A Radio Test Report

FOR

European Engineers Limited

ON

foc.us v2 dock

Document No. TRA-023656-01-47-00A

HULL
Unit E, South Orbital Trading Park, Hedon Road, Hull, HU9 1NJ, UK.
T +44 (0)1482 801801 **F** +44 (0)1482 801806 **E** test@tracglobal.com
www.tracglobal.com

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Applicant	**:** European Engineers Limited
Apparatus	**:** foc.us v2 dock
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Section 1: Introduction

1.1 General

This report contains an assessment of an apparatus against Electromagnetic Compatibility Standards based upon tests carried out on samples submitted to the Laboratory.

Test performed at:

TRaC Global [ ]
Unit E
South Orbital Trading Park
Hedon Road
Hull, HU9 1NJ.
United Kingdom.

Telephone: +44 (0) 1482 801801
Fax: +44 (0) 1482 801806

TRaC Global [X]
Unit 1
Pendle Place
Skelmersdale
West Lancashire, WN8 9PN
United Kingdom

Telephone: +44 (0) 1695 556666
Fax: +44 (0) 1695 577077

Email: test@tracglobal.com
Web site: http://www.tracglobal.com

Tests performed by: A Tosif

Report author: A Tosif

1.2 Tests Requested By

This testing in this report was requested by:

European Engineers Limited
16 Beaufort Court
London
E14 9XL
United Kingdom

1.3 Manufacturer

As Above

1.4 Apparatus Assessed

The following apparatus was assessed between 10th December 2014 and 15th January 2015.

- foc.us v2 dock

The above product is a Bluetooth LE usb powered device operating in the 2.4 GHz ISM band. It is intended to communicate with and recharge the foc.us v2 controller.

1.5 Test Result Summary

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

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

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

Test Type	Regulation	Measurement standard	Result
Radiated spurious emissions (Restricted bands)	Title 47 of the CFR: Part 15 Subpart C; 15.247 (d)	ANSI C63.10:2013	Pass
Conducted spurious emissions (Non-restricted bands)	Title 47 of the CFR: Part 15 Subpart C; 15.247 (d)	ANSI C63.10:2013	Pass
AC Power conducted emissions	Title 47 of the CFR: Part 15 Subpart C; 15.207	ANSI C63.10:2013	Pass
Occupied Bandwidth	Title 47 of the CFR : Part 15 Subpart C; 15.247(a)(2)	ANSI C63.10:2013	Pass
Conducted Carrier Power	Title 47 of the CFR : Part 15 Subpart C; 15.247(b)	ANSI C63.10:2013	Pass
Power Spectral Density	Title 47 of the CFR : Part 15 Subpart C; 15.247(e)	ANSI C63.10:2013	Pass
Unintentional Radiated Spurious Emissions	Title 47 of the CFR: Part 15 Subpart B; 15.109	ANSI C63.10:2013	Pass
RF Safety	KDB 447498	-	Pass

Abbreviations used in the above table:

CFR : Code of Federal Regulations ANSI : American National Standards Institution

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 (Power Meter) = **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.

Test Details:	
Regulation	Part 15 Subpart (c) 15.247(a)(2)
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop with charger
Temperature	22^0C
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	F_{lower}	Fh_{igher}	Measured 6 dB Bandwidth (kHz)	Limit	Result
2402	2401.703526	2402.400641	697.12	>500kHz	Pass
2440	2439.703526	2440.400641	697.12	>500kHz	Pass
2480	2479.695513	2480.392628	697.12	>500kHz	Pass

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

A2 Transmitter Peak Output Power

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

Test Details:	
Regulation	Title 47 of the CFR: Part15 Subpart (c) 15.247(b)(3)
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop with charger
Temperature	22^0C
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Conducted Peak Carrier Power (dBm)	Conducted Peak Carrier Power (mW)	Limit (W)	Result
2402	-1.60	0.69	1	Pass
2440	-2.10	0.62	1	Pass
2480	-2.70	0.54	1	Pass

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(e)
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop with charger
Temperature	22^0C
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Conducted Peak Power Spectral Density (dBm)	Limit (dBm)	Result
2402	-1.68	8	Pass
2440	-2.24	8	Pass
2480	-2.80	8	Pass

Notes:

Measurements performed as per KDB Document:

558074 D01 DTS Meas Guidance v03
Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

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: 2402 MHz 2440MHz 2480MHz	
Regulation	Part 15 Subpart (c) Clause 15.247(d)
Measurement standard	ANSI C63.10, KDB Document: 558074
Frequency range	9 kHz to 25 GHz
EUT sample number	S06
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop with charger
Temperature	22^0C
EUT set up	Refer to Appendix C

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

Ref No.	Emission Freq (MHz)	Det.	Restricted band? (Y/N)	Emission power (RBW =100kHz) (dBm)	15.247(d) Limit (dBm)	Summary
No emissions detected within 20dB of the limit						

Notes:

1. The conducted emission limit for emissions outside the restricted bands, defined in 47CFR15.205(a) are based on a transmitted carrier level of 15.247(b). With the EUT transmitting on its lowest, centre and highest carrier frequencies in turn, emissions from the EUT are required to be 20 dB below the level of the highest fundamental as measured within a 100 kHz RBW in accordance with 15.247(d) using a peak detector.
2. The RBW = 100 kHz, Video bandwidth (VBW) > RBW and the radio spectrum was investigated up to the 10th harmonic in accordance15.33 (a)(1).
3. The measurements at 2400 MHz and 2483.5 MHz were made to ensure band edge compliance.
4. The carrier level was measured whilst varying the supply voltage between 85% and 105% of the nominal supply voltage as required by 15.31(e). No variation in carrier level was observed.
5. The plots for operating mode producing the highest output power can be found in Appendix B

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

A5 Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 100kHz. The radiated electric field emission test applies to spurious emissions and harmonics that fall within the restricted bands. The EUT was set to transmit on its lowest, centre and highest carrier frequency.

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

3m open area test site : ☐ 3m alternative test site : ☒

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

Test Details:2402MHz 2440MHz 2480MHz	
Regulation	Part 15 Subpart (c) Clause 15.247(d)
Measurement standard	ANSI C63.10, KDB Document: 558074
Frequency range	30MHz – 25GHz
EUT sample number	S01
Modification state	0
SE in test environment	Laptop with charger, S09
SE isolated from EUT	None
Temperature	24^0C
EUT set up	Refer to Appendix 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:

Ref No.	Freq. (MHz)	Detector	Meas Rx (dBµV)	Cable Loss (dB)	Ant Factor (dB/m)	Pre-Amp (dB)	Field Strength (dBµV/m)	Field Strength (µV/m)	Limit (µV/m)
2402 MHz									
1.	2338.0	Average	43.5	2.5	28.1	36.0	38.1	80.0	500.0
2.	2370.0	Average	41.9	2.5	28.2	36.0	36.6	67.5	500.0
3.	4804.0	Average	41.3	5.0	32.8	35.2	43.8	155.4	500.0
2440 MHz									
4.	2376.0	Average	46.2	2.5	28.2	36.0	40.9	111.4	500.0
5.	4880.0	Average	41.4	5.1	33.1	35.2	44.4	166.7	500.0
2480 MHz									
6.	4960.0	Average	40.4	5.1	33.3	35.2	43.6	151.4	500.0

Notes:

1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.10: section 4.5, Table 1
2 In accordance with 15.35(b), above 1 GHz, emissions measured using a peak detector shall not exceed a level 20 dB above the average limit.
3 Measurements at 2400 & 2483.5 MHz were made to ensure band edge compliance.
4 Testing was performed with the EUT orientated in three orthogonal planes and the maximum emissions level recorded. In addition, the EUT antenna was varied within its range of motion in order to maximise emissions.
5 For Frequencies below 1 GHz, RBW= 100 kHz, testing was performed with CISPR16 compliant test receiver with QP detector. Above 1 GHz tests were performed using a spectrum analyser using the following settings:

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

These settings as per ANSI C63.10

The plots for worst case emissions on all modulation types can be found in Appendix B

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

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

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

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

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

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 Antenna Gain

The maximum antenna gain for the antenna types to be used with the EUT, as declared by the client, is 5.30dBi.

A7 Unintentional Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 100kHz. The maximum permitted field strength is listed in Section 15.109. 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 Subpart (b) Clause 15.109
Measurement standard	ANSI C63.10
Frequency range	30MHz to 25 GHz
EUT sample number	S01
Modification state	0
SE in test environment	Laptop with charger, S09
SE isolated from EUT	None
Temperature	24^0C
EUT set up	Refer to Appendix C
Photographs (Appendix F)	1 & 2

The worst case radiated emission measurements for spurious emissions:

Ref No.	Freq. (MHz)	Detector	Meas Rx (dBµV)	Cable Loss (dB)	Ant Factor (dB/m)	Pre-Amp (dB)	Field Strength (dBµV/m)	Field Strength (µV/m)	Limit (µV/m)
2402 MHz									
1.	4805.9	Average	42.9	3.8	32.7	35.6	43.8	154.7	500.0
2440 MHz									
2.	4882.1	Average	39.4	3.7	33.0	35.6	40.5	105.9	500.0
2480 MHz									
3.	4958.0	Average	41.2	3.6	33.2	35.6	42.4	131.8	500.0

