A RADIO TEST REPORT

FOR

SAM Labs Ltd

ON

SAM BLE base board

DOCUMENT NO. TRA-024586-03-47-00A

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UKAS TESTING
0026

TRaC Wireless Test Report	**:** TRA-024586-03-47-00A
Applicant	**:** SAM Labs Ltd
Apparatus	**:** SAM BLE base board
Specification(s)	**:** CFR47 Part 15.247 & RSS-210 Annex 8
FCCID	**:** 2AEAASL001
Certification Number	**:** 12759A-SL001
Purpose of Test	**: Certification**
Authorised by	: John Charters Digitally signed by John Charters DN: cn=John Charters, o=TRAC Global Ltd, ou=Radio Product Manager, email=john.charters@tracglobal.com, c=GB Date: 2015.03.13 14:34:23 Z : Radio Product Manager
Issue Date	**:**13th March 2015

Total number of pages : 61

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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 :

SAM Labs Ltd
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1.3 Manufacturer

As Above

1.4 Apparatus Assessed

The following apparatus was assessed between 19th – 25th February 2014

SAM BLE base board

The above equipment is a Bluetooth Low energy Module operating in the 2,4 GHz band

1.5 Test Result Summary

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

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

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

Test Type	Regulation		Measurement standard	Result
	Title 47 of the CFR: Part 15 Subpart (c)	RSS – 210 Issue 8, December 2010		
Radiated spurious emissions (Restricted bands)	15.247	Annex 8, A8.5	ANSI C63.10:2013 KDB 558074 D01	Pass
Conducted spurious emissions (Non-restricted bands)	15.247	Annex 8, A8.5	ANSI C63.10:2013 KDB 558074 D01	Pass
AC Power conducted emissions	15.207	RSS-Gen Issue 4 Section 8.8	ANSI C63.10:2013 KDB 558074 D01	Pass
Power Spectral Density	15.247(d)	Annex 8.A8.2b	ANSI C63.10:2013 KDB 558074 D01	Pass
Conducted Carrier Power	15.247(b)(2)	Annex 8, A8.4(2)	ANSI C63.10:2013	Pass
Occupied Bandwidth	15.247(a)(2)	Annex 8.A8.2a	ANSI C63.10:2013 KDB 558074 D01	Pass
Unintentional Radiated Spurious Emissions	15.109	Section 7.2.3	ANSI C63.10:2013 KDB 558074 D01	Pass
Extrapolation Factor:	15.31(f)	RSS-Gen Issue 4 7.2.7	-	Pass
Maximum Frequency of Search:	15.33	RSS-Gen Issue 4 4.9	-	Pass
Antenna Arrangements Integral:	15.203	RSS-Gen Issue 4 7.1.2	-	Pass
Antenna Arrangements External Connector:	15.204	RSS-Gen Issue 4 7.1.2	-	Pass
Restricted Bands:	15.205	RSS-Gen Issue 4 7.2.2	-	Pass
Digital Modulation	15.403	-	-	Pass
RF Safety	RSS-102	15.247(b)(5) KDB447498 SAR Exclusion Calculation	-	Pass

Abbreviations used in the above table:

ANSI C 63.10:2013 is outside the scope of the laboratories UKAS accreditation.

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

1.6 Notes Relating To The Assessment

With regard to this assessment, the following points should be noted:

The results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 1.7 of this test report (Deviations from Test Standards).

For emissions testing, throughout this test report, “Pass” indicates that the results for the sample as tested were below the specified limit (refer also to Section 2, Measurement Uncertainty).

Where relevant, the apparatus was only assessed using the monitoring methods and susceptibility criteria defined in this report.

All testing with the exception of testing at the Open Area Test Site was performed under the following environmental conditions:

Temperature	: 17 to 23 °C
Humidity	: 45 to 75 %
Barometric Pressure	: 86 to 106 kPa

All dates used in this report are in the format dd/mm/yy.

This assessment has been performed in accordance with the requirements of ISO/IEC 17025.

1.7 Deviations from Test Standards

There were no deviations from the standards tested to.

Section 2: Measurement Uncertainty

2.1 Measurement Uncertainty Values

For the test data recorded the following measurement uncertainty was calculated.

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95% confidence where no required test level exists.

[1] Adjacent Channel Power

Uncertainty in test result = **1.86dB**

[2] Carrier Power

Uncertainty in test result (Power Meter) = **1.08dB**
Uncertainty in test result (Spectrum Analyser) = **2.48dB**

[3] Effective Radiated Power

Uncertainty in test result = **4.71dB**

[4] Spurious Emissions

Uncertainty in test result = **4.75dB**

[5] Maximum frequency error

Uncertainty in test result (Frequency Counter) = **0.113ppm**
Uncertainty in test result (Spectrum Analyser) = **0.265ppm**

[6] Radiated Emissions, field strength OATS 14kHz-18GHz Electric Field

Uncertainty in test result (14kHz – 30MHz) = **4.8dB**,
Uncertainty in test result (30MHz – 1GHz) = **4.6dB**,
Uncertainty in test result (1GHz – 18GHz) = **4.7dB**

[7] Frequency deviation

Uncertainty in test result = **3.2%**

[8] Magnetic Field Emissions

Uncertainty in test result = **2.3dB**

[9] Conducted Spurious

Uncertainty in test result – Up to 8.1GHz = **3.31dB**
Uncertainty in test result – 8.1GHz – 15.3GHz = **4.43dB**
Uncertainty in test result – 15.3GHz – 21GHz = **5.34dB**
Uncertainty in test result – Up to 26GHz = **3.14dB**

[10] Channel Bandwidth

Uncertainty in test result = **15.5%**

[11] Amplitude and Time Measurement – Oscilloscope

Uncertainty in overall test level = **2.1dB**,
Uncertainty in time measurement = **0.59%,**
Uncertainty in Amplitude measurement = **0.82%**

[12] Power Line Conduction

Uncertainty in test result = **3.4dB**

[13] Spectrum Mask Measurements

Uncertainty in test result = **2.59% (frequency)**
Uncertainty in test result = **1.32dB (amplitude)**

[14] Adjacent Sub Band Selectivity

Uncertainty in test result = **1.24dB**

[15] Receiver Blocking – Listen Mode, Radiated

Uncertainty in test result = **3.42dB**

[16] Receiver Blocking – Talk Mode, Radiated

Uncertainty in test result = **3.36dB**

[17] Receiver Blocking – Talk Mode, Conducted

Uncertainty in test result = **1.24dB**

[18] Receiver Threshold

Uncertainty in test result = **3.23dB**

[19] Transmission Time Measurement

Uncertainty in test result = **7.98%**

Section 3: Modifications

3.1 Modifications Performed During Assessment

No modifications were performed during the assessment

Section 4 General Test Procedures

4.1 Radiated Test Setup and Procedures

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst case determined for function, operation, orientation etc for both vertical and horizontal polarisations

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

For devices with intentional emissions below 30 MHz, a shielded loop antenna is used as the test antenna. It is placed at a 1 meter receive height and appropriate low frequency magnetic field extrapolation to the regulatory limit distance is employed. The EUT is rotated through 360˚in the azimuth.

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360˚ in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Where regulations allow for direct measurement of field strength, power values measured on the test receiver / analyzer are converted to dBuV/m at the regulatory distance, using:

$$FS = PR + AF + CL - PA + KG + DC - CF \text{ (dBuV/m)}$$

Where:

PR is the power recorded on receiver / spectrum analyzer (dBuV),
AF is the test antenna factor in dB/m,
CL is the cable loss in dB,
PA is the pre-amplifier gain dB (when applicable),
DC is duty correction factor (when applicable) in dB, and
CF is a distance correction (employed only for measurements at alternate distance to limit) in dB.

This field strength value is then compared with the regulatory limit.

If effective radiated power (ERP) or effective isotropic radiated power (EIRP) is required, it is computed as per ANSI C63.10

$$P = \frac{(Ed)^2}{30G}$$

Where

P is the power, in W
E is the measured peak field strength, in V/m
d is the distance at which the measurement was made, in m
G is the numeric gain of the radiating element

If the gain of the radiating element is not known, then either the effective radiated power (ERP) or the effective isotropic radiated power (EIRP) may be calculated from the measured peak field strength, by using either G = 1.64 or G = 1, respectively.

4.2 AC Powerline Conducted Emissions Test Setup and Procedures

AC Powerline Conducted Emissions from the EUT are checked first by preview scans with Peak and average detectors covering both live and neutral lines. A spectrum analyser is used to determine if any periodic emissions are present. Preview scans are performed in standby or receive mode if the device is subject to these requirements. For transmit mode of operation the device is set to one of the following modes.

- Transmitting operating at full power (single mode device)
- Transmitting at freq / modulation that gives highest output power (multi mode device)
- Transmitter operating in normal TX mode (e.g. FHSS, TDMA etc)

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans.

Battery Power devices are not subject to power line conducted emissions measurements when it is powered solely by its internal battery.

4.3 Antenna Port Conducted Emissions

Antenna port conducted emissions can include, but are not limited to, Carrier power, Power Spectral Density, Occupied bandwidth and spurious emission.

Spurious Emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked to identify frequencies to perform formal measurements on.

Formal measurements are made on frequencies identified from the preview scans and fundamental emission(s). Measurements are made using the correct instrumentation (inc. power meter, receiver, spectrum analyser) that operate with the required detector(s) and bandwidth.

Care is taken to ensure the measurement instrument is not overloaded by the presence of the transmitted signal by use of external attenuation and filtering where required.

Measured levels are corrected for cables, attenuators, and filters. If applicable, for the specific measurement, antenna gain is also taken into account.

4.4 Power Supply Variation

Tests at extreme supply voltages are made if required by the procedures specified in the test standard, and results of this testing are detailed in this report.

In the case the EUT is designed for operation from a lead-acid battery power source, the extreme test voltages are evaluated between 90% and 130% of the nominal battery voltage declared by the manufacturer.

For float charge applications using gel-cell type batteries, extreme test voltages are evaluated between 85% and 115% of the nominal battery voltage declared.

For all battery operated equipment, worst case intentional and spurious emissions are re-checked employing a new (fully charged) battery.

4.5 Thermal Variation

Tests at extreme temperatures are made if required by the procedures specified in the test standard, and results of this testing are detailed in this report.

Tests are performed at the upper and lower extremes as required and typically at 10˚ steps between.

Before any temperature measurements are made, the equipment is allowed to reach a thermal balance in the test chamber.

4.6 Time Domain Measurements

Time domain measurements are made for (but not limited to) use in duty cycle correction, to ensure compliance with time restrictions on certain types of devices.

If measurements of a transmitter's on time are required these are performed with a spectrum analyser in the time domain or with an oscilloscope and RF detector. If time on a specific frequency is required (e.g. FHSS timing) the measurement can only be made with a spectrum analyser.

The triggering, timescale and amplitude settings are adjusted according to the signal to be measured on a case by case basis.

For devices with sharp rise/fall times measurements are made between RF reaching full power (T_{on}) and RF dropping to the measurement instrument noise floor (T_{off}). For longer rise times measurements are made for T_{on} and T_{off} at the RF level required by the occupied bandwidth measurement (e.g. 6 dB, 20 dB etc).

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
CDN	: Coupling & decoupling network

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

A1 6 dB Bandwidth

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

RSS-210 Issue 8 December 2010 requires the measurement of the bandwidth of the transmission between the -6 dB points on the transmitted spectrum.

Test Details:	
Regulation	Part15 Subpart (c) 15.247(b)(3), RSS-210 Annex 8.A8.2b
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S01
Modification state	0
SE in test environment	S04, S05
SE isolated from EUT	None
Temperature	$27^{O}C$
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	F_{lower} (MHz)	F_{Higher} (MHz)	Measured 20 dB Bandwidth (kHz)	Limit	Result
2402	2401.644231	2402.336538	692.307	> 500kHz	Pass
2440	2439.644231	2440.336538	692.307	> 500kHz	Pass
2480	2479.629808	2480.331731	701.923	> 500kHz	Pass

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

558074 D01 DTS Meas Guidance v03r02
Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

A2 Transmitter Peak Output Power

Carrier power was verified with the EUT transmitting on its lowest, centre and highest carrier frequency in turn.

Test Details:	
Regulation	Part15 Subpart (c) 15.247(b)(3), RSS-GEN Annex 8.A4 (4).
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S01
Modification state	0
SE in test environment	S04, S05
SE isolated from EUT	None
Temperature	27 ^{O}C
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Conducted Peak Carrier Power (dBm)	Conducted Peak Carrier Power (mW)	Limit (W)	Result
2402.0	7.85	6.10	1	Pass
2440.0	8.32	6.79	1	Pass
2480.0	8.50	7.08	1	Pass

Notes:

Conducted Measurement

Highest Gain of any antenna to be used = 0.5 dBi
Conducted measurements were performed with a temporary antenna connector provided by the client.

558074 D01 DTS Meas Guidance v03r02
Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

A3 Transmitter Power Spectral Density

Transmitter Power Spectral Density was verified with the EUT transmitting on its lowest, centre and highest carrier frequency in turn.

