

Report on the Radio Testing

For

Pace plc

on

2.4 GHz WiFi Module

Report no. TRA-028175-47-01A

27th November 2015

RF915 2.0

Report Number: TRA-028175-47-01A
Issue: A

REPORT ON THE RADIO TESTING OF A
Pace plc
2.4 GHz WiFi Module
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 1st October - 13th November 2015

Written by: D Winstanley

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Department Manager - Radio

Date: 27th November 2015

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 2.0

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	27th November 2015	Original

2 Summary

TEST REPORT NUMBER: TRA-028175-47-01A

WORKS ORDER NUMBER TRA-028175-00

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.

TEST SPECIFICATION(S): 47CFR15.247

EQUIPMENT UNDER TEST (EUT): 2.4 GHz WiFi Module

FCC IDENTIFIER: NQ82G401

EUT SERIAL NUMBER: Unknown

MANUFACTURER/AGENT: Pace plc

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

CLIENT CONTACT: Robert Turner
☎ 01274 537080
✉ robert.turner@pace.com

ORDER NUMBER: Not Applicable

TEST DATE: 1st October - 13th November 2015

TESTED BY: D Winstanley, A Tosif
Element

2.1 Test Summary

Test Method and Description		Requirement Clause 47CFR15	Applicable to this equipment	Result / Note
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.205	<input checked="" type="checkbox"/>	Note 2
AC power line conducted emissions		15.207	<input type="checkbox"/>	Note 1
Occupied bandwidth		15.247(a)(2)	<input checked="" type="checkbox"/>	Pass
Conducted carrier power	Peak	15.247(b)(3)	<input type="checkbox"/>	Pass
	Max.		<input checked="" type="checkbox"/>	
Conducted / radiated RF power out-of-band		15.247(d)	<input checked="" type="checkbox"/>	Pass
Power spectral density, conducted		15.247(e)	<input checked="" type="checkbox"/>	Pass
Calculation of duty correction		15.35(c)	<input type="checkbox"/>	N/A

Notes:

1. See Test report TRA-028175-47-06A. AC Power line Conducted emissions were recorded For complete device with all radio devices active simultaneously
2. See Test report TRA-028175-47-00A. Radiated spurious emissions results for device containing the 2.4 GHz WiFi module detailed in this report.

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).

3 Contents

1	Revision Record.....	3
2	Summary.....	4
2.1	Test Summary.....	5
3	Contents.....	6
4	Introduction	7
5	Test Specifications.....	8
5.1	Normative References	8
5.2	Deviations from Test Standards	8
6	Glossary of Terms.....	9
7	Equipment Under Test	10
7.1	EUT Identification.....	10
7.2	System Equipment.....	10
7.3	EUT Mode of Operation	11
7.3.1	Transmission.....	11
7.4	EUT Radio Parameters	12
7.4.1	General	12
7.4.2	Antennas.....	12
7.4.3	Product specific declarations.....	12
7.5	EUT Description	12
8	Modifications	13
9	EUT Test Setup	14
9.1	Block Diagram.....	14
10	General Technical Parameters.....	15
10.1	Normal Conditions.....	15
10.2	Varying Test Conditions	15
11	Occupied Bandwidth	16
11.1	Definition	16
11.2	Test Parameters.....	16
11.3	Test Limit.....	16
11.4	Test Method	17
11.5	Test Equipment.....	17
11.6	Test Results	18
12	Maximum conducted output power	21
12.1	Definition	21
12.2	Test Parameters.....	21
12.3	Test Limit.....	21
12.4	Test Method	22
12.5	Test Equipment.....	22
12.6	Test Results	23
13	Out-of-band and conducted spurious emissions	25
13.1	Definition	25
13.2	Test Parameters.....	25
13.3	Test Limit.....	25
13.4	Test Method	26
13.5	Test Equipment.....	26
13.6	Test Results	27
14	Power spectral density	39
14.1	Definition	39
14.2	Test Parameters.....	39
14.3	Test Limit.....	39
14.4	Test Method	40
14.5	Test Equipment.....	40
14.6	Test Results	41
15	Measurement Uncertainty.....	43

4 Introduction

This report TRA-028175-47-01A presents the results of the antenna port conducted Radio testing on a Pace plc, 2.4 GHz WiFi Module to specification 47CFR15 Radio Frequency Devices.

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

<input type="checkbox"/>	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	<input checked="" type="checkbox"/>	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.

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-210, Issue 8, December 2010 – Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment.
- 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: 2.4 GHz WiFi Module
- Serial Number: Unknown
- Model Number: 2G401
- Build Revision
 - 260-2251000 Layer 3 TV DDR3 Main Board Assembly
 - 262-2227000 Layer 3 TV Server Front Panel assembly
 - 260-2264000 PCA 2.4G WIFI MODULE
 - 260-E397020 PCA 5G WIFI
- Software Version
 - Video Soc
 - BootLoader: CBL v1.74
 - Firmware version: v1.161
 - Bluetooth Driver version: BCM20705B0_002.001.014.0590.0927
 - CableModem
 - CM Bootloader : v1.144
 - CM App: v1.144-ltw

7.2 System Equipment

Equipment listed below is host device 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.

- Name: DOCSIS 3 HYBRID GATEWAY STB
- Sample Number: S03
- Serial Number: PAN900000146
- Model Number: ND7506

7.3 EUT Mode of Operation

7.3.1 Transmission

WiFi transmitter control was via commands sent through a terminal program (Tera Term in this case). The commands provided by the manufacturer setup the device into a permanent transmit mode. The commands allowed adjustment of the following parameters of significant interest.

