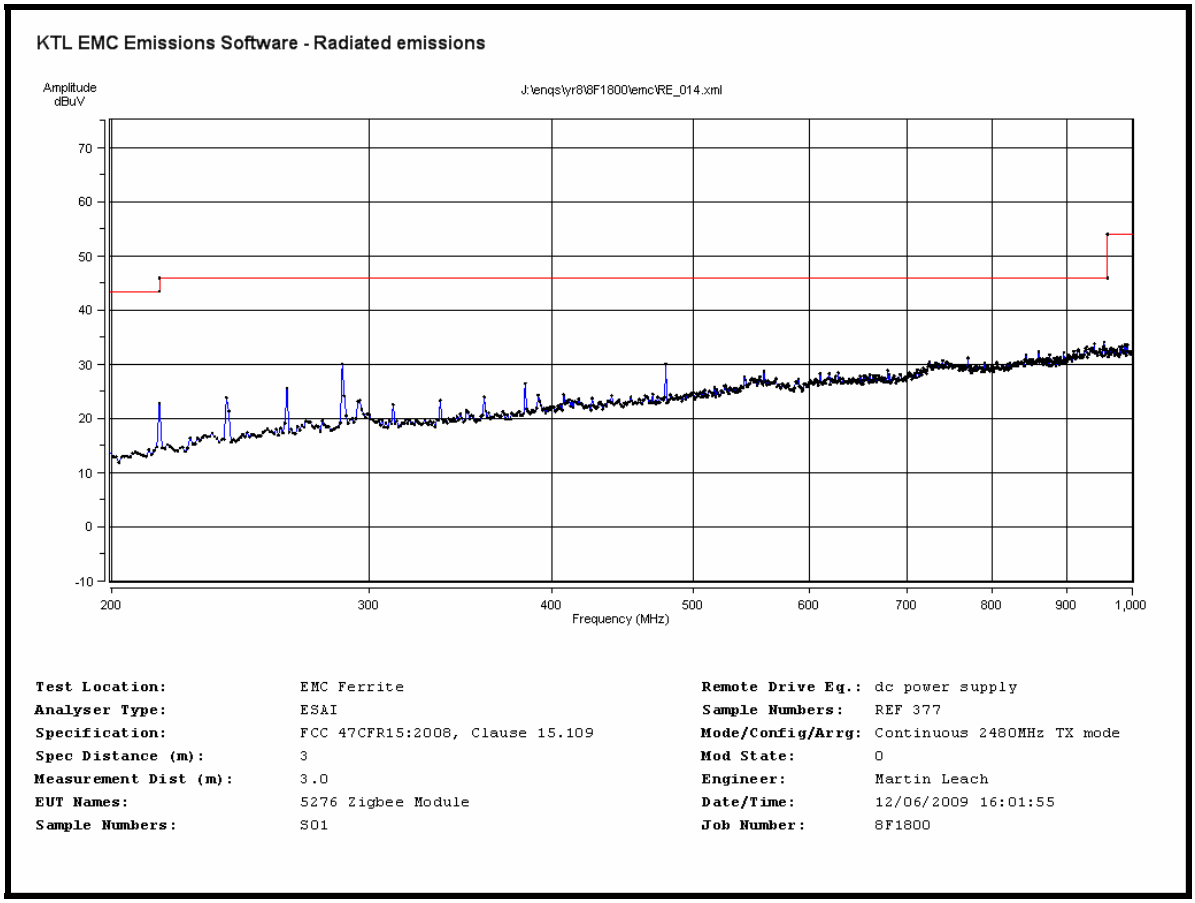
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



