

A RADIO TEST REPORT

FOR

ROOT4 LLP

ON

CAR UNIT CONTROLLER: T950

DOCUMENT NO. TRA-013183-02-47-01B

HULL

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TRaC Wireless Test Report : TRA-013183-02-47-01B

Applicant : Root4 LLP

Apparatus : Car Unit Controller: T950

Specification(s) : CFR47 Part 15.247 & RSS-210 Annex 8

Purpose of Test : **Certification**

FCCID : 2ACUNRAT950

IC ID : 12213A-RAT950

Authorised by :



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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

This testing in this report was requested by:

Root4 LLP
Hampden House
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Chalgrove
Oxfordshire
GB

1.3 Manufacturer

As Above

1.4 Apparatus Assessed

The following apparatus was assessed between 13th and 27th July 2014

- Car Unit Controller: T950

The above equipment is a Bluetooth Low Energy transmitter operating in the 2400 MHz to 2483.5 MHz band.

1.5 Test Result Summary

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

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

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

Test Type	Regulations		Measurement standard	Result
Radiated spurious emissions (Restricted bands)	RSS-210 Issue 8 December 2010 Annex 8, A8.5	Title 47 of the CFR: Part 15 Subpart C; 15.247 (d)	ANSI C63.10:2009	Pass
Radiated spurious emissions (Non-restricted bands)	RSS-210 Issue 8 December 2010 Annex 8, A8.5	Title 47 of the CFR: Part 15 Subpart C; 15.247 (d)	ANSI C63.10:2009	Pass
AC Power conducted emissions	RSS-GEN Issue 3 December 2010 Annex 7, 7.2.4	Title 47 of the CFR: Part 15 Subpart C; 15.207	ANSI C63.10:2009	N/A
Occupied Bandwidth	RSS-210 Issue 8 December 2010 Annex 8, A8.2a	Title 47 of the CFR : Part 15 Subpart C; 15.247(a)(2)	ANSI C63.10:2009	Pass
Carrier Power	RSS-210 Issue 8 December 2010 Annex 8, A8.4 (4)	Title 47 of the CFR : Part 15 Subpart C; 15.247(b)	ANSI C63.10:2009	Pass
Power Spectral Density	RSS-210 Issue 8 December 2010 Annex 8, A8.2b	Title 47 of the CFR : Part 15 Subpart C; 15.247(e)	ANSI C63.10:2009	Pass
Unintentional Radiated Spurious Emissions	RSS-GEN Issue 3 December 2010 7.2.2(c)	Title 47 of the CFR: Part 15 Subpart B; 15.109	ANSI C63.10:2009	Pass
RF Safety	RSS-102	Title 47 of the CFR : Part 15 Subpart C; 15.247	-	Pass
Digital Modulation	-	Title 47 of the CFR: Part 15 Subpart C; 15.403	-	Pass

Abbreviations used in the above table:

Mod : Modification
CFR : Code of Federal Regulations
REFE : Radiated Electric Field Emissions

ANSI : American National Standards Institution
PLCE : Power Line Conducted Emissions

1.6 Notes Relating To the Assessment

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

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

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

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

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

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

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

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

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

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

1.7 Deviations from Test Standards

There were no deviations from the standards tested to.

Section 2:**Measurement Uncertainty****2.1 Measurement Uncertainty Values**

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

A1 6 dB Bandwidth

Title 47 of the CFR: Part 15 Subpart (c) 15.247(a) (2) and RSS-210 Issue 8 December 2010 require the measurement of the bandwidth of the transmission between the -6 dB points on the transmitted spectrum.

Test Details:	
Regulation	Part15 Subpart (c) 15.247(a)(2); RSS-210 Annex 8, A8.2a
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
Temperature	22.4°C
EUT set up	Refer to Appendix C

Channel Frequency (MHz)	F _{lower} (MHz)	F _{higher} (MHz)	Measured 6 dB Bandwidth (kHz)	Limit (kHz)	Result
2402	2401.647436	2402.344551	697.115	>500	Pass
2440	2439.647436	2440.344551	697.115	>500	Pass
2480	2479.647436	2480.344551	697.115	>500	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 all operating frequencies in turn.

Test Details:	
Regulation	Part15 Subpart (c) 15.247(b)(3); RSS-210 Annex 8, A8.2a
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	22.4° C

Channel Frequency (MHz)	Radiated Peak Carrier Power (dBµV/m)	EIRP (W)	Limit (W)	Result
2402	97.93	0.002	1	Pass
2440	98.86	0.002	1	Pass
2480	98.51	0.002	1	Pass

EIRP calculated from Field Strength as Per ANSI C63.10

Notes:

Radiated Measurement

Measuring distances 3 meters.

EUT 0.8 metre above ground plane.

Emissions maximised by rotation of EUT, on an automatic turntable.

Raising and lowering the receiver antenna between 1m & 4m >30MHz

Horizontal and vertical polarisations, of the receive antenna.

EUT orientation in three orthogonal planes

Maximum results recorded

558074 D01 DTS Meas Guidance v03r01

Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS)

Operating Under §15.247

A3 Transmitter Power Spectral Density

Transmitter Power Spectral Density was verified with the EUT transmitting on all operating frequencies in turn.

Test Details:	
Regulation	Part15 Subpart (c) 15.247(e); RSS-210 Annex 8, A8.2b
Measurement standard	ANSI C63.10, KDB Document: 558074
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	22.4°C

Channel Frequency (MHz)	Radiated Peak Power Spectral Density (dBμV/m)	Power Spectral Density (dBm)	Limit (dBm)	Result
2402	97.63	2.40	8	Pass
2440	98.58	3.35	8	Pass
2480	98.27	3.04	8	Pass

PSD calculated from Field Strength as Per ANSI C63.10

Notes:

Radiated Measurement

Measuring distances 3 meters.

EUT 0.8 metre above ground plane.

Emissions maximised by rotation of EUT, on an automatic turntable.

Raising and lowering the receiver antenna between 1m & 4m >30MHz

Horizontal and vertical polarisations, of the receive antenna.

EUT orientation in three orthogonal planes

Maximum results recorded

558074 D01 DTS Meas Guidance v03r01

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

A4 Radiated Electric Field Emissions

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

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

3m open area test site : ☐

3m alternative test site : ☒

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

Test Details: 2402 MHz	
Regulation	Part 15 Subpart (c) Clause 15.247(d); RSS – 210 Annex 8, A8.5
Measurement standard	ANSI C63.10, KDB Document: 558074
Frequency range	30 MHz – 25 GHz
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	22.4°C
Photographs	Appendix E

The worst case radiated emission measurements for spurious emissions and harmonics are listed below:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4805.9pk	47.81	6.1	35.7	35.6	-	54.0	501.8	5000
2.	4805.9av	39.44	6.1	35.7	35.6	-	45.6	191.4	500

No further emissions were detected within 20dB of the limit

Radiated Electric Field Emissions continued:

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

Test Details: 2440 MHz	
Regulation	Part 15 Subpart (c) Clause 15.247(d); RSS – 210 Annex 8, A8.5
Measurement standard	ANSI C63.10, KDB Document: 558074
Frequency range	30 MHz – 25 GHz
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	21°C
Photographs	Appendix E

The worst case radiated emission measurements for spurious emissions and harmonics are listed below:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4881.9pk	47.27	6.1	35.8	35.6	-	53.6	477.0	5000
2.	4881.9av	37.66	6.1	35.8	35.6	-	44.0	157.8	500

No further emissions were detected within 20dB of the limit

Radiated Electric Field Emissions continued:

