A RADIO TEST REPORT

FOR

SIGFOX

ON

SBS T 902

DOCUMENT NO. TRA-020168-02-47-00-B

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TRaC Wireless Test Report	**:** TRA-020168-02-47-00-B
Applicant	**:** SigFox
Apparatus	**:** SBS T 902
Specification(s)	**:** CFR47 Part 15.247 & RSS-210 Annex 8
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Section 1: Introduction

1.1 General

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

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1.2 Tests Requested By

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1.3 Manufacturer

As Above

1.4 Apparatus Assessed

The following apparatus was assessed between 11th June – 28th July 2014

SBS T 902

The SBS T 902 is a FHSS device operating in the 902 -928 MHz abnd.

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 (d) 15.209	Annex 8, A8.5	ANSI C63.10:2009	Pass
Conducted spurious emissions (Non-restricted bands)	15.247(d)	Annex 8, A8.5	ANSI C63.10:2009	Pass
AC Power conducted emissions	15.207	Section 7.2.2	ANSI C63.10:2009	Pass
20dB Bandwidth and Channel Spacing	15.247(a)(1)(i)	Annex 8, A8.1(b)	ANSI C63.10:2009	Pass
Conducted Carrier Power	15.247(b)(2)	Annex 8, A8.4(1)	ANSI C63.10:2009	Pass
Hopping Frequencies	15.247(a)(1)(i)	Annex 8, A8.1(c)	ANSI C63.10:2009	Pass
Channel Occupancy	15.247(a)(1)(i)	Annex 8, A8.1(c)	ANSI C63.10:2009	Pass
Unintentional Radiated Spurious Emissions	15.109	Section 7.2.3	ANSI C63.10:2009	Pass
Extrapolation Factor:	15.31(f)	RSS-Gen Issue 3 7.2.7	-	-
Maximum Frequency of Search:	15.33	RSS-Gen Issue 3 4.9	-	-
Antenna Arrangements Integral:	15.203	RSS-Gen Issue 3 7.1.2	-	-
Antenna Arrangements External Connector:	15.204	RSS-Gen Issue 3 7.1.2	-	-
Restricted Bands:	15.205	RSS-Gen Issue 3 7.2.2	-	-

Abbreviations used in the above table:

ANSI C 63.10:2009 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^{o} 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-amplifer gain dB, (when applicable)
DC is duty correction factor (when applicable) in dB, and
CF is a distance correction (employed only if 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 (mutil 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 are made on frequencies identified from the preview scans and fundamental emission(s). Measurements 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 10^0 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 transmitters 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 (eg. FHSS timing) the measurement can only be made

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 (eg 6dB, 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 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	Part 15.247(b)(1) RSS – 210, Annex 8, A8.4(1)
Measurement standard	ANSI C63.10:2009, RSS-GEN
EUT sample number	S19,S13
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Peak Carrier Power (W)	Limit (W)	Result
902.2	0.504	0.631	Pass
910.0	0.572		Pass
918.1	0.513		Pass

Notes:

Number of hopping channels employed is 50

Conducted Measurements

Highest Gain of any antenna to be used = 8 dBi

As per 15.247(b)(4) and Annex 8, A8.4(1) as the gain of the antenna is greater than 6dBi the conducted output power limit is reduced as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi

Antenna gain exceeds 6 dBi by 2 dB therefore conducted output power limit of 1W (30 dBm) is reduced to 0.631W (28 dBm)

A2 RF Antenna Conducted Spurious Emissions

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

Test Details: 902.2 MHz	
Regulation	Part 15.247(d) and Clause 15.205, RSS-210 Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	9 kHz to 10 GHz
EUT sample number	S19,S13
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
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.	Within Restricted bands (Y/N)	Emission Level (dBm)	Limit (dBm)	Summary
1.	917.612	Pk	N	0.44	5.34	Pass

RF Antenna Conducted Spurious Emissions continued:

Test Details: 910.0MHz	
Regulation	Part 15.247(d) and Clause 15.205, RSS-210 Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	9 kHz to 10 GHz
EUT sample number	S19,S13
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
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.	Within Restricted bands (Y/N)	Emission Level (dBm)	Limit (dBm)	Summary
1.	917.612	Pk	N	0.44	5.34	Pass

RF Antenna Conducted Spurious Emissions continued:

Test Details: 918.1 MHz	
Regulation	Part 15.247(d) and Clause 15.205, RSS-210 Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	9 kHz to 10 GHz
EUT sample number	S19,S13
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
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.	Within Restricted bands (Y/N)	Emission Level (dBm)	Limit (dBm)	Summary
1.	917.612	Pk	N	0.44	5.34	Pass

Notes:

1. The conducted emission limit for emissions are based on a transmitted carrier level of 15.247(b) and Annex 8, A8.4(1).. 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) and Annex 8, A8.5 using a peak detector.
2. The RBW = 100 kHz, Video bandwidth (VBW) > RBW and the radio spectrum was investigated in accordance with 15.33 (a)(1) and RSS – GEN 4.9.
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 measurements at 2400 MHz and 2483.5 MHz were made to ensure band edge compliance. All other emissions were at least 20dB below the test limit

The limit outside the restricted band in 100 kHz RBW is defined using the following formula in accordance with 15.247(d) and Annex 8, A8.5:

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

A3 Radiated Electric Field Emissions

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

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

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

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

Test Details: 902.2 MHz	
Regulation	Part 15.247(d) and 15.205, RSS – 210, Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz – 25GHz
EUT sample number	S19, S13, S05, S06, S10
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
EUT set up	Refer to Appendix C
Temperature	24˚C
Photographs (Appendix F)	Photograph 1 and 2

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

Ref No.	**FREQ. (MHz)**	**MEAS Rx (dBµV)**	**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)**
1.	5456.09_{Pk}	48.61	4.3	33.9	35.7	51.11	-	359.34	500

Peak levels meet average limit therefore average measurements not performed.

Radiated Electric Field Emissions:

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

Test Details: 910.0MHz	
Regulation	Part 15.247(d) and 15.205, RSS – 210, Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz to 10 GHz
EUT sample number	S19, S13, S05, S06, S10
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
EUT set up	Refer to Appendix C
Temperature	24˚C
Photographs (Appendix F)	Photograph 1 and 2

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

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	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)
1.	No Significant Emissions								

Radiated Electric Field Emissions:

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

Test Details: 918.1 MHz	
Regulation	Part 15.247(d) and 15.205, RSS – 210, Annex 8, A8.5
Measurement standard	ANSI C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	30MHz to 10 GHz
EUT sample number	S19, S13, S05, S06, S10
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
EUT set up	Refer to Appendix C
Temperature	24˚C
Photographs (Appendix F)	Photograph 1 and 2

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

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	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)
1	4590.54_{Pk}	50.33	3.8	32.3	35.6	52.30	-	412.10	500

Peak levels meet average limit therefore average measurements not performed.

Notes:

1 Any testing performed below 30 MHz was performed using a magnetic loop antenna in accordance with ANSI C63.10:2009: section 4.5, Table 1 and ANSI C63.4: 2003 section 8.2.1

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

3 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 C63.10:2009 and DA 00-705.

6 In accordance with DA 00-705, the average level of the spurious radiated emission may be reduced by the duty cycle correction factor. If the dwell time per channel (refer to the measured channel occupancy time, section A7 of this test report) of the hopping signal is less than 100ms then the average measurement may be further adjusted by the duty cycle correction factor which is derived from

$$20\log_{10}\left(\frac{\text{dwell time}}{100ms}\right)$$

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

(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

A4 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 C63.10:2009, RSS – GEN, ANSI C63.4:2003
Frequency range	150kHz to 30MHz
EUT sample number	S19, S13, S05, S06, S10
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
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 average limit

Ref No.	Freq (MHz)	Result (dBuV)	Operating Mode / Conductor	Spec Limit (dBuV)	Margin (dB)	Result Summary
1	0.160	40.59	TX Neutral	55.46	14.87	Pass
2	0.210	35.64	RX Neutral	53.21	17.57	Pass
3	0.240	34.71	TX Neutral	52.10	17.39	Pass
4	0.280	34.52	RX Neutral	50.82	16.30	Pass
5	0.285	33.60	RX Neutral	50.67	17.07	Pass
6	0.350	32.07	TX Neutral	48.96	16.89	Pass
7	0.425	39.11	RX Neutral	47.35	8.24	Pass
8	0.440	34.43	TX Neutral	47.06	12.63	Pass
9	0.460	38.80	RX Neutral	46.69	7.89	Pass
10	0.600	27.80	RX Neutral	46.00	18.20	Pass
11	10.065	31.48	TX Live	50.00	18.52	Pass
12	10.400	30.62	TX Live	50.00	19.38	Pass
13	19.605	30.34	TX Live	50.00	19.66	Pass
14	21.605	31.81	TX Live	50.00	18.19	Pass

Results measured using the quasi-peak detector compared to the quasi–peak limit

Ref No.	Freq (MHz)	Result (dBuV)	Operating Mode / Conductor	Spec Limit (dBuV)	Margin (dB)	Result Summary
1	0.160	50.01	TX Neutral	65.46	15.45	Pass
2	0.195	44.64	TX Neutral	63.82	19.18	Pass
3	0.210	44.90	RX Neutral	63.21	18.31	Pass
4	0.240	46.28	TX Neutral	62.10	15.82	Pass
5	0.280	43.03	RX Neutral	60.82	17.79	Pass
6	0.285	42.93	RX Neutral	60.67	17.74	Pass
7	0.335	43.20	TX Neutral	59.33	16.13	Pass
8	0.345	40.27	TX Live	59.08	18.81	Pass
9	0.415	44.38	TX Neutral	57.55	13.17	Pass
10	0.430	46.30	RX Neutral	57.25	10.95	Pass
11	0.460	45.85	RX Neutral	56.69	10.84	Pass
12	0.485	44.67	TX Neutral	56.25	11.58	Pass
13	0.560	37.85	TX Neutral	56.00	18.15	Pass

