

Report on the Radio Testing

For

Dyson Technology Ltd

on

Dyson 360 eye

Report no. TRA-026979-03-47-02A

19th April 2016

RF915 3.0

Report Number: TRA-026979-03-47-02A
Issue: A

REPORT ON THE RADIO TESTING OF A
Dyson Technology Ltd
Dyson 360 eye
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247 & IC RSS-247

TEST DATE: 18th - 24th December 2015

Written by: D Winstanley

D Winstanley
Radio Senior Test Engineer

Approved by:

J Charters
Department Manager - Radio

Date: 19th April 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

RF915 3.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	19th April 2016	Original

2 Summary

TEST REPORT NUMBER:	TRA-026979-03-47-02A
WORKS ORDER NUMBER	TRA-026979-03
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):	Dyson 360 eye
FCC IDENTIFIER:	QVHRB01001
CERTIFICATION NUMBER	7986A-RB01001
EUT SERIAL NUMBER:	HV1-JP-GKA0552A, HV1-JP-GKA0685A, HV1-JP-GKA1373A, HV1-JP-GKA1540A, HV1-JP-GKA1201A
MANUFACTURER/AGENT:	Dyson Technology Ltd
ADDRESS:	Tetbury Hill Malmesbury Wiltshire SN16 0RP United Kingdom
CLIENT CONTACT:	Nicholas Jordan ☎ 01666 827464 ✉ Nicholas.Jordan@dyson.com
ORDER NUMBER:	Not Applicable
TEST DATE:	18th - 24th December 2015
TESTED BY:	D Winstanley 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

1 EUT is a battery powered device, the battery is powered via a base unit using wireless power transfer.

AC power line conducted emissions was performed on the on the base unit with the robot charging, results can be found in Element test report number, TRA-026979-03-47-00A.

Notes:

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-026979-03-47-02A presents the results of the Radio testing on a Dyson Technology Ltd, Dyson 360 eye 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 Dyson Technology Ltd by Element, at the address(es) detailed below.

☐	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	☒	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK
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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 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

§	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: Dyson 360 eye
- Serial Number: HV1-JP-GKA0552A, HV1-JP-GKA0685A, HV1-JP-GKA1373A, HV1-JP-GKA1540A, HV1-JP-GKA1201A
- Model Number: RB01
- Software Revision: Version R5 SP7.01
- Build Level / Revision Number: Production / 65021-01/10

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.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

7.3.1 Transmission

The mode of operation for Tx tests was as follows...

The Wifi Module in the robot was set via USB Serial command to transmit on the required operating frequency and with the relevant modulation type and data rate.
USB – Serial adaptor as removed before testing.

7.3.2 Reception

This report covers on transmit operation of the robot.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2412MHz – 2462 MHz
Modulation type(s):	802.11b – CCK; 802.11g – OFDM, 802.11n - OFDM
Occupied channel bandwidth(s):	20 MHz
Channel spacing:	5 MHz
Declared output power(s):	+18 dBm (conducted)
Nominal Supply Voltage:	14.8 Vdc
Location of notice for license exempt use:	Label / user manual / both.
Duty cycle:	Upto 100 %

7.4.2 Antennas

Type:	Ceramic chip antenna: Unictron Technologies Corporation H2U34WGTQW0100
Frequency range:	2400 – 2883.5 MHz
Impedance:	50 Ohms
SWR:	Unknown
Gain:	2.5 dBi
Polarisation:	Omni
Beam width:	Not Applicable
Connector type:	Not Applicable
Mounting:	Solder

7.5 EUT Description

The EUT is a robot vacuum cleaner containing a 2.4 WiFi radio.

8 Modifications

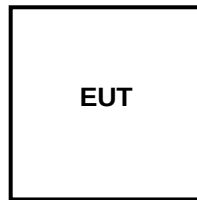
No modifications were performed during this assessment.

9 EUT Test Setup

9.1 Block Diagram

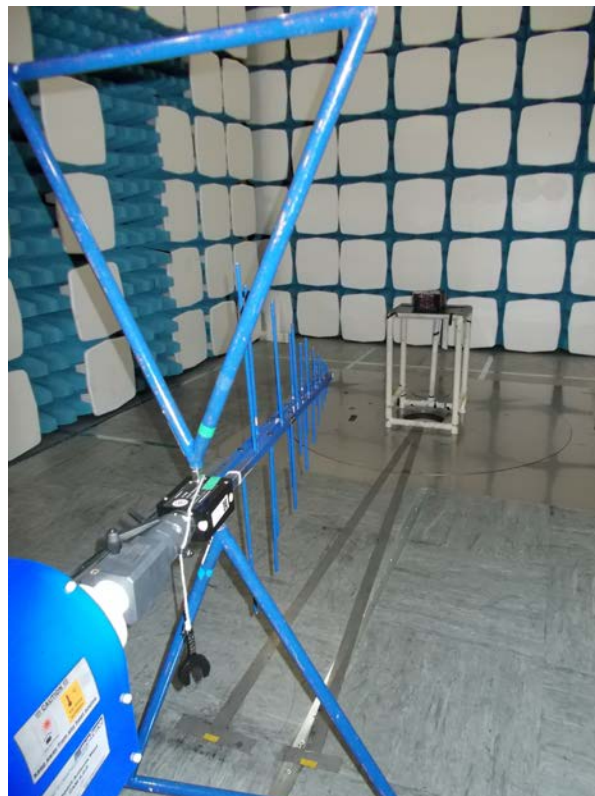
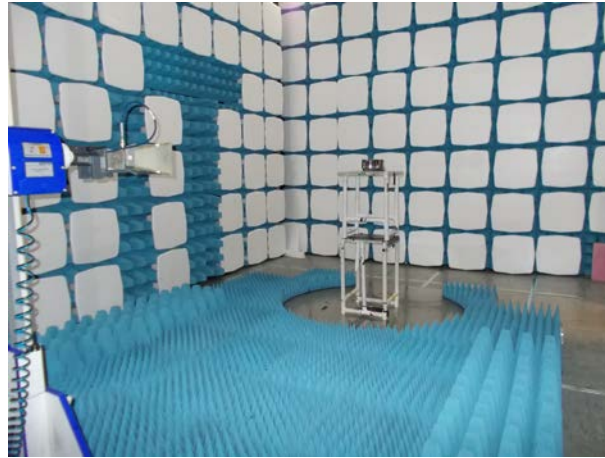
The following diagram shows basic EUT interconnections with cable type and cable lengths identified:

EUT is a battery powered device with no cables.



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 approx. 14.8V dc from rechargeable batteries.

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	Fully Charged 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 Skelmersdale
Test Chamber:	Radio Chamber (REF940)
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels / Frequencies Measured:	2412.0 MHz / 2442.0 MHz/ 2462.0 MHz
EUT Channel Bandwidths:	20 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: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 39 % RH	20 % RH to 75 % RH (as declared)
Supply: 14.8 Vdc	14.8Vdc

11.3 Test Limit

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 (μV/m at 3 m)</i>
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

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;

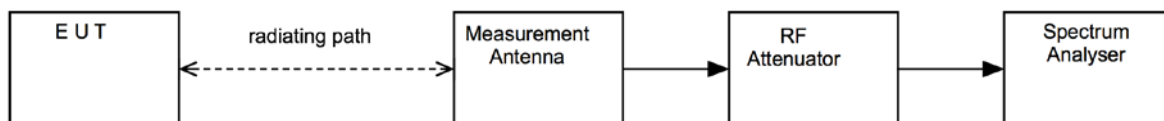
PA is the pre-amplifier gain in dB (where used);

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

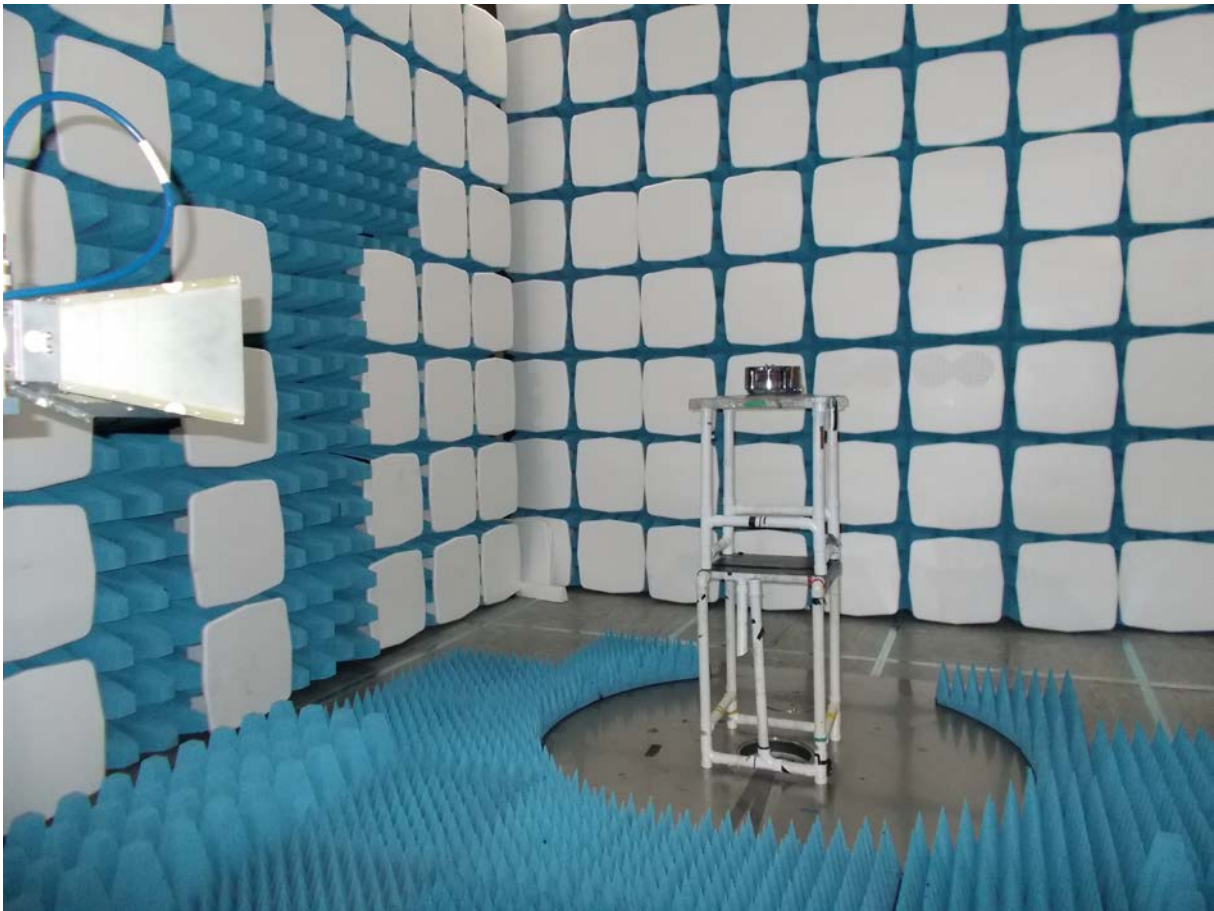
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph



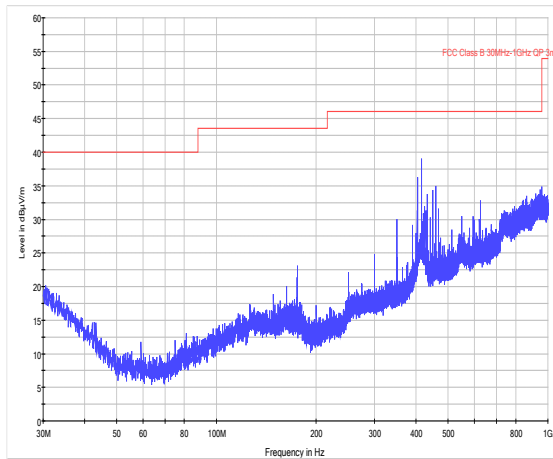
11.6 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>	<i>Calibration Interval</i>
Bilog	Chase	CBL611/A	UH191	26/02/2017	12
ESVS10	R&S	ESVS10	L352	07/08/2016	12
Spectrum Analyser	R&S	FSU46	U281	24/04/2016	12
Horn Antenna	EMCO	3115	L139	20/09/2015	24
Pre-Amplifier	Agilent	8449B	L572	10/02/2016	12
Horn Antenna	Flann	20240-20	L300	10/02/2016	12

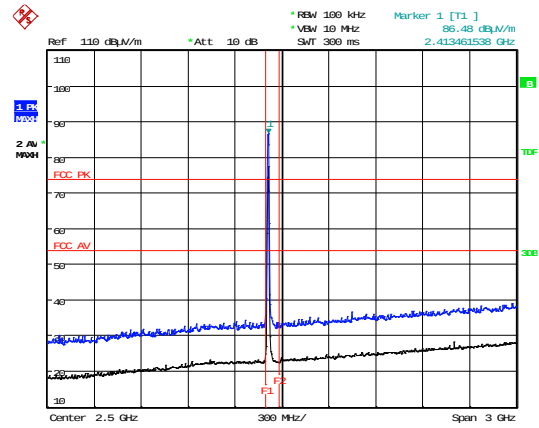
11.7 Test Results

802.11b; 2412 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)
Pk	19295.93	52.45	9.90	37.30	34.75	0.00	-9.54	55.36	585.97	5012
Av	19295.93	44.79	9.90	37.30	34.75	0.00	-9.54	47.70	242.59	500

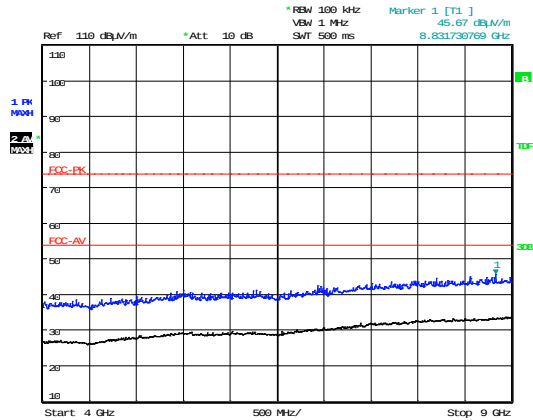


30 MHz – 1 GHz



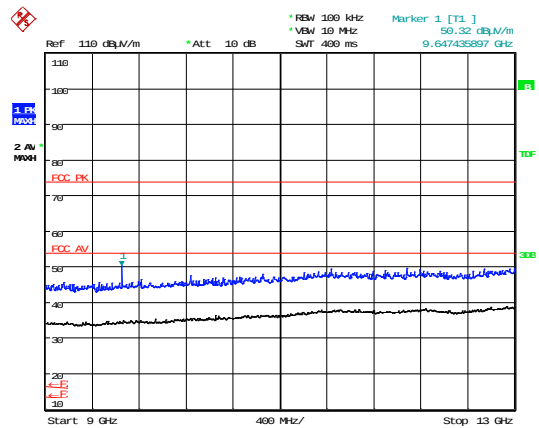
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1 GHz – 4 GHz