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

Test Details: 2480 MHz	
Regulation	Part 15 Subpart (c) Clause 15.247(d); RSS – 210 Annex 8, A8.5
Measurement standard	ANSI C63.10, KDB Document: 558074
Frequency range	30 MHz – 25 GHz
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	21°C
Photographs	Appendix E

The worst case radiated emission measurements for spurious emissions and harmonics are listed below:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4957.9pk	46.57	6.2	35.9	35.6	-	53.1	450.3	5000
2.	4957.9av	35.87	6.2	35.9	35.6	-	42.4	131.4	500

No further emissions were detected within 20dB of the limit

Delta Marker Method Frequency = 2480 MHz					
Detector	Carrier Power in 1MHz RBW (dBµV/m)	Carrier Power in 100kHz RBW (dBµV/m)	Delta in 100kHz RBW (dB)	Power at Band Edge (dBµV/m)	Limit (dBµV/m)
pk	98.5	98.3	-51.0	47.5	74.0
av	97.8	90.3	-55.8	42.0	54.0

See Appendix B for plot of 100 kHz levels

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 upper and lower frequency of the measurement range was decided according to 47 CFR Part 15 Clause 15.33(a) and 15.33(a)(1) and RSS-Gen 4.3.

Radiated emission limits (47 CFR Part 15: Clause 15.209) for emissions falling within the restricted bands defined in 15.205(a) and RSS-Gen 7.2.2:

Frequency of emission (MHz)	Field strength ($\mu\text{V/m}$)	Measurement Distance (m)	Field strength ($\text{dB}\mu\text{V/m}$)
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

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 Carrier measured in 100 kHz RBW)-20dB

Where:

The maximum peak power was measured using a spectrum analyser using a 100 kHz resolution bandwidth.

Channel Frequency (MHz)	Measured Peak Carrier in 100kHz RBW ($\text{dB}\mu\text{V/m}$)	Measured Peak Carrier -20dB ($\text{dB}\mu\text{V/m}$)	Emission Limit In a 100 kHz RBW ($\text{dB}\mu\text{V/m}$)
2402	97.63	77.63	77.63
2440	98.58	78.58	78.58
2480	98.27	78.27	78.27

Notes:

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

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

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				

A5 Antenna Gain

Not Applicable as radiated measurements only were performed.

A6 Unintentional Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 100 kHz. The maximum permitted field strength is listed in Section 15.109 and in 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 :

☒

Test Details: 2402MHz, 2440MHz, 2480MHz	
Regulation	Part 15 Subpart (b) Clause 15.109; RSS – GEN Section 7.2.3
Measurement standard	ANSI C63.10
Frequency range	30 MHz to 1 GHz
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	22.4°C
Photographs	Appendix E

The worst case radiated emission measurements for spurious emissions and harmonics are listed overleaf:

Unintentional Radiated Electric Field Emissions continued:

Ref No.	FREQ. (MHz)	MEAS Rx (dBμV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	FIELD ST'GH (dBμV/m)	FIELD ST'GH (μV/m)	LIMIT (μV/m)
1.	36.0	6.3	0.7	16.2	23.2	14.5	100
2.	40.0	10.6	0.8	13.9	25.3	18.4	100
3.	60.0	15.2	1.0	6.0	22.2	12.9	100
4.	72.0	13.3	1.2	6.8	21.3	11.6	100
5.	80.0	29.7	1.2	8.0	38.9	88.1	100
6.	96.0	21.6	1.3	10.2	33.1	45.2	150
7.	100.0	11.5	1.3	10.7	23.5	15.0	150
8.	120.0	18.5	1.5	12.4	32.4	41.7	150
9.	144.0	10.6	1.7	12.1	24.4	16.6	150
10.	160.0	24.7	1.8	11.0	37.5	75.0	150
11.	180.0	13.3	1.8	9.8	24.9	17.7	150
12.	200.0	18.5	2.0	8.4	28.9	27.9	150
13.	260.0	15.0	2.3	13.2	30.5	33.5	200
14.	280.0	15.0	2.4	12.6	30.0	31.4	200
15.	340.0	14.0	2.7	14.2	30.9	34.9	200
16.	380.0	11.1	2.7	14.7	28.5	26.6	200
17.	420.0	11.8	3.0	16.2	31.0	35.4	200
18.	460.0	16.6	3.0	16.6	36.2	64.8	200
19.	500.0	5.8	3.2	17.4	26.4	21.0	200
20.	540.0	10.1	3.4	19.3	32.8	43.7	200
21.	580.0	7.3	3.4	19.1	29.8	31.0	200
22.	620.0	9.9	3.7	19.8	33.4	46.7	200
23.	640.0	4.6	3.7	19.8	28.1	25.4	200
24.	660.0	10.7	3.7	19.8	34.2	51.3	200
25.	700.0	8.1	3.8	20.3	32.2	40.9	200
26.	740.0	5.6	3.9	22.1	31.6	38.0	200
27.	780.0	3.9	4.0	21.6	29.5	29.9	200
28.	864.2	1.1	4.3	22.4	27.8	24.4	200
29.	931.1	0.7	4.5	24.1	29.3	29.1	200
30.	959.1	0.4	4.6	23.9	28.8	27.6	200

No further emissions were detected within 20dB of the limit

Unintentional Radiated Electric Field Emissions continued:

Test Details: 2402 MHz	
Regulation	Part 15 Subpart (b) Clause 15.109; RSS – GEN Section 7.2.3
Measurement standard	ANSI C63.10
Frequency range	1 GHz – 25 GHz
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	22.4°C
Photographs	Appendix E

The worst case radiated emission measurements for spurious emissions and harmonics are listed below:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4806.0	49.1	6.1	35.7	35.6	-9.5	45.7	193.4	5000
2.	4806.0	41.7	6.1	35.7	35.6	-9.5	38.3	82.7	500

No further emissions were detected within 20dB of the limit

Unintentional Radiated Electric Field Emissions continued:

Test Details: 2440 MHz	
Regulation	Part 15 Subpart (b) Clause 15.109; RSS – GEN Section 7.2.3
Measurement standard	ANSI C63.10
Frequency range	1 GHz – 25 GHz
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	22.4°C
Photographs	Appendix E

The worst case radiated emission measurements for spurious emissions and harmonics are listed below:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4877.2	48.9	6.1	35.8	35.6	-9.5	45.6	191.6	5000
2.	4877.2	43.1	6.1	35.8	35.6	-9.5	39.9	98.7	500

No further emissions were detected within 20dB of the limit

Unintentional Radiated Electric Field Emissions continued:

Test Details: 2480 MHz	
Regulation	Part 15 Subpart (b) Clause 15.109; RSS – GEN Section 7.2.3
Measurement standard	ANSI C63.10
Frequency range	1 GHz – 25 GHz
EUT sample number	S20
Modification state	0
SE in test environment	S33, S34
SE isolated from EUT	S29, S31
EUT set up	Refer to Appendix C
Temperature	22.4°C
Photographs	Appendix E

The worst case radiated emission measurements for spurious emissions and harmonics are listed below:

Ref No.	FREQ. (MHz)	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
1.	4958.0	49.6	6.2	35.9	35.6	-9.5	46.5	211.5	5000
2.	4958.0	42.8	6.2	35.9	35.6	-9.5	39.8	97.2	500

No further emissions were detected within 20dB of the limit

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(a) and 15.33(a)(1) and RSS-Gen 4.3.