Modulation Scheme	Channel	Power setting	Data Rate	Transmit Chain Setting
802.11b	1	106	11 mbps	txchain 1, txchain 2, txchain 4
	6	106	11 mbps	txchain 1, txchain 2, txchain 4
	11	106	11 mbps	txchain 1, txchain 2, txchain 4
802.11g	1	95	54 mbps	txchain 1, txchain 2, txchain 4
	6	104	54 mbps	txchain 1, txchain 2, txchain 4
	11	104	54 mbps	txchain 1, txchain 2, txchain 4
802.11n HT20	1	90	MCS7	txchain 1, txchain 2, txchain 4
	6	107	MCS7	txchain 1, txchain 2, txchain 4
	11	106	MCS7	txchain 1, txchain 2, txchain 4
802.11n HT40	3	88	MCS23	txchain 1, txchain 2, txchain 4
	6	103	MCS23	txchain 1, txchain 2, txchain 4
	9	91	MCS23	txchain 1, txchain 2, txchain 4

txchain 1 : Chain 0 only

txchain 2 : Chain 1 only

txchain 4 : Chain 2 only

txchain 7 : Chains 0, 1 and 2 simultaneously

Where applicable only the selected chain under test is active, unused chains are terminated in a load.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2400 – 2483.5 MHz
Modulation type(s):	DSSS, OFDM
Occupied channel bandwidth(s):	20 MHz – 40 MHz
Channel spacing:	5 MHz
Declared output power(s):	Up to 1 Watt (conducted)
Warning against use of alternative antennas in user manual (yes/no):	Not Applicable
Location of notice for license exempt use:	Label / user manual / both.
Duty cycle:	Upto 100 %

7.4.2 Antennas

Antennas are not taken into account for determining the power settings as recorded 7.3.1.

Antennas must be assessed on a case by case basis to determine if correction is required to take antenna array gain into account.

7.4.3 Product specific declarations

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

7.5 EUT Description

The NQ82G401 is a cost effective PCIe 2.4GHz WiFi module board. It is for incorporation into products designed on behalf of or by Pace Plc, not for sale or distribution as a standalone module.

It incorporates the Broadcom BCM4360 IC and supports 3x3 MIMO and is capable of supporting 802.11a/b/g/n modes. The modules utilises the Skyworks SKY65971 Low noise Amplifier and is designed for use in the US.

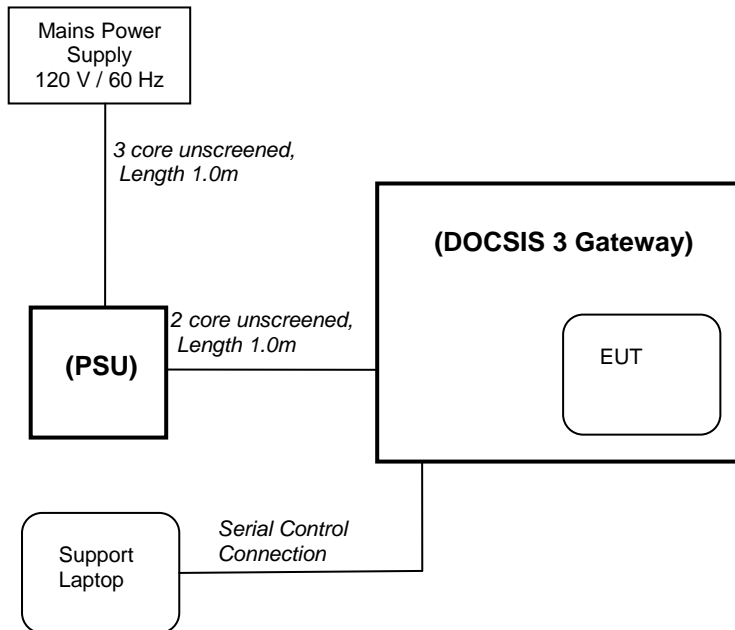
8 Modifications

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:



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. 5 V dc from the adaptor / 3V dc from alkaline batteries / 110 V ac, 60 Hz, from the mains.

10.2 Varying Test Conditions

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

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

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

11 Occupied Bandwidth

11.1 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.

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	FCC: ANSI C63.10-2013, Clause 11.8, KDB 558074
EUT Channels / Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz
EUT Channel Bandwidths:	20 MHz / 40 MHz
Deviations From Standard:	None
Measurement BW: (FCC requirement: 100 kHz)	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	20 MHz 25 MHz 50 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 110V ac	110 V ac \pm 10 % (as declared)

11.3 Test Limit

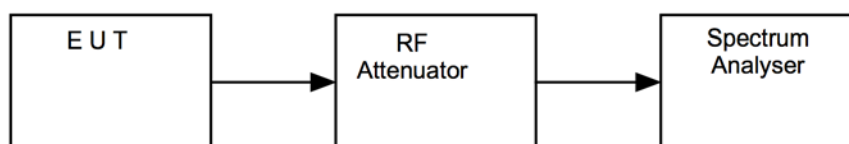
The minimum -6 dB bandwidth shall be at least 500 kHz.

11.4 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



11.5 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016
Spectrum Analyser	R&S	FSU26	UH405	11/05/2016
10 dB Attenuator	Radiall	R411820121	N/A	In Use
20 dB Attenuator	Radiall	R411810121	N/A	In Use

11.6 Test Results

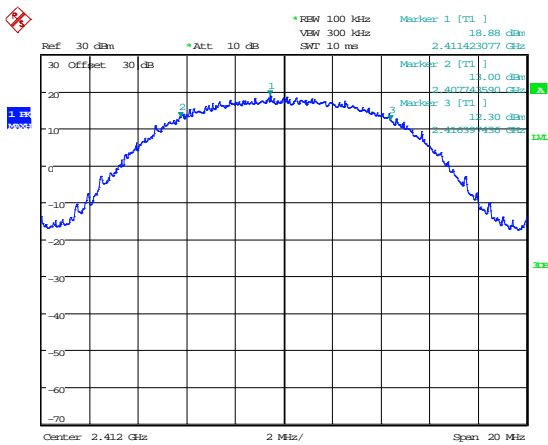
FCC 15.247. Modulation: 802.11b; Data rate:11Mbps					
Channel Frequency (MHz)	Power setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	106	2407.744	2416.397	8653.846	PASS
2437	106	2432.635	2441.673	9038.462	PASS
2462	106	2457.487	2466.378	8891.026	PASS