Test Details:	
Regulation	Part15 Subpart (c) 15.247(b)(3), RSS-210 Annex 8.A8.2b
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S01
Modification state	0
SE in test environment	S04, S05
SE isolated from EUT	None
Temperature	27 ^{O}C
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Conducted Peak Power Spectral Density (dBm)	Limit (dBm)	Result
2402.0	5.87	+8	Pass
2440.0	6.41	+8	Pass
2480.0	6.69	+8	Pass

Notes:

Conducted Measurement

558074 D01 DTS Meas Guidance v03r02
Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

Measurement Bandwidth of 30 kHz

A4 RF Antenna Conducted Spurious Emissions

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

Test Details:	
Regulation	Part 15.109, RSS – GEN, Section 7.2.3
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	9 kHz to 25 GHz
EUT sample number	S01
Modification state	0
SE in test environment	S04, S05
SE isolated from EUT	None
Temperature	27 ^{O}C
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
2402.0 MHz						
No Significant Emissions Within 20 dB of Limit						
2440.0 MHz						
No Significant Emissions Within 20 dB of Limit						
2480.0 MHz						
No Significant Emissions Within 20 dB of Limit						

Notes:

1. The conducted emission limit for emissions are based on a transmitted carrier level . 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 the regulations using a peak detector.
2. The RBW = 100 kHz, Video bandwidth (VBW) > RBW and the radio spectrum was investigated up to the 10th harmonic in accordance15.33 (a)(1).
3. The measurements at 2400 MHz and 2483.5 MHz were made to ensure band edge compliance.
4. The carrier level was measured whilst varying the supply voltage between 85% and 105% of the nominal supply voltage as required by 15.31(e). No variation in carrier level was observed.

The limit outside the restricted band in 100 kHz RBW is defined using the following formula.

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

A5 Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 100 kHz. The maximum permitted field strength are described in Section 15.247(d) and per RSS – 210 Annex 8, A8.5. The EUT was set to transmit.

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

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

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

Test Details:	
Regulation	Part 15.109, RSS – GEN, Section 7.2.3
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz – 25GHz
EUT sample number	S02
Modification state	0
SE in test environment	S06
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	26 ^{O}C
Photographs (Appendix F)	1 & 2

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

Det	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
2402.0 MHz									
Pk	4804.006	49.0	3.8	32.7	35.6	49.9	0.00	312.25	5012
Av	4804.006	39.1	3.8	32.7	35.6	40.0	0.00	99.66	500
2440.0 MHz									
Pk	4880.024	49.8	3.7	33.0	35.6	50.9	0.00	350.75	5012
Av	4880.024	39.1	3.7	33.0	35.6	40.3	0.00	103.28	500
2480.0 MHz									
Pk	4959.952	50.7	3.6	33.2	35.6	51.9	0.00	394.91	5012
Av	4959.952	39.8	3.6	33.2	35.6	41.0	0.00	112.20	500

Notes:

1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.10: and ANSI C63.4:
2 In accordance with 15.35(b), above 1 GHz, emissions measured using a peak detector shall not exceed a level 20 dB above the average limit.
3 Measurements at 2400 & 2483.5 MHz were made to ensure band edge compliance.
4 Testing was performed with the EUT orientated in three orthogonal planes and the maximum emissions level recorded. In addition, the EUT antenna was varied within its range of motion in order to maximise emissions.
5 For Frequencies below 1 GHz, RBW= 100 kHz, testing was performed with CISPR16 compliant test receiver with QP detector. Above 1 GHz tests were performed using a spectrum analyser using the following settings:
Peak RBW=VBW= 1MHz
Average RBW=VBW= 1MHz

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

Radiated emission limits for emissions falling within the restricted bands.

Frequency of emission (MHz)	Field strength (μV/m)	Measurement Distance (m)	Field strength (dBμV/m)
30-88	100	3	40.0
88-216	150	3	43.5
216-960	200	3	46.0
Above 960	500	3	54.0

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

A6 Power Line Conducted Emissions

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

Test Details:	
Regulation	Part 15 Clause 15.207, RSS – GEN, Section 7.2.2
Measurement standard	ANSI C63.10
Frequency range	150kHz to 30MHz
EUT sample number	S02
Modification state	0
SE in test environment	S06
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Photographs (Appendix F)	Photograph 3

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

Results measured using the Average detector compared to the quasi–peak limit						
Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
No Significant Emissions Within 20 dB of limit						

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
No Significant Emissions Within 20 dB of limit						

Specification limits :

Conducted emission limits (47 CFR Part 15: Clause 15.207):

Conducted disturbance at the mains ports.

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

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

Notes:

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

(b) The following table summarises the effect of the EUT operating mode and internal configuration on the measured emission levels :

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

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

A7 Antenna Gain

The maximum antenna gain for the antenna types to be used with the EUT, as declared by the client, is 0.5 dBi.

"High Frequency Ceramic Solutions"

2450 MHz Antenna — **P/N 2450AT18B100**
Detail Specification: 08/10/09 — Page 1 of 3

General Specifications

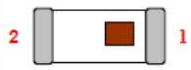
Part Number	2450AT18B100
Frequency Range	2400 - 2500 Mhz
Peak Gain	0.5 dBi typ. (XZ-V)
Average Gain	-0.5 dBi typ. (XZ-V)
Return Loss	9.5 dB min.

Input Power	3W max.
Impedance	50 Ω
Operating Temperature	-40 to +85°C
Reel Quanity	3,000

P/N Suffix				
	Packaging Style	Bulk	Suffix = S	Eg. 2450AT18B100S
		T & R	Suffix = E	Eg. 2450AT18B100E
	Termination Style	100% Tin	Suffix = None	Eg. 2450AT18B100(E or S)
		Tin / Lead	Please consult Factory	

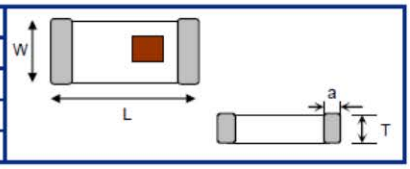
Terminal Configuration

No.	Function
1	Feeding Point
2	NC



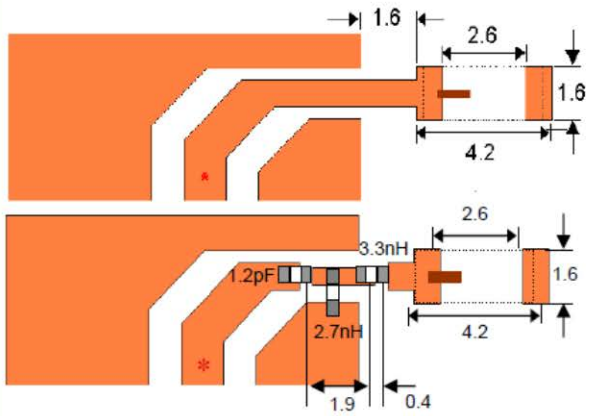
Mechanical Dimensions

	In	mm
L	0.126 ± 0.008	3.20 ± 0.20
W	0.063 ± 0.008	1.60 ± 0.20
T	0.051 +.004/-.008	1.30 +0.1/-0.2
a	0.020 ± 0.012	0.50 ± 0.30



Mounting Considerations

Mount these devices with brown mark facing up. Units: mm
Line width should be designed to provide 50 Ω impedance matching characteristics.



a) Without Matching Circuits

b) With Matching Circuits

JTI P/N for Matching Circuit:
Cap (1.2pF): 500R07S1R2BV4T
Inductor (2.7nH): L-07C2N7SV6T
Inductor (3.3nH): L-07C3N3SV6T

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JOHANSON TECHNOLOGY

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A8 Unintentional Radiated Electric Field Emissions

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

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

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

Test Details:	
Regulation	Part 15.109, RSS – GEN, Section 7.2.3
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz to 25 GHz
EUT sample number	S02
Modification state	0
SE in test environment	S06
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	26 ^{O}C
Photographs (Appendix F)	1 & 2

The worst case radiated emission measurements for spurious emissions:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
Pk	1144.231	58.8	1.9	25.6	37.5	48.9	0.00	277.65	5012
Av	1144.231	48.5	1.9	25.6	37.5	38.6	0.00	85.02	500

Appendix B: Supporting Graphical Data

This appendix contains graphical data obtained during testing.

Notes:

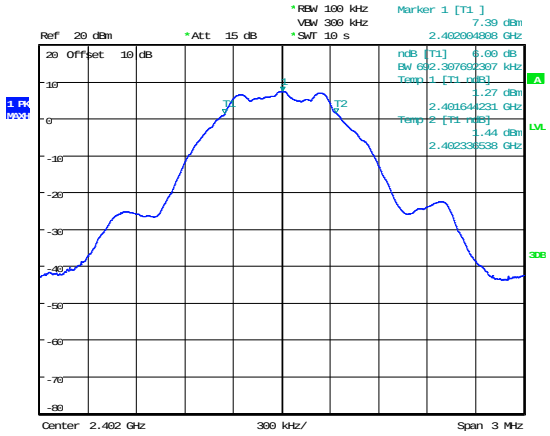
(a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.

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

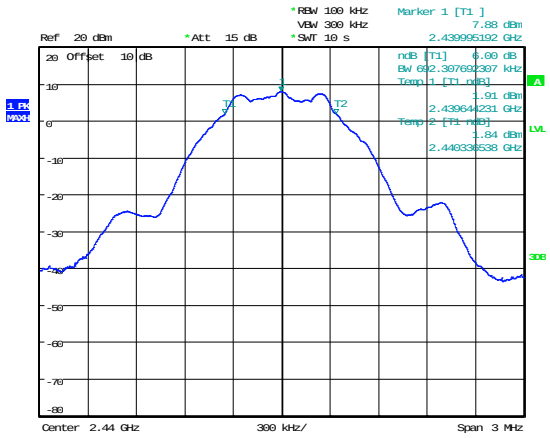
(c) Where relevant, on power line conducted emission plots, the limit displayed is the average limit, which is stricter than the quasi peak limit.

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

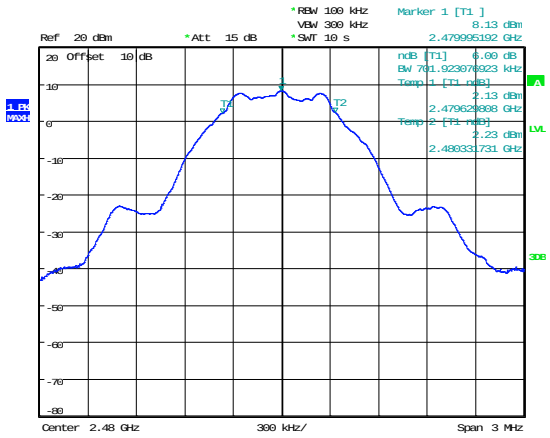
(e) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.