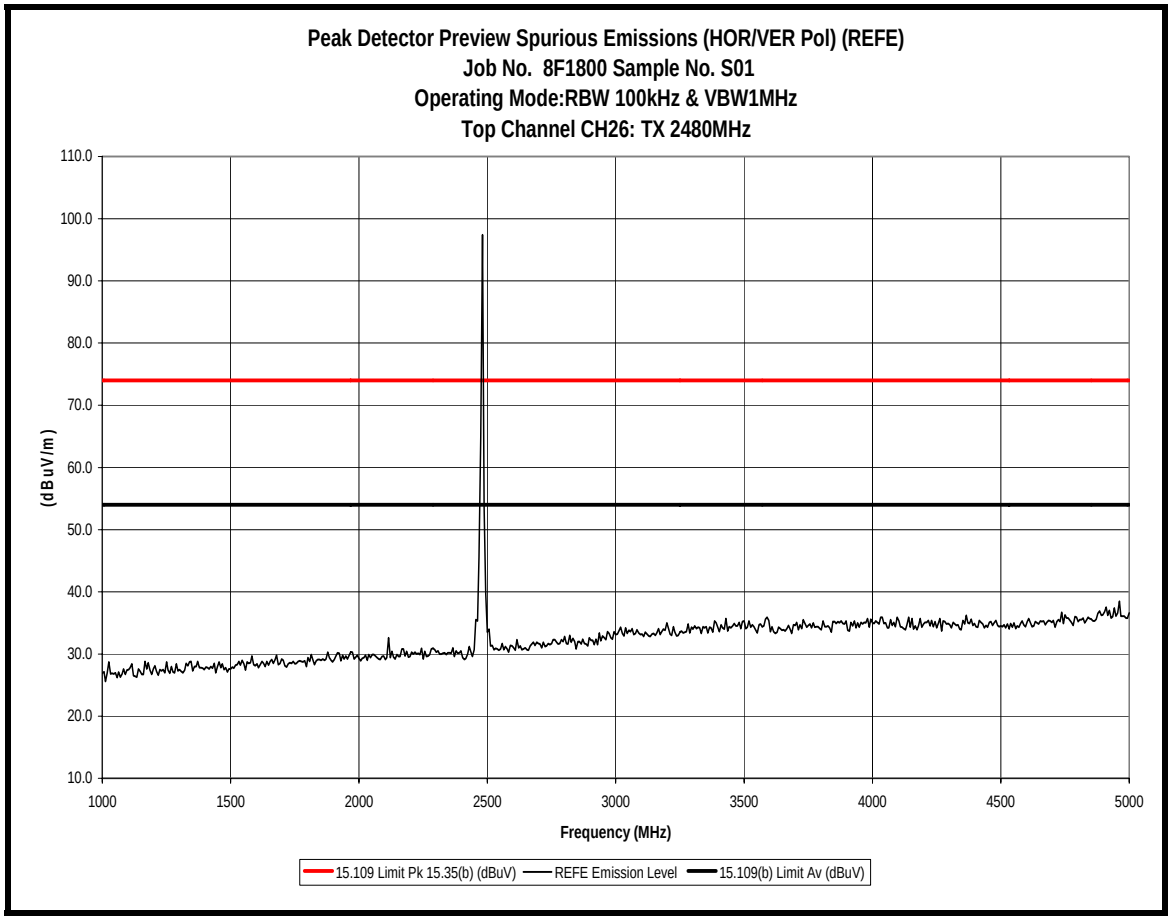
Radiated Transmitter Emissions Channel 18 2440MHz (15.209)