Specification limits :

Conducted emission limits (47 CFR 15: Clause 15.207 and RSS – GEN, Section 7.2.2 Table 2:)

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

A5 20 dB Bandwidth and Carrier Frequency Separation

Title 47 of the CFR: Part 15 Subpart (c) 15.247(a)(1)(i) and RSS-210 Annex 8, A8.1(b) requires the measurement of the bandwidth of the transmission between the -20 dB points on the transmitted spectrum. The results of this test determine the limits for channel spacing. The channel separation shall be a minimum of 25 kHz or the 20 dB bandwidth, whichever is the greater. The formal measurements are detailed below:

Test Details:	
Regulation	Part 15.247(a)(1)(i). RSS-210 Annex 8, A8.1(b)
EUT sample number	S19, S13
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	Measured 20 dB Bandwidth (kHz)	Limit	Result
902.2	175.400641	<250kHz	Pass
910.0	175.400641	<250kHz	Pass
918.1	175.400641	<250kHz	Pass

Measured Channel Spacing (kHz)	Limit	Result
300.48	25 (kHz) or ≥ 20 dB Bandwidth (kHz)	Pass

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

A6 Hopping frequencies

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

Test Details:	
Regulation	Part 15.247(a)(1)(i), RSS – 210, Annex 8, A8.1(c)
EUT sample number	S19, S13
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
EUT set up	Refer to Appendix C

No. of Hopping Channels	Requirement	Result
50	50	Pass

Plots showing the hopping channels are contained in Appendix B

A7 Channel Occupancy

Channel occupancy time was verified using a spectrum analyser in zero span mode, centred on the middle hopping channel frequency (910.0MHz), while the EUT was operating in its normal frequency hopping mode. The other channels were then verified to ensure that the channel occupancy was identical for all channels.

Test Details:	
Regulation	Part 15.247(a)(1), RSS – 210, Annex 8, A8.1(c)
EUT sample number	S19, S13
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
EUT set up	Refer to Appendix C

Measured Channel Occupancy Time (ms)	Measurement Period (ms)	Number of Transmission in Measurement period (ms)	Average Channel Occupancy Time Limit (S)	Result
376.25	20	1	0.37625	Pass

Plots showing the channel occupancy time and time between successive transmissions are contained in Appendix B of this test report. These are identical for all modulation modes.

A8 Antenna Gain

The maximum antenna gain for the antenna types to be used with the EUT, as declared by the client, is 8 dBi.

As per 15.247(b)(4) and Annex 8, A8.4(1) as the gain of the antenna is greater than 6dBi the conducted output power limit is reduced as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi

Antenna gain exceeds 6 dBi by 2 dB therefore conducted output power limit of 1W (30 dBm) is reduced to 0.631W (28 dBm)

A9 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 and RSS- GEN Section 7.2.3. 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 10 GHz
EUT sample number	S19, S13, S05, S06, S10
Modification state	0
SE in test environment	S13
SE isolated from EUT	S03
EUT set up	Refer to Appendix C
Temperature	24˚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)	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)
1	30.00	9	0.7	19.5	-	29.2	-	28.84	100
2	30.70	6.15	0.7	19.2	-	26.0	-	19.95	100
3	34.50	6.35	0.7	17.1	-	24.1	-	16.03	100
4	34.60	6.62	0.7	17.0	-	24.3	-	16.41	100
5	35.40	16.79	0.7	16.5	-	34.0	-	50.12	100
6	35.70	9.82	0.7	16.4	-	26.9	-	22.13	100
7	35.95	10.03	0.7	16.2	-	27.0	-	22.39	100
8	36.15	9.14	0.8	16.1	-	26.0	-	19.95	100
9	36.55	10.25	0.8	15.9	-	26.9	-	22.13	100
10	38.35	16.17	0.8	14.9	-	31.9	-	39.36	100
11	38.55	15.97	0.8	14.8	-	31.6	-	38.02	100
12	39.90	12.43	0.8	14.0	-	27.2	-	22.91	100
13	40.15	12.27	0.8	13.8	-	26.9	-	22.13	100
14	40.85	11.42	0.8	13.5	-	25.7	-	19.28	100

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)
15	42.15	11.8	0.9	12.7	-	25.4	-	18.62	100
16	43.00	8.6	0.9	12.3	-	21.8	-	12.30	100
17	43.70	11.65	0.9	12.0	-	24.5	-	16.79	100
18	52.55	17.86	1.0	7.5	-	26.4	-	20.89	100
19	55.90	12.67	1.0	6.6	-	20.3	-	10.35	100
20	60.10	14.81	1.0	6.0	-	21.8	-	12.30	100
21	62.50	19.5	1.0	6.0	-	26.5	-	21.13	100
22	63.25	20.72	1.0	6.0	-	27.7	-	24.27	100
23	63.90	17.85	1.0	5.9	-	24.8	-	17.38	100
24	64.90	19.21	1.1	6.0	-	26.3	-	20.65	100
25	66.10	17.6	1.2	6.1	-	24.9	-	17.58	100
26	66.95	14.21	1.2	6.3	-	21.7	-	12.16	100
27	69.00	13.1	1.2	6.5	-	20.8	-	10.96	100
28	71.35	17.36	1.2	6.7	-	25.3	-	18.41	100
29	85.65	12.85	1.2	8.8	-	22.9	-	13.96	100
30	87.50	12.84	1.3	9.1	-	23.2	-	14.45	100
31	138.75	10.29	1.6	12.3	-	24.2	-	16.22	150
32	1827.0_{Pk}	49.55	3	27.1	36.3	**43.35**	-		500

Peak levels meet average limit therefore average measurements not performed.

Appendix B: Supporting Graphical Data

This appendix contains graphical data obtained during testing.

Notes:

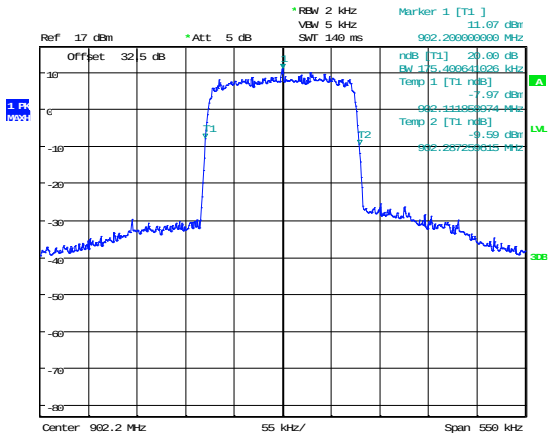
(a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.

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

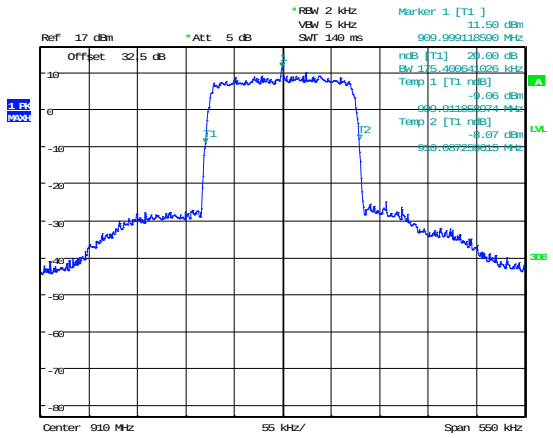
(c) Where relevant, on power line conducted emission plots, the limit displayed is the average limit, which is stricter than the quasi peak limit.

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

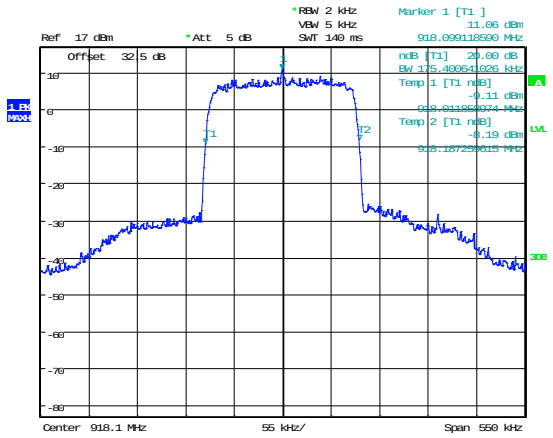
(e) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.