Radiated emission limits 47 CFR Part 15: Clause 15.209 and RSS – GEN Section 7.2.3 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:

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

- (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				

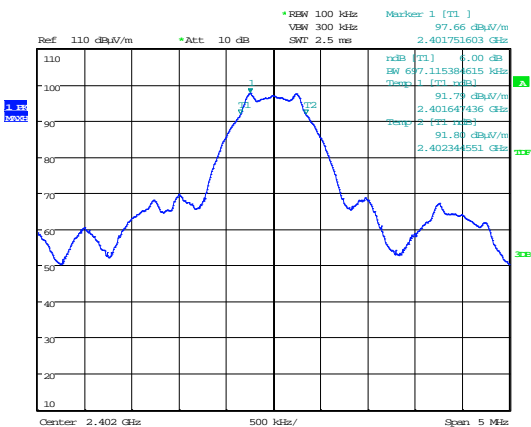
Appendix B:**Supporting Graphical Data**

This appendix contains graphical data obtained during testing.

Notes:

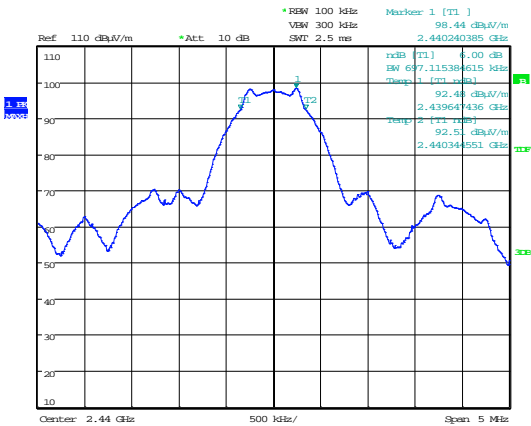
- (a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.
- (b) The time and date on the plots do not necessarily equate to the time of the test.
- (c) Where relevant, on power line conducted emission plots, the limit displayed is the average limit, which is stricter than the quasi peak limit.
- (d) Appendix C details the numbering system used to identify the sample and its modification state.
- (e) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.

6dB Bandwidth



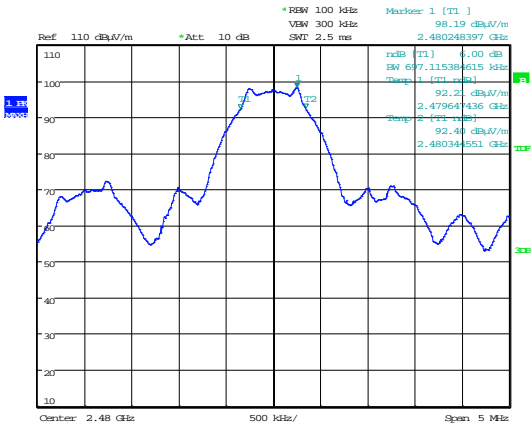
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2402 MHz



Date: 17.JUL.2014 13:16:19

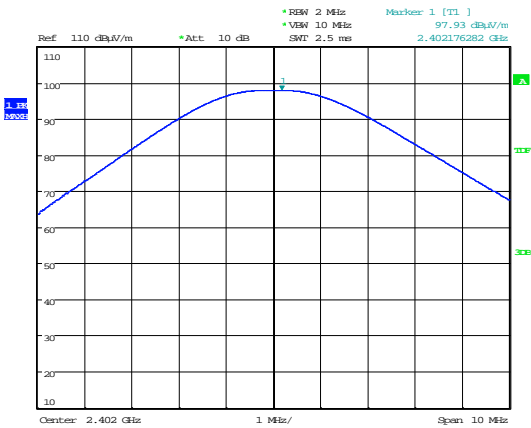
2440 MHz



Date: 17.JUL.2014 13:36:02

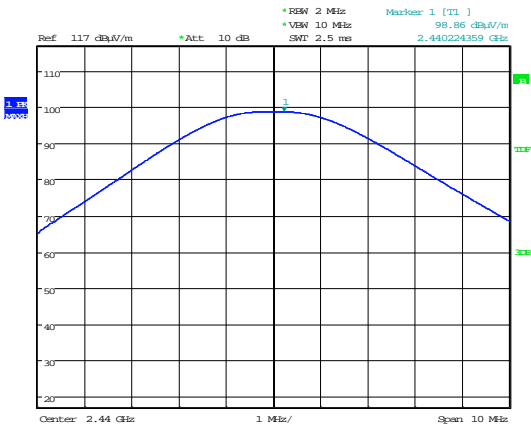
2480 MHz

Carrier Power



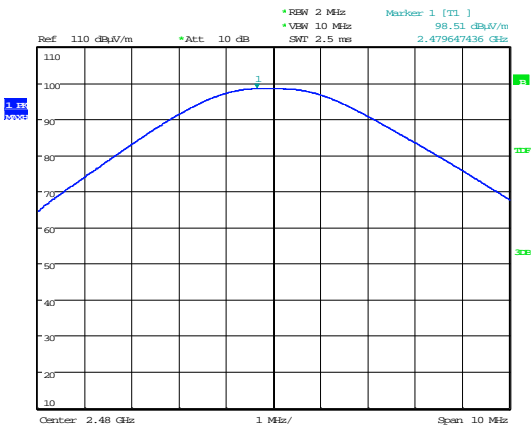
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2402 MHz



Date: 17.JUL.2014 13:13:58

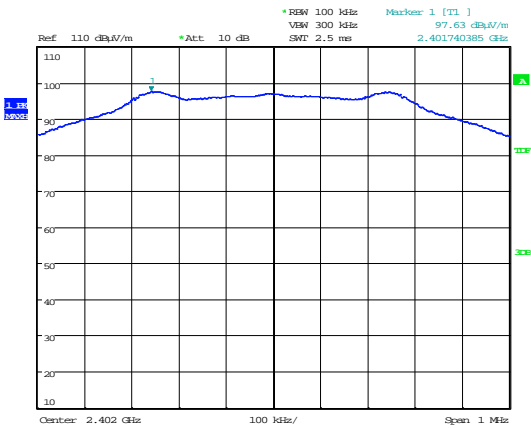
2440 MHz



Date: 17.JUL.2014 13:31:26

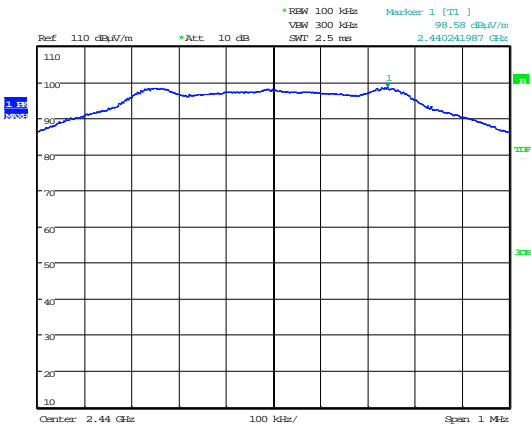
2480 MHz

Power Spectral Density



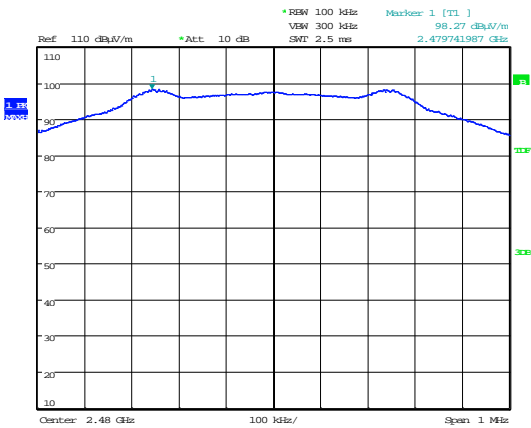
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2402 MHz