FCC 15.247. Modulation: 802.11g; Data rate:54Mbps					
Channel Frequency (MHz)	Power setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	95	2403.777	2420.123	16346.154	PASS
2437	104	2428.876	2445.199	16323.257	PASS
2462	104	2453.877	2470.095	16217.949	PASS

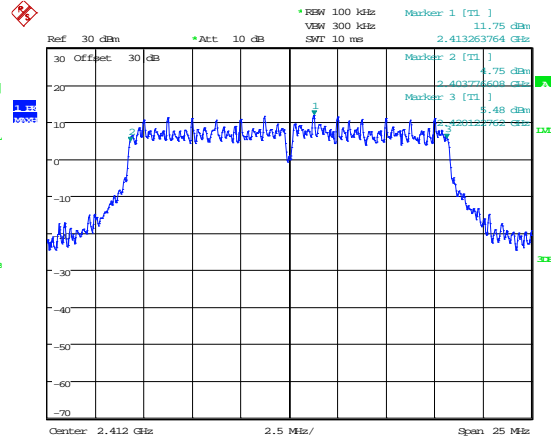
FCC 15.247. Modulation: 802.11N HT20; Data rate:MCS7					
Channel Frequency (MHz)	Power setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2412	90	2403.144	2420.884	17740.384	PASS
2437	107	2428.130	2445.871	17740.385	PASS
2462	106	2453.156	2470.856	17700.321	PASS

FCC 15.247. Modulation: 802.11N HT40; Data rate:MCS23					
Channel Frequency (MHz)	Power setting	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2422	88	2403.726	2440.248	36522.435	PASS
2437	103	2418.705	2455.328	36623.354	PASS
2452	91	2434.356	2470.237	35881.410	PASS

802.11b

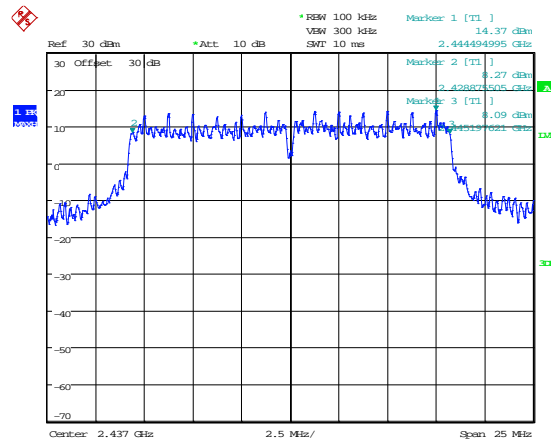
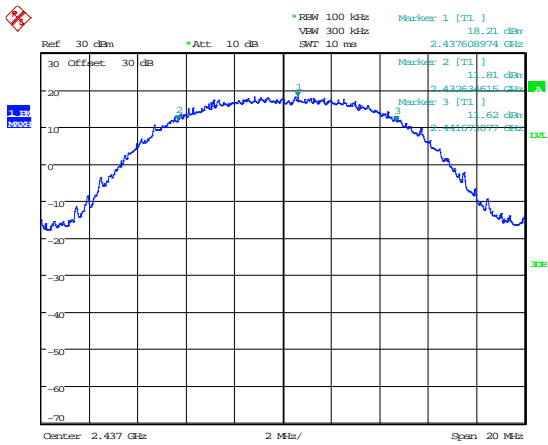


802.11g



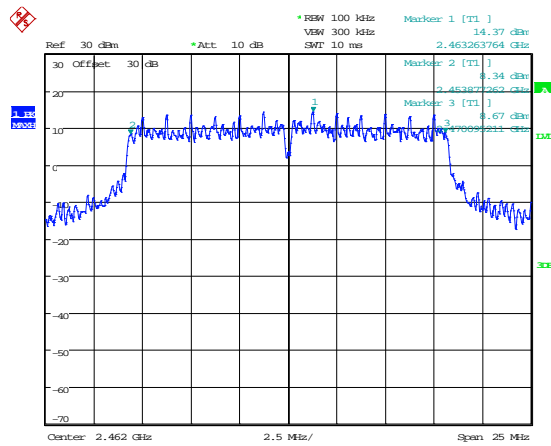
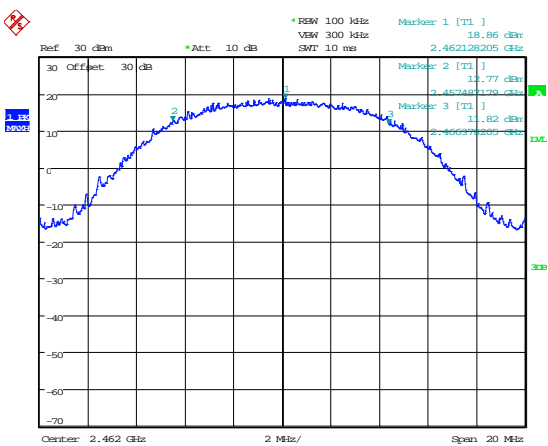
2412 MHz