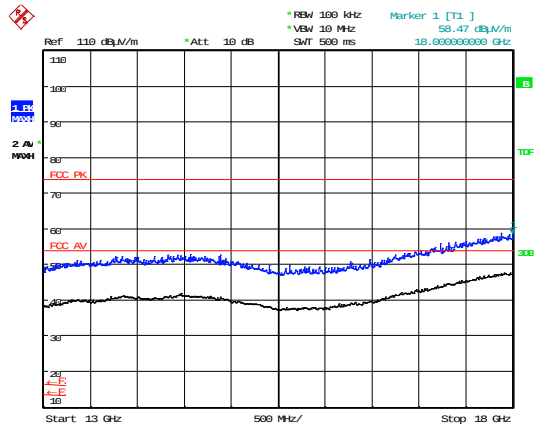
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4 GHz – 9 GHz



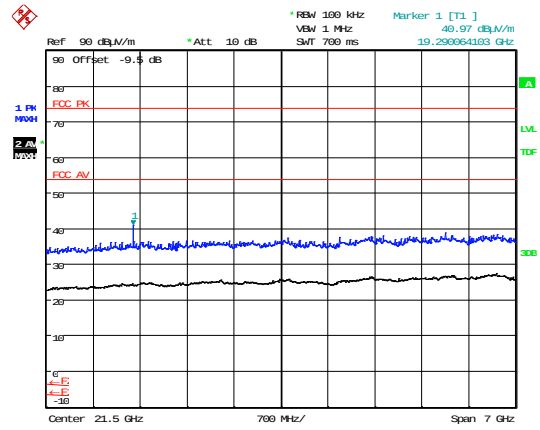
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9 GHz – 13 GHz



Date: 18.DEC.2015 10:18:13

13 GHz – 18 GHz

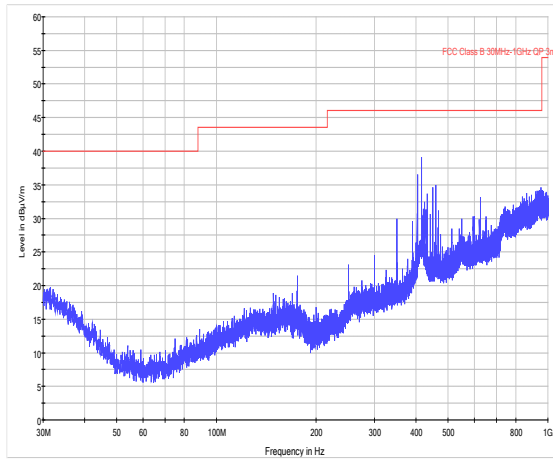


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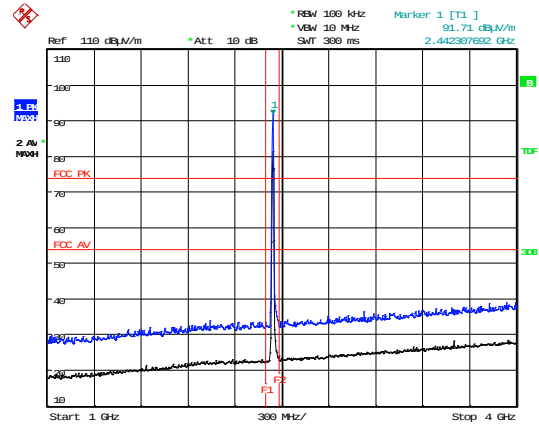
18 GHz – 25 GHz

802.11b; 2442 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)
Pk	4883.87	51.10	5.10	33.30	35.90	0.00	0.00	53.60	478.63	5012
Av	4883.87	42.43	5.10	33.30	35.90	0.00	0.00	44.93	176.40	500
Pk	19535.92	52.57	9.50	37.20	35.11	0.00	-9.54	54.62	538.12	5012
Av	19535.92	45.58	9.50	37.20	35.11	0.00	-9.54	47.63	240.65	500

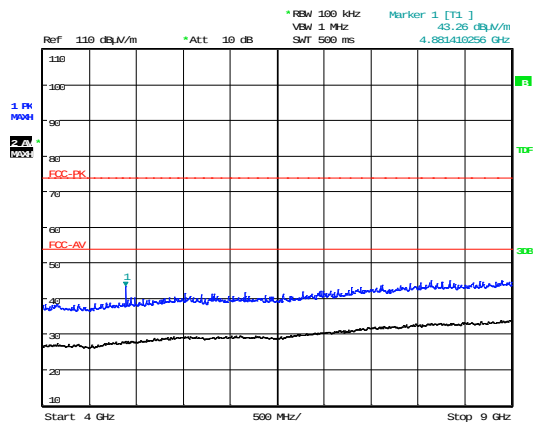


30 MHz – 1 GHz



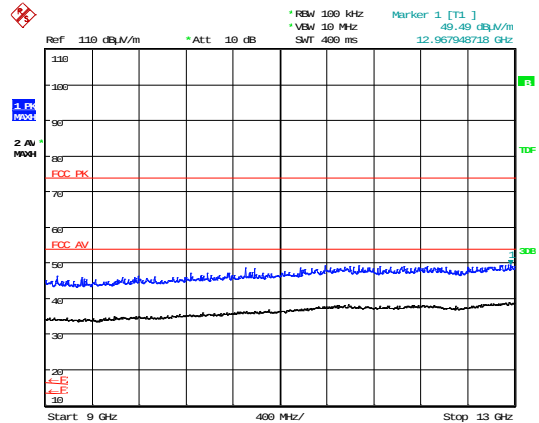
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1 GHz – 4 GHz



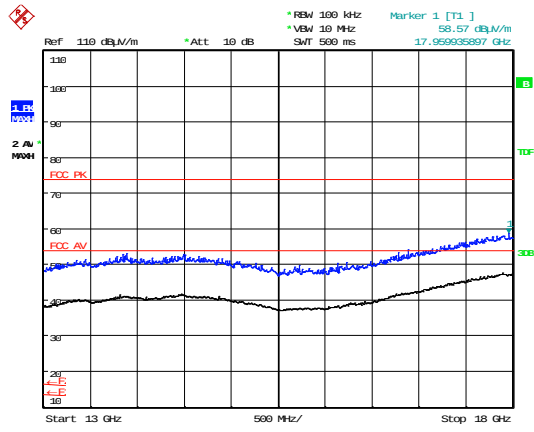
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4 GHz – 9 GHz



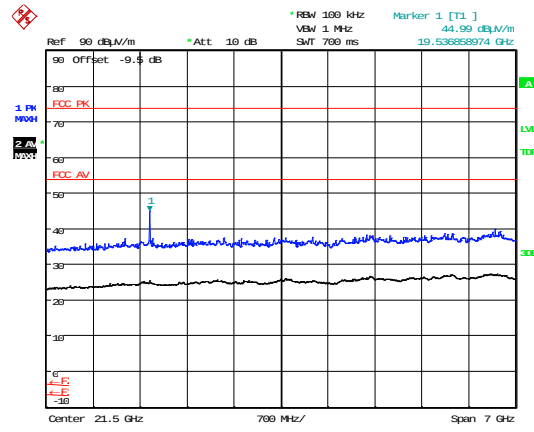
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9 GHz – 13 GHz



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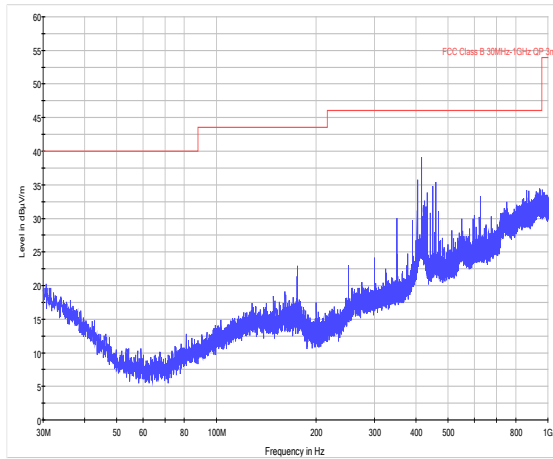
13 GHz – 18 GHz



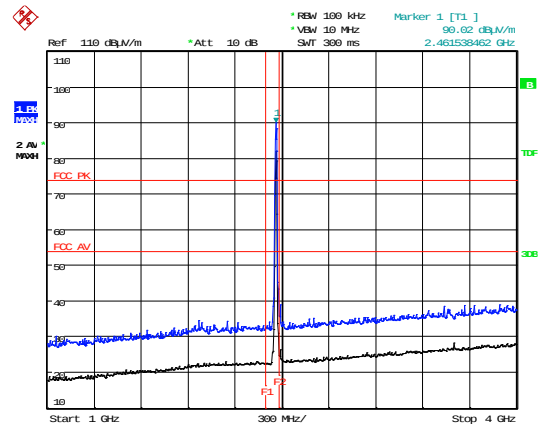
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18 GHz – 25 GHz

802.11b; 2462 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)
Pk	4923.98	50.33	5.10	33.40	35.89	0.00	0.00	52.94	443.61	5012
Av	4923.98	40.05	5.10	33.40	35.89	0.00	0.00	42.66	135.83	500
Pk	19695.90	54.79	9.60	37.20	35.33	0.00	-9.54	56.72	685.30	5012
Av	19695.90	47.61	9.60	37.20	35.33	0.00	-9.54	49.54	299.83	500

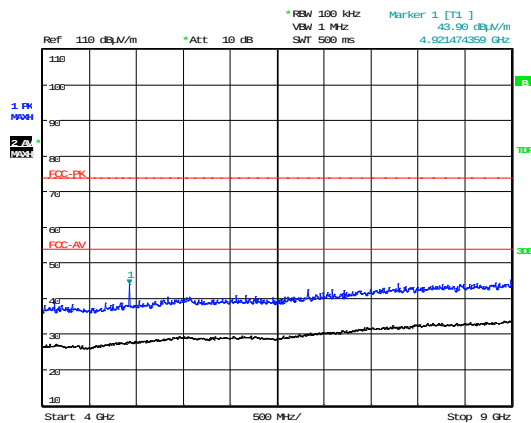


30 MHz – 1 GHz



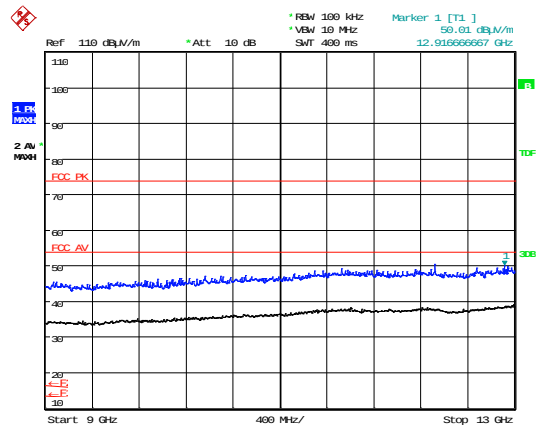
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1 GHz – 4 GHz



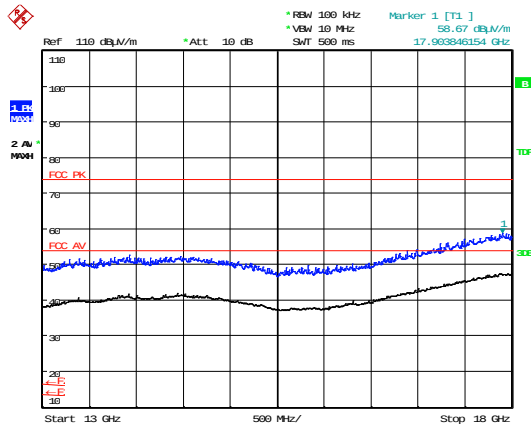
Date: 11.JAN.2016 11:28:24

4 GHz – 9 GHz



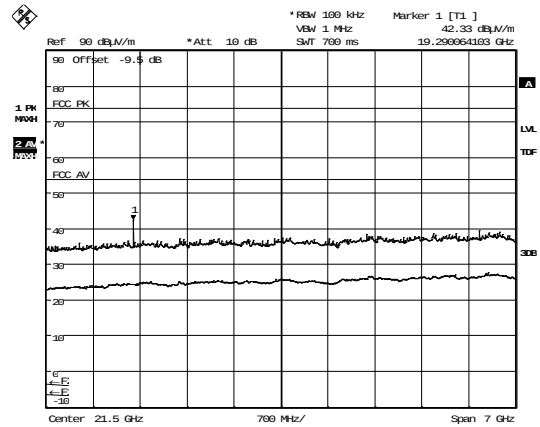
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9 GHz – 13 GHz



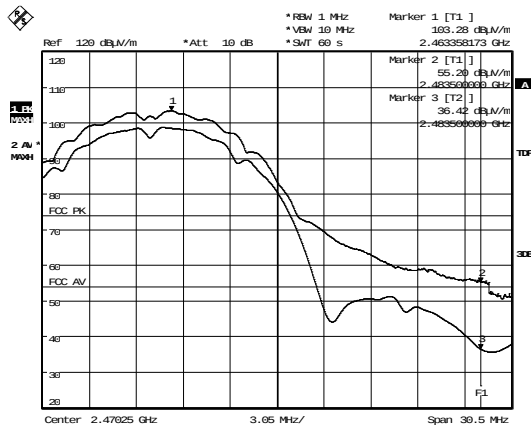
Date: 18.DEC.2015 11:00:44

13 GHz – 18 GHz



Date: 21.DEC.2015 14:12:33

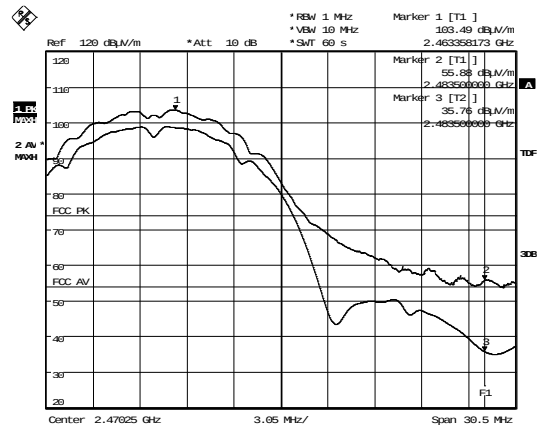
18 GHz – 25 GHz



Date: 17.DEC.2015 11:43:57

1 Mbps

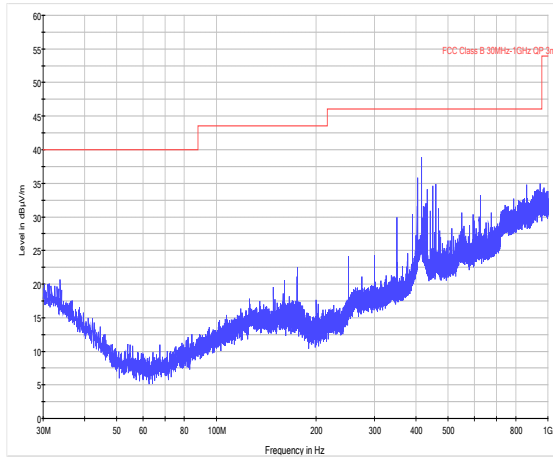
Upper band edge Compliance



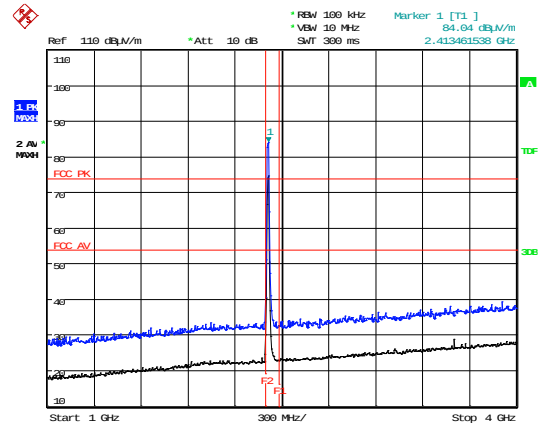
Date: 17.DEC.2015 11:55:31

11 Mbps

802.11g; 2412 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)
Pk	19295.91	52.41	9.90	37.30	34.75	0.00	-9.54	55.32	583.28	5012
Av	19295.91	45.01	9.90	37.30	34.75	0.00	-9.54	47.92	248.82	500