Date: 17.JUL.2014 13:17:38

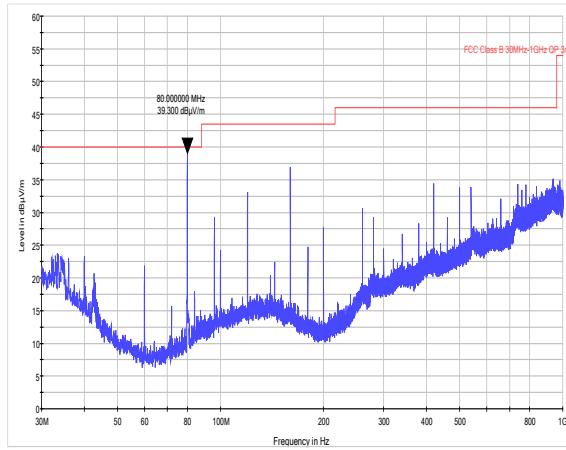
2440 MHz



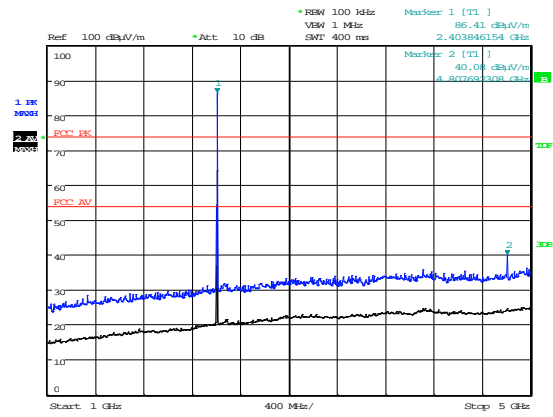
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2480 MHz