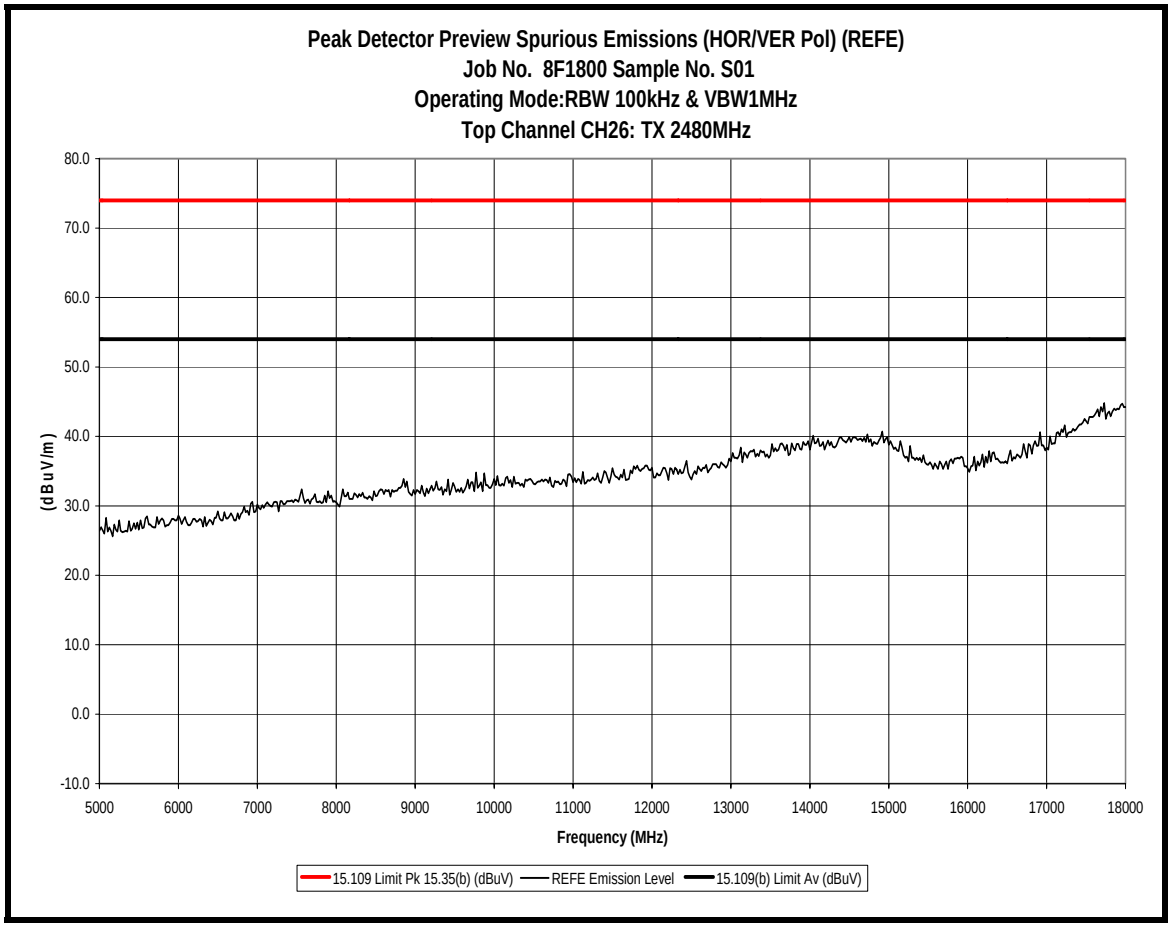
Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



