A RADIO TEST REPORT

FOR

MANTRACOURT ELECTRONICS LTD

ON

RA24 RADIO MODULE

DOCUMENT NO. TRA-025939-00-47-00A

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UKAS TESTING
0026

TRaC Wireless Test Report	: TRA-025939-00-47-00A
Applicant	: Mantracourt Electronics Ltd
Apparatus	: RA24 Radio Module
Specification(s)	: CFR47 Part 15.247 & RSS-210 Annex 8
Purpose of Test	: **Certification**
FCCID	: VHARA24
IC ID	: 7224A-RA24
Authorised by	: John Charters Digitally signed by John Charters DN: cn=John Charters, o=TRAC Global Ltd, ou=Radio Product Manager, email=john.charters@tracglobal.com, c=GB Date: 2015.07.01 11:58:41 +01'00'
	: Radio Product Manager
Issue Date	: 1st July 2015
Authorised Copy Number	: *PDF*

Total number of pages: 75

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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:

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1.3 Manufacturer

As Above

1.4 Apparatus Assessed

The following apparatus was assessed between 17th March 2015 and 03rd June 2015

- RA24 Radio Module

The above equipment is a DTS multi-channel transceiver operating in 2400 MHz and 2483.5 MHz band.

It has got two model variants: RA24i and RA24e. The ‘e’ model has an external antenna connection and the ‘i’ model uses an on board chip antenna and two feed components. The ‘e’ model was tested with two different antenna types: A Half Wave antenna and an F-type antenna. Radiated testing was performed on all variants and antennas, while conducted testing and power line testing was performed only on ‘e’ variant.

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 Annex 8, A8.5	Title 47 of the CFR: Part 15 Subpart C; 15.247 (d)	ANSI C63.10:2009	Pass
Conducted spurious emissions (Non-restricted bands)	RSS-210 Issue 8 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 4 8.8	Title 47 of the CFR: Part 15 Subpart C; 15.207	ANSI C63.10:2009	Pass
Occupied Bandwidth	RSS-210 Issue 8 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 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 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 4 7.1	Title 47 of the CFR: Part 15 Subpart B; 15.109	ANSI C63.10:2009	Pass
RF Safety	RSS-102	KDB 447498	-	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

$$EIRP = p_t x\, g_t = (E \times d)^2 / 30$$

Where

p_t is the transmitter output power in watts
g_t is the numeric gain of the transmitting antenna (dimensionless)
E is the electric field strength in V/m
d is the measurement distance in meters (m)

$$ERP = EIRP \times 1.64 = (E \times d)\ 2 / (30 \times 1.64) = (E \times d)\ 2 / 49.2$$

Where, all terms are as previously defined.

4.2 AC Powerline Conducted Emissions Test Setup and Procedures

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

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

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

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

4.3 Antenna Port Conducted Emissions

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

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

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

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

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

4.4 Power Supply Variation

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

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

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

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

4.5 Thermal Variation

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

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

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

4.6 Time Domain Measurements

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

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

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

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

Appendix A: Formal Emission Test Results

Abbreviations used in the tables in this appendix:

Spec	: Specification
Mod	: Modification
EUT	: Equipment Under Test
SE	: Support Equipment
L	: Live Power Line
N	: Neutral Power Line
E	: Earth Power Line
Pk	: Peak Detector
QP	: Quasi-Peak Detector
Av	: Average Detector
CDN	: Coupling & decoupling network

ALSR	: Absorber Lined Screened Room
OATS	: Open Area Test Site
ATS	: Alternative Test Site
Ref	: Reference
Freq	: Frequency
MD	: Measurement Distance
SD	: Spec Distance
Pol	: Polarisation
H	: Horizontal Polarisation
V	: Vertical Polarisation

A1 6 dB Bandwidth

Title 47 of the CFR: Part 15 Subpart (c) 15.247(a) (2) and RSS-210 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	S18
Modification state	0
SE in test environment	None
SE isolated from EUT	None
Temperature	23˚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
2405	2404.198718	2405.849359	1650.641	>500	Pass
2440	2439.214744	2440.833333	1618.589	>500	Pass
2475	2474.230769	2475.833333	1602.564	>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	S18
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	23˚C

Channel Frequency (MHz)	Conducted Output Power (dBm)	Conducted Output Power (mW)	Limit (W)	Result
2405	13.44	22.08	1	Pass
2440	13.47	22.23	1	Pass
2475	13.57	22.75	1	Pass

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	S18
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	23˚C

Channel Frequency (MHz)	Power Spectral Density (dBm)	Limit (dBm)	Result
2405	-1.27	8	Pass
2440	-1.97	8	Pass
2475	-0.90	8	Pass

A4 RF Antenna Conducted Spurious Emissions

Measurement of conducted spurious emissions at the antenna port was performed using a peak detector with the RBW set to 100 kHz 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: RA24e	
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	9 kHz to 25 GHz
EUT sample number	S18
Modification state	0
SE in test environment	None
SE isolated from EUT	None
Temperature	27^{o}C
EUT set up	Refer to Appendix C

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

Ref No.	Emission Freq (MHz)	Det.	Restricted band? (Y/N)	Emission power (RBW =100kHz) (dBm)	15.247(d) Limit (dBm)	Summary
2405 MHz						
No emissions were detected within 20dB of the limit						
2440 MHz						
No emissions were detected within 20dB of the limit						
2475 MHz						
No emissions were detected within 20dB of the limit						

Notes:

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

The limit outside the restricted band in 100 kHz RBW is defined using the following formula in accordance with 15.247(d):

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

A5 Radiated Electric Field Emissions

Preliminary scans were performed using a peak detector with the RBW = 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 : [X]

Test Details: RA24i	
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	30MHz – 10 GHz
EUT sample number	S16
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25˚C

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

Ref No.	FREQ. (MHz)	DET.	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HIGH PASS FILTER LOSS (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
2405 MHz										
1.	4811.1	Pk	54.3	3.8	32.7	35.9	0.4	55.3	582.1	5000.0
2.	4811.1	Av	44.8	3.8	32.7	35.9	0.4	45.8	195.4	500.0
2440 MHz										
3.	4879.0	Pk	54.5	3.7	33.0	35.9	0.4	55.7	608.1	5000.0
4.	4879.0	Av	45.4	3.7	33.0	35.9	0.4	46.6	212.6	500.0
5.	7318.6	Pk	52.1	4.5	36.5	36.6	0.4	56.9	702.3	5000.0
6.	7318.6	Av	41.2	4.5	36.5	36.6	0.4	46.0	198.8	500.0
2475 MHz										
7.	4949.1	Pk	55.1	3.6	33.2	35.9	0.4	56.4	659.2	5000.0
8.	4949.1	Av	46.6	3.6	33.2	35.9	0.4	48.0	249.7	500.0
9.	7423.6	Pk	51.5	4.6	36.7	36.6	0.4	56.6	674.5	5000.0
10.	7423.6	Av	39.7	4.6	36.7	36.6	0.4	44.7	172.4	500.0

No further emission was detected within 20dB of the specification limit.

Radiated Electric Field Emissions – continued:

Test Details: RA24e with Half Wave Antenna	
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	30MHz – 10 GHz
EUT sample number	S18
Modification state	0
SE in test environment	S07
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25˚C

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

Ref No.	FREQ. (MHz)	DET.	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HIGH PASS FILTER LOSS (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
2405 MHz										
1.	2261.1	Pk	61.7	2.5	27.9	36.2	N/A	55.9	622.3	5000.0
2.	2261.1	Av	52.2	2.5	27.9	36.2	N/A	46.4	208.9	500.0
3.	2697.1	Pk	60.6	2.6	29.2	36.1	N/A	56.3	650.1	5000.0
4.	2697.1	Av	49.4	2.6	29.2	36.1	N/A	45.0	178.4	500.0
5.	4811.1	Pk	52.1	3.8	32.7	35.9	0.4	53.1	452.9	5000.0
6.	4811.1	Av	42.1	3.8	32.7	35.9	0.4	43.1	143.2	500.0
2440 MHz										
7.	4879.0	Pk	51.9	3.7	33.0	35.9	0.4	53.1	452.9	5000.0
8.	4879.0	Av	41.0	3.7	33.0	35.9	0.4	42.2	129.1	500.0
9.	7318.6	Pk	56.7	4.5	36.5	36.6	0.4	61.5	1191.2	5000.0
10.	7318.6	Av	47.6	4.5	36.5	36.6	0.4	52.4	414.5	500.0
2475 MHz										
11.	2327.0	Pk	61.9	2.5	28.1	36.2	N/A	56.3	655.4	5000.0
12.	2327.0	Av	53.4	2.5	28.1	36.2	N/A	47.8	246.0	500.0
13.	2774.9	Pk	60.2	2.7	29.1	36.1	N/A	55.8	619.4	5000.0
14.	2774.9	Av	49.1	2.7	29.1	36.1	N/A	44.8	173.8	500.0
15.	4949.1	Pk	52.1	3.6	33.2	35.9	0.4	53.4	467.2	5000.0
16.	4949.1	Av	42.2	3.6	33.2	35.9	0.4	43.6	150.5	500.0
17.	7423.6	Pk	54.6	4.6	36.7	36.6	0.4	59.7	963.8	5000.0
18.	7423.6	Av	45.2	4.6	36.7	36.6	0.4	50.2	324.3	500.0

No further emission was detected within 20dB of the specification limit.

Radiated Electric Field Emissions – continued:

Test Details: RA24e with F-Type Antenna	
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	30MHz – 10 GHz
EUT sample number	S18
Modification state	0
SE in test environment	S14
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	24˚C

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

Ref No.	FREQ. (MHz)	DET.	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HIGH PASS FILTER LOSS (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
2405 MHz										
1.	2261.1	Pk	59.4	2.5	27.9	36.2	N/A	53.6	478.6	5000.0
2.	2261.1	Av	52.0	2.5	27.9	36.2	N/A	46.2	205.1	500.0
3.	2697.1	Pk	60.7	2.6	29.2	36.1	N/A	56.3	656.1	5000.0
4.	2697.1	Av	48.4	2.6	29.2	36.1	N/A	44.0	159.0	500.0
5.	4811.1	Pk	58.8	3.8	32.7	35.9	0.4	59.8	972.7	5000.0
6.	4811.1	Av	51.1	3.8	32.7	35.9	0.4	52.0	399.9	500.0
2440 MHz										
7.	4879.0	Pk	54.5	3.7	33.0	35.9	0.4	55.7	608.8	5000.0
8.	4879.0	Av	45.5	3.7	33.0	35.9	0.4	46.7	216.5	500.0
9.	7318.6	Pk	57.6	4.5	36.5	36.6	0.4	62.4	1318.3	5000.0
10.	7318.6	Av	48.5	4.5	36.5	36.6	0.4	53.3	462.9	500.0
2475 MHz										
11.	2327.0	Pk	59.1	2.5	28.1	36.2	N/A	53.5	472.6	5000.0
12.	2327.0	Av	51.2	2.5	28.1	36.2	N/A	45.7	191.6	500.0
13.	2774.9	Pk	56.7	2.7	29.1	36.1	N/A	52.4	417.3	5000.0
14.	2774.9	Av	45.6	2.7	29.1	36.1	N/A	41.3	115.5	500.0
15.	4949.1	Pk	50.5	3.6	33.2	35.9	0.4	51.8	388.6	5000.0
16.	4949.1	Av	39.1	3.6	33.2	35.9	0.4	40.4	105.0	500.0
17.	7423.6	Pk	57.0	4.6	36.7	36.6	0.4	62.1	1269.1	5000.0
18.	7423.6	Av	47.7	4.6	36.7	36.6	0.4	52.7	433.5	500.0

No further emission was detected within 20dB of the specification 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
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 6.13.

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 8.10:

Frequency of emission (MHz)	Field strength (µV/m)	Measurement Distance (m)	Field strength (dBµV/m)
0.009-0.490	2400/F(kHz)	300	67.6/F (kHz)
0.490-1.705	24000/F(kHz)	30	87.6/F (kHz
1.705-30	30	30	29.5
30-88	100	3	40.0
88-216	150	3	43.5
216-960	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

Notes:

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

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

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

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

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

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

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

A6 Antenna Gain

The maximum antenna gain of all antenna types, as declared by the client, is as follow.

Chip Antenna (2450AT43B100): 1.3 dBi

Dipole Half Wave Antenna (ANT-2.4-CW-RCT-RP): 2.2 dBi

F- Type Antenna (ANTA revision B): 3 dBi

A7 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 7.1.2. 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: RA24i	
Regulation	Part 15 Subpart (b) Clause 15.109; RSS – GEN Section 7.1
Measurement standard	ANSI C63.10
Frequency range	30MHz to 10 GHz
EUT sample number	S16
Modification state	0
SE in test environment	None
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	25˚C

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

Ref No.	FREQ. (MHz)	DET.	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HIGH PASS FILTER LOSS (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
2405 MHz										
No emissions were detected within 20dB of the limit										
2440 MHz										
No emissions were detected within 20dB of the limit										
2475 MHz										
No emissions were detected within 20dB of the limit										

Test Details: RA24e with Half Wave Antenna	
Regulation	Part 15 Subpart (b) Clause 15.109; RSS – GEN Section 7.1
Measurement standard	ANSI C63.10
Frequency range	30MHz to 10 GHz
EUT sample number	S18
Modification state	0
SE in test environment	S07
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	28˚C

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

Ref No.	FREQ. (MHz)	DET.	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HIGH PASS FILTER LOSS (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
2405 MHz										
No emissions were detected within 20dB of the limit										
2440 MHz										
No emissions were detected within 20dB of the limit										
2475 MHz										
No emissions were detected within 20dB of the limit										

Test Details: RA24e with F-Type Antenna	
Regulation	Part 15 Subpart (b) Clause 15.109; RSS – GEN Section 7.1
Measurement standard	ANSI C63.10
Frequency range	30MHz to 10 GHz
EUT sample number	S18
Modification state	0
SE in test environment	S14
SE isolated from EUT	None
EUT set up	Refer to Appendix C
Temperature	22˚C

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

Ref No.	FREQ. (MHz)	DET.	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	HIGH PASS FILTER LOSS (dB)	FIELD ST'GH (dBµV/m)	FIELD ST'GH (µV/m)	LIMIT (µV/m)
2405 MHz										
No emissions were detected within 20dB of the limit										
2440 MHz										
No emissions were detected within 20dB of the limit										
2475 MHz										
No 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 8.9 for all emissions:

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

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

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

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

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

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

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

A8 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.

Test Details:	
Regulation	Title 47 of the CFR: Part 15 Clause 15.207 / RSS Gen Section 8.8
Measurement standard	ANSI C63.10:2009
Frequency range	150kHz to 30MHz
EUT sample number	S18
Modification state	0
SE in test environment	S14
SE isolated from EUT	None
EUT set up	Refer to Appendix C

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)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
No emissions within 20dB of the specification limit						

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

Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
No emissions within 20dB of the specification limit						

Specification limits:

Conducted emission limits (47 CFR Part 15: Clause 15.207 / RSS-Gen Section 8.8):

Conducted disturbance at the mains ports.

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

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

Notes:

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

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

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

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

Appendix B: Supporting Graphical Data

This appendix contains graphical data obtained during testing.

Notes:

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

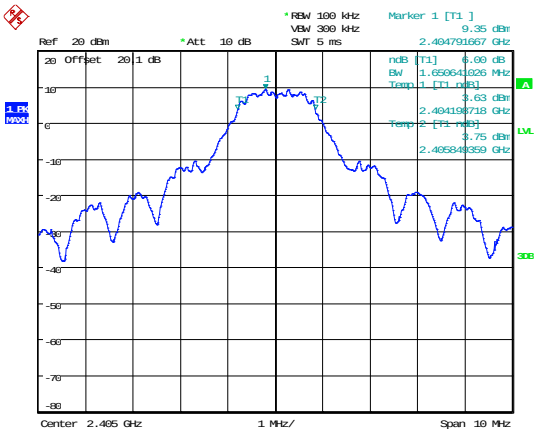
(b) The time and date on the plots do not necessarily equate to the time of the test.

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

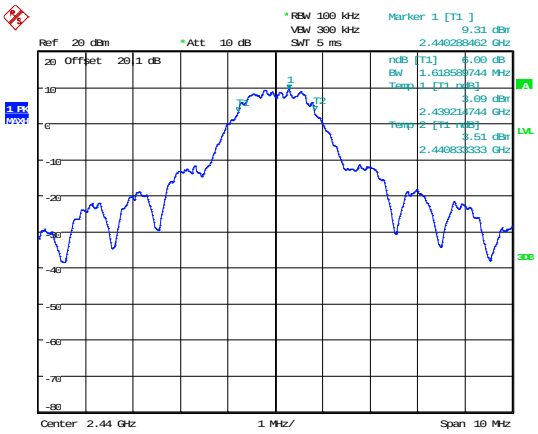
(d) Appendix C details the numbering system used to identify the sample and its modification state.