2412 MHz



2437 MHz

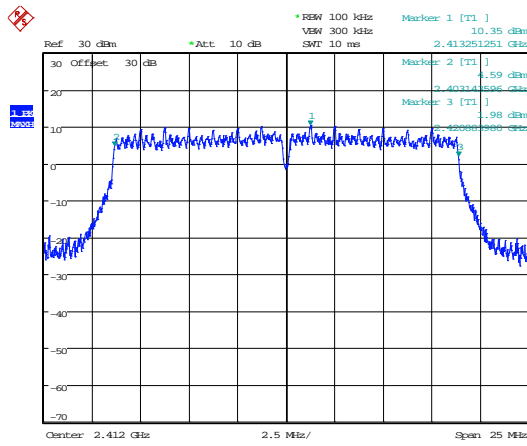
2437MHz



2462 MHz

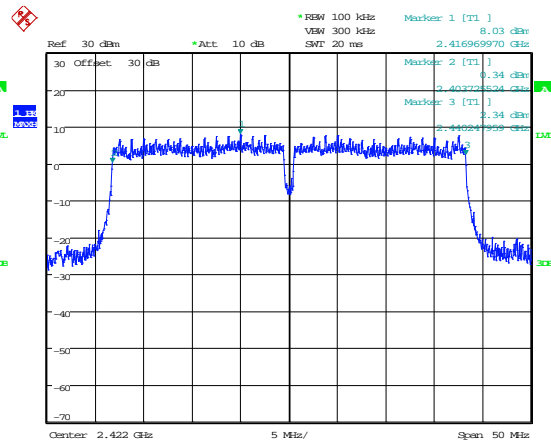
2462 MHz

802.11N HT20

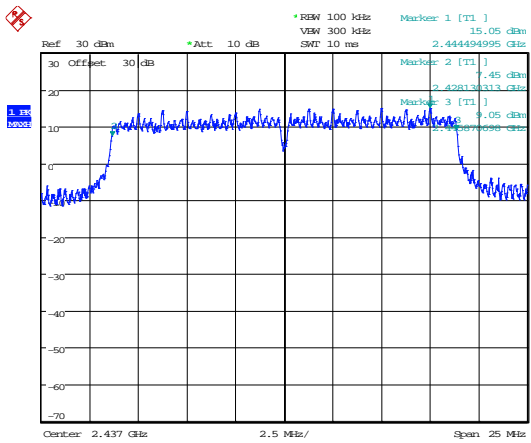


2412 MHz

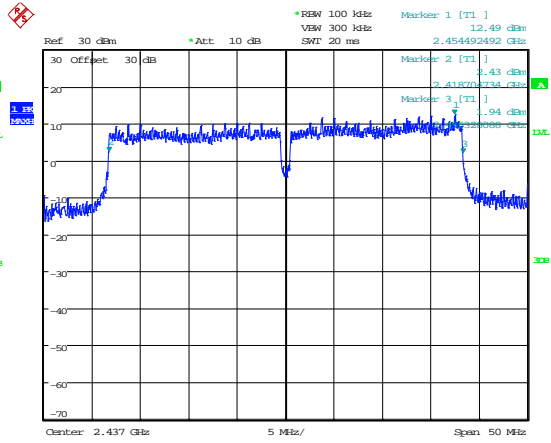
802.11N HT40



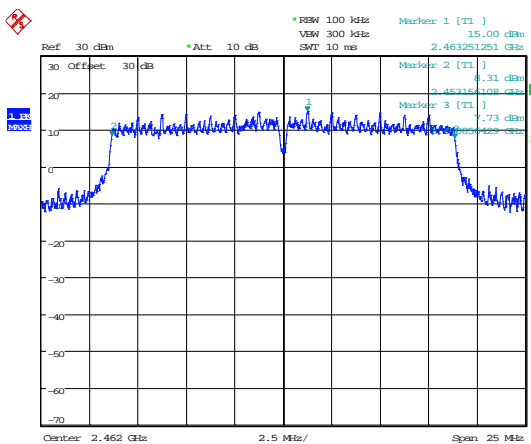
2422 MHz



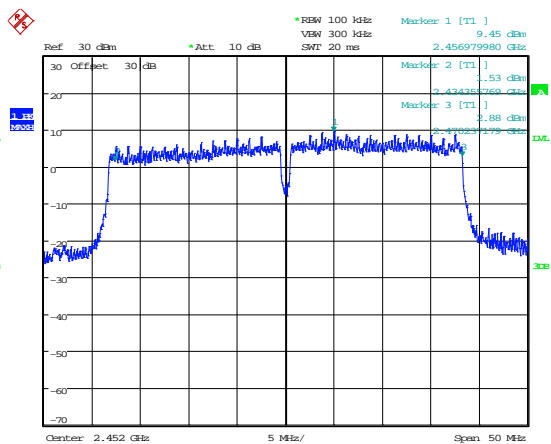
2437 MHz



2437 MHz



2462 MHz



2452 MHz

12 Maximum conducted output power

12.1 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.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Lab
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.2, KDB 558074
EUT Channels / Frequencies Measured:	2412 MHz / 2437 MHz / 2462 MHz
EUT Occupied Bandwidths:	20 MHz / 40 MHz
EUT Duty Cycle:	<98%
Deviations From Standard:	None
Measurement BW:	200 kHz 500 kHz 1 MHz 13MHz
Measurement Span:	25 MHz 100MHz
Measurement Detector:	RMS
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

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

12.3 Test Limit

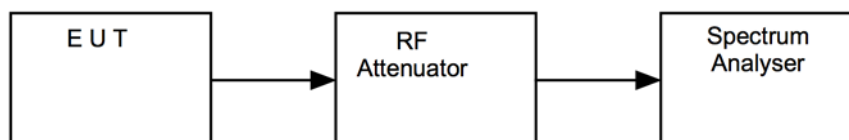
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

12.4 Test Method

The EUT was setup as per section 9 of this report and, as per Figure iv, the analyser was used to measure each antenna output in turn, having taken account of all path losses. The resolution bandwidth of the spectrum analyser was set between 1 and 5 % of the EUT occupied bandwidth and the analyser band power function used to calculate the average power. The results were summed as in the tables be2412.

