

Report on the Radio Testing

For

Pace plc

on

Xi5

Report no. TRA-029286-02-45-01A

23rd May 2016

RF915 3.0

Report Number: TRA-029286-02-45-01A  
Issue: A

REPORT ON THE RADIO TESTING OF A  
Pace plc  
Xi5  
WITH RESPECT TO SPECIFICATION  
FCC 47CFR 15.247

TEST DATE: 01st March - 15th April 2016

Written by: A Tosif

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Radio Test Engineer

Approved by:

J Charters  
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Date: 23rd May 2016

Disclaimers:

- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE  
[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

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RF915 3.0

## 1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	23rd May 2016	Original

## 2 Summary

TEST REPORT NUMBER: TRA-029286-02-45-01A

WORKS ORDER NUMBER TRA-029286-02

PURPOSE OF TEST: Certification

TEST SPECIFICATION(S): 47CFR15.247

EQUIPMENT UNDER TEST (EUT): Xi5

FCC IDENTIFIER: NQ8PX051AEI

EUT SERIAL NUMBER: PAW400000737 & PAW400000759

MANUFACTURER/AGENT: Pace plc

ADDRESS: Victoria Road  
Saltaire  
Shipley  
West Yorkshire  
BD18 3LF  
United Kingdom

CLIENT CONTACT: James Humphrey  
☎ 01274 537259  
✉ James.Humphrey1@pace.com

ORDER NUMBER: 5185322

TEST DATE: 01st March - 15th April 2016

TESTED BY: A Tosif  
Element

## 2.1 Test Summary

Test Method and Description		Requirement Clause		Applicable to this equipment	Result / Note
		RSS	47CFR15		
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		Gen, 8.10	15.205	<input checked="" type="checkbox"/>	Pass
AC power line conducted emissions		Gen, 8.8	15.207	<input type="checkbox"/>	Note 1
Occupied bandwidth		247, 5.2 (1) / 6.1.4(1)	15.247(a)(2)	<input checked="" type="checkbox"/>	Pass
Conducted carrier power	Peak	247, 5.4 (4) / 6.2.4 (1)	15.247(b)(3)	<input checked="" type="checkbox"/>	Pass
	Max.			<input type="checkbox"/>	
Conducted / radiated RF power out-of-band		247, 5.5 / 6.2.4 (2)	15.247(d)	<input checked="" type="checkbox"/>	Pass
Power spectral density, conducted		247, 5.2 (2)	15.247(e)	<input checked="" type="checkbox"/>	Pass

### Notes:

1. See Test report TRA-029286-02-45-03A. AC Power line Conducted emissions were recorded with all radio devices active simultaneously

The results contained in this report relate only to the items tested, in the condition at time of test, 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. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

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## 4 Introduction

This report TRA-029286-02-45-01A presents the results of the RF4CE Radio testing on a Pace plc, Xi5 to specification 47CFR15 Radio Frequency Devices and RSS-247 Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices.

The testing was carried out for Pace plc by Element, at the address(es) detailed below.

- |   |   |
|---|---|
| <input checked="" type="checkbox"/> Element Hull<br>Unit E<br>South Orbital Trading Park<br>Hedon Road<br>Hull<br>HU9 1NJ<br>UK | <input type="checkbox"/> Element Skelmersdale<br>Unit 1<br>Pendle Place<br>Skelmersdale<br>West Lancashire<br>WN8 9PN<br>UK |
|---|---|

This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

All test and measurement equipment under the control of the laboratory and requiring calibration is subject to an established programme and procedures to control and maintain measurement standards. The quality management system meets the principles of ISO 9001, and has quality control procedures for monitoring the validity of tests undertaken. Records and sufficient detail are retained to establish an audit trail of calibration records relating to its test results for a defined period. Under control of the established calibration programme, key quantities or values of the test & measurement instrumentation are within specification and comply with the relevant traceable internationally recognised and appropriate standard specifications, which are UKAS calibrated as such where these properties have a significant effect on results. Participation in inter-laboratory comparisons and proficiency testing ensures satisfactory correlation of results conform to Elements own procedures, as well as statistical techniques for analysis of test data providing the appropriate confidence in measurements.

Throughout this report EUT denotes equipment under test.

### FCC Site Listing:

Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

### IC Registration Number(s):

Element Hull	3483A
Element Skelmersdale	3930B

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

## 5 Test Specifications

### 5.1 Normative References

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
- Industry Canada RSS-247, Issue 1, May 2015 – Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- Industry Canada RSS-Gen, Issue 4, November 2014 – General Requirements for Compliance of Radio Apparatus

### 5.2 Deviations from Test Standards

There were no deviations from the test standard.



## 6 Glossary of Terms

<b>§</b>	denotes a section reference from the standard, not this document
<b>AC</b>	Alternating Current
<b>ANSI</b>	American National Standards Institute
<b>BW</b>	bandwidth
<b>C</b>	Celsius
<b>CFR</b>	Code of Federal Regulations
<b>CW</b>	Continuous Wave
<b>dB</b>	decibel
<b>dBm</b>	dB relative to 1 milliwatt
<b>DC</b>	Direct Current
<b>DSSS</b>	Direct Sequence Spread Spectrum
<b>EIRP</b>	Equivalent Isotropically Radiated Power
<b>ERP</b>	Effective Radiated Power
<b>EUT</b>	Equipment Under Test
<b>FCC</b>	Federal Communications Commission
<b>FHSS</b>	Frequency Hopping Spread Spectrum
<b>Hz</b>	hertz
<b>IC</b>	Industry Canada
<b>ITU</b>	International Telecommunication Union
<b>LBT</b>	Listen Before Talk
<b>m</b>	metre
<b>max</b>	maximum
<b>MIMO</b>	Multiple Input and Multiple Output
<b>min</b>	minimum
<b>MRA</b>	Mutual Recognition Agreement
<b>N/A</b>	Not Applicable
<b>PCB</b>	Printed Circuit Board
<b>PDF</b>	Portable Document Format
<b>Pt-mpt</b>	Point-to-multipoint
<b>Pt-pt</b>	Point-to-point
<b>RF</b>	Radio Frequency
<b>RH</b>	Relative Humidity
<b>RMS</b>	Root Mean Square
<b>Rx</b>	receiver
<b>s</b>	second
<b>SVSWR</b>	Site Voltage Standing Wave Ratio
<b>Tx</b>	transmitter
<b>UKAS</b>	United Kingdom Accreditation Service
<b>V</b>	volt
<b>W</b>	watt
<b>Ω</b>	ohm

## 7 Equipment Under Test

### 7.1 EUT Identification

- Name: Xi5
- Serial Number: PAW400000737 & PAW400000759
- Model Number: PX051AEI
- Software Revision: Not Applicable
- Build Level / Revision Number: DV

Incorporating the following external interconnecting cables, ports or terminals:

	<i>Description</i>	<i>Cable Type</i>	<i>Test Length</i>	<i>Max. Length</i>
1	DC input	2 core unshielded	1.5m	1.5m
2	Ethernet	CAT5e UTP	10m	>3m
3	HDMI in	HDMI unshielded	1m	1m
4	HDMI out	HDMI unshielded	1m	1m
5	Micro USB*	None	N/A	N/A

\*The micro USB port is not used in normal operation, so it wasn't terminated during the testing.

### 7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

EPS-2 (AC Adapter)  
 Pace HDMI Input Load  
 Sharp Television  
 Dell Latitude Laptop  
 Dell AC/DC Adapter

### 7.3 EUT Mode of Operation

#### 7.3.1 Transmission

EUT was transmitting permanent modulated carrier using GFSK, QPSK and 8PPSK modulation on bottom, middle and top channels with and without hopping as required. The power setting on the test software (i.e. DigDebug) was set to 007.

#### 7.3.2 Reception

This report covers transmitter operation only, results for unintentional emissions can be found in test report TRA-029286-44-00A.