6dB Bandwidth 2402MHz

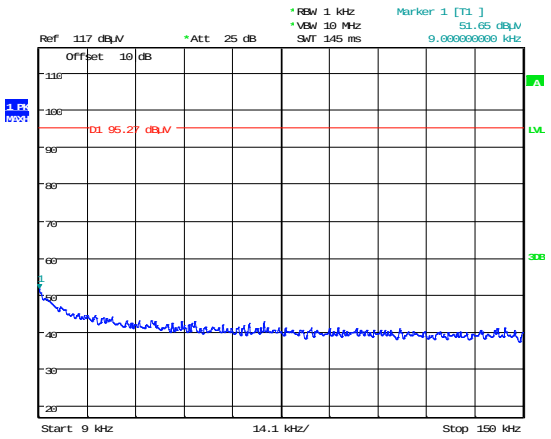


6dB Bandwidth 2440 MHz

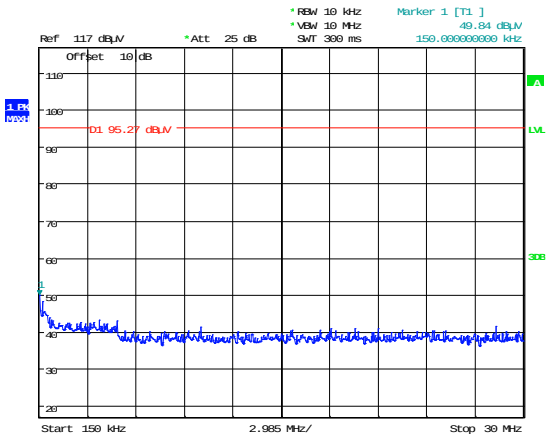


6dB Bandwidth 2480 MHz

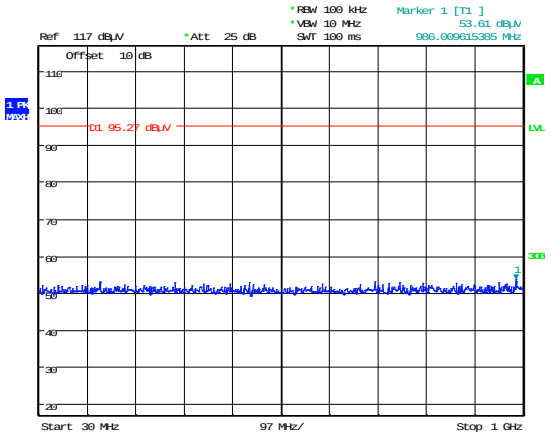
Conducted Spurious emissions 2402.0 MHz



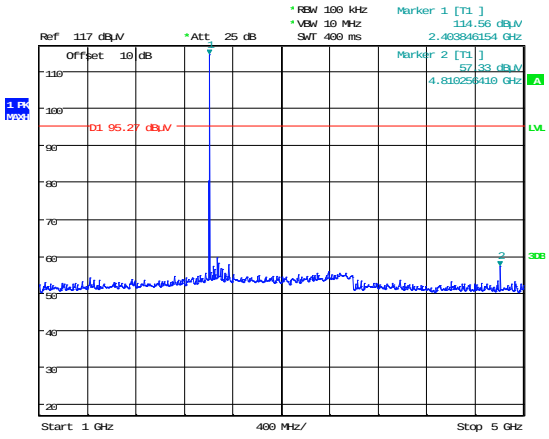
9kHz – 150 kHz



150kHz – 30 MHz

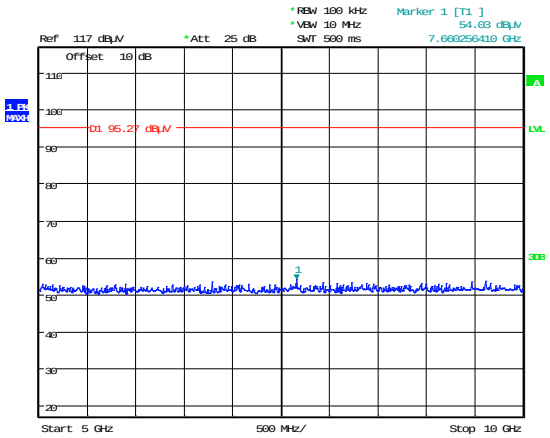


30 MHz to 1 GHz



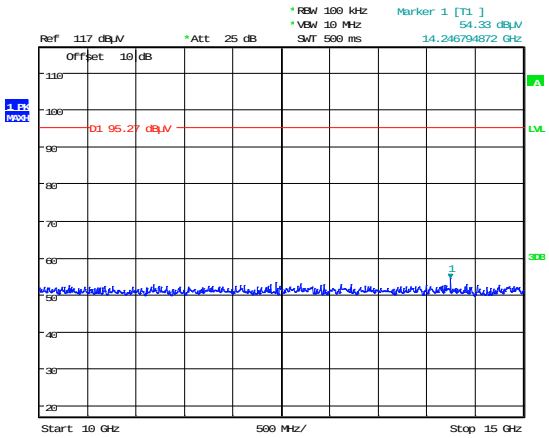
1 GHz to 5 GHz

Conducted Spurious emissions 2402.0 MHz



Date: 18.FEB.2015 14:52:10

5 GHz to 10 GHz



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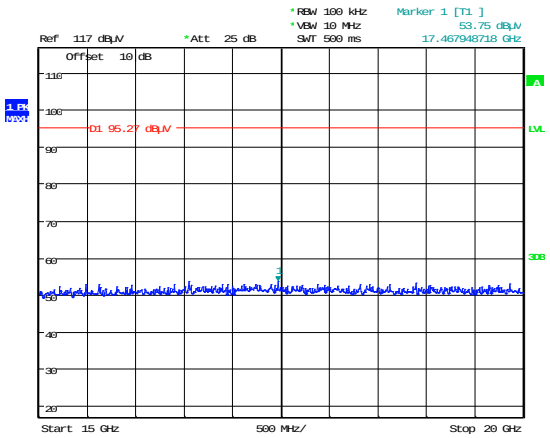
10 GHz to15 GHz



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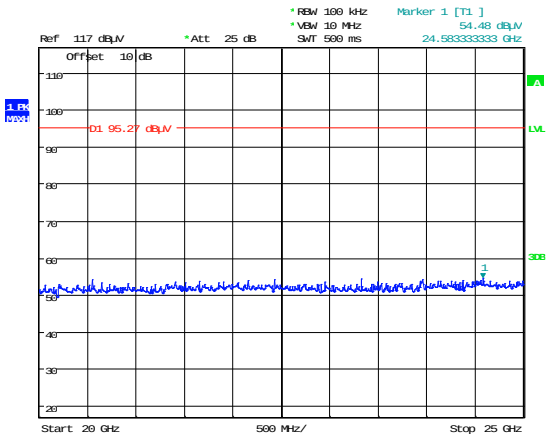
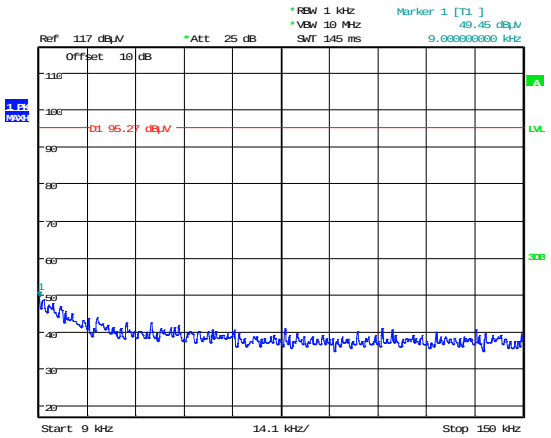
15 GHz to 20 GHz



Date: 18.FEB.2015 14:52:49

20 GHz to 25 GHz

Conducted Spurious emissions 2440.0 MHz



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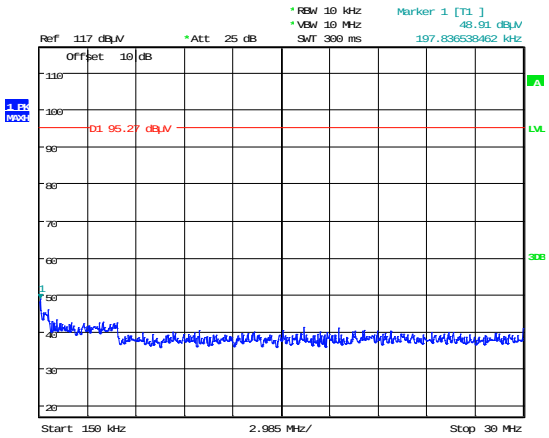
9kHz – 150 kHz



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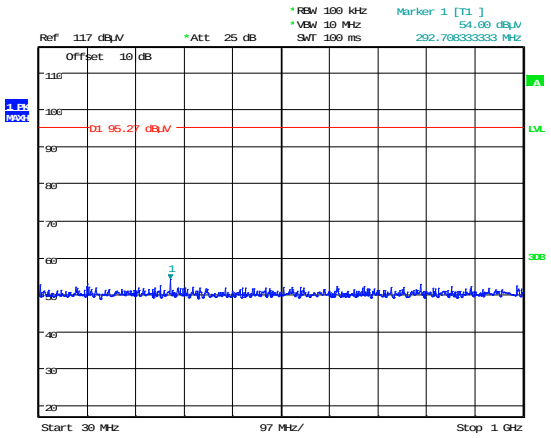
150kHz – 30 MHz



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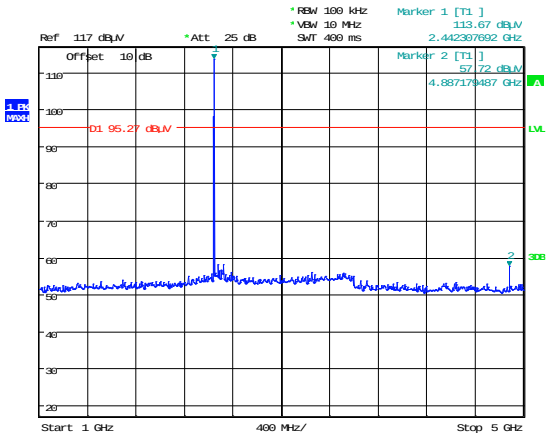
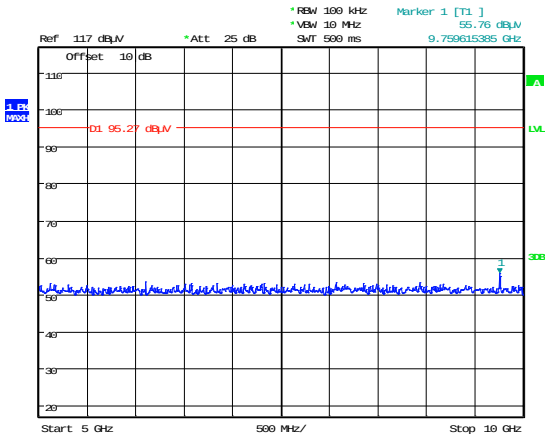
30 MHz to 1 GHz



Date: 18.FEB.2015 14:35:37

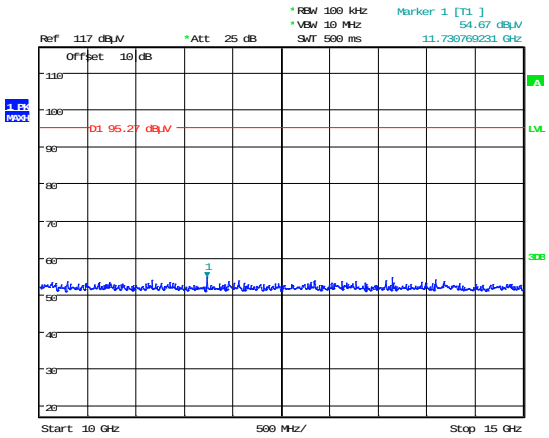
1 GHz to 5 GHz

Conducted Spurious emissions 2440.0 MHz



Date: 18.FEB.2015 14:35:49

5 GHz to 10 GHz



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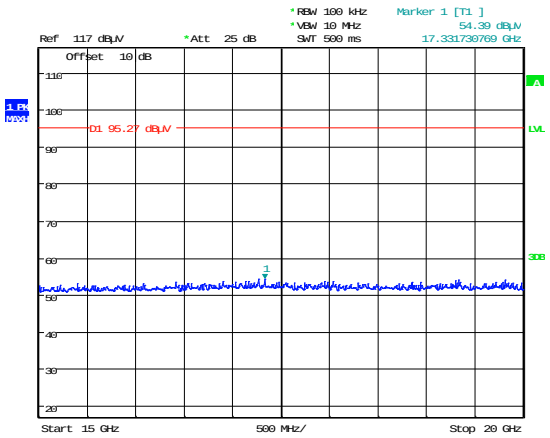
10 GHz to15 GHz



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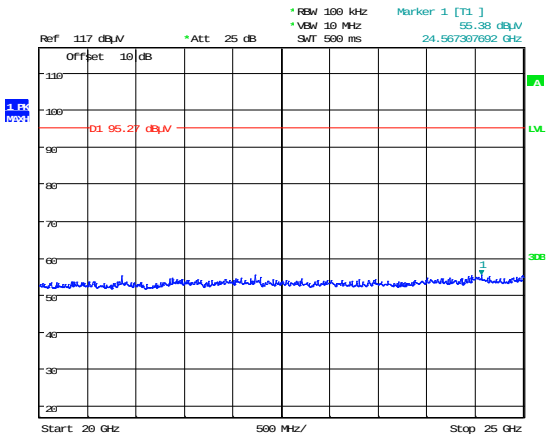
15 GHz to 20 GHz



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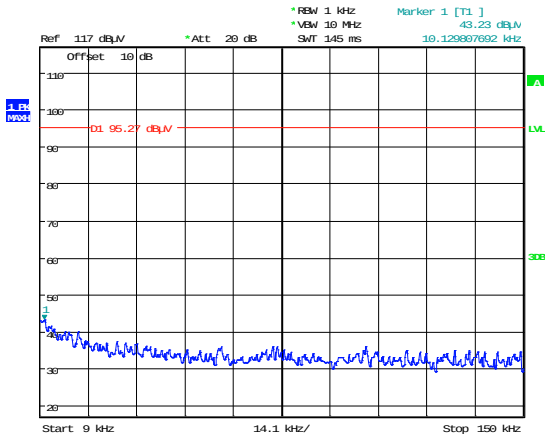
20 GHz to 25 GHz

Conducted Spurious emissions 2480.0 MHz



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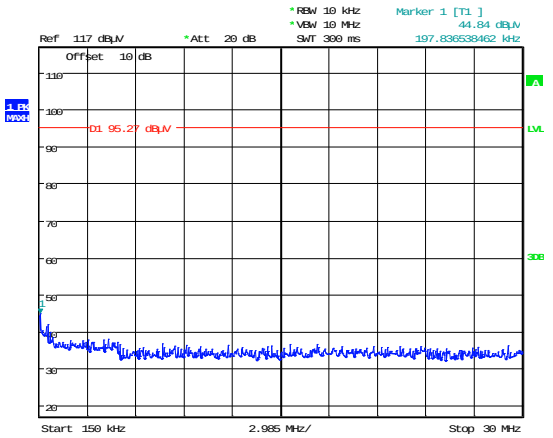
9kHz – 150 kHz



