Report on the Radio Testing

For

Vicon Motion Systems Ltd

on

Vicon Pulsar LED cluster S11

Report no. TRA-040048-45-07A

30th August 2018

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Report Number: TRA-040048-45-07A
Issue: A

REPORT ON THE RADIO TESTING OF A
Vicon Motion Systems Ltd
Vicon Pulsar LED cluster S11
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-247

TEST DATE: 5th July – 6th July 2018

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John Charters
Department Manager - Radio

Date: 30th August 2018

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

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	30th August 2018	Original

2 Summary

TEST REPORT NUMBER:	TRA-040048-45-07A
WORKS ORDER NUMBER	TRA-040048-00
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J. Canada: Testing of radio apparatus for TAC (technical acceptance certificate) per subsections 4(2) of the Radiocommunication Act and 21(1) of the Radiocommunication Regulations.
TEST SPECIFICATION(S):	47CFR15.247 & RSS-247
EQUIPMENT UNDER TEST (EUT):	Vicon Pulsar LED cluster S11
FCC IDENTIFIER:	DMR- VICP1
ISED IDENTIFIER:	11323A-VICP1
EUT SERIAL NUMBER:	P-1000021
MANUFACTURER/AGENT:	Vicon Motion Systems Ltd
ADDRESS:	Unit 6 Oxford Industrial Park Mead Road Yarnton OXFORD OX5 1QU United Kingdom
CLIENT CONTACT:	Tom Shannon ☎ TPS01865 781398 ✉ thomas.shannon@omg3d.com
ORDER NUMBER:	PO:POR011981
TEST DATE:	5th July – 6th July 2018
TESTED BY:	David Garvey/ Alan Wong Ian Broadwell 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	☒	*PASS*
AC power line conducted emissions		Gen, 8.8	15.207	☐	*Note 1*
Occupied bandwidth		247, 5.2 (1)	15.247(a)(2)	☒	*PASS*
Conducted carrier power	Peak	247, 5.4 (4)	15.247(b)(3)	☒	*PASS*
	Max.			☐	
Conducted / radiated RF power out-of-band		247, 5.5	15.247(d)	☒	*PASS*
Power spectral density, conducted		247, 5.2 (2)	15.247(e)	☒	*PASS*
Calculation of duty correction		-	15.35(c)	☐	*N/A*

Notes:

1. When transmitter operates the unit is battery powered.

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-040048-45-07A presents the results of the Radio testing on a Vicon Motion Systems Ltd, Vicon Pulsar LED cluster S11 to specification 47CFR15 Radio Frequency Devices and RSS-247 Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.

The testing was carried out for Vicon Motion Systems Ltd by Element, at the address detailed below.

☒	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	☐	Element Skelmersdale Unit 1 Pendle Place Skemersdale West Lancashire WN8 9PN 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 North West	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 2, February 2017 – 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

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

7 Equipment Under Test

7.1 EUT Identification

- Name: Vicon Pulsar LED cluster S11
- Serial Number: P-1000021
- Model Number: P1

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.

Support Board
Charger
Laptop

7.3 EUT Mode of Operation

7.3.1 Transmission

The EUT was transmitting modulated carrier on the frequencies indicated.

7.3.2 Reception

The EUT was tuned to permanent receive mode on the frequencies indicated.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2.400–2.4835 GHz ISM band
Modulation type(s):	802.15.4
Occupied channel bandwidth(s):	2 MHz approx.
Channel spacing:	2 MHz
Declared output power(s):	3.16 mW
Nominal Supply Voltage:	3.7V DC
Location of notice for license exempt use:	Label / user manual / both.
Duty cycle:	25%

7.4.2 Antennas

Type:	Integral antenna.
Frequency range:	2.400–2.4835 GHz ISM band
Impedance:	50 ohm
Gain:	1.5 dBi
Connector type:	SMA

7.5 EUT Description

A system of 6 body-worn LED clusters under the control of a Beacon master to provide a unique 3D estimate of the location in space of the body with multiple video cameras.

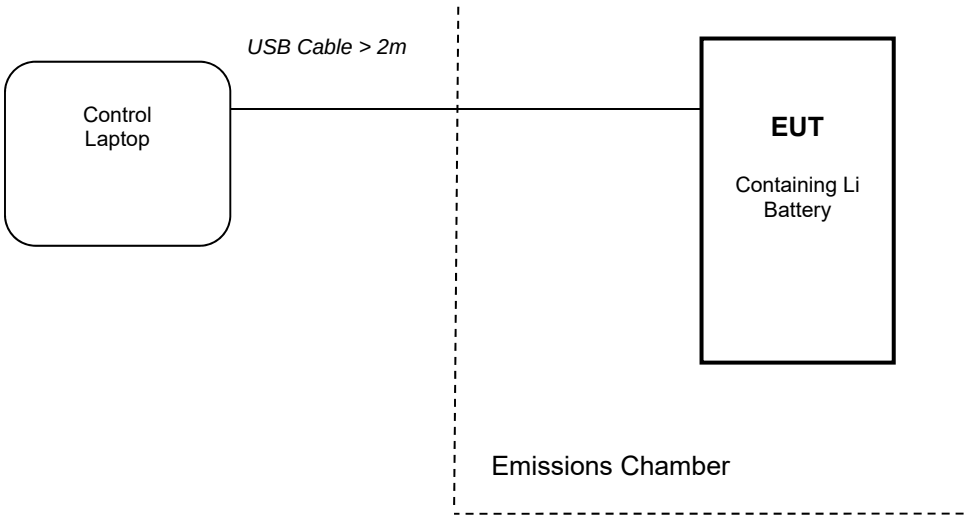
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

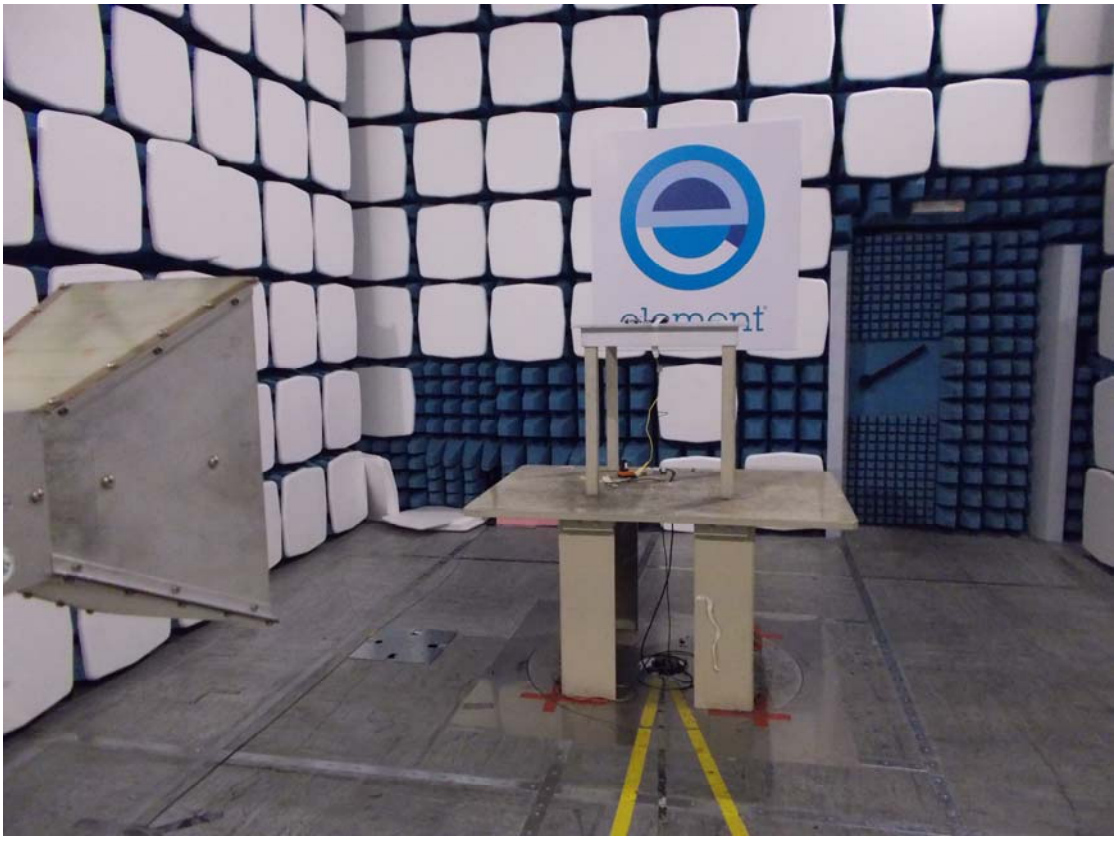
9.1 Block Diagram

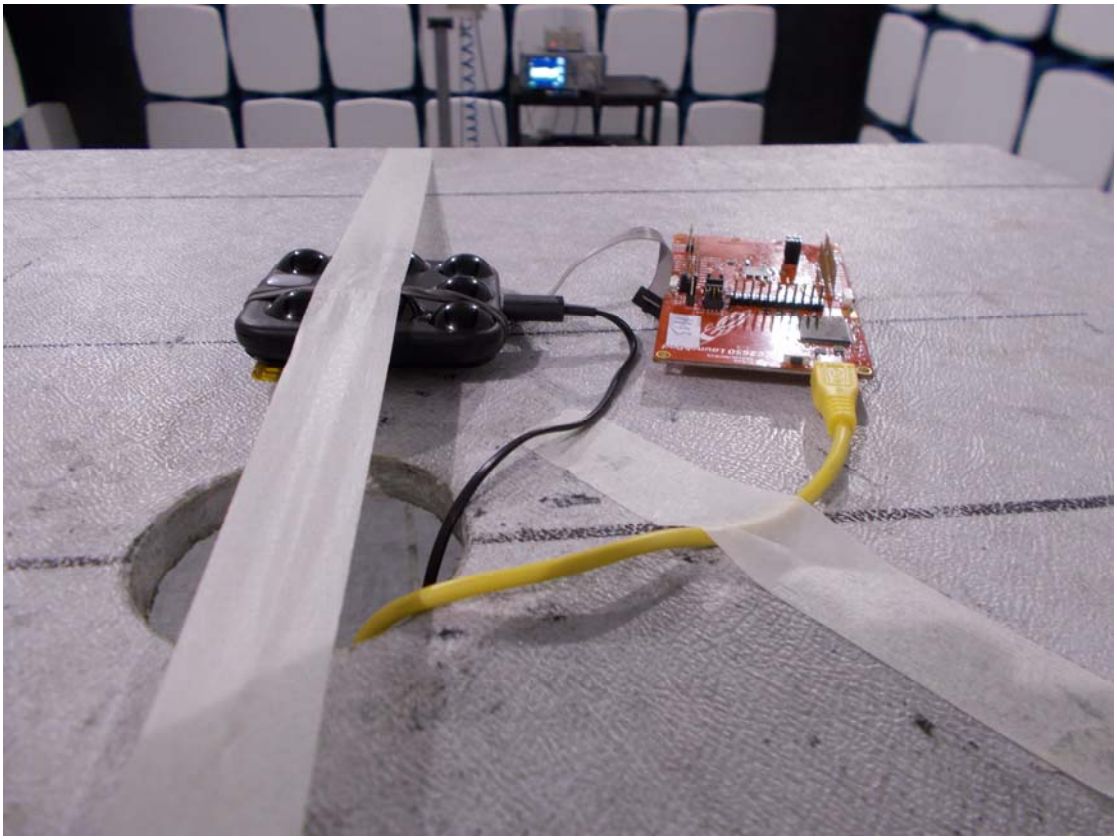
The following diagram shows basic EUT interconnections with cable type and cable lengths identified:



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:





10 General Technical Parameters

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 3.7 V dc a Lithium polymer battery LP-422339-PACK.