## 7.4 EUT Radio Parameters

### 7.4.1 General

<b>Frequency of operation:</b>	2400 – 2483.5 MHz
<b>Modulation type(s):</b>	RF4CE
<b>Occupied channel bandwidth(s):</b>	2 MHz
<b>Channel spacing:</b>	5 MHz
<b>Declared output power(s):</b>	7 dBm
<b>Warning against use of alternative antennas in user manual (yes/no):</b>	Not Applicable
<b>Nominal Supply Voltage:</b>	110 Vac
<b>Duty cycle:</b>	Up to 100%

### 7.4.2 Product specific declarations

<b>Multiple antenna configuration(s), e.g. MIMO:</b>	Not Applicable
<b>Fixed pt-pt operations (yes/no):</b>	No
<b>Installation manual advice on pt-pt operational restrictions (yes/no):</b>	Not Applicable
<b>Fixed pt-mpt operations (yes/no):</b>	Not Applicable
<b>Simultaneous tx (yes/no):</b>	Yes

### 7.4.3 Antennas

<b>Frequency range:</b>	2400 – 2483.5 MHz
<b>Impedance:</b>	50 Ohms
<b>Gain:</b>	See Table on the next page
<b>Polarisation:</b>	Omni
<b>Beam width:</b>	Not Applicable
<b>Mounting:</b>	Case Mounted

Frequency [MHz]	BT [%]	RF4CE [%]
2350	2.0	1.0
2360	2.0	0.9
2370	2.0	0.8
2380	2.0	0.8
2390	1.8	0.9
2400	1.7	0.8
2410	1.7	1.1
2420	1.7	1.4
2430	1.6	1.7
2440	1.6	1.9
2450	1.6	2.2
2460	1.5	2.3
2470	1.4	2.3
2480	1.3	2.2
2490	1.4	2.1
2500	1.3	2.0
2510	1.3	2.0
2520	1.3	2.0
2530	1.2	1.8
2540	1.2	1.4
2550	1.1	1.2
<b>Average</b>	<b>1.6</b>	<b>1.8</b>

### 7.5 EUT Description

The EUT is a set top box with one HDMI output for connection to a television. The EUT can accept inputs from Wi-Fi, HDMI and Ethernet. The EUT is controlled by remote control over RF4CE and/or Bluetooth.

## **8 Modifications**

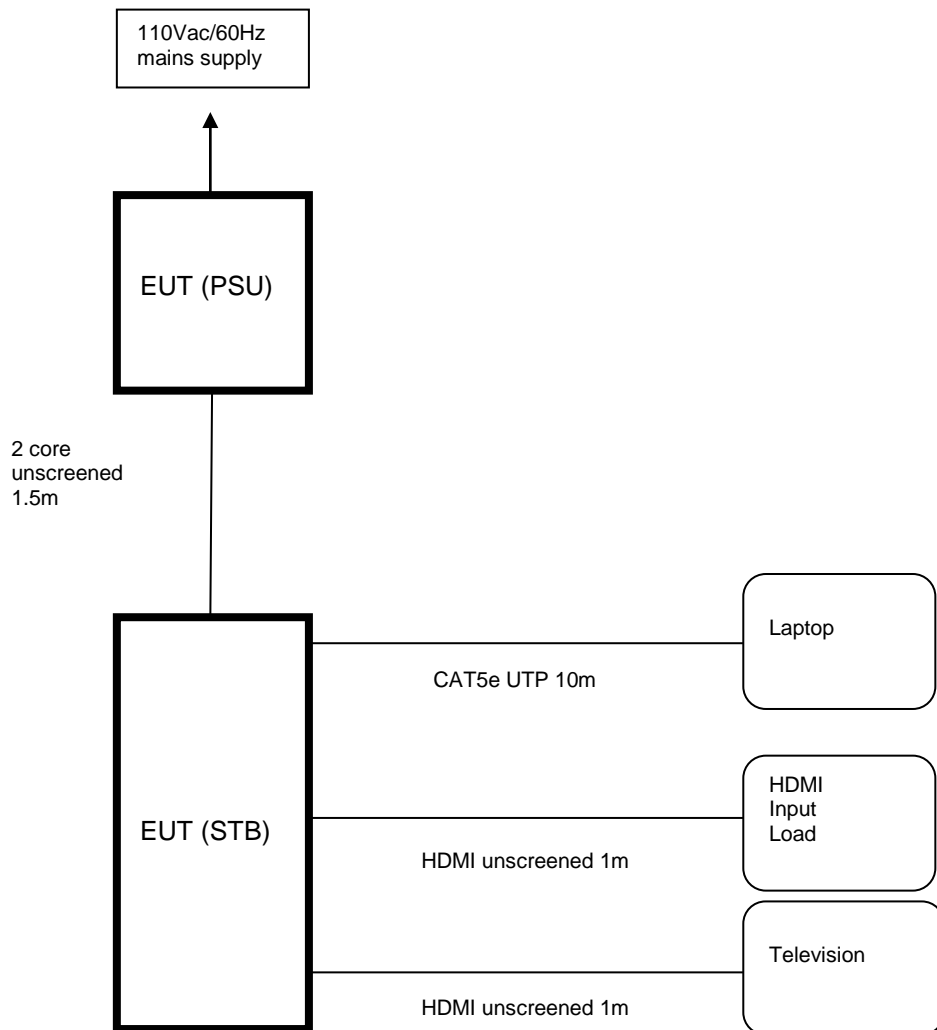
No modifications were performed during this assessment.

## 9 EUT Test Setup

### 9.1 Block Diagram

The following diagram shows basic EUT interconnections with cable type and cable lengths identified:

The following diagram shows basic EUT interconnections with major functional component units, cable type and cable lengths identified in Section **Error! Reference source not found.**



## 10 General Technical Parameters

### 10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 110 Vac from the mains.

### 10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band and the manufacturer has declared sufficient frequency stability (refer to section 7.4).

Variation of supply voltage is required to ensure stability of the declared output power. During carrier power testing the following variations were made:

	<b>Category</b>	<b>Nominal</b>	<b>Variation</b>
<input checked="" type="checkbox"/>	Mains	110 V ac +/-2 %	85 % and 115 %
<input type="checkbox"/>	Battery	New battery	N/A

## 11 Radiated emissions

### 11.1 Definitions

#### *Spurious emissions*

Emissions on a frequency or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

#### *Restricted bands*

A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

### 11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	REF886
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	2425 MHz / 2450 MHz / 2475 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: RMS average and Peak

#### **Environmental Conditions (Normal Environment)**

Temperature: 26 °C	+15 °C to +35 °C (as declared)
Humidity: 22 %RH	20%RH to 75%RH (as declared)
Supply: 110 Vac	110 Vac +/-10% (as declared)

#### **Test Limits**

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

#### **General Field Strength Limits for License-Exempt Transmitters at Frequencies Above 30 MHz**

<i>Frequency (MHz)</i>	<i>Field Strength (<math>\mu\text{V/m}</math> at 3m)</i>
30-88	100
88-216	150
216-960	200
Above 960	500



### 11.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

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. Pre-scan plots are shown with a peak detector and 100kHz RBW.

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).

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 degrees 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.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dB $\mu$ V/m at the regulatory distance, using:

$$FS = PR + CL + AF - PA + DC - CF$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dB $\mu$ V;

CL is the cable loss in dB;

AF is the test antenna factor in dB/m;

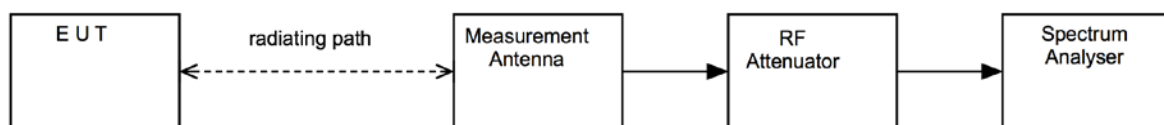
PA is the pre-amplifier gain in dB (where used);

DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

CF is the distance factor in dB (where measurement distance different to limit distance);

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

**Figure i Test Setup**



## 11.4 Test Equipment

<b>Equipment Description</b>	<b>Manufacturer</b>	<b>Equipment Type</b>	<b>Element No</b>	<b>Last Cal Calibration</b>	<b>Calibration Period</b>	<b>Due For Calibration</b>
Ferrite Lined Chamber	Rainford	ATS	REF886	21/07/2014	24	21/07/2016
Spectrum Analyser	R&S	FSU46	REF910	28/05/2015	12	28/05/2016
EMI Test Receiver	R&S	ESVS20	RFG126	17/04/2015	12	17/04/2016
Biconical Antenna	EMCO	3109	RFG095	09/05/2013	36	09/05/2016
Log Periodic Antenna	EMCO	3146	RFG191	09/05/2013	36	09/05/2016
Horn Antenna	EMCO	3115	RFG129	09/02/2016	24	09/02/2018
Horn Antenna	Q-Par	n/a	RFG629	30/09/2015	24	30/09/2017
Pre-Amp (9kHz – 1GHz)	Sonoma	310	REF927	01/07/2014	24	01/07/2016
Pre-Amp (1 – 26.5GHz)	Agilent	8449B	REF913	02/02/2016	24	02/02/2018