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

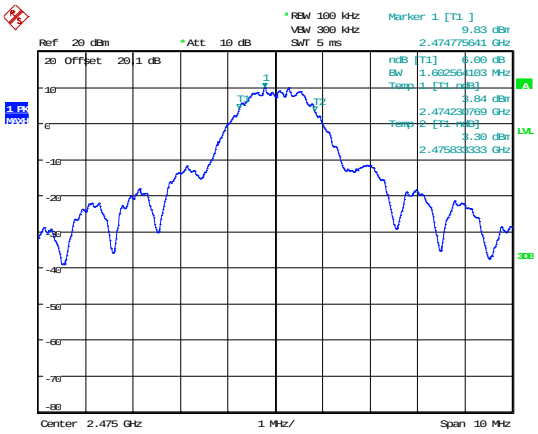
6dB Bandwidth



2405 MHz

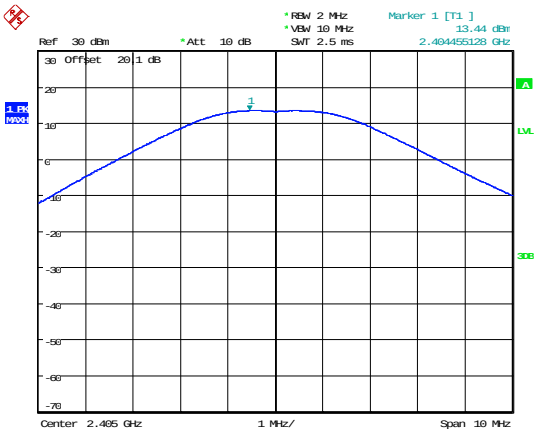


2440 MHz

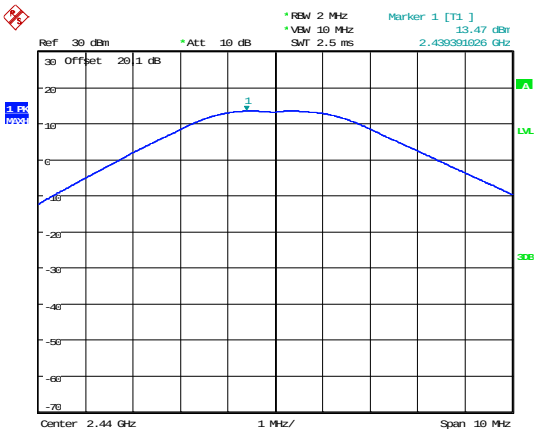


2475 MHz

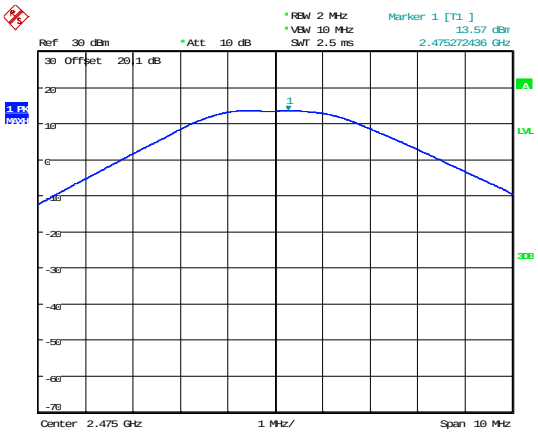
Carrier Power



2405 MHz

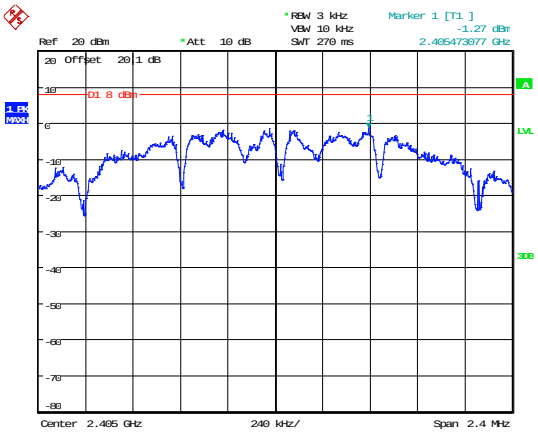


2440 MHz

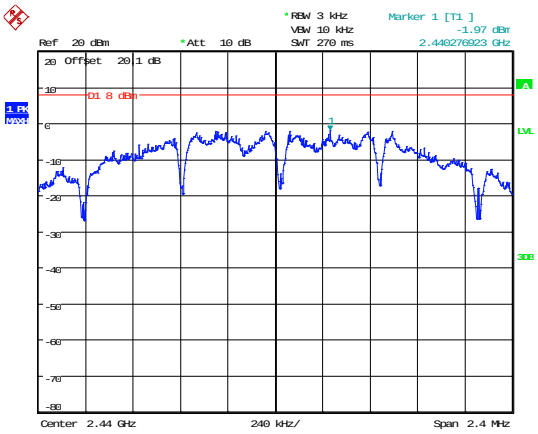


2475 MHz

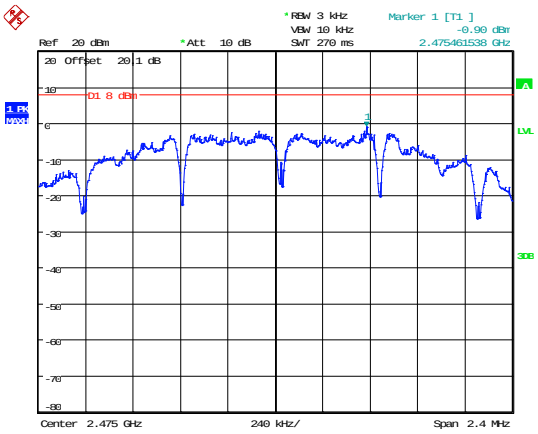
Power Spectral Density



2405 MHz

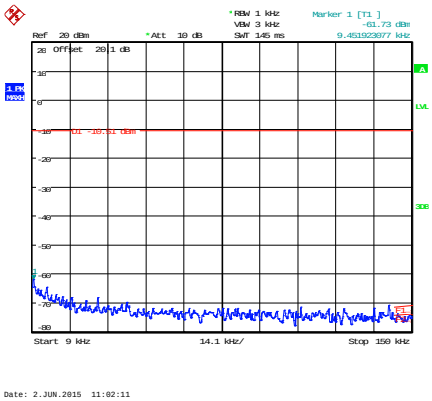


2440 MHz



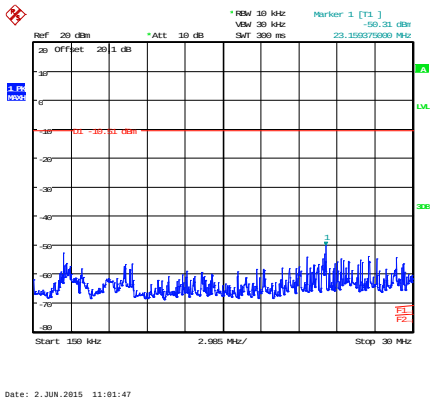
2475 MHz

Conducted Spurious Emissions– 2405 MHz



Date: 2.JUN.2015 11:02:11

9 kHz to 150 kHz



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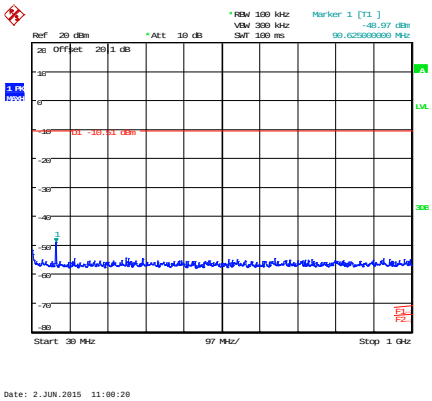
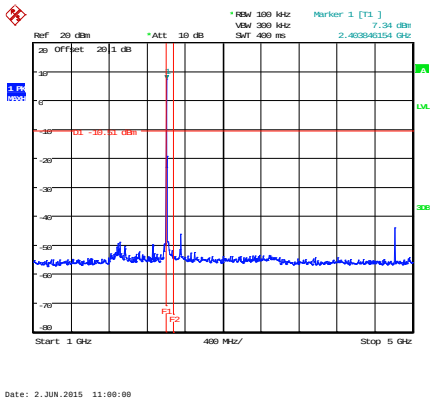
150 kHz to 30 MHz



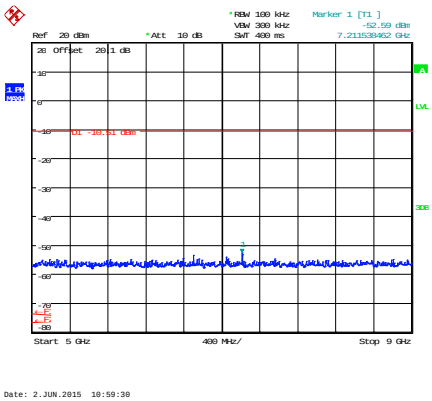
Date: 2.JUN.2015 11:00:20

30 MHz to 1 GHz



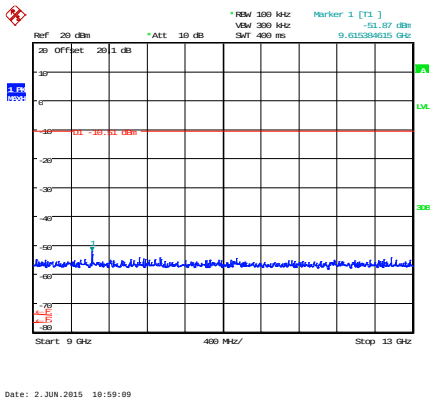
Date: 2.JUN.2015 11:00:00

1 GHz to 5 GHz



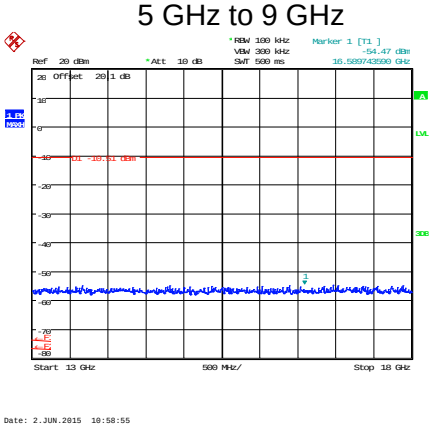
Date: 2.JUN.2015 10:59:30

5 GHz to 9 GHz



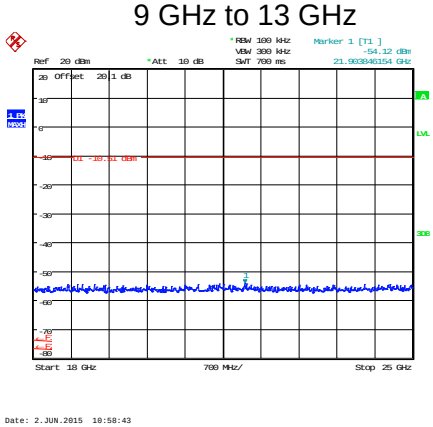
Date: 2.JUN.2015 10:59:09

9 GHz to 13 GHz



Date: 2.JUN.2015 10:58:55

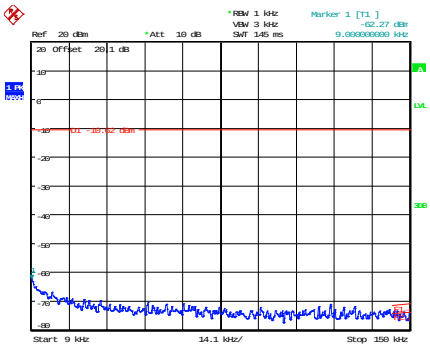
13 GHz to 18 GHz



Date: 2.JUN.2015 10:58:43

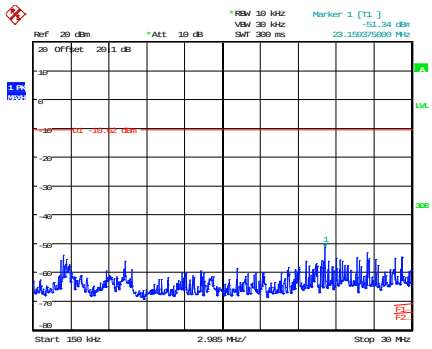
18 GHz to 25 GHz

Conducted Spurious Emissions– 2440 MHz



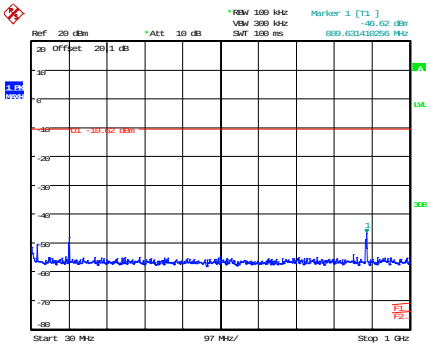
Date: 2.JUN.2015 11:10:20

9 kHz to 150 kHz



Date: 2.JUN.2015 11:09:59

150 kHz to 30 MHz



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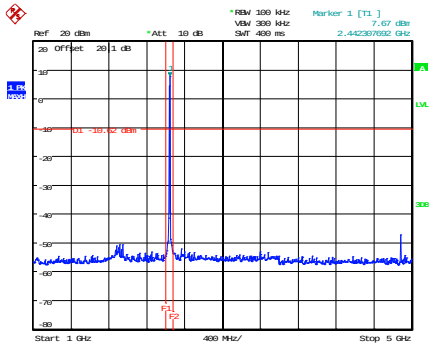
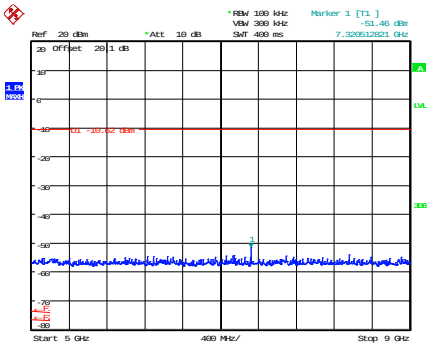
30 MHz to 1 GHz



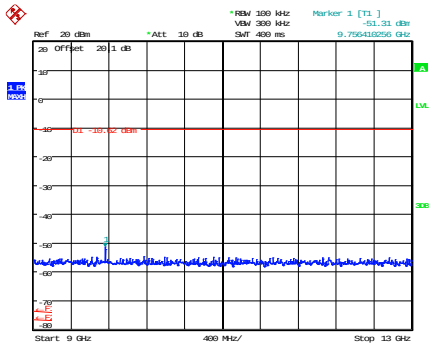
Date: 2.JUN.2015 11:08:44

1 GHz to 5 GHz



Date: 2.JUN.2015 11:08:25

5 GHz to 9 GHz



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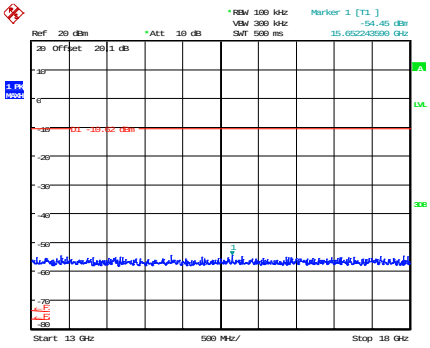
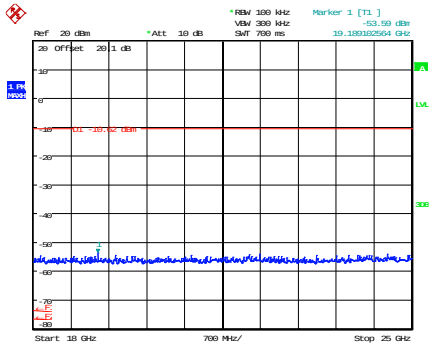
9 GHz to 13 GHz



Date: 2.JUN.2015 11:07:57

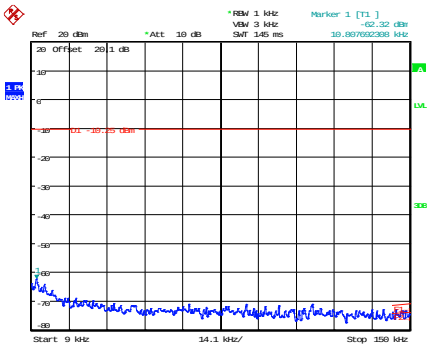
13 GHz to 18 GHz



Date: 2.JUN.2015 11:07:42

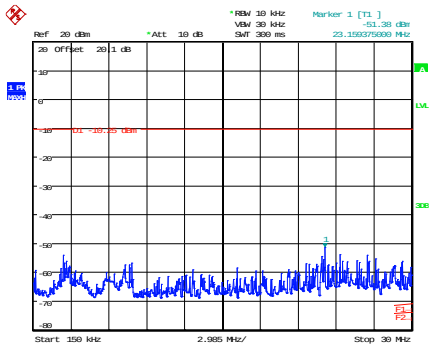
18 GHz to 25 GHz

Conducted Spurious Emissions– 2475 MHz



Date: 2.JUN.2015 10:56:19

9 kHz to 150 kHz



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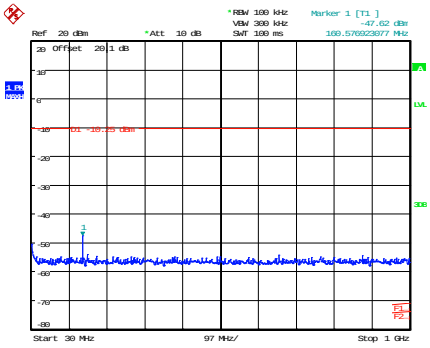
150 kHz to 30 MHz



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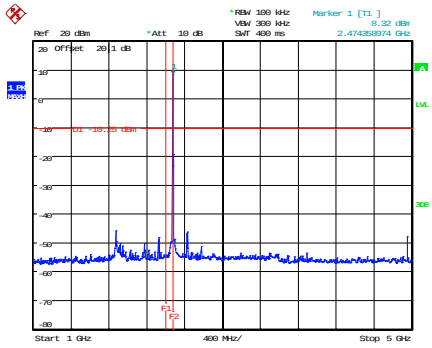
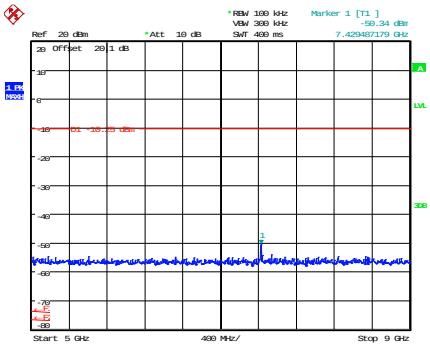
30 MHz to 1 GHz