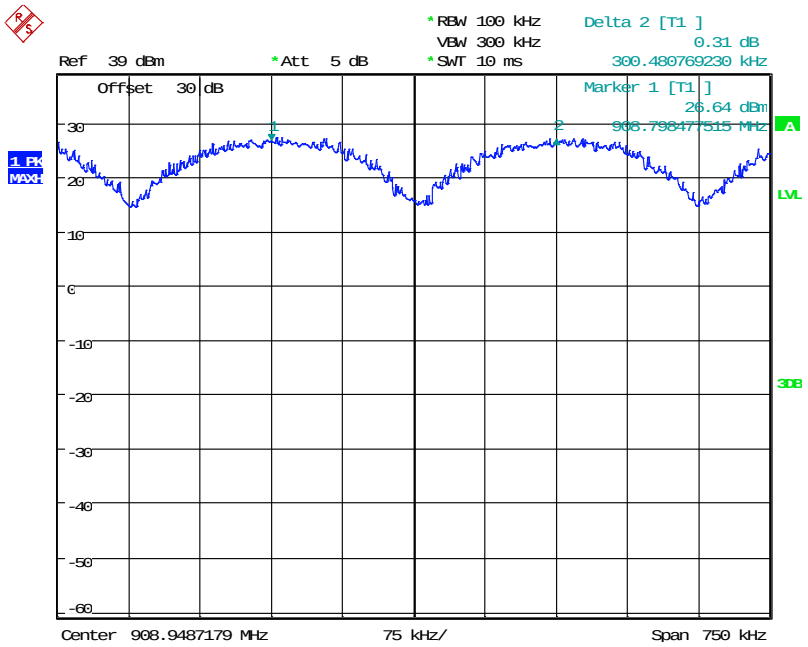
20dB Bandwidth – 902.2 MHz



20dB Bandwidth – 910.0 MHz

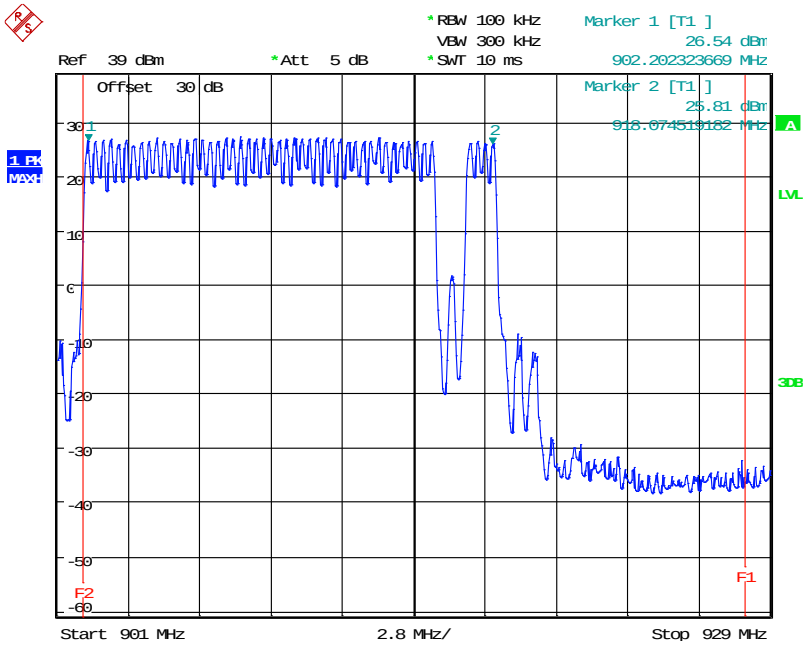


20dB Bandwidth – 918.1 MHz



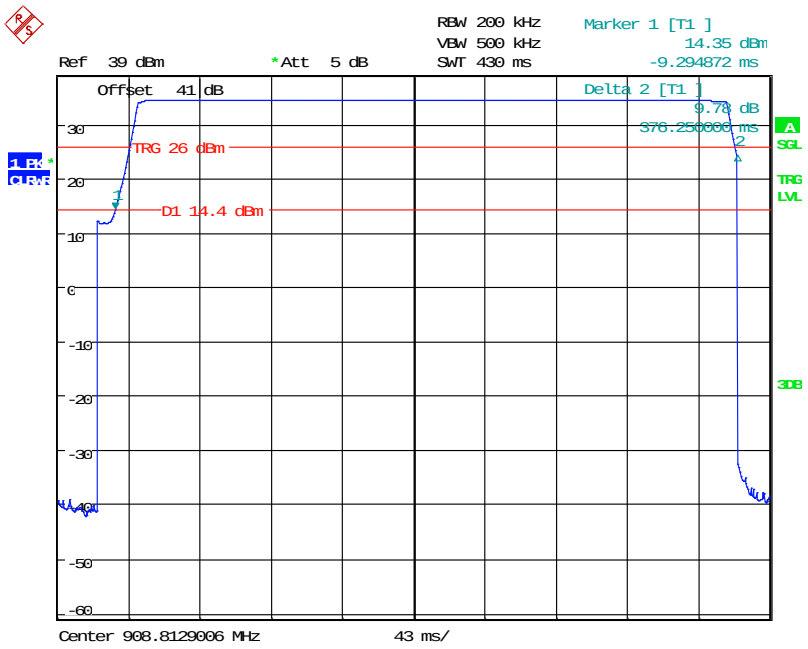
Date: 23.JUL.2014 11:54:59

Channel Spacing

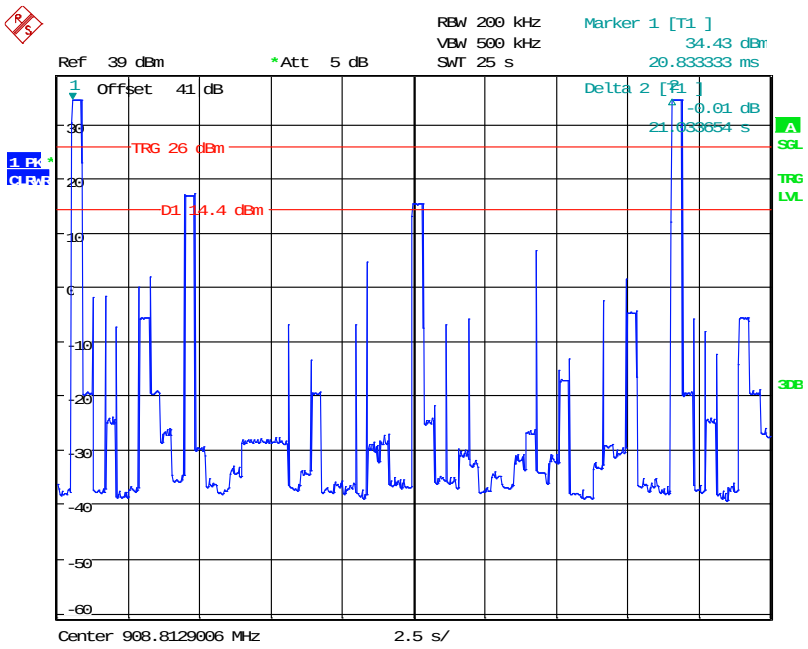


Date: 23.JUL.2014 11:46:04

Number of Hopping Channel

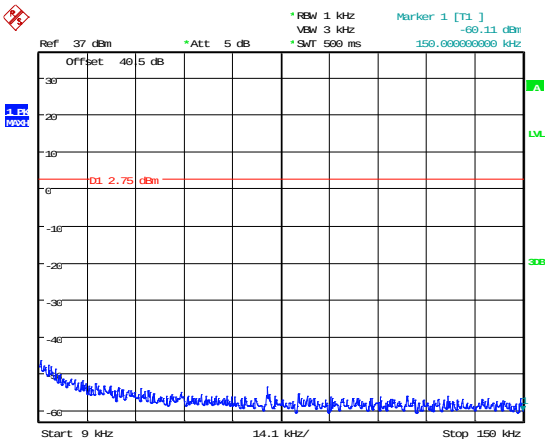


Channel Occupancy Time



Channel repetition time

Conducted Spurious emissions 902.2MHz



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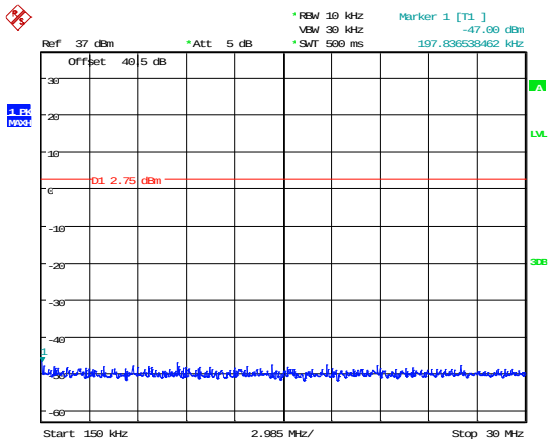
9kHz – 150kHz



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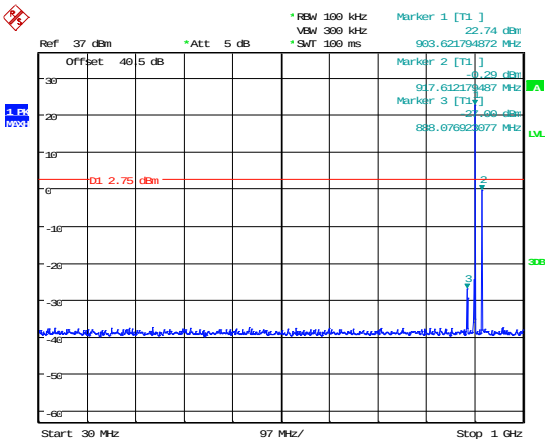
150kHz to 30 MHz