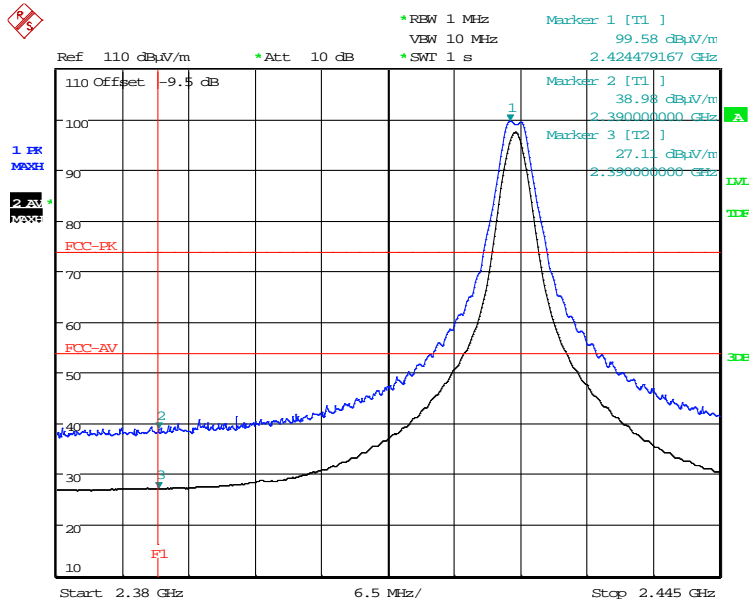
## 11.5 Test Results

<b>Channel: 2425 MHz</b>										
<b>Detector</b>	<b>Freq. (MHz)</b>	<b>Meas'd Emission (dBµV)</b>	<b>Cable Loss (dB)</b>	<b>Antenna Factor (dB/m)</b>	<b>Pre-amp Gain (dB)</b>	<b>Duty Cycle Corr'n (dB)</b>	<b>Distance Extrap'n Factor (dB)</b>	<b>Field Strength (dBµV/m)</b>	<b>Field Strength (µV/m)</b>	<b>Limit (µV/m)</b>
No emissions were detected within 20 dB of the limit										

<b>Channel: 2450 MHz</b>										
<b>Detector</b>	<b>Freq. (MHz)</b>	<b>Meas'd Emission (dBµV)</b>	<b>Cable Loss (dB)</b>	<b>Antenna Factor (dB/m)</b>	<b>Pre-amp Gain (dB)</b>	<b>Duty Cycle Corr'n (dB)</b>	<b>Distance Extrap'n Factor (dB)</b>	<b>Field Strength (dBµV/m)</b>	<b>Field Strength (µV/m)</b>	<b>Limit (µV/m)</b>
No emissions were detected within 20 dB of the limit										

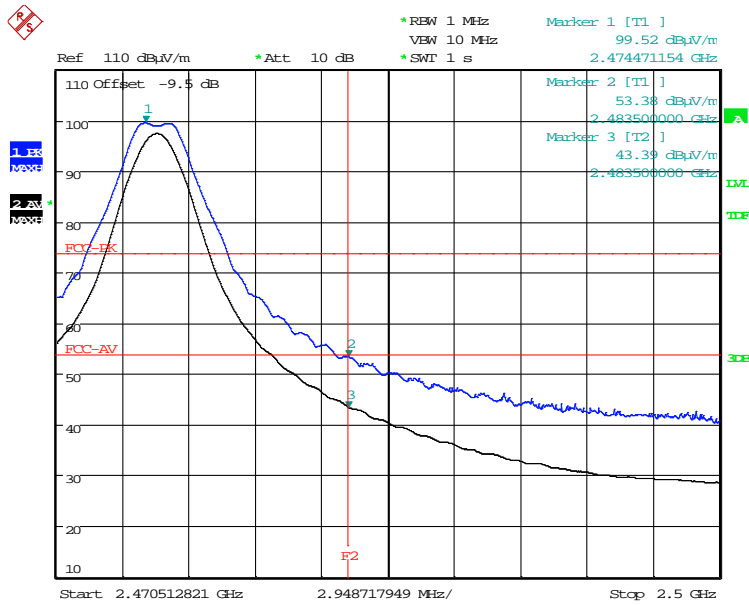
<b>Channel: 2475 MHz</b>										
<b>Detector</b>	<b>Freq. (MHz)</b>	<b>Meas'd Emission (dBµV)</b>	<b>Cable Loss (dB)</b>	<b>Antenna Factor (dB/m)</b>	<b>Pre-amp Gain (dB)</b>	<b>Duty Cycle Corr'n (dB)</b>	<b>Distance Extrap'n Factor (dB)</b>	<b>Field Strength (dBµV/m)</b>	<b>Field Strength (µV/m)</b>	<b>Limit (µV/m)</b>
No emissions were detected within 20 dB of the limit										

### Radiated Bandedge Compliance



Date: 2.MAR.2016 11:24:11

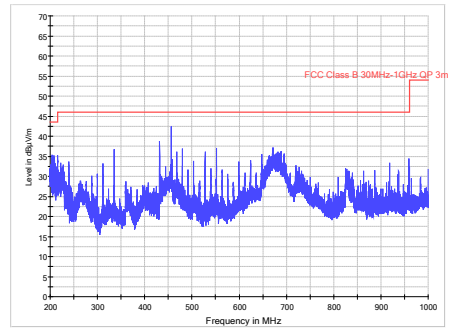
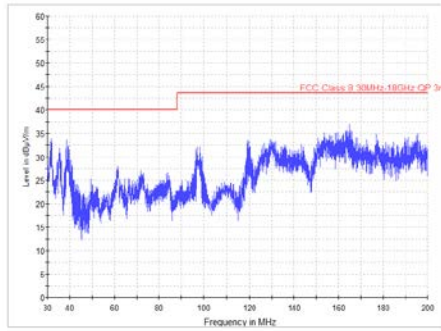
### Lower Bandedge



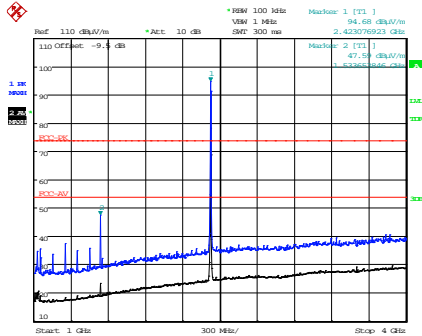
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### Upper Bandedge

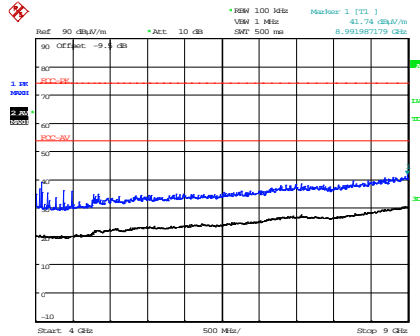
## Radiated Spurious Emission - 2425 MHz



### 30 MHz – 200 MHz

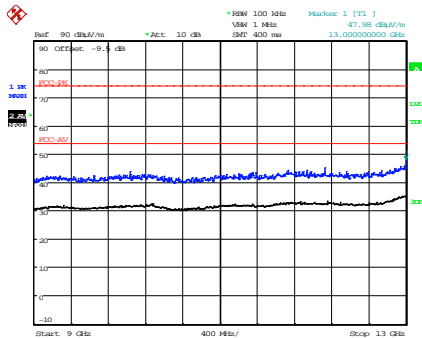


### 200 MHz – 1 GHz



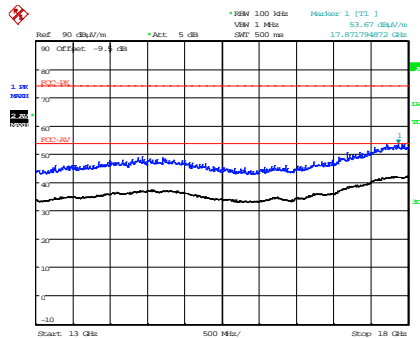
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### 1 GHz – 4 GHz