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 Set-up



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>
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016
Spectrum Analyser	R&S	FSU26	UH405	11/05/2016
10 dB Attenuator	Radiall	R411820121	N/A	In Use
20 dB Attenuator	Radiall	R411810121	N/A	In Use

12.6 Test Results

Modulation: 802.11b; Data rate: 11Mbps					
Channel (MHz)	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2412	106	0	-5.33	30	293.09
		1	-4.82	30	329.61
		2	-4.78	30	332.66
Total:					955.36
Result:					PASS
2437	106	0	-5.31	30	294.44
		1	-4.80	30	331.13
		2	-4.71	30	338.06
Total:					963.64
Result:					PASS
2462	106	0	-5.26	30	297.85
		1	-4.84	30	328.10
		2	-4.54	30	351.56
Total:					977.51
Result:					PASS

Modulation: 802.11g; Data rate: 54Mbps					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2412	95	0	-1.24	23	149.97
		1	-0.38	23	182.81
		2	-0.20	23	190.55
Total:					523.32
Result:					PASS
2437	104	0	1.63	23	290.40
		1	2.09	23	322.85
		2	2.35	23	342.77
Total:					956.02
Result:					PASS
2462	104	0	1.60	23	288.40
		1	2.23	23	333.43
		2	2.26	23	335.74
Total:					957.57
Result:					PASS

Modulation: 802.11n HT20; Data rate: MCS7					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2412	90	0	-3.09	23	97.95
		1	-2.16	23	121.34
		2	-2.00	23	125.89
Total:					345.18
Result:					PASS
2437	107	0	1.82	23	303.39
		1	2.26	23	335.74
		2	2.53	23	357.27
Total:					996.40
Result:					PASS
2462	106	0	1.59	23	287.74
		1	2.26	23	335.74
		2	2.32	23	340.41
Total:					963.89
Result:					PASS

Modulation: 802.11n HT40; Data rate: MCS23					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2422	88	0	-1.95	23	127.35
		1	-1.44	23	143.22
		2	-1.14	23	153.46
Total:					424.03
Result:					PASS
2437	103	0	1.59	23	287.74
		1	2.12	23	325.09
		2	2.38	23	345.14
Total:					957.97
Result:					PASS
2452	91	0	-1.10	23	154.88
		1	-0.79	23	166.34
		2	-0.52	23	177.01
Total:					489.23
Result:					PASS

13 Out-of-band and conducted spurious emissions

13.1 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.

13.2 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 MHz / 2437 MHz / 2462 MHz
EUT Channel Bandwidths:	20 MHz / 40 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	>100kHz
Measurement Detector:	Peak
Measurement Range:	9kHz to 25 GHz

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 110V ac	230 V ac ±10 % (as declared)

13.3 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).

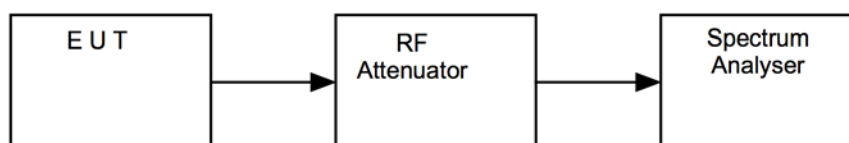
13.4 Test Method

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.

Reference and band edge plots taken for chain with highest output power level, spurious emissions plots taken for each chain, plot for chain with highest output power only recorded below

Figure v Test Setup

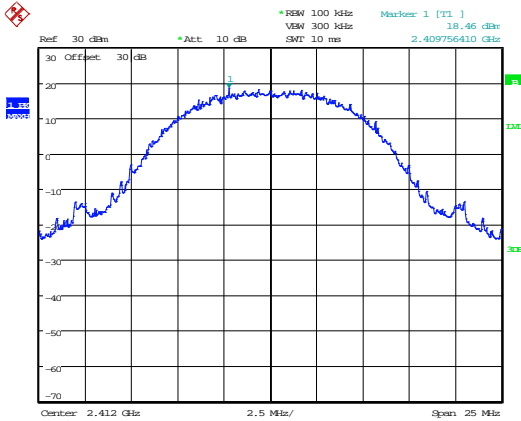


13.5 Test Equipment

<i>Type of Equipment</i>	<i>Maker/Supplier</i>	<i>Model Number</i>	<i>Element Number</i>	<i>Calibration Due Date</i>
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016
Spectrum Analyser	R&S	FSU26	UH405	11/05/2016
10 dB Attenuator	Radiall	R411820121	N/A	In Use
20 dB Attenuator	Radiall	R411810121	N/A	In Use

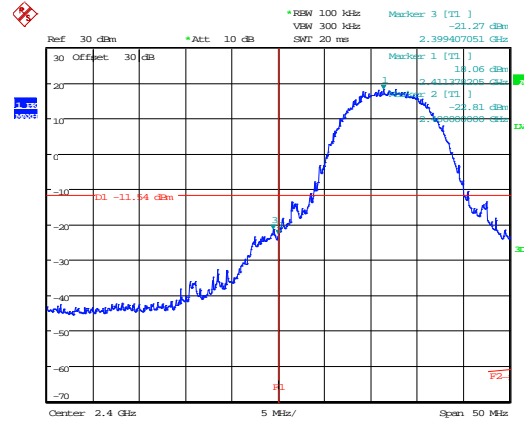
13.6 Test Results

Modulation: 802.11b; Data rate: 11Mbps – 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 Limit						PASS