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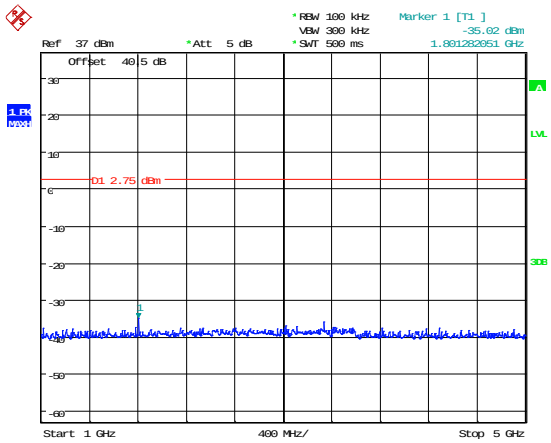
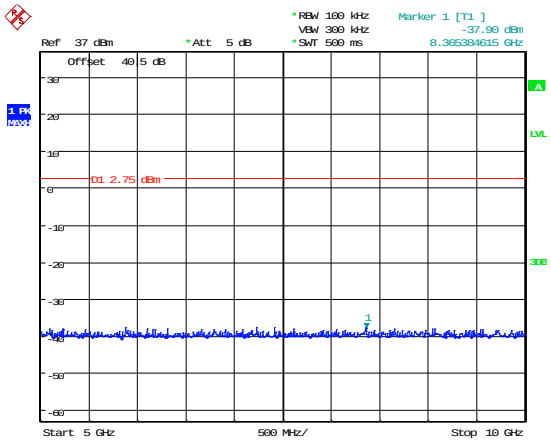
30 MHz to 1 GHz



Date: 23.JUL.2014 13:39:57

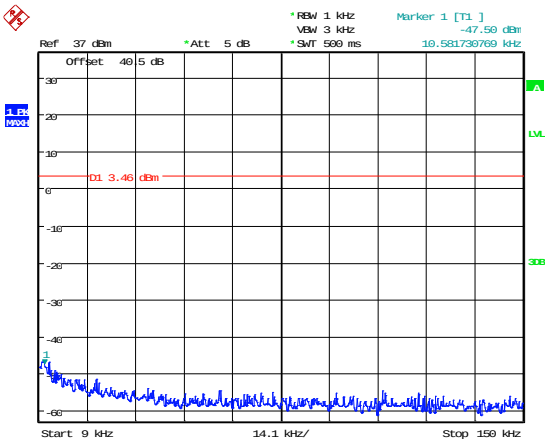
1 GHz to 5 GHz



Date: 23.JUL.2014 13:40:48

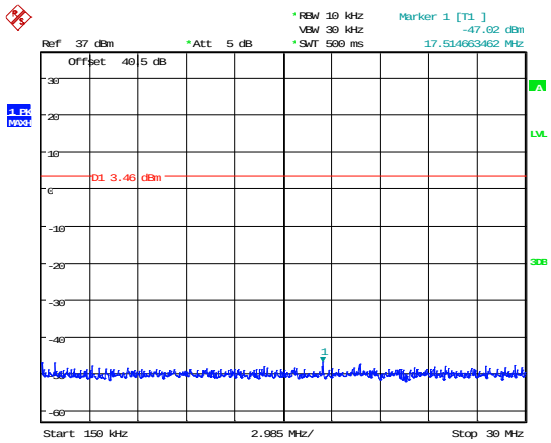
5 GHz to 10 GHz

Conducted Spurious emissions 910.0MHz



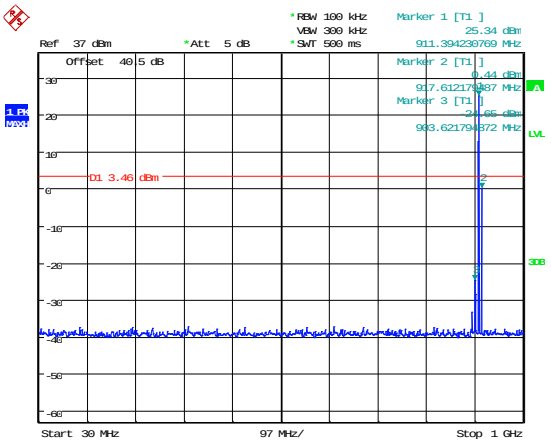
Date: 23.JUL.2014 13:45:25

9kHz – 150kHz



Date: 23.JUL.2014 13:45:56

150kHz to 30 MHz



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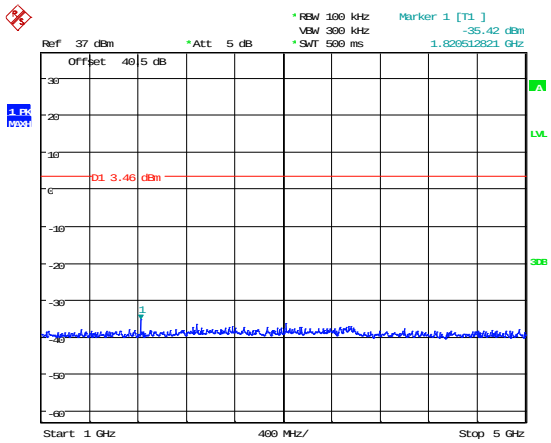
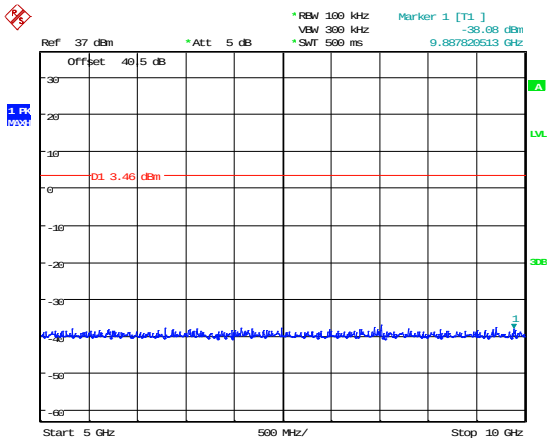
30 MHz to 1 GHz



Date: 23.JUL.2014 13:44:19

1 GHz to 5 GHz



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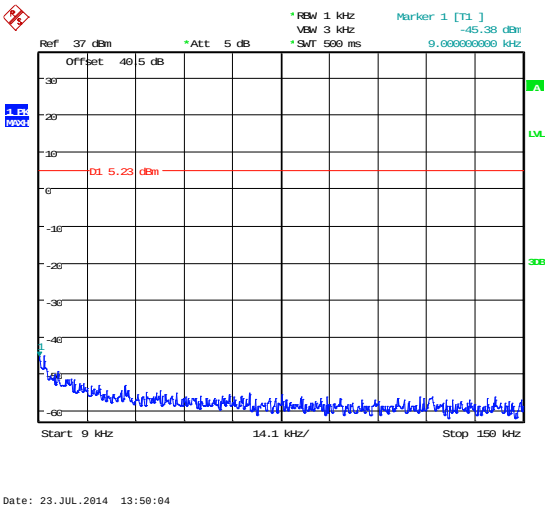
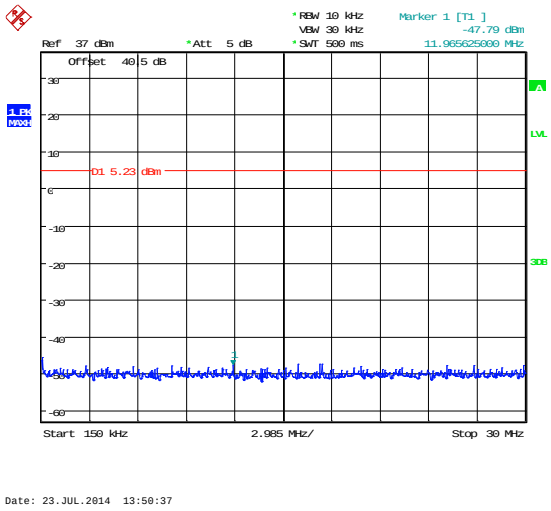
5 GHz to 10 GHz