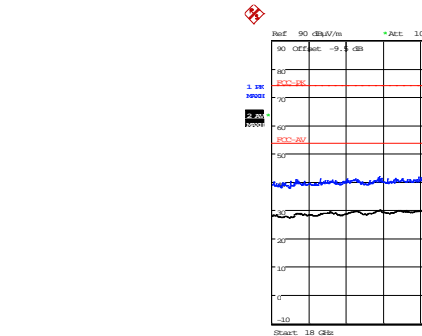
Date: 2 MAR 2016 09:04:13

### 4 GHz - 9 GHz



Date: 1 MAR 2016 13:33:09

### 9 GHz – 13 GHz



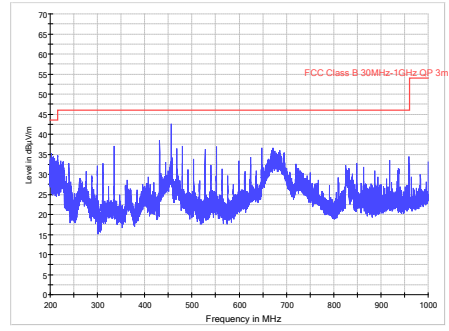
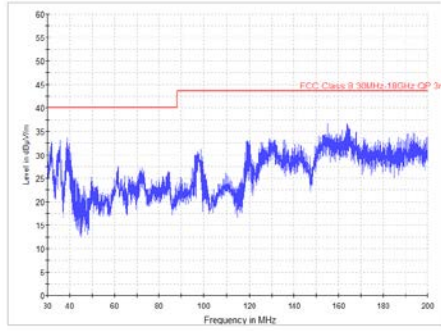
Date: 1 MAR 2016 13:35:20

### 13 GHz - 18 GHz

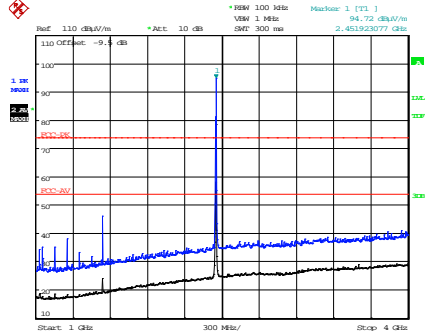
Date: 3 MAR 2016 10:34:27

### 18 GHz – 26 GHz

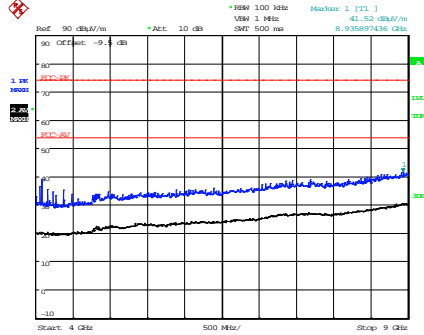
### Radiated Spurious Emission - 2450 MHz



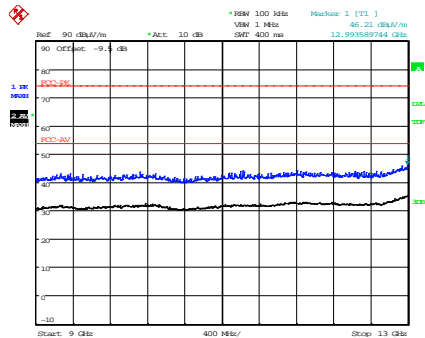
30 MHz – 200 MHz



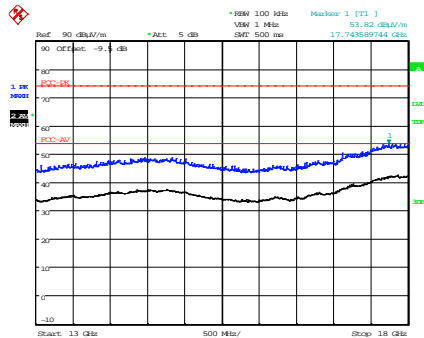
200 MHz – 1 GHz



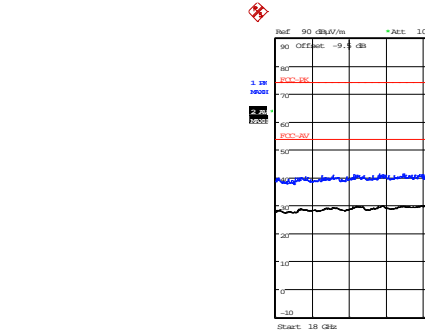
1 GHz – 4 GHz



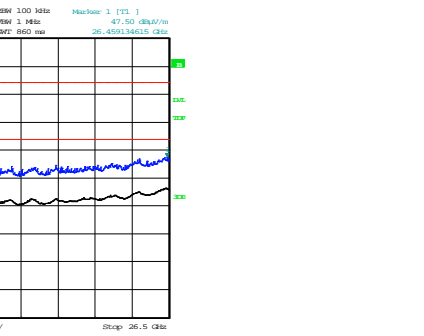
4 GHz - 9 GHz



9 GHz – 13 GHz

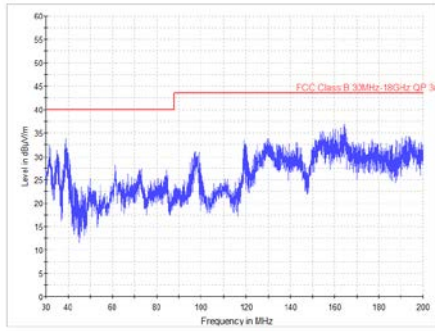


13 GHz - 18 GHz

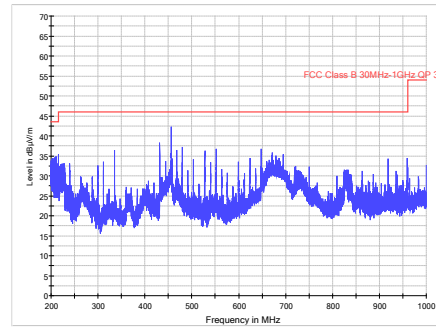


18 GHz – 26 GHz

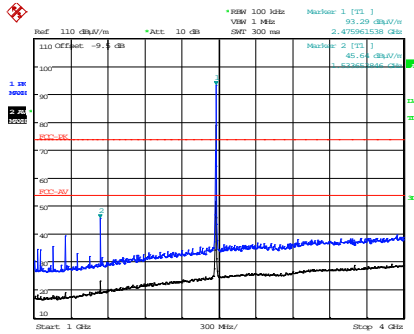
## Radiated Spurious Emission - 2475 MHz



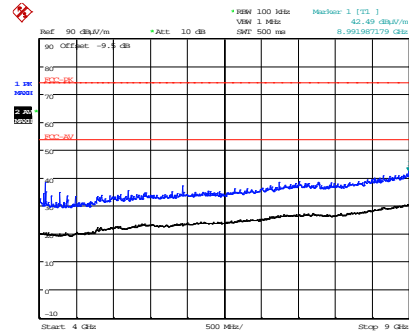
30 MHz – 200 MHz



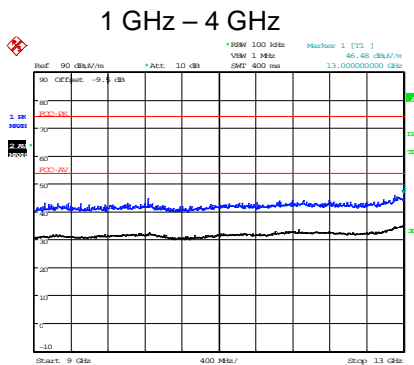
200 MHz – 1 GHz



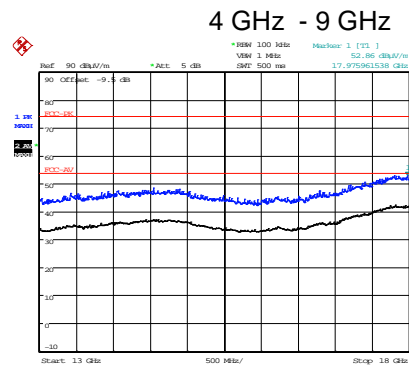
Date: 1.MAR.2016 14:08:13



Date: 2.MAR.2016 08:56:59



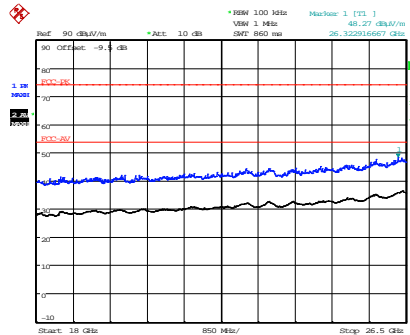
Date: 2.MAR.2016 07:39:13



Date: 2.MAR.2016 07:40:43

9 GHz – 13 GHz

13 GHz - 18 GHz



Date: 3.MAR.2016 10:44:03

18 GHz – 26 GHz

## 12 Occupied Bandwidth

### 12.1 Definition

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

### 12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	2425 MHz / 2450 MHz / 2475 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span:	10 MHz
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 28 %RH	20%RH to 75%RH (as declared)
Supply: 110 Vac	110 Vac +/-10% (as declared)

### Test Limits

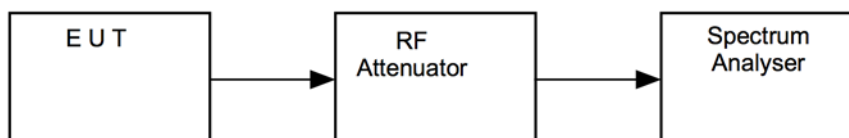
The minimum -6 dB bandwidth shall be at least 500 kHz.