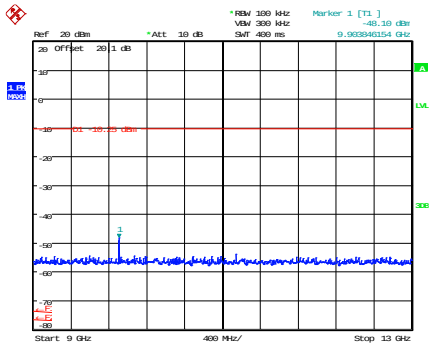
Date: 2.JUN.2015 10:54:38

1 GHz to 5 GHz



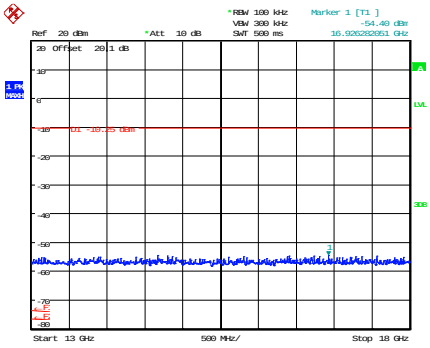
Date: 2.JUN.2015 10:53:39

5 GHz to 9 GHz



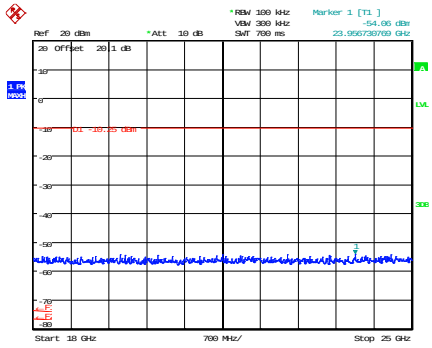
Date: 2.JUN.2015 10:53:22

9 GHz to 13 GHz



Date: 2.JUN.2015 10:53:06

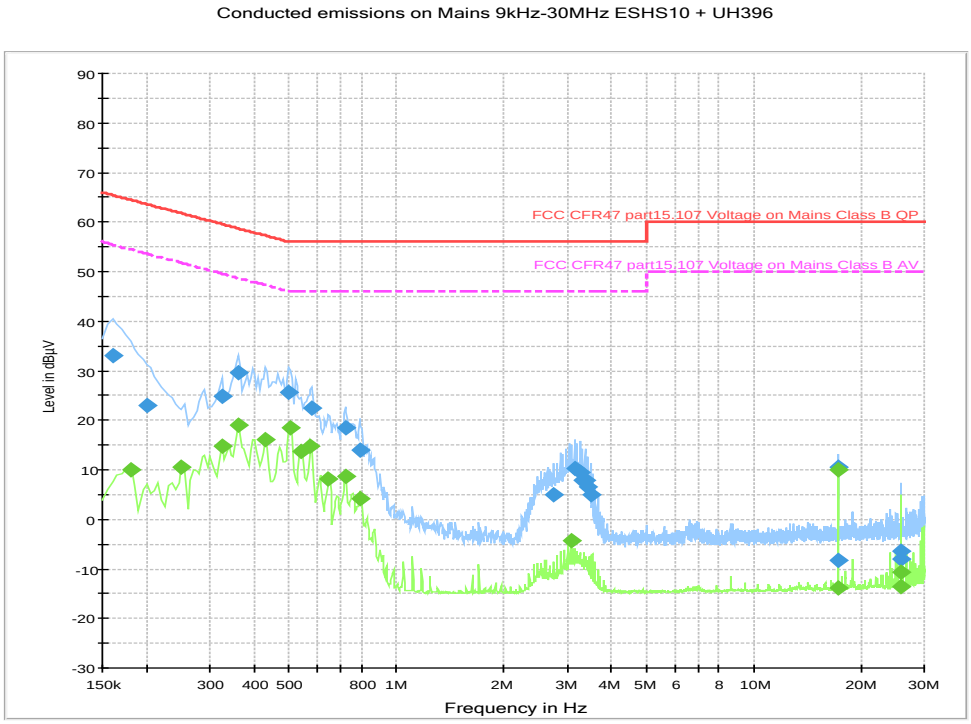
13 GHz to 18 GHz



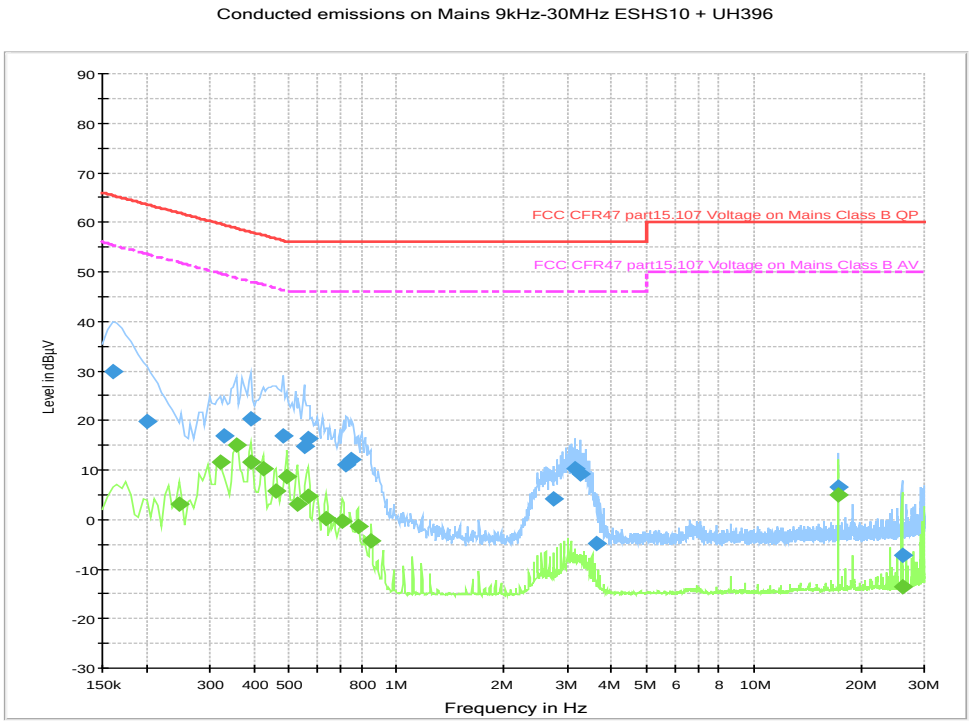
Date: 2.JUN.2015 10:52:49

18 GHz to 25 GHz

Power line Conducted Emissions

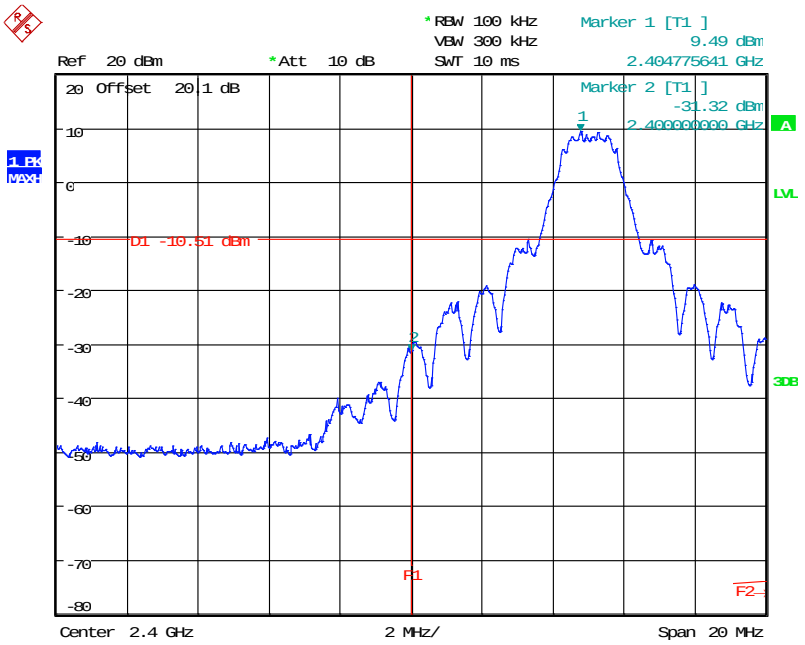


Power line Conducted Emissions - Transmit



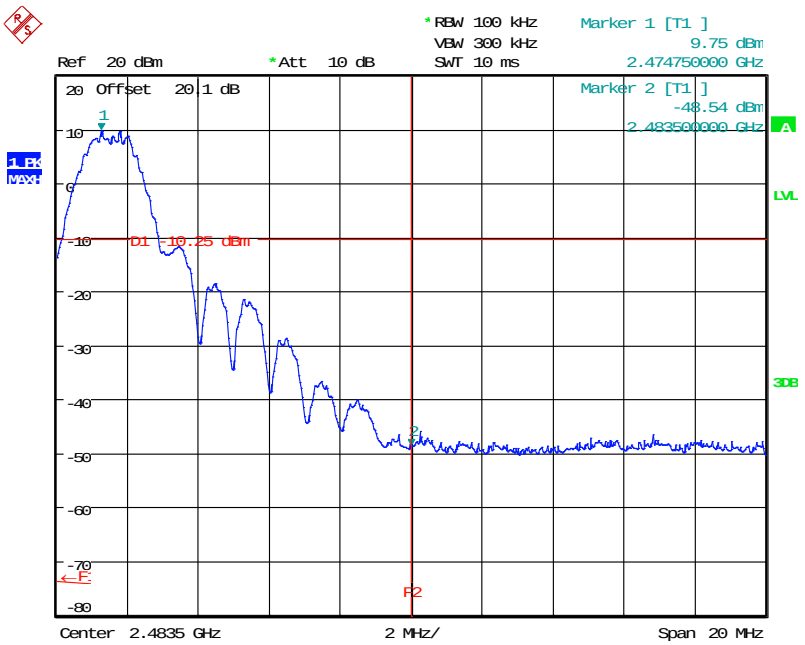
Power line Conducted Emissions - Receive

Conducted Band Edge Compliance



Date: 2.JUN.2015 10:58:09

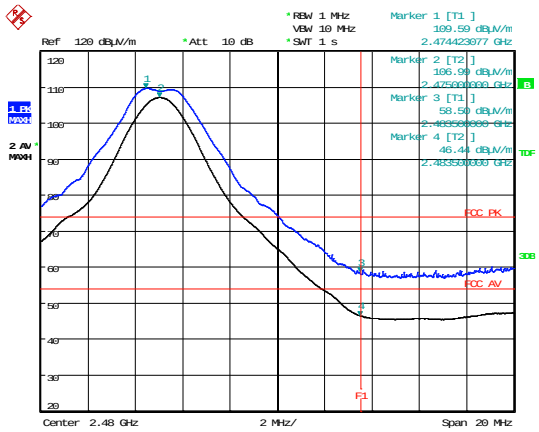
Conducted Lower Band Edge Compliance



Date: 2.JUN.2015 10:49:55

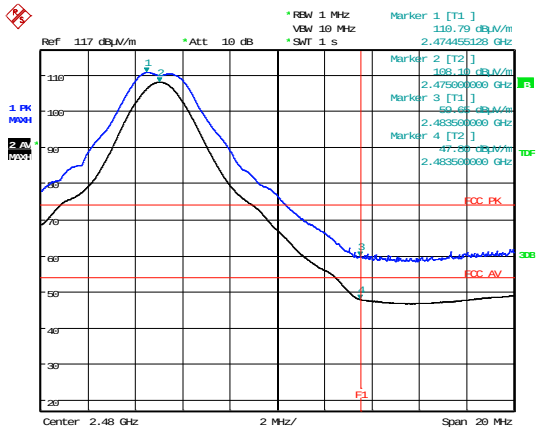
Conducted Upper Band Edge Compliance

Radiated Band Edge Compliance



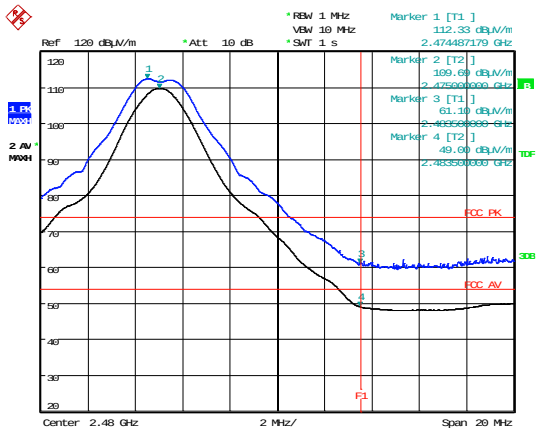
Date: 31.MAY.2015 15:01:23

Radiated Upper Band Edge Compliance – RA24i



Date: 28.MAY.2015 17:17:26

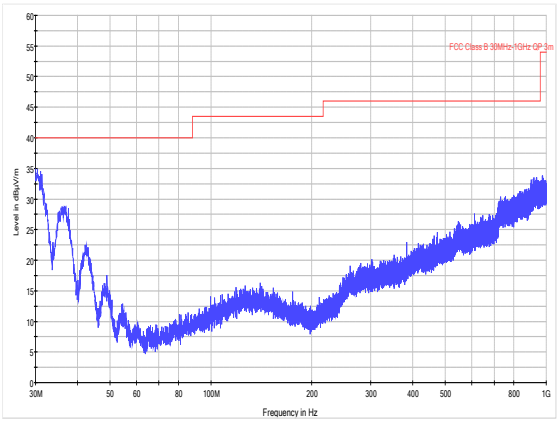
Radiated Upper Band Edge Compliance – RA24e with Half Wave Antenna



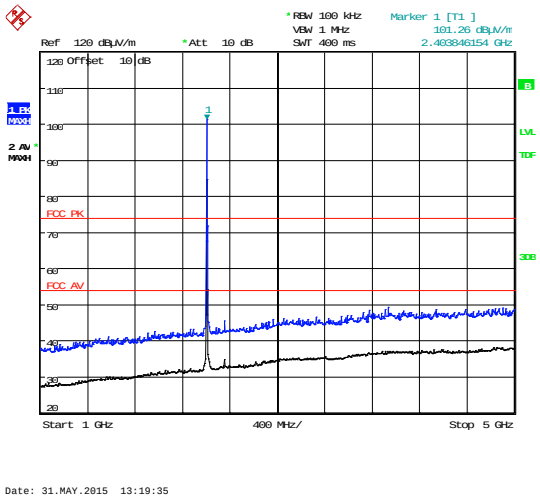
Date: 31.MAY.2015 14:45:46

Radiated Upper Band Edge Compliance – RA24e with F-Type Antenna

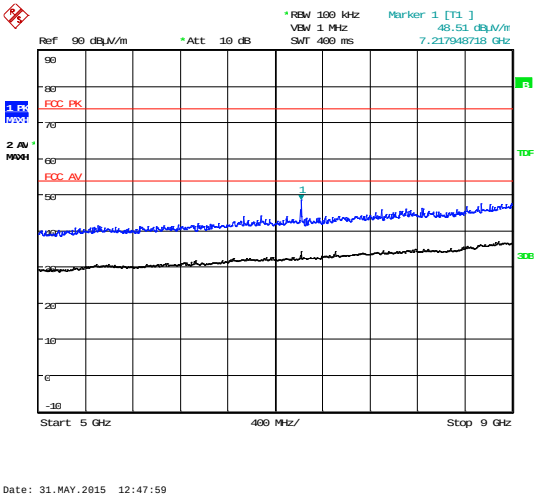
Radiated Spurious Emissions - RA24i 2405 MHz