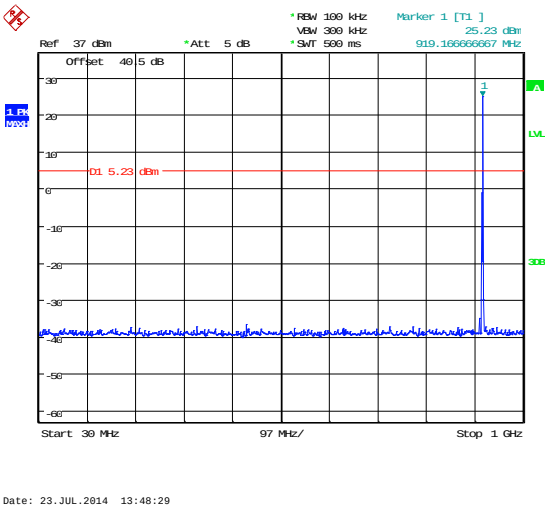
Conducted Spurious emissions 918.1MHz



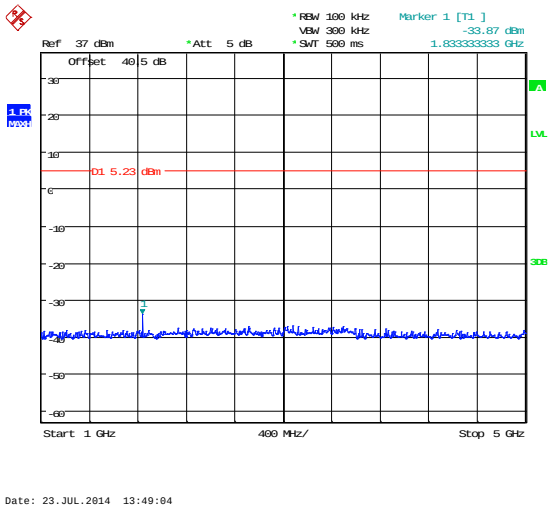
9kHz – 150kHz



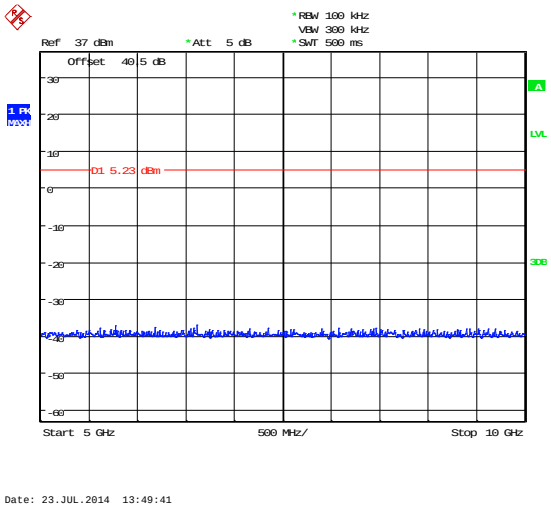
150kHz to 30 MHz



30 MHz to 1 GHz

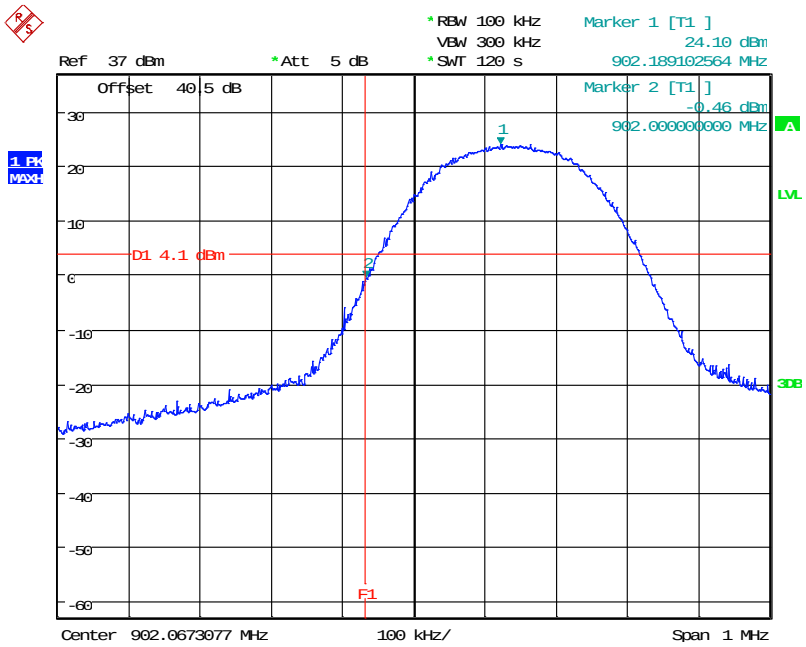


1 GHz to 5 GHz



5 GHz to 10 GHz

Conducted Bandedge Compliance



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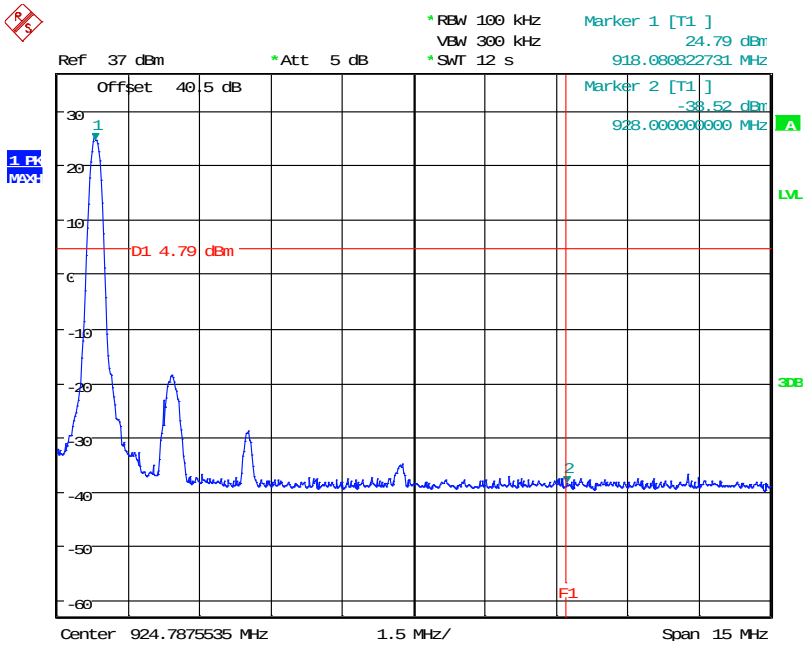
Lower Bandedge



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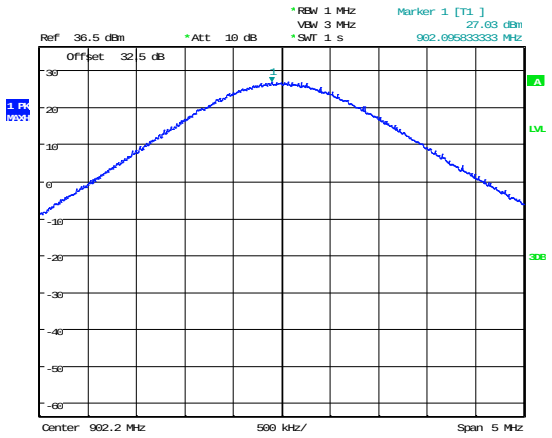
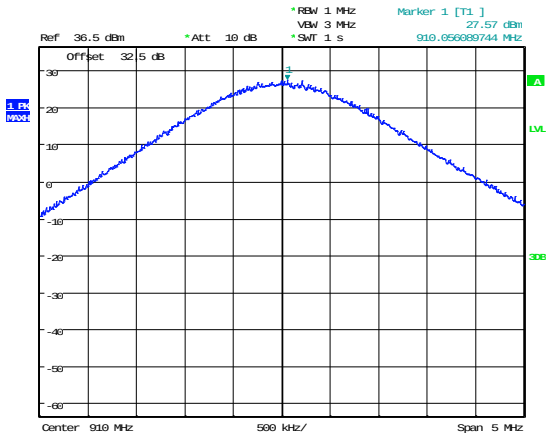
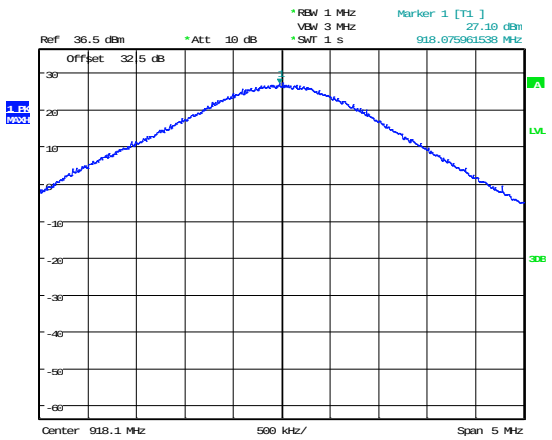
Upper Bandedge