Ref No.	Freq. (MHz)	Detector	Meas Rx (dBµV)	Cable Loss (dB)	Ant Factor (dB/m)	Pre-Amp (dB)	Field Strength (dBµV/m)	Field Strength (µV/m)	Limit (µV/m)
Emissions unrelated to Operating Frequency									
1.	36.4	Qp	7.9	0.5	14.4	-	22.8	13.9	100
2.	38.3	Qp	9.4	0.5	13.3	-	23.2	14.5	100
3.	43.6	Qp	9.4	0.6	10.6	-	20.6	10.7	100
4.	54.5	Qp	15.3	0.6	6.3	-	22.2	12.8	100
5.	94.3	Qp	19.6	0.8	9.5	-	29.9	31.1	150
6.	95.8	Qp	17.7	0.8	9.7	-	28.2	25.7	150
7.	98.8	Qp	13.3	0.8	10.2	-	24.3	16.3	150
8.	148.9	Qp	15.3	1.0	10.1	-	26.4	20.9	150
9.	152.5	Qp	13.4	1.0	9.9	-	24.3	16.3	150
10.	156.2	Qp	17.0	1.0	9.6	-	27.6	24.1	150
11.	168.0	Qp	16.6	1.1	9.0	-	26.7	21.6	150
12.	180.0	Qp	14.6	1.1	8.3	-	24.0	15.9	150
13.	192.0	Qp	19.4	1.2	8.5	-	29.1	28.3	150
14.	408.0	Qp	9.4	1.7	16.3	-	27.4	23.4	200
15.	663.7	Qp	19.7	2.2	19.0	-	40.9	110.9	200
16.	995.3	Qp	10.6	2.7	21.7	-	35.0	56.2	500
17.	999.4	Qp	10.3	2.7	21.9	-	34.9	55.3	500

Notes:

1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.10: section 4.5, Table 1 For emissions below 30MHz the cable losses are assumed to be negligible.
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 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.
4 For Frequencies below 1 GHz, RBW = 120 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= 1MHz, VBW ≥ RBW
Average	RBW= 1MHz, VBW ≥ RBW

The upper and lower frequency of the measurement range was decided according to 47 CFR Part 15 Clause 15.33

Radiated emission limits 47 CFR Part 15: Clause 15.209 for all emissions:

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

(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:

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

(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

A8 Power Line Conducted Emissions

Preview power line conducted emission measurements were performed with a peak detector in a screened room. Where applicable formal measurements of the emissions were performed with an average and/or quasi peak detector.

Test Details:	
Regulation	Title 47 of the CFR: Part 15 Subpart (c) Clause 15.207
Measurement standard	ANSI C63.10
Frequency range	150kHz to 30MHz
EUT sample number	S11
Modification state	0
SE in test environment	Laptop with charger, S09
SE isolated from EUT	None
EUT set up	Refer to Appendix C

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

Ac Power line Conducted Emissions Transmit Mode						
Results measured using the average detector						
Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
No Significant Emissions within 20 dB of the Limit						
Results measured using the Quasi Peak detector						
Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
No Significant Emissions within 20 dB of the Limit						

AC Power line Conducted Emissions Receive Mode						
Results measured using the average detector						
Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
No Significant Emissions within 20 dB of the Limit						
Results measured using the Quasi Peak detector						
Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
No Significant Emissions within 20 dB of the 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

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.

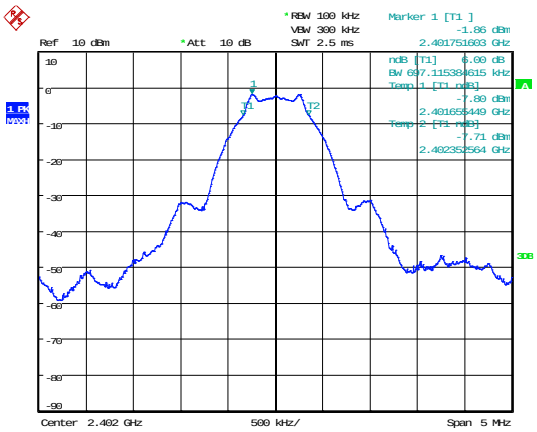
(b) The time and date on the plots do not necessarily equate to the time of the test.

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

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

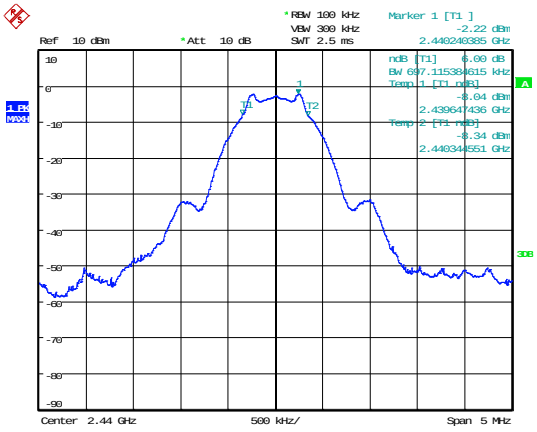
(e) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.

20dB Bandwidth



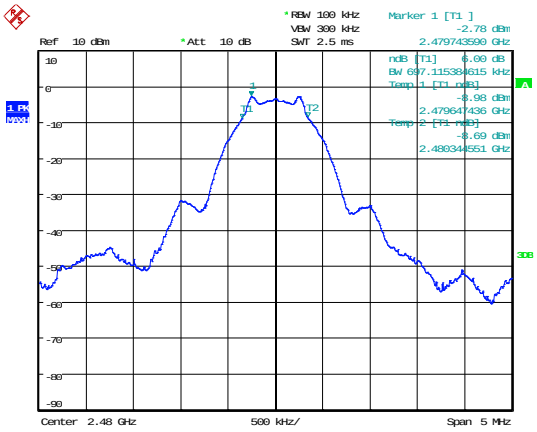
Date: 17.DEC.2014 09:53:29

20dB Bandwidth 2402MHz



Date: 17.DEC.2014 09:44:10

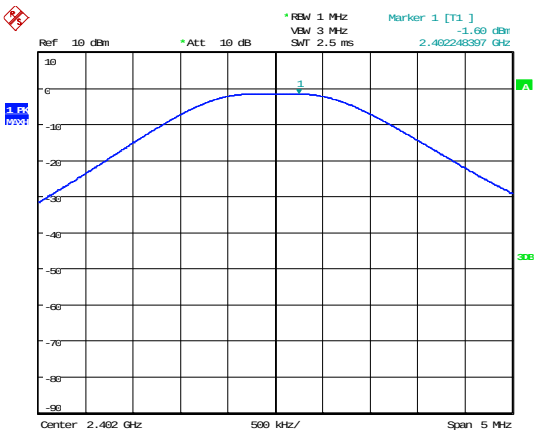
20dB Bandwidth 2440MHz



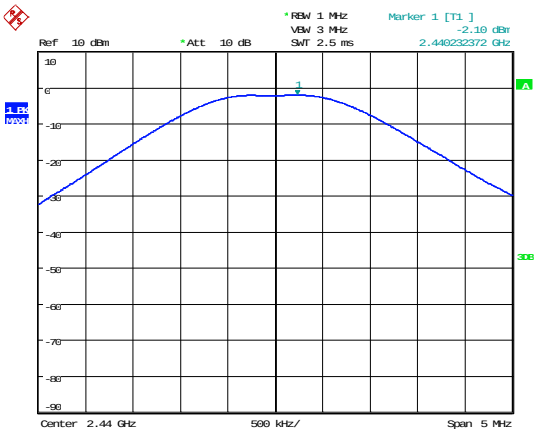
Date: 17.DEC.2014 09:51:20

20dB Bandwidth 2480MHz

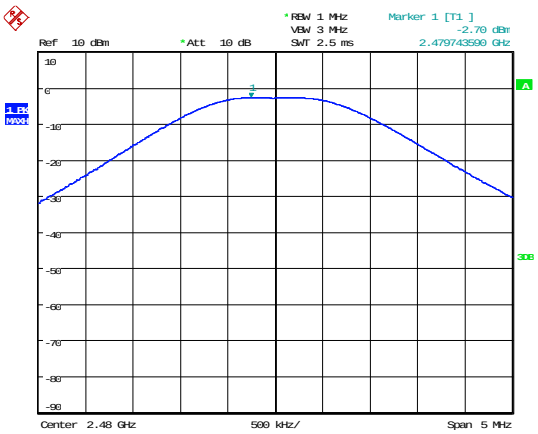
Carrier Power



Carrier Power - 2402MHz

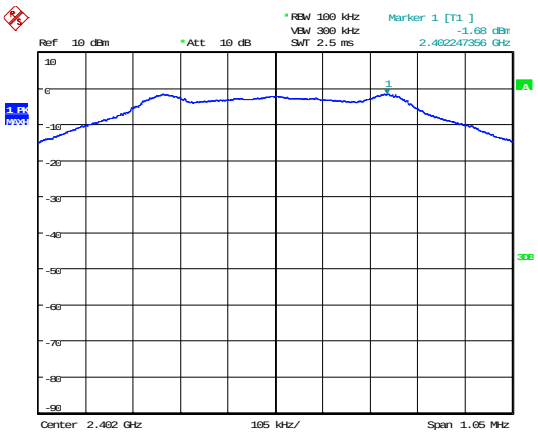


Carrier Power - 2440MHz



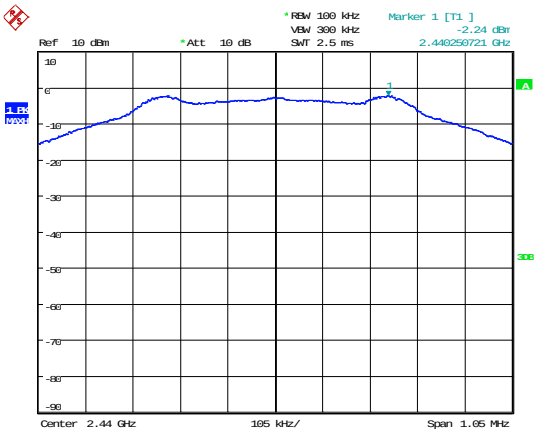
Carrier Power - 2480MHz

Power Spectral Density



Date: 17.DEC.2014 10:06:05

Power Spectral Density - 2402MHz



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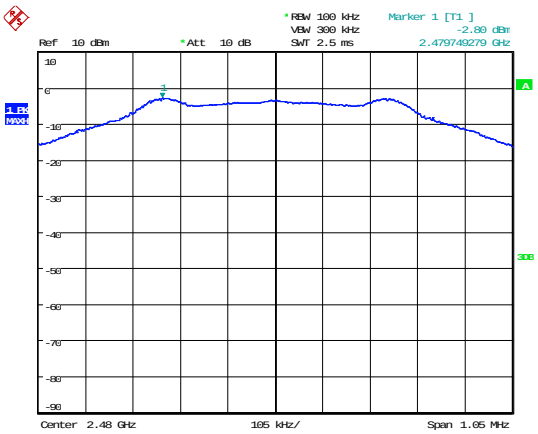
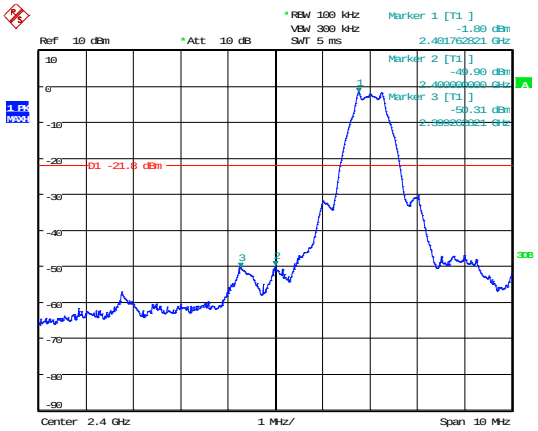
Power Spectral Density - 2440MHz