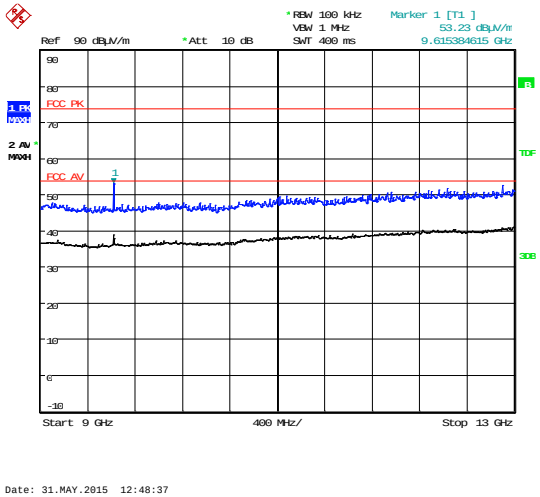
30 MHz to 1 GHz



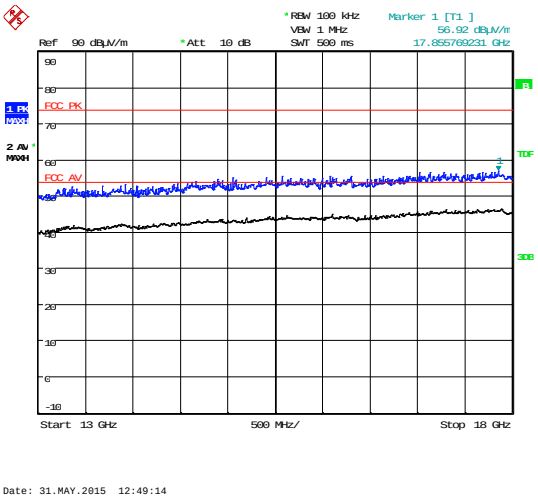
1 GHz to 5 GHz



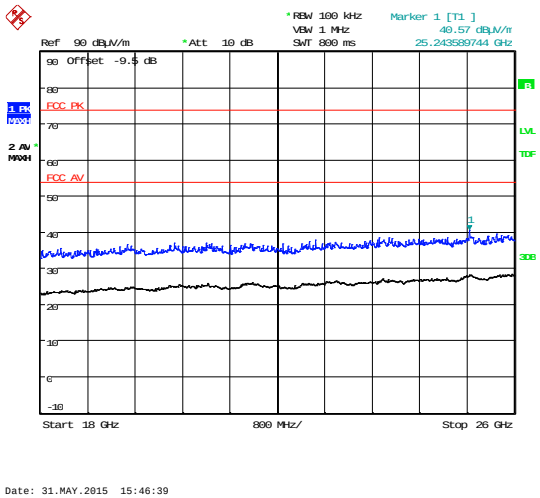
5 GHz to 9 GHz



9 GHz to 13 GHz

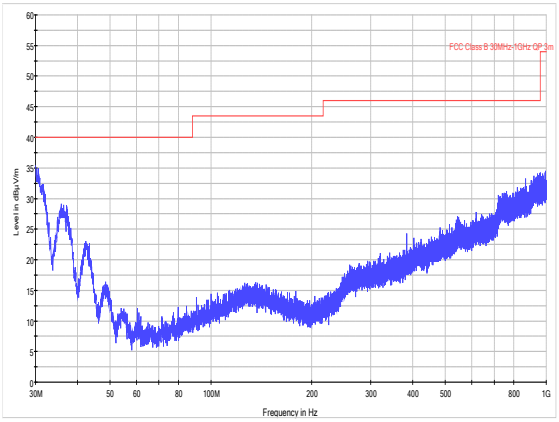


13 GHz to 18 GHz

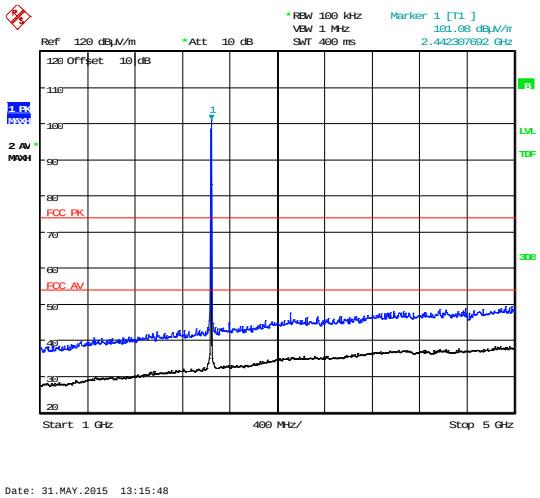


18 GHz to 25 GHz

Radiated Spurious Emissions - RA24i 2440 MHz

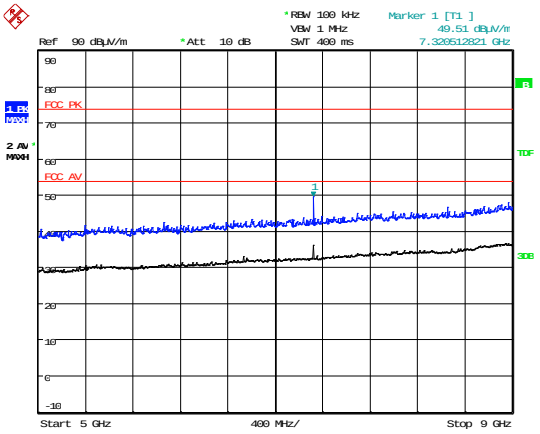


30 MHz to 1 GHz



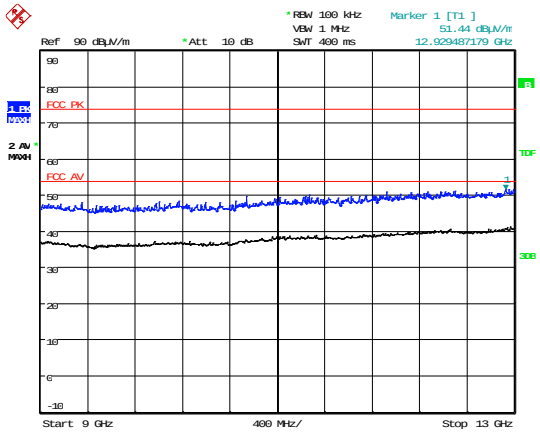
Date: 31.MAY.2015 13:15:48

1 GHz to 5 GHz



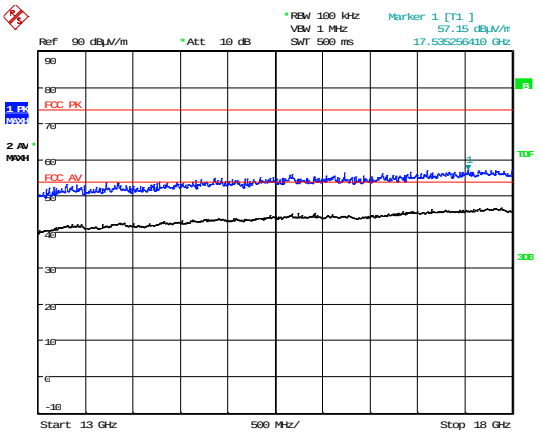
Date: 31.MAY.2015 13:00:28

5 GHz to 9 GHz



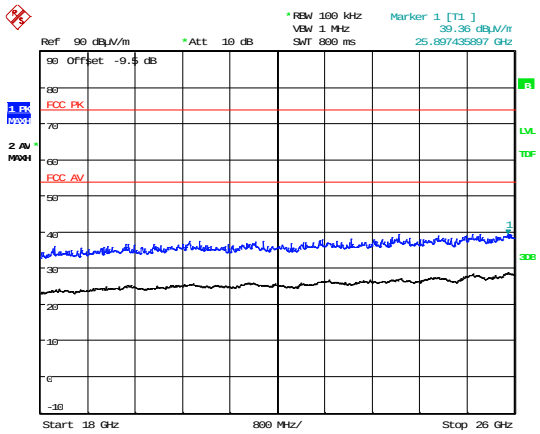
Date: 31.MAY.2015 12:59:46

9 GHz to 13 GHz



Date: 31.MAY.2015 12:58:56

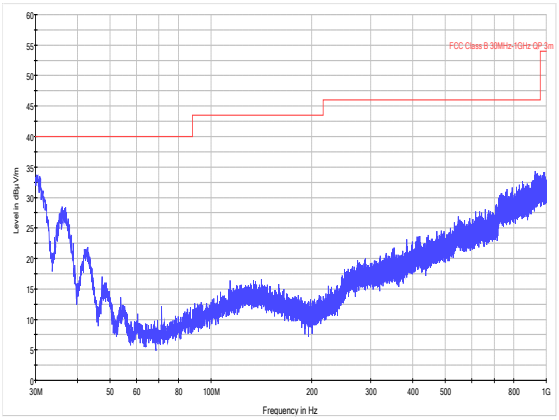
13 GHz to 18 GHz



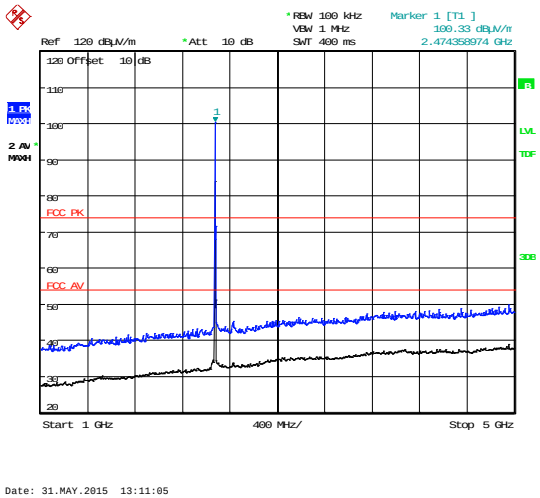
Date: 31.MAY.2015 15:51:44

18 GHz to 25 GHz

Radiated Spurious Emissions - RA24i 2475 MHz

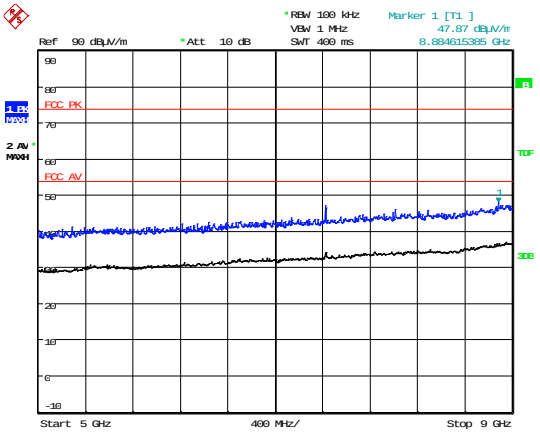


30 MHz to 1 GHz



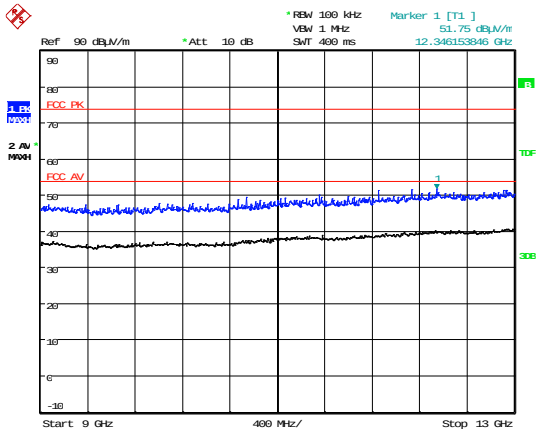
Date: 31.MAY.2015 13:11:05

1 GHz to 5 GHz



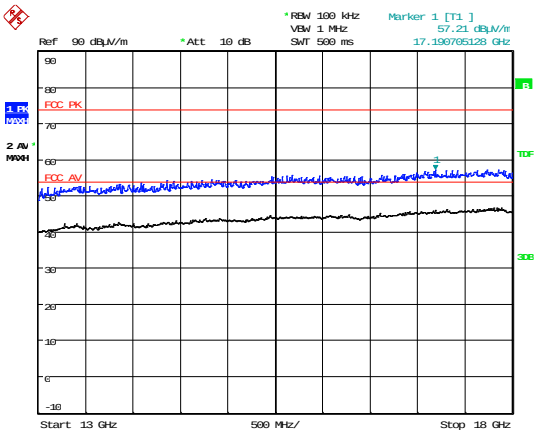
Date: 31.MAY.2015 13:02:07

5 GHz to 9 GHz



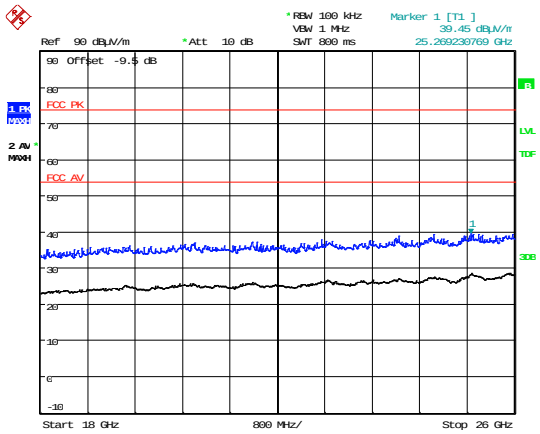
Date: 31.MAY.2015 13:02:33

9 GHz to 13 GHz



Date: 31.MAY.2015 13:03:19

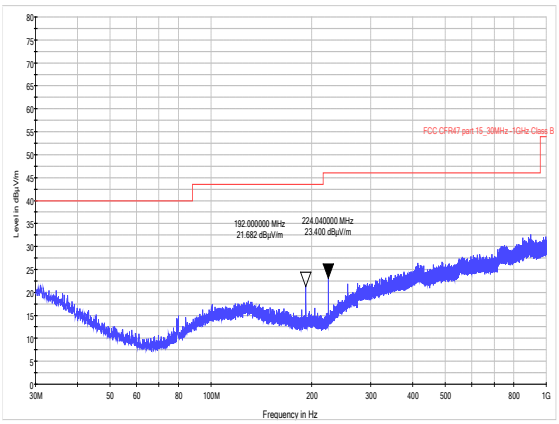
13 GHz to 18 GHz



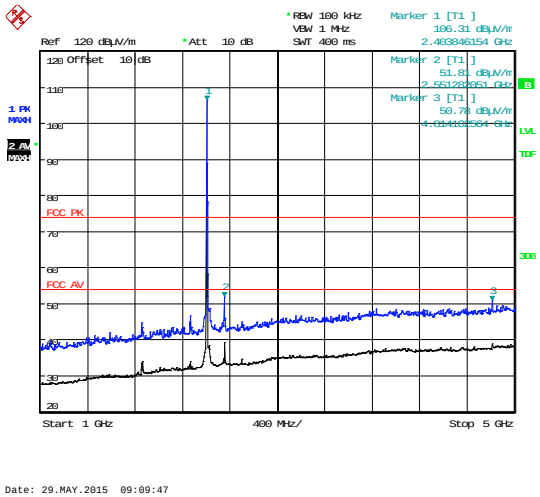
Date: 31.MAY.2015 15:56:21

18 GHz to 25 GHz

Radiated Spurious Emissions - RA24e with Half Wave Antenna 2405 MHz

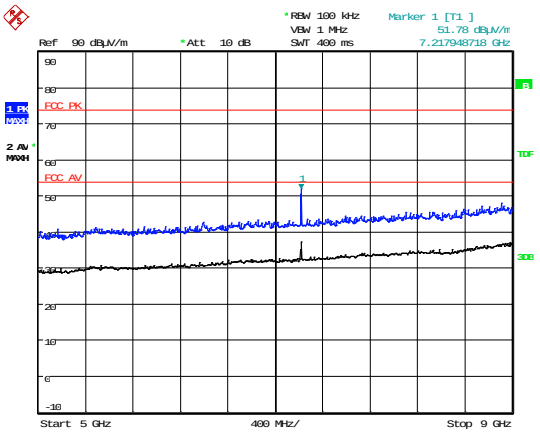


30 MHz to 1 GHz



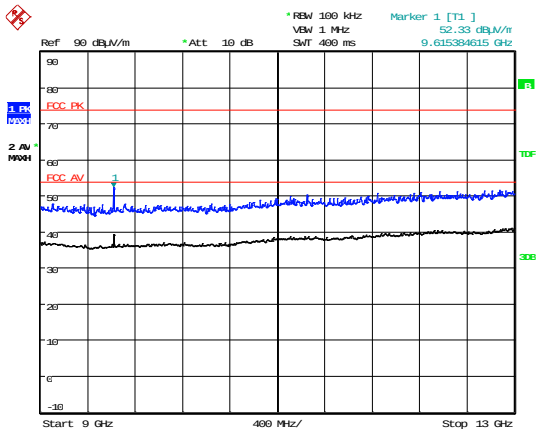
Date: 29.MAY.2015 09:09:47

1 GHz to 5 GHz



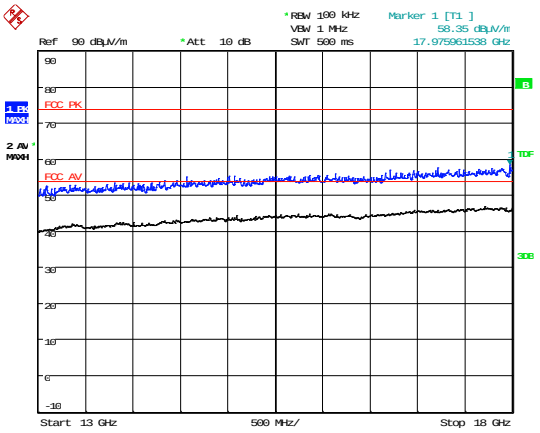
Date: 29.MAY.2015 13:55:56

5 GHz to 9 GHz



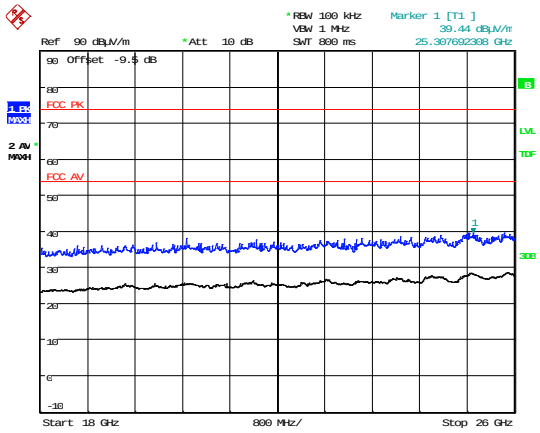
Date: 29.MAY.2015 13:56:33

9 GHz to 13 GHz



Date: 29.MAY.2015 13:57:17

13 GHz to 18 GHz



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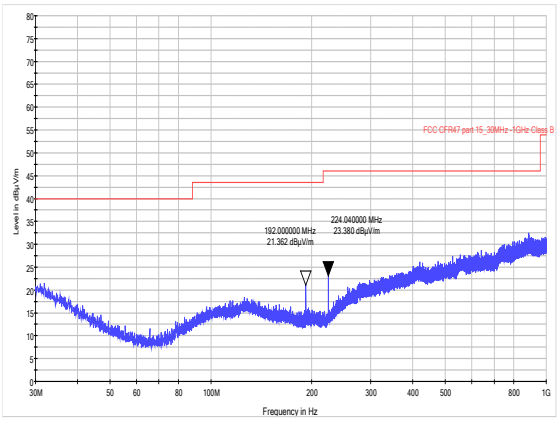
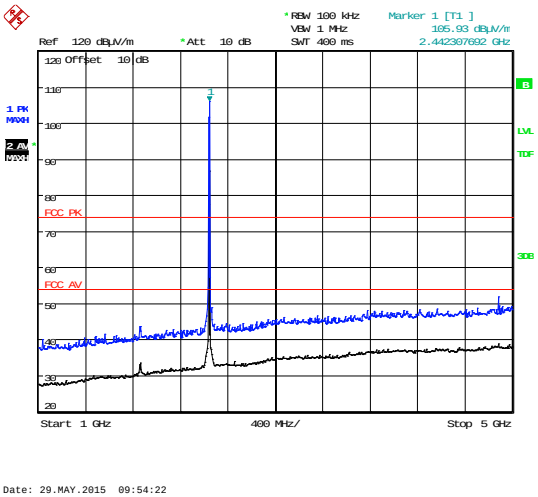
18 GHz to 25 GHz

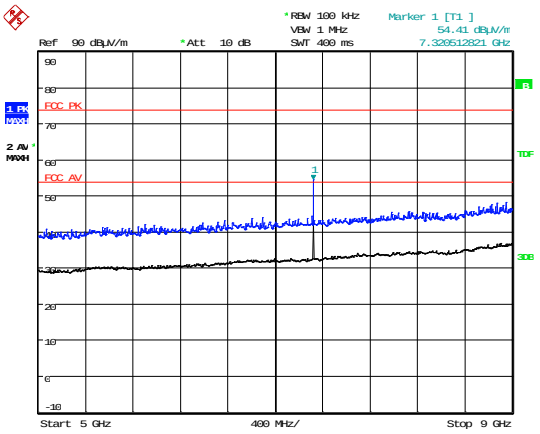
Radiated Spurious Emissions - RA24e with Half Wave Antenna 2440 MHz



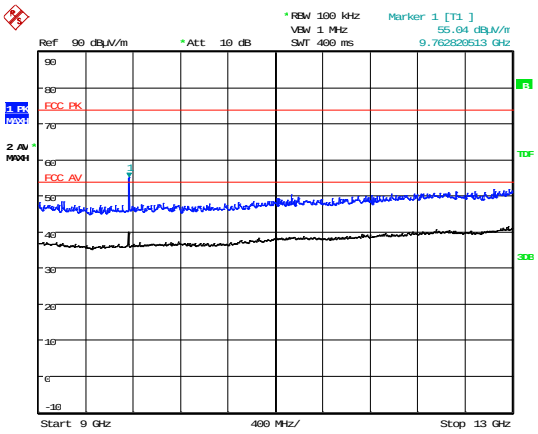
30 MHz to 1 GHz



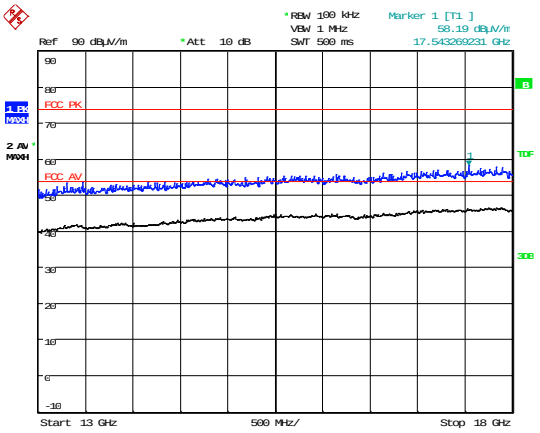
1 GHz to 5 GHz



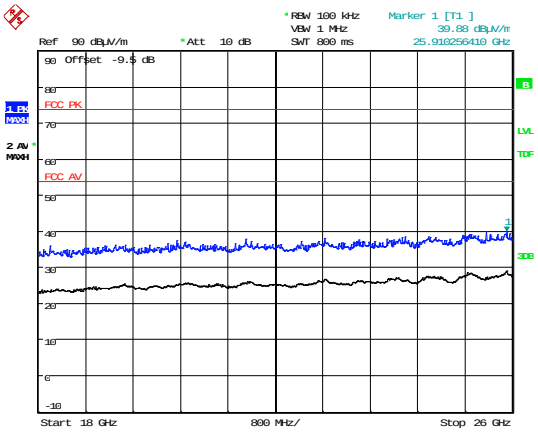
5 GHz to 9 GHz



9 GHz to 13 GHz

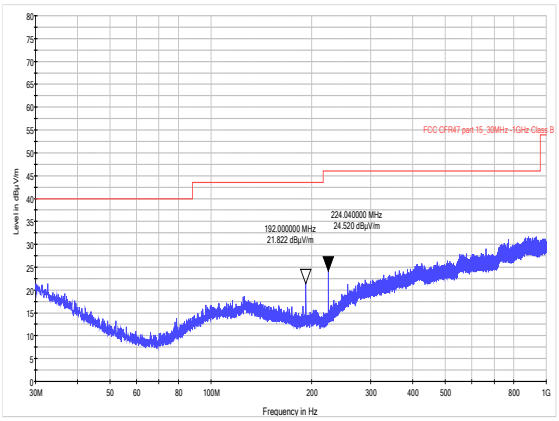


13 GHz to 18 GHz

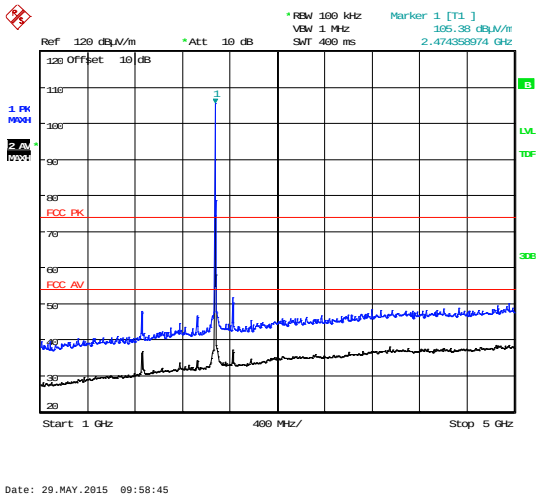


18 GHz to 25 GHz

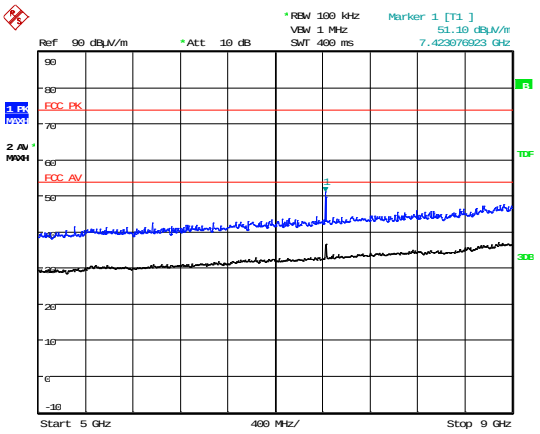
Radiated Spurious Emissions - RA24e with Half Wave Antenna 2475 MHz