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:

	Category	***Nominal***	***Variation***
☐	Mains	110 V ac +/-2 %	85 % and 115 %
☒	Battery	New battery	N/A

11 Radiated emissions

11.1 Definitions

Out-of-band emissions
Emissions on a frequency or frequencies immediately outside the necessary bandwidth which result from the modulation process, but exclude spurious emissions.

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:	Wireless Lab 2
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	Low / Mid / High
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: 21 °C	+15 ºC to +35 ºC (as declared)
Humidity: 50 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.7 Vdc	

11.3 Test Limit

Except for harmonics, out-of-band emissions shall be attenuated by at least 50 dB below the level of the fundamental or to the general field strength limits listed in FCC 47CFR15.209 / RSS-Gen {see table below}, whichever is less stringent.

Harmonics shall be limited to a maximum level of 0.5 mV/m measured at 3 metres.

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

Frequency (MHz)	***Field Strength (µV/m at 3 m)***
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

n.b. per FCC 47CFR15.35(b) / RSS-Gen 8.1, peak limit is 20 dB above average.

11.4 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 100 kHz 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 dBµV/m at the regulatory distance, using:

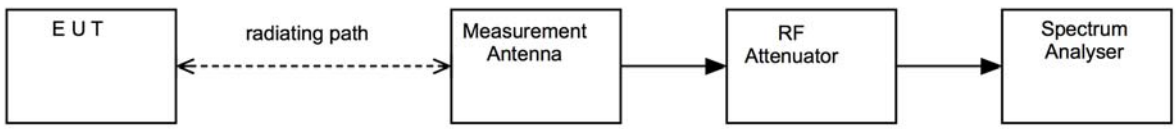
$$FS = PR + CL + AF - PA + DC - CF$$

Where,

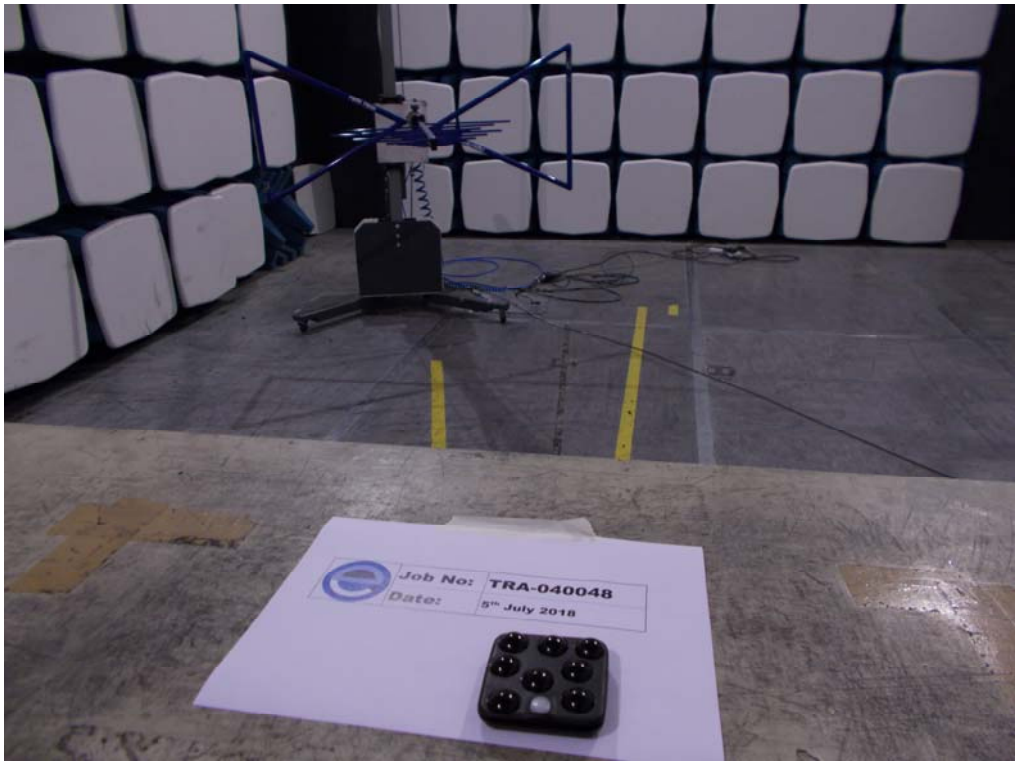
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph



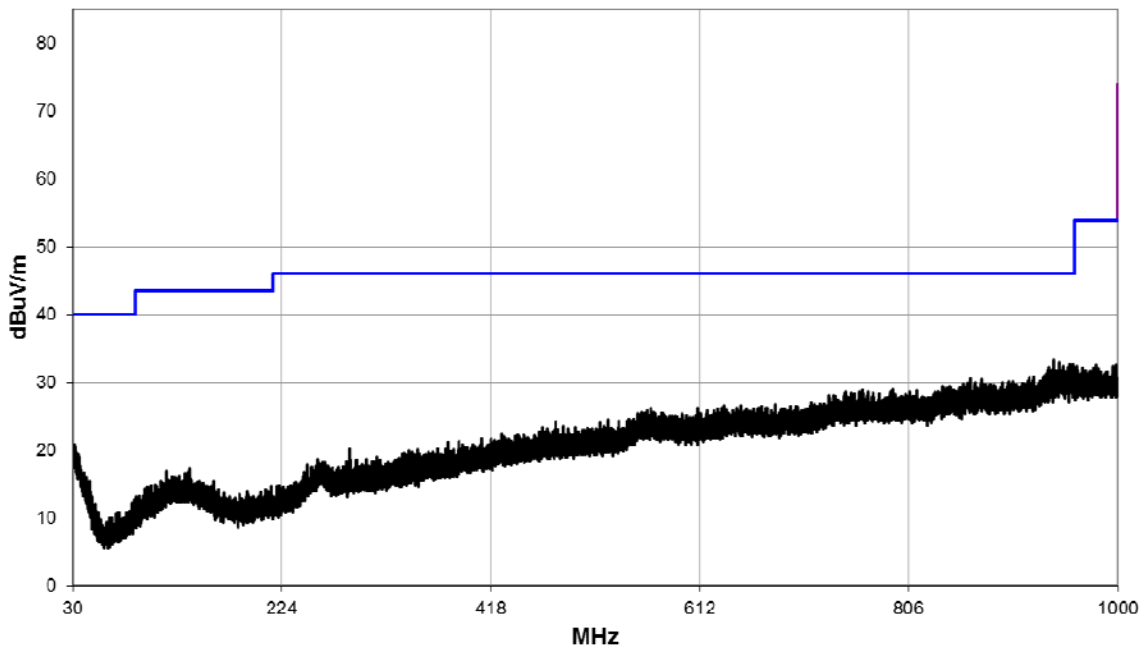
11.6 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Pre-Amp (9kHz – 1GHz)	Sonoma	310	REF927	2019-05-22
Spectrum Analyser	R&S	FSU46	U281	2018-07-19
Bilog Antenna	Chase	CBL6111B	REF2218	2019-11-06
Ferrite Lined Chamber	Rainford	ATS	REF886	2019-07-24
Pre-Amp (1 – 26.5GHz)	Agilent	8449B	REF913	2019-02-07
Horn Antenna	EMCO	3115	RFG129	2020-02-12
Horn Antenna	Q-Par	22240-25	RFG629	2019-09-26

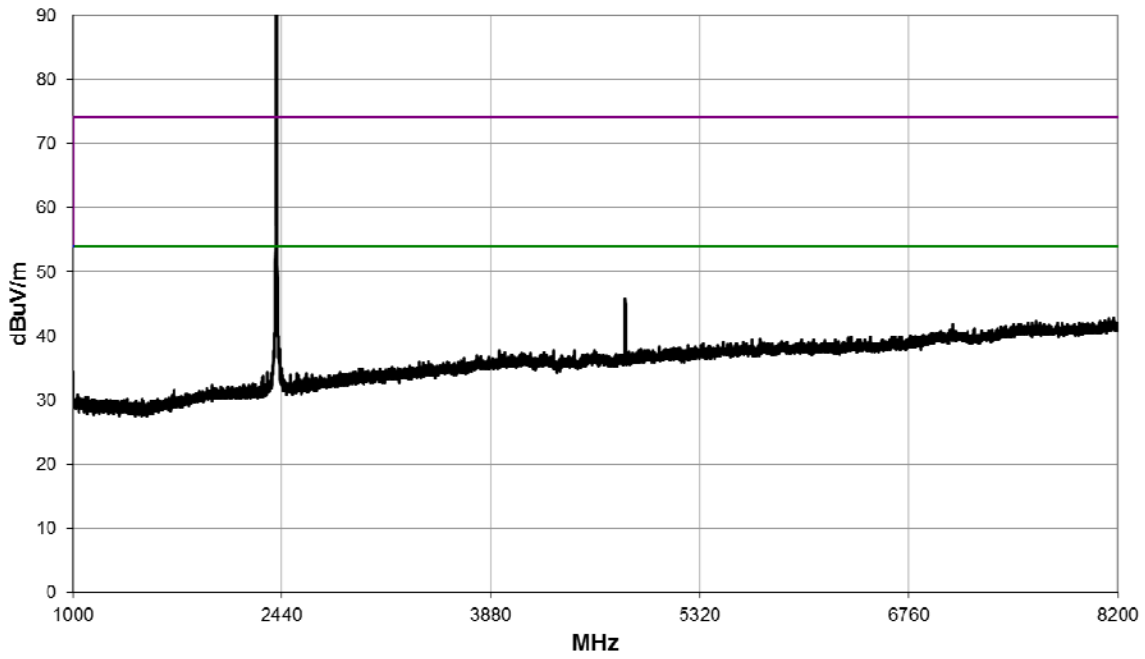
Test Results

High Power; Channel: low 2405 MHz										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
There were no emissions within 10 dB of the restricted band QP limit as specified in 15.205.										