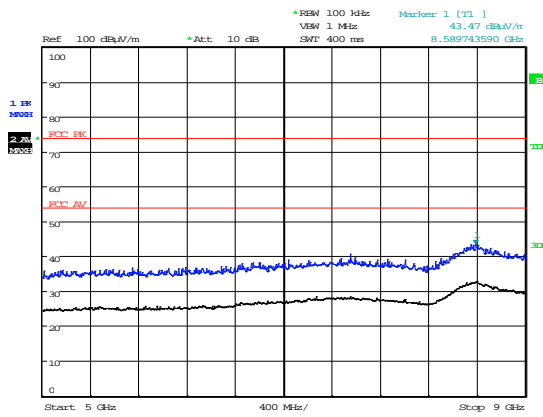
Radiated Spurious Emissions– 2402MHz



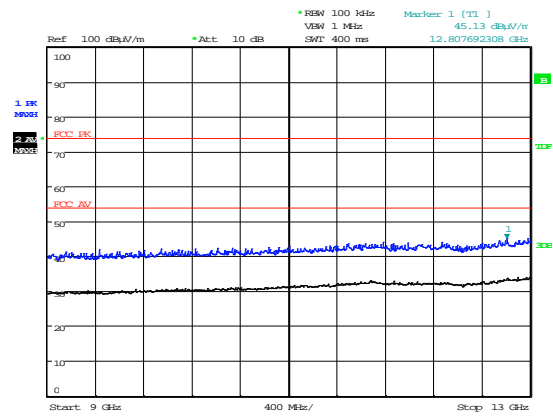
30 MHz to 1 GHz



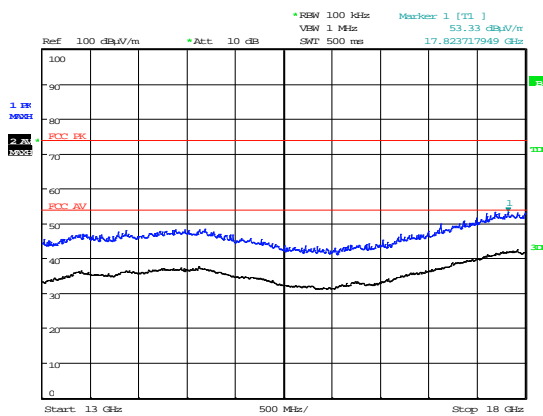
1 GHz to 5 GHz



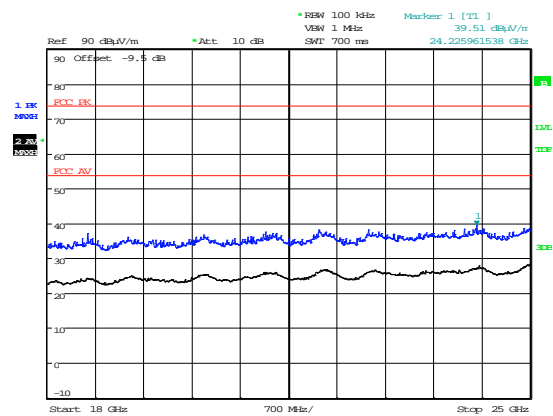
5 GHz to 9 GHz



9 GHz to 13 GHz

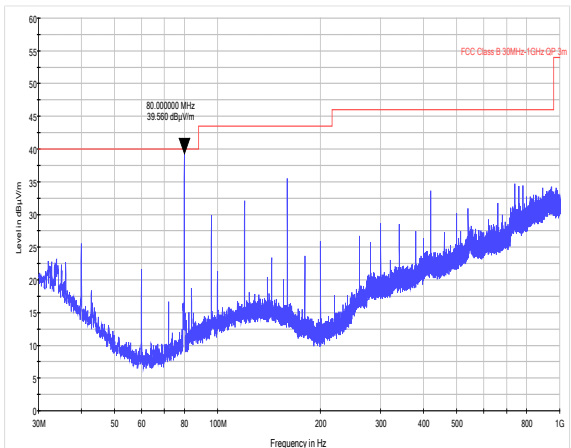


13 GHz to 18 GHz

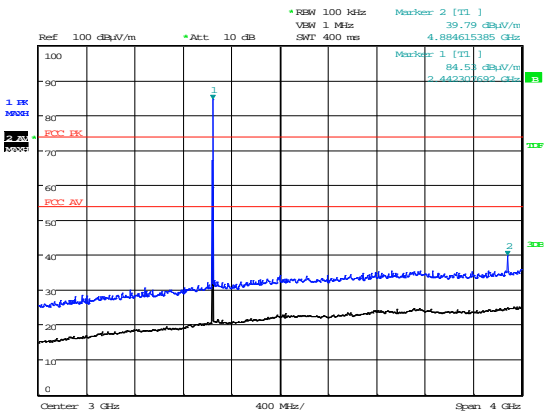


18 GHz to 25 GHz

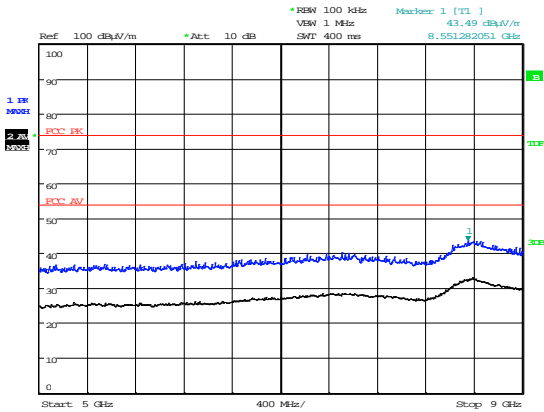
Radiated Spurious Emissions– 2440MHz



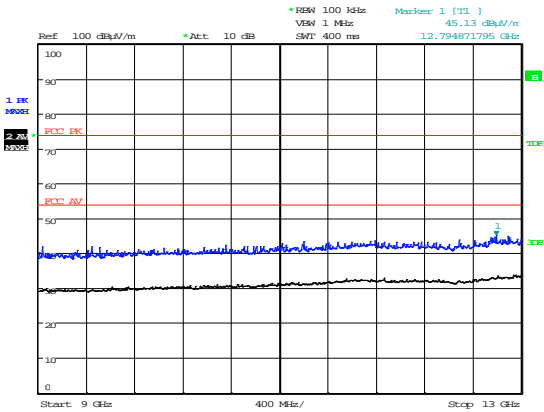
30 MHz to 1 GHz



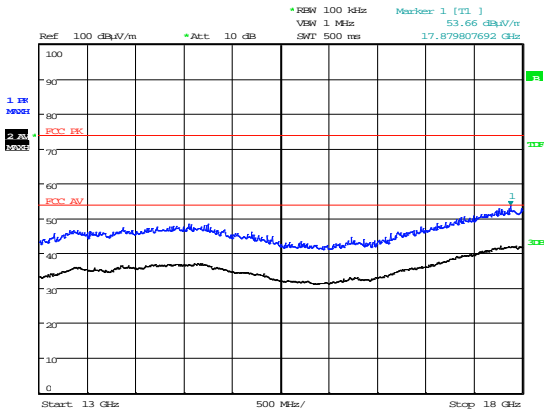
1 GHz to 5 GHz



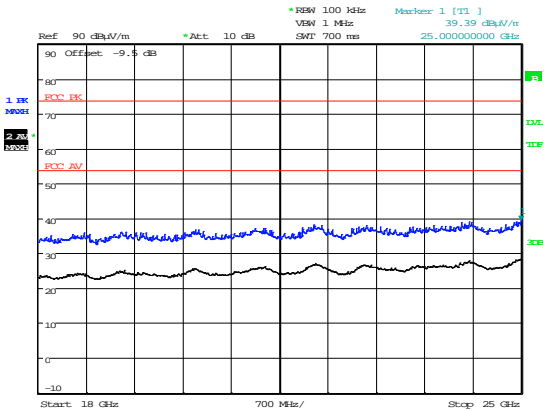
5 GHz to 9 GHz



9 GHz to 13 GHz

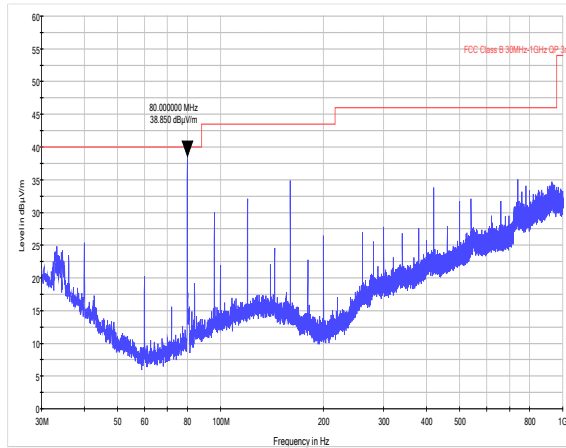


13 GHz to 18 GHz