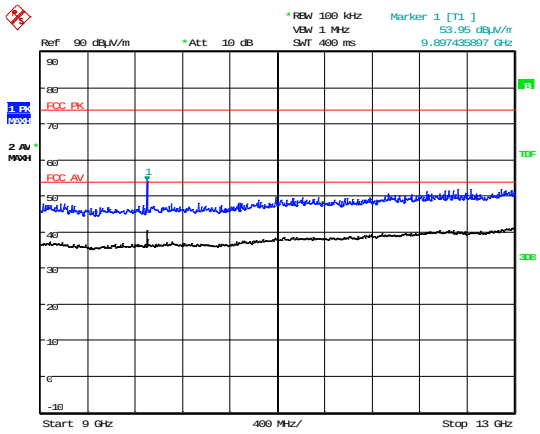
30 MHz to 1 GHz



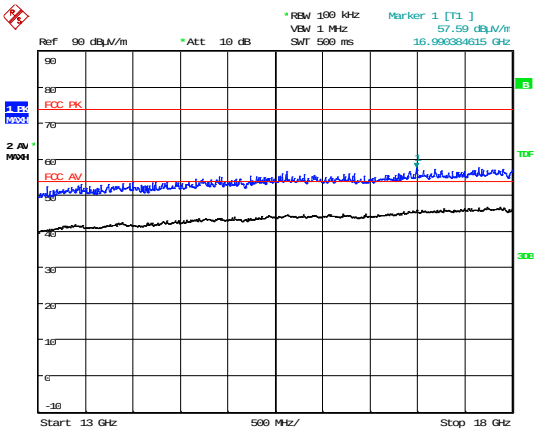
1 GHz to 5 GHz



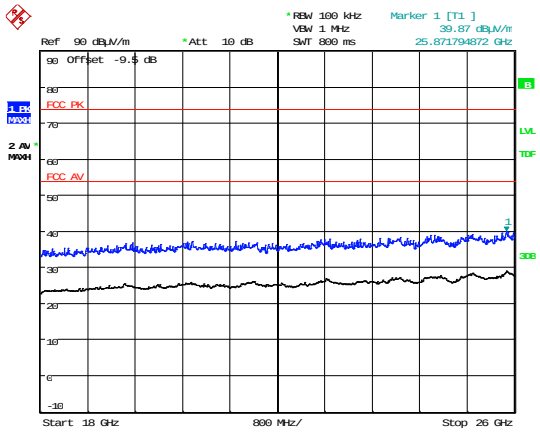
5 GHz to 9 GHz



9 GHz to 13 GHz

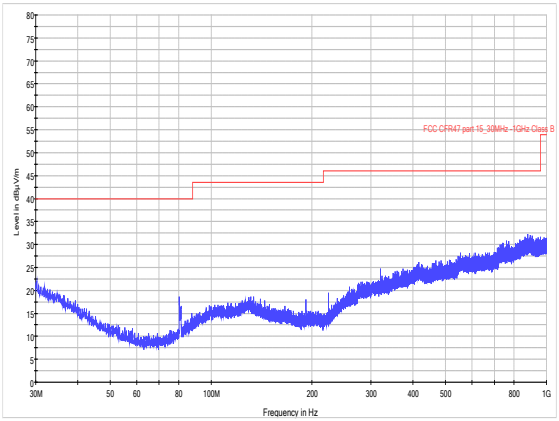


13 GHz to 18 GHz

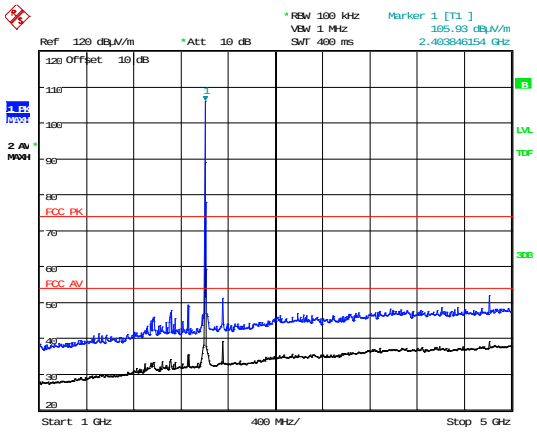


18 GHz to 25 GHz

Radiated Spurious Emissions - RA24e with F-Type Antenna 2405 MHz



30 MHz to 1 GHz



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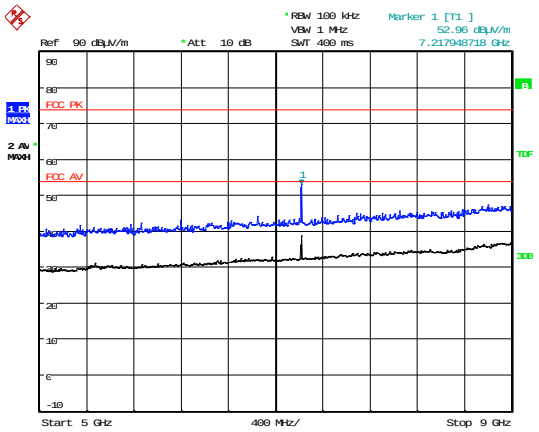
1 GHz to 5 GHz



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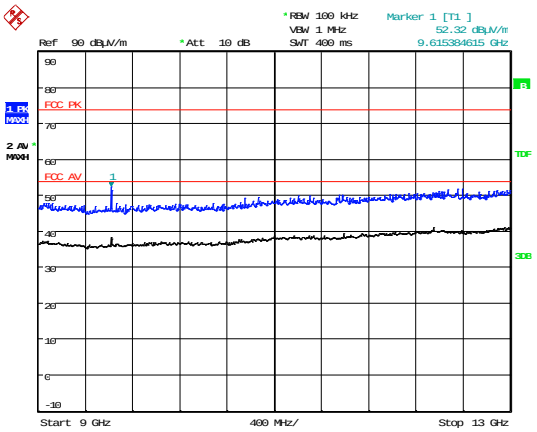
5 GHz to 9 GHz



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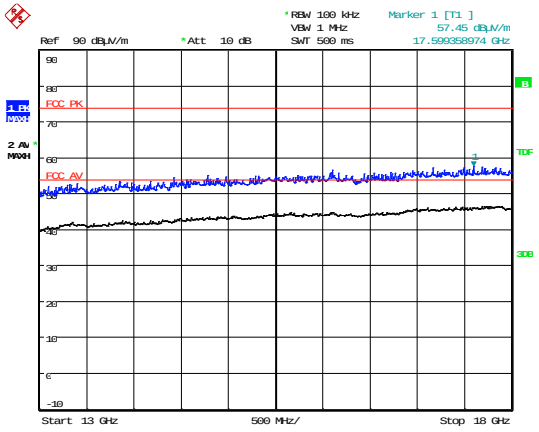
9 GHz to 13 GHz



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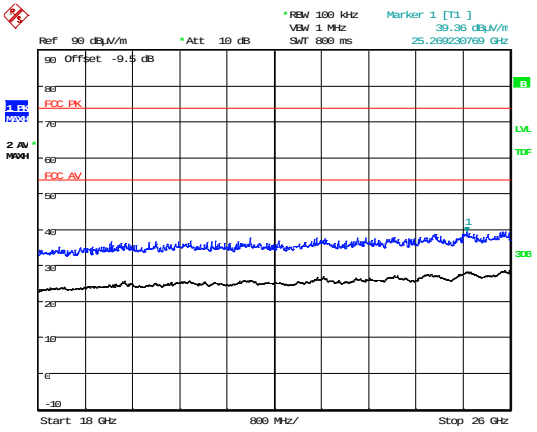
13 GHz to 18 GHz



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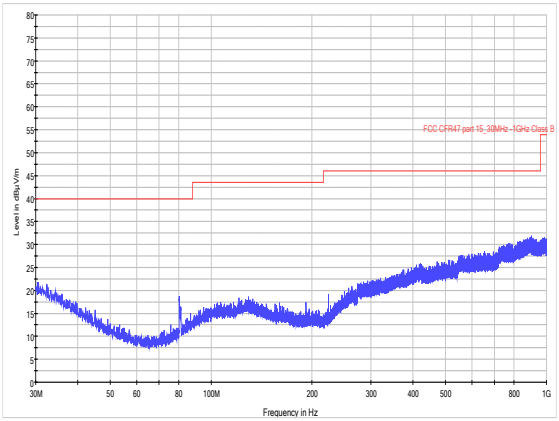
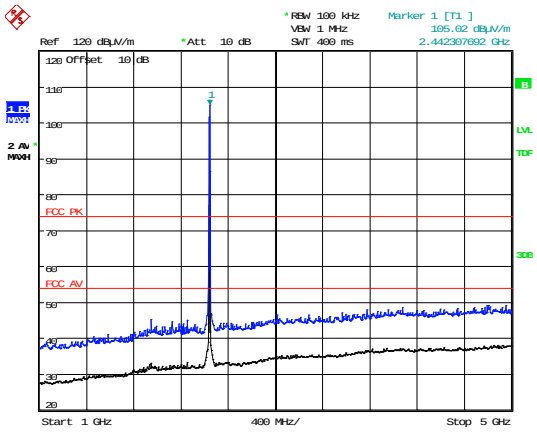
18 GHz to 25 GHz

Radiated Spurious Emissions - RA24e with F-Type Antenna 2440 MHz



30 MHz to 1 GHz



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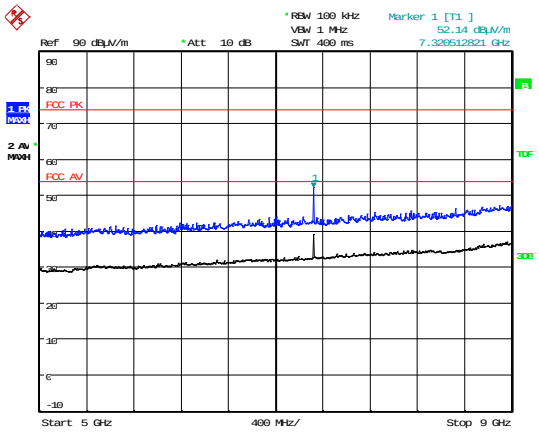
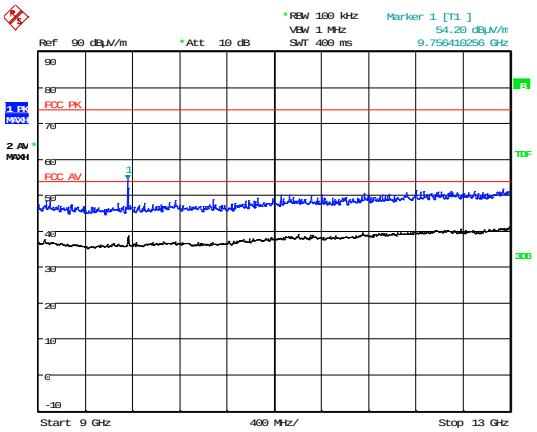
1 GHz to 5 GHz



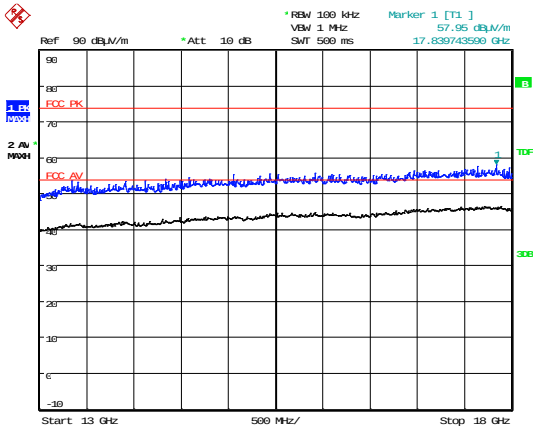
Date: 29.MAY.2015 14:28:12

5 GHz to 9 GHz



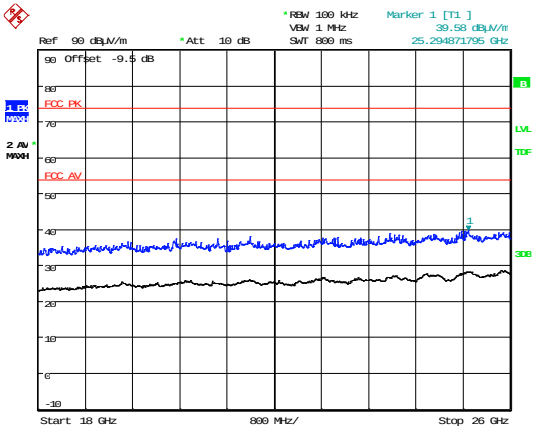
Date: 29.MAY.2015 14:28:50

9 GHz to 13 GHz



Date: 29.MAY.2015 14:29:19

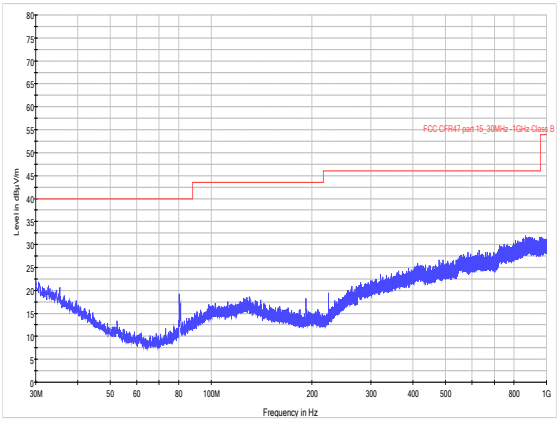
13 GHz to 18 GHz



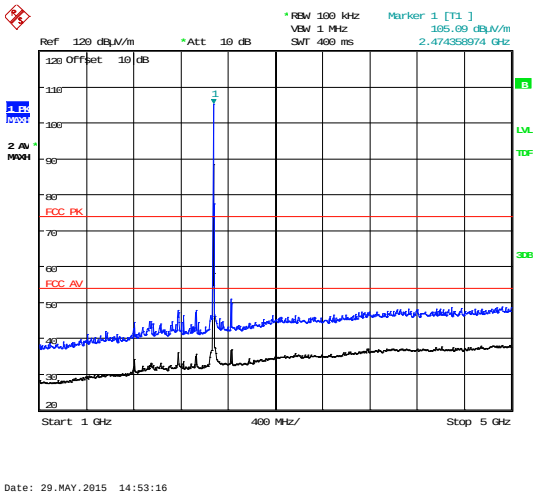
Date: 31.MAY.2015 16:09:54

18 GHz to 25 GHz

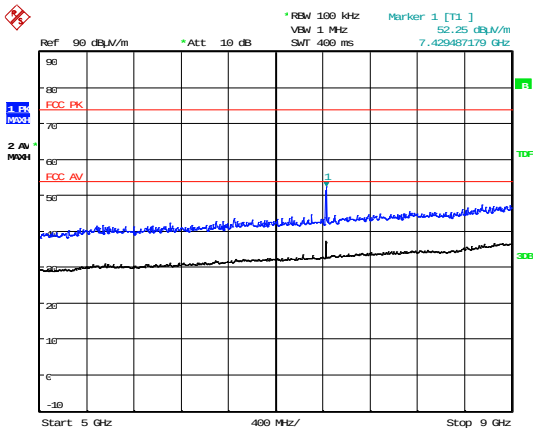
Radiated Spurious Emissions - RA24e with F-Type Antenna 2475 MHz



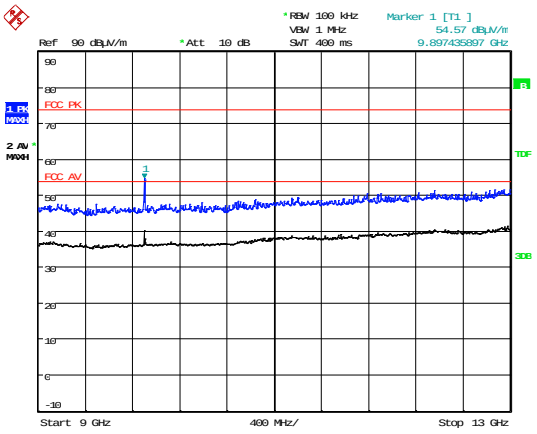
30 MHz to 1 GHz



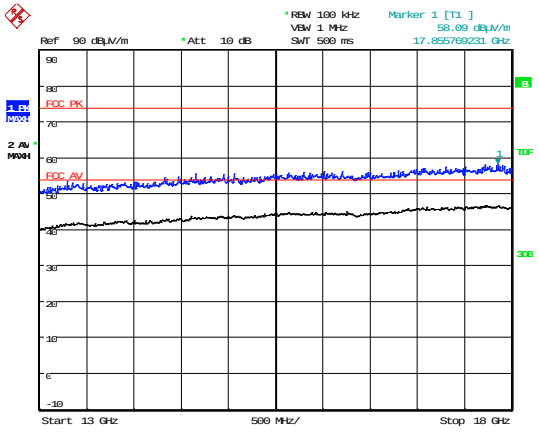
1 GHz to 5 GHz



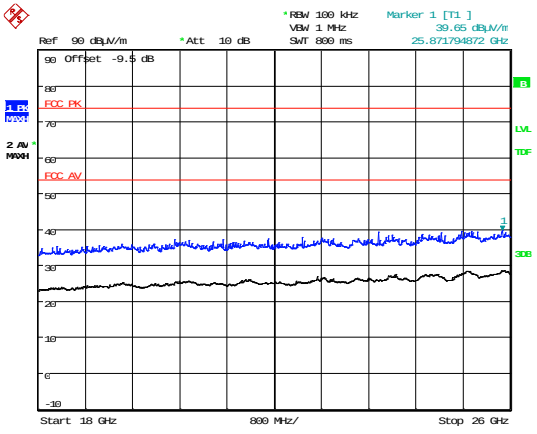
5 GHz to 9 GHz



9 GHz to 13 GHz

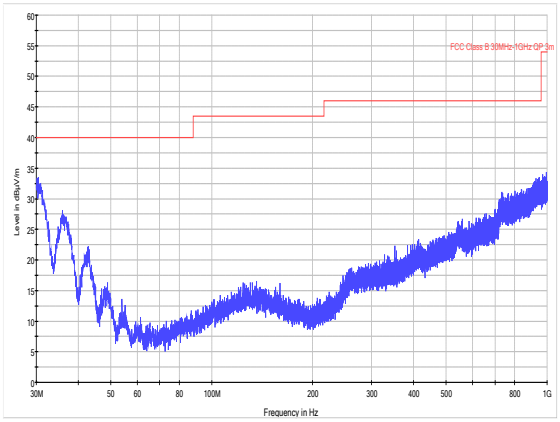


13 GHz to 18 GHz

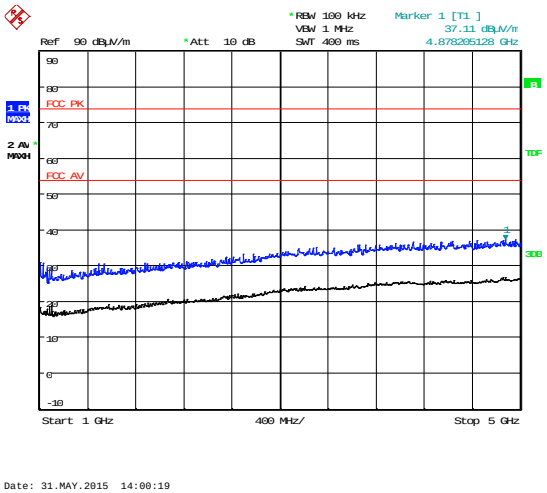


18 GHz to 25 GHz

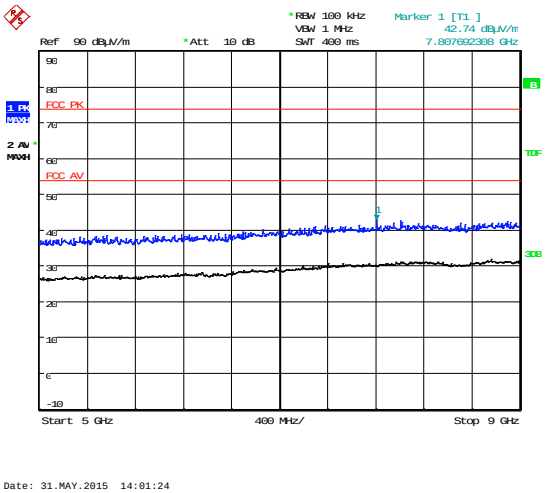
Unintentional Radiated Spurious Emissions - RA24i 2405 MHz