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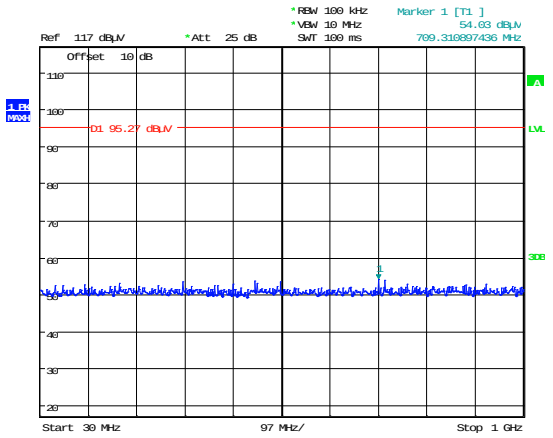
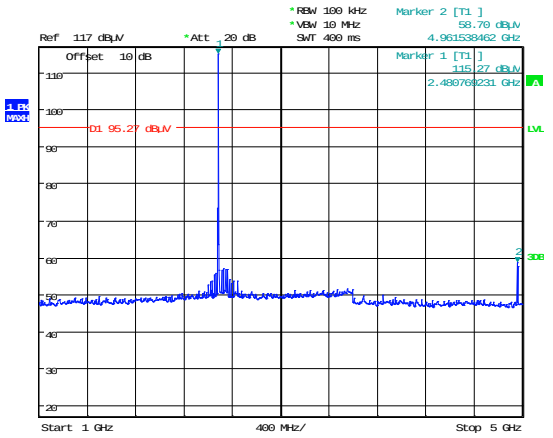
150kHz – 30 MHz



Date: 18.FEB.2015 14:30:44

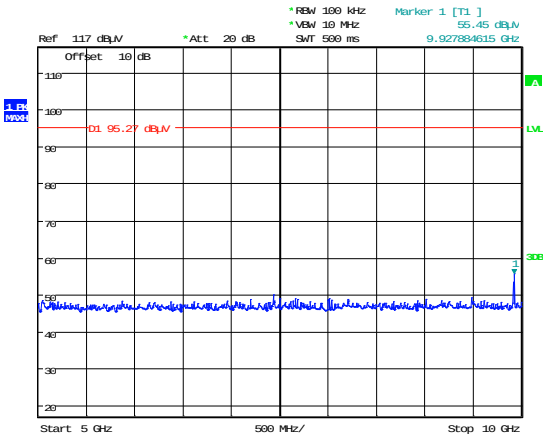
30 MHz to 1 GHz



Date: 18.FEB.2015 14:28:13

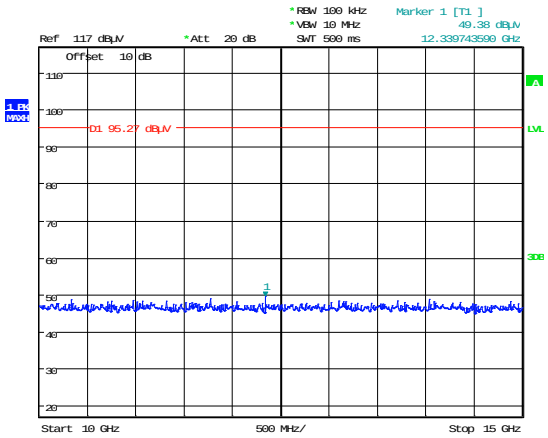
1 GHz to 5 GHz

Conducted Spurious emissions 2480.0 MHz



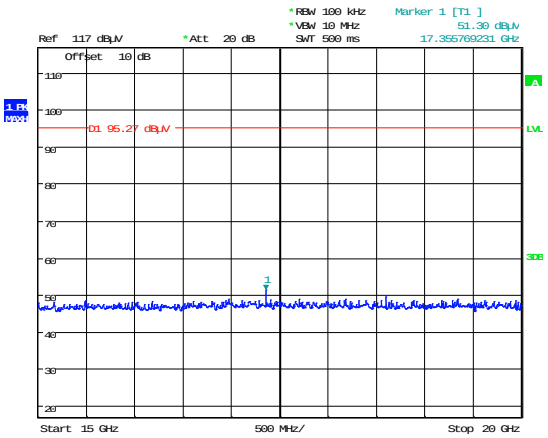
Date: 18.FEB.2015 14:29:10

5 GHz to 10 GHz



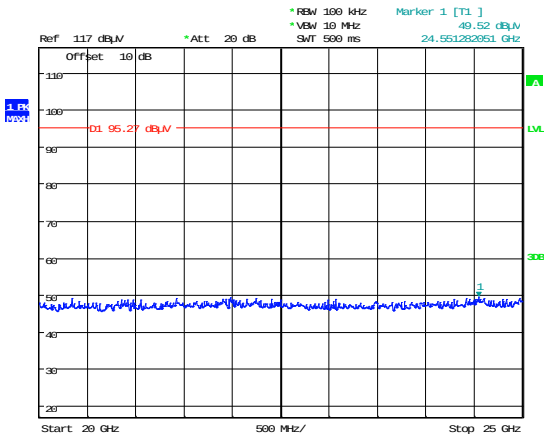
Date: 18.FEB.2015 14:29:21

10 GHz to15 GHz



Date: 18.FEB.2015 14:29:43

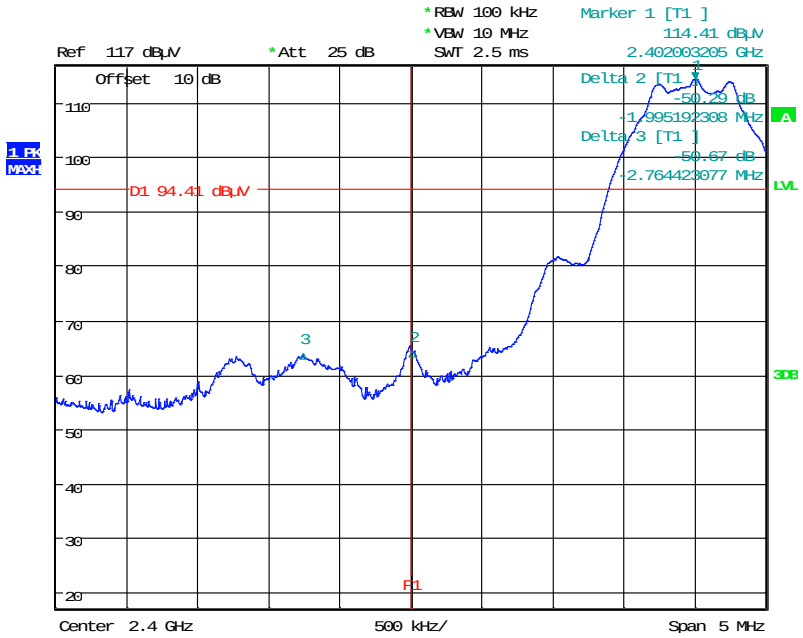
15 GHz to 20 GHz



Date: 18.FEB.2015 14:29:54

20 GHz to 25 GHz

Conducted band-edge compliance



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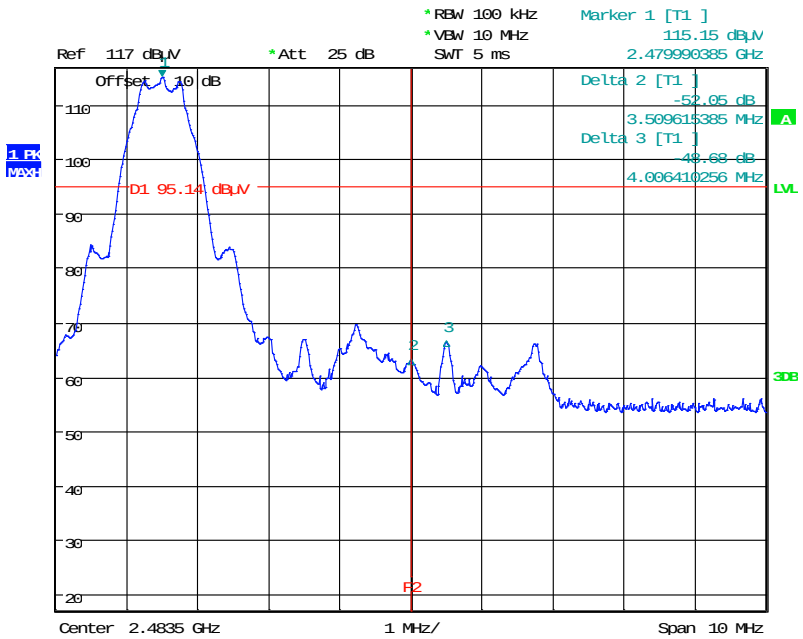
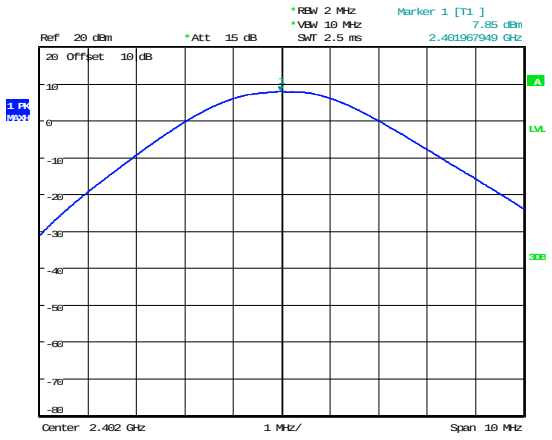
lower band edge