Conducted carrier power 902.2MHz

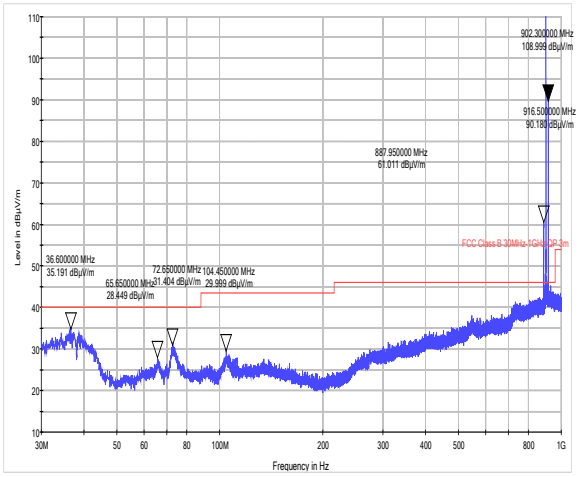


Conducted carrier power 910.0MHz

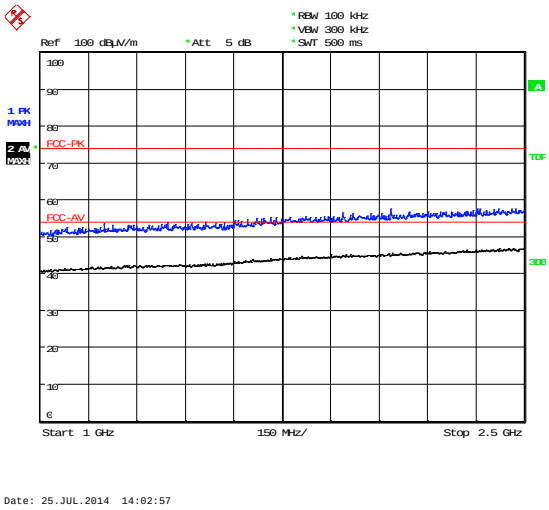


Conducted carrier power 918.1 MHz

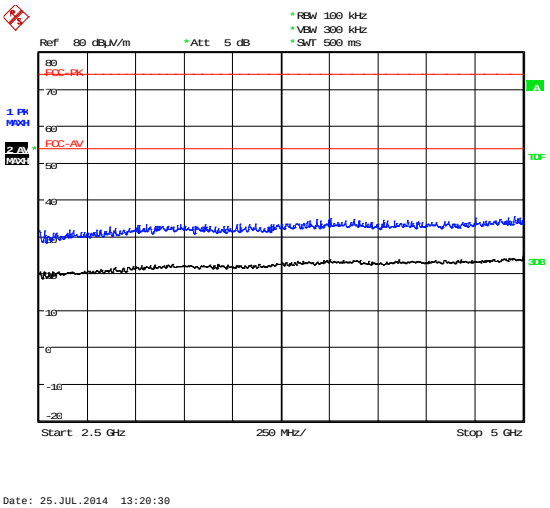
Radiated Spurious emissions 902.2 MHz



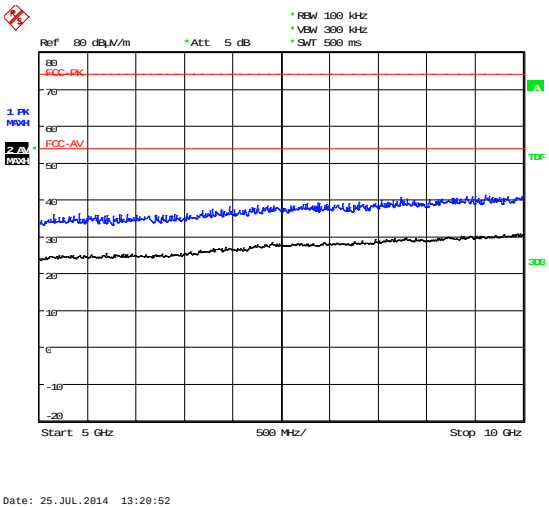
30 MHz to 1 GHz –1



1 GHz to 2.5 GHz

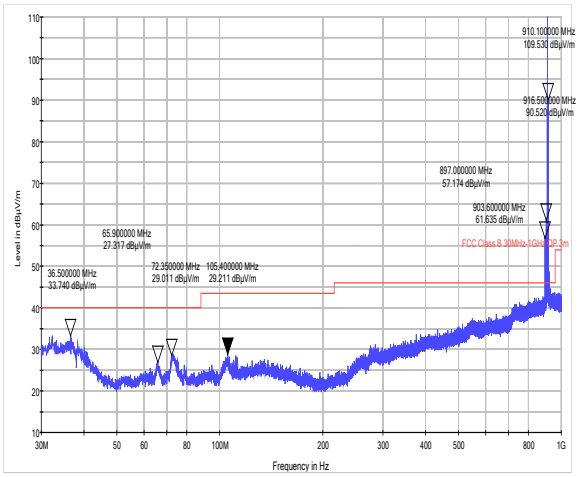


2.5 GHz to 5 GHz

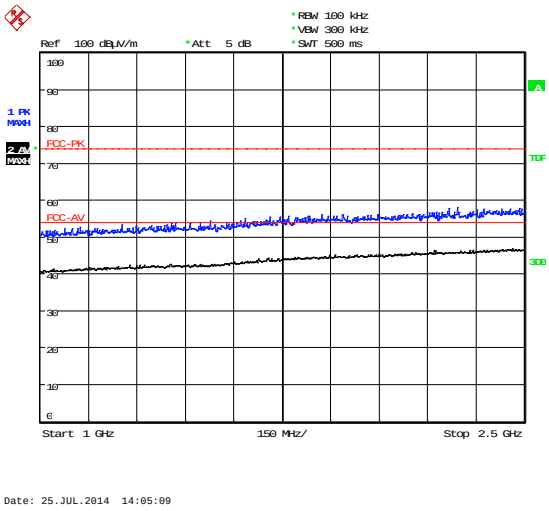


5 GHz to 10 GHz

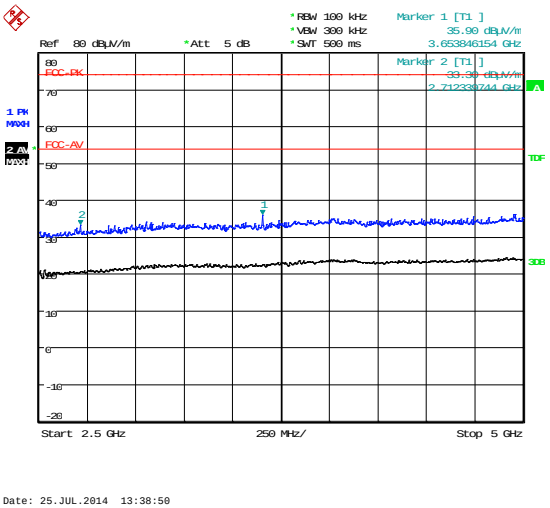
Radiated Spurious emissions 910.0 MHz



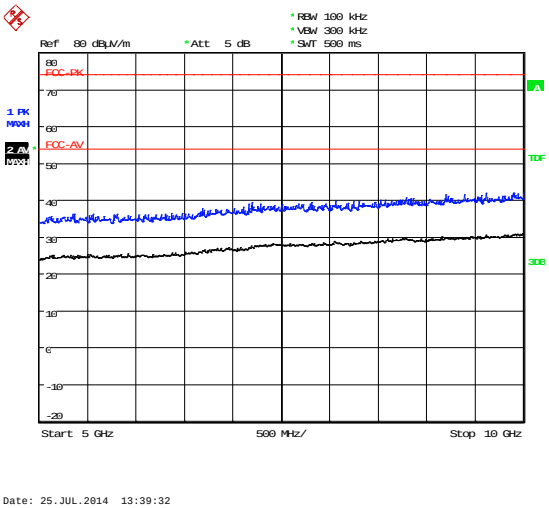
30 MHz to 1 GHz –1



1 GHz to 2.5 GHz

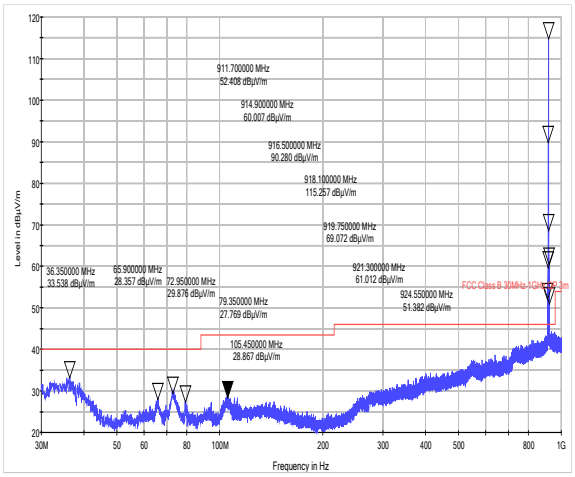


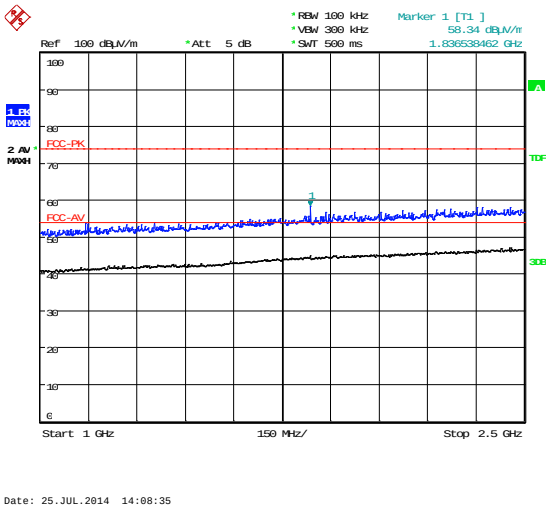
2.5 GHz to 5 GHz



5 GHz to 10 GHz

Radiated Spurious emissions 918.1 MHz





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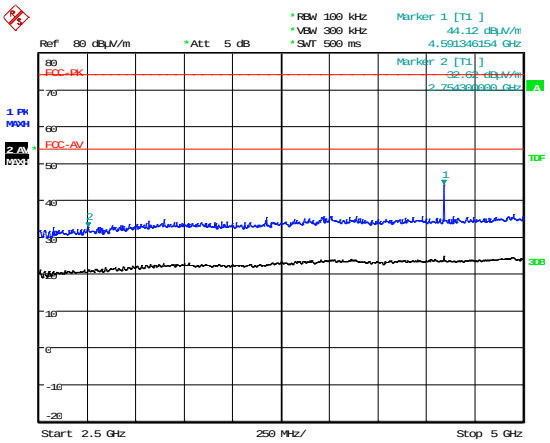
30 MHz to 1 GHz –1