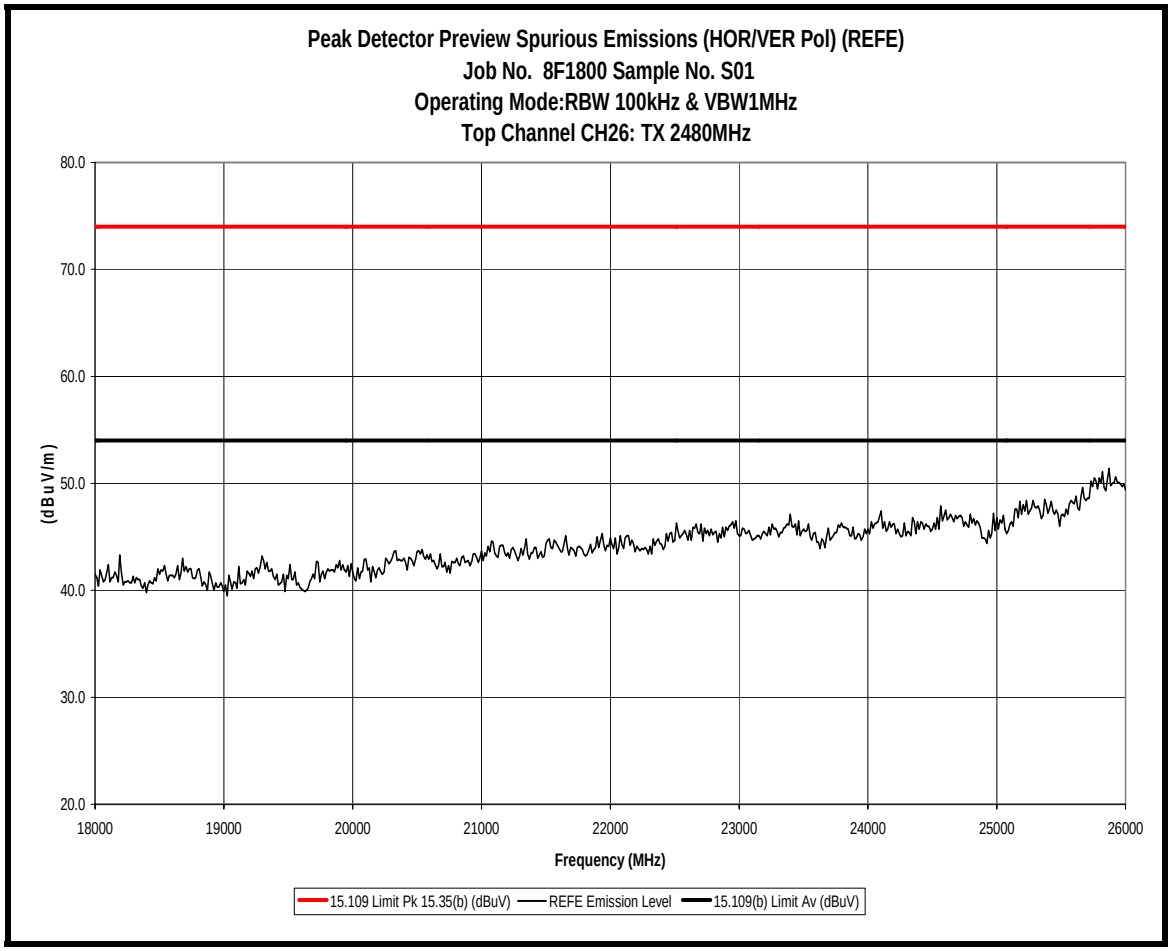
Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



Radiated Transmitter Emissions Channel 26 2480MHz (15.209)



Radiated Transmitter Emissions Channel 26 2480MHz (15.209)

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
S01	5276 ZigBee module (Radiated sample) Product Assembly number 527602-01	None
S02	5276 ZigBee module (Conducted sample) Product Assembly number 527602-01	None

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

Sample No.	Description	Identification
S03	ISA box (Ember)	00:0d:6f:00:0c:0c
S04	Plug Top Switch-Mode PSU for S03 3A-061WP12	EMS120050-P5P-SZ

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

TRaC Telecoms & Radio Identification	Description
RFG389	Thurlby & Thander 30V-2A dc PSU

C2) EUT Operating Mode During Testing.

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

Test	Description of Operating Mode:
CFCP	The EUT was powered via REF389 dc power supply. The EUT was transmitting on maximum power 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
RF Antenna Port Conducted Spurious Emissions	
6dB Bandwidth	
Power Spectral Density	
REFE 15.209	
REFE 15.205 within the restricted band)	

Test	Description of Operating Mode:
REFE 15.109 (Digital devices)	The EUT was powered via REF389 dc power supply. The EUT was in continuous receive mode.

C3) EUT Configuration Information.