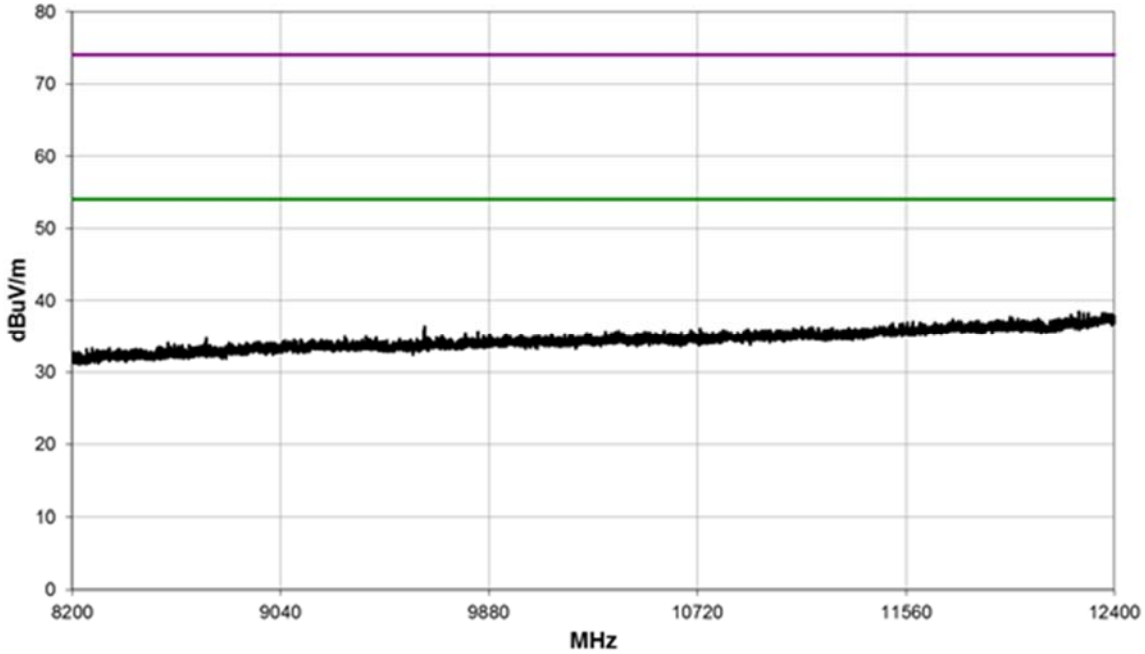
30 MHz – 1 GHz plot with fundamental at 2405 MHz and 5dBm output power



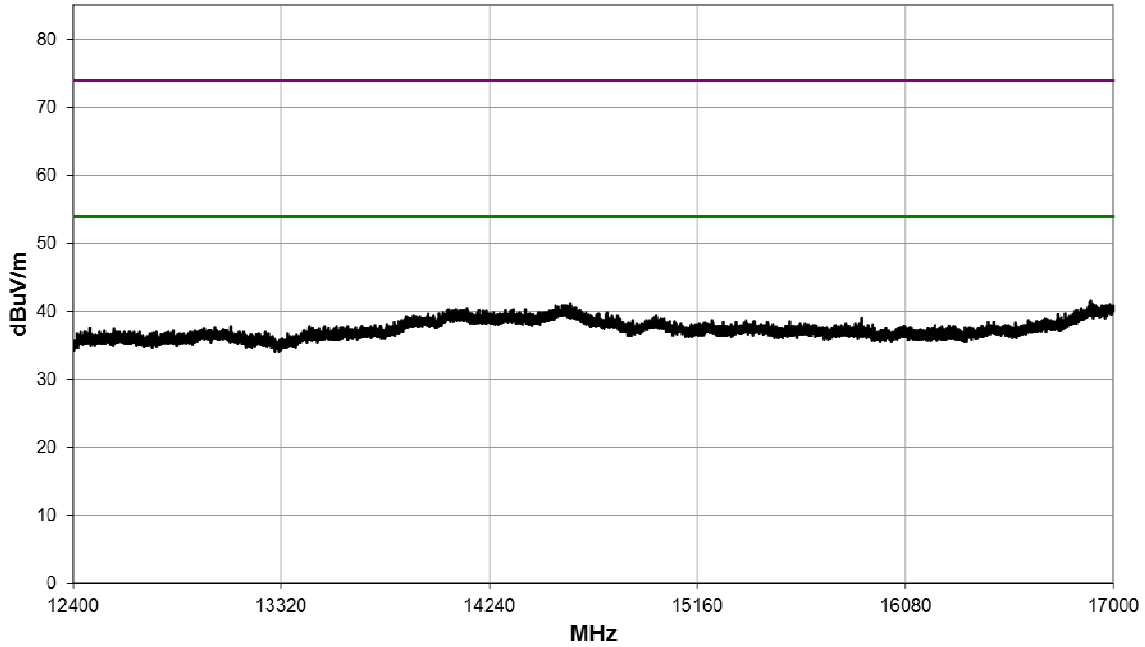
1 – 8.2 GHz plot with fundamental at 2405 MHz and 5dBm output power



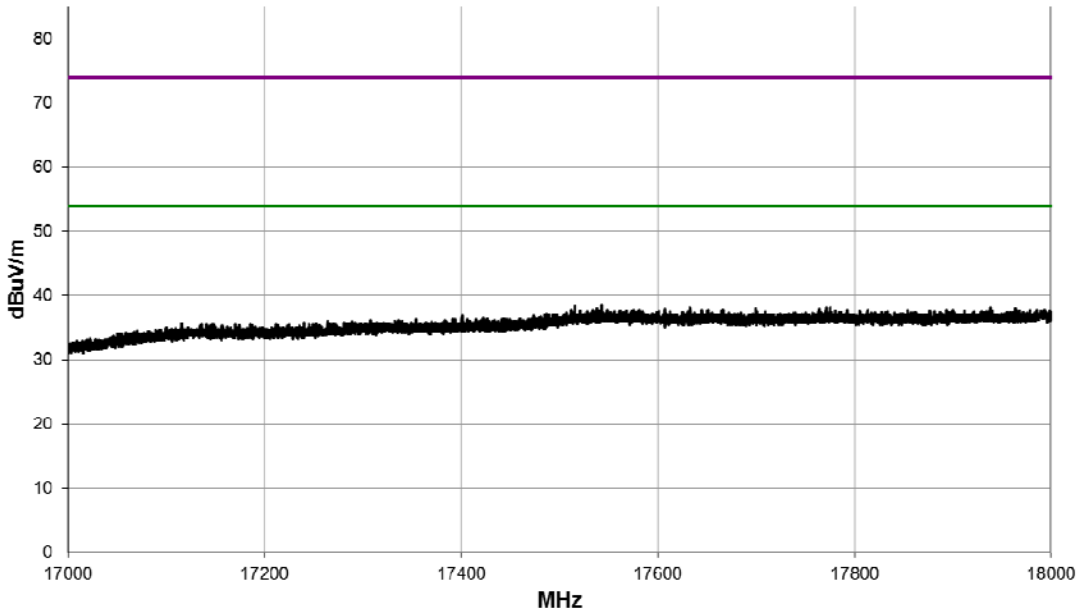
8.2 – 12.4 GHz plot with fundamental at 2405 MHz and 5dBm output power



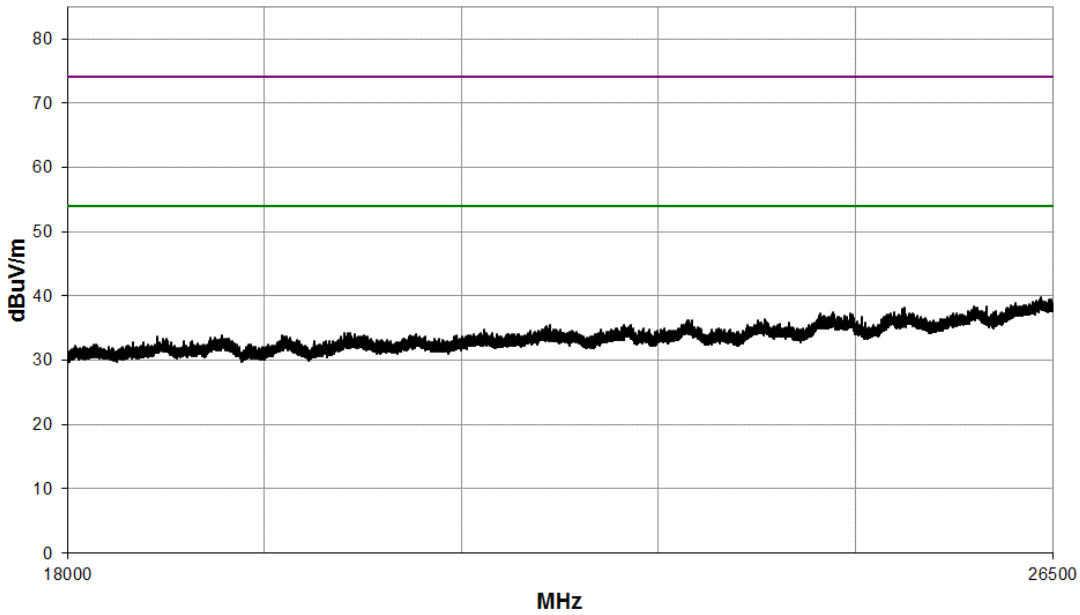
12.4 – 17 GHz plot with fundamental at 2405 MHz and 5dBm output power



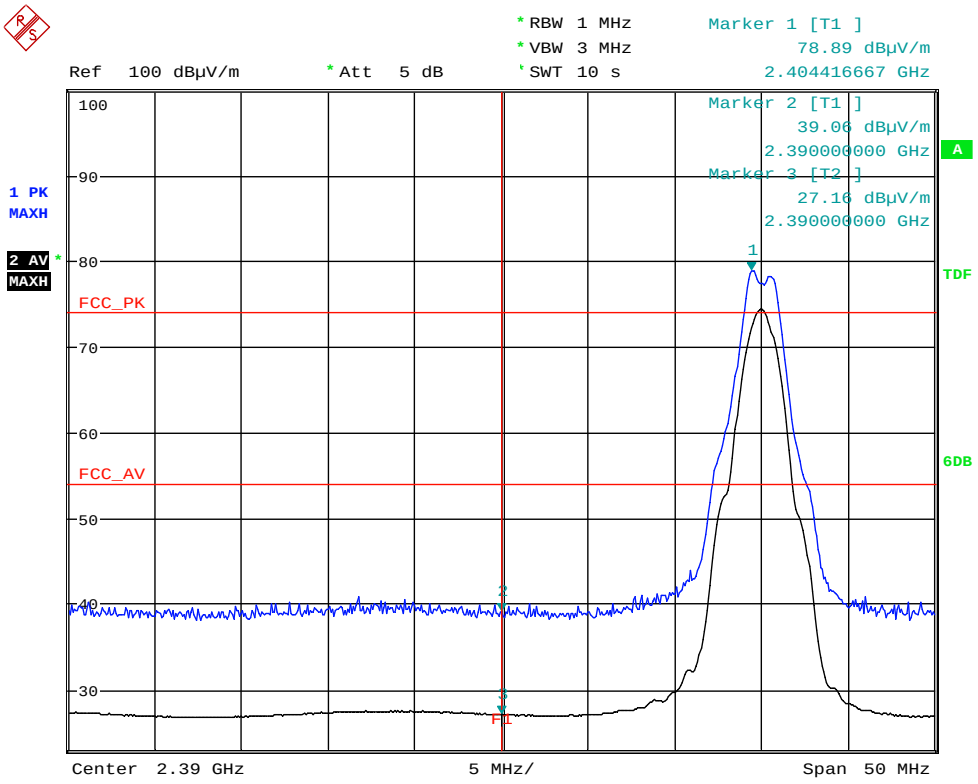
17 – 18 GHz plot with fundamental at 2405 MHz and 5 dBm output power