Date: 17.DEC.2014 10:08:10

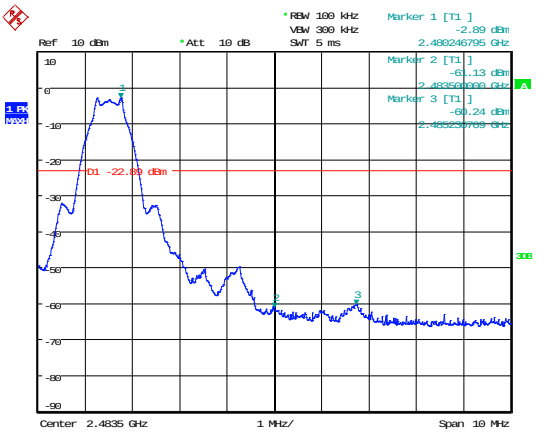
Power Spectral Density - 2480MHz

Bandedge Compliance



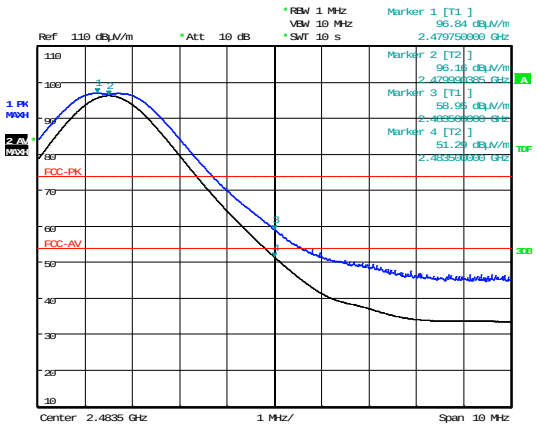
Date: 17.DEC.2014 10:30:56

Conducted Lower Bandedge Compliance



Date: 17.DEC.2014 10:33:44

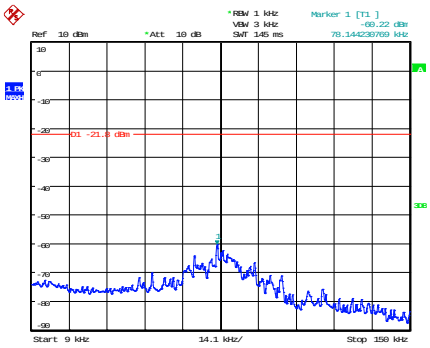
Conducted Upper Bandedge Compliance



Date: 18.DEC.2014 11:46:40

Radiated Upper Bandedge Compliance

Conducted Spurious Emissions – 2402MHz



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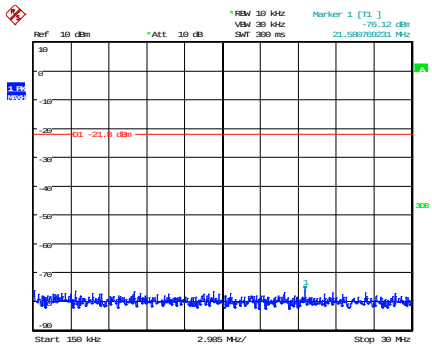
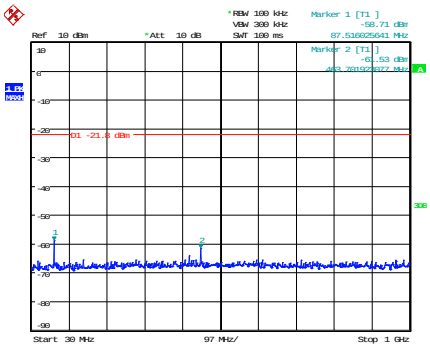


Date: 17.DEC.2014 11:12:26

9kHz – 150kHz



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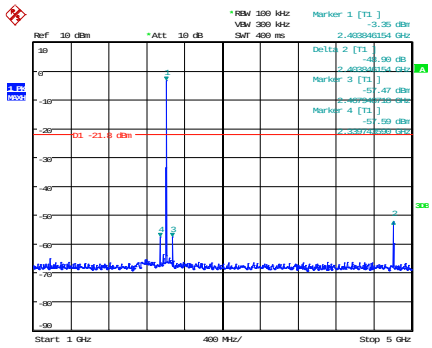
150kHz – 30MHz



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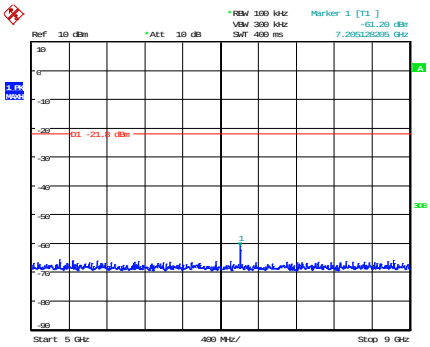
30MHz – 1GHz



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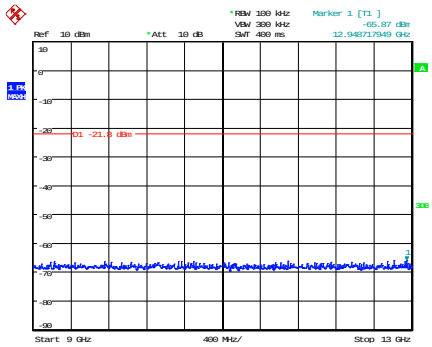
1GHz – 5GHz



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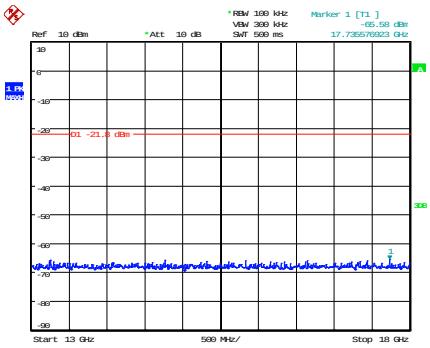
5GHz – 9GHz



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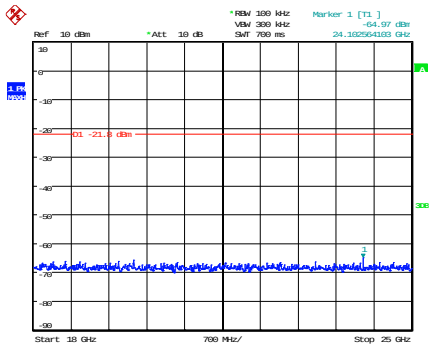
9GHz – 13GHz



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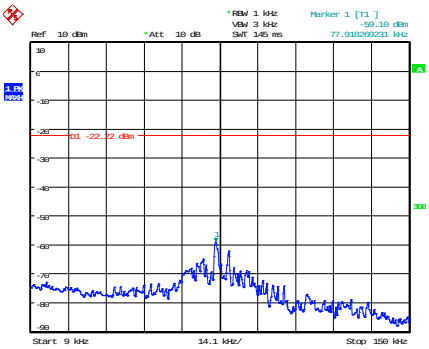
13GHz – 18GHz

18GHz – 25GHz

Conducted Spurious Emissions – 2440MHz



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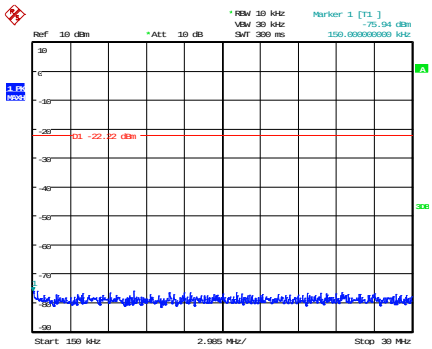
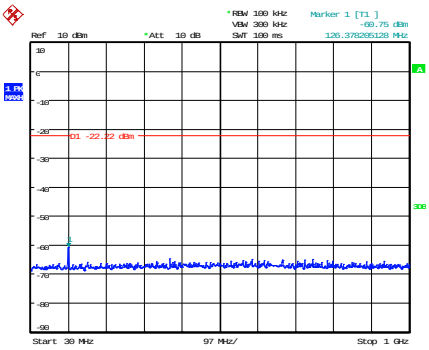


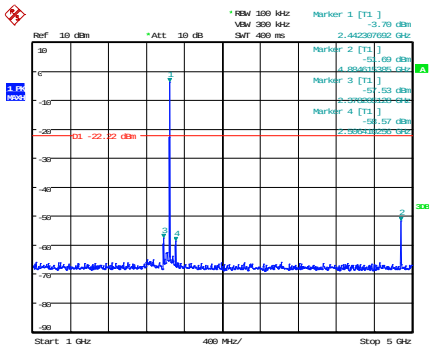
Date: 17.DEC.2014 10:56:41

9kHz – 150kHz



Date: 17.DEC.2014 10:56:13

150kHz – 30MHz



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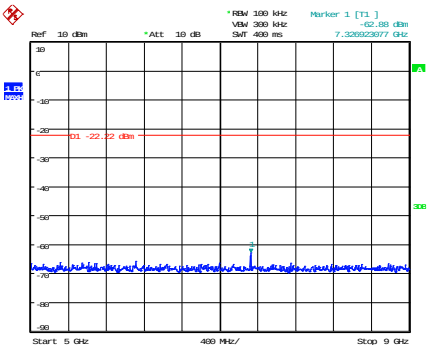
30MHz – 1GHz