Sample	Internal Configuration Details
S01	Single possible internal configuration
S02	Single possible internal configuration

C4) List of EUT Ports

The table below describes the termination of EUT ports:

Sample : S01
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	>3m	RFG389

Sample : S02
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	None	7cm	REF847
dc power port	2 core unscreened	>3m	RFG389

C5 Details of Equipment Used

For Radiated Electric Field Emissions 30MHz to 1GHz:15.109, 15.209 and 15.205 (Restricted band)

RFG No	Type	Description	Manufacturer	Date Calibrated.
274	ATS	Ferrite Lined Chamber	TRaC Telecoms & Radio	29/02/08
231	CBL6111	Blue Bilog Antenna (0.03 - 1GHz)	Chase	12/08/08
214	ESAI	Spec Analyser/Test Rxer (LF/HF)	R & S	11/03/09
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R&S	08/05/09
007	8447F	Dual Pre-Amp	HP	02/01/08
267	N-type	RF coaxial cable (Lab 10)	TRaC Telecoms & Radio	28/01/08
270	N-type	RF coaxial cable (Lab 10)	TRaC Telecoms & Radio	28/01/08
278	N-type	RF coaxial cable (Lab 10)	TRaC Telecoms & Radio	28/01/08

For Radiated Electric Field Emissions 1GHz to 18GHz 15.109, 15.209 and 15.205 (Restricted band)

RFG No	Type	Description	Manufacturer	Date Calibrated
274	ATS	Ferrite Lined Chamber	TRaC Telecoms & Radio	29/02/08
129	3115	Horn Antenna	EMCO	29/07/98
307	HP8449B	Microwave Pre-Amp (1-26.5GHz)	HP	18/02/08
650	N-106	Sucoflex uW Cable 3m	Suhner	14/07/08
651	N-106	Sucoflex uW Cable 7m	Suhner	14/07/08
643	ST18/Nm/Nm/48	48 inch Sucoflex cable	Suhner	18/07/08
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R&S	08/05/09

For Radiated Electric Field Emissions 18GHz to 26GHz 15.109, 15.209 and 15.205 (Restricted band)

RFG No	Type	Description	Manufacturer	Date Calibrated
274	Lab 10	Large anechoic chamber	TRaC Telecoms & Radio	29/02/08
630	QSH20S20S	Horn antenna	Q-par	02/11/06
307	8449B	Microwave Pre-Amp	HP	18/02/08
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R&S	08/05/09
REF831		5m K-Type M-M	Teledyne Reynolds	22/04/09
REF832		2m K-Type M-M	Teledyne Reynolds	22/04/09
476	60637	3m HF cable (SMA to SMA)	Semflex	22/04/09
RFG422	34401A	Multi-meter	HP	19/12/08
RFG389	30V-2A	dc power supply	Thurlby	CAL date N/A

Details of Equipment Used Continued:

For Conducted Emissions

RFG No	Type	Description	Manufacturer	Date Calibrated
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R&S	08/05/09
RFG422	34401A	Multi-meter	HP	19/12/08
RFG389	30V-2A	dc power supply	Thurlby	CAL date N/A

For Conducted RF power

RFG No	Type	Description	Manufacturer	Date Calibrated
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R&S	08/05/09
RFG422	34401A	Multi-meter	HP	19/12/08
RFG389	30V-2A	dc power supply	Thurlby	CAL date N/A

For 6dB Bandwidth measurement

RFG No	Type	Description	Manufacturer	Date Calibrated
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R&S	08/05/09
RFG422	34401A	Multi-meter	HP	19/12/08
RFG389	30V-2A	dc power supply	Thurlby	CAL date N/A

For Power Spectral density

RFG No	Type	Description	Manufacturer	Date Calibrated
REF847	ESU	EMI Test Receiver (Spectrum analyser)	R&S	08/05/09
RFG422	34401A	Multi-meter	HP	19/12/08
RFG389	30V-2A	dc power supply	Thurlby	CAL date N/A

Appendix D: Additional Information

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

The following information is a copy of email correspondence from the client, detailing the change in power level with respect to the two highest channels (channel 24 =2475MHz and channel 26 2480MHz) and remaining operating channels used by the EUT.