18 – 26 GHz plot with fundamental at 2405 MHz and 5 dBm output power



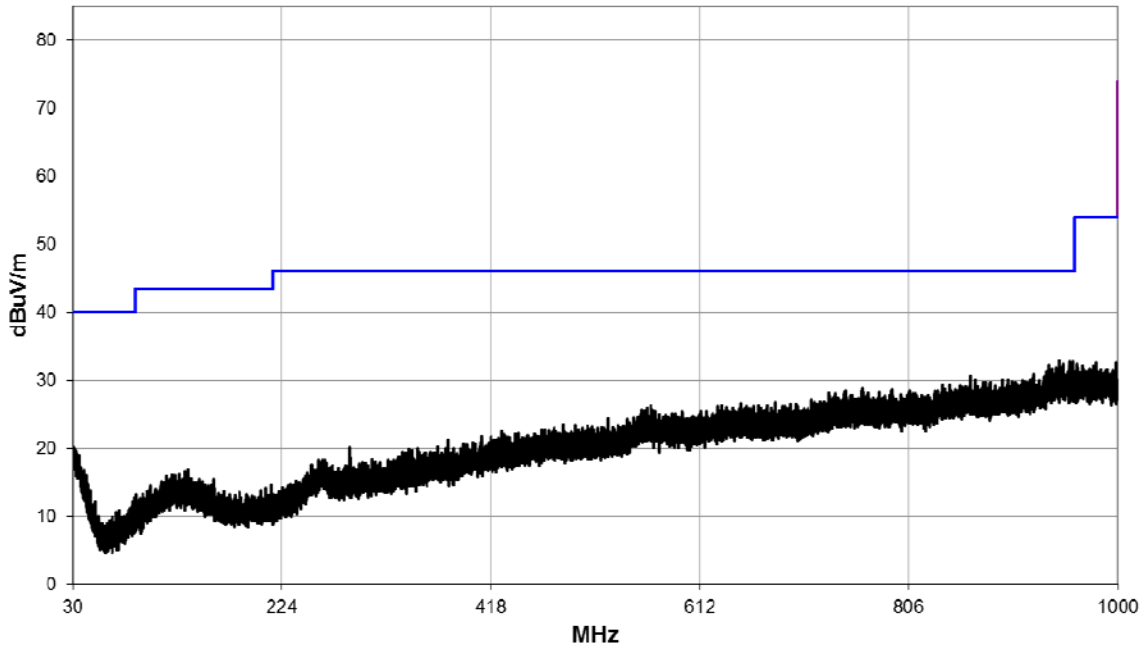
Lower band edge plot



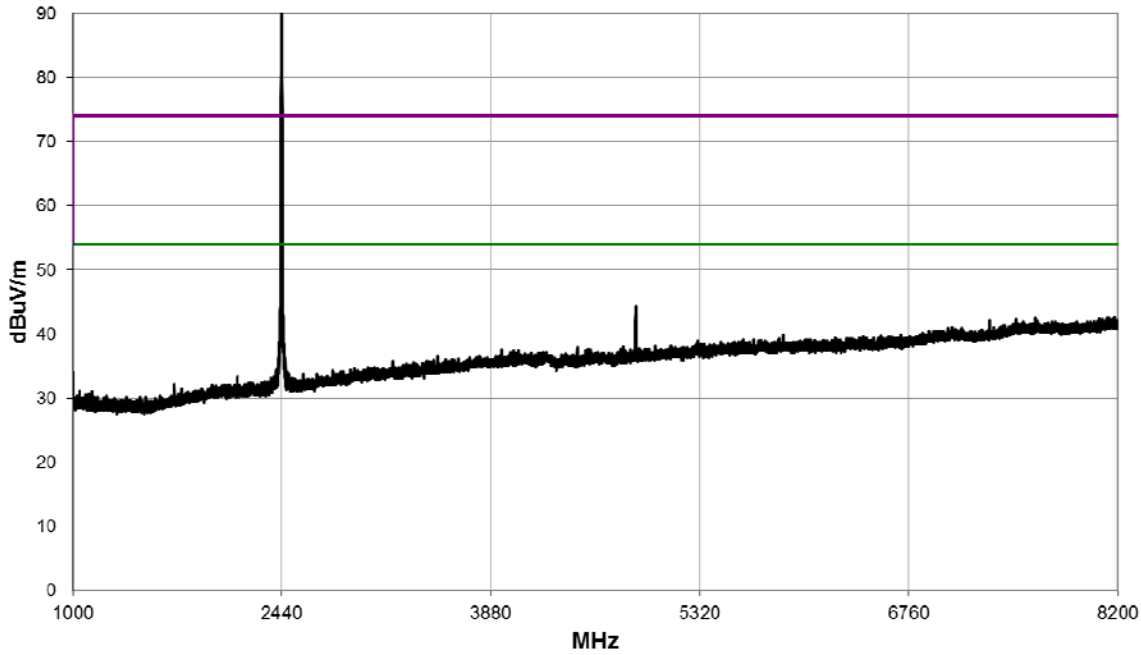
Date: 5.JUL.2018 09:25:12

High Power; Channel: mid 2440 MHz										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
There were no emissions within 10 dB of the restricted band QP limit as specified in 15.205.										

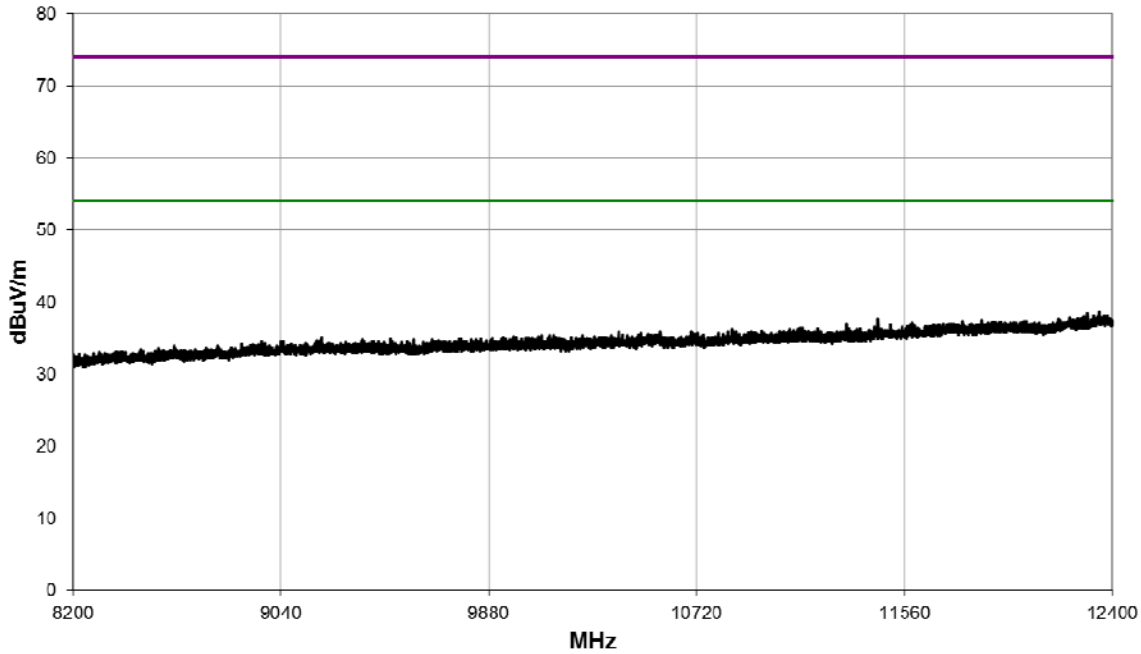
30 MHz – 1 GHz plot with fundamental at 2440 MHz and 5dBm output power



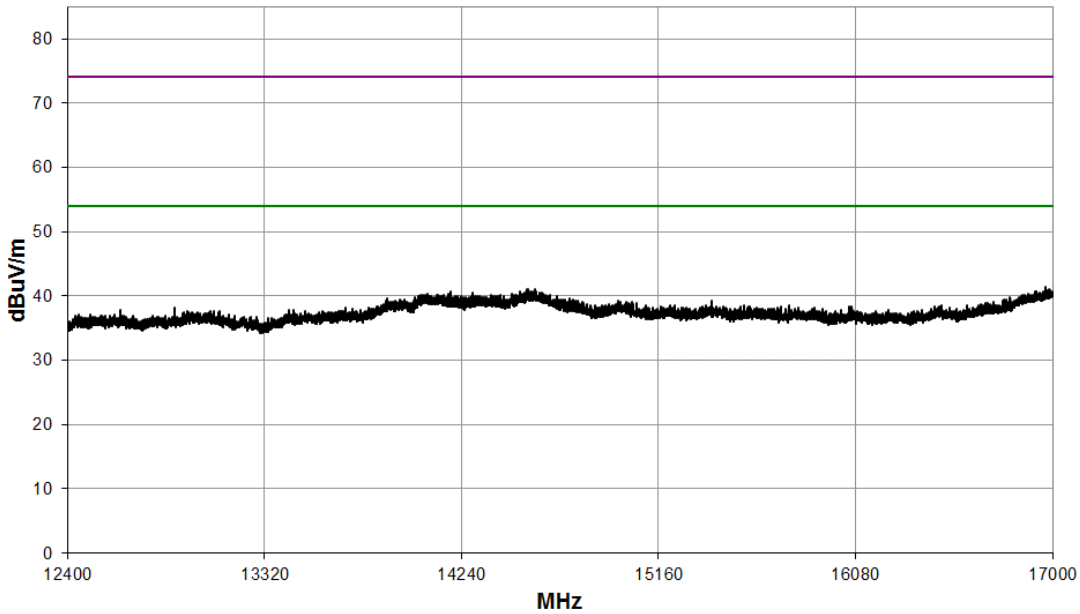
1 – 8.2 GHz plot with fundamental at 2440 MHz and 5dBm output power



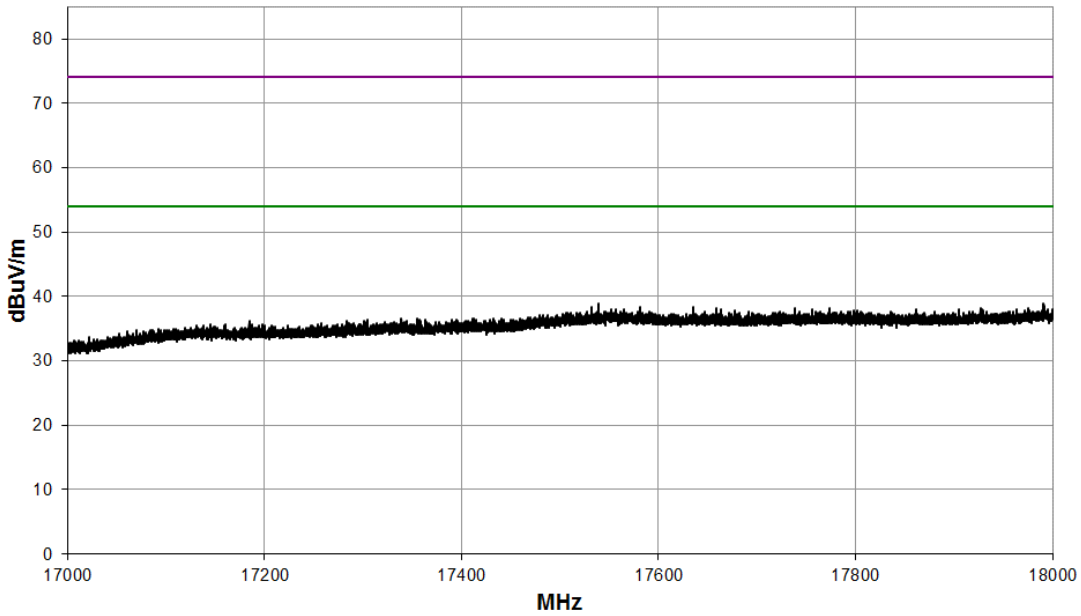
8.2 – 12.4 GHz plot with fundamental at 2440 MHz and 5dBm output power