### 12.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

**Figure iii Test Setup**



### 12.4 Test Equipment

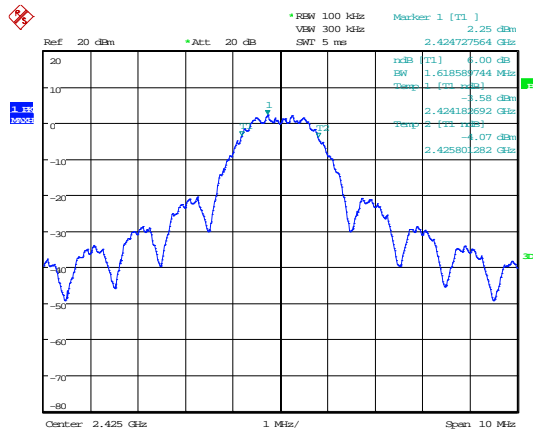
<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Last Cal Calibration</i>	<i>Calibration Period</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU46	REF910	28/05/2015	12	28/05/2016

### 12.5 Test Results

<i>Channel Frequency (MHz)</i>	<i>F<sub>L</sub> (MHz)</i>	<i>F<sub>H</sub> (MHz)</i>	<i>6dB Bandwidth (kHz)</i>	<i>Result</i>
2405	2424.182692	2425.801282	1618.590	PASS
2440	2449.182692	2450.785256	1602.564	PASS
2475	2474.198718	2475.785256	1586.538	PASS

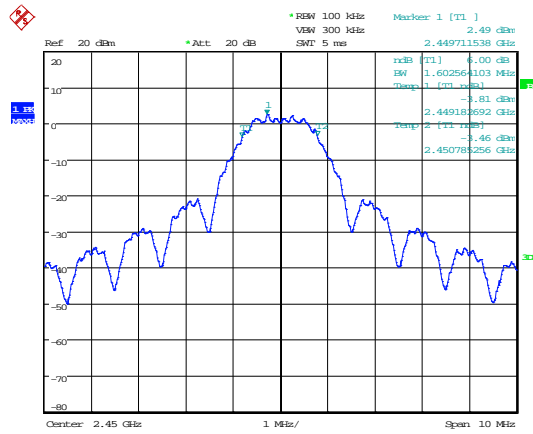


### Occupied Bandwidth



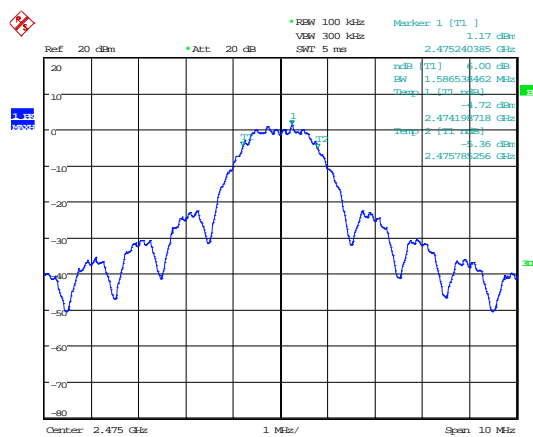
Date: 4.MAR.2016 10:38:28

### 2425 MHz



Date: 4.MAR.2016 10:42:03

### 2450 MHz



Date: 4.MAR.2016 10:46:02

### 2475 MHz

## 13 Maximum peak conducted output power

### 13.1 Definition

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the signal bandwidth.

The maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

### 13.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Channels / Frequencies Measured:	2425 MHz / 2450 MHz / 2475 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	3 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Mains Power = 85% and 115% of Nominal (FCC only requirement);

### Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 °C to +35 °C (as declared)
Humidity: 28 %RH	20%RH to 75%RH (as declared)

### Test Limits

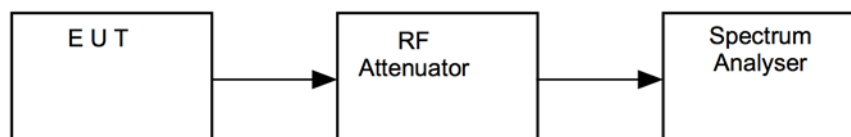
For systems employing digital modulation techniques operating in the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

### 13.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iv Test Setup



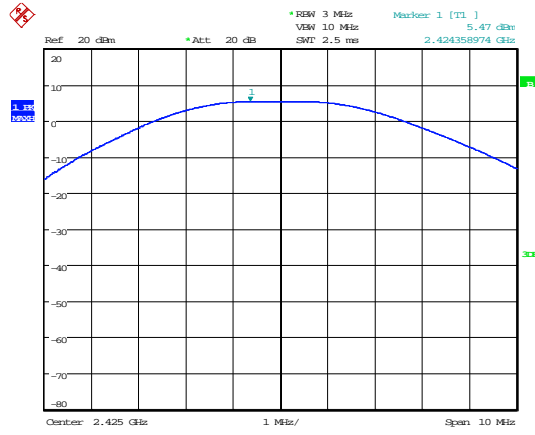
**13.4 Test Equipment**

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Last Cal Calibration</i>	<i>Calibration Period</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU46	REF910	28/05/2015	12	28/05/2016

**13.5 Test Results**

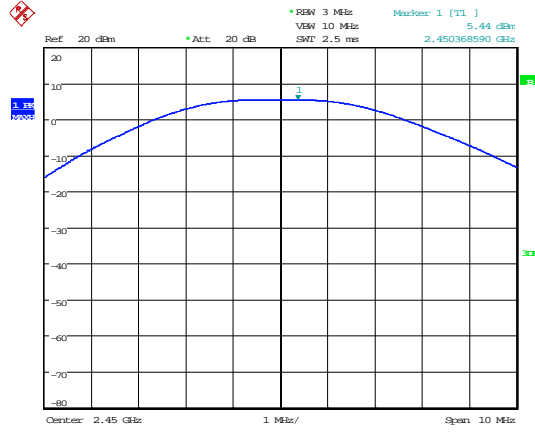
<i>Channel Frequency (MHz)</i>	<i>Maximum peak conducted output power (dBm)</i>	<i>Maximum peak conducted output power (W)</i>	<i>Antenna gain (dBi)</i>	<i>E.I.R.P. (W)</i>	<i>Result</i>
2425	5.5	0.00352	2.3	0.00598	PASS
2450	5.4	0.00350	2.3	0.00594	PASS
2470	4.1	0.00256	2.3	0.00436	PASS

### Output Power



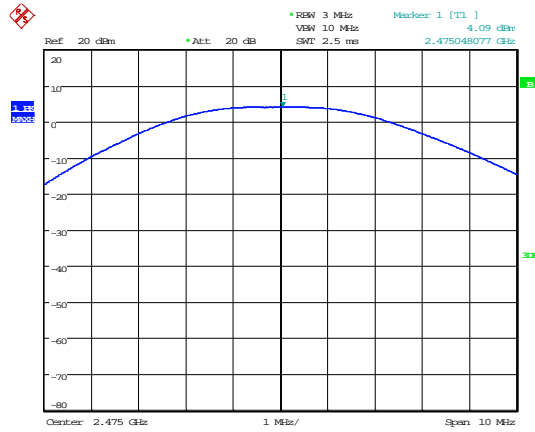
Date: 4.MAR.2016 10:51:17

### 2425 MHz



Date: 4.MAR.2016 10:50:10

### 2450 MHz



Date: 4.MAR.2016 10:49:23

### 2475 MHz

## 14 Out-of-band and conducted spurious emissions

### 14.1 Definition

#### *Out-of-band emission.*

Emission on a frequency or frequencies immediately outside the necessary bandwidth that results from the modulation process but excluding spurious emissions.

#### *Spurious emission.*

Emission on a frequency or frequencies that are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products, and frequency conversion products, but exclude out-of-band emissions.

### 14.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Channels / Frequencies Measured:	2425 MHz / 2450 MHz / 2475 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	30 MHz to 26.5 GHz

### Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 27 %RH	20%RH to 75%RH (as declared)
Supply: 110 Vac	110 Vac +/-10% (as declared)

### Test Limits

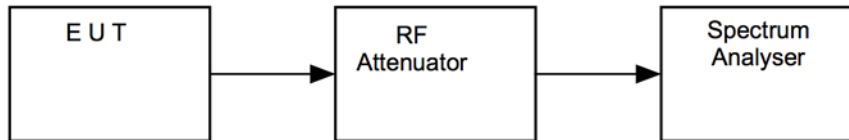
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in FCC 47CFR15.209(a) / RSS-Gen is not required.