Landis+Gyr
1 Lysander Drive,
Northfields Industrial Estate,
Market Deeping,
Peterborough,
PE6 8FB UK

contact:
phone:
email:
fax: +44 (0)1778 349701
switchboard: +44 (0)1778 349700
internet: www.landisgyr.com/europe

Landis+Gyr
manage energy better

6th July 2009

TRaC Global
100 Frobisher Business Park
Leigh Sinton Road
Malvern
Worcestershire
WR14 1BX
UK

RE: Channel Power Settings

FCC ID: ROV-ZIG527602

To Whom It May Concern:

Please be advised that Landis+Gyr have dropped the channel power settings as follows to meet the band edge criteria:-

Channel 11 – 24 = +3dBm output from EM260, Skyworks PA in high power mode
Channel 25 = -3dBm output from EM260, Skyworks PA in high power mode
Channel 26 = -20dBm output from EM260, Skyworks PA in high power mode

Yours faithfully

Landis+Gyr

Ivan Yallup
Product Validation Manager

eama

Landis+Gyr is a trading style of Ampy Metering Ltd,
a limited company registered in England and Wales. Registered number: 1202284.
Registered office: 1 Lysander Drive, Northfields Industrial Estate, Market Deeping, Peterborough, PE6 8FB, UK

Appendix E: Calculation of the duty cycle correction factor

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

Transmit Power Duty Cycle -- Ember Confidential

Version	1.4	
Date of Release	15/05/2009	

Goal: Calculate the worse case time a ZigBee Node will be in TX Mode in any 100ms Time Window.
With the result, a TX Duty Cycle Correction Factor can be used to increase FCC compliance Margin.
Correction Factor is: 20*Log10(Duty Cycle)

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

Worst Case Scenario: The worst case scenario utilizes LIFS, and a TX, RX ACK, TX, RX ACK... from a single node.
It has been proven through calculation, this scenario keeps the node in TX Mode for the longest period of time.

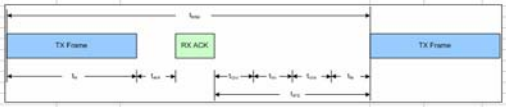
Summary: If you are using EmberZNet Stack SW, the TX duty cycle: 42%
If you are using EmberNet Stack SW, the TX duty cycle: 27%

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 Pramble, 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	IEEE 802.15.4 specifies 5, ZigBee specifies 8
aMaxFrameResponseTime	1220	symbols
aMaxFrameRetries	3	
aUnitBackoffPeriod	20	symbols
macAckWaitDuration	54	symbols
macBattLifeExtPeriods	6	Backoff periods
macMaxCSMABackoffs	4	
macMinBE	3	IEEE 802.15.4 specifies 3, ZigBee specifies 5
aMinLIFSPeriod	40	symbols
aMinSIFSPeriod	12	symbols
aMinCAPLength	440	symbols
NB	0	
CW	2	
BE	5	Will use ZigBee Value



Long Frame Scenario:

1) TX Frame — Assume Frame is Data Frame
2) Wait for ACK
3) RX ACK
4) CPU Processing of ACK
5) Wait for Backoff
6) Repeat 1)

Short Frame Scenario:

1) TX Frame — Assume Frame — Assume Frame is Data Frame
2) Wait for ACK
3) RX ACK
4) CPU Processing of ACK
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	31		Random between 0 and 31
Backoff Required	2		
Backoff Time	300	sym	Average at 15

Transmit Time		
TX Time (Packet)	0.004256	
Total TX Time (sec)	0.004256	

NOT Transmit time (RX or Idle)		
Wait for ACK (tack)	0.000192	
RX Time (ACK)	0.000352	
Backoff Time (tbo)	0.0048	(Backoff Time * Backoff Period)
CPU Processing (tcpu)	0.0002	(0.2ms average on EM2xx running EmberZNet)
CCA Assessment (tcca)	0.000128	(averaged over 8 symbols in RX Mode)
Turn Around Time (RX to TX)	0.000192	(After CCA, Radio turns over to TX in 12 symbols)
Total Off Time (sec)	0.005864	

Total Time (ttotal)	0.01012	
Number of RX / TX cycles in 100ms	9.881422925	
Worse Case (100ms window)		
TX Frame 10 times	0.04256	
RX or IDLE 10 Times	0.05864	
Sum	0.1012	

MAC TX Duty Cycle (On /total)	42.06%	Represents theoretical ZigBee / MAC performance (This number should be used for FCC compliance testing.)