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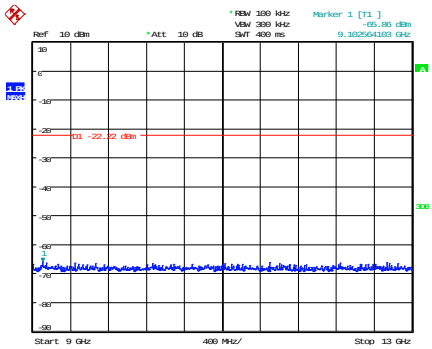
1GHz – 5GHz



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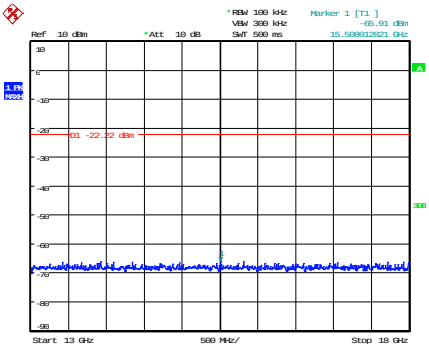
5GHz – 9GHz



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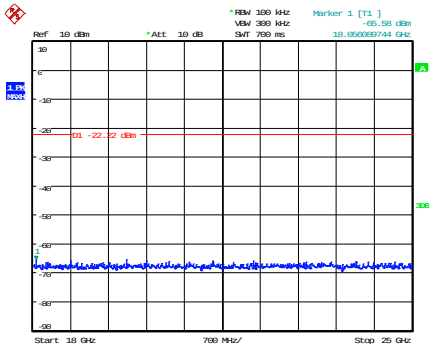
9GHz – 13GHz

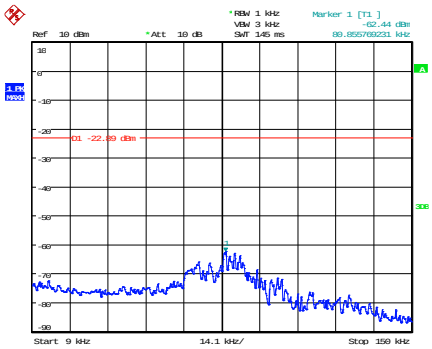


Date: 17.DEC.2014 10:54:08

13GHz – 18GHz

18GHz – 25GHz

Conducted Spurious Emissions – 2480MHz



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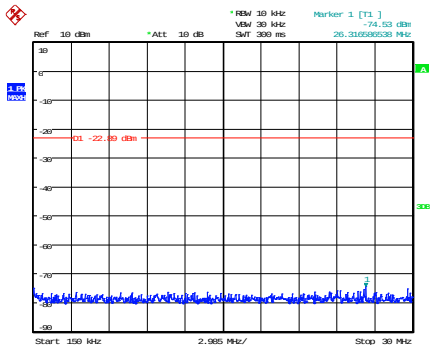
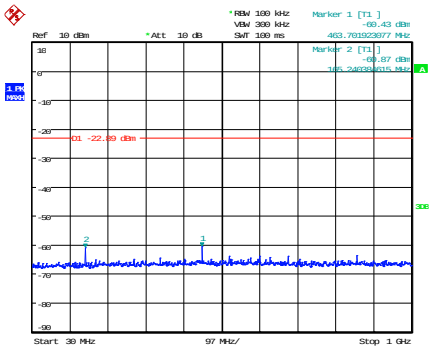