### 14.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the emissions from the EUT were measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure v Test Setup



#### 14.4 Test Equipment

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Last Cal Calibration</i>	<i>Calibration Period</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU46	REF910	28/05/2015	12	28/05/2016

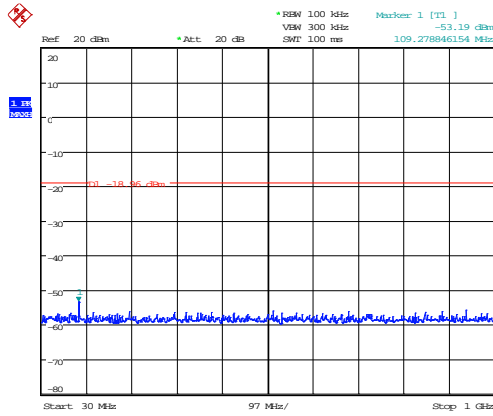
#### 14.5 Test Results

<i>Channel Frequency: 2425 MHz</i>						
<i>Channel Frequency (MHz)</i>	<i>Emission Frequency (MHz)</i>	<i>Analyzer Level (dBm)</i>	<i>Emission Level (dBm)</i>	<i>Limit (dBm)</i>	<i>Margin (dB)</i>	<i>Result</i>
No emissions were detected within 10 dB of the limit						

<i>Channel Frequency: 2450 MHz</i>						
<i>Channel Frequency (MHz)</i>	<i>Emission Frequency (MHz)</i>	<i>Analyzer Level (dBm)</i>	<i>Emission Level (dBm)</i>	<i>Limit (dBm)</i>	<i>Margin (dB)</i>	<i>Result</i>
No emissions were detected within 10 dB of the limit						

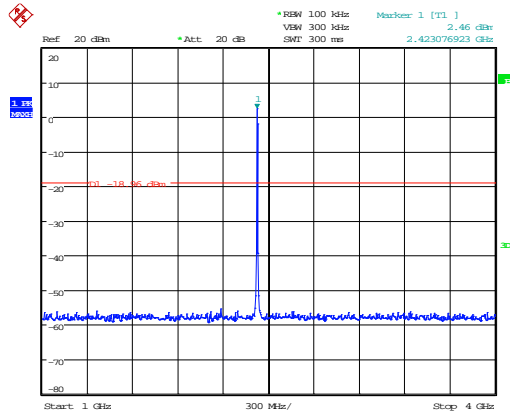
<i>Channel Frequency: 2475 MHz</i>						
<i>Channel Frequency (MHz)</i>	<i>Emission Frequency (MHz)</i>	<i>Analyzer Level (dBm)</i>	<i>Emission Level (dBm)</i>	<i>Limit (dBm)</i>	<i>Margin (dB)</i>	<i>Result</i>
No emissions were detected within 10 dB of the limit						