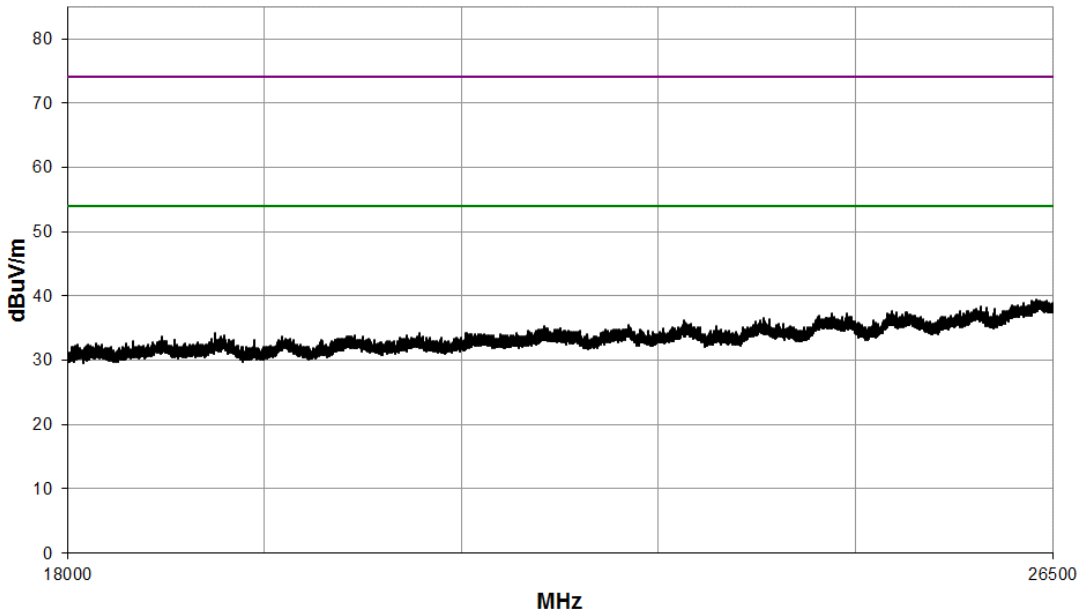
12.4 – 17 GHz plot with fundamental at 2440 MHz and 5dBm output power



17 – 18 GHz plot with fundamental at 2440 MHz and 5dBm output power

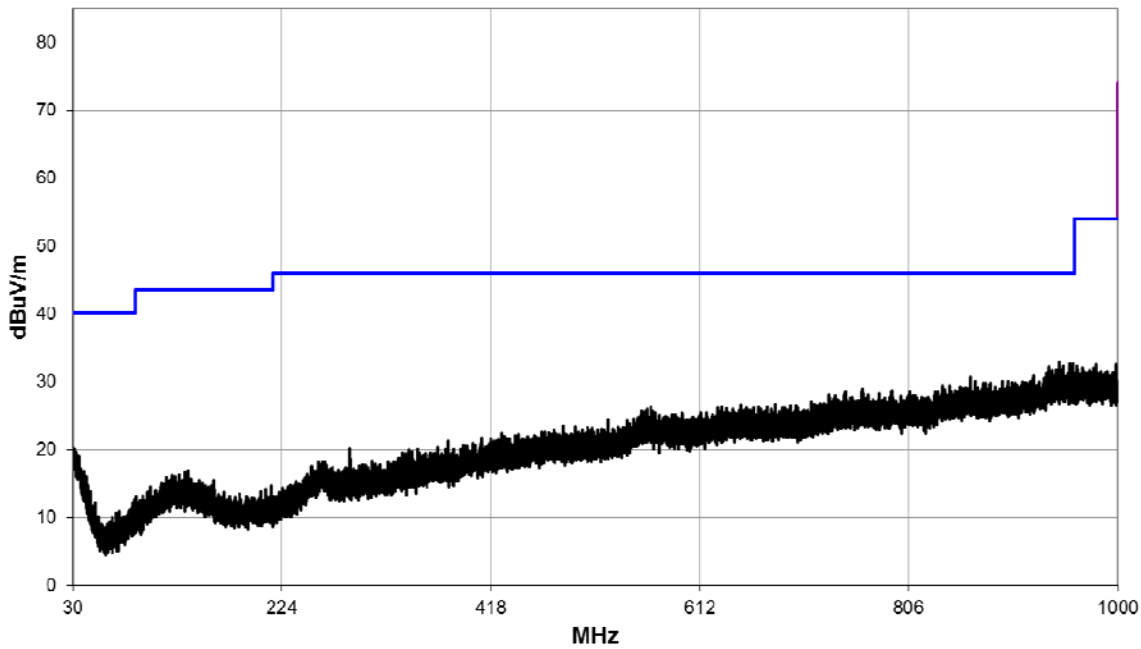


18 – 26.5 GHz plot with fundamental at 2440 MHz and 5dBm output power

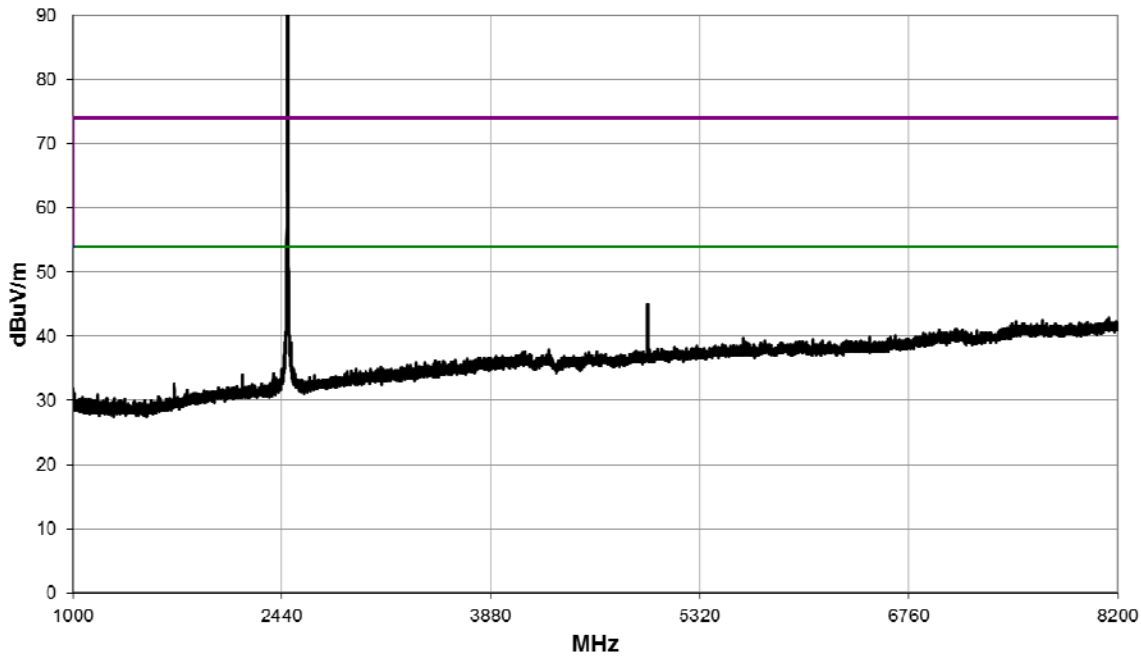


High Power; Channel: high 2480 MHz										
Detector	***Freq. (MHz)***	***Meas'd Emission (dBµV)***	***Cable Loss (dB)***	***Antenna Factor (dB/m)***	***Pre-amp Gain (dB)***	***Duty Cycle Corr'n (dB)***	***Distance Extrap'n Factor (dB)***	***Field Strength (dBµV/m)***	***Field Strength (µV/m)***	***Limit (µV/m)***
There were no emissions within 10 dB of the restricted band QP limit as specified in 15.205.										

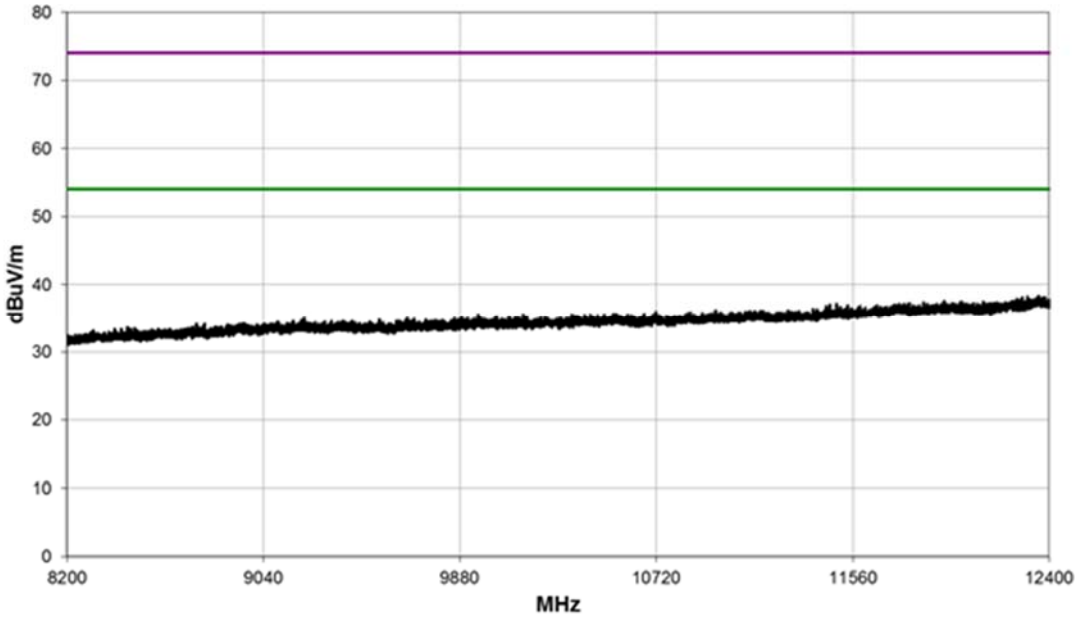
30 MHz – 1 GHz plot with fundamental at 2480 MHz and 5dBm output power