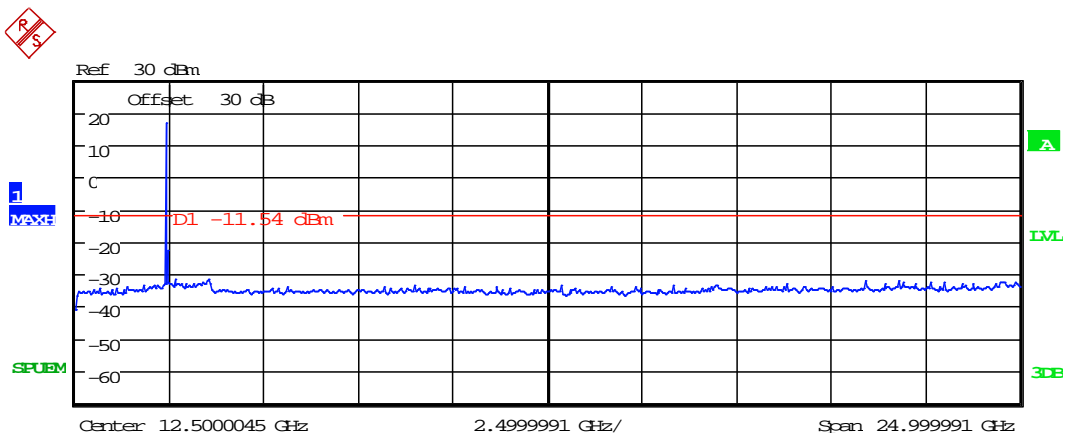
Date: 15.OCT.2015 15:34:41

Reference



Date: 15.OCT.2015 15:36:32

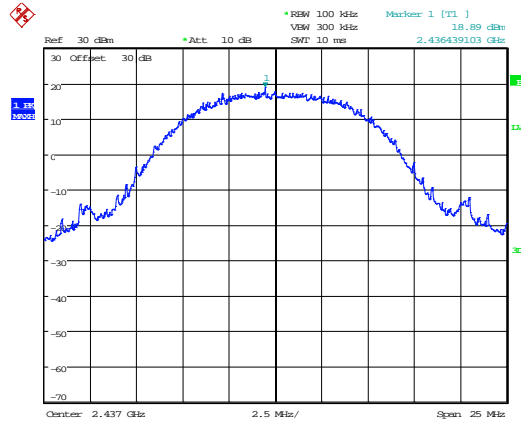
Bandedge



Center: 12.5000045 GHz 2.4999991 GHz/ Span: 24.999991 GHz

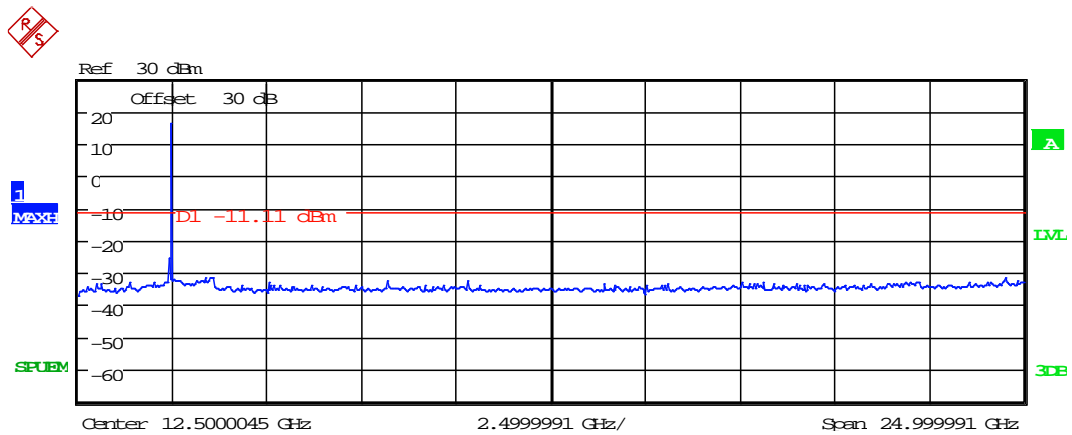
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.000000 k	-41.00	-200.00
150.000 k	30.000 M	10.00 k	179.850000 k	-41.27	-200.00
30.000 M	1.000 G	100.00 k	652.449000 M	-34.53	-200.00
1.000 G	5.000 G	100.00 k	2.413600 G	16.83	-200.00
5.000 G	10.000 G	100.00 k	8.957500 G	-33.63	-200.00
10.000 G	15.000 G	100.00 k	12.864500 G	-33.43	-200.00
15.000 G	20.000 G	100.00 k	18.813000 G	-33.26	-200.00
20.000 G	25.000 G	100.00 k	21.790000 G	-31.98	-200.00

Modulation: 802.11b; Data rate: 11Mbps – 2437 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 Limit						PASS