### Spurious emissions – 2425 MHz



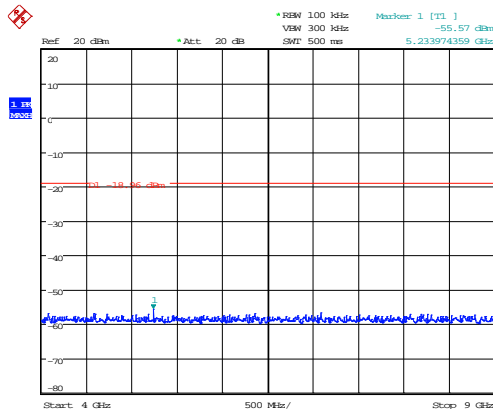
Date: 4.MAR.2016 12:46:22

30 MHz – 1 GHz



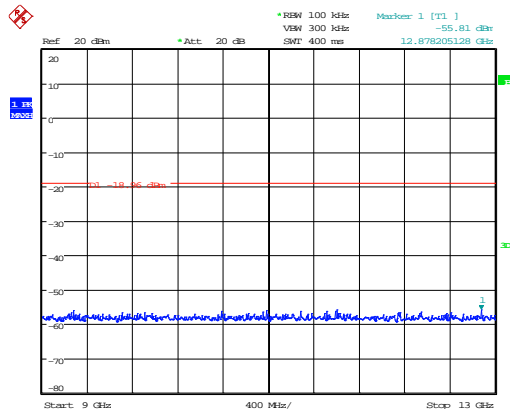
Date: 4.MAR.2016 12:47:20

1 GHz – 4 GHz



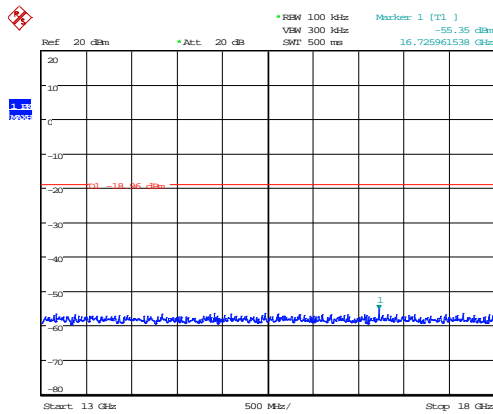
Date: 4.MAR.2016 12:47:44

4 GHz – 9 GHz



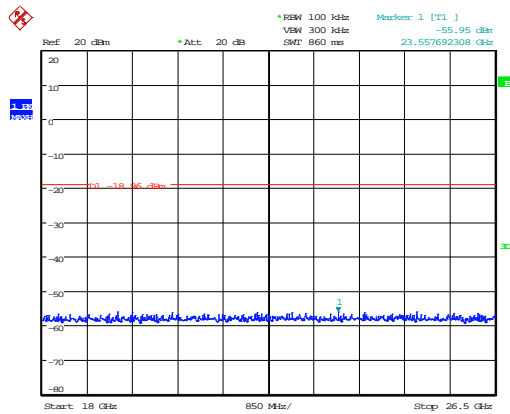
Date: 4.MAR.2016 12:48:13

9 GHz – 13 GHz



Date: 4.MAR.2016 12:48:37

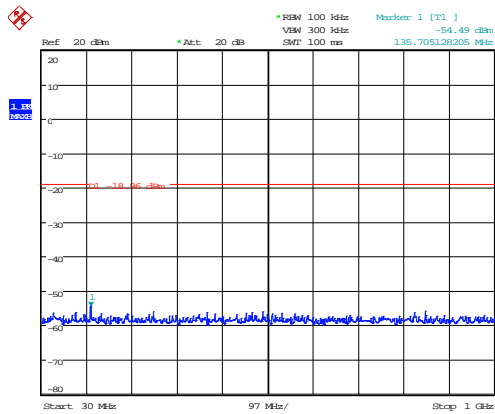
13 GHz – 18 GHz



Date: 4.MAR.2016 12:49:06

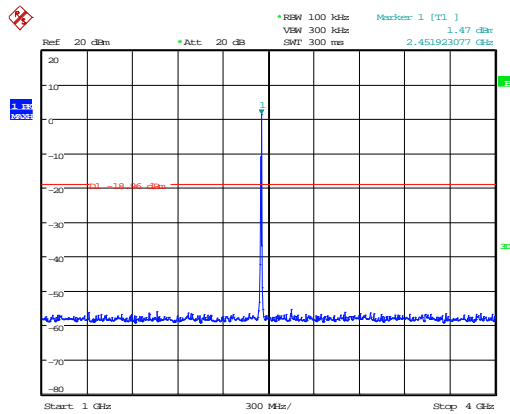
18 GHz – 26.5 GHz

### Spurious emissions – 2450 MHz



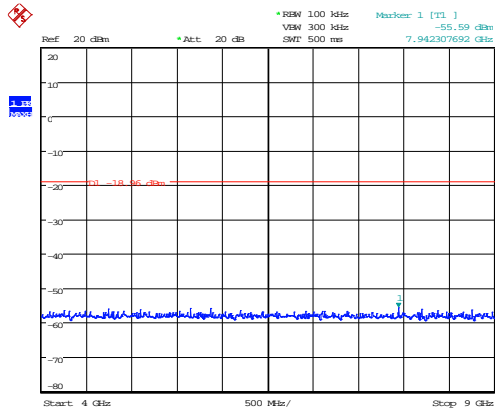
Date: 4.MAR.2016 12:37:17

30 MHz – 1 GHz



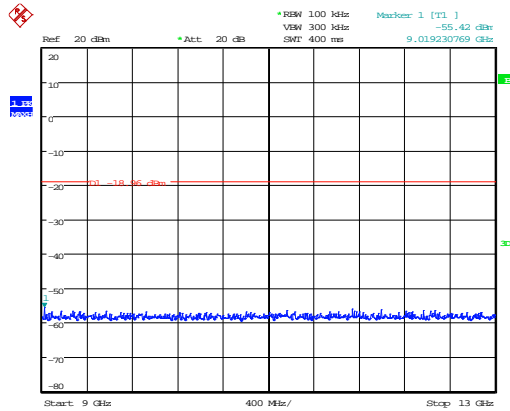
Date: 4.MAR.2016 12:37:49

1 GHz – 4 GHz



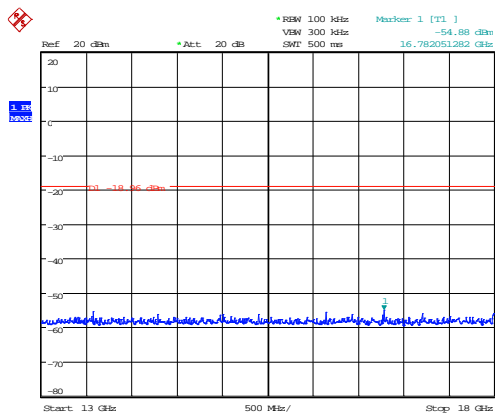
Date: 4.MAR.2016 12:38:28

4 GHz – 9 GHz



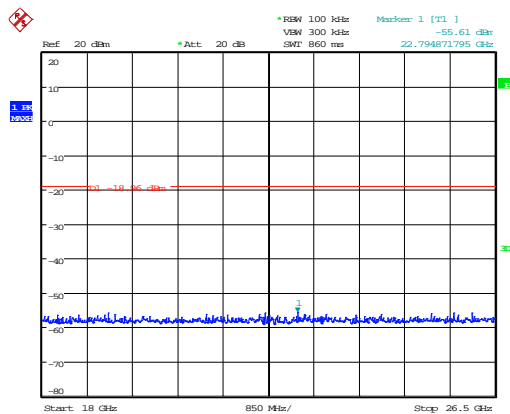
Date: 4.MAR.2016 12:38:54

9 GHz – 13 GHz



Date: 4.MAR.2016 12:39:22

13 GHz – 18 GHz

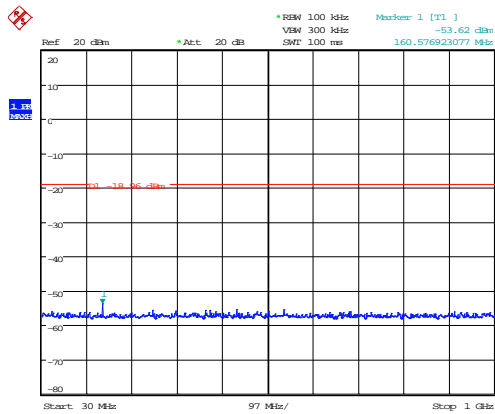


Date: 4.MAR.2016 12:40:05

18 GHz – 26.5 GHz

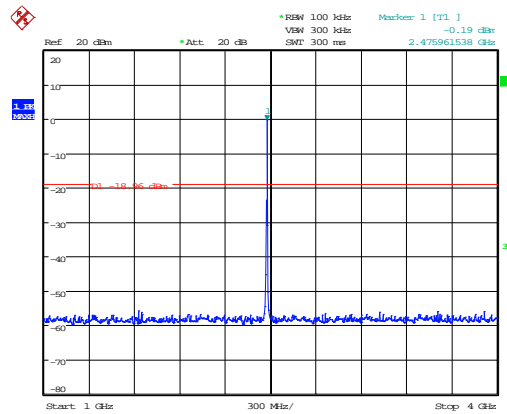


### Spurious emissions – 2475 MHz



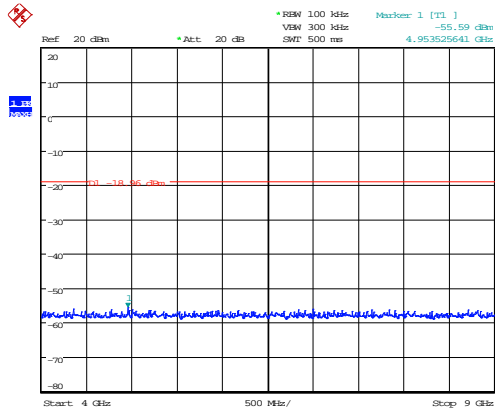
Date: 4.MAR.2016 12:31:16

30 MHz – 1 GHz



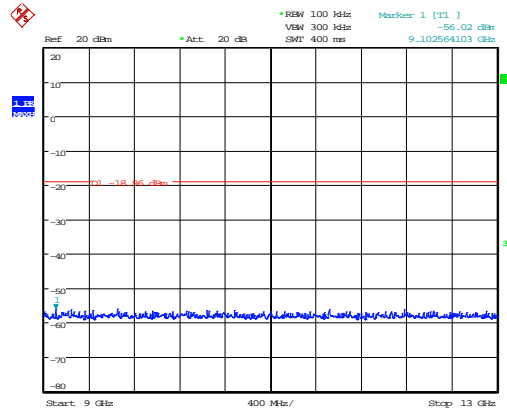
Date: 4.MAR.2016 12:31:42

1 GHz – 4 GHz



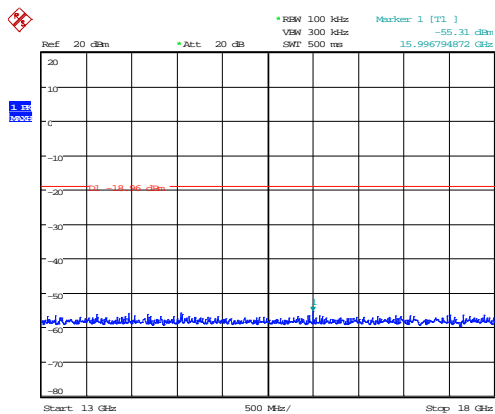
Date: 4.MAR.2016 12:32:45

4 GHz – 9 GHz



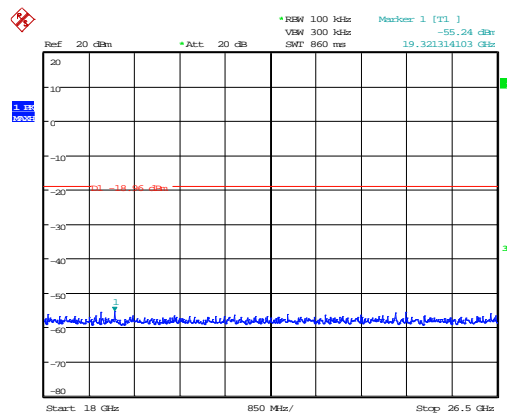
Date: 4.MAR.2016 12:33:22

9 GHz – 13 GHz



Date: 4.MAR.2016 12:44:00

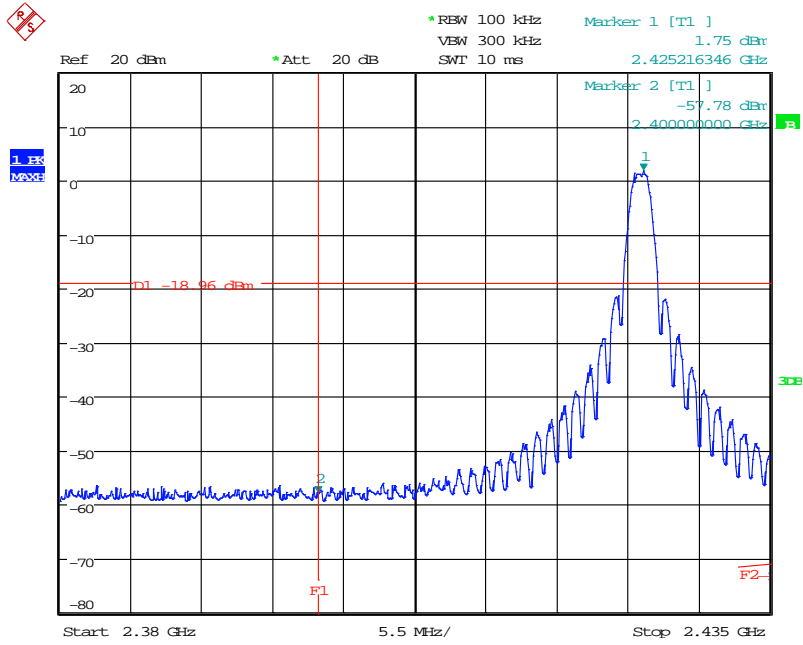
13 GHz – 18 GHz



Date: 4.MAR.2016 12:34:21

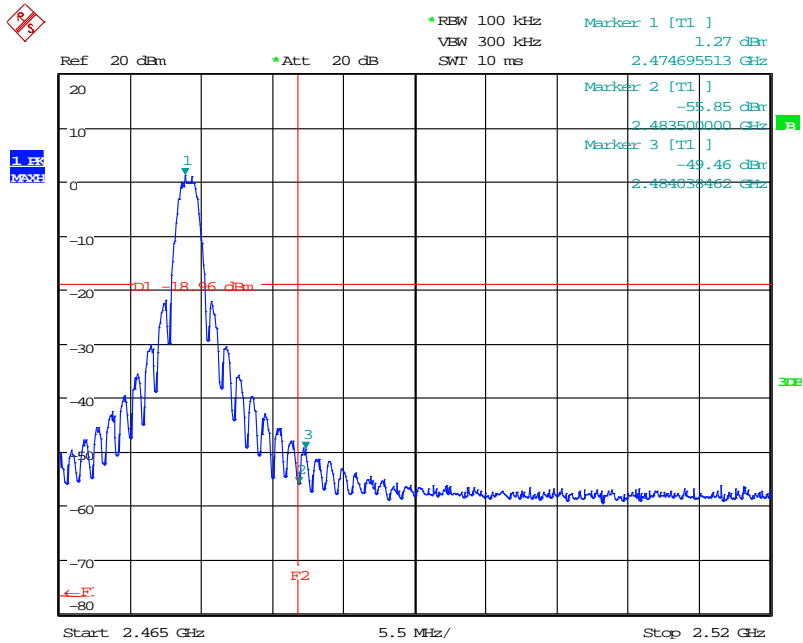
18 GHz – 26.5 GHz

### Out-of-band Emissions



Date: 4.MAR.2016 12:57:20

### Conducted Lower Bandedge



Date: 4.MAR.2016 12:55:43

### Conducted Upper Bandedge

## 15 Power spectral density

### 15.1 Definition

The power per unit bandwidth.

### 15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	2425 MHz / 2450 MHz / 2475 MHz
EUT Channel Bandwidths:	2 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 1.5 times Channel BW)	2.5 MHz
Measurement Detector:	Peak

### Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 28 %RH	20%RH to 75%RH (as declared)
Supply: 110 Vac	110 Vac +/-10% (as declared)

### Test Limits

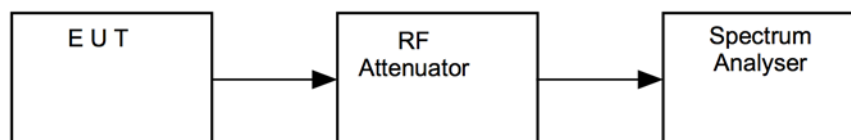
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

### 15.3 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

**Figure vi Test Setup**



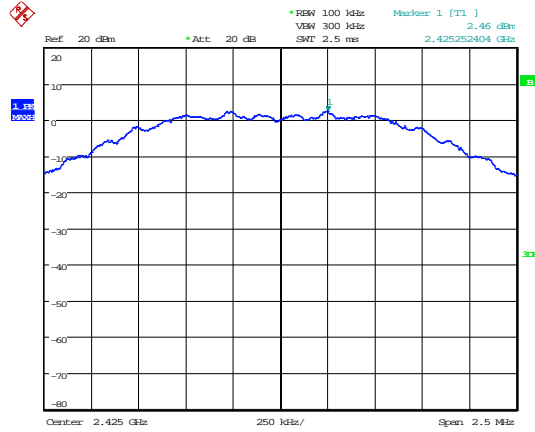
**15.4 Test Equipment**

<i>Equipment Description</i>	<i>Manufacturer</i>	<i>Equipment Type</i>	<i>Element No</i>	<i>Last Cal Calibration</i>	<i>Calibration Period</i>	<i>Due For Calibration</i>
Spectrum Analyser	R&S	FSU46	REF910	28/05/2015	12	28/05/2016

**15.5 Test Results**

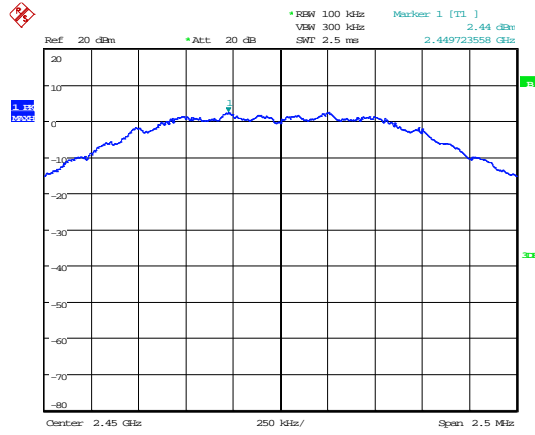
<i>Channel Frequency (MHz)</i>	<i>Power (dBm)</i>	<i>Result</i>