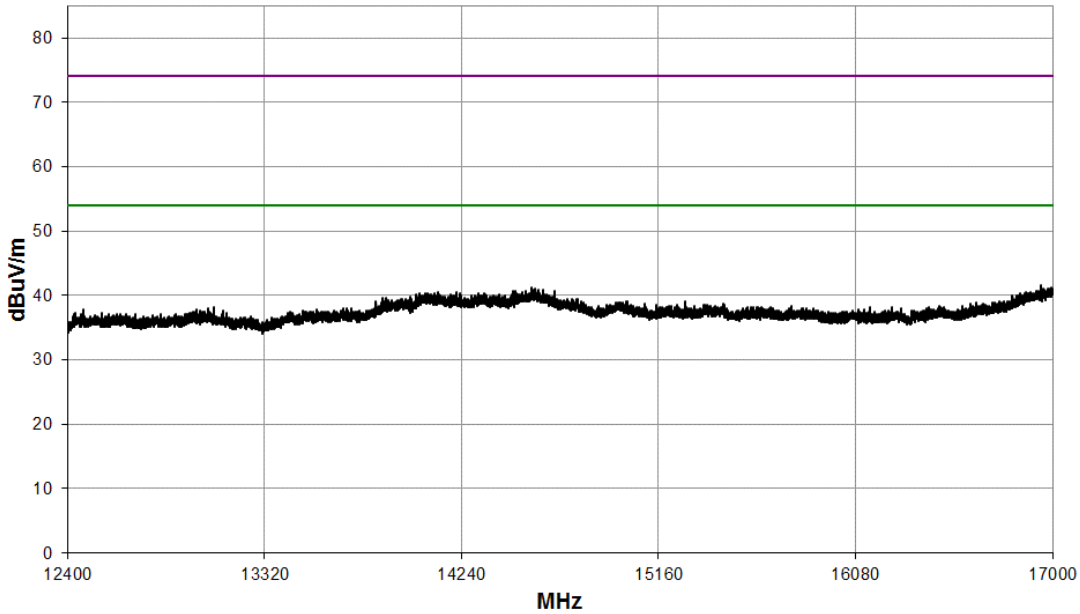
1 – 8.2 GHz plot with fundamental at 2480 MHz and 5dBm output power



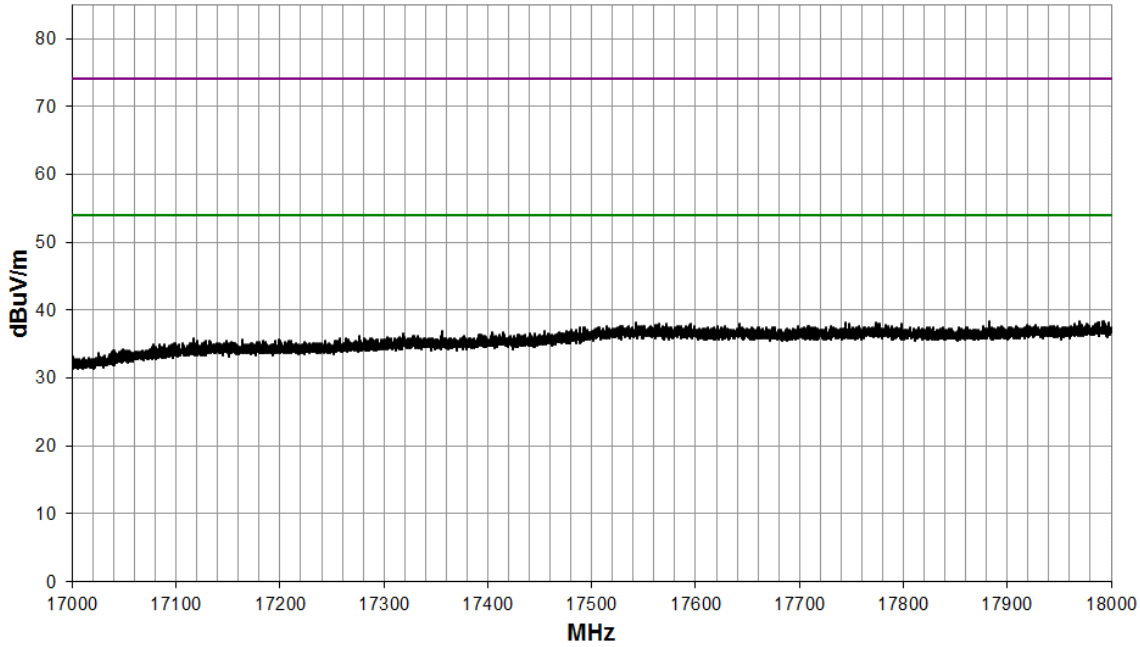
8.2 – 12.4 GHz plot with fundamental at 2480 MHz and 5dBm output power



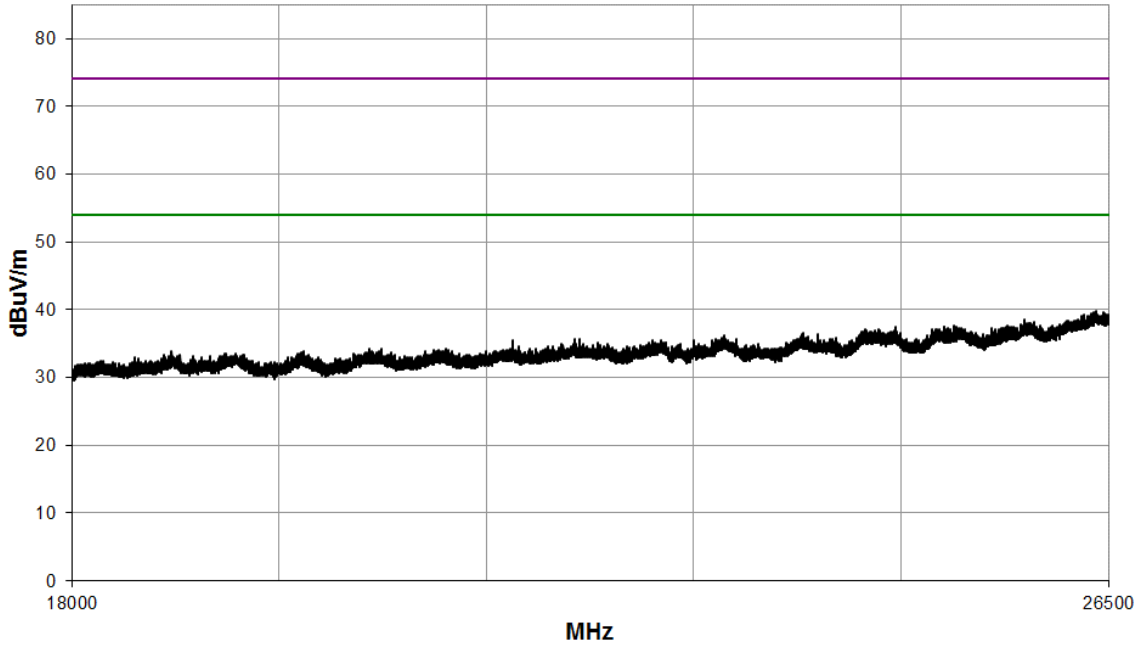
12.4 – 17 GHz plot with fundamental at 2480 MHz and 5dBm output power

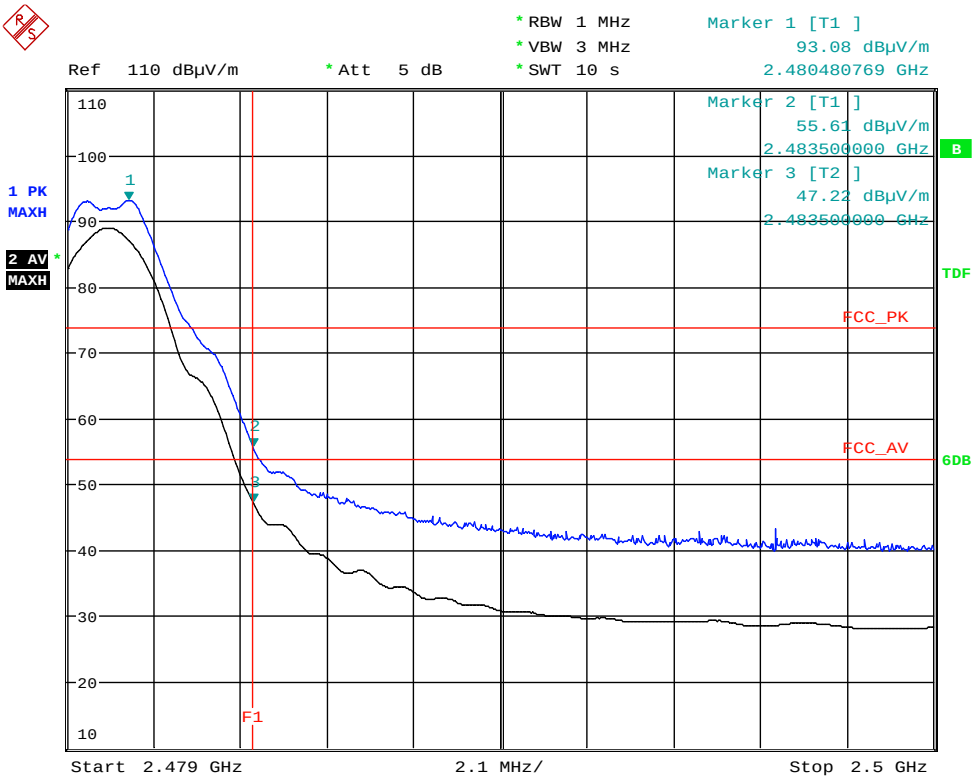


17 – 18 GHz plot with fundamental at 2480 MHz and 5dBm output power



18 – 26.5 GHz plot with fundamental at 2480 MHz and 5dBm output power





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Upper Bandedge Worst Case

12 Occupied Bandwidth

12.1 Definition

The emission bandwidth (6 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 6 dB below the maximum in-band spectral density of the modulated signal.

The 99% emission bandwidth is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained.

12.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clauses:	6 dB Bandwidth: ANSI C63.10-2013, Clause 11.8 99% Bandwidth: ANSI C63.10-2013, Clause 6.9
EUT Frequencies Measured:	2405 MHz, 2440 MHz & 2480 MHz
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

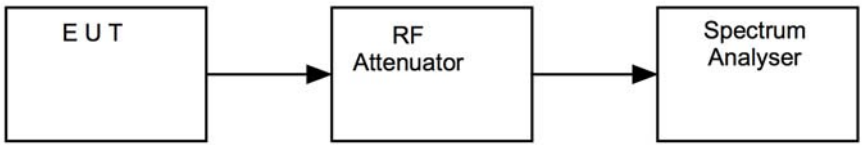
The minimum -6 dB bandwidth shall be at least 500 kHz.