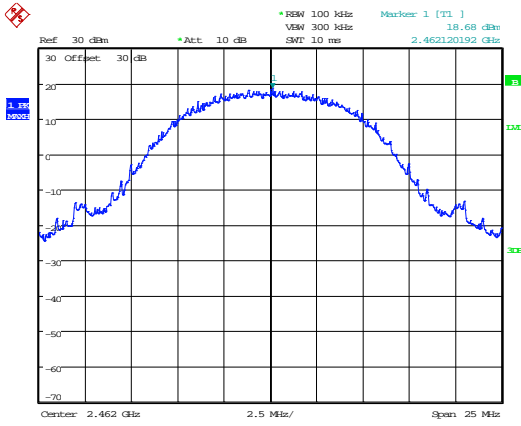
Date: 16.OCT.2015 13:50:44

Reference



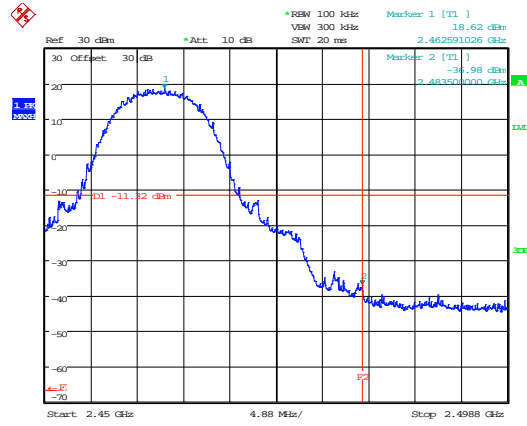
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.451923 k	-38.92	-200.00
150.000 k	30.000 M	10.00 k	182.835000 k	-37.59	-200.00
30.000 M	1.000 G	100.00 k	473.775000 M	-33.56	-200.00
1.000 G	5.000 G	100.00 k	2.436400 G	16.36	-200.00
5.000 G	10.000 G	100.00 k	8.192000 G	-32.66	-200.00
10.000 G	15.000 G	100.00 k	10.296500 G	-32.54	-200.00
15.000 G	20.000 G	100.00 k	17.546500 G	-32.97	-200.00
20.000 G	25.000 G	100.00 k	24.506000 G	-31.69	-200.00

Modulation: 802.11b; Data rate: 11Mbps – 2462MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Significant Emissions Within 20 dB of Limit						PASS



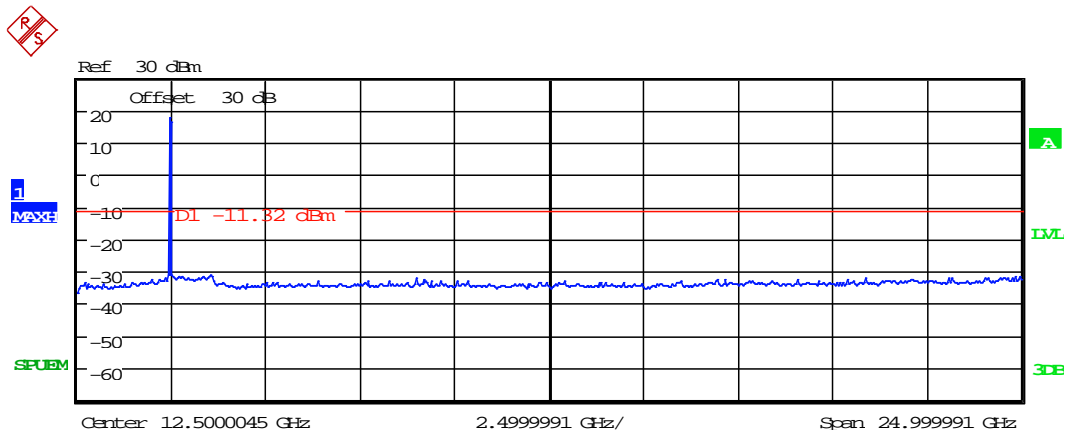
Date: 15.OCT.2015 16:18:15

Reference



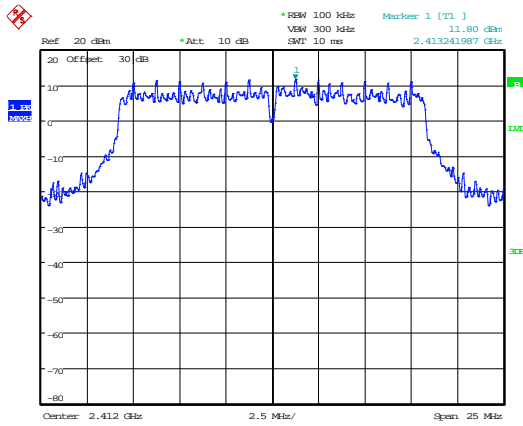
Date: 15.OCT.2015 16:19:46

Bandedge



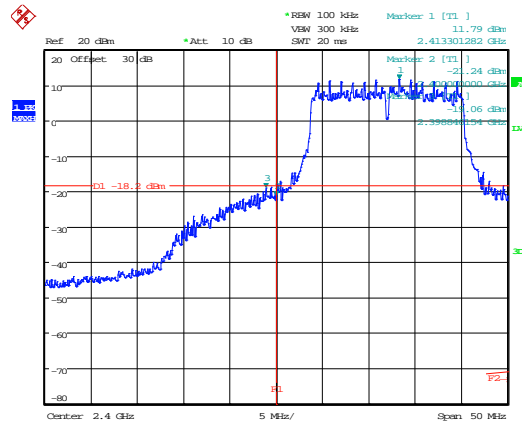
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.000000 k	-37.77	-200.00
150.000 k	30.000 M	10.00 k	167.910000 k	-36.71	-200.00
30.000 M	1.000 G	100.00 k	184.618000 M	-33.80	-200.00
1.000 G	5.000 G	100.00 k	2.463200 G	17.74	-200.00
5.000 G	10.000 G	100.00 k	8.987500 G	-32.39	-200.00
10.000 G	15.000 G	100.00 k	10.045000 G	-32.98	-200.00
15.000 G	20.000 G	100.00 k	19.072000 G	-32.52	-200.00
20.000 G	25.000 G	100.00 k	24.857000 G	-31.70	-200.00

Modulation: 802.11g; Data rate: 54Mbps – 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 Limit						PASS