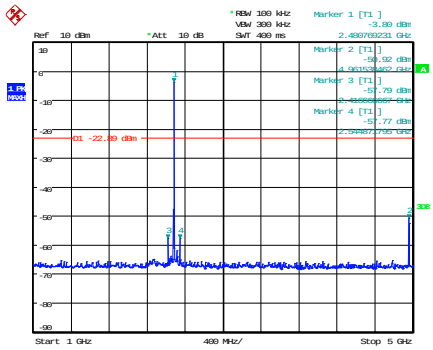
Date: 17.DEC.2014 10:40:49

9kHz – 150kHz



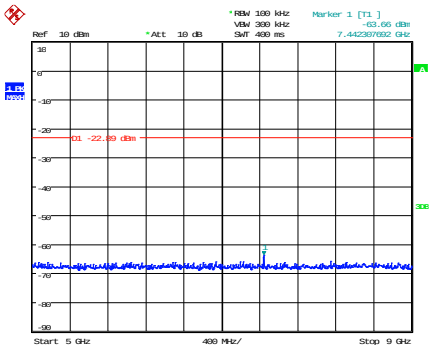
Date: 17.DEC.2014 10:42:13

150kHz – 30MHz



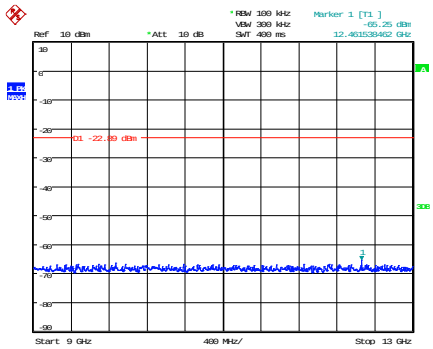
Date: 17.DEC.2014 10:43:18

30MHz – 1GHz



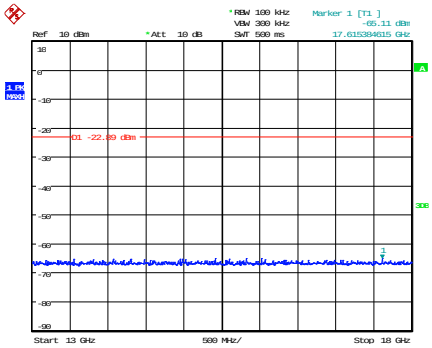
Date: 17.DEC.2014 10:44:02

1GHz – 5GHz



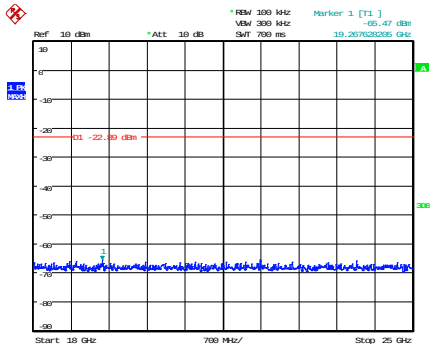
Date: 17.DEC.2014 10:44:16

5GHz – 9GHz



Date: 17.DEC.2014 10:48:56

9GHz – 13GHz

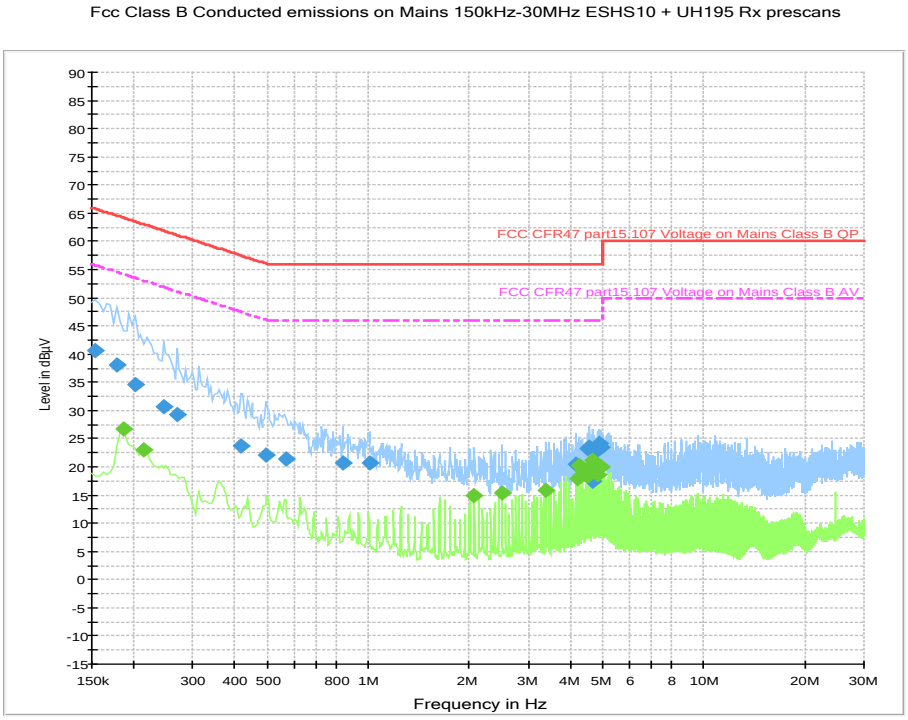


Date: 17.DEC.2014 10:49:10

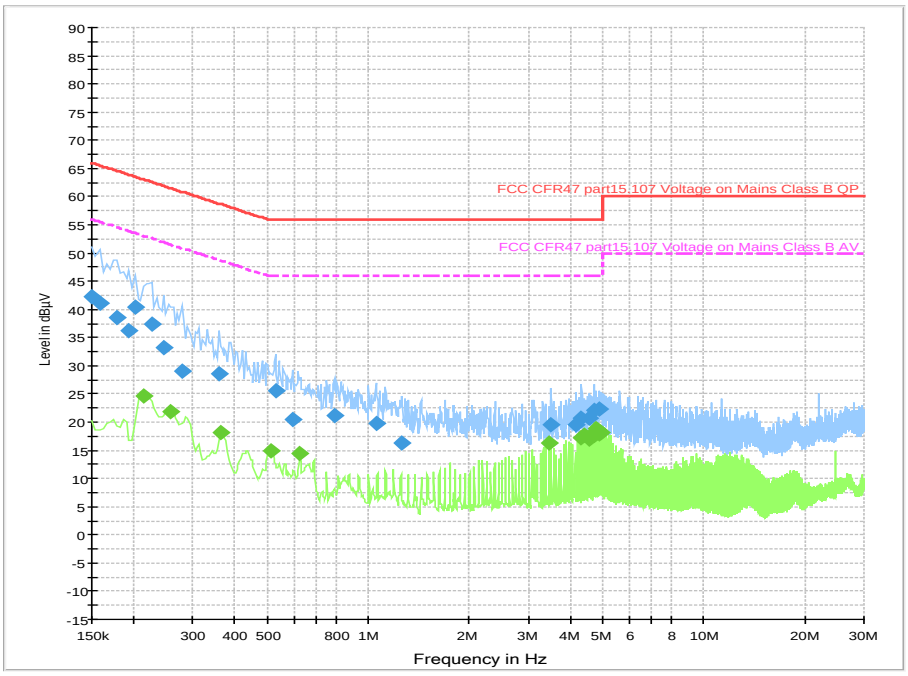
13GHz – 18GHz

18GHz – 25GHz

AC Powerline Conducted Emissions

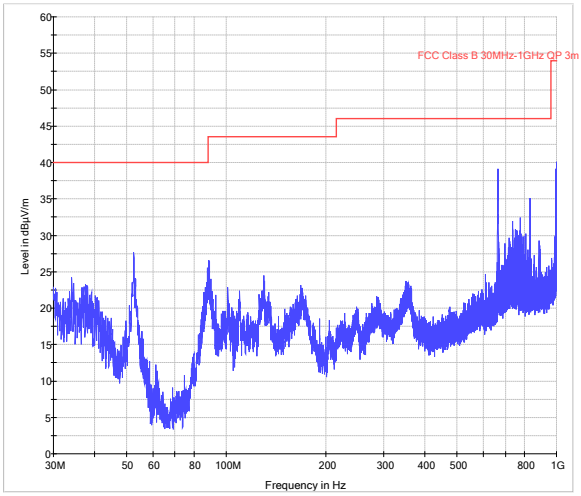


AC Powerline Conducted Emissions – Transmit

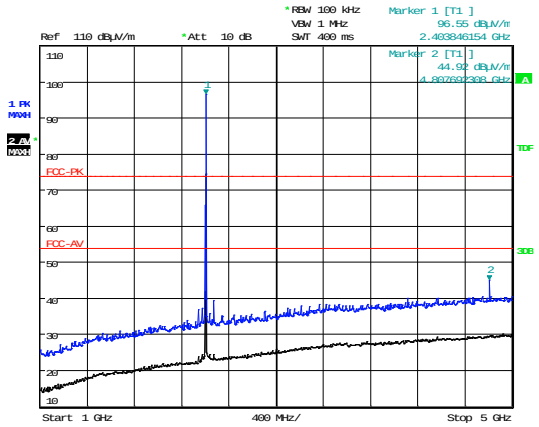


AC Powerline Conducted Emissions - Receive

Radiated Transmitter Emissions – 2402MHz

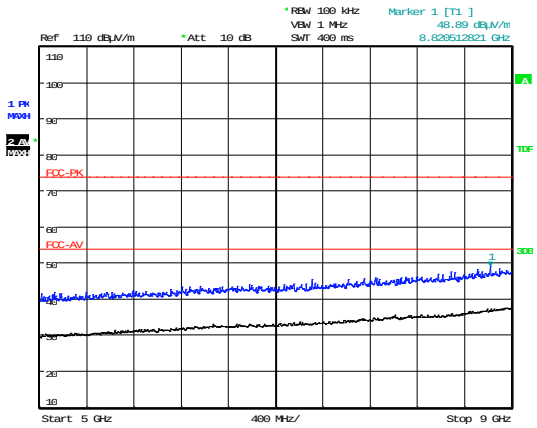


30MHz – 1GHz



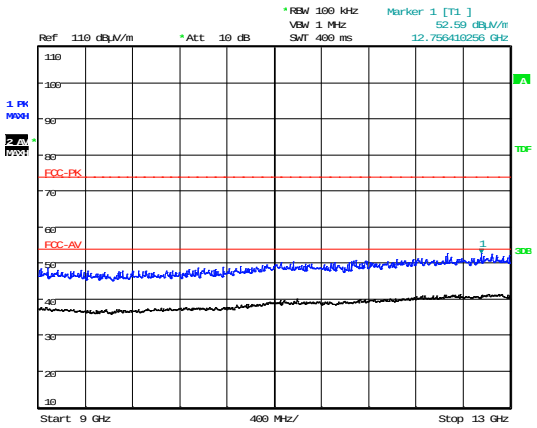
Date: 18.DEC.2014 12:30:37

1GHz – 5GHz



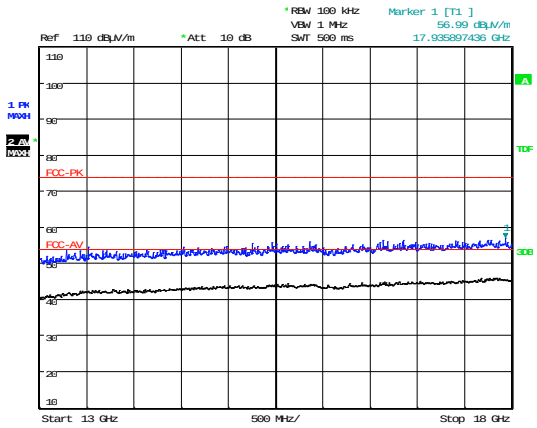
Date: 18.DEC.2014 12:29:33

5GHz – 9GHz



Date: 18.DEC.2014 12:24:02

9GHz – 13GHz



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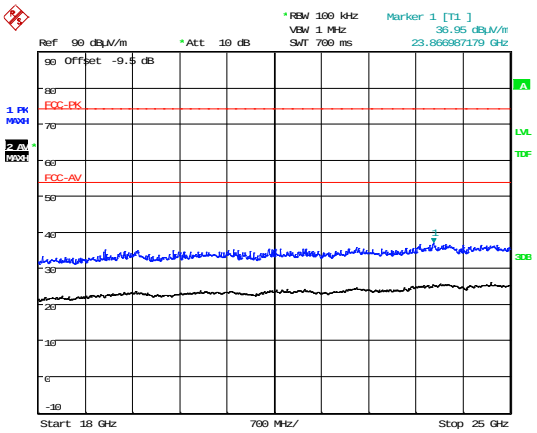
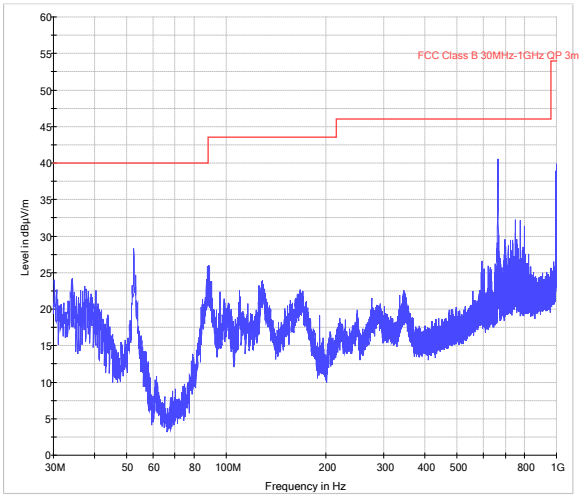
13GHz – 18GHz



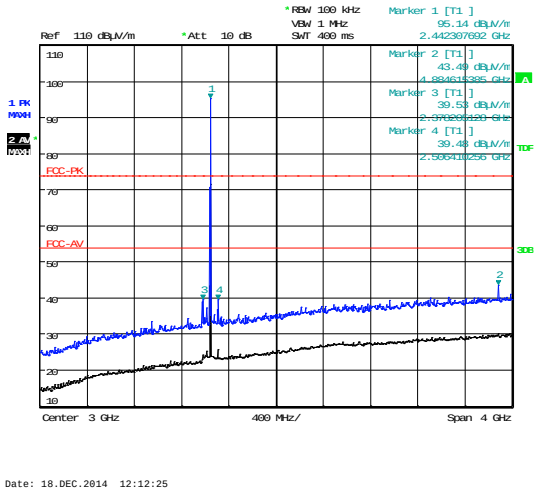
Date: 24.DEC.2014 09:02:08

18GHz – 25GHz

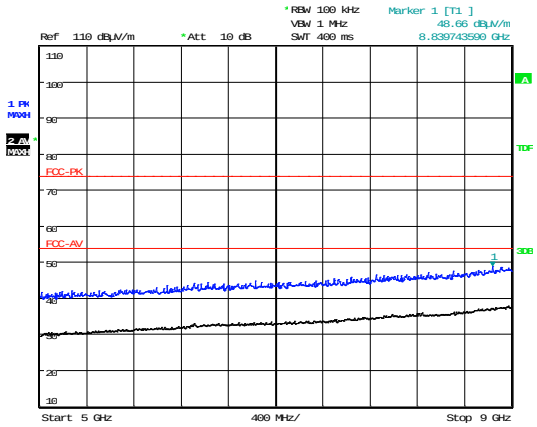
Radiated Transmitter Emissions – 2440MHz