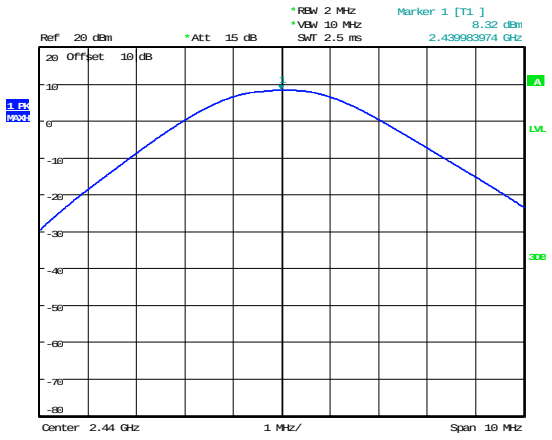


Date: 18.FEB.2015 14:54:49

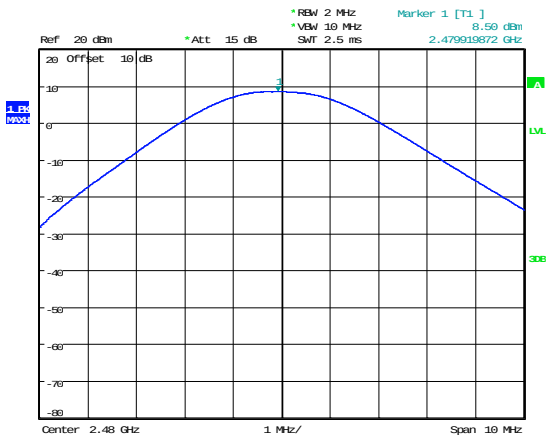
upper band-edge



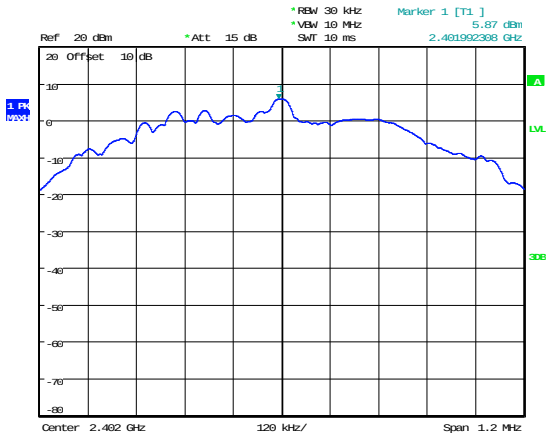
Carrier power 2402MHz



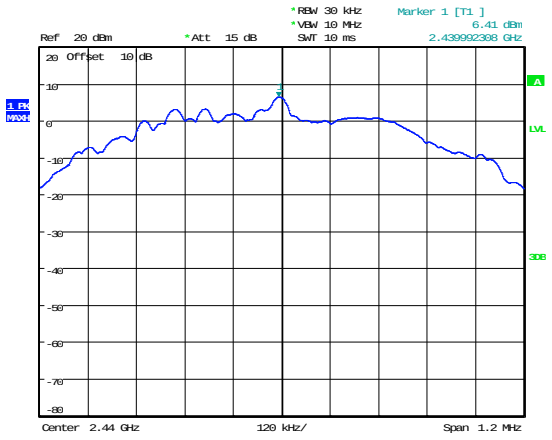
Carrier power 2440 MHz



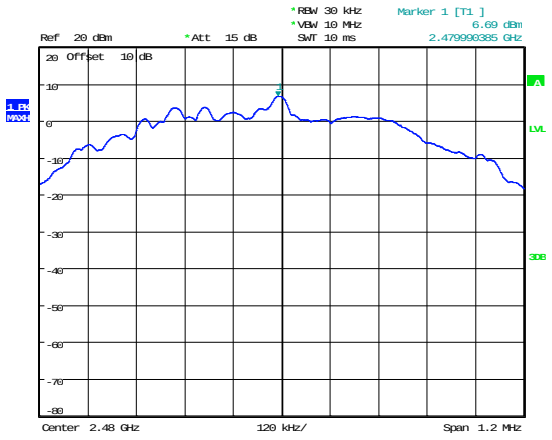
Carrier power 2480 MHz



Power spectral density 2402MHz

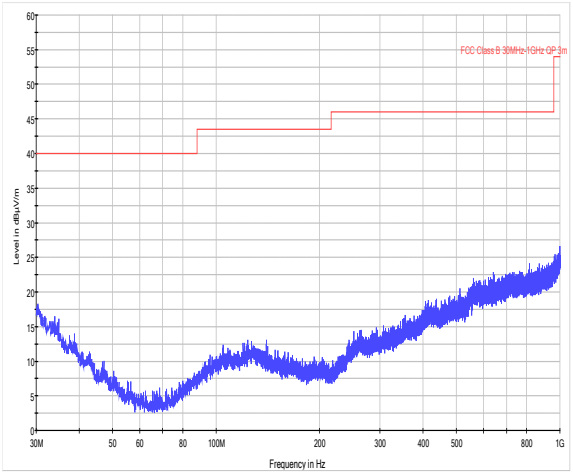


Power spectral density 2440 MHz

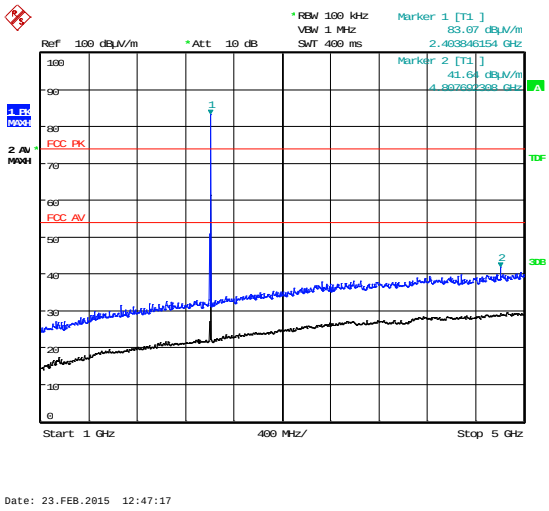


Power spectral density 2480 MHz

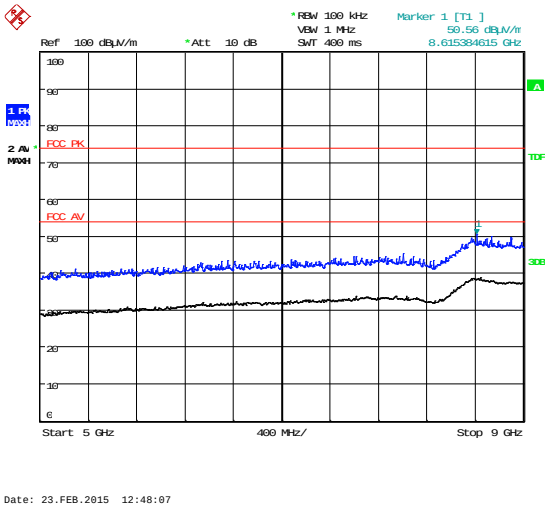
Radiated Spurious emissions– 2402MHz



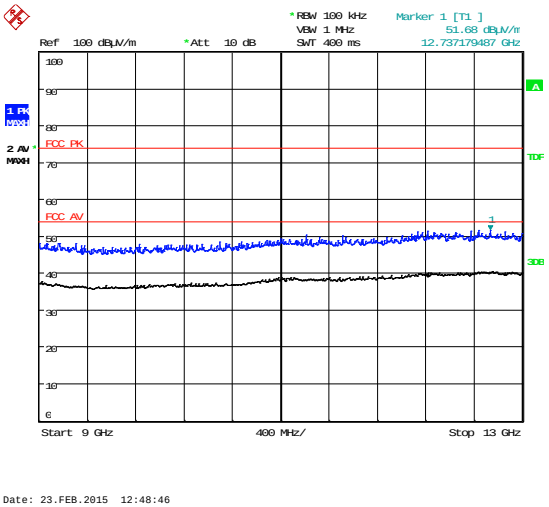
30 MHz to 1 GHz



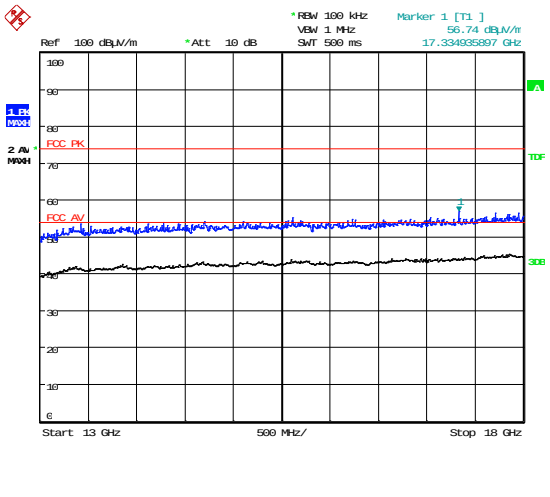
1 GHz to 5 GHz



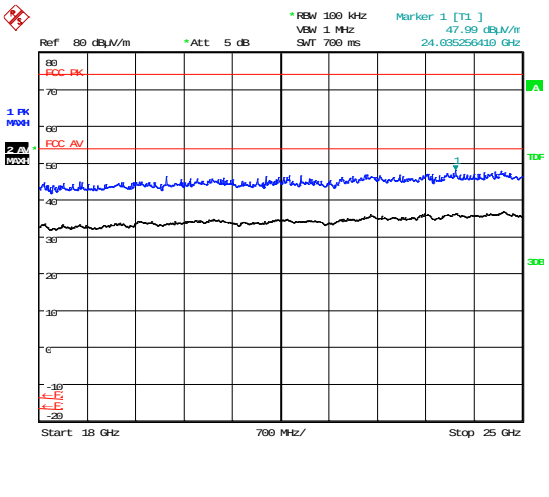
5 GHz to 9 GHz



9 GHz to 13 GHz

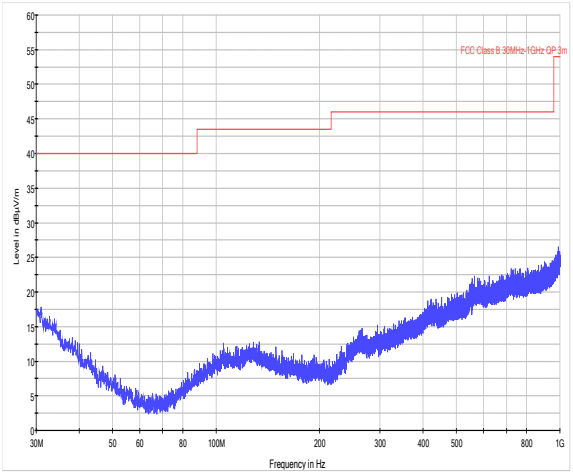


13 GHz to 18GHz

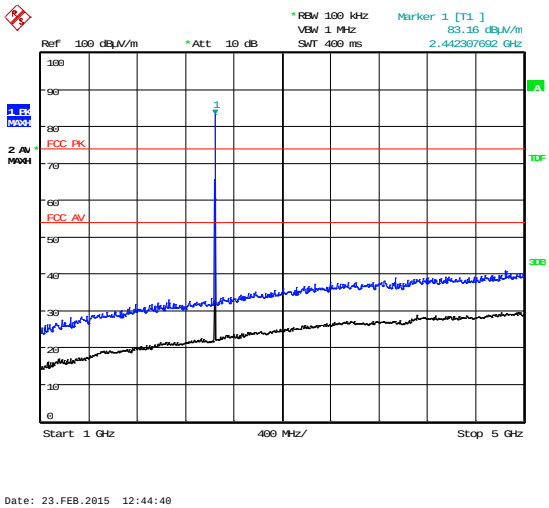


18 GHz to 25 GHz

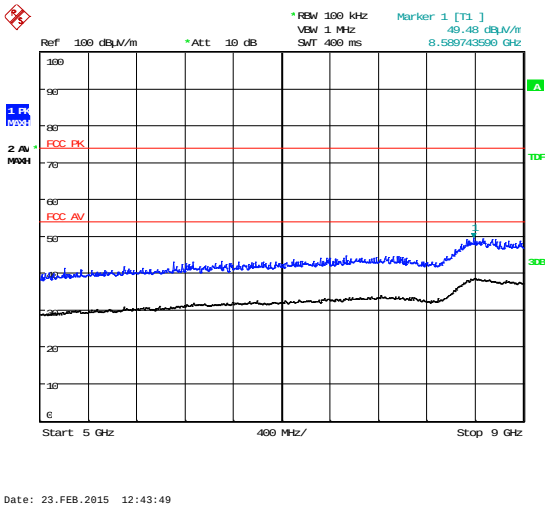
Radiated Spurious emissions– 2440MHz



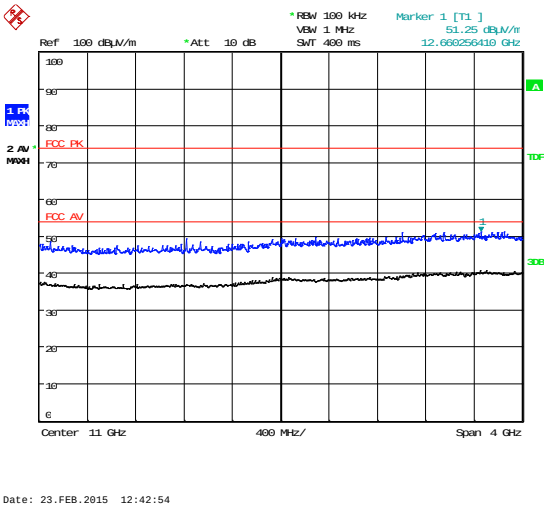
30 MHz to 1 GHz



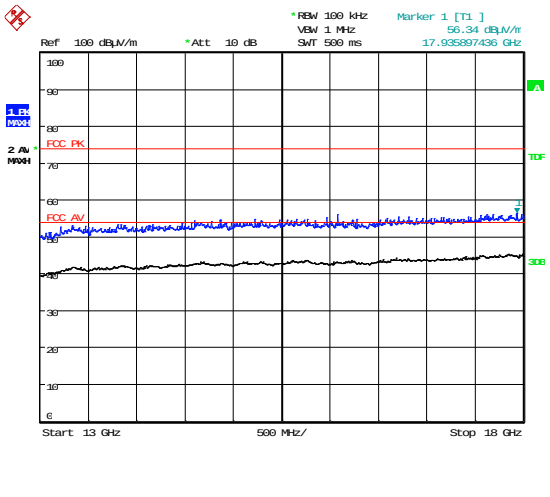
1 GHz to 5 GHz



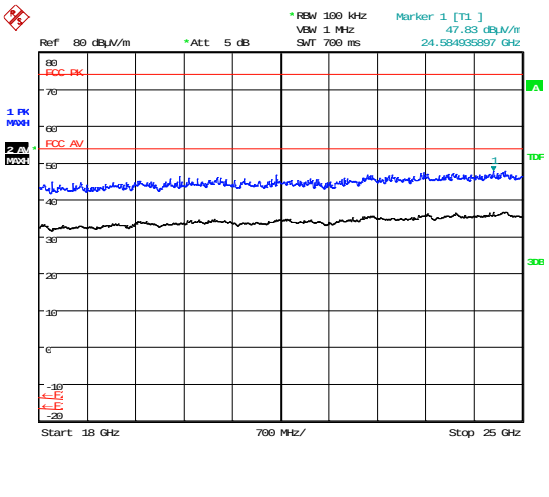
5 GHz to 9 GHz