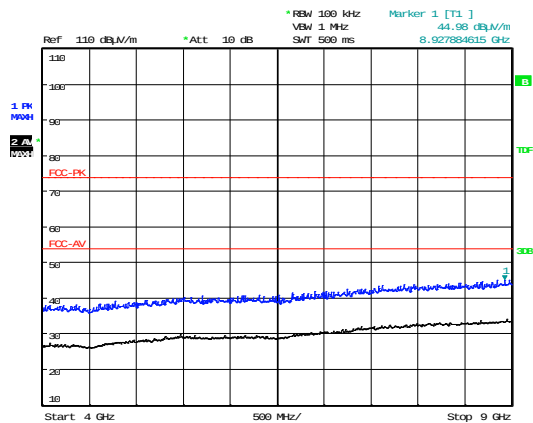


30 MHz – 1 GHz



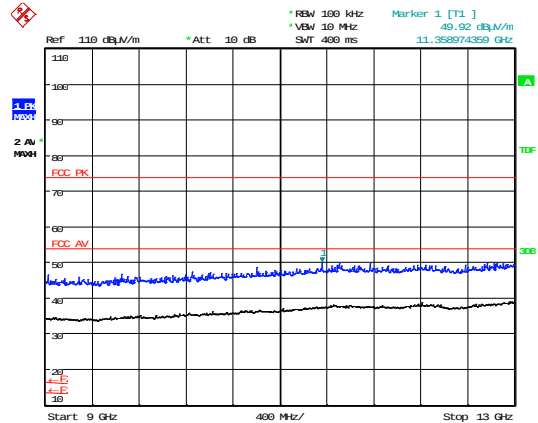
Date: 17.DEC.2015 15:37:04

1 GHz – 4 GHz



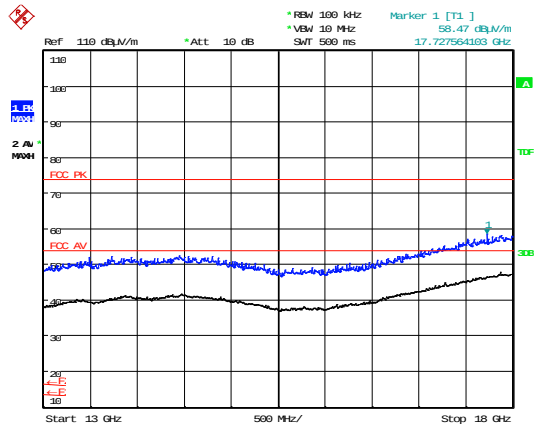
Date: 11.JAN.2016 10:59:57

4 GHz – 9 GHz



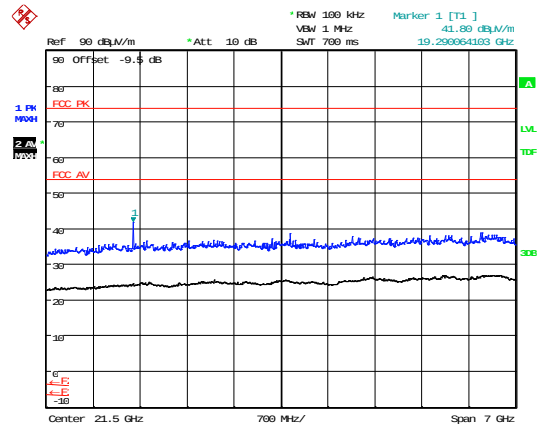
Date: 17.DEC.2015 16:45:32

9 GHz – 13 GHz



Date: 17.DEC.2015 16:52:28

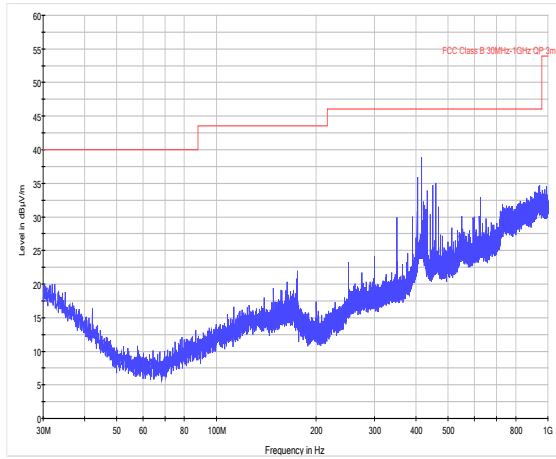
13 GHz – 18 GHz



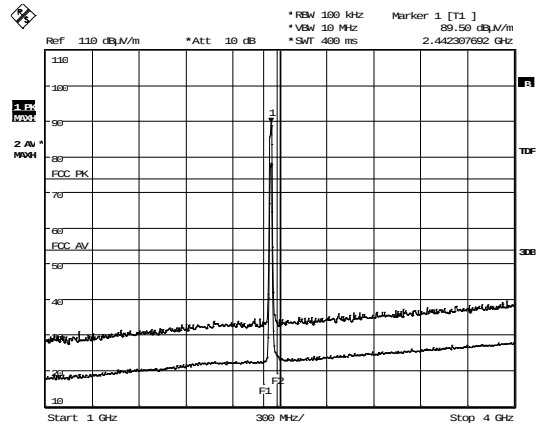
Date: 21.DEC.2015 15:17:41

18 GHz – 25 GHz

802.11g; 2442 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)
Pk	19535.91	53.90	9.50	37.20	35.11	0.00	-9.54	55.95	627.16	5012
Av	19535.91	46.62	9.50	37.20	35.11	0.00	-9.54	48.67	271.26	500

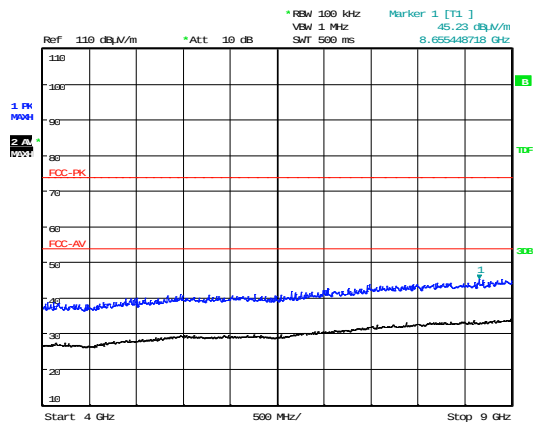


30 MHz – 1 GHz



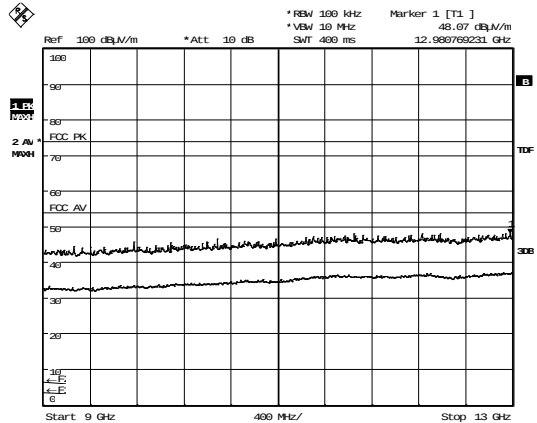
Date: 18.DEC.2015 09:18:52

1 GHz – 4 GHz



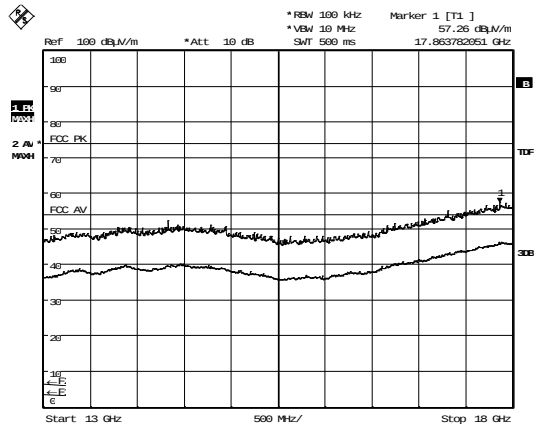
Date: 11.JAN.2016 11:04:07

4 GHz – 9 GHz



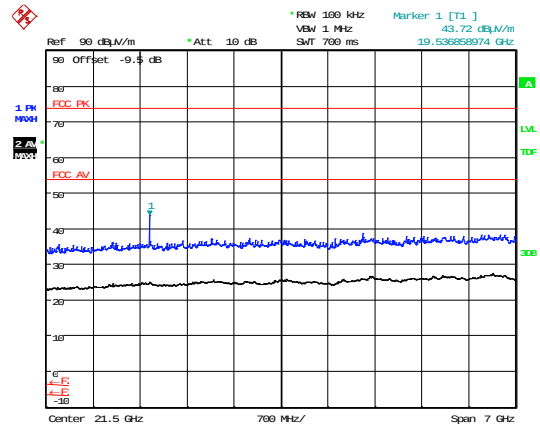
Date: 18.DEC.2015 09:33:00

9 GHz – 13 GHz



Date: 18.DEC.2015 09:34:33

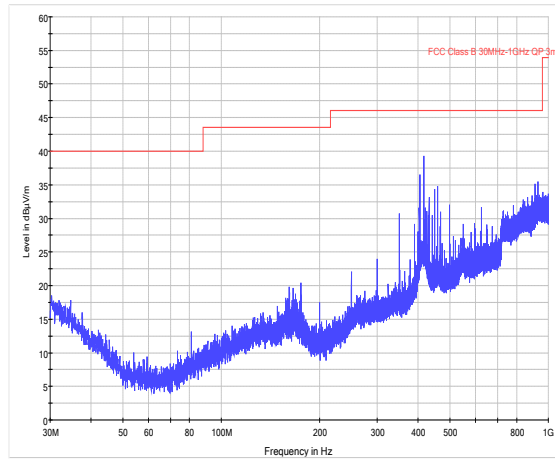
13 GHz – 18 GHz



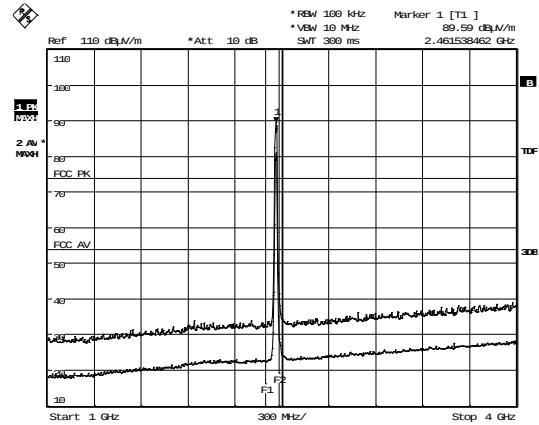
Date: 21.DEC.2015 15:34:23

18 GHz – 25 GHz

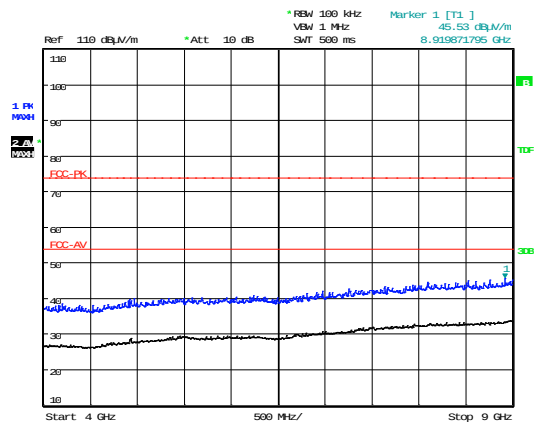
802.11g; 2462 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4923.83	53.49	5.10	33.40	35.89	0.00	0.00	56.10	638.26	5012
Av	4923.83	37.63	5.10	33.40	35.89	0.00	0.00	40.24	102.80	500
Pk	19695.91	54.23	9.60	37.20	35.33	0.00	-9.54	56.16	642.51	5012
Av	19695.91	47.36	9.60	37.20	35.33	0.00	-9.54	49.29	291.33	500