2425	2.46	PASS
2450	2.44	PASS
2475	1.04	PASS

### Power Spectral Density



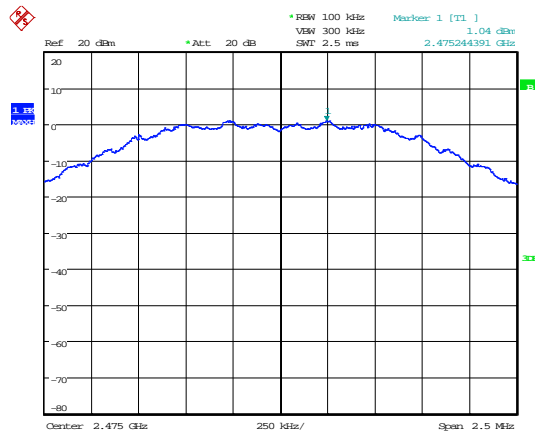
Date: 4.MAR.2016 11:07:25

### 2425 MHz



Date: 4.MAR.2016 11:03:38

### 2450 MHz



Date: 4.MAR.2016 11:01:00

### 2475 MHz

## 16 Measurement Uncertainty

### Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95% confidence:

#### [1] Radiated spurious emissions

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

#### [2] AC power line conducted emissions

Uncertainty in test result = **3.4dB**

#### [3] Occupied bandwidth

Uncertainty in test result = **15.5%**

#### [4] Conducted carrier power

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

#### [5] Conducted / radiated RF power out-of-band

Uncertainty in test result – Up to 8.1GHz = **3.31dB**  
Uncertainty in test result – 8.1GHz – 15.3GHz = **4.43dB**  
Uncertainty in test result (30MHz – 1GHz) = **4.6dB**,  
Uncertainty in test result (1GHz – 18GHz) = **4.7dB**

#### [6] Power spectral density

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

## 17 General SAR test reduction & exclusion guidance / 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 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

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

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)

TSDA = Min Test separation Distance or 50mm (whichever is lower) = 50 mm (in this case)

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

$$= [(NT \times TSDA) / \sqrt{f_{GHz}}]$$

For Distances Greater than 50 mm Step 2 applies

Step 2

$$(TSDB - 50mm) * 10\}$$

Where:

TSDB = Min Test separation Distance (mm) = 50

Note: Step 2 is not required here as the TSDA is 50 mm.

Operating Frequency 2.425 GHz

$$SARET = [(3.0 \times 5) / \sqrt{2.425}]$$

$$SARET = 96.8 \text{ mW}$$

Operating Frequency 2.450 GHz

$$SARET = [(3.0 \times 5) / \sqrt{2.450}]$$

$$SARET = 96.0 \text{ mW}$$

Operating Frequency 2.470 GHz

$$SARET = [(3.0 \times 5) / \sqrt{2.470}]$$

$$SARET = 95.3 \text{ mW}$$

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold (mW)	SAR Evaluation
2425	5.98	96.8	Not Required
2450	5.94	96.0	Not Required
2470	4.36	95.3	Not Required

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

## MPE Calculation

### Prediction of MPE limit at a given distance

For purposes of these requirements mobile devices are defined by the FCC 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 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 rules.

Equation from IEEE C95.1

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

Where:

S = power density

R = distance to the centre of radiation of the antenna

EIRP = EUT Maximum power

Result

Prediction Frequency (MHz)	EIRP (mW)	Power density limit (S) (mW/cm <sup>2</sup> )	Distance (R) cm required to be less than the power density limit
2425	5.98	1.00	0.69