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	31		Random between 0 and 31
Backoff Required	2		
Backoff Time	300	sym	Average at 15

Transmit Time		
TX Time (Packet)	0.000768	
Total TX Time (sec)	0.000768	

NOT Transmit time (RX or Idle)		
Wait for ACK (tack)	0.000192	
RX Time (ACK)	0.000352	
Backoff Time (tbo)	0.0048	(Backoff Time * Backoff Period)
CPU Processing (tcpu)	0.0002	(0.2ms average on EM2xx running EmberZNet)
CCA Assessment (tcca)	0.000128	(averaged over 8 symbols in RX Mode)
Turn Around Time (RX to TX)	0.000192	(After CCA, Radio turns over to TX in 12 symbols)
Total Off Time (sec)	0.005864	

Total Time (ttotal)	0.006632	
Number of periods in 100ms Window	15.07840772	
Worse Case (100ms window)		
TX Frame 15 times	0.01152	
RX or IDLE 15 Times	0.08796	
Sum	0.09948	

MAC TX Duty Cycle (On /total)	11.58%	

Network Based Calculation (LIFS on Ember Net)

Long InterFrame Spacing (Slotted w/ ACK)			LIFS is the worse of the two (LIFS vs. SIFS)
Long Frame	127	bytes	
Data Frame Payload	102	bytes	
ACK Frame	5	bytes	
tack	12	sym	
LIFS	625	sym	Single hop data indicates 10 ms interpacket spacing
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	0.01	
Total Off Time (sec)	0.012464	

Total Time (ttotal)	0.01672	
Number of periods in 100ms Window	5.980861244	
Worse Case (100ms window)		
TX Frame 6 times	0.025536	
RX or IDLE 6 Times	0.074784	
Sum	0.10032	

Network TX Duty Cycle (On /total)	25.45%	Represents theoretical EmberNet / MAC performance (This number should be used for FCC compliance testing.)

Alternative EmberNet calculation

Max radio throughput	250000	bps
Measured throughput single hop	66816	bps
		Max test network results 44544 (packet payload)
Network TX Duty Cycle (On /total)	26.73%	***Measured Network Performance***
Use for FCC Calculations	27%	In TX Mode 27ms worst case in any 100ms window.