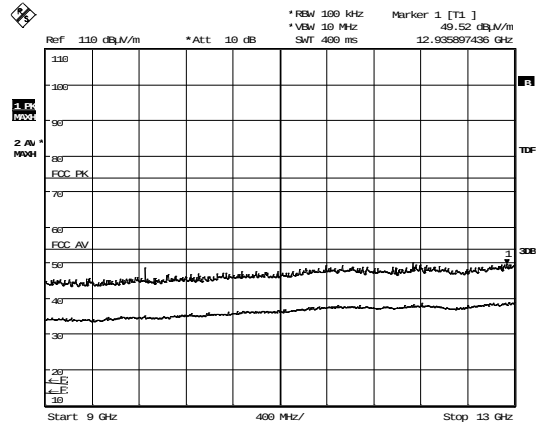
30 MHz – 1 GHz



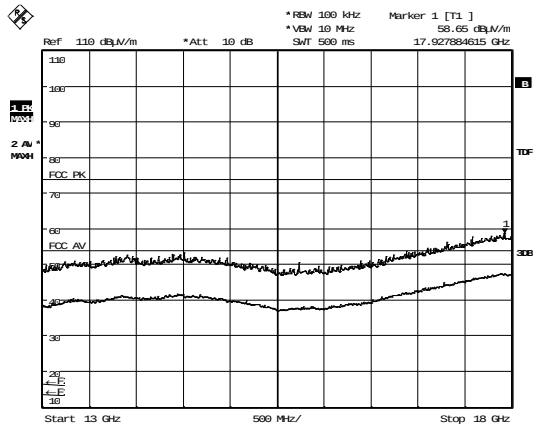
1 GHz – 4 GHz



4 GHz – 9 GHz

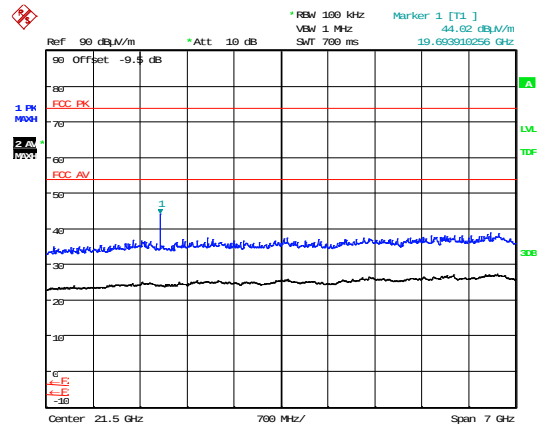


9 GHz – 13 GHz



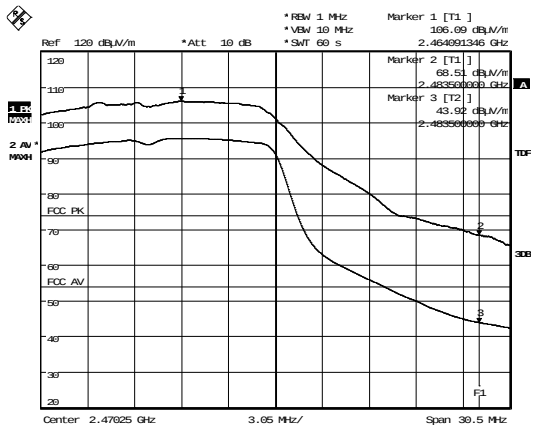
Date: 18.DEC.2015 09:59:49

13 GHz – 18 GHz



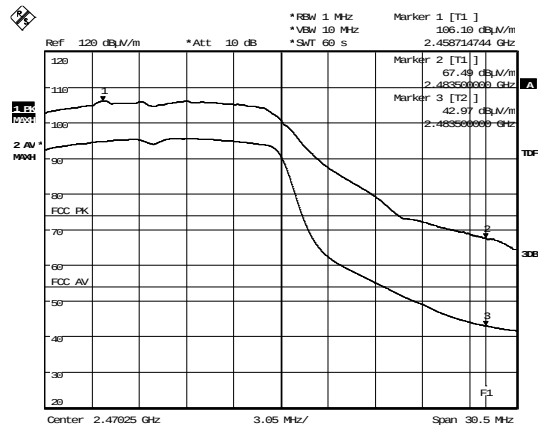
Date: 21.DEC.2015 14:31:18

18 GHz – 25 GHz



Date: 17.DEC.2015 11:40:12

6.5 Mbps

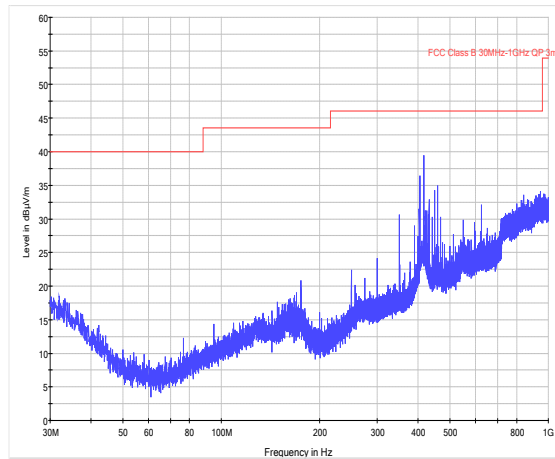


Date: 17.DEC.2015 12:05:16

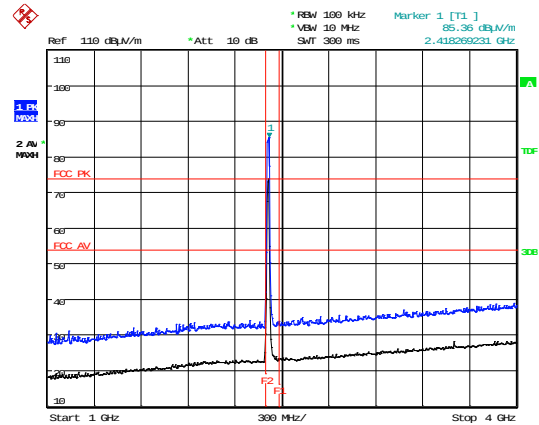
Upper band edge Compliance

54 Mbps

802.11n; 2412 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)
Pk	19295.91	52.23	9.90	37.30	34.75	0.00	-9.54	55.14	571.32	5012
Av	19295.91	43.61	9.90	37.30	34.75	0.00	-9.54	46.52	211.78	500

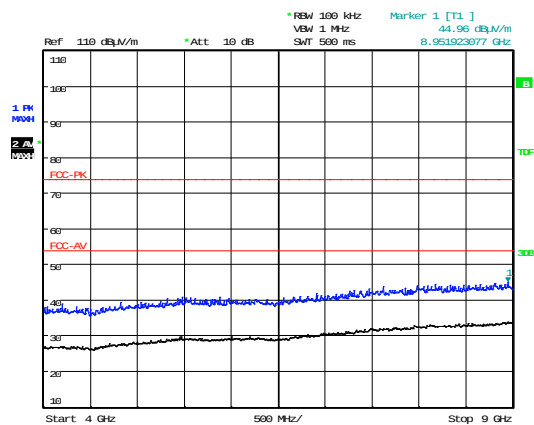


30 MHz – 1 GHz



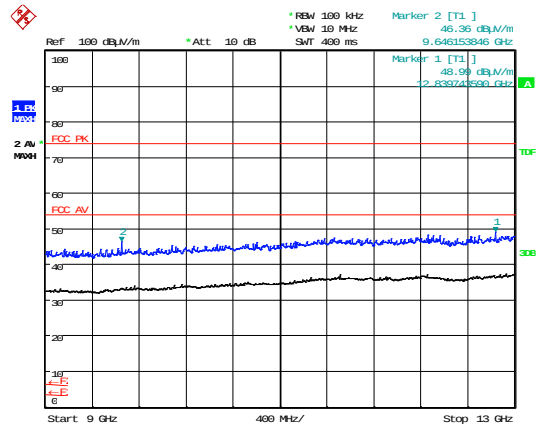
Date: 17.DEC.2015 15:26:11

1 GHz – 4 GHz



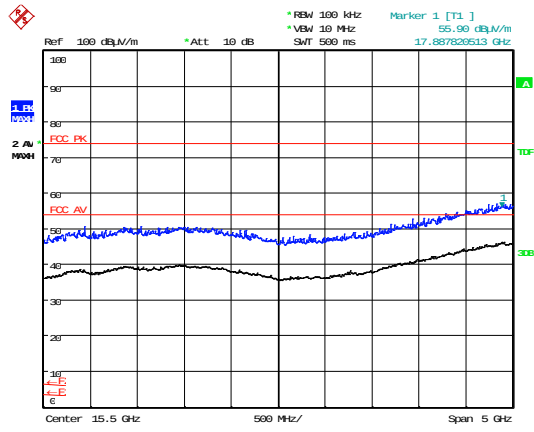
Date: 11.JAN.2016 10:33:45

4 GHz – 9 GHz



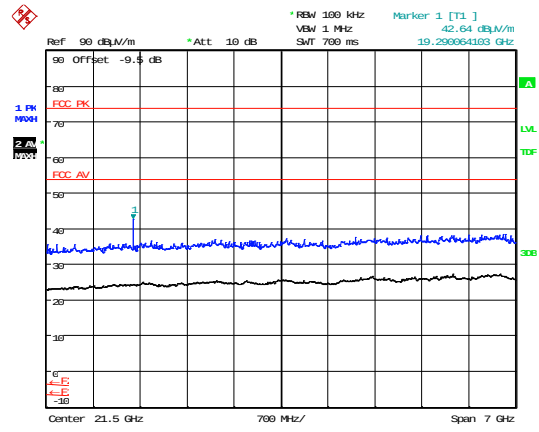
Date: 17.DEC.2015 15:14:15

9 GHz – 13 GHz



Date: 17.DEC.2015 15:20:49

13 GHz – 18 GHz

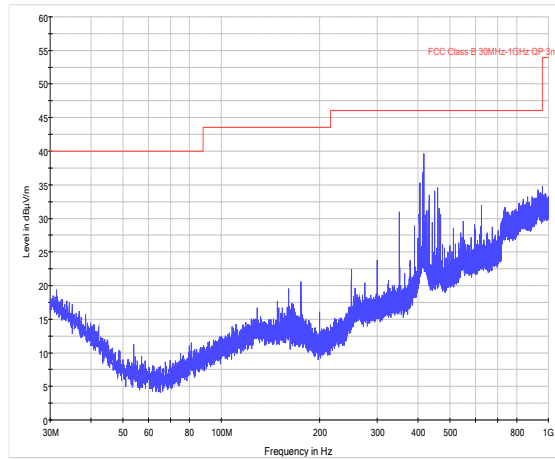


Date: 21.DEC.2015 15:22:10

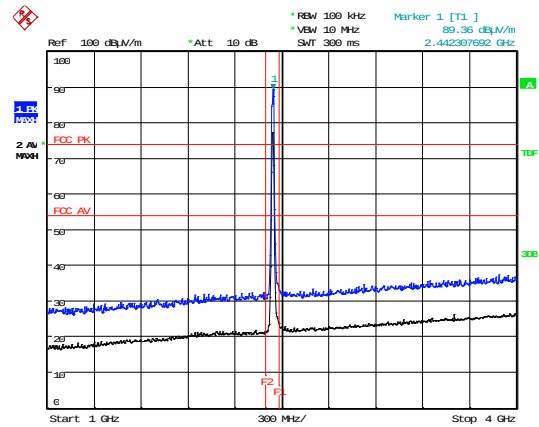
18 GHz – 25 GHz

802.11n; 2442 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)
Pk	4882.71	50.34	5.10	33.30	35.90	0.00	0.00	52.84	438.53	5012
Av	4882.71	35.42	5.10	33.30	35.90	0.00	0.00	37.92	78.70	500
Pk	19535.90	53.51	9.50	37.20	35.11	0.00	-9.54	55.56	599.62	5012
Av	19535.90	46.11	9.50	37.20	35.11	0.00	-9.54	48.16	255.79	500

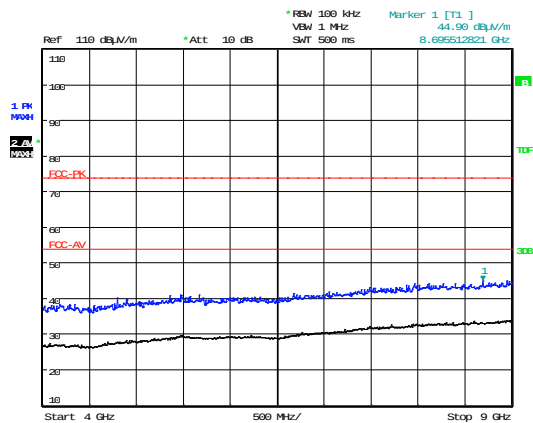


30 MHz – 1 GHz



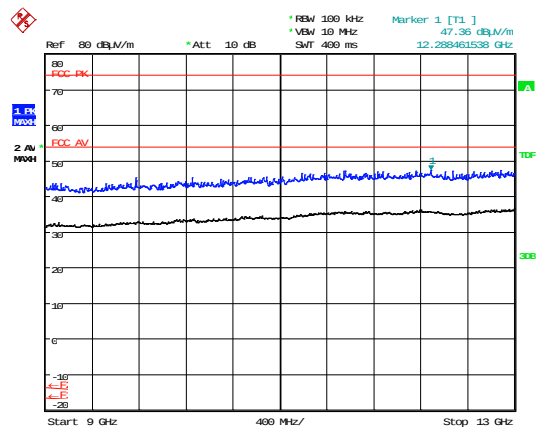
Date: 17.DEC.2015 14:23:39

1 GHz – 4 GHz



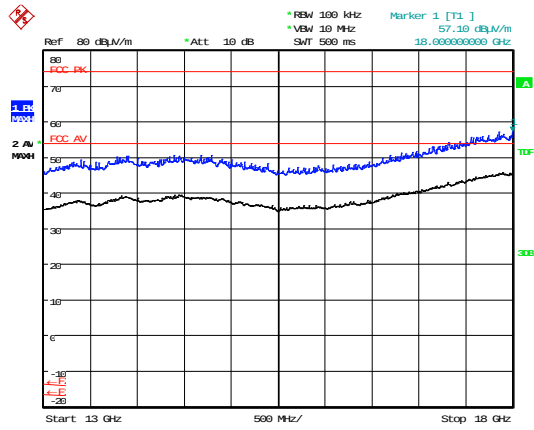
Date: 11.JAN.2016 10:27:09

4 GHz – 9 GHz



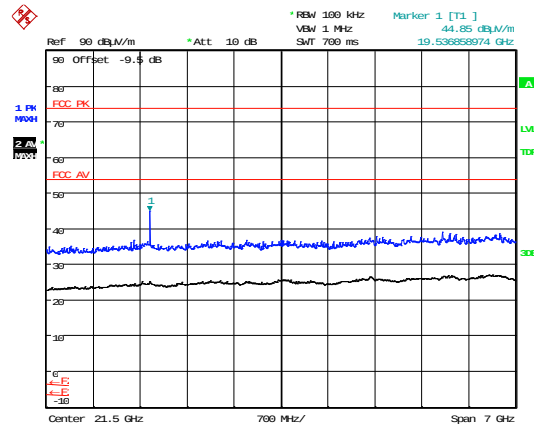
Date: 17.DEC.2015 14:34:36

9 GHz – 13 GHz



Date: 17.DEC.2015 14:42:46

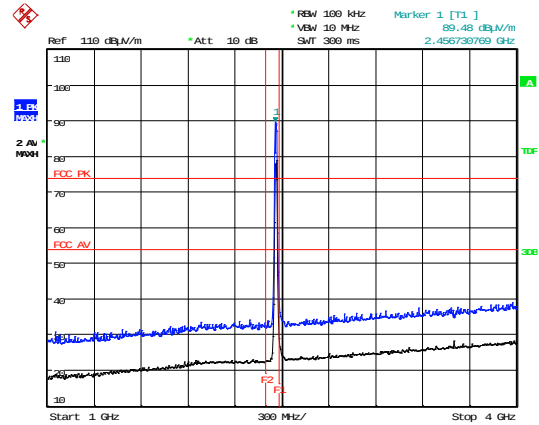
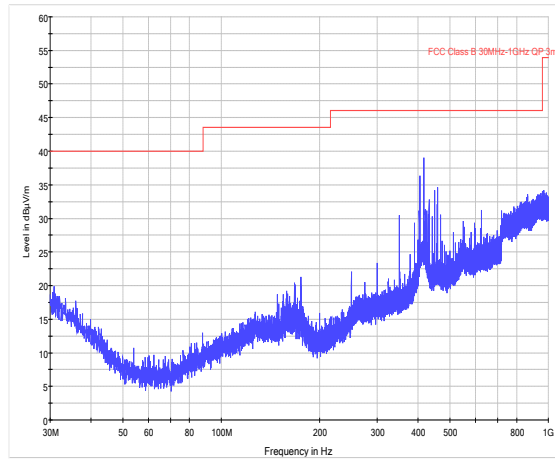
13 GHz – 18 GHz