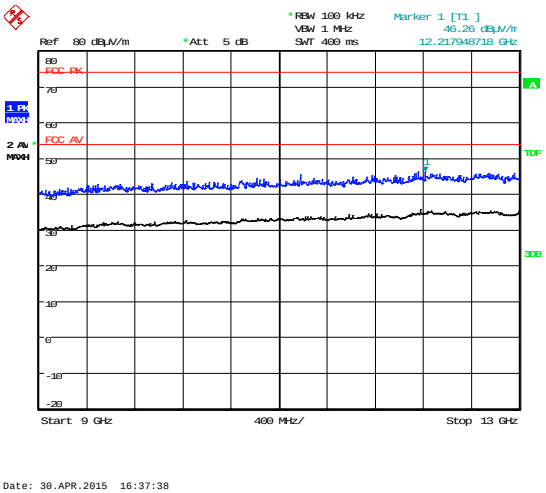
30 MHz to 1 GHz



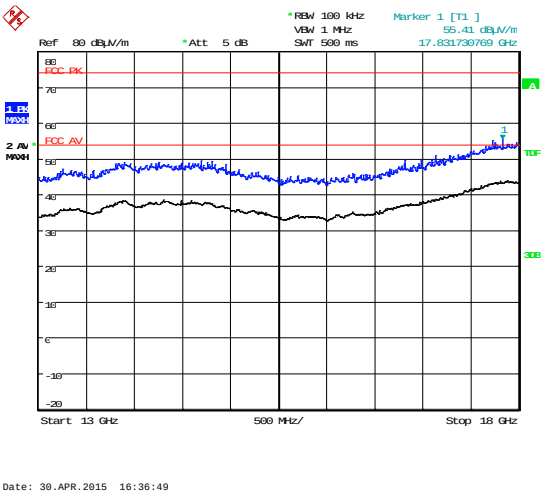
1 GHz to 5 GHz



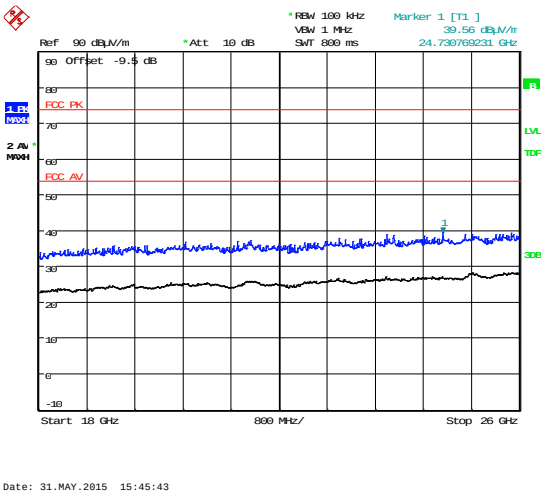
5 GHz to 9 GHz



9 GHz to 13 GHz

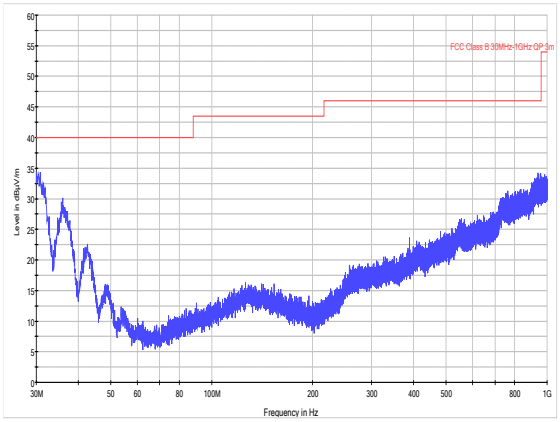


13 GHz to 18 GHz

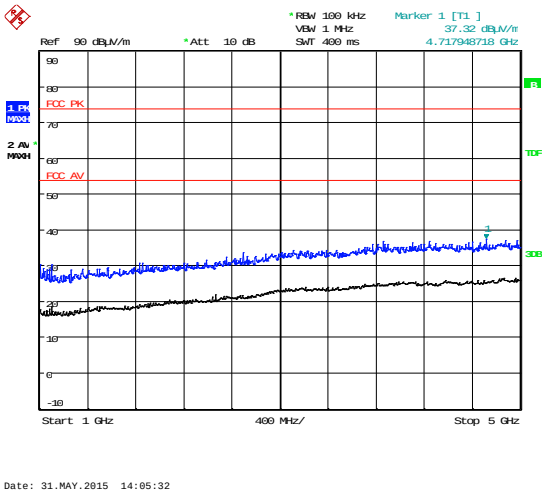


18 GHz to 25 GHz

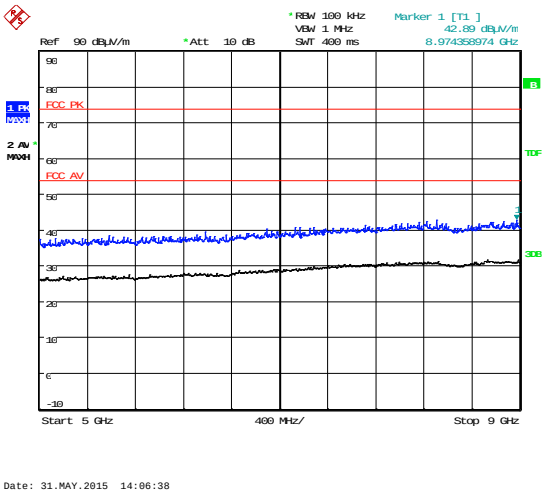
Unintentional Radiated Spurious Emissions - RA24i 2440 MHz



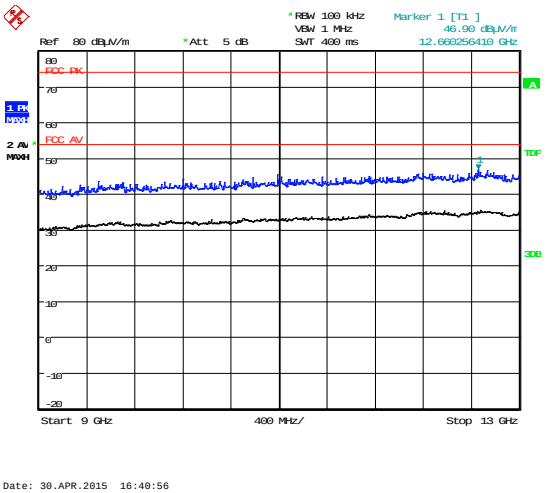
30 MHz to 1 GHz



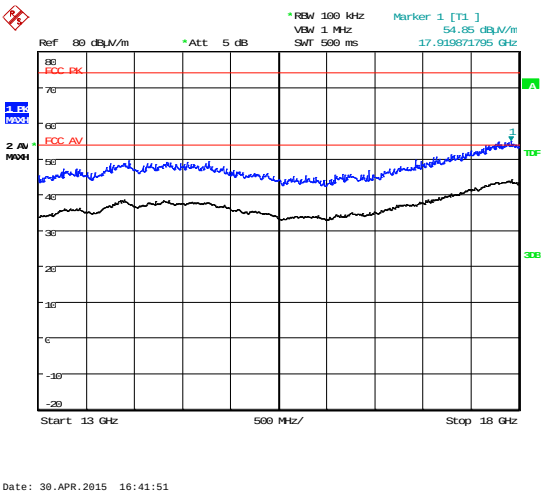
1 GHz to 5 GHz



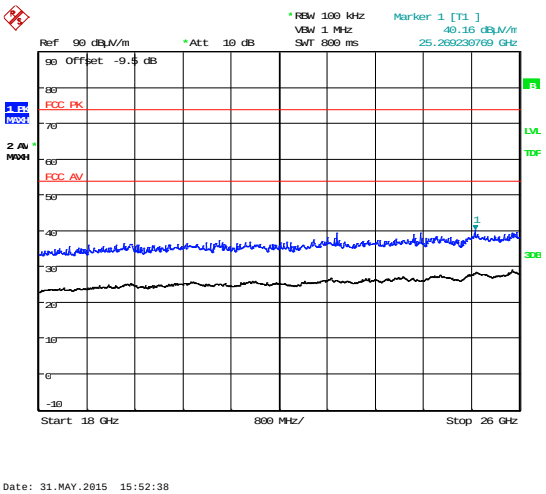
5 GHz to 9 GHz



9 GHz to 13 GHz

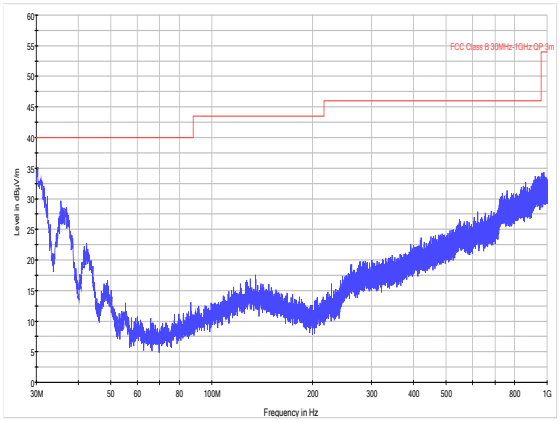


13 GHz to 18 GHz

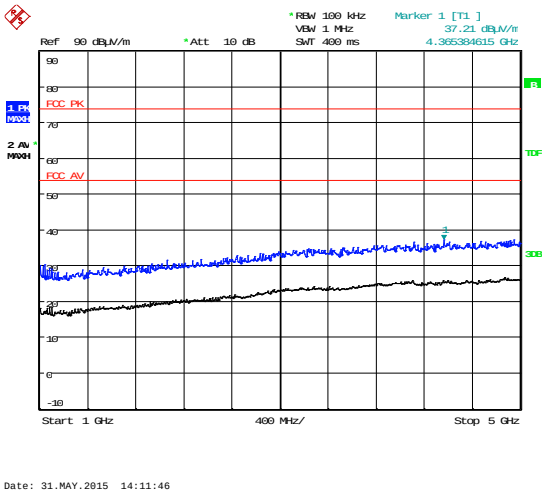


18 GHz to 25 GHz

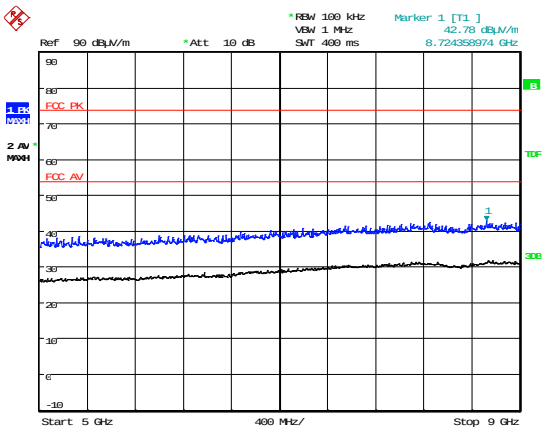
Unintentional Radiated Spurious Emissions - RA24i 2475 MHz



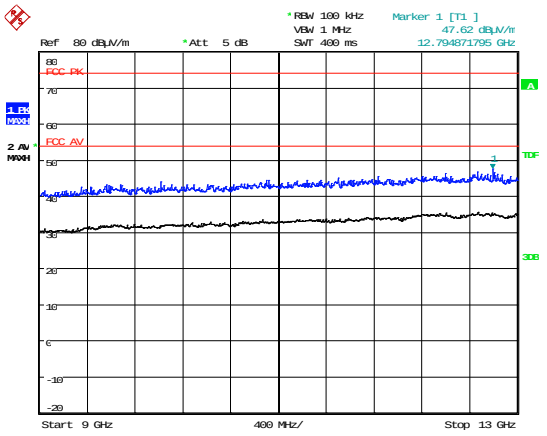
30 MHz to 1 GHz



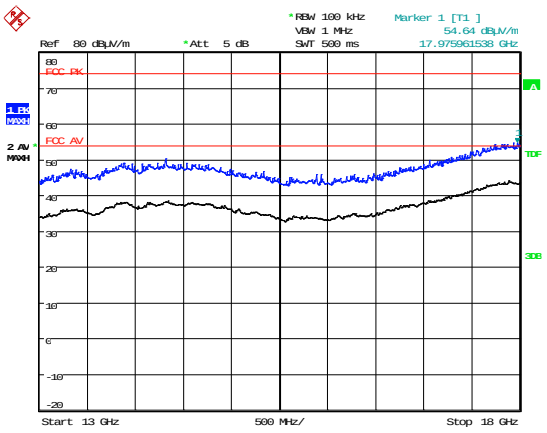
1 GHz to 5 GHz



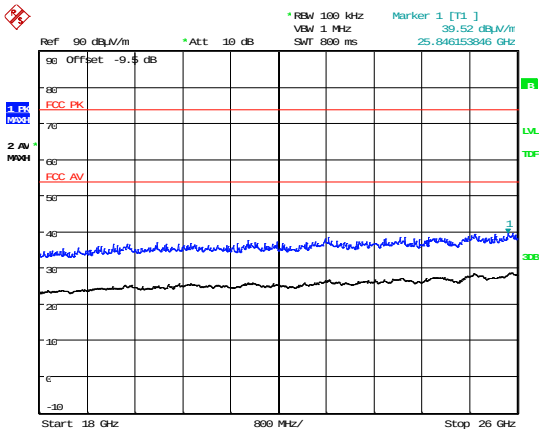
5 GHz to 9 GHz



9 GHz to 13 GHz

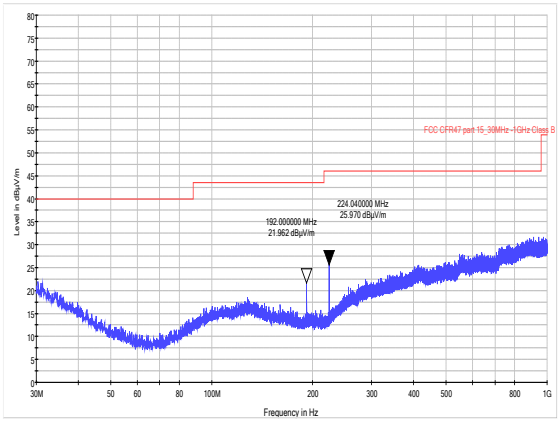


13 GHz to 18 GHz

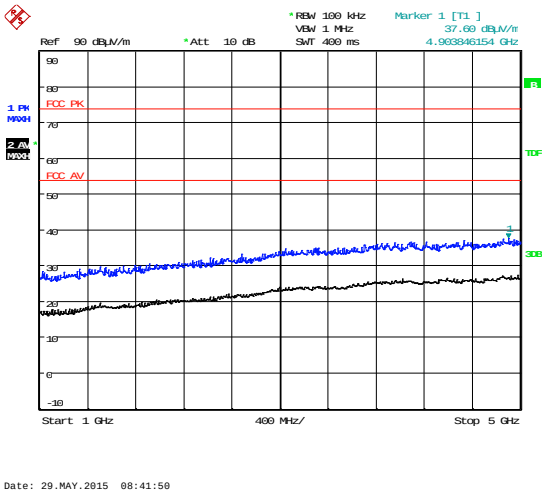


18 GHz to 25 GHz

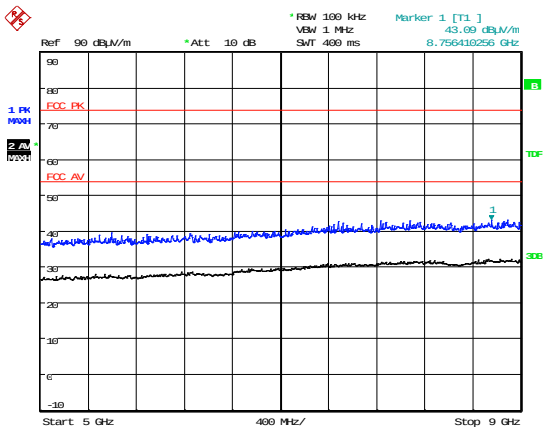
Unintentional Radiated Spurious Emissions - RA24e with Half Wave Antenna 2405 MHz



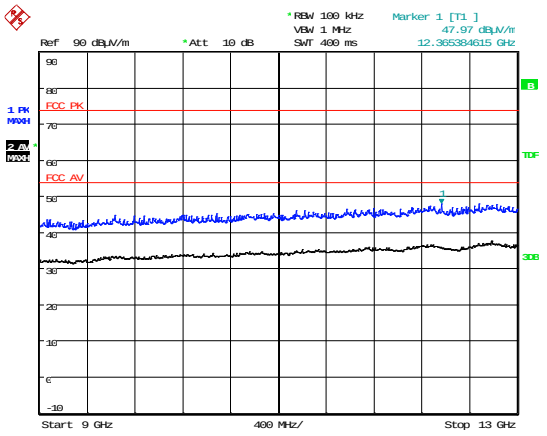
30 MHz to 1 GHz



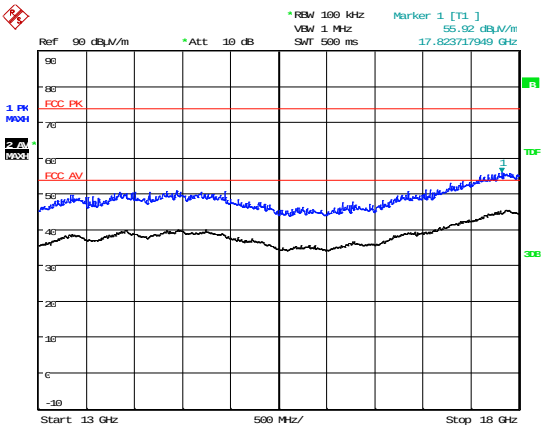
1 GHz to 5 GHz



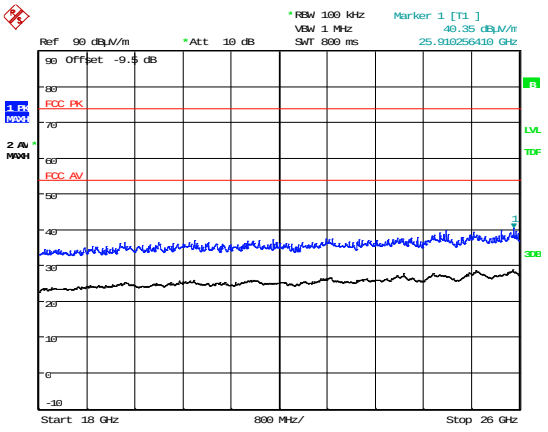
5 GHz to 9 GHz



9 GHz to 13 GHz

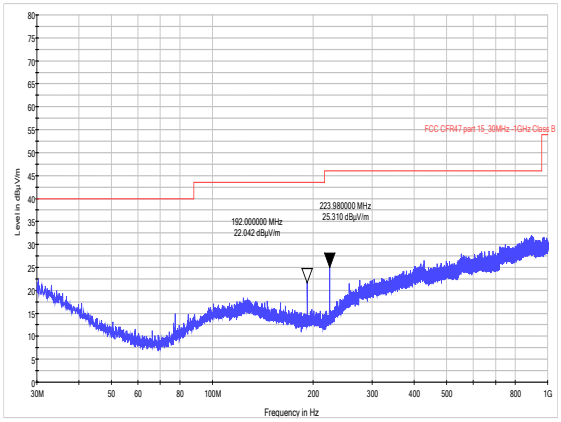


13 GHz to 18 GHz

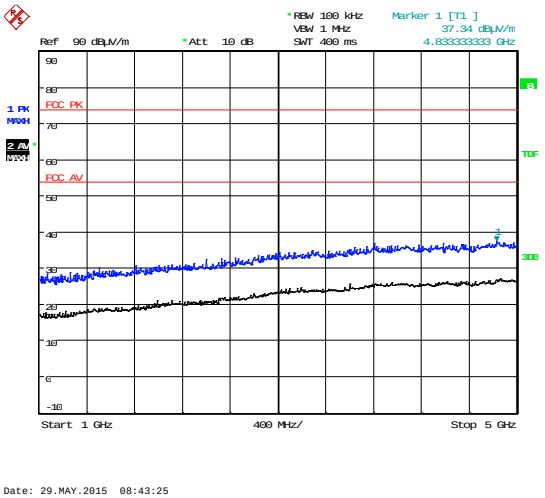


18 GHz to 25 GHz

Unintentional Radiated Spurious Emissions - RA24e with Half Wave Antenna 2440 MHz