1 GHz to 2.5 GHz



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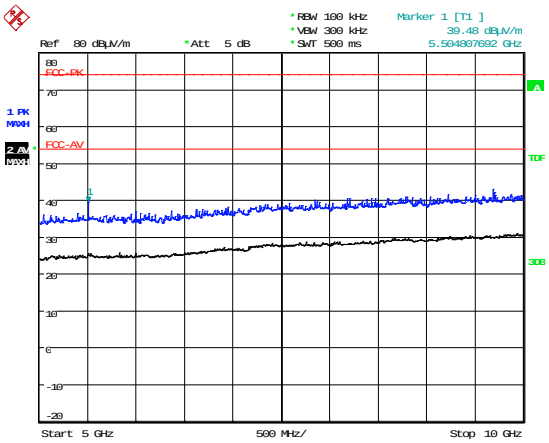
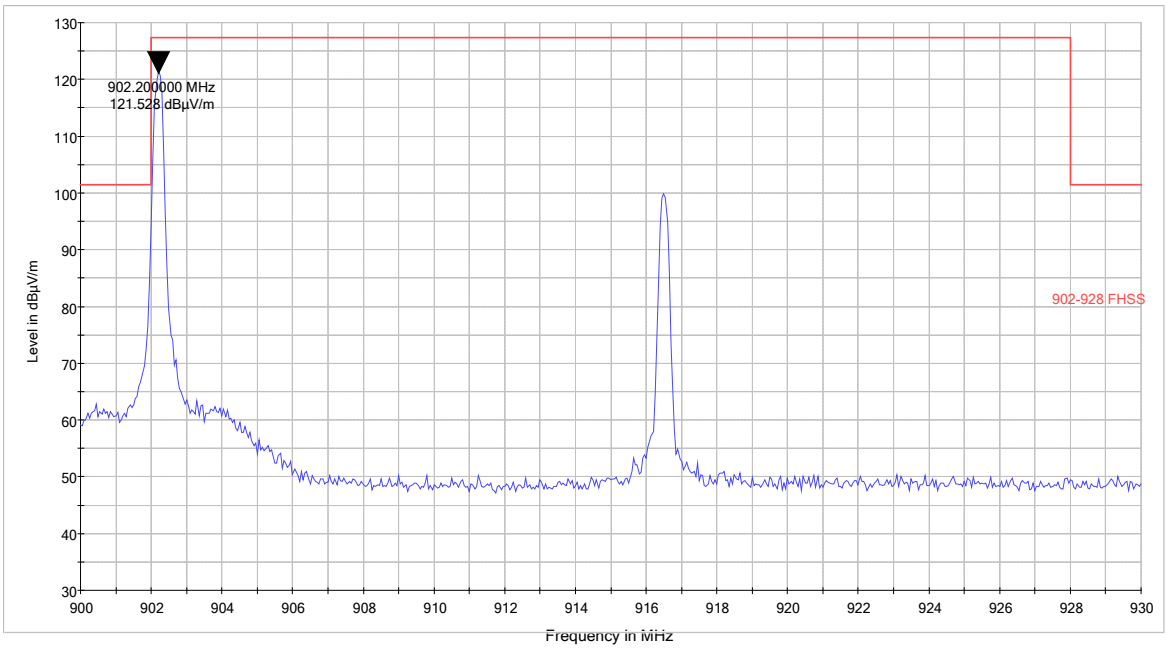


Date: 25.JUL.2014 13:52:52

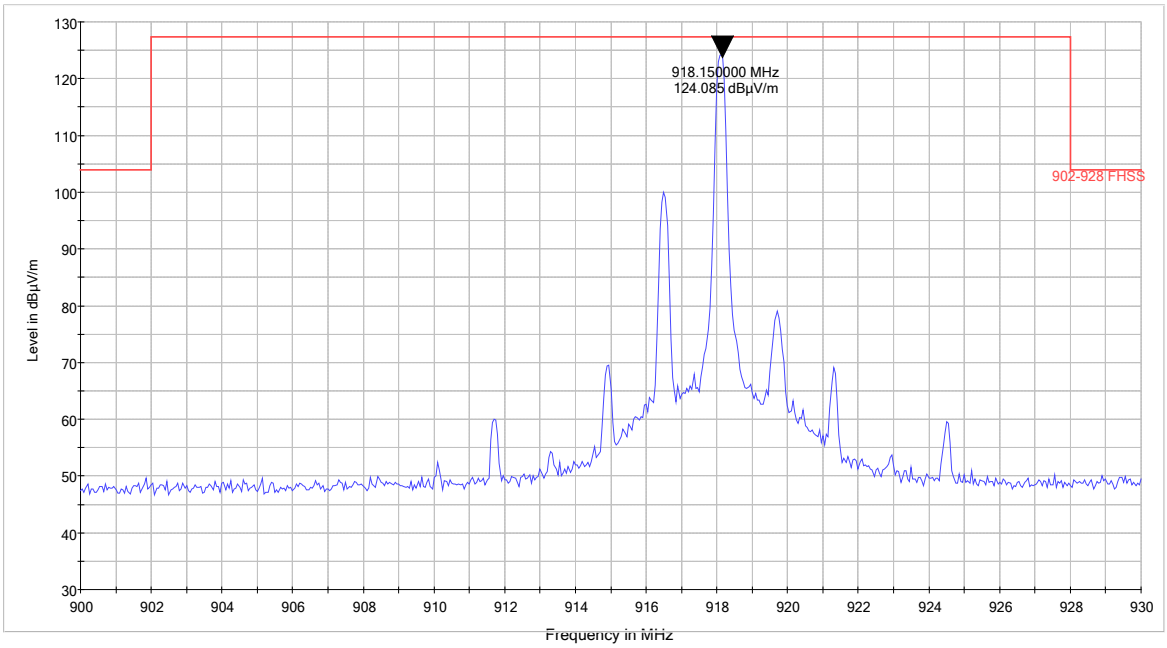
2.5 GHz to 5 GHz

5 GHz to 10 GHz

Radiated Bandedge Compliance

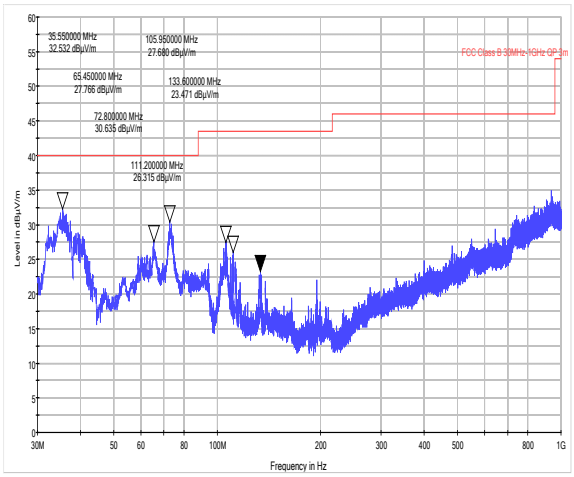


Lower Bandedge

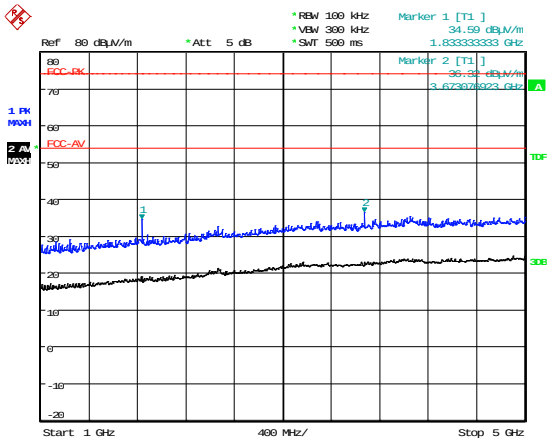


Upper Bandedge

Unintentional Radiated Spurious emissions 902.2 MHz



30 MHz to 1 GHz



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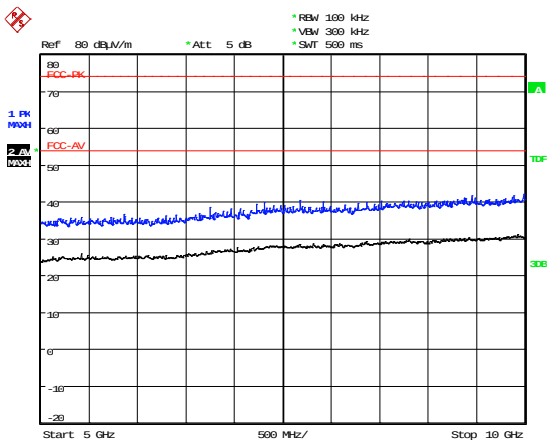
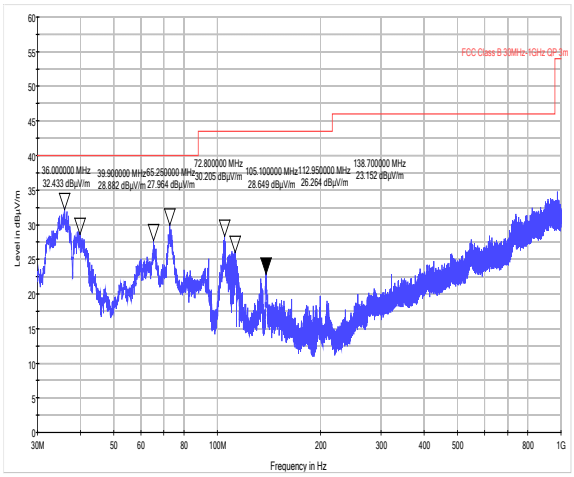
1 GHz to 5 GHz