Date: 21.DEC.2015 15:41:21

18 GHz – 25 GHz

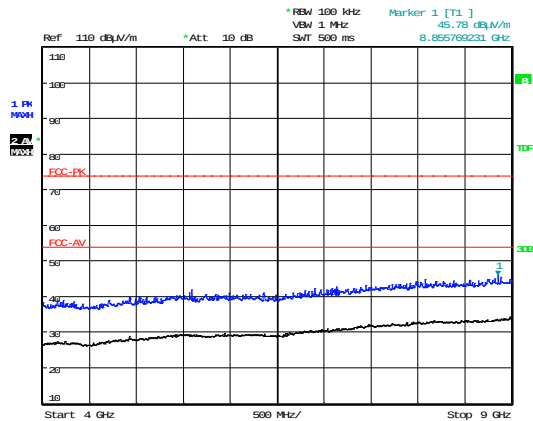
802.11n; 2462 MHz										
Detector	Freq. (MHz)	Meas'd Emission (dBμV)	Cable Loss (dB)	Antenna Factor (dB/m)	Pre-amp Gain (dB)	Duty Cycle Corr'n (dB)	Distance Extrap'n Factor (dB)	Field Strength (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
Pk	4922.71	53.09	5.10	33.40	35.89	0.00	0.00	55.70	609.54	5012
Av	4922.71	36.89	5.10	33.40	35.89	0.00	0.00	39.50	94.41	500
Pk	19695.91	54.22	9.60	37.20	35.33	0.00	-9.54	56.15	641.77	5012
Av	19695.91	46.88	9.60	37.20	35.33	0.00	-9.54	48.81	275.66	500



Date: 17.DEC.2015 13:30:40

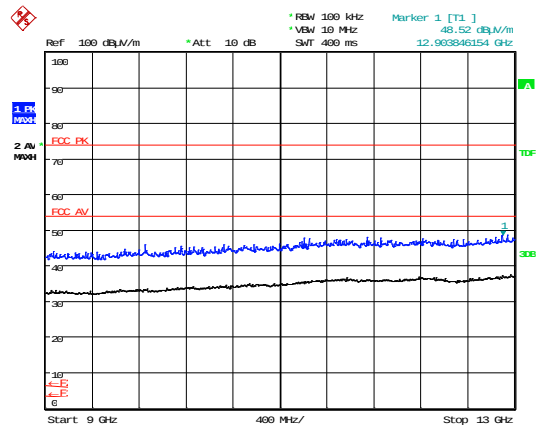
30 MHz – 1 GHz

1 GHz – 4 GHz



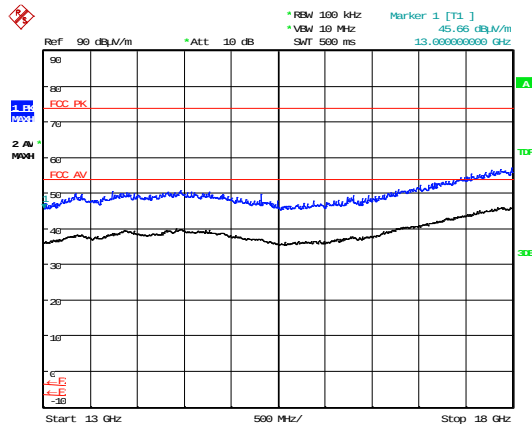
Date: 11.JAN.2016 10:24:02

4 GHz – 9 GHz



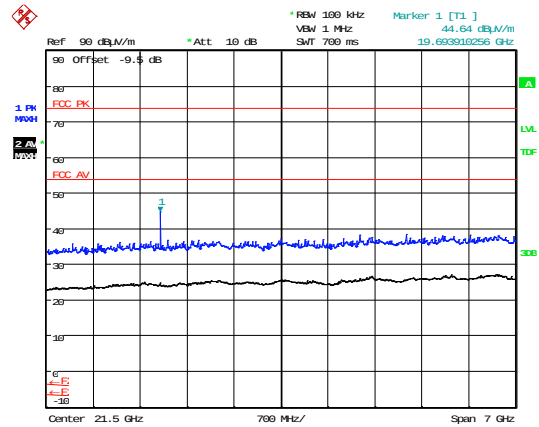
Date: 17.DEC.2015 13:46:24

9 GHz – 13 GHz



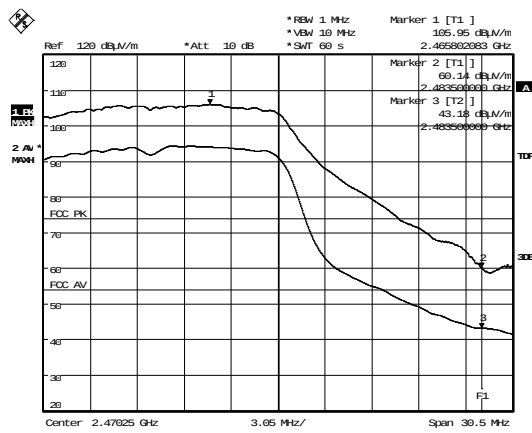
Date: 17.DEC.2015 13:48:36

13 GHz – 18 GHz



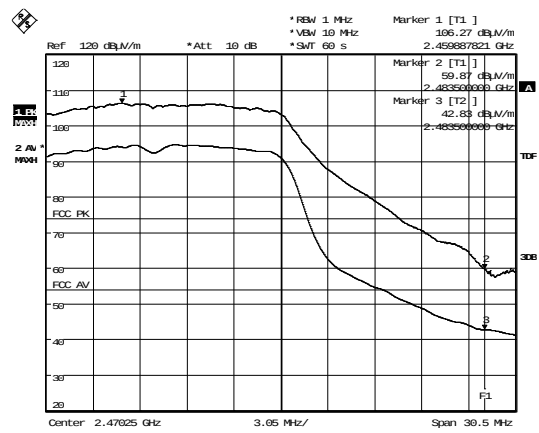
Date: 21.DEC.2015 14:36:37

18 GHz – 25 GHz



Date: 17.DEC.2015 12:14:41

MCS 0



Date: 17.DEC.2015 12:25:28

Upper band edge Compliance

MCS 7

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 Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	IC: ANSI C63.10-2013, Clause 6.9 FCC: ANSI C63.10-2013, Clause 11.8
EUT Channels / Frequencies Measured:	2412.0 MHz / 2442.0 MHz/ 2462.0 MHz
EUT Channel Bandwidths:	20.0 MHz
EUT Test Modulations:	802.11b 11Mbps; 802.11g, 54Mbps; 802.11n MCS7
Deviations From Standard:	None
Measurement BW:	100kHz
(IC requirement: 1% to 5% OBW; FCC requirement: 100 kHz)	
Spectrum Analyzer Video BW:	300kHz
(requirement at least 3x RBW)	
Measurement Span:	25 MHz
(requirement 2 to 5 times OBW)	
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 48 % RH	20 % RH to 75 % RH (as declared)
Supply: 14.8 Vdc	14.8Vdc

12.3 Test Limit

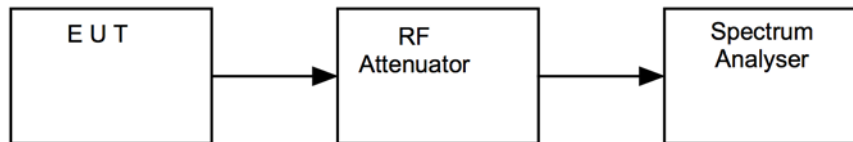
The minimum -6 dB bandwidth shall be at least 500 kHz.

12.4 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

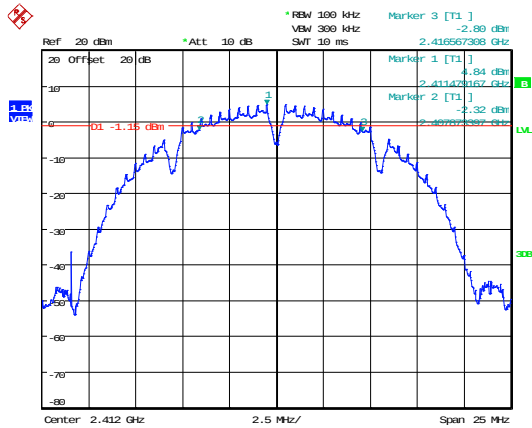


12.5 Test Equipment

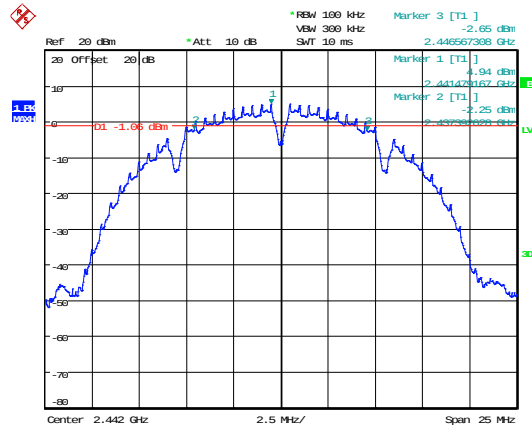
<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>	<i>Calibration Interval</i>
Spectrum Analyser	R&S	FSU46	U281	24/04/2016	12
Attenuator	RS	N/A	N/A	In use	N/A

12.6 Test Results

Modulation: 802.11b; Data rate: 11Mbps;				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	2407.878897	2416.567308	8688.411	PASS
2442	2437.392628	2446.567308	9174.68	PASS
2462	2457.392628	2466.567308	9174.68	PASS



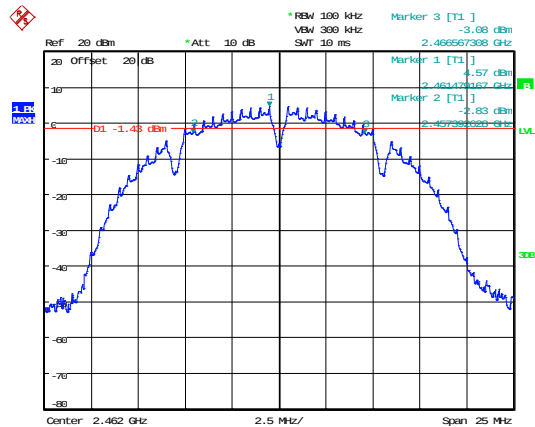
Date: 23.DEC.2015 11:06:39



Date: 23.DEC.2015 11:25:31

802.11b – 2412MHz

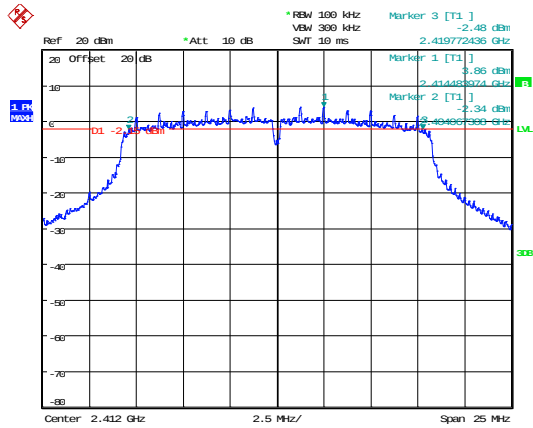
802.11b – 2442MHz



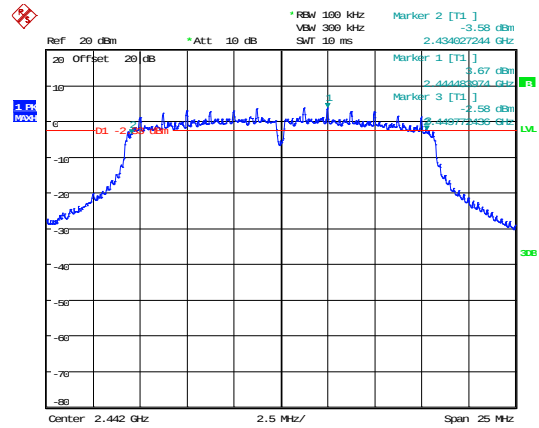
Date: 23.DEC.2015 11:37:51

802.11b – 2462MHz

Modulation: 802.11g; Data rate: 54Mbps;				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	2404.067398	2419.772436	15705.038	PASS
2442	2434.027244	2449.772436	15745.192	PASS
2462	2454.027244	2469.612179	15584.935	PASS



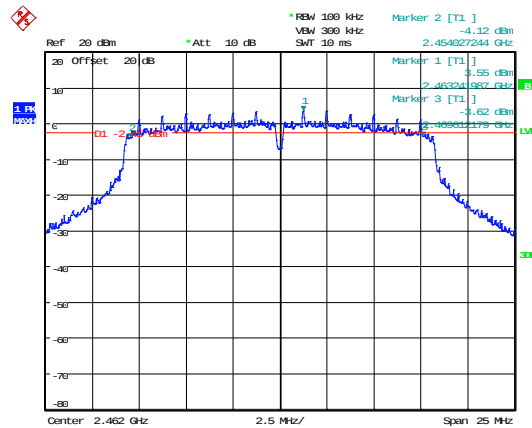
Date: 23.DEC.2015 11:15:27



Date: 23.DEC.2015 11:29:07

802.11g – 2412MHz

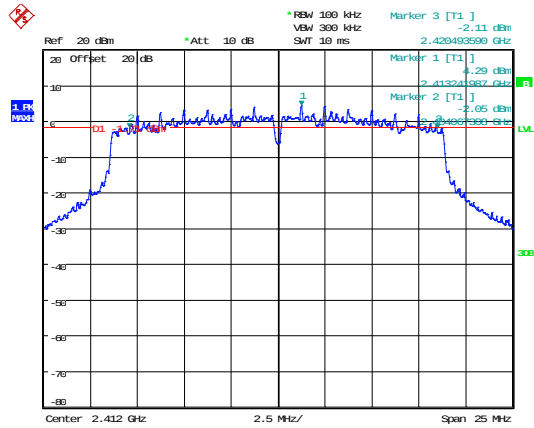
802.11g – 2442MHz



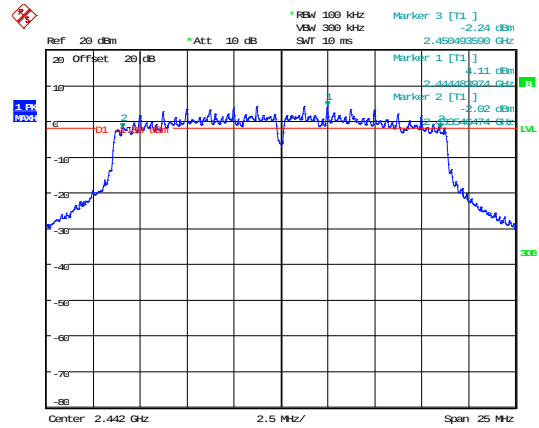
Date: 23.DEC.2015 11:42:25

802.11g – 2462MHz

Modulation: 802.11n; Data rate: 11Mbps;				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	2404.067398	2419.772436	15705.038	PASS
2442	2434.027244	2449.772436	15745.192	PASS
2462	2454.027244	2469.612179	15584.935	PASS