9 GHz to 13 GHz

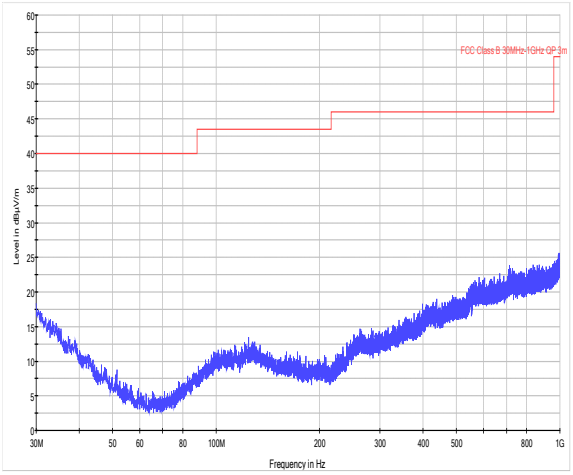


13 GHz to 18GHz

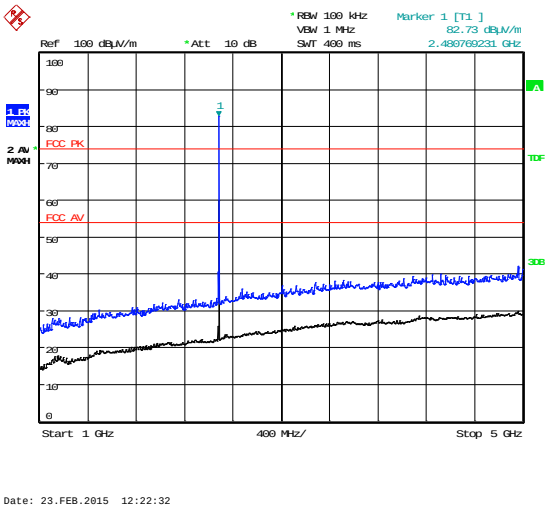


18 GHz to 25 GHz

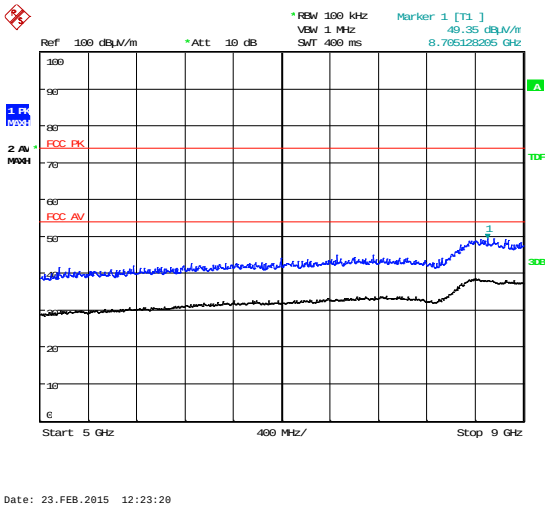
Radiated Spurious emissions– 2480MHz



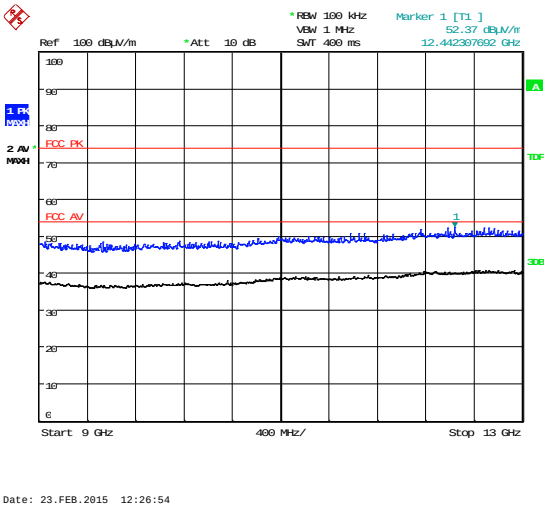
30 MHz to 1 GHz



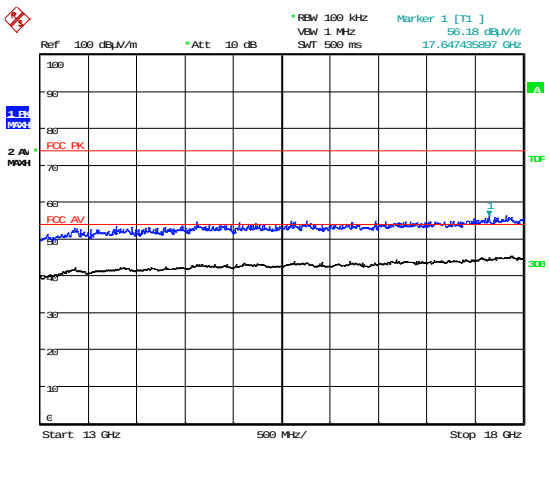
1 GHz to 5 GHz



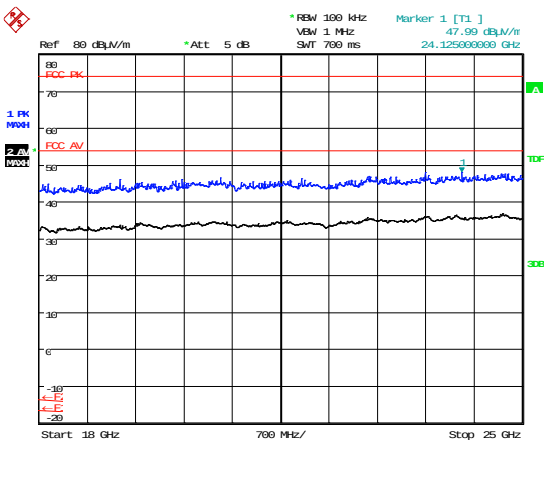
5 GHz to 9 GHz



9 GHz to 13 GHz

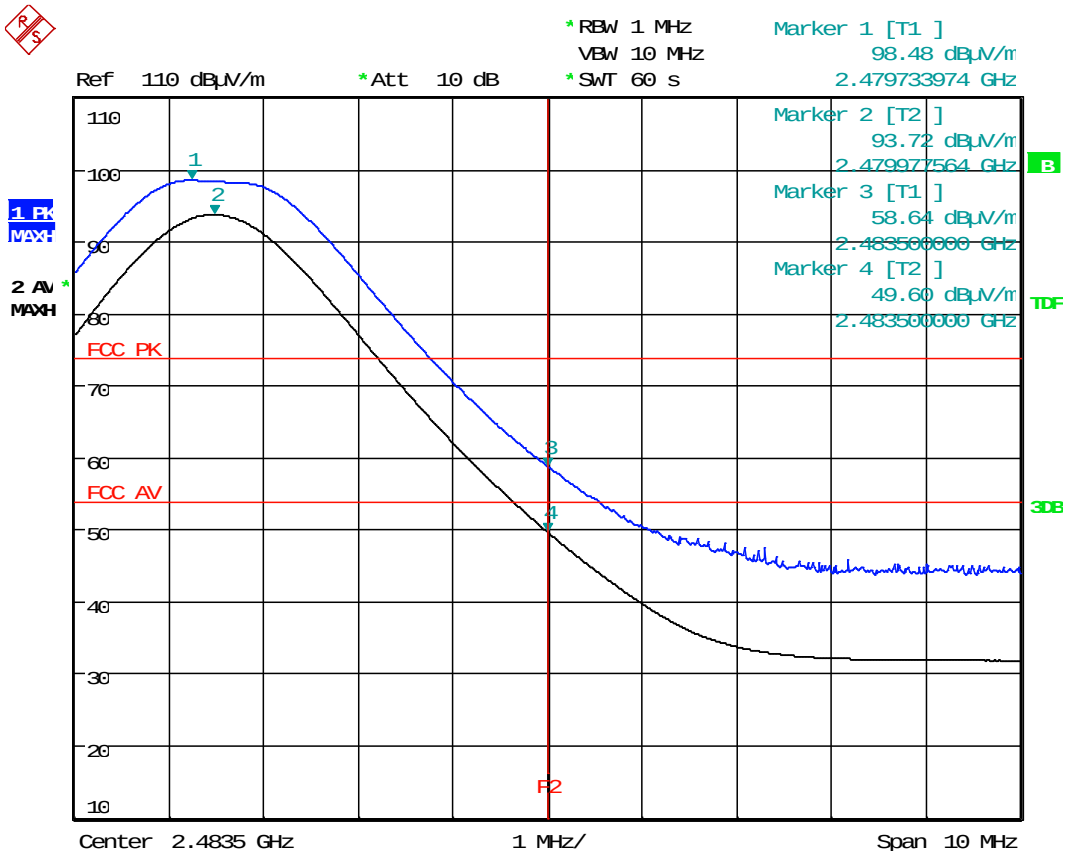


13 GHz to 18GHz



18 GHz to 25 GHz

Radiated Bandedge Compliance



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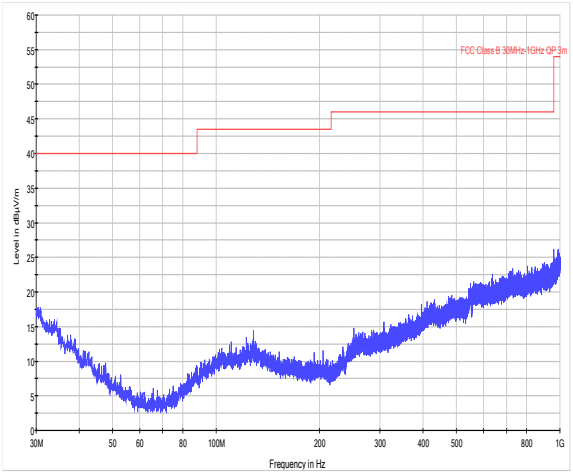
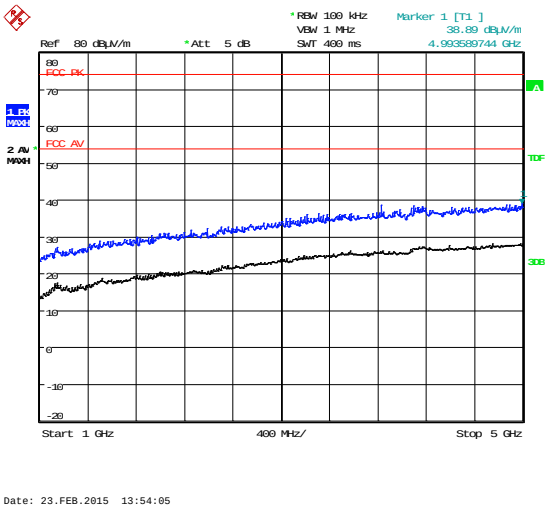
Upper Bandedge

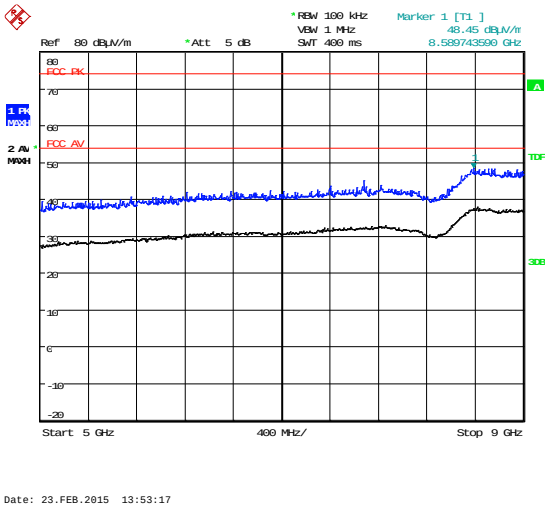
Unintentional Radiated Spurious emissions– 2402MHz



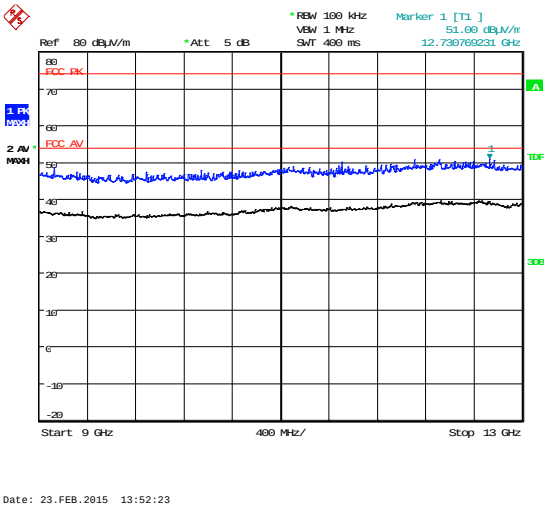
30 MHz to 1 GHz



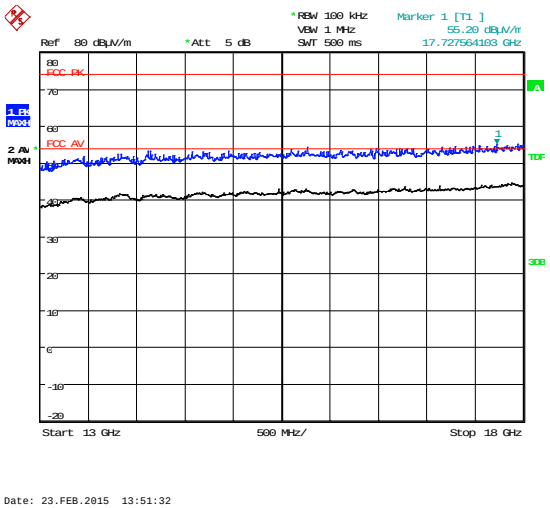
1 GHz to 5 GHz



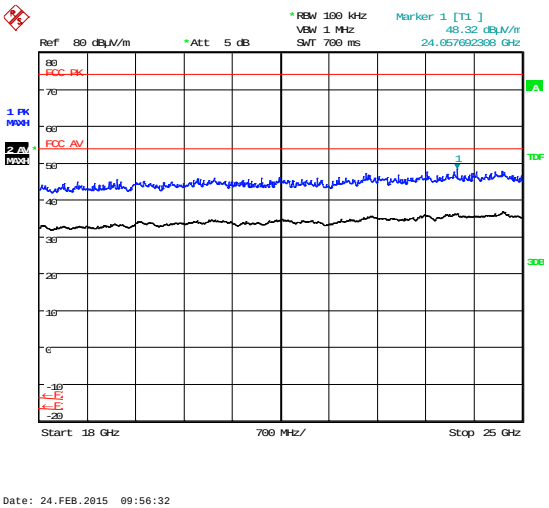
5 GHz to 9 GHz



9 GHz to 13 GHz

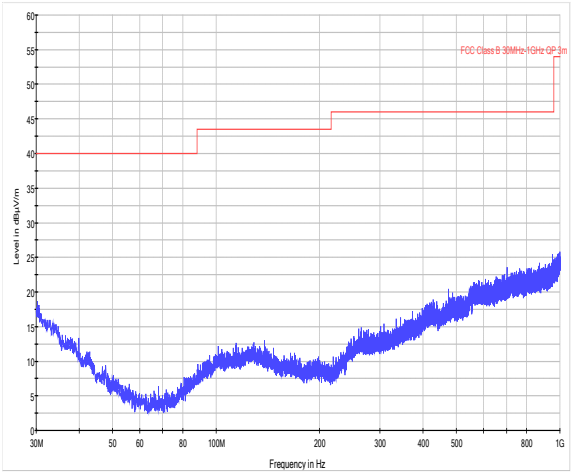


13 GHz to 18GHz

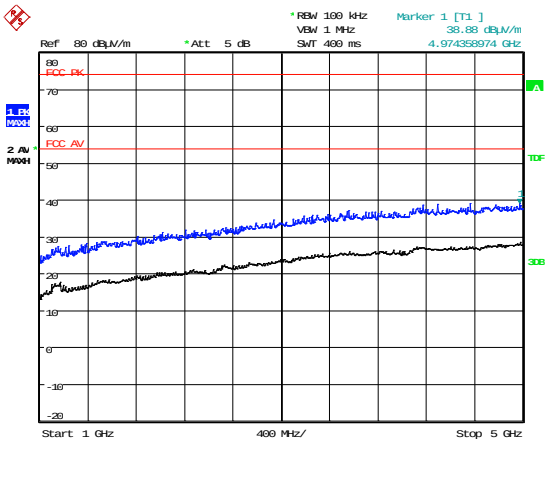


18 GHz to 25 GHz

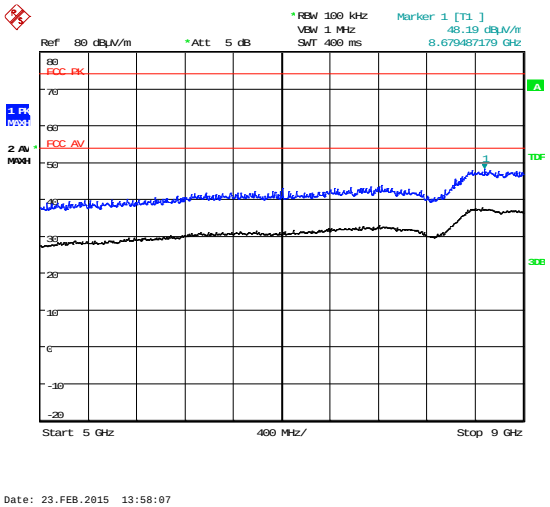
Unintentional Radiated Spurious emissions– 2440MHz