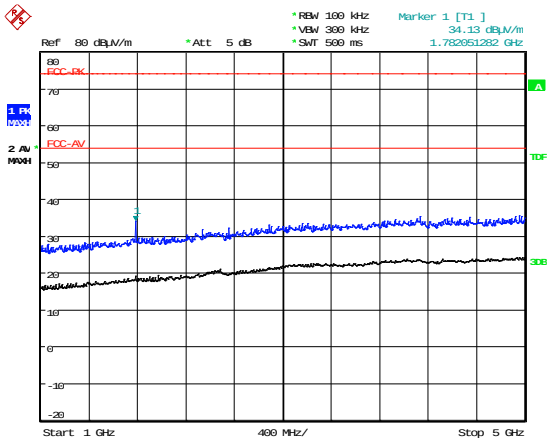
Date: 25.JUL.2014 14:27:15

5 GHz to 10 GHz

Unintentional Radiated Spurious emissions 910.0 MHz

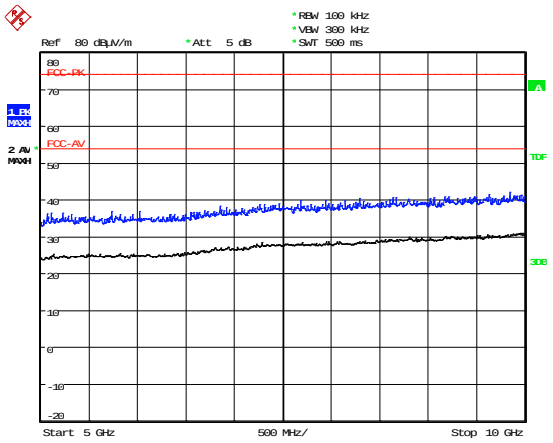


30 MHz to 1 GHz



Date: 25.JUL.2014 14:33:18

1 GHz to 5 GHz



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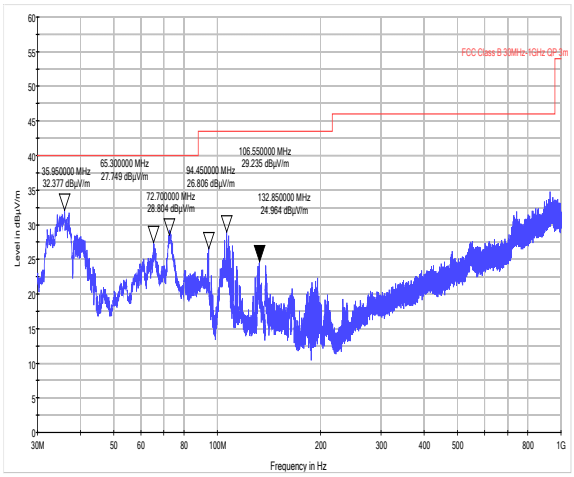
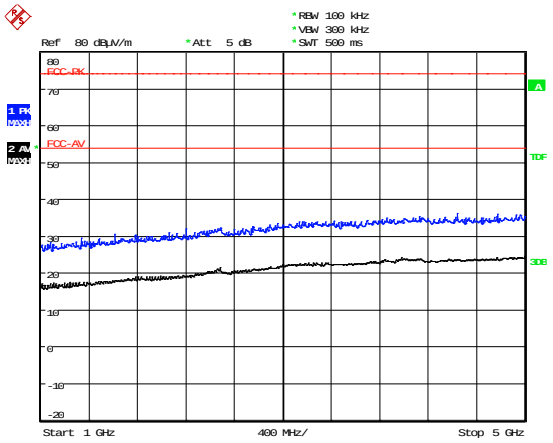
5 GHz to 10 GHz

Unintentional Radiated Spurious emissions 910.0 MHz



30 MHz to 1 GHz



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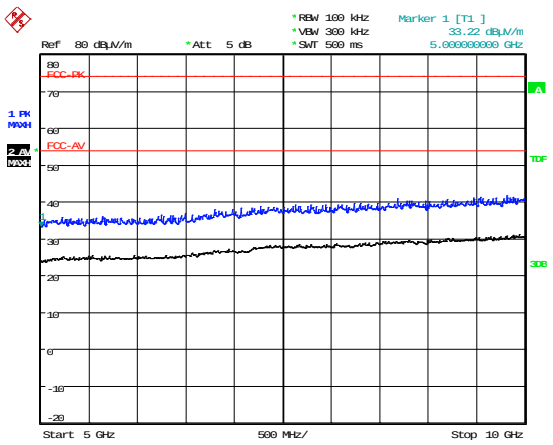
1 GHz to 5 GHz



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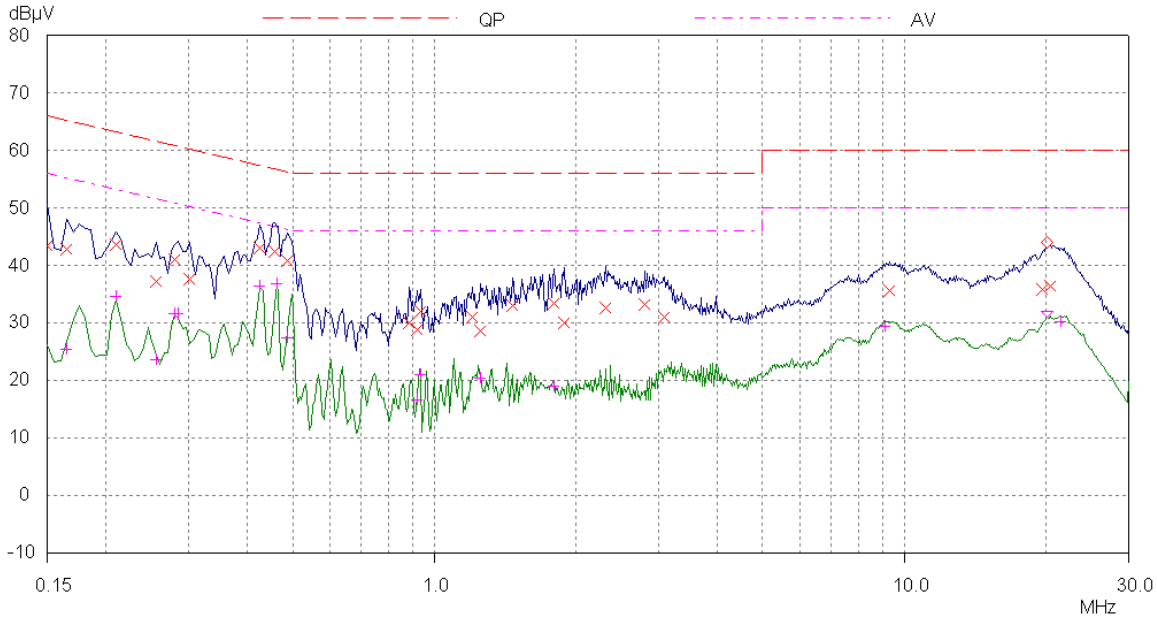
5 GHz to 10 GHz

AC Powerline Conducted Emissions



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
S19	SBS-T-902	
S13	LNA Switch	None
S10	Procom cxl 900-6lw (Antenna)	None
S06	Coaxial Cable	None
S05	Coaxial Cable	None

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

Sample No.	Description	Identification
S03	Linux PC	None
S13	Cat 6 Patch Cable	None

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

Identification	Description
None	

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 a modulated carrier at top, middle or bottom frequency or hopping as required

Test	Description of Operating Mode:
Receiver conducted and radiated (ERP) spurious emissions	EUT active but non-transmitting.

Test	Description of Operating Mode:
PLCE	ETU hopping across all channels in either TX or RX mode.

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 : S19, S13
Tests : Conducted

Port	Description of Cable Attached	Cable length	Equipment Connected
Ethernet	Cat 6 Patch cable	5m	S03

Sample : S19, S13
Tests : Radiated Emissions

Port	Description of Cable Attached	Cable length	Equipment Connected
Ethernet	Cat 6 Patch cable	5m	S03

* 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
UH191	CBL611/A	Bilog	Chase	13/12/2012	24	13/12/2014
UH195	ESH3-Z5.831.5	Lisn	R&S	03/07/2013	12	03/07/2014
UH281	FSU46	Spectrum Analyser	R&S	26/03/2014	12	26/03/2015
UH396	ENV216	Lisn	R&S	22/05/2014	12	22/05/2015
UH405	FSU26	Spectrum Analyser	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
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
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
REF940	ATS	Radio Chamber - PP	Rainford EMC	09/07/2013	24	09/07/2015
REF976	34405a	Multimeter	Agilent	19/05/2014	12	19/05/2015
REF977	SH4141	High Pass Filter	BSC	25/02/2013	24	25/02/2015

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.

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

e.g

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

0.07459 or 7.459%

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

The section is for information on how duty cycle correction is calculated.
Please note that duty cycle correction may not be applicable.

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: Overview

Photograph 1

Photograph 2

Appendix G: MPE Calculation

47 CFR §§1.1307 and 2.1091 RSS-102

Radio frequency radiation exposure evaluation against the limits defined in the quoted rule parts:

Prediction of MPE limit at a given distance

Equation from IEEE C95.1

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

where:

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

Note:

The EIRP measurement was calculated from the peak conducted carrier power plus the antenna gain.

Result

Prediction Frequency (MHz)	Conducted Output Power dBm	Maximum Antenna Gain (dBi)	Peak Output Power EIRP (dBm)	Peak Output Power EIRP (mW)	Power Density limit (S) (mW/cm^2)	Distance (R) cm required to be less than (S)
902.2	27.03	8	35.03	3184.1975	0.601	21
910	27.57	8	35.57	3605.7864	0.607	22
918.1	27.1	8	35.10	3235.9366	0.612	21

$1mW/cm^2 \equiv 10W/m^2$