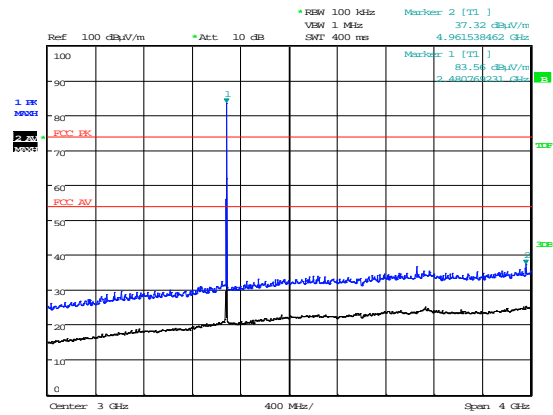


18 GHz to 25 GHz

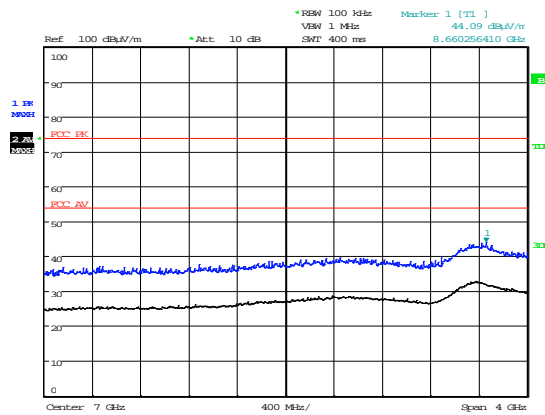
Radiated Spurious Emissions– 2480MHz



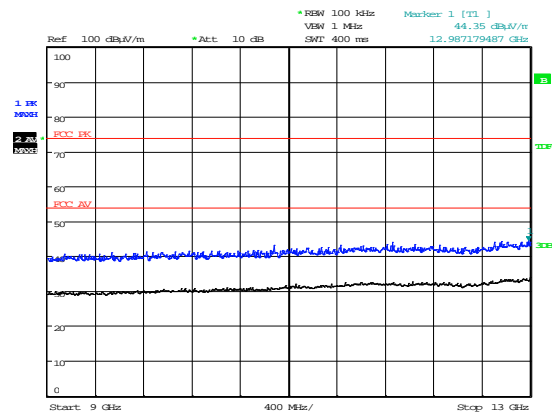
30 MHz to 1 GHz



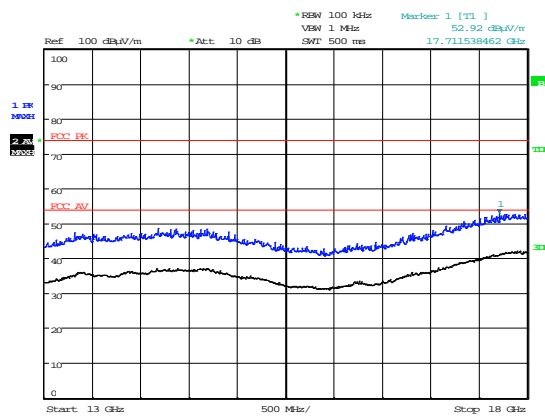
1 GHz to 5 GHz



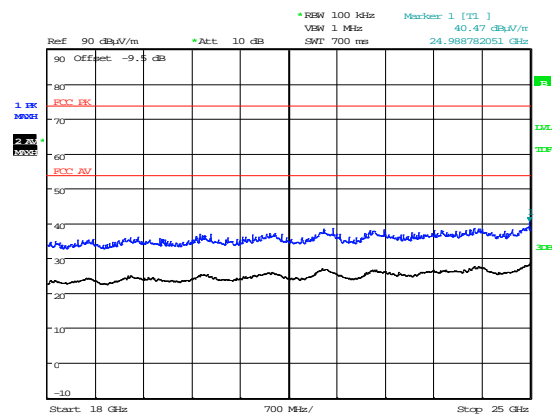
5 GHz to 9 GHz



9 GHz to 13 GHz

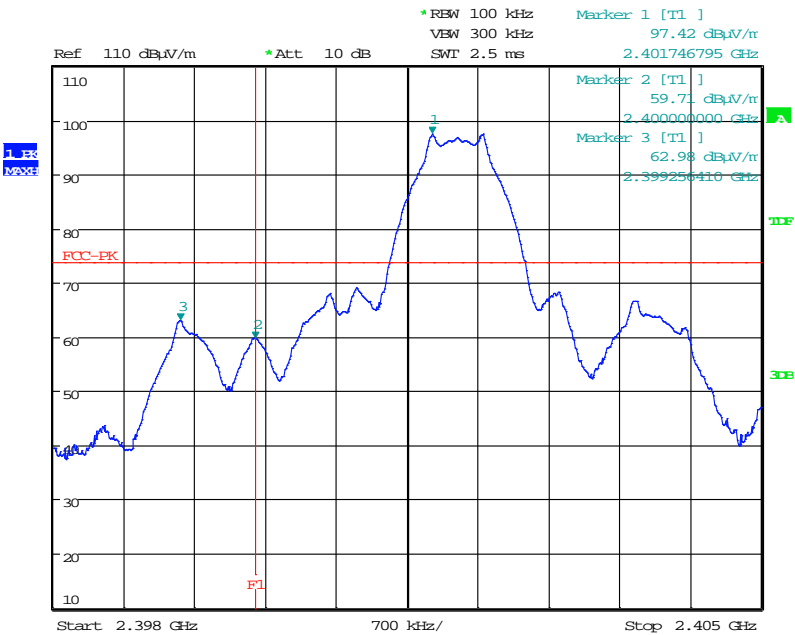


13 GHz to 18 GHz



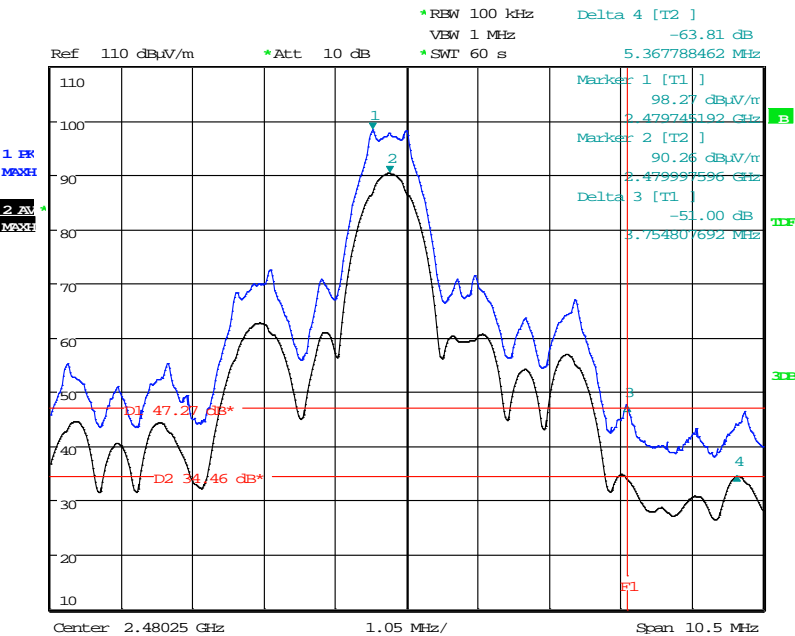
18 GHz to 25 GHz

Radiated Band Edge Compliance



Date: 17.JUL.2014 13:00:12

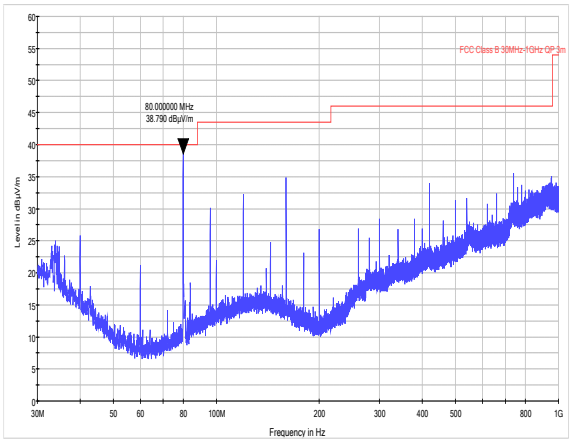
Lower Band Edge



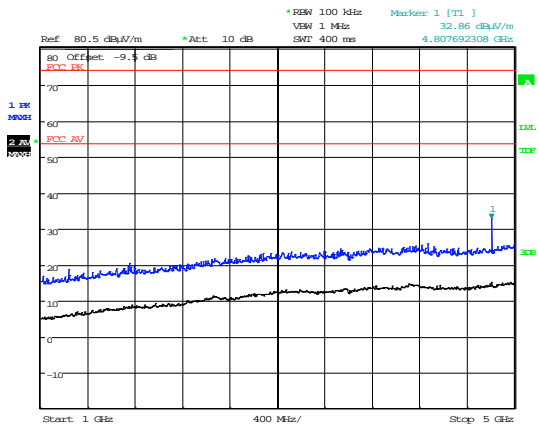
Date: 17.JUL.2014 13:53:52

Upper Band Edge (100kHz RBW)

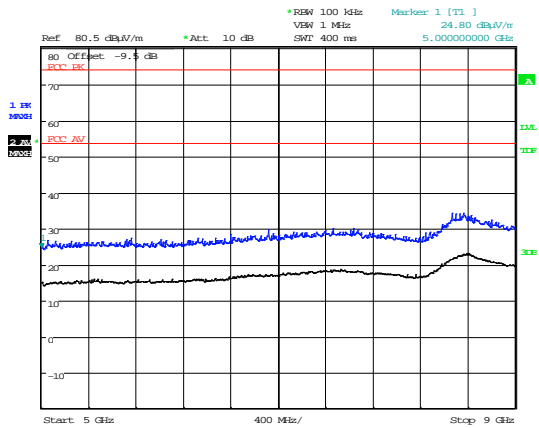
Unintentional Radiated Spurious emissions– 2402MHz