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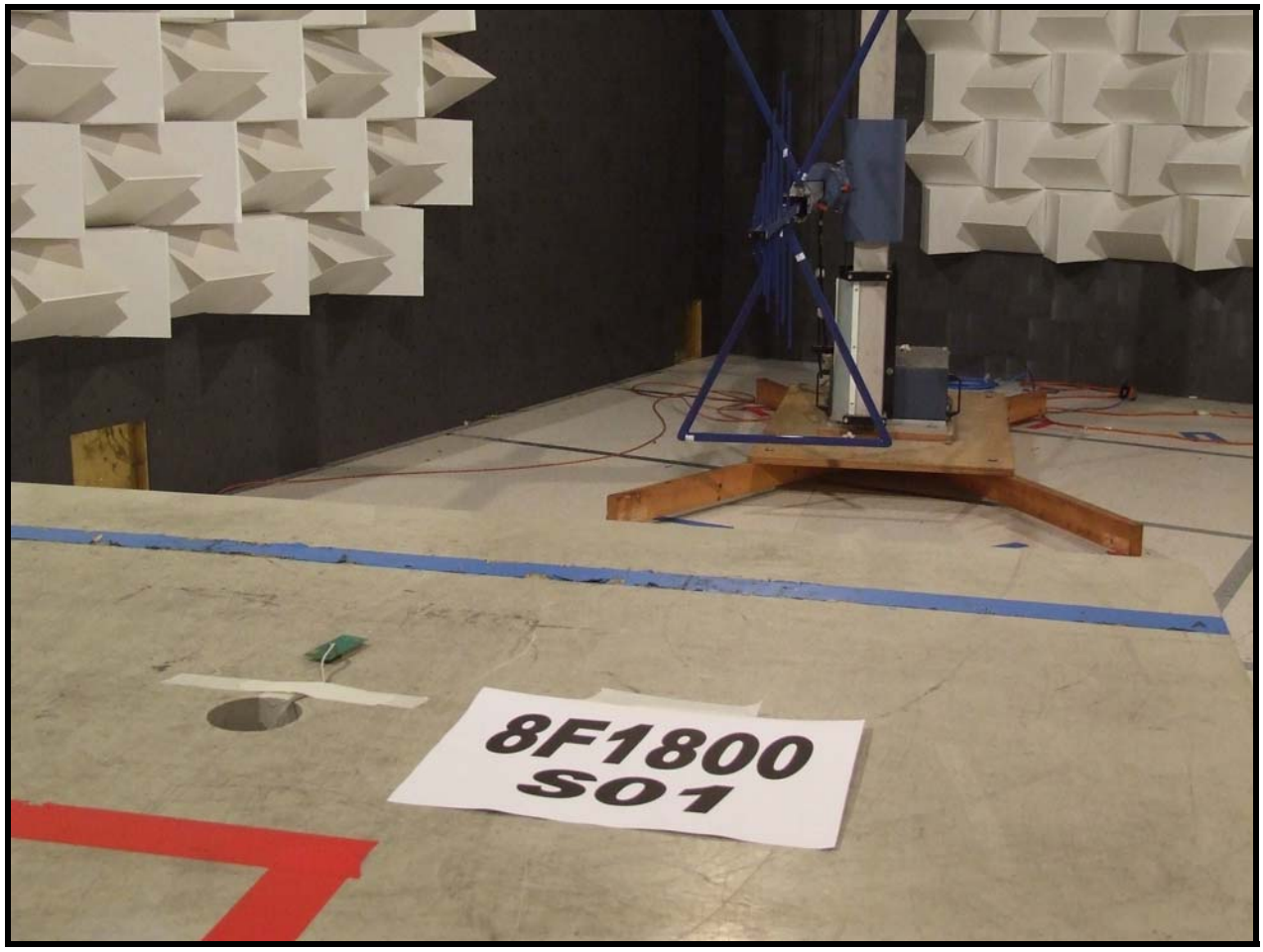
Appendix F: Photographs and Figures

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. Photo of the RF module front view
4. Photo of the RF module front view
5. Photo of the RF module front view
6. Photo of the RF module rear view

Photograph 1



Photograph 2

Photograph 3

Photograph 4

Photograph 5

Photograph 6

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.

A mobile device is defined as a transmitting device 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 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. In this context, the term ''fixed location'' means that the device is physically secured at one location and is not able to be easily moved to another location. Transmitting devices designed to be used by consumers or workers that can be easily re-located, such as wireless devices associated with a personal computer, are considered to be mobile devices if they meet the 20 centimetre separation requirement.

Prediction of MPE limit at a given distance

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

$$S = \frac{PG}{4\pi R^2}$$

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

Maximum peak output power at the antenna terminal:	19.25	dBm
Maximum peak output power at the antenna terminal:	84.13951416	mW
Antenna gain (typical):	9.69	dBi
Maximum antenna gain:	9.311078755	numeric
Prediction distance:	20	cm
Prediction frequency:	2440.000	MHz

Result

Prediction Frequency (MHz)	Maximum allowable antenna gain: (dBi)	Power density (S) at prediction frequency: (mW/cm^2)	MPE limit for uncontrolled exposure at prediction frequency: (mW/cm^2)	Result
2440	17.76269855	0.155858	1	Pass