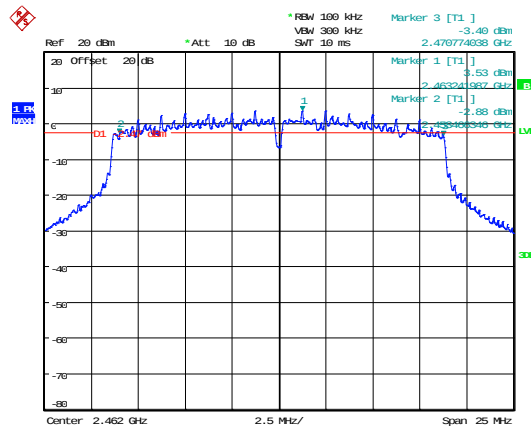
Date: 23.DEC.2015 11:20:27



Date: 23.DEC.2015 11:33:20

802.11n – 2412MHz

802.11n – 2442MHz



Date: 23.DEC.2015 11:44:42

802.11n – 2462MHz

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.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Channels / Frequencies Measured:	2412.0 MHz / 2442.0 MHz/ 2462.0 MHz
EUT Channel Bandwidths:	20MHz
Deviations From Standard:	None
Measurement BW:	1 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	3 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Battery Power = Fully Charged Battery

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 48 % RH	20 % RH to 75 % RH (as declared)

13.3 Test Limit

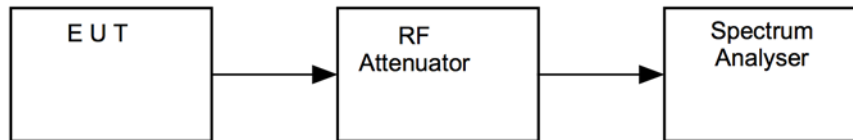
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

13.4 Test Method

With the EUT 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



13.5 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>	<i>Calibration Interval</i>
Spectrum Analyser	R&S	FSU46	U281	24/04/2016	12
Attenuator	RS	N/A	N/A	In use	N/A

13.6 Test Results

Modulation: 802.11b; Data rate: 1Mbps;				
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)	Result
2412	-1.07	20.00	78.16	PASS
2442	-1.53	20.00	70.31	PASS
2462	-1.96	20.00	63.68	PASS

Modulation: 802.11g; Data rate: 6Mbps;				
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)	Result
2412	3.83	20.00	241.55	PASS
2442	3.45	20.00	221.31	PASS
2462	3.42	20.00	219.79	PASS

Modulation: 802.11n; Data rate: MCS0;				
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)	Result
2412	4.10	20.00	257.04	PASS
2442	3.84	20.00	242.10	PASS
2462	3.54	20.00	225.94	PASS

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 Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Channels / Frequencies Measured:	2412.0 MHz / 2442.0 MHz/ 2462.0 MHz
EUT Channel Bandwidths:	20.0 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: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 48 % RH	20 % RH to 75 % RH (as declared)
Supply: 14.8 Vdc	14.8Vdc

14.3 Test Limit

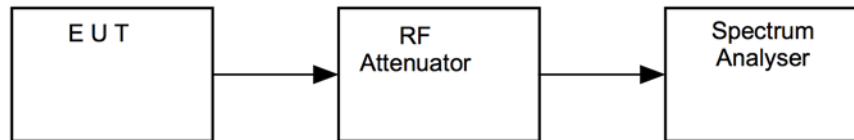
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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 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

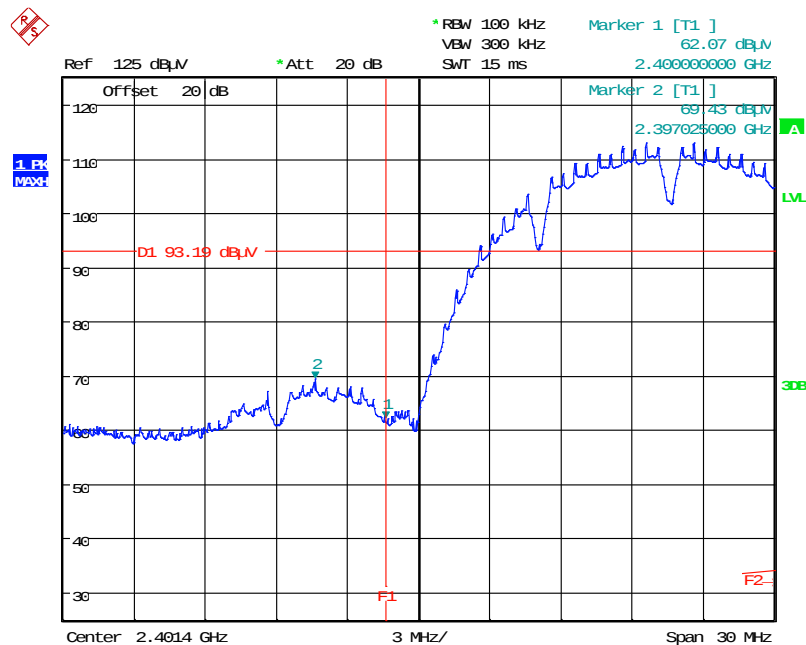
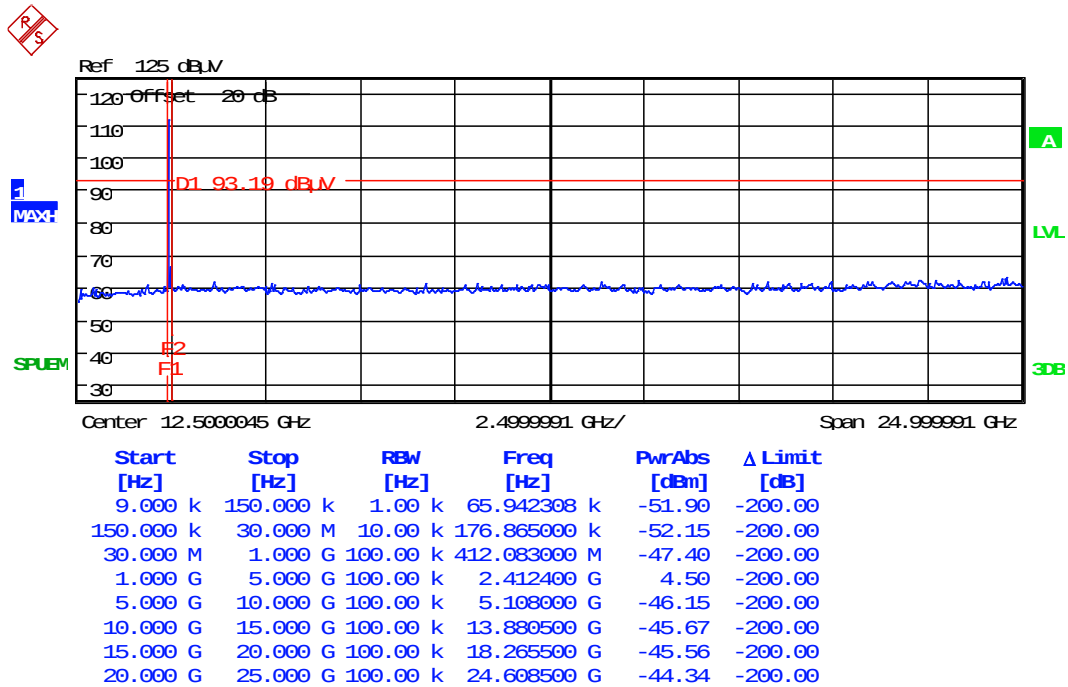


14.5 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>	<i>Calibration Interval</i>
Spectrum Analyser	R&S	FSU46	U281	24/04/2016	12
Attenuator	RS	N/A	N/A	In use	N/A

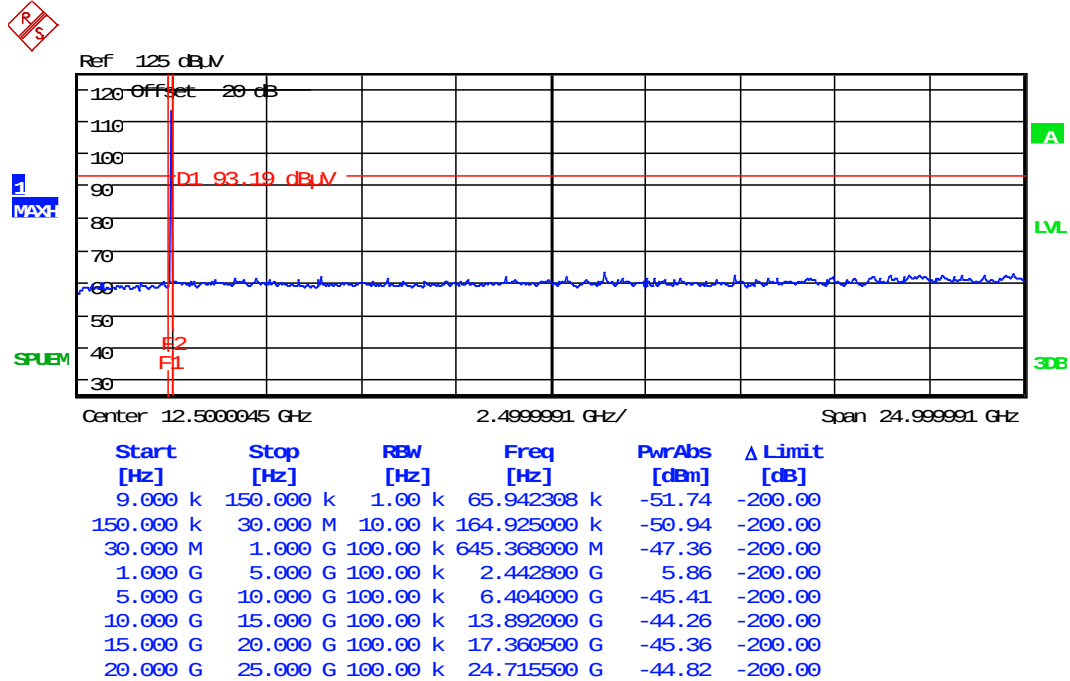
14.6 Test Results

Modulation: 802.11b; Frequency: 2412 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS

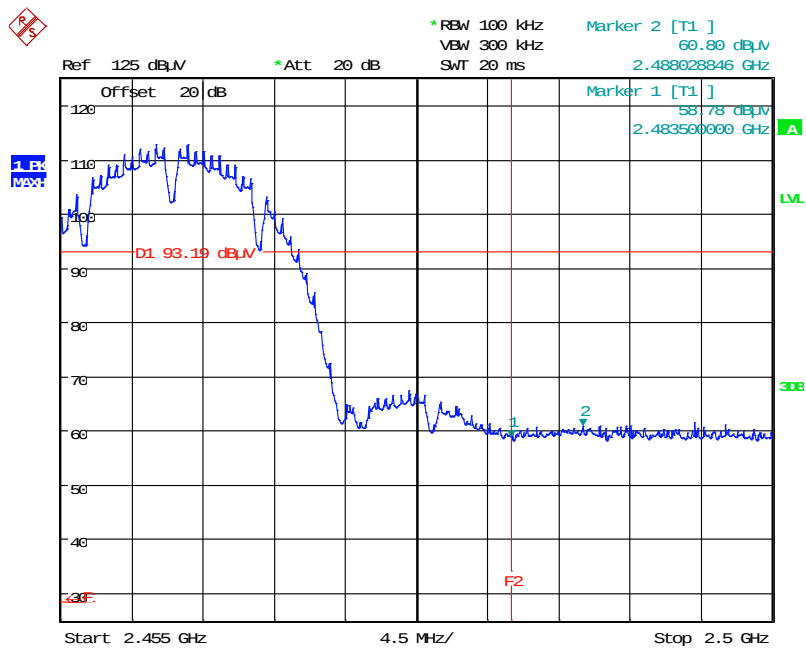
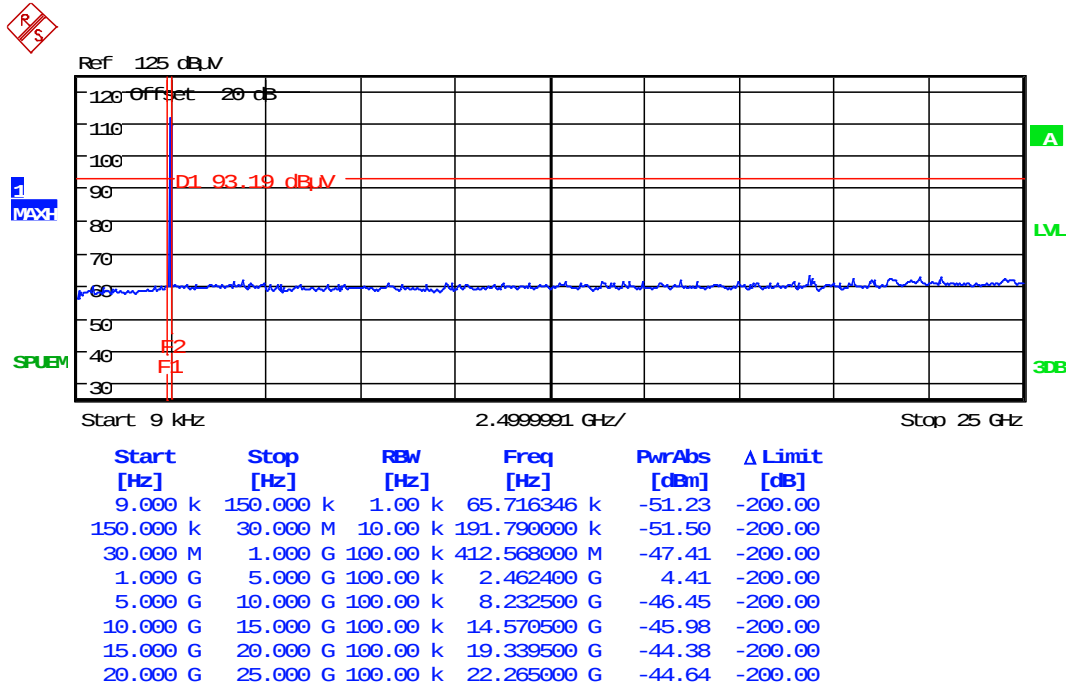


Lower Bandedge Compliance

Modulation: 802.11b; Frequency: 2442 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS