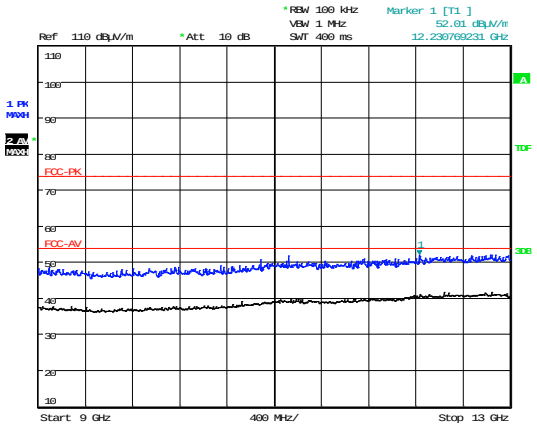
30MHz – 1GHz



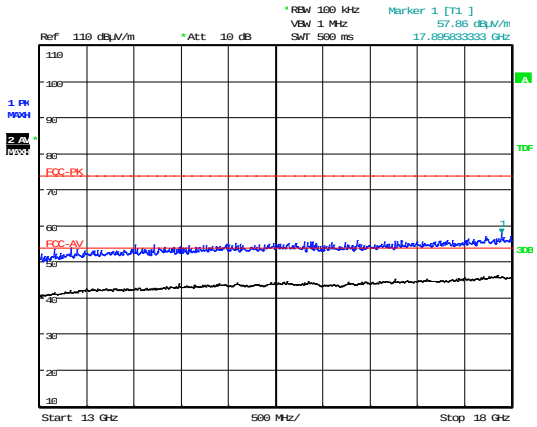
1GHz – 5GHz



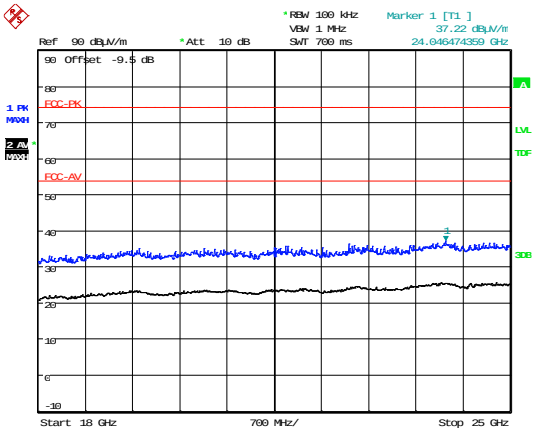
5GHz – 9GHz



9GHz – 13GHz

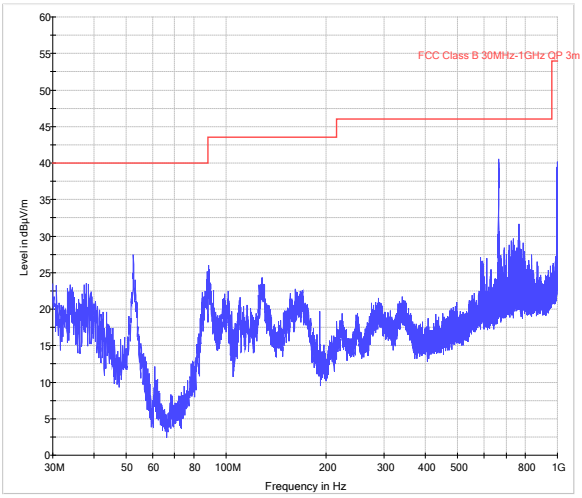


13GHz – 18GHz

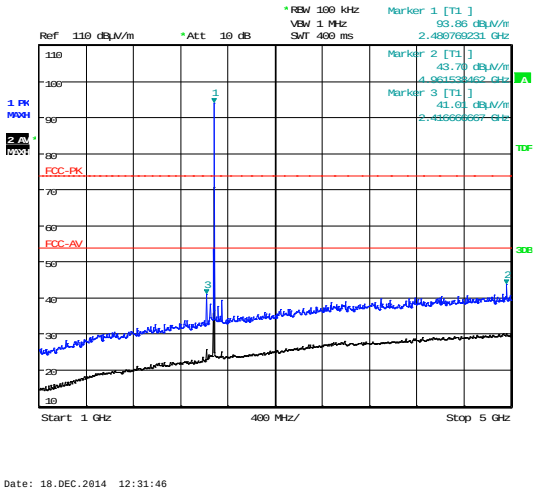


18GHz – 25GHz

Radiated Transmitter Emissions – 2480MHz



30MHz – 1GHz



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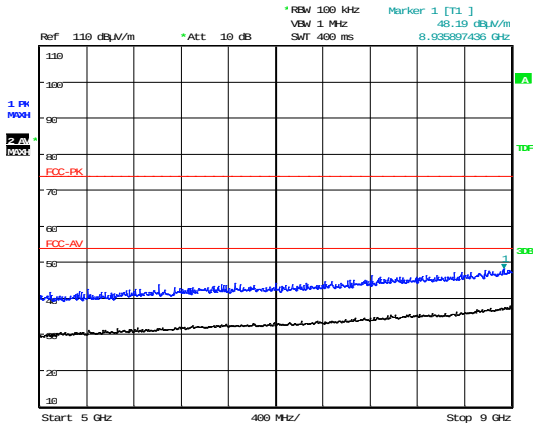
1GHz – 5GHz



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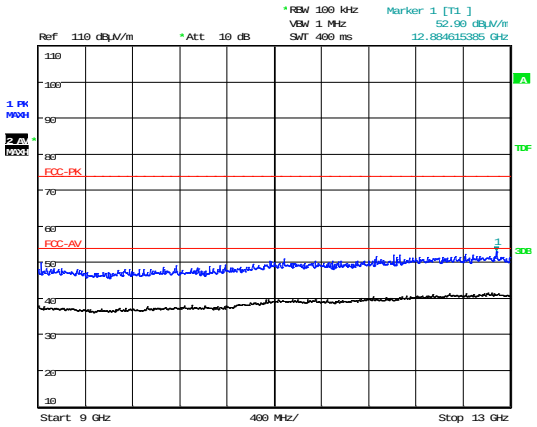
5GHz – 9GHz



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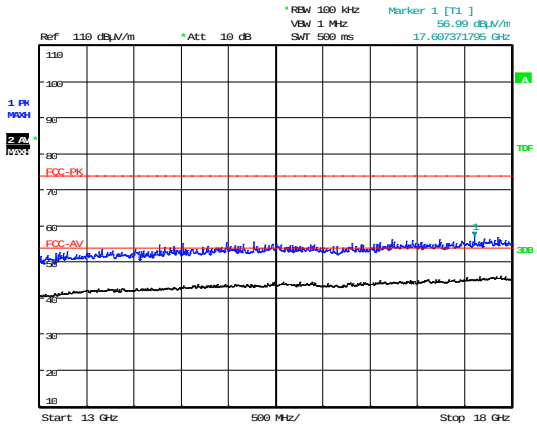
9GHz – 13GHz



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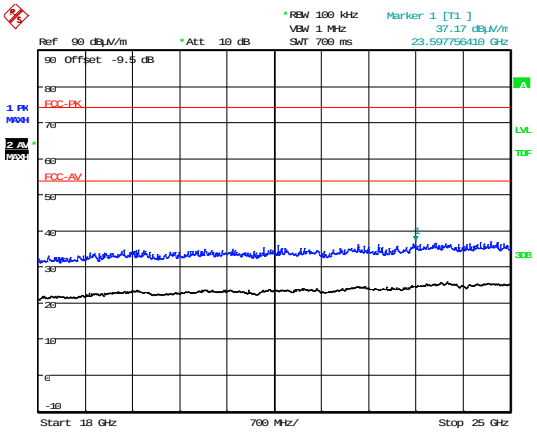
13GHz – 18GHz



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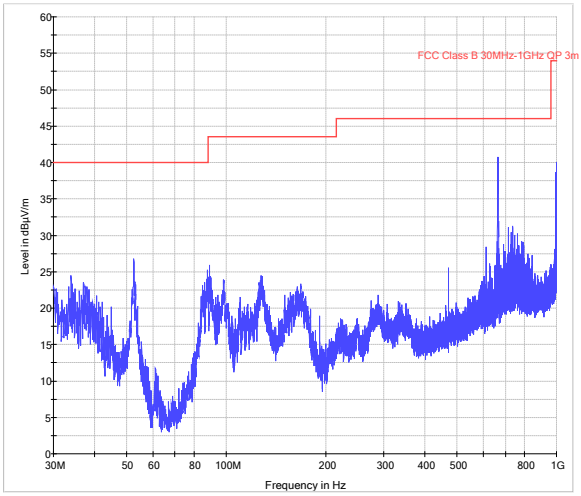
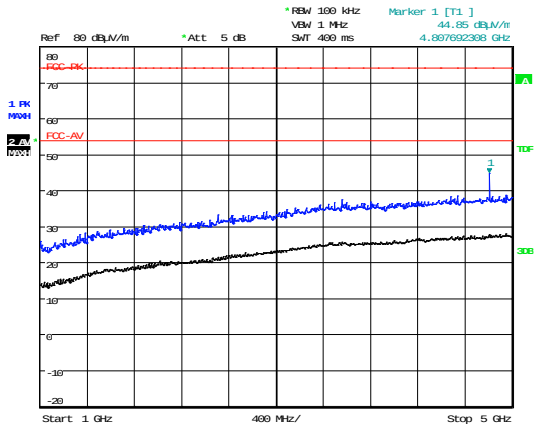
18GHz – 25GHz

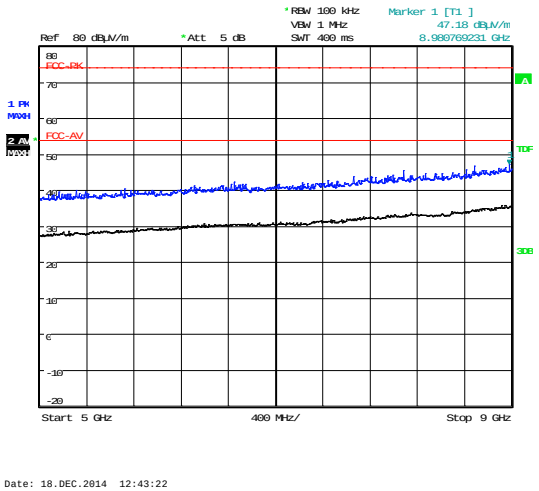
Unintentional Radiated Emissions – 2402MHz