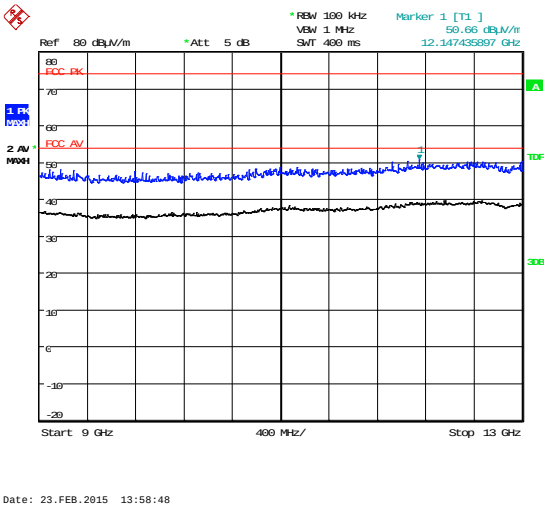
30 MHz to 1 GHz



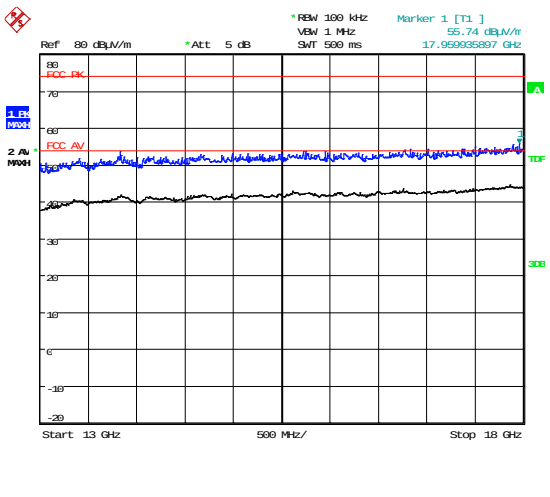
1 GHz to 5 GHz



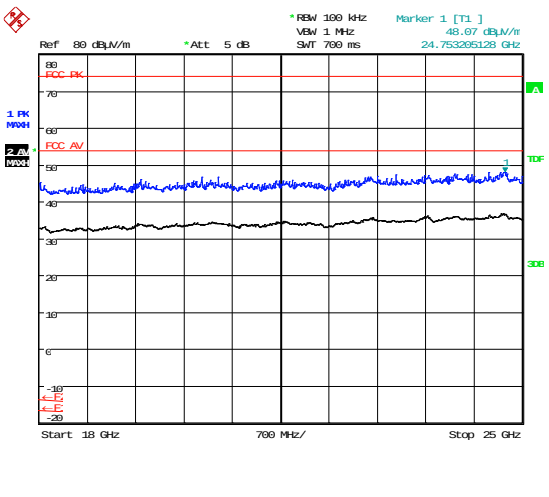
5 GHz to 9 GHz



9 GHz to 13 GHz

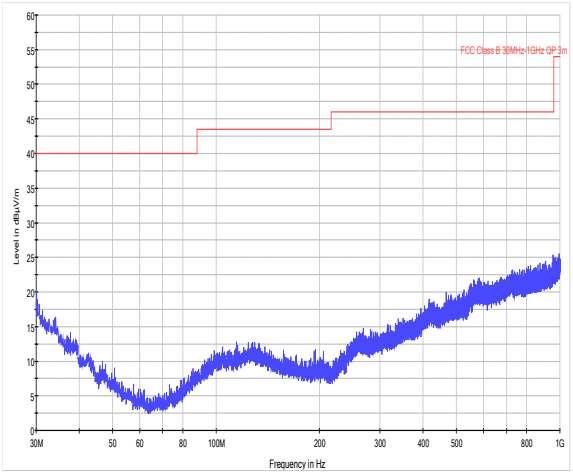


13 GHz to 18GHz

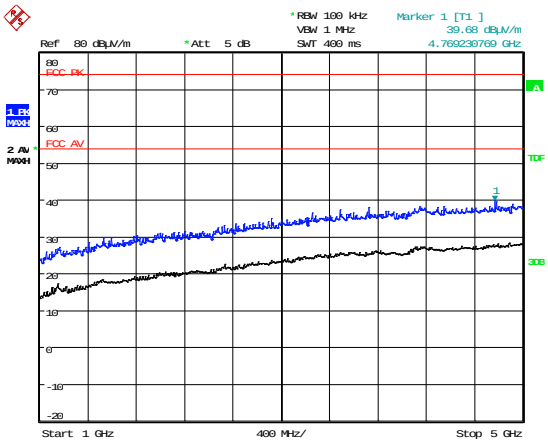


18 GHz to 25 GHz

Unintentional Radiated Spurious emissions– 2480MHz



30 MHz to 1 GHz



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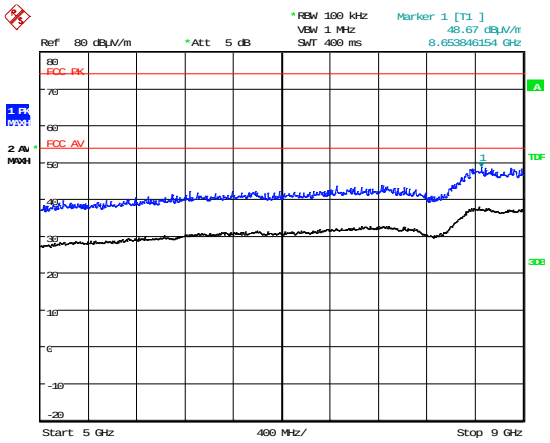
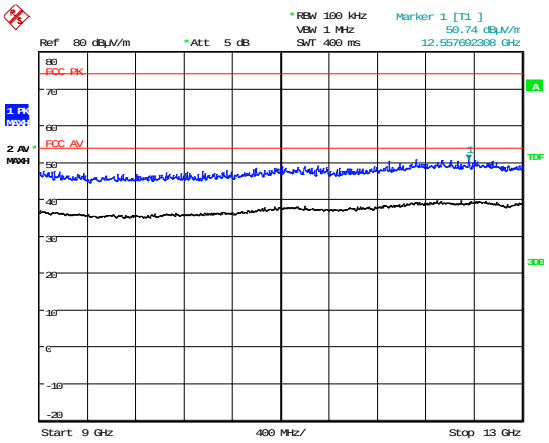
1 GHz to 5 GHz



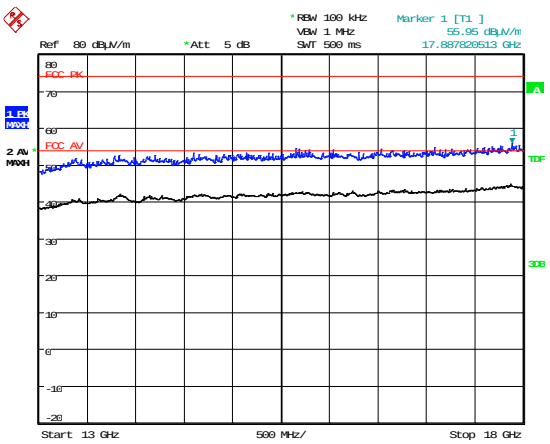
Date: 23.FEB.2015 14:13:54

5 GHz to 9 GHz



Date: 23.FEB.2015 14:13:03

9 GHz to 13 GHz



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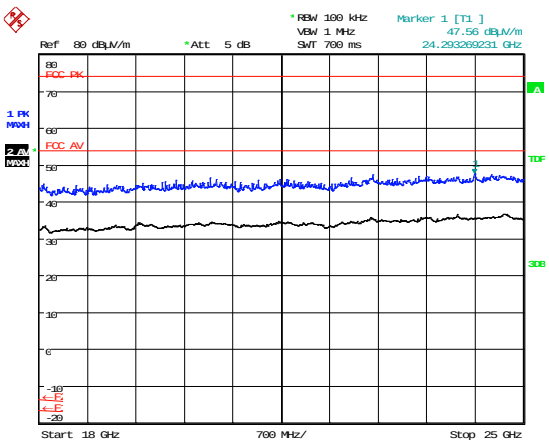
13 GHz to 18GHz



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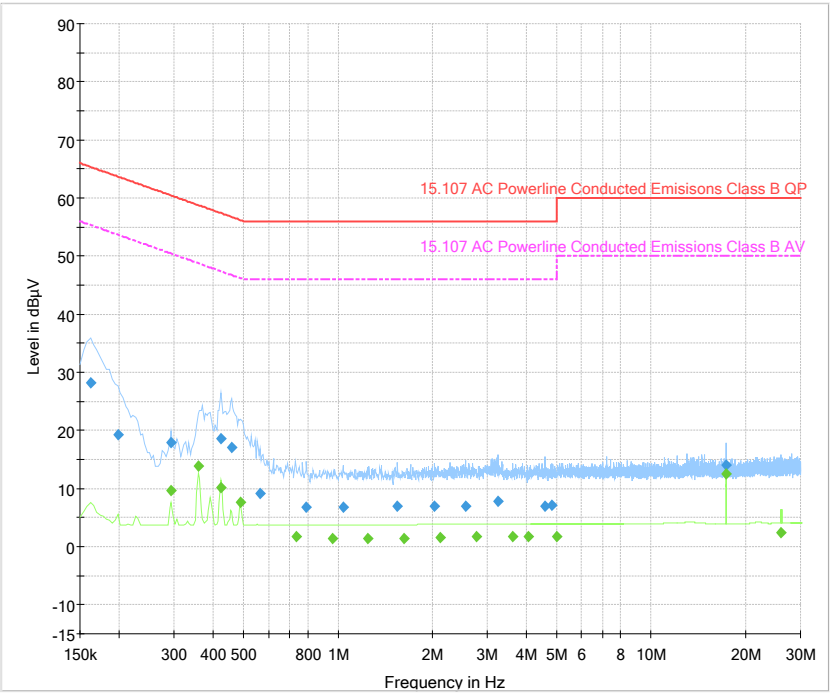
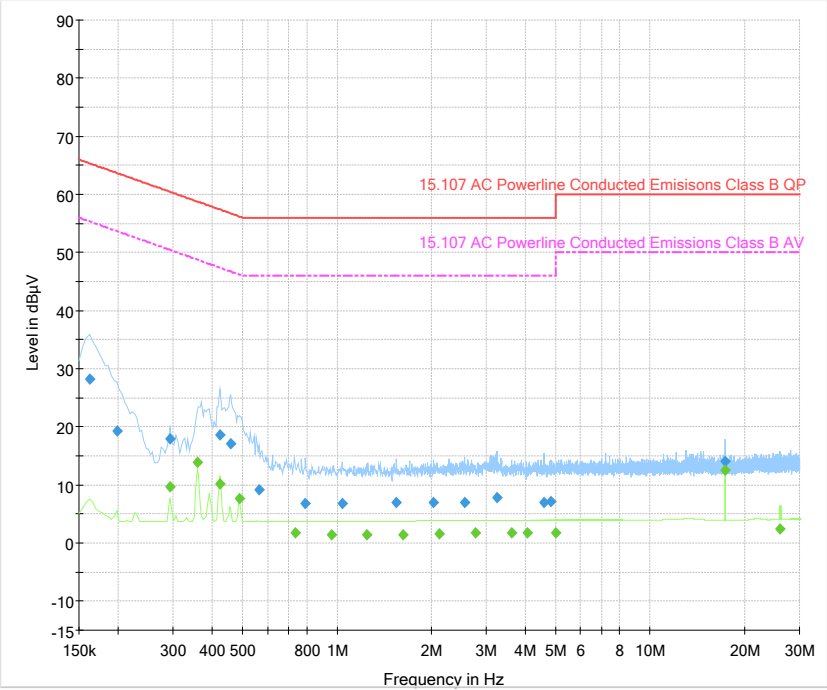
18 GHz to 25 GHz

AC Powerline Conducted Emissions



Transmit Mode



Receive Mode

Appendix C: **Additional Test and Sample Details**

This appendix contains details of:

1. The samples submitted for testing.
2. Details of EUT operating mode(s)
3. Details of EUT configuration(s) (see below).
4. EUT arrangement (see below).