12.4 Test Method

With the EUT 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

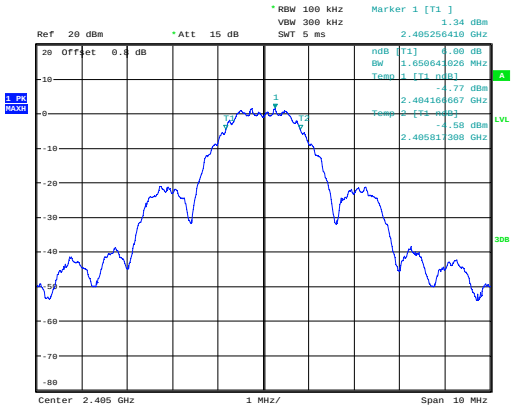


12.5 Test Equipment

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU26	REF909	2019-06-15

12.6 Test Results

Test: 6 dB Bandwidth; Power Setting: 5 dBm				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2405	2404.167	2405.817	1650.6	PASS
2440	2439.167	2440.817	1650.6	PASS
2480	2479.183	2480.801	1618.6	PASS



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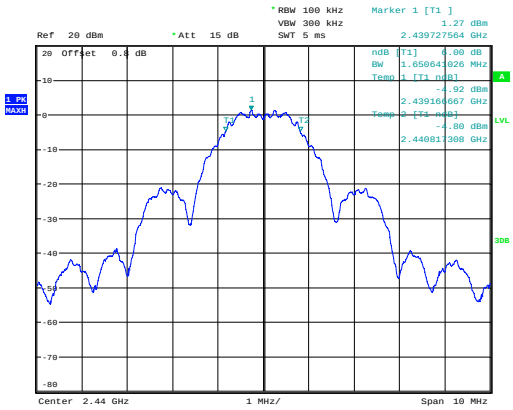

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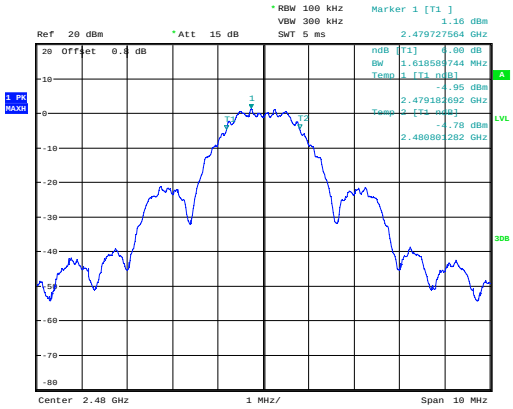

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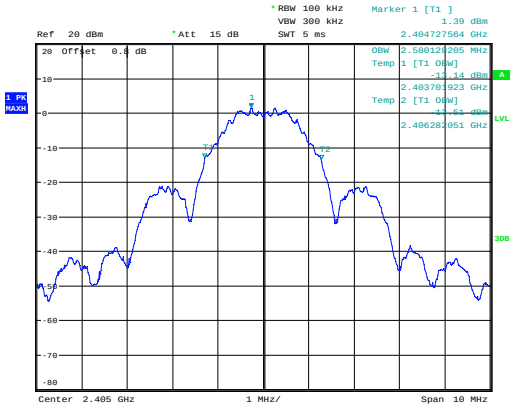
Test: 99% Bandwidth; Power Setting: 5 dBm				
Channel Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***99% Bandwidth (kHz)***	***Result***
2405	2403.702	2406.282	2580.1	PASS
2440	2438.702	2441.282	2580.1	PASS
2480	2478.702	2481.282	2580.1	PASS



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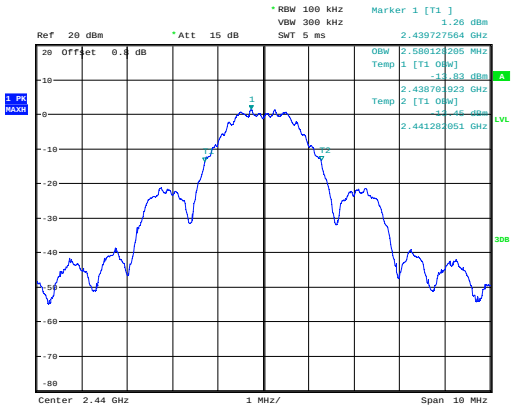

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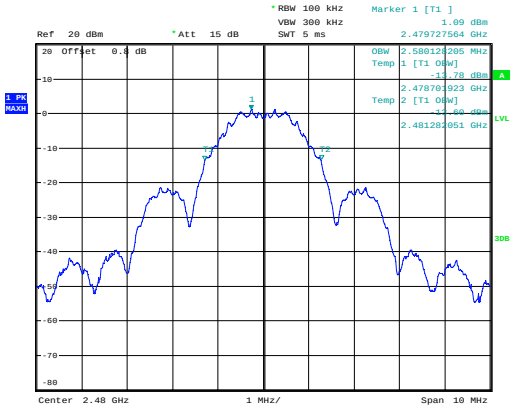

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13 Maximum peak conducted output power

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 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Frequencies Measured:	2405 MHz, 2440 MHz & 2480 MHz
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)

13.3 Test Limit

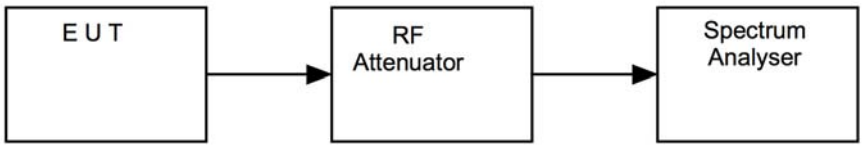
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

13.4 Test Method

With the EUT 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

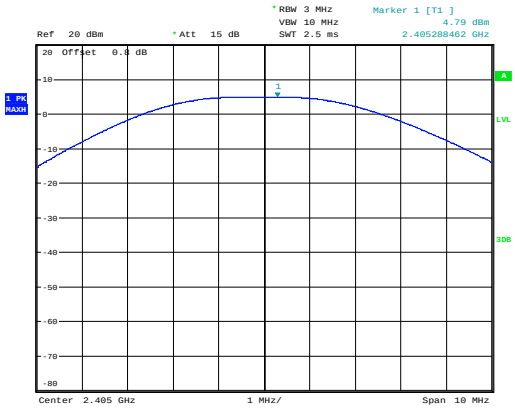


13.5 Test Equipment

Equipment Description	Manufacturer	Equipment Type	Element No	Due For Calibration
Spectrum Analyser	R&S	FSU26	REF909	2019-06-15

13.6 Test Results

Power Setting: 5 dBm						
Channel Frequency (MHz)	Maximum peak conducted output power		Antenna gain (dBi)	E.I.R.P.		Result
	(dBm)	(W)		(dBm)	(W)	
2405	4.79	0.0030	1.5	6.29	0.0043	PASS
2440	4.61	0.0029	1.5	6.11	0.0041	PASS
2480	4.43	0.0028	1.5	5.93	0.0039	PASS



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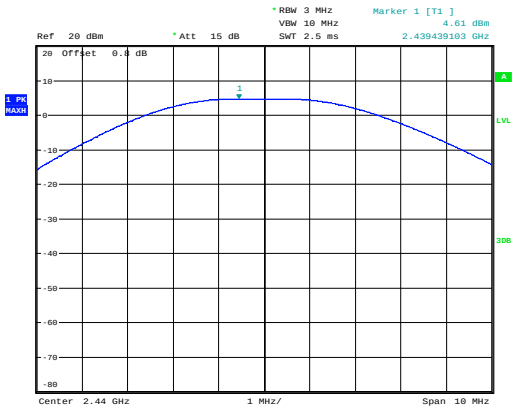

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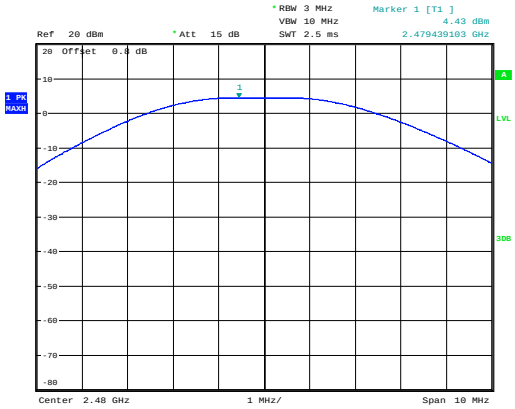

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14 Out-of-band and conducted spurious emissions

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 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Frequencies Measured:	2405 MHz, 2440 MHz & 2480 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW:	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 25 GHz

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

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.

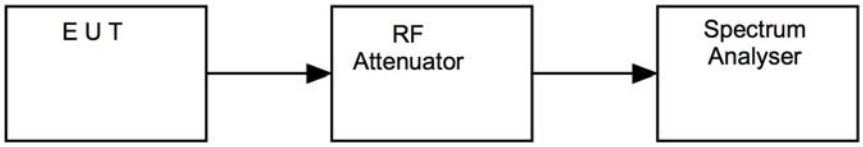
Attenuation below the general field strength limits specified in FCC 47CFR15.209 (a) / RSS-Gen is not required.