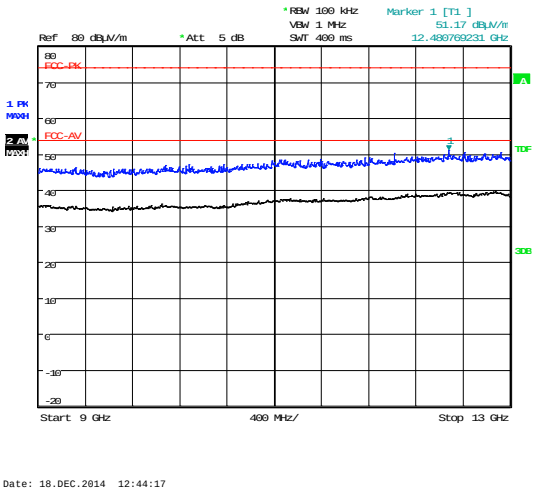
30MHz – 1GHz



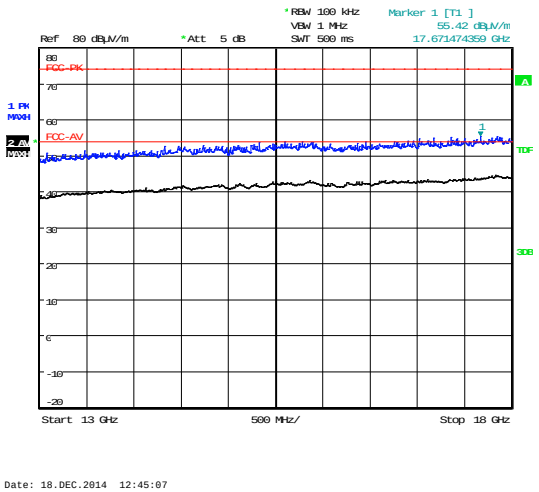
1GHz – 5GHz



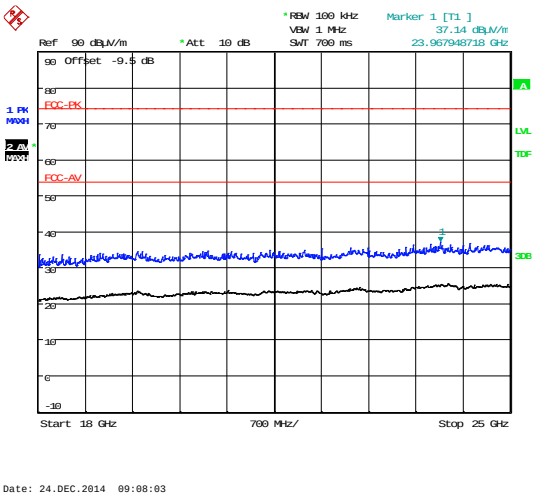
5GHz – 9GHz



9GHz – 13GHz

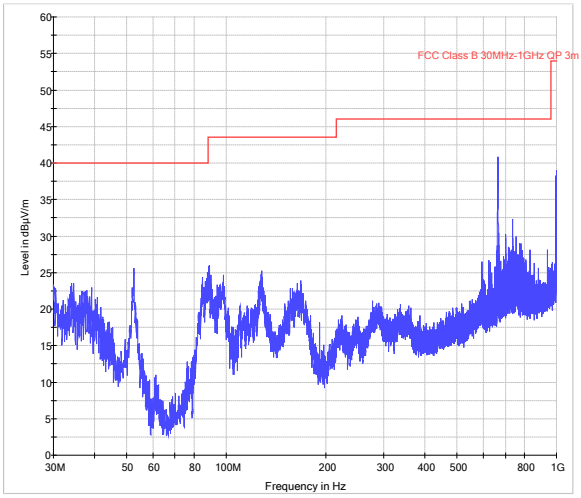


13GHz – 18GHz

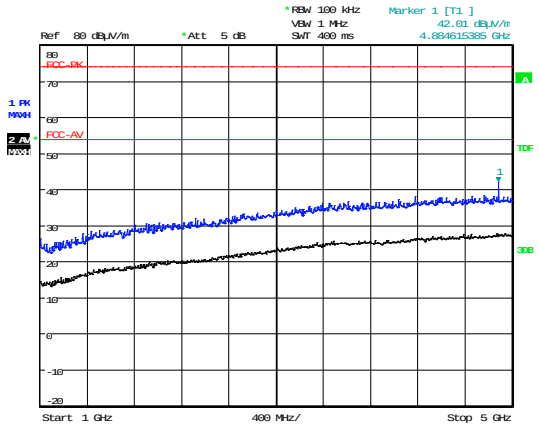


18GHz – 25GHz

Unintentional Radiated Emissions – 2440MHz



30MHz – 1GHz



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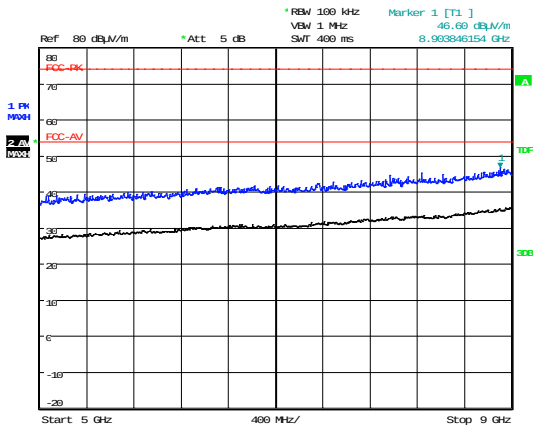
1GHz – 5GHz



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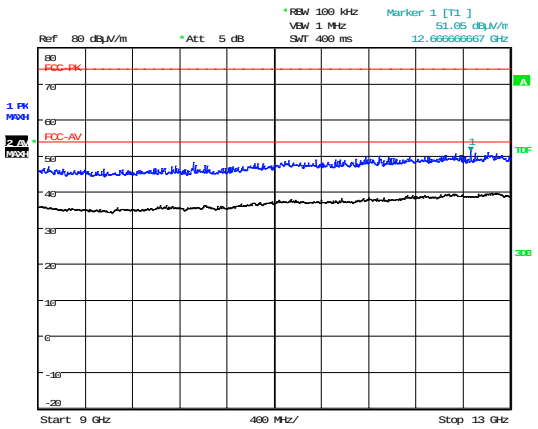
5GHz – 9GHz



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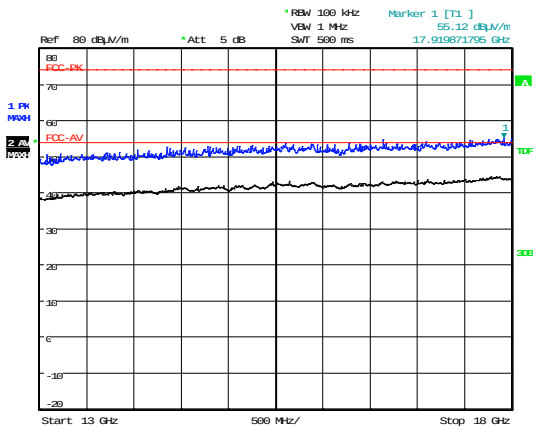
9GHz – 13GHz



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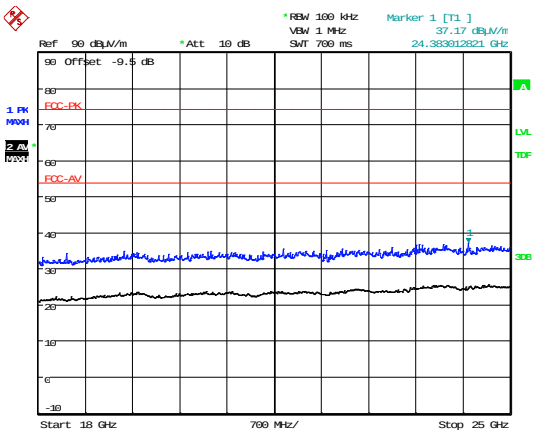
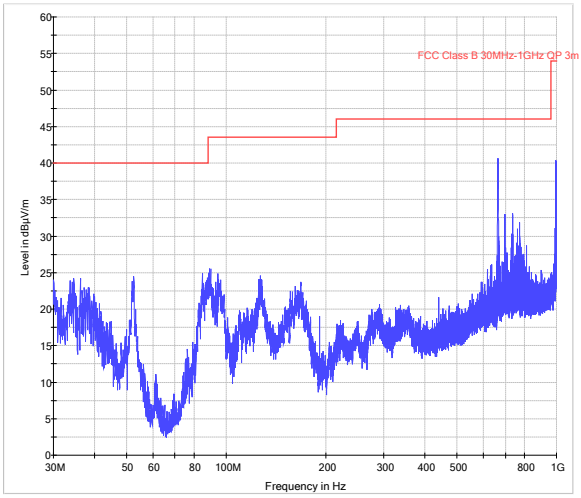
13GHz – 18GHz



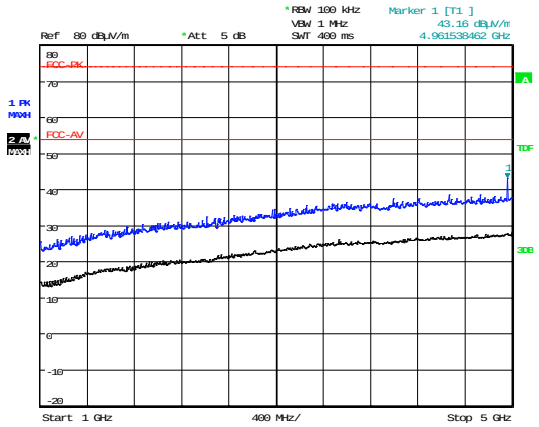
Date: 24.DEC.2014 09:10:58

18GHz – 25GHz

Unintentional Radiated Emissions – 2480MHz



30MHz – 1GHz



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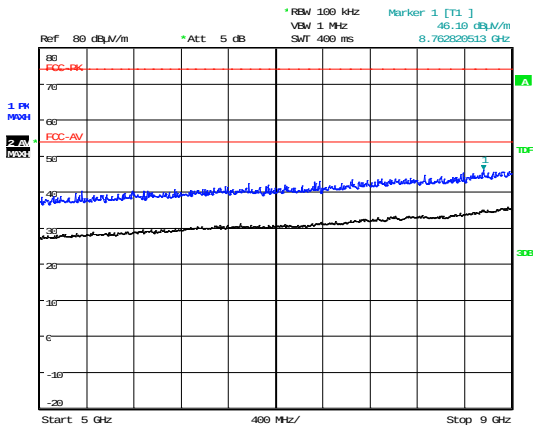
1GHz – 5GHz