Throughout testing, the following numbering system is used to identify the sample and it's modification state:

Sample No: Sxx Mod w

where:

xx = sample number eg. S01
w = modification number eg. Mod 2

The following terminology is used throughout the test report:

Support Equipment (SE) is any additional equipment required to exercise the EUT in the applicable operating mode. Where relevant SE is divided into two categories:

SE in test environment: The SE is positioned in the test environment and is not isolated from the EUT (e.g. on the table top during REFE testing).

SE isolated from the EUT: The SE is isolated via filtering from the EUT. (e.g. equipment placed externally to the ALSR during REFE testing).

EUT configuration refers to the internal set-up of the EUT. It may include for example:

Positioning of cards in a chassis.
Setting of any internal switches.
Circuit board jumper settings.
Alternative internal power supplies.

Where no change in EUT configuration is **possible**, the configuration is described as “single possible configuration”.

EUT arrangement refers to the termination of EUT ports / connection of support equipment, and where relevant, the relative positioning of samples (EUT and SE) in the test environment.

For further details of the test procedures and general test set ups used during testing please refer to the related document "EMC Test Methods - An Overview", which can be supplied by TRaC Global upon request.

C1) Test samples

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

Sample No.	Description	Identification
1	RF Module - Conducted Sample	
2	RF Module - Radiated Sample	
3	RF Module - Radiated Sample	

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

Sample No.	Description	Identification
4	SPI - Module Interface	
5	USB - SPI Interface (inc USB Cable)	
6	Battery	
7	Battery	
8	USB Stick	
9	Battery Charger	
10	PSU for Battery Charger	

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

Identification	Description
IT1035	Toshiba Laptop

C2) EUT Operating Mode During Testing.

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

Test	Description of Operating Mode:
All tests detailed in this report	EUT transmitting on the required channel with modulation. EUT centre frequency to as close as possible to 2440 MHZ before start of testing using software trimming, trim setting 18 for all testing EUT set Via software to maximum power setting 7.

Test	Description of Operating Mode:
Receiver radiated spurious emissions	EUT in a receive mode on the required channel

Test	Description of Operating Mode:
PLCE	EUR operating in a receive mode of transmitting on the channel with the highest output power.

C3) EUT Configuration Information.

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

C4) List of EUT Ports

The tables below describe the termination of EUT ports:

Sample :
Tests : Conducted

Port	Description of Cable Attached	Cable length	Equipment Connected
Antenna	Coaxial	<30cm	Measurement system
Headers	None	0	*S04*

Sample :
Tests : Radiated Emissions & PLCE

Port	Description of Cable Attached	Cable length	Equipment Connected
Power	2 x Multi strand	10	S06 (PSU for PLCE)

* Only connected during setup.

C5 Details of Equipment Used

TRaC No	Equipment Type	Equipment Description	Manufacturer	Last Cal Calibration	Calibration Period	Due For Calibration
UH004	ESVS10	Receiver	R&S	27/02/2014	12	27/02/2015
UH093	CBL6112B	Bilog	Chase	08/07/2013	24	08/07/2015
UH187	ESHS10	Receiver	R&S	19/02/2014	12	19/02/2015
UH191	CBL611/A	Bilog	Chase	13/12/2012	24	13/12/2014
UH195	ESH3-Z5.831.5	Lisn	R&S	21/07/2014	12	21/07/2015
UH281	FSU46	Spectrum Analyser	R&S	26/02/2014	12	26/02/2015
UH387	ATS	Chamber 1	Rainford EMC	04/07/2013	24	04/07/2015
UH403	ESCI 7	Recevier	R&S	20/08/2014	12	20/08/2015
UH405	FSU26	Spectrum Analyser	R&S	16/04/2014	12	16/04/2015
UH420	CBL6112	Bilog	Chase	25/07/2014	24	25/07/2016
UH456	ESR7	EMI Receiver	R&S	16/04/2014	12	16/04/2015
UH457	8449B	Pre Amp	Agilent	07/08/2014	12	07/08/2015
L138	3115	1-18GHz Horn	EMCO	17/10/2013	24	17/10/2015
L139	3115	1-18GHz Horn	EMCO	20/09/2013	24	20/09/2015
L176	2042	Signal Generator	Marconi	17/12/2014	12	17/12/2015
L254	2042	Signal Generator	Marconi	08/01/2014	12	08/01/2015
L290	CBL611/A	Bilog	Chase	02/12/2014	24	02/12/2016
L300	20240-20	Horn 18-26GHz (&UH330)	Flann	10/02/2014	24	10/02/2016
L572	8449B	Pre Amp	Agilent	10/02/2015	12	10/02/2016
REF909	FSU26	Spectrum Analyser	R&S	13/02/2015	12	13/02/2016
REF940	ATS	Radio Chamber - PP	Rainford EMC	08/09/2014	24	08/09/2016
REF940	ATS	IC Reg Radio Chamber - PP	Rainford EMC	19/11/2014	36	19/11/2017

Appendix D: Additional Information

No additional information is included within this test report.

Appendix E: Calculation of the duty cycle correction factor

Using a spectrum analyser in zero span mode, centred on the fundamental carrier frequency with a RBW of 1MHz and a video Bandwidth of 1MHz the sweep time was set accordingly to capture the pulse train. The transmit pulsewidths and period was measured. A plots of the pulse train is contained in Appendix B of this test report.

If the pulse train was less than 100 ms, including blanking intervals, the duty cycle was calculated by averaging the sum of the pulsewidths over one complete pulse train. However if the pulse train exceeds 100ms then the duty cycle was calculated by averaging the sum of the pulsewidths over the 100ms width with the highest average value. (The duty cycle is the value of the sum of the pulse widths in one period (or 100ms), divided by the length of the period (or 100ms). The duty cycle correction factor was then expressed in dB and the peak emissions adjusted accordingly to give an average value of the emission.

Correction factor dB = 20 x (Log_{10} Calculated Duty Cycle)

Therefore the calculated duty cycle was determined:

The pulse train period was greater than >100ms and in as shown from the plots in contained in appendix B of this test report.

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

e.g

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

0.07459 or 7.459%

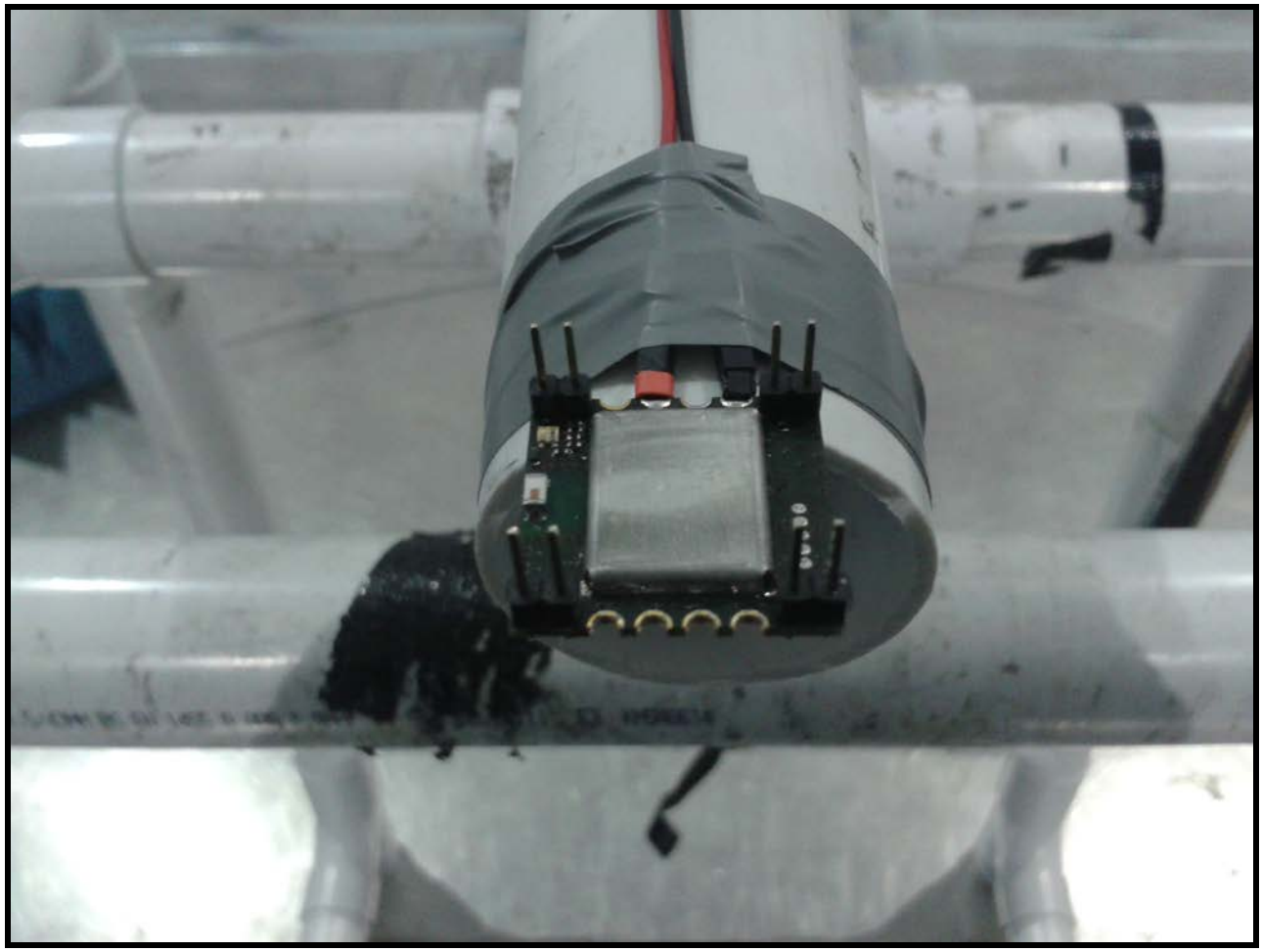
Correction factor (dB) = 20 x (Log_{10} 0.07459) = -22.54dB

Appendix F: Photographs and Figures

The following photographs were taken of the test samples:

1. Radiated electric field emissions arrangement: Overview.
2. Radiated electric field emissions arrangement: Close up.
3. AC Powerline Conducted emissions arrangement: Overview.

Photograph 1



Photograph 2

Photograph 3

Appendix G: General SAR test reduction and exclusion guidance

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

For Standalone SAR exclusion consideration, when SAR Exclusion Threshold requirement in KDB 447498 is satisfied, standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

In the frequency range below 100 MHz to 6 GHz and test separation distance of 50mm, the SAR Test Exclusion Threshold for operation in the 2400 – 2483.5 MHz band will be determined as follows

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + Step 2

Step 1

$$NT = [(MP/TSD^{A}) * \sqrt{f_{GHz}}]$$

NT = Numeric Threshold (3.0 for 1-g SAR and 7.5 for 10-g SAR)
MP = Max Power of channel (mW) (inc tune up)
TSD^{A} = Min Test separation Distance or 50mm (whichever is lower) = 50

We can transpose this formula to allow us to find the maximum power of a channel allowed and compare this to the measured maximum power.

$$= [(NT \times TSD^{A}) / \sqrt{f_{GHz}}]$$

For Distances Greater than 50 mm Step 2 applies

Step 2

$$(TSD^{B} – 50mm) * 10\}$$

Where:
TSD^{B} = Min Test separation Distance (mm) = 50

Operating Frequency 2.402 GHz

SARET = [(3.0 x 50) / √2.402] + { (50 – 50) * 10 }
SARET = [150 / 1.55] + (0 * 10 }
SARET = 96.77mW

Operating Frequency 2.440 GHz

SARET = [(3.0 x 50) / √2.44] + { (50 – 50) * 10 }
SARET = [150 / 1.56] + (0 * 10 }
SARET = 96.15mW

Operating Frequency 2.480 GHz

SARET = [(3.0 x 50) / √2.48] + { (50 – 50) * 10 }
SARET = [150 / 1.57] + (0 * 10 }
SARET = 95.54mW

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold	SAR Evaluation
2402	6.84	96.77	Not Required
2440	7.62	96.15	Not Required
2480	7.94	95.54	Not Required

Therefore standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

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

where:

S = power density
R = distance to the centre of radiation of the antenna
EIRP = EUT Maximum power

Note:

The EIRP measurement was performed using a signal substitution method.

Result

Prediction Frequency (MHz)	Maximum EIRP	Power density limit (S) (mW/cm^2)	Distance (R) cm required to be less than $1mW/cm^2$
2402	6.84	1	0.8
2440	7.62	1	0.8
2480	7.94	1	0.8

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