14.4 Test Method

With the EUT 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

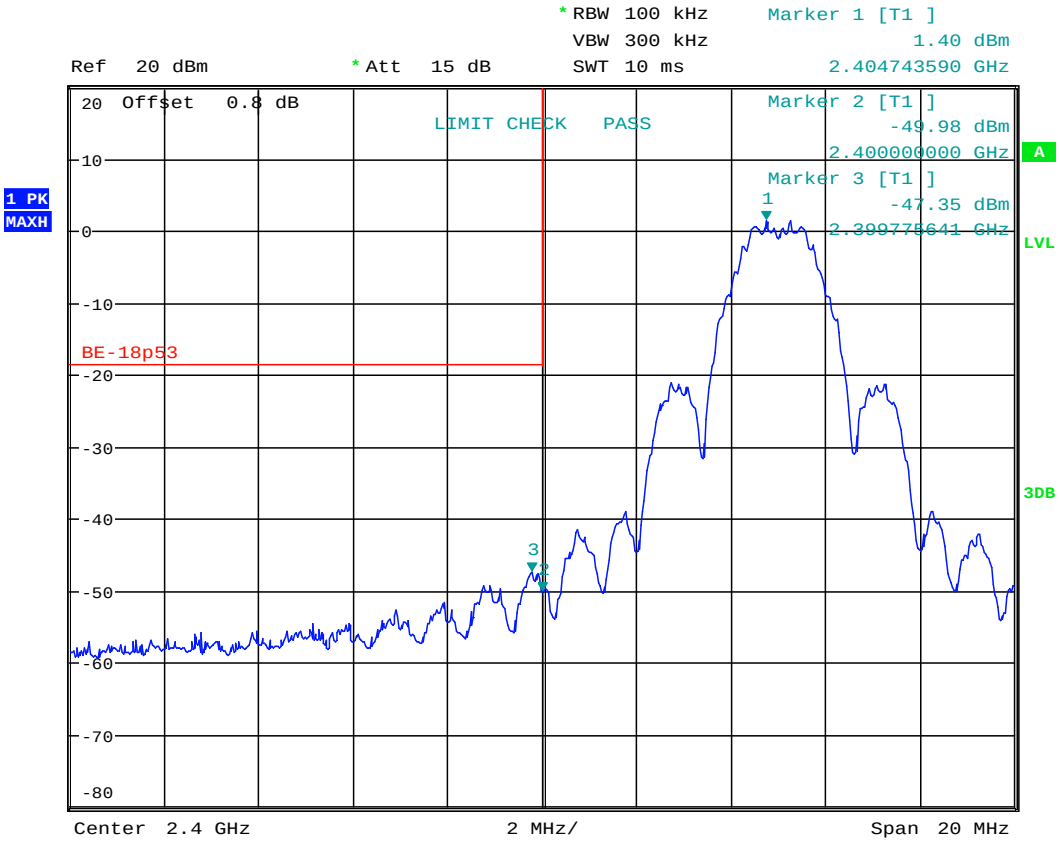


14.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2019-06-15

14.6 Test Results

Frequency: 2405 MHz; Power setting: 5 dBm



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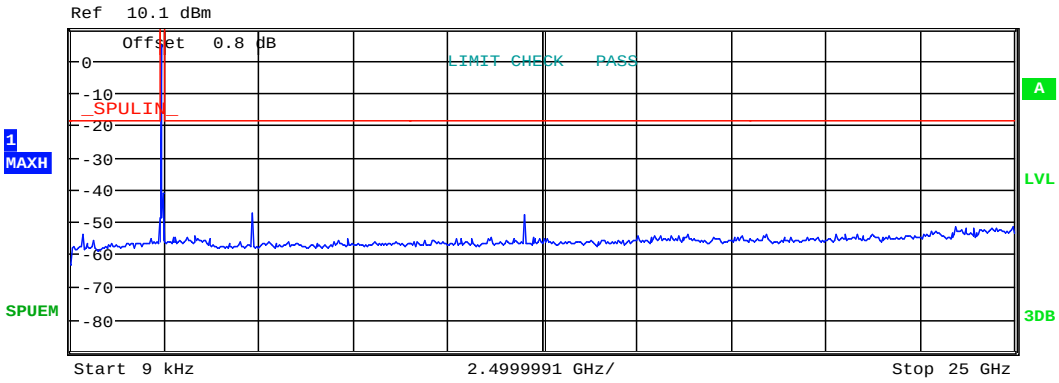
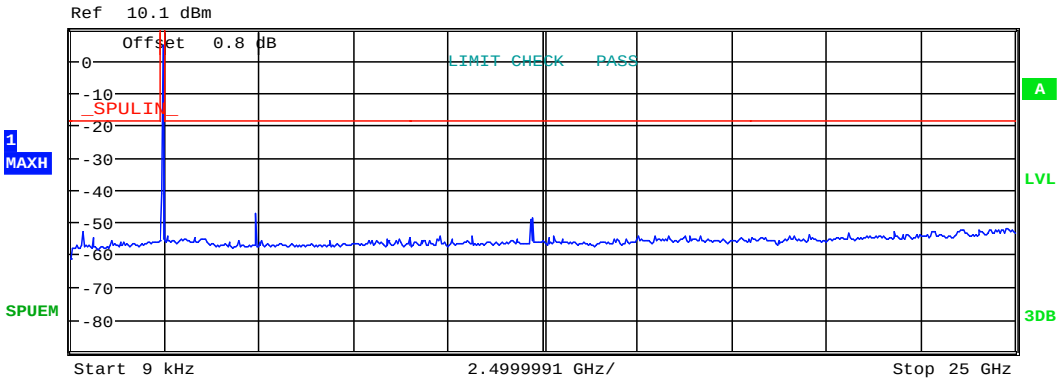


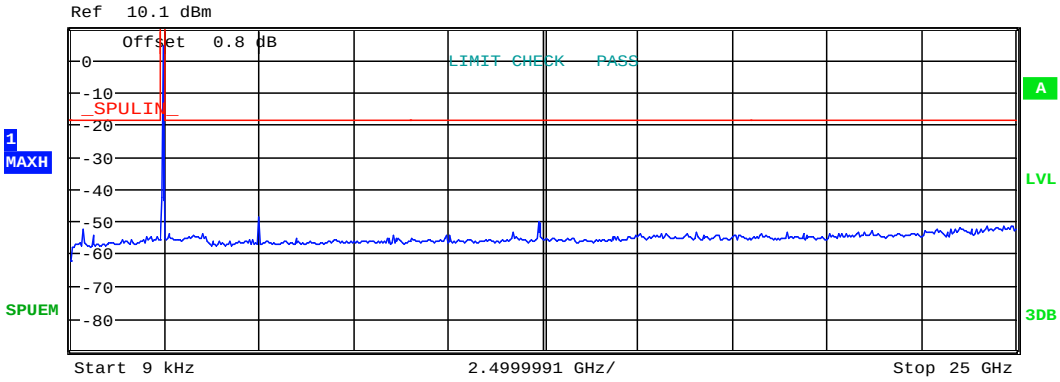
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	19.168269 k	-69.77	-51.24
150.000 k	30.000 M	10.00 k	293.280000 k	-63.57	-45.04
30.000 M	1.000 G	100.00 k	300.597667 M	-54.00	-35.47
1.000 G	2.400 G	100.00 k	2.399907 G	-48.62	-30.09
2.400 G	2.483 G	3.00 M	2.404880 G	4.80	-25.20
2.483 G	9.000 G	100.00 k	4.810933 G	-47.19	-28.66
9.000 G	18.000 G	100.00 k	12.027600 G	-47.66	-29.13
18.000 G	25.000 G	100.00 k	23.448100 G	-51.77	-33.24

Frequency: 2440 MHz; Power setting: 5 dBm



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	38.600962 k	-68.91	-50.38
150.000 k	30.000 M	10.00 k	170.895000 k	-61.62	-43.09
30.000 M	1.000 G	100.00 k	304.962667 M	-52.94	-34.41
1.000 G	2.400 G	100.00 k	2.374660 G	-55.63	-37.10
2.400 G	2.483 G	3.00 M	2.440666 G	4.63	-25.37
2.483 G	9.000 G	100.00 k	4.881051 G	-47.19	-28.66
9.000 G	18.000 G	100.00 k	12.202800 G	-49.01	-30.48
18.000 G	25.000 G	100.00 k	24.775300 G	-52.02	-33.49

Frequency: 2480 MHz; Power setting: 5 dBm



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	65.716346 k	-67.67	-49.14
150.000 k	30.000 M	10.00 k	170.895000 k	-62.36	-43.83
30.000 M	1.000 G	100.00 k	310.006667 M	-52.36	-33.83
1.000 G	2.400 G	100.00 k	1.999133 G	-55.01	-36.48
2.400 G	2.483 G	3.00 M	2.480247 G	4.41	-25.59
2.483 G	9.000 G	100.00 k	2.484021 G	-44.01	-25.48
9.000 G	18.000 G	100.00 k	12.397200 G	-50.07	-31.54
18.000 G	25.000 G	100.00 k	24.920900 G	-51.54	-33.01

15 Power spectral density

15.1 Definition

The power per unit bandwidth.

15.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 1
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequencies Measured:	2405 MHz, 2440 MHz & 2480 MHz
Deviations From Standard:	None
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 22 °C	+15 ºC to +35 ºC (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

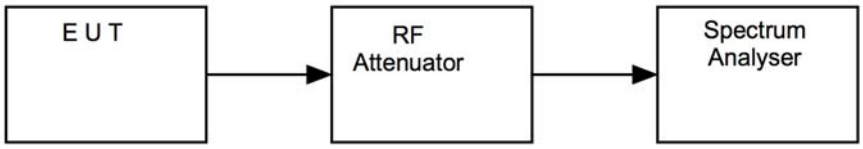
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

15.4 Test Method

With the EUT 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

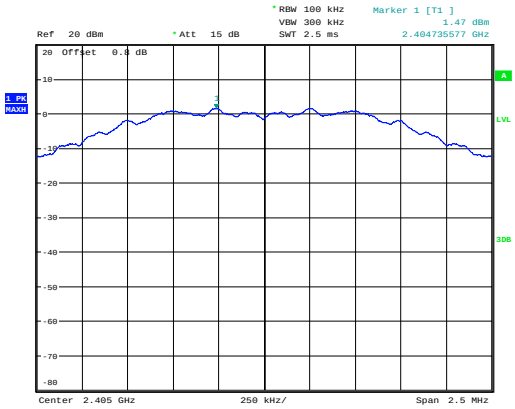


15.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	REF909	2019-06-15

15.6 Test Results

Power Setting: 5 dBm				
Channel Frequency (MHz)	**Analyzer Level (dBm)**	**Cable loss (dB)**	**Power (dBm)**	**Result**
2405	1.47	0.0	1.47	PASS
2440	1.33	0.0	1.33	PASS
2480	1.13	0.0	1.13	PASS



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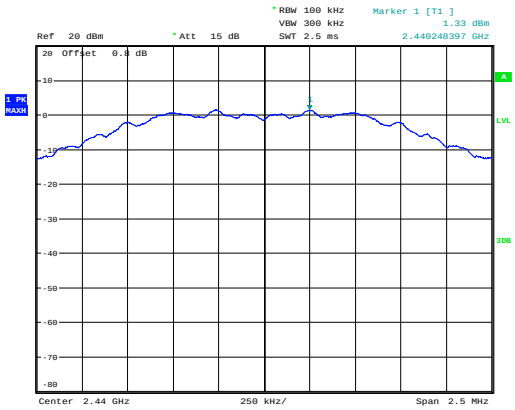

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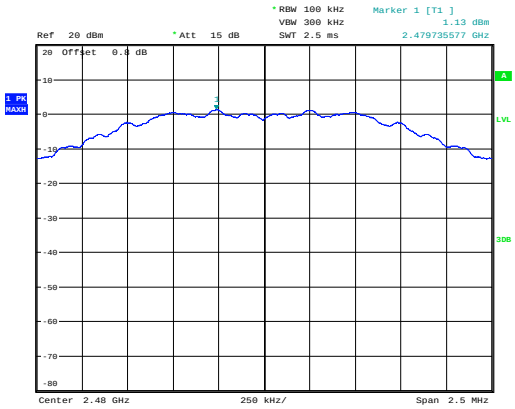

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16 Measurement Uncertainty

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 (30 MHz to 1 GHz) = **4.75 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.2 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.58 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **0.93 dB**

[5] Conducted RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**
Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**

[6] Radiated RF power out-of-band

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[7] Power spectral density

Uncertainty in test result (Spectrum Analyser) = **3.11 dB**

[8] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**
Uncertainty in test result (Pershore OATS) = **4.26 dB**

17 Appendix G: General SAR test reduction and exclusion guidance

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

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

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

SAR Exclusion Threshold (SARET)

SAR Exclusion Threshold = Step 1 + Step 2

Step 1

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

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

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

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

For Distances Greater than 50 mm Step 2 applies

Step 2

$$(TSD^{B} – 50mm) * 10\}$$

Where:

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

Operating Frequency 2.402 GHz

SARET = [(3.0 x 50) / √2.405] + { (50 – 50) * 10}
SARET = [150 / 1.55] + (0 * 10}
SARET = 96.72 mW

Operating Frequency 2.440 GHz

SARET = [(3.0 x 50) / √2.44] + { (50 – 50) * 10}
SARET = [150 / 1.56] + (0 * 10}
SARET = 96.15 mW

Operating Frequency 2.480 GHz

SARET = [(3.0 x 50) / √2480] + { (50 – 50) * 10}
SARET = [150 / 1.57] + (0 * 10}
SARET = 95.54 mW

Channel Frequency (MHz)	EIRP (mW)	SAR Exclusion Threshold	SAR Evaluation
2405	4.3	96.72	Not Required
2440	4.1	96.15	Not Required
2480	3.9	95.54	Not Required

Therefore standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is no