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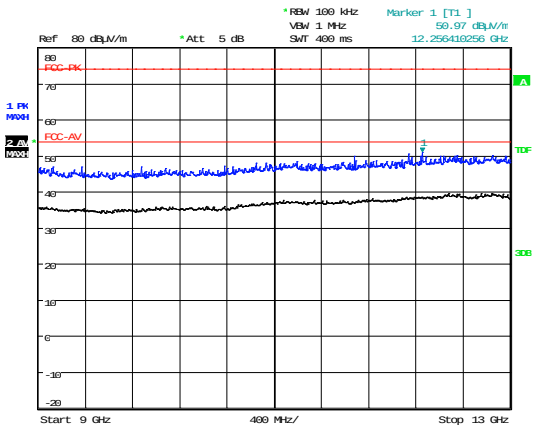
5GHz – 9GHz



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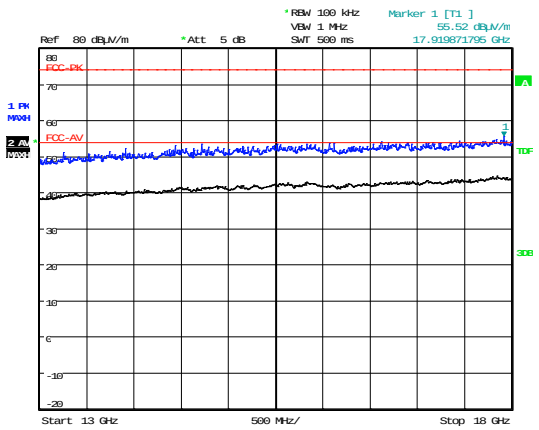
9GHz – 13GHz



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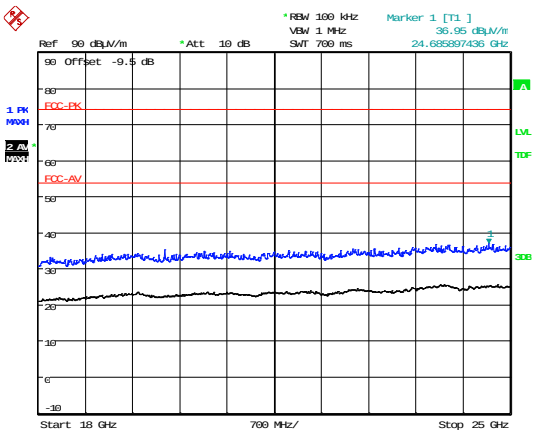
13GHz – 18GHz



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18GHz – 25GHz

Appendix C: Additional Test and Sample Details

This appendix contains details of:

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

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

Sample No: Sxx Mod w

where:

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

The following terminology is used throughout the test report:

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

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

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

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

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

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

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

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

C1 Test samples

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

Sample No.	Description	Identification
S01	foc.us v2 dock	None
S06	foc.us v2 dock	None
S11	foc.us v2 dock	None

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

Sample No.	Description	Identification
S09	foc.us v2 controller	None

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

Identification	Description
CNU7523BKR	HP Compaq 6720s Laptop with charger

The following hardware and software versions were used for testing.

Hardware Version	Software Version
1.0	1.3

C2 EUT Operating Mode during Testing

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

Test	Description of Operating Mode:
All Transmitter tests detailed in this report	EUT actively transmitting on required channels, with and without modulation as required

Test	Description of Operating Mode:
Receiver conducted and radiated spurious emissions	EUT in receive mode on required channels

Test	Description of Operating Mode:
Powerline conducted emissions	EUT operating in transmit and receive mode as required.

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 : S06
Tests : Conducted

Port	Description of Cable Attached	Cable length	Equipment Connected
Charging	n/a	n/a	Not Terminated
Micro USB	USB to micro USB cable	20cm	Laptop with charger

Sample : S01, S11
Tests : Radiated/Powerline

Port	Description of Cable Attached	Cable length	Equipment Connected
Charging	n/a	n/a	S09
Micro USB	USB to micro USB cable	20cm	Laptop with charger

C5 Details of Equipment Used

TRaC No	Equipment Type	Equipment Description	Manufacturer	Last Cal Calibration	Calibration Period	Due For Calibration
UH003	ESHS10	Receiver	R&S	03/07/2014	12	03/07/2015
UH004	ESVS10	Receiver	R&S	27/02/2014	12	27/02/2015
UH093	CBL6112B	Bilog	Chase	08/07/2013	24	08/07/2015
UH191	CBL611/A	Bilog	Chase	02/12/2014	24	02/12/2016
UH195	ESH3-Z5.831.5	Lisn	R&S	21/07/2014	12	21/07/2015
UH281	FSU46	Spectrum Analyser	R&S	26/03/2014	12	26/03/2015
UH387	ATS	Chamber 1	Rainford EMC	04/07/2013	24	04/07/2015
UH388	ATS	Chamber 2	Rainford EMC	04/07/2013	24	04/07/2015
UH396	ENV216	Lisn	R&S	22/05/2014	12	22/05/2015
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
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
L193	VHA 9103 balu	Bicone Antenna	Chase	25/06/2014	24	25/06/2016
L203	UPA6108	Log Periodic Ant	Chase	25/06/2014	24	25/06/2016
L300	20240-20	Horn 18-26GHz (&UH330)	Flann	10/02/2014	24	10/02/2016
L352	ESVS10	Receiver	R&S	21/03/2014	12	21/03/2015
L426	52 Series II	Temperature Indicator	Fluke	22/05/2014	12	22/05/2015
L572	8449B	Pre Amp	Agilent	11/02/2014	12	11/02/2015
REF909	FSU26	Spectrum Analyser	R&S	12/02/2014	12	12/02/2015
REF910	FSU46	Spectrum Analyser	R&S	31/03/2014	12	31/03/2015
REF916	SMBV100A	Signal Generator	R&S	19/02/2014	12	19/02/2015
REF940	ATS	Radio Chamber - PP	Rainford EMC	08/09/2014	24	08/09/2016
REF977	SH4141	High Pass Filter	BSC	25/02/2013	24	25/02/2015
REF978	HL 050	Log Periodic Antenna	R&S	08/04/2014	24	08/04/2016

Appendix D: Additional Information

No additional information is included within this test report.

Appendix E: Calculation of the duty cycle correction factor

Duty cycle correction was not used during for the device.

Appendix F: Photographs and Figures

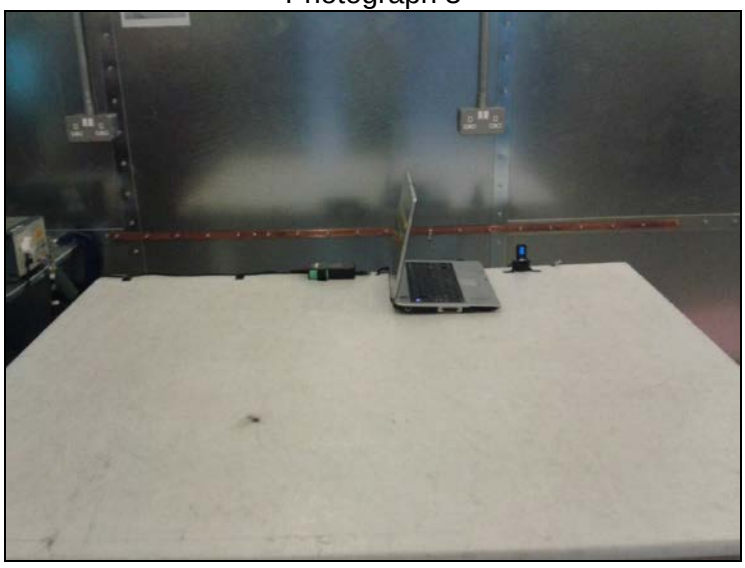
The following photographs were taken of the test samples:

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

Photograph 1

Photograph 2

Photograph 3



Appendix G: SAR Exclusion & MPE Calculation

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 100 MHz to 6 GHz and test separation distance of ≤ 50mm, the SAR Test Exclusion Threshold 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) = 5mm (in this case)

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

Note: Step 2 is not required here as the TSD^{A} is less than 50mm.

Operating Frequency 2.402 GHz

SARET = [(3.0 x 5) / √2.402]
SARET = 9.68mW

Operating Frequency 2.440 GHz

SARET = [(3.0 x 5) / √2.440]
SARET = 9.60mW

Operating Frequency 2.480 GHz

SARET = [(3.0 x 5) / √2.480]
SARET = 9.53mW

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold	SAR Evaluation
2402	2.34	9.68	Not Required
2440	2.09	9.60	Not Required
2480	1.82	9.53	Not Required

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

Prediction of MPE limit at a given distance

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

Where:

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

Note:

The EIRP was calculated by addition of the maximum conducted carrier power and the maximum antenna gain.

Result

Prediction Frequency (MHz)	Maximum EIRP (mW)	Power density limit (S) (mW/cm^2)	Distance (R) cm Required to be less than 1 mW/cm^2
2402	2.34	1	0.44

HULL
Unit E, South Orbital Trading Park, Hedon Road, Hull, HU9 1NJ, UK.
T +44 (0)1482 801801 **F** +44 (0)1482 801806 **E** test@tracglobal.com
www.tracglobal.com