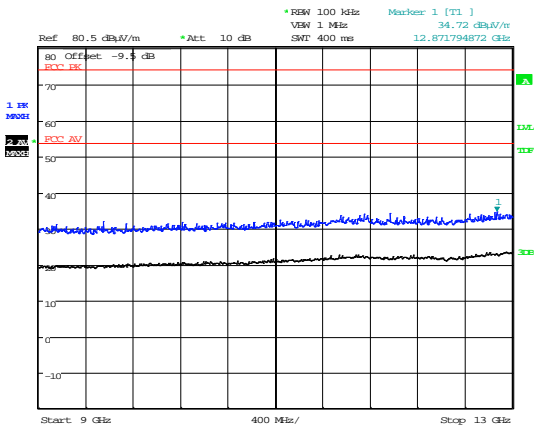
30 MHz to 1 GHz



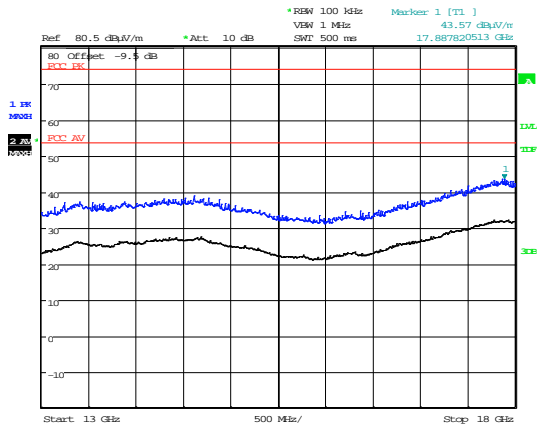
1 GHz to 5 GHz



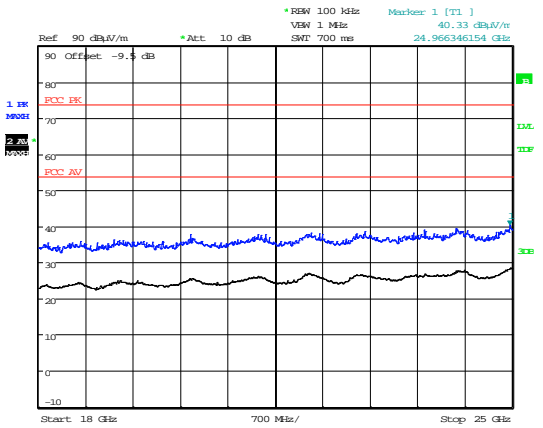
5 GHz to 9 GHz



9 GHz to 13 GHz

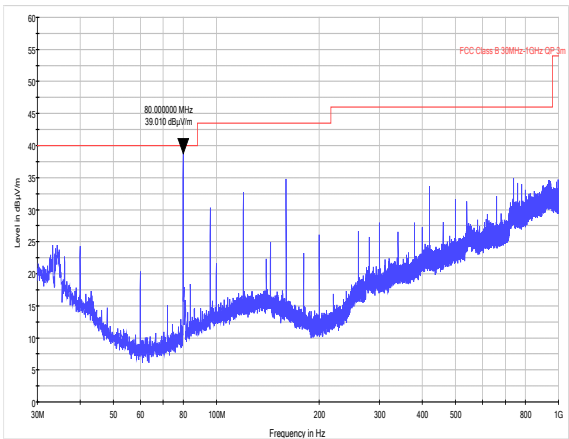


13 GHz to 18 GHz

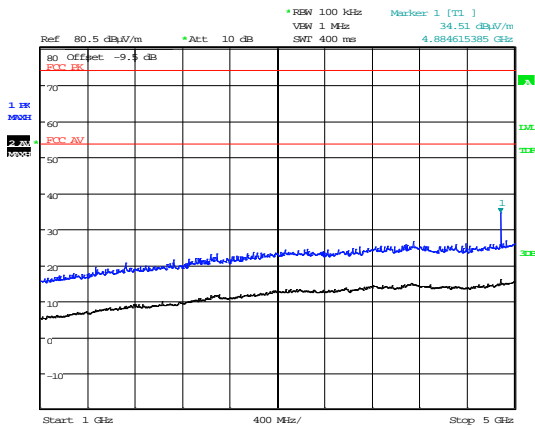


18 GHz to 25 GHz

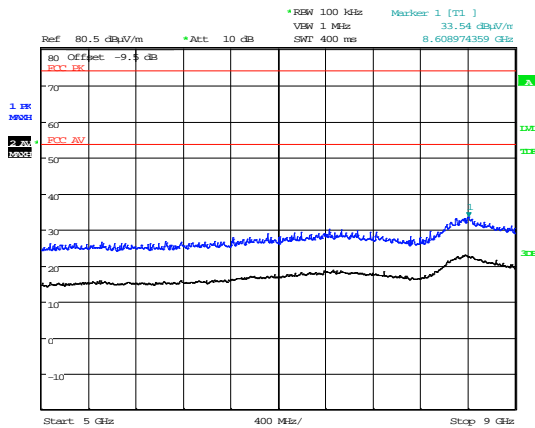
Unintentional Radiated Spurious emissions– 2440MHz