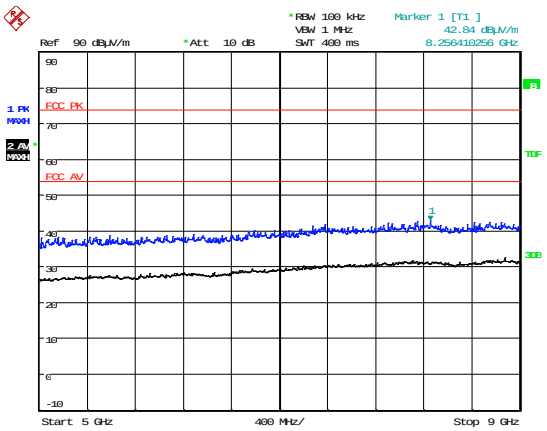


30 MHz to 1 GHz



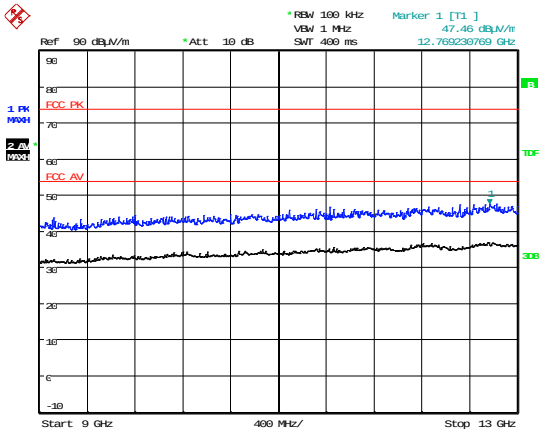
Date: 29.MAY.2015 08:43:25

1 GHz to 5 GHz



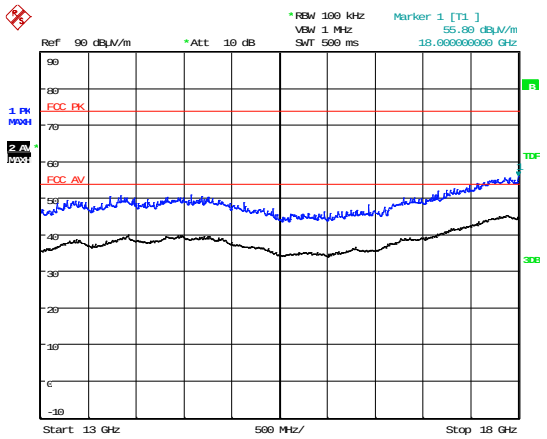
Date: 29.MAY.2015 08:43:52

5 GHz to 9 GHz



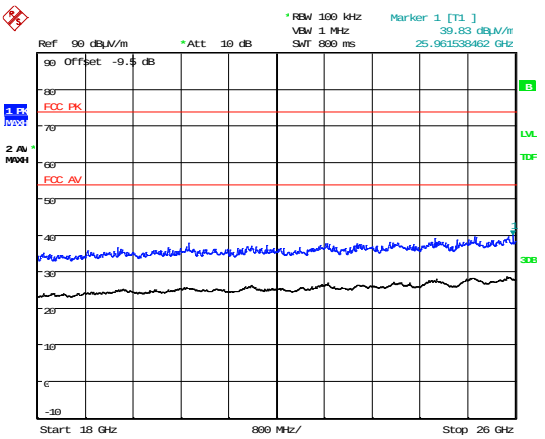
Date: 29.MAY.2015 08:44:20

9 GHz to 13 GHz



Date: 29.MAY.2015 08:45:09

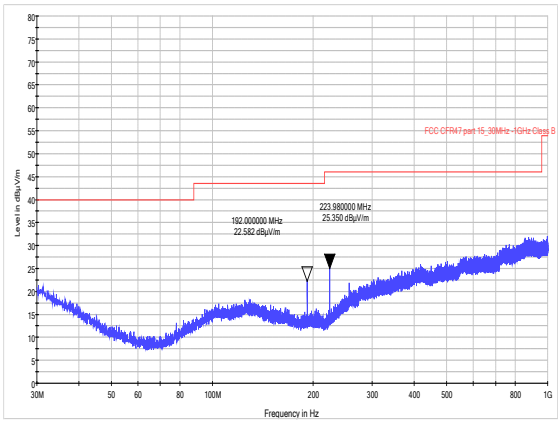
13 GHz to 18 GHz



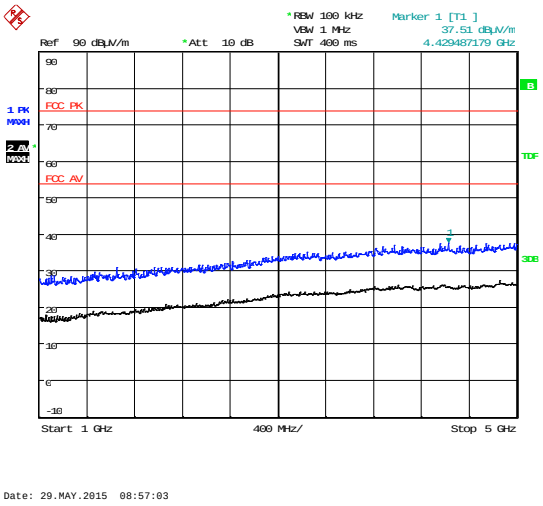
Date: 31.MAY.2015 16:21:44

18 GHz to 25 GHz

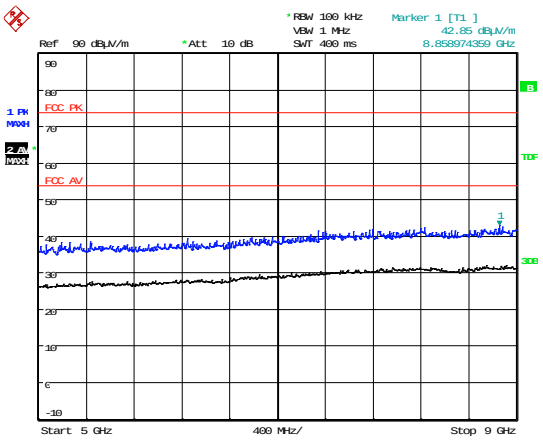
Unintentional Radiated Spurious Emissions - RA24e with Half Wave Antenna 2475 MHz



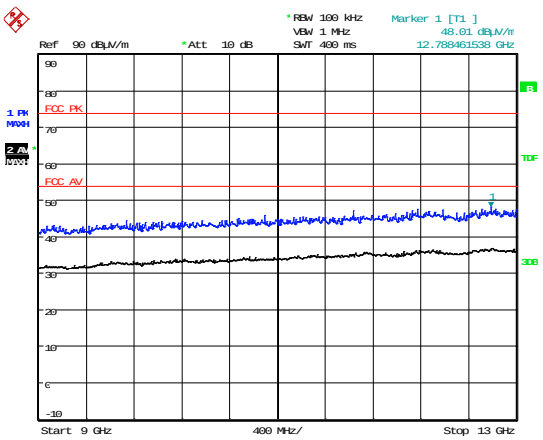
30 MHz to 1 GHz



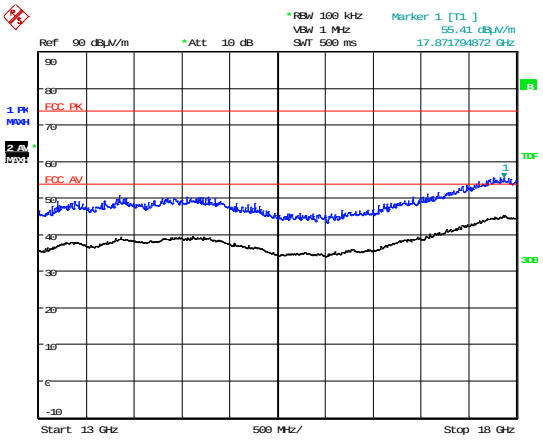
1 GHz to 5 GHz



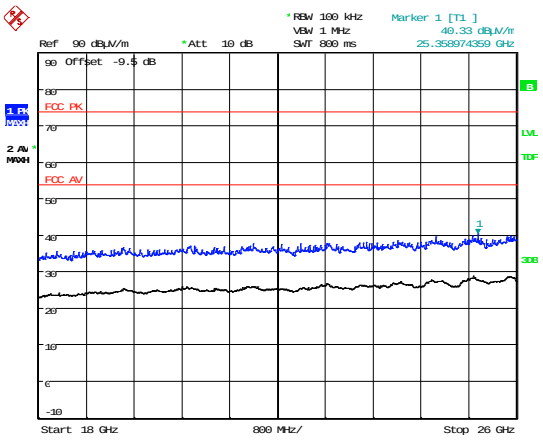
5 GHz to 9 GHz



9 GHz to 13 GHz

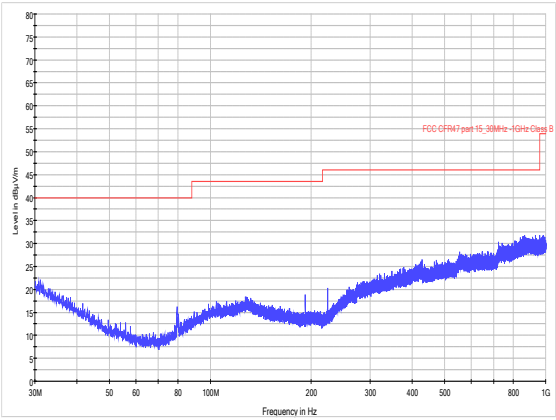


13 GHz to 18 GHz

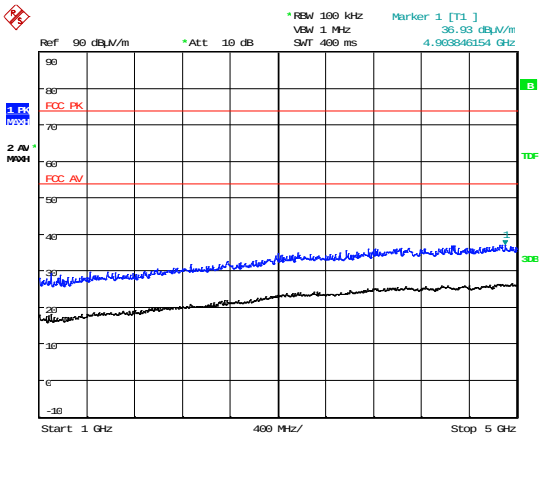


18 GHz to 25 GHz

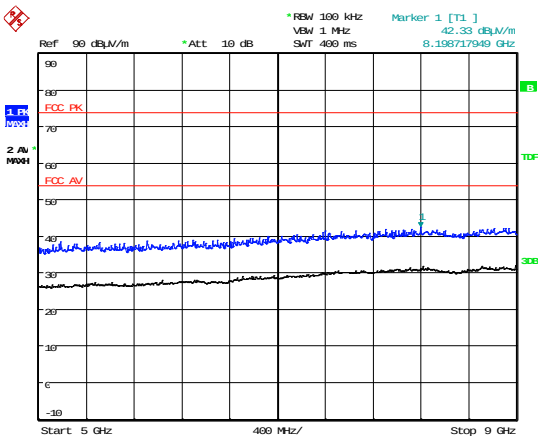
Unintentional Radiated Spurious Emissions - RA24e with F-Type Antenna 2405 MHz



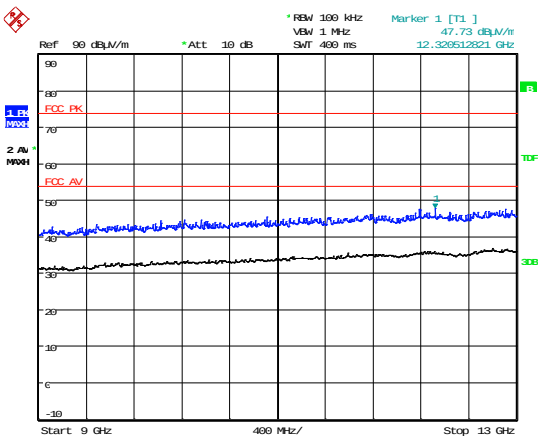
30 MHz to 1 GHz



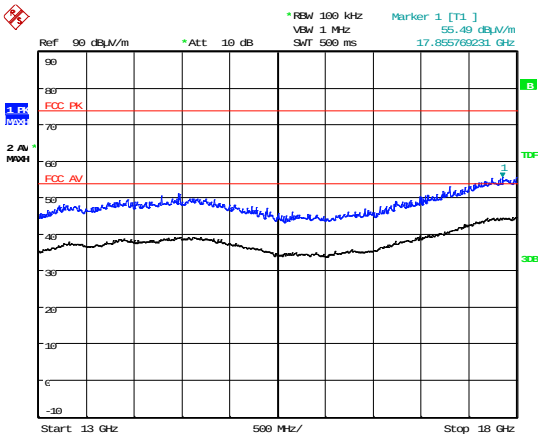
1 GHz to 5 GHz



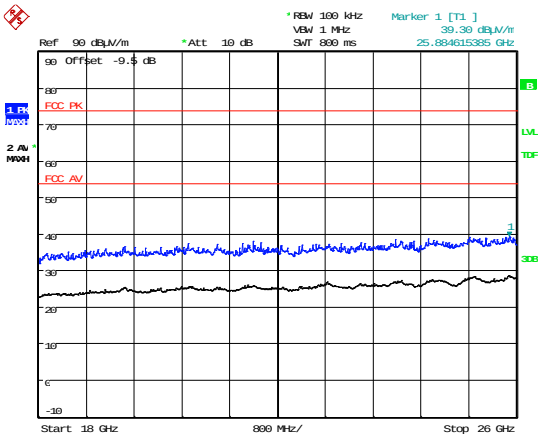
5 GHz to 9 GHz



9 GHz to 13 GHz

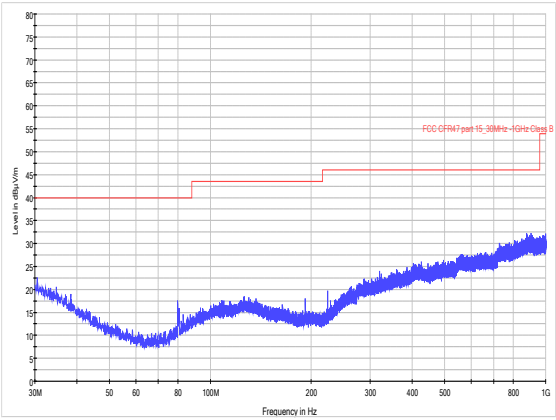


13 GHz to 18 GHz

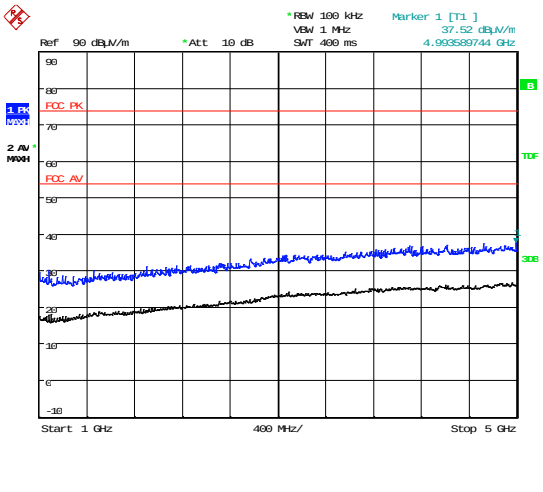


18 GHz to 25 GHz

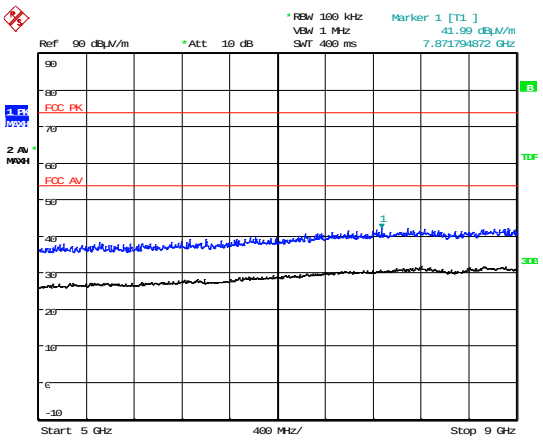
Unintentional Radiated Spurious Emissions - RA24e with F-Type Antenna 2440 MHz