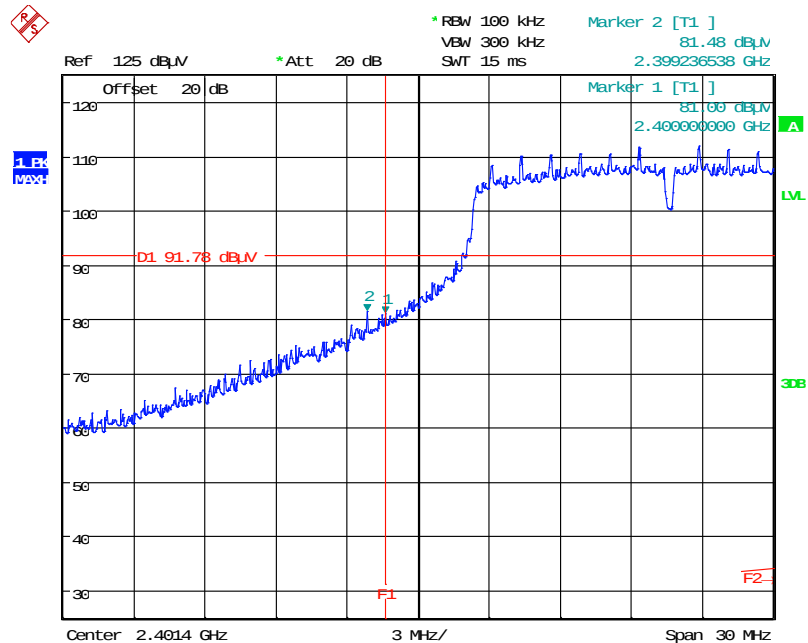
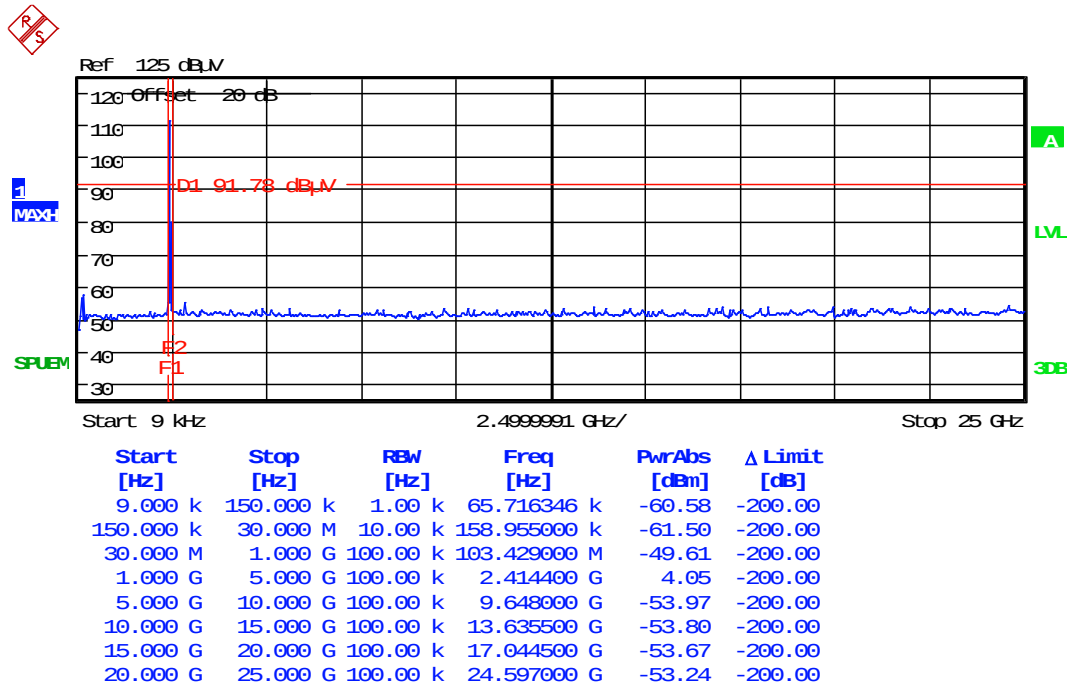


Modulation: 802.11b; Frequency: 2462 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS



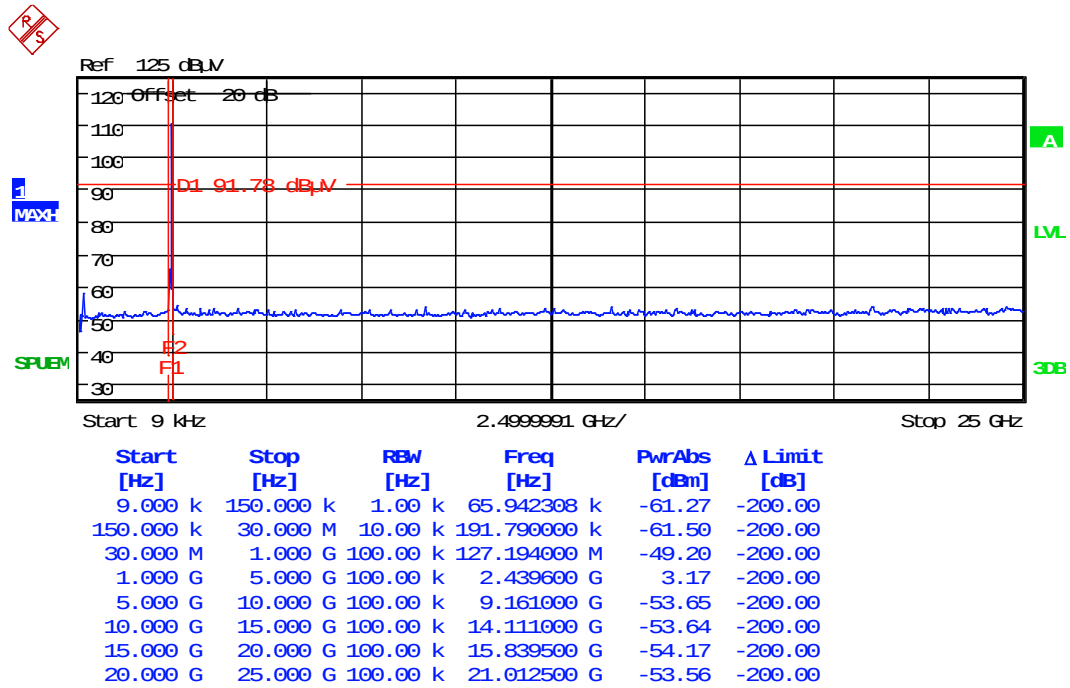
Upper Bandedge Compliance

Modulation: 802.11g; Frequency: 2412 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS

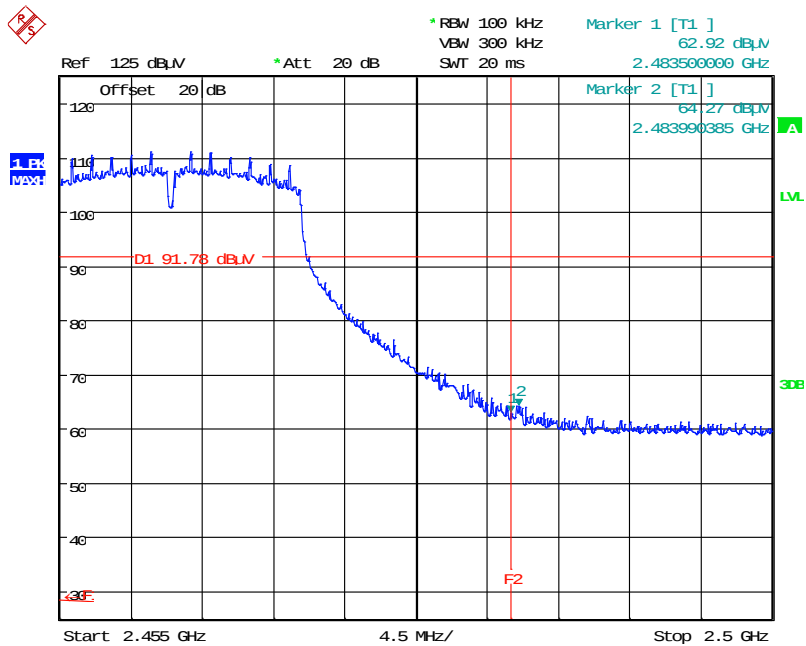
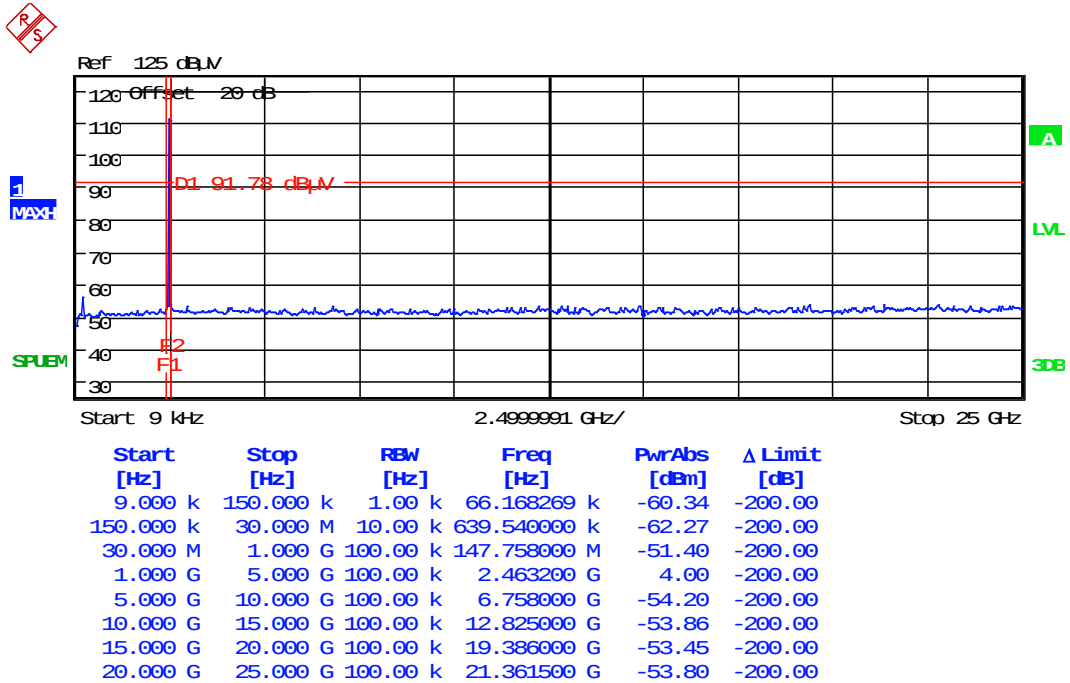


Lower Bandedge Compliance

Modulation: 802.11g; Frequency: 2442 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS

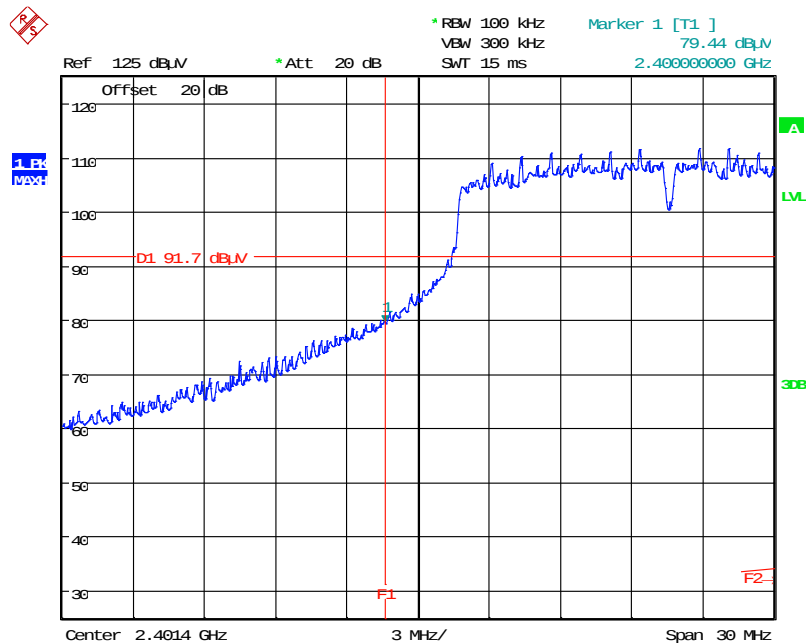
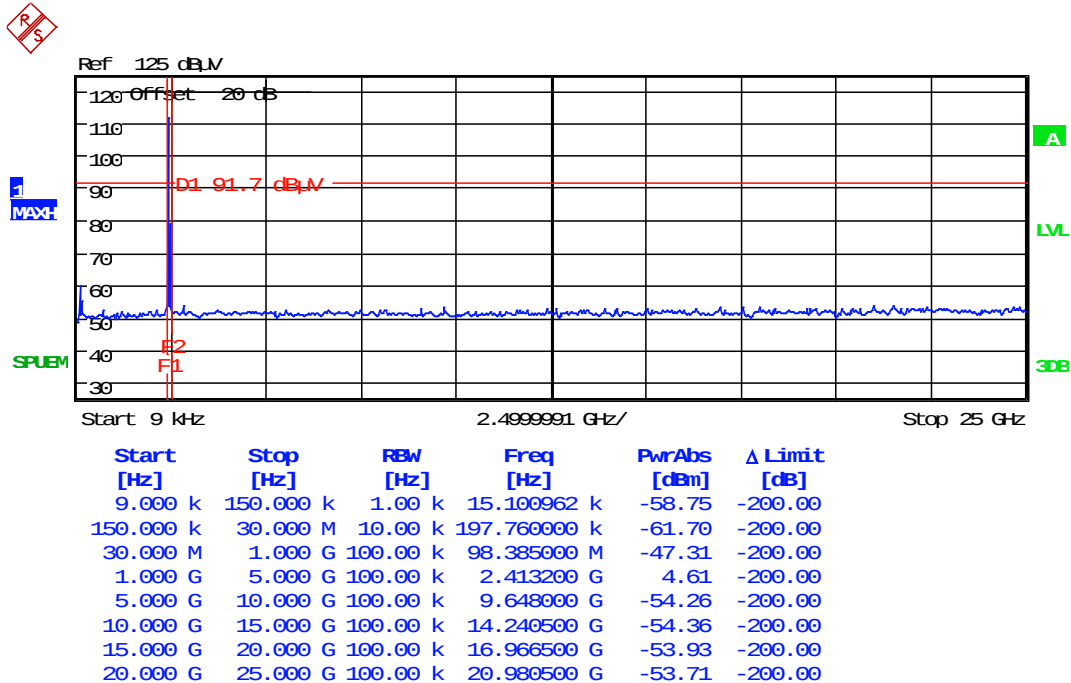


Modulation: 802.11g; Frequency: 2462 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS



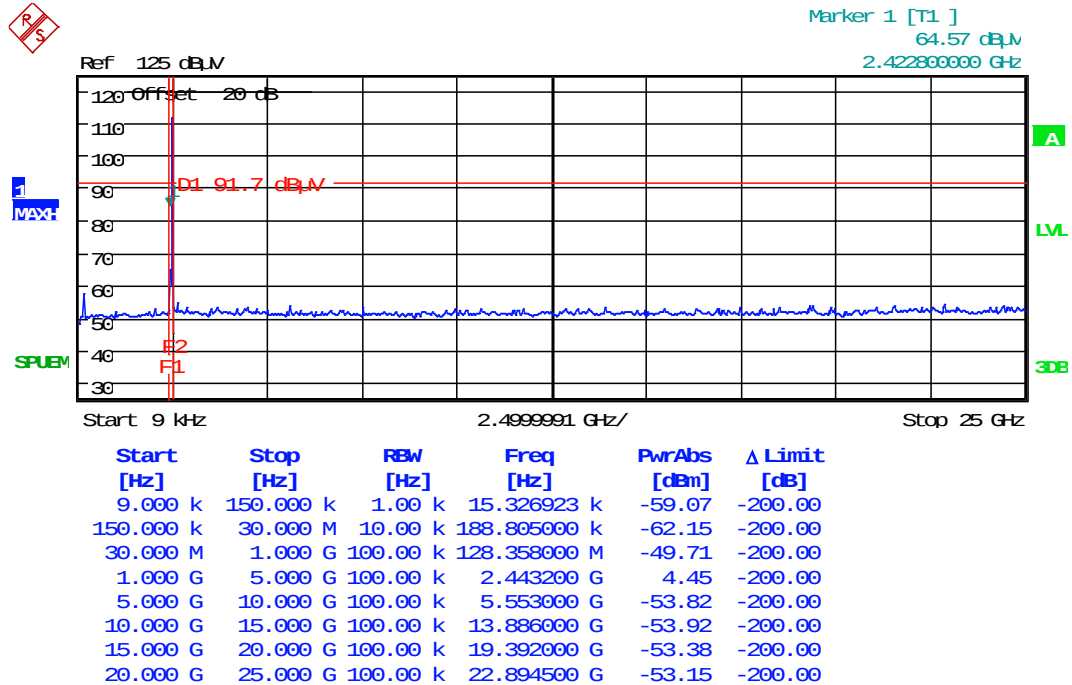
Upper Bandedge Compliance

Modulation: 802.11n; Frequency: 2412 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS