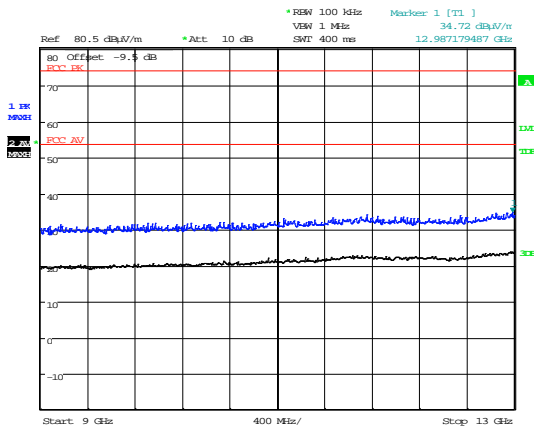
30 MHz to 1 GHz



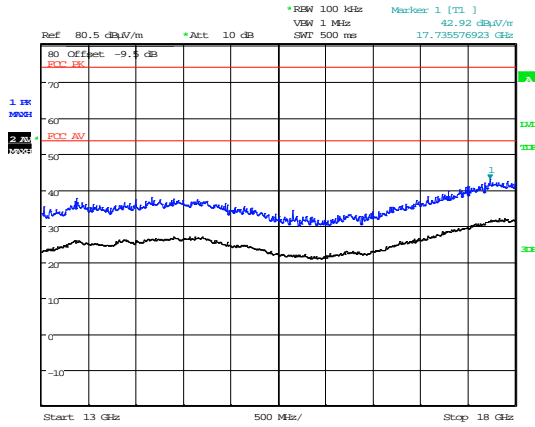
1 GHz to 5 GHz



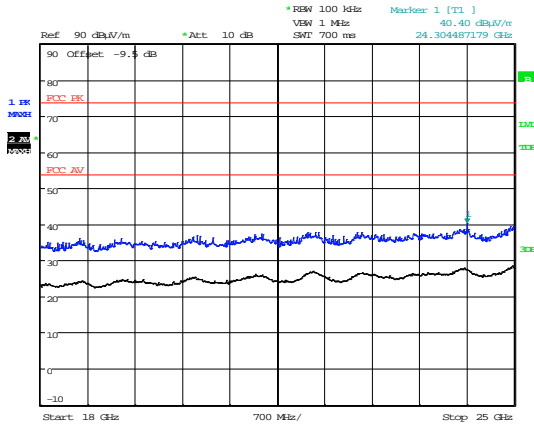
5 GHz to 9 GHz



9 GHz to 13 GHz

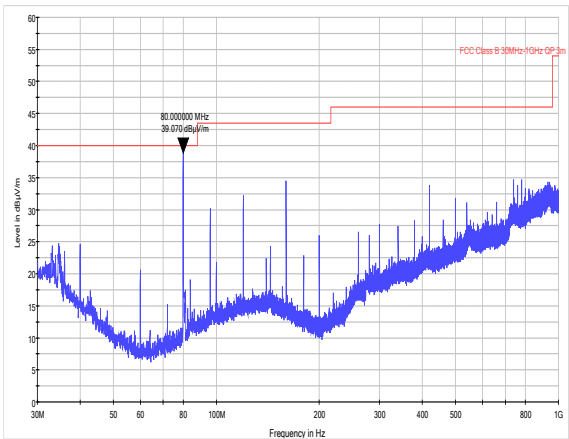


13 GHz to 18 GHz

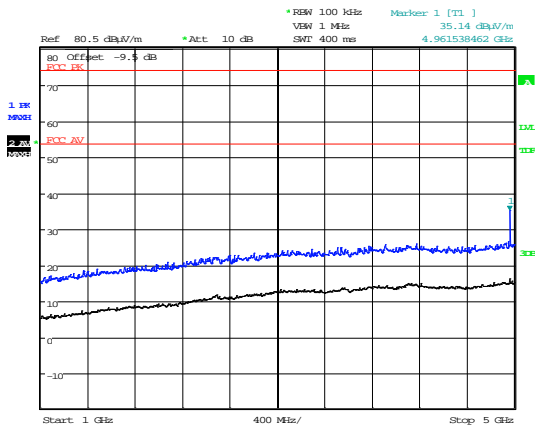


18 GHz to 25 GHz

Unintentional Radiated Spurious emissions– 2480MHz

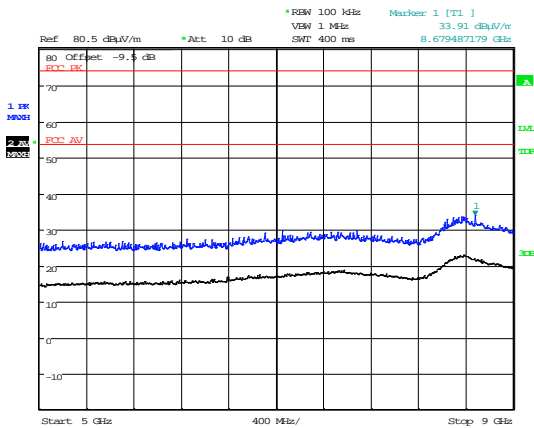


30 MHz to 1 GHz



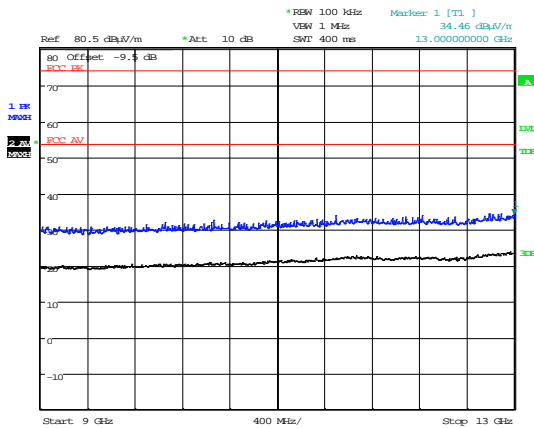
Date: 14.JUL.2014 14:13:00

1 GHz to 5 GHz



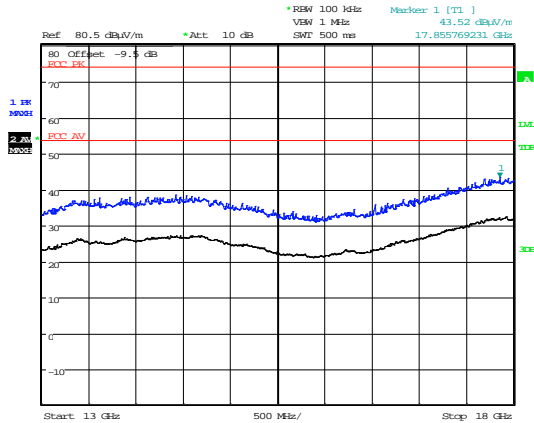
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5 GHz to 9 GHz



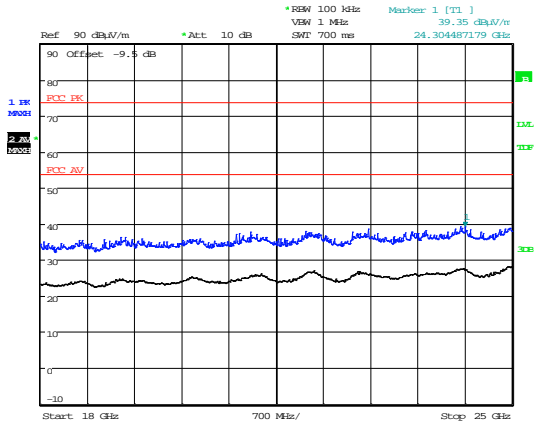
Date: 14.JUL.2014 14:15:42

9 GHz to 13 GHz



Date: 14.JUL.2014 14:16:58

13 GHz to 18 GHz



Date: 15.JUL.2014 12:33:36

18 GHz to 25 GHz

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
S20	Car Unit Controller: T950	None

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

Sample No.	Description	Identification
S29	Samsung Netbook	None
S31	Simulated CAN Generator	None
S33	Valve1	None
S34	Valve2	None

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

Identification	Description
None	12V Battery

C2) EUT Operating Mode during Testing

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

Test	Description of Operating Mode: Transmit
All transmitter tests detailed in this report	EUT transmitting permanent modulated carrier

Test	Description of Operating Mode: Receive
Receiver radiated spurious emissions	EUT in receive 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 : S20
Tests : All

Port	Description of Cable Attached	Cable length	Equipment Connected
Power	2 wires	1m	12v battery
Valve1	Multiple wires cable	5m	S33
Valve2	Multiple wires cable	5m	S34
CAN	2 wires	5m	S31
S31	Mini USB Cable	1m	S29

C5 Details of Equipment Used

TRaC No	Equipment Type	Equipment Description	Manufacturer	Last Cal Calibration	Calibration Period	Due For Calibration
UH191	CBL611/A	Bilog	Chase	13/12/2012	24	13/12/2014
UH387	ATS	Chamber 1	Rainford EMC	04/07/2013	24	04/07/2015
UH405	FSU26	Spectrum Analyser	R&S	16/04/2014	12	16/04/2015
UH281	FSU46	Spectrum Analyser	R&S	26/03/2014	12	26/03/2015
UH385	HL 050	Log Periodic Antenna	R&S	16/07/2014	24	16/07/2016
L317	ESVS10	Receiver	R&S	12/02/2014	12	12/02/2015
REF940	ATS	Radio Chamber - PP	Rainford EMC	09/07/2013	24	09/07/2015
L572	8449B	Pre Amp	Agilent	11/02/2014	12	11/02/2015
L300	20240-20	Horn 18-26GHz (&UH330)	Flann	10/02/2014	24	10/02/2016

Appendix D:

Additional Information

No additional information is included within this test report.

Appendix E:

Photographs and Figures

The following photographs were taken of the test samples:

1. Radiated electric field emissions arrangement: overview.
2. Radiated electric field emissions arrangement: close up.

Photograph 1



Photograph 2



Appendix F: General SAR test reduction and exclusion guidance**KDB 447498**

Section 4.3 General SAR test reduction and exclusion guidance

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

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

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + Step 2

Step 1

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

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

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

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

For Distances Greater than 50 mm Step 2 applies

Step 2

Not applicable TSD^A less than 50mm

Operating Frequency 2.402 GHz

$$\begin{aligned} \text{SARET} &= [(3.0 \times 5) / \sqrt{2.402}] \\ \text{SARET} &= [15 / 1.55] \\ \text{SARET} &= 9.677\text{mW} \end{aligned}$$

Operating Frequency 2.440 GHz

$$\begin{aligned} \text{SARET} &= [(3.0 \times 5) / \sqrt{2.44}] \\ \text{SARET} &= [15 / 1.56] \\ \text{SARET} &= 9.615\text{mW} \end{aligned}$$

Operating Frequency 2.480 GHz

$$\begin{aligned} \text{SARET} &= [(3.0 \times 5) / \sqrt{2.48}] \\ \text{SARET} &= [15 / 1.57] \\ \text{SARET} &= 9.554\text{mW} \end{aligned}$$

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold	SAR Evaluation
2402	1.86	9.677	Not Required
2440	2.31	9.615	Not Required
2480	2.13	9.554	Not Required

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

RSS-102

Radio frequency radiation exposure evaluation: mobile devices.

For purposes of these requirements mobile devices are defined as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits. As the 20cm separation specified may not be achievable under normal operation of the EUT, an RF exposure calculation is needed to show the minimum distance required to be less than the power density limit.

Prediction of MPE limit at a given distance

Equation from IEEE C95.1

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

Where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Result

Prediction Frequency (MHz)	Maximum EIRP (mW)	Power density limit (S) (mW/cm ²)	Distance (R) cm required to be less than 1mW/cm ²
2440	2.31	1	0.43

1mW/cm² ≡ 10W/m²



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