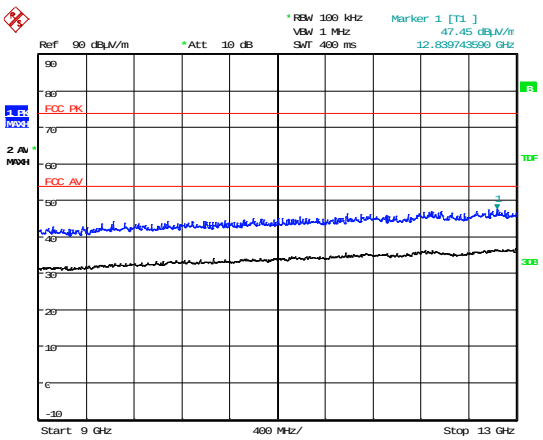
30 MHz to 1 GHz



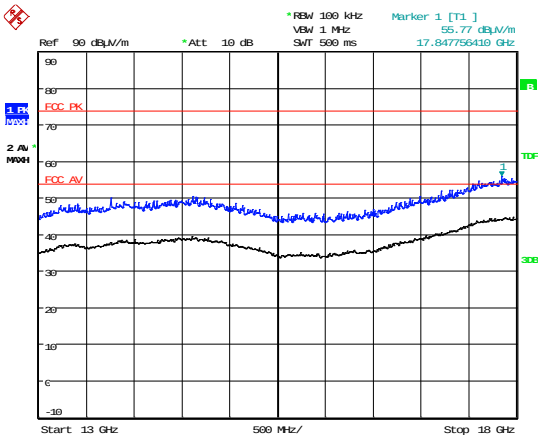
1 GHz to 5 GHz



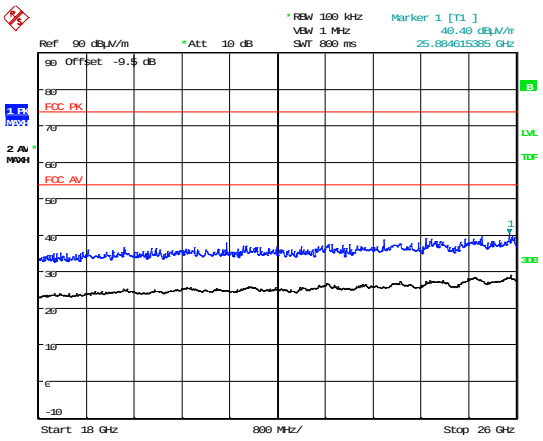
5 GHz to 9 GHz



9 GHz to 13 GHz

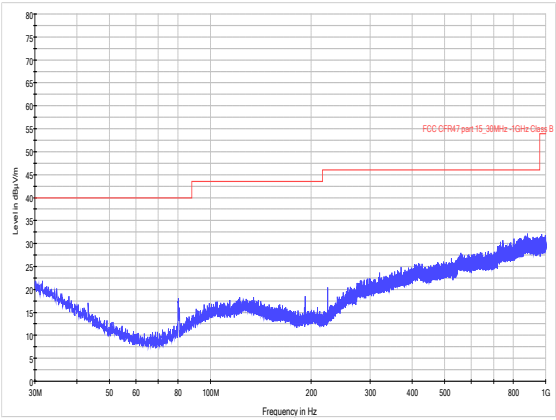


13 GHz to 18 GHz

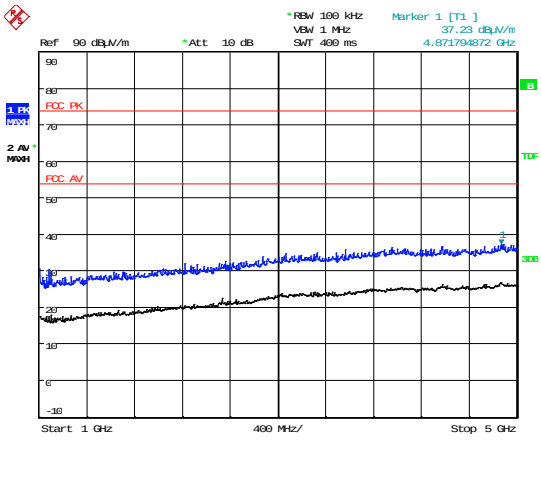


18 GHz to 25 GHz

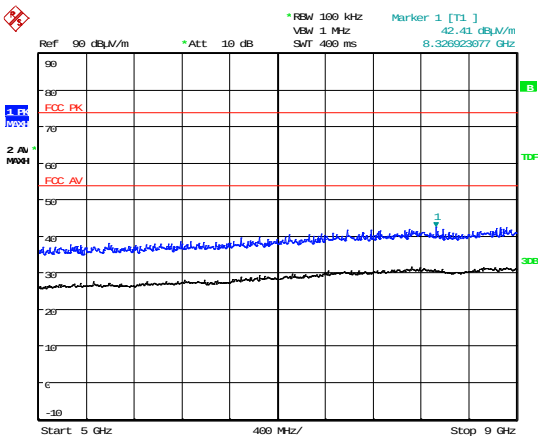
Unintentional Radiated Spurious Emissions - RA24e with F-Type Antenna 2475 MHz



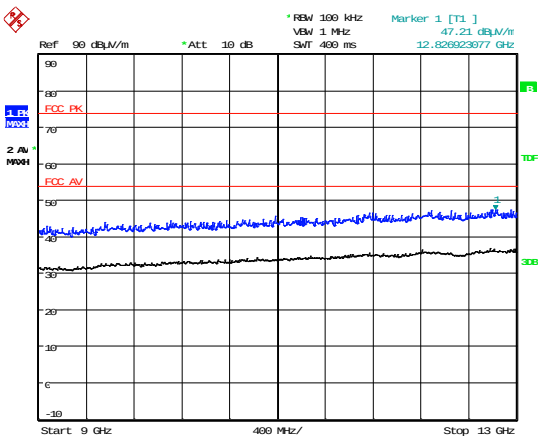
30 MHz to 1 GHz



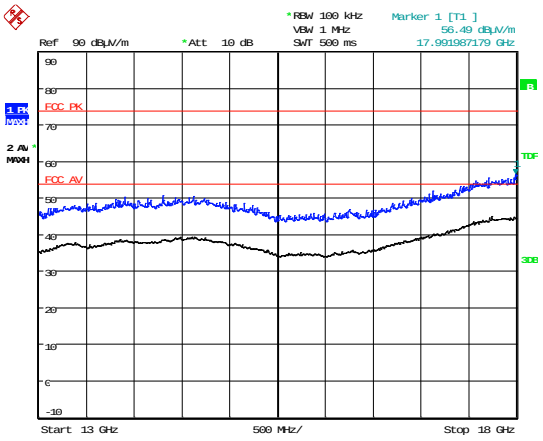
1 GHz to 5 GHz



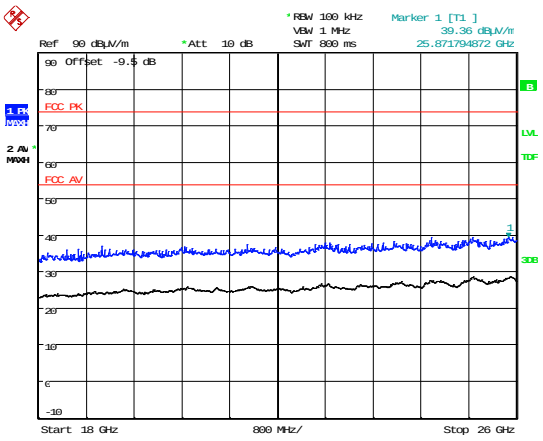
5 GHz to 9 GHz



9 GHz to 13 GHz



13 GHz to 18 GHz



18 GHz to 25 GHz

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
S16	RA24i	None
S18	RA24e	None
S07	Dipole ½ wave Whip antenna ((ANT-2.4-CW-RCT-RP) with a 100mm long U.FL to RSMA Cable	None
S14	F-Type Antenna (ANTA rev B) with a 60mm long U.FL to U.FL cable	None

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

Sample No.	Description	Identification
S10	RA24 Base Station	None

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

Identification	Description
None	Hp Laptop

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 carrier with and without modulation on bottom, middle and top channels as required. Power setting on software: 18

Test	Description of Operating Mode: Receive
Receiver radiated spurious emissions	EUT in receive mode on bottom, middle and top channels.

Test	Description of Operating Mode: Transmit and Receive mode
PLCE	EUT in transmit and receive modes.

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 : S16
Tests : Radiated

Port	Description of Cable Attached	Cable length	Equipment Connected
None			

Sample : S18 (with Half Wave Antenna)
Tests : Radiated

Port	Description of Cable Attached	Cable length	Equipment Connected
Antenna	U.FL to RSMA cable	100 mm	S07

Sample : S18 (with F-Type Antenna)
Tests : Radiated, Power line

Port	Description of Cable Attached	Cable length	Equipment Connected
Antenna	UF.L to UF.L cable	60 mm	S14

Sample : S18
Tests : Conducted

Port	Description of Cable Attached	Cable length	Equipment Connected
Antenna	U.FL Cable to SMA cable	50 mm	Measurement system

C5) Details of Equipment Used

TRaC No	Equipment Type	Equipment Description	Manufacturer	Last Cal Calibration	Calibration Period	Due For Calibration
UH003	ESHS10	Receiver	R&S	03/07/2014	12	03/07/2015
UH093	CBL6112B	Bilog	Chase	08/07/2013	24	08/07/2015
UH191	CBL611/A	Bilog	Chase	26/02/2015	24	26/02/2017
UH281	FSU46	Spectrum Analyser	R&S	24/04/2015	12	24/04/2016
UH387	ATS	Chamber 1	Rainford EMC	06/09/2014	12	06/09/2015
UH387	ATS	IC Reg - Chamber 1	Rainford EMC	19/11/2014	36	19/11/2017
UH396	ENV216	Lisn	R&S	22/05/2014	12	22/05/2015
UH405	FSU26	Spectrum Analyser	R&S	11/05/2015	12	11/05/2016
L138	3115	1-18GHz Horn	EMCO	17/10/2013	24	17/10/2015
L300	20240-20	Horn 18-26GHz (&UH330)	Flann	10/02/2014	24	10/02/2016
L317	ESVS10	Receiver	R&S	26/02/2015	12	26/02/2016
L352	ESVS10	Receiver	R&S	26/03/2015	12	26/03/2016
L572	8449B	Pre Amp	Agilent	10/02/2015	12	10/02/2016
REF909	FSU26	Spectrum Analyser	R&S	13/02/2015	12	13/02/2016
REF916	SMBV100A	Signal Generator	R&S	17/02/2015	12	17/02/2016
REF940	ATS	Radio Chamber - PP	Rainford EMC	08/09/2014	24	08/09/2016
REF940	ATS	IC Reg Radio Chamber - PP	Rainford EMC	19/11/2014	36	19/11/2017
REF977	SH4141	High Pass Filter	BSC	25/02/2015	24	25/02/2017

Appendix D: Additional Information

No additional information is included within this test report.

Appendix E: Calculation of the duty cycle correction factor

Using a spectrum analyser in zero span mode, centred on the fundamental carrier frequency with a RBW of 1MHz and a video Bandwidth of 1MHz the sweep time is set accordingly to capture the pulse train. The transmit pulse widths and period is measured. Any applicable plot will be contained in appendix B of this test report.

If the pulse train is less than 100 ms, including blanking intervals, the duty cycle is calculated by averaging the sum of the pulse widths over one complete pulse train. However if the pulse train exceeds 100ms then the duty cycle is calculated by averaging the sum of the pulse widths 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 100 ms), divided by the length of the period (or 100 ms). The duty cycle correction factor is 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)

For the pulse train period greater than 100 ms

Duty cycle = (the sum of the highest average value pulse widths over 100ms) / 100 ms

e.g.

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

0.07459 Or 7.459 %

So

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

Duty cycle correction may not be applicable / required by the device covered in this report. The correction factor above is for example of how the correction is calculated. Any applicable duty cycle used will be recorded in the relevant results sections of this report.

Appendix F: Photographs and Figures

The following photographs were taken of the test samples:

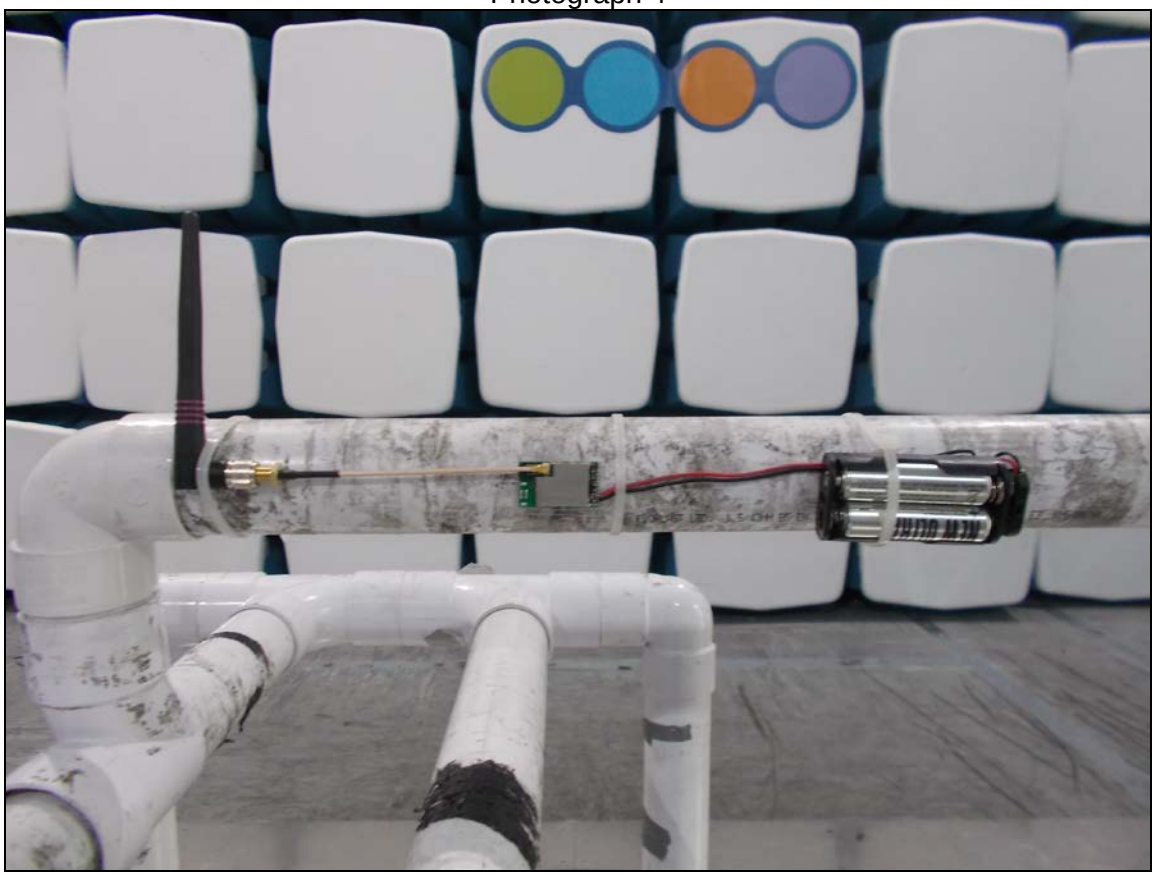
1. Radiated electric field emissions arrangement – RA24i : overview
2. Radiated electric field emissions arrangement – RA24i : close up
3. Radiated electric field emissions arrangement – RA24e With Half Wave Antenna : overview
4. Radiated electric field emissions arrangement – RA24e With Half Wave Antenna : close up
5. Radiated electric field emissions arrangement – RA24e with F-Type Antenna : overview
6. Radiated electric field emissions arrangement – RA24e with F-Type Antenna : close up

Photograph 1

Photograph 2

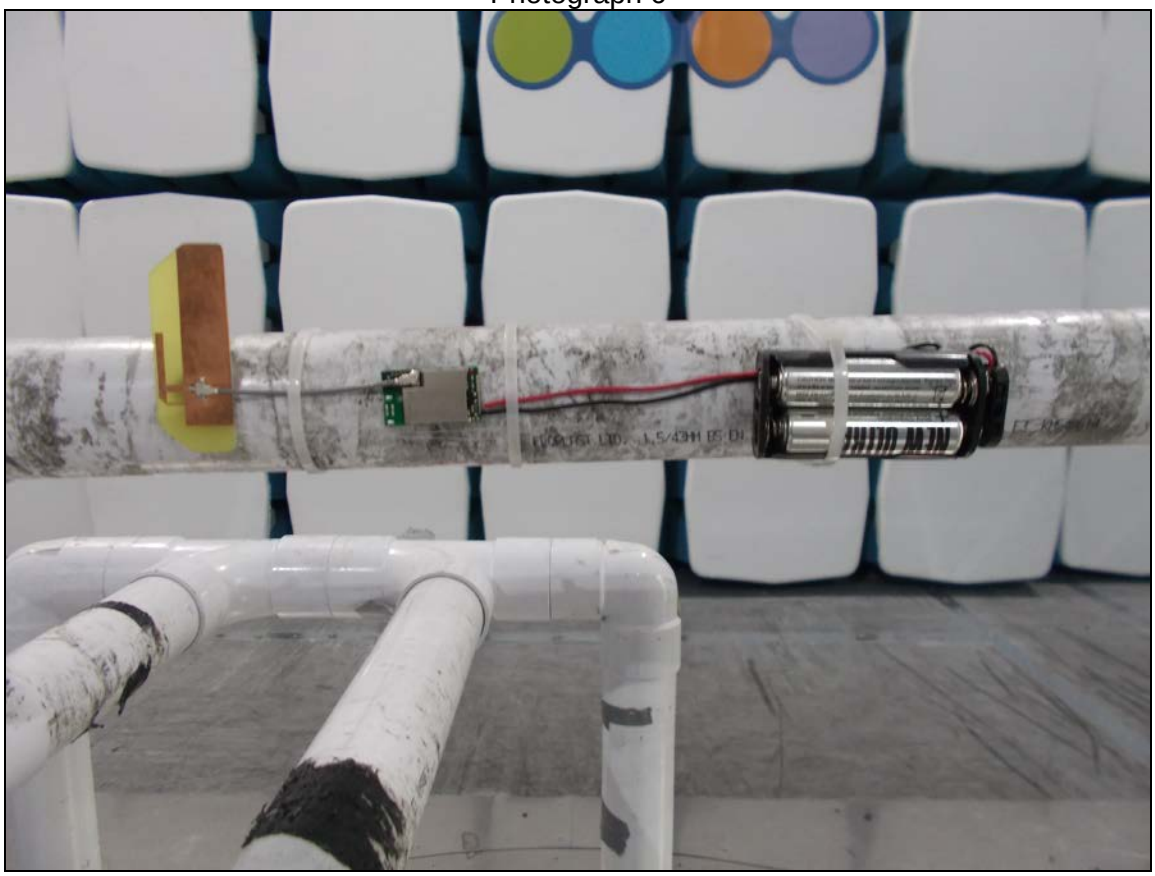
Photograph 3

Photograph 4



Photograph 5

Photograph 6



Appendix G: General SAR test reduction & exclusion guidance and MPE calculation

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

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

The SAR Test Exclusion Threshold for 100 MHz to 6 GHz will be determined as follows.

SAR Exclusion Threshold (SARET) = 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) (including tune-up tolerance)
TSD^{A} = Min Test separation Distance or 50 mm (whichever is lower) = 50 mm

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

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

For Distances Greater than 50 mm Step 2 applies

Step 2

$$(TSD^{B} - 50mm) * 10$$

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

Note: Step 2 doesn't apply here as the TSD^{A} is less than 50 mm

Operating Frequency 2405 MHz

SARET = [(3.0 x 50) / √0.2405]
SARET = 96.58 mW

Operating Frequency 2440 MHz

SARET = [(3.0 x 50) / √0.2440]
SARET = 96.03 mW

Operating Frequency 2475 MHz

SARET = [(3.0 x 50) / √0.2475]
SARET = 95.35 mW

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold (mW)	SAR Evaluation
2405.0	44.06	96.72	Not Required
2440.0	44.36	96.03	Not Required
2475.0	45.39	95.35	Not Required

Note: EIRP was calculated by addition of the maximum conducted carrier power and the maximum antenna gain (3 dBi).

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

Appendix H: MPE Calculation

Prediction of MPE limit at a given distance

For purposes of these requirements mobile devices are defined by the FCC and Industry Canada 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 under FCC and Industry Canada rules 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, as required under FCC and Industry Canada rules.

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

FCC Result

Prediction Frequency (MHz)	EIRP (mW)	Power density limit (S) (mW/cm^2)	Distance (R) cm required to be less than power density limit
2475.0	45.39	1.00	1.91

IC Result

Prediction Frequency (MHz)	EIRP (W)	Exemption Limit (W)	Result
2475.0	0.045	2.684	Exempt

Note: EIRP was calculated by addition of the maximum conducted carrier power (13.57 dBm) and the maximum antenna gain (3 dBi).

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