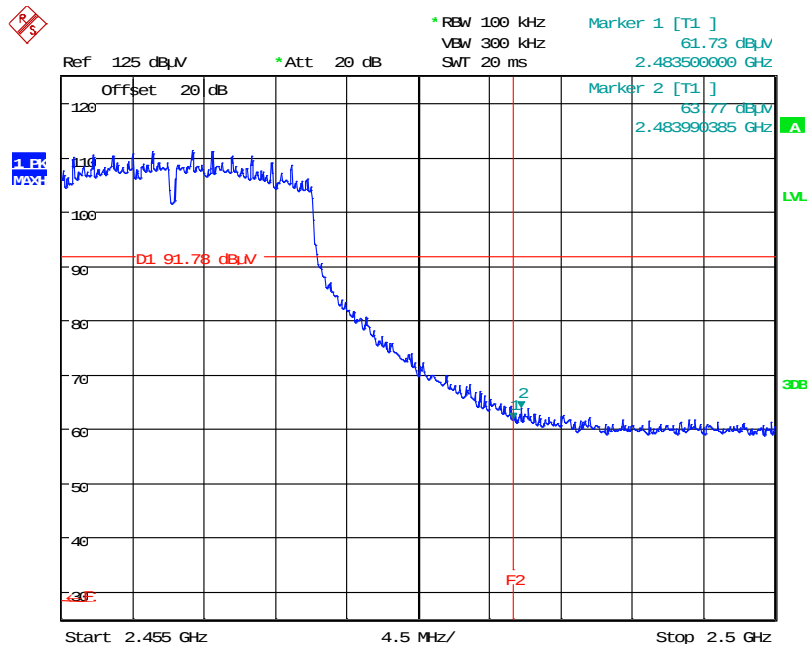
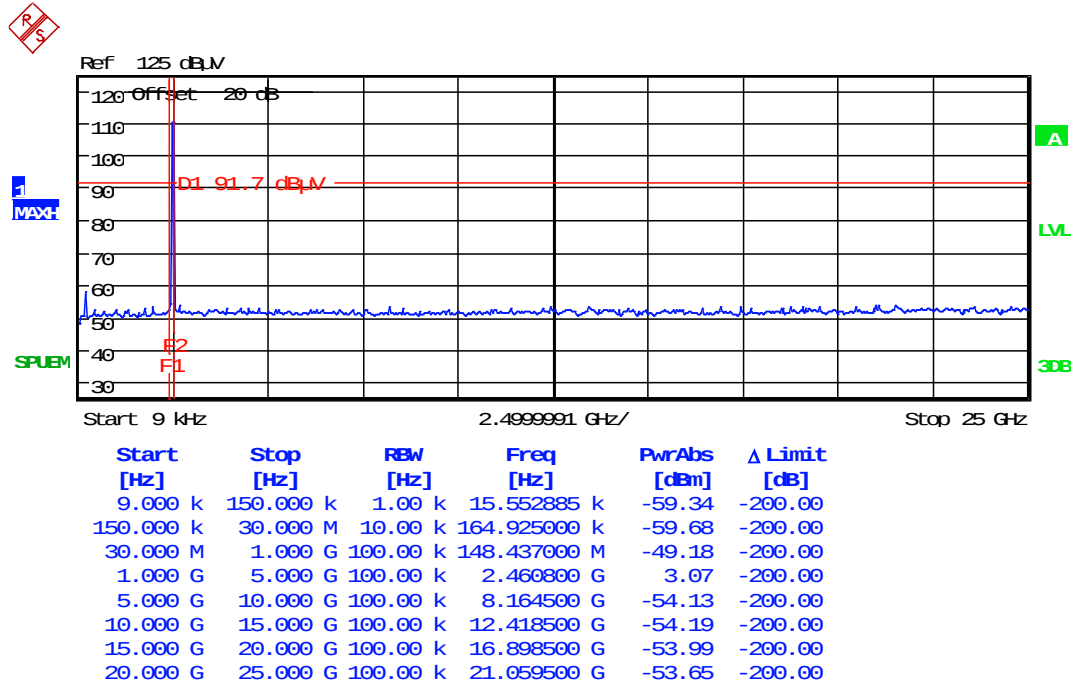


Lower Bandedge Compliance

Modulation: 802.11n ; Frequency: 2442 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS



Modulation: 802.11n; Frequency: 2462 MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No significant Emissions within 20 dB of the limit						PASS



Upper Bandedge Compliance

15 Power spectral density

15.1 Definition

The power per unit bandwidth.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels / Frequencies Measured:	2412.0 MHz / 2442.0 MHz/ 2462.0 MHz
EUT Channel Bandwidths:	20.0 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)	14 MHz / 24 MHz / 26 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 20 °C	+15 °C to +35 °C (as declared)
Humidity: 48 % RH	20 % RH to 75 % RH (as declared)
Supply: 14.8 Vdc	14.8Vdc

15.3 Test Limit

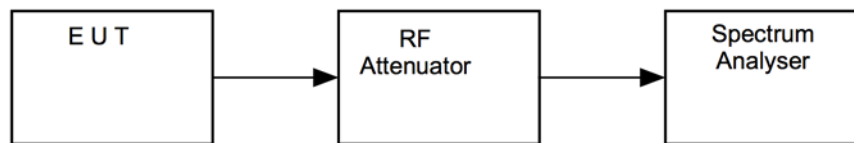
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

15.4 Test Method

With the EUT 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

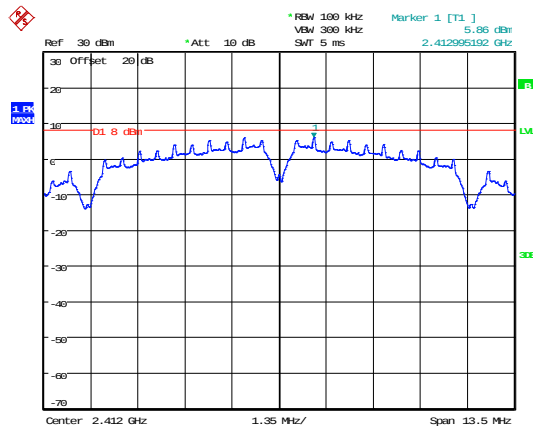


15.5 Test Equipment

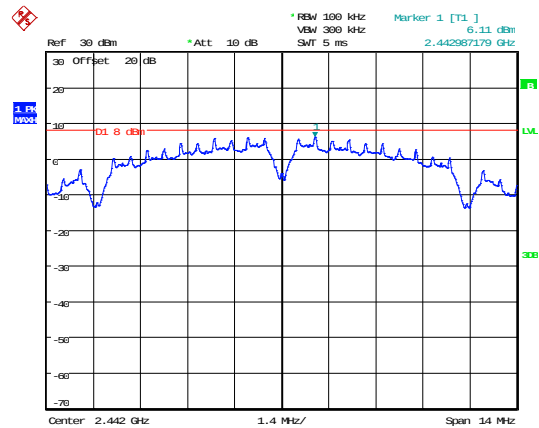
<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>	<i>Calibration Interval</i>
Spectrum Analyser	R&S	FSU46	U281	24/04/2016	12
Attenuator	RS	N/A	N/A	In use	N/A

15.6 Test Results

Modulation: 802.11b; Data rate: 1Mbps				
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Result
2412	-14.14	20.00	5.86	PASS
2442	-13.89	20.00	6.11	PASS
2462	-13.81	20.00	6.19	PASS



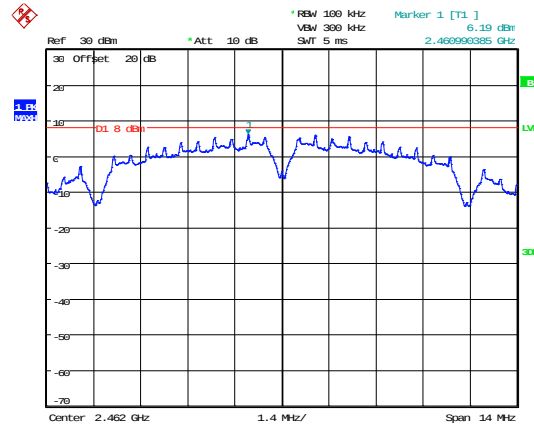
Date: 23.DEC.2015 15:40:18



Date: 23.DEC.2015 15:43:29

802.11b – 2412MHz

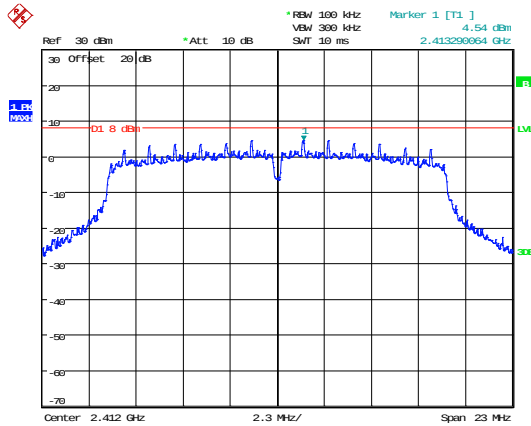
802.11b – 2442MHz



Date: 23.DEC.2015 15:44:34

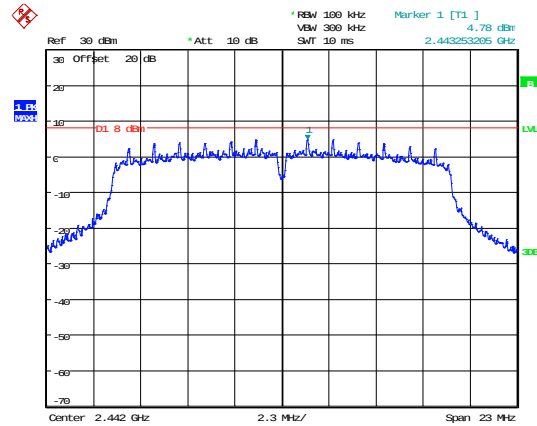
802.11b – 2462MHz

Modulation: 802.11g; Data rate: 54Mbps				
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Result
2412	-15.46	20.00	4.54	PASS
2442	-15.22	20.00	4.78	PASS
2462	-15.34	20.00	4.66	PASS



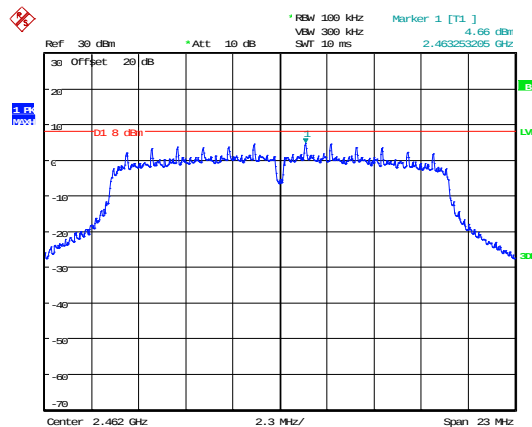
Date: 23.DEC.2015 15:48:02

802.11g – 2412MHz



Date: 23.DEC.2015 15:47:01

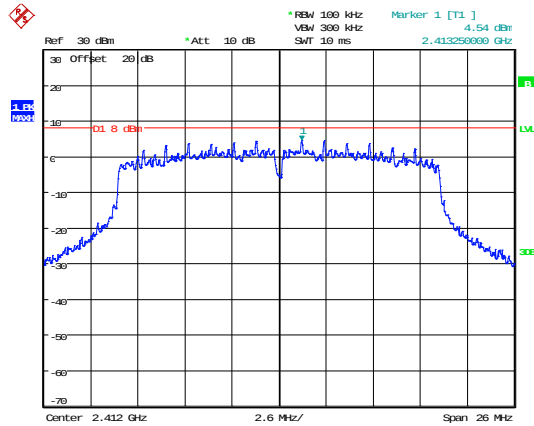
802.11g – 2442MHz



Date: 23.DEC.2015 15:46:01

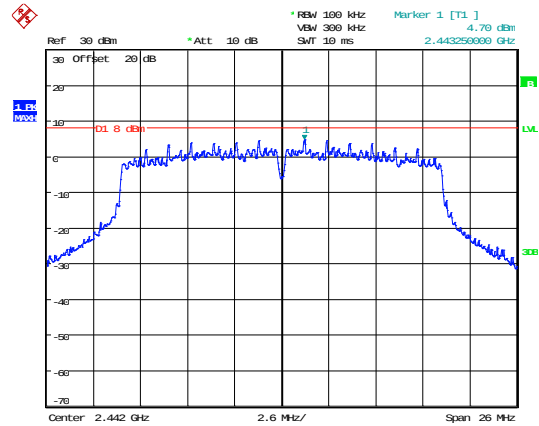
802.11g – 2462MHz

Modulation: 802.11n; Data rate: MCS7				
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Result
2412	-15.46	20.00	4.54	PASS
2442	-15.30	20.00	4.70	PASS
2462	-15.64	20.00	4.36	PASS



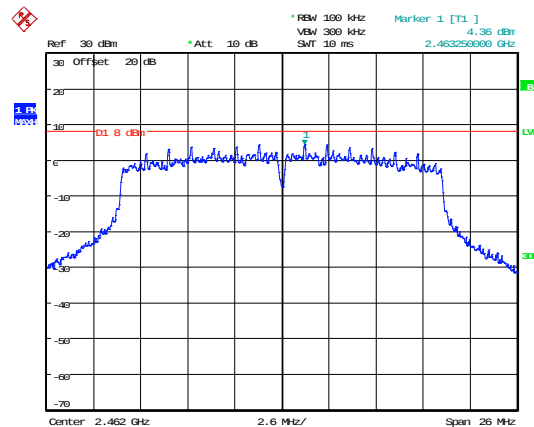
Date: 23.DEC.2015 15:49:17

802.11n – 2412MHz



Date: 23.DEC.2015 15:50:17

802.11n – 2442MHz



Date: 23.DEC.2015 15:51:25

802.11n – 2462MHz

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) = **4.6 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.4 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.5 %**

[4] Conducted carrier power

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

[5] Conducted / radiated 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**

Uncertainty in test result (30 MHz to 1 GHz) = **4.6 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**

[6] Power spectral density

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