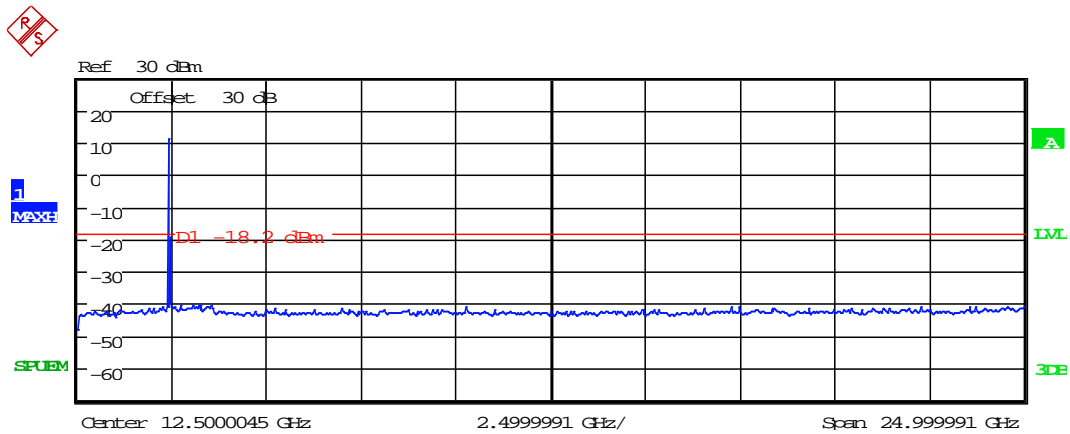
Date: 15.OCT.2015 15:28:19

Reference



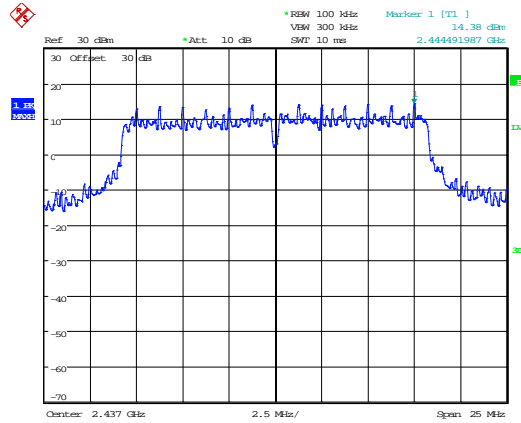
Date: 15.OCT.2015 15:29:13

Bandedge



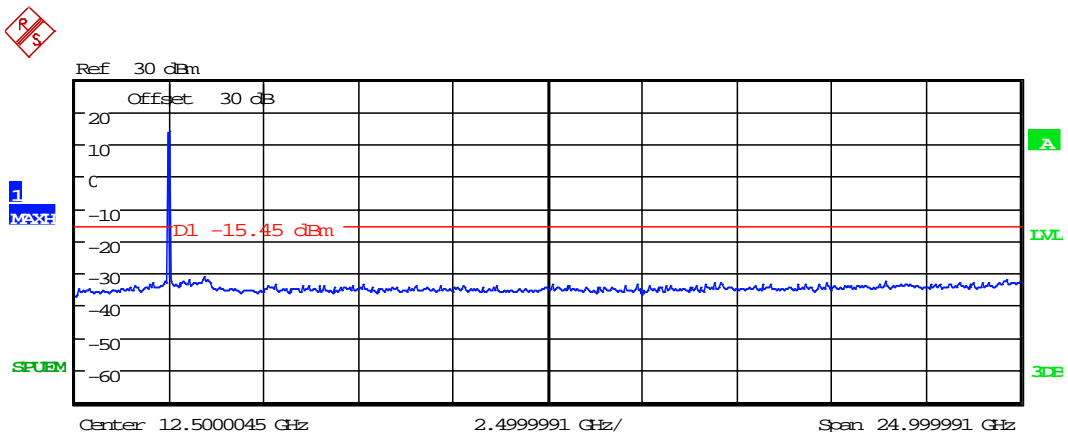
Start [Hz]	Stop [Hz]	REW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	10.581731 k	-48.77	-200.00
150.000 k	30.000 M	10.00 k	197.760000 k	-48.33	-200.00
30.000 M	1.000 G	100.00 k	457.188000 M	-42.47	-200.00
1.000 G	5.000 G	100.00 k	2.414400 G	11.18	-200.00
5.000 G	10.000 G	100.00 k	5.208000 G	-41.71	-200.00
10.000 G	15.000 G	100.00 k	10.258000 G	-41.32	-200.00
15.000 G	20.000 G	100.00 k	17.447500 G	-41.27	-200.00
20.000 G	25.000 G	100.00 k	23.724500 G	-40.91	-200.00

Modulation: 802.11g; Data rate: 54Mbps – 2437 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 Limit						PASS



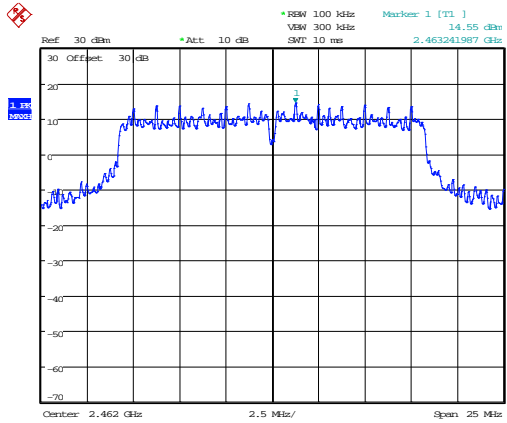
Date: 16.OCT.2015 14:00:12

Reference



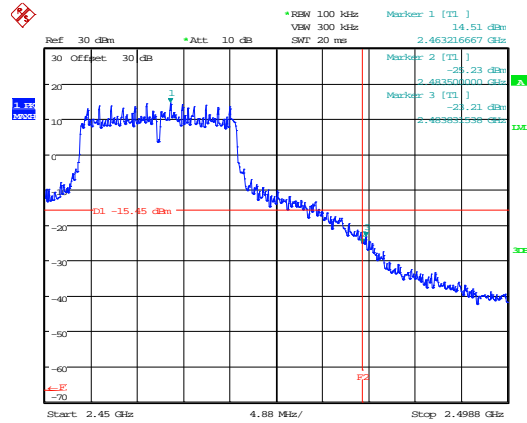
Start [Hz]	Stop [Hz]	REW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.677885 k	-38.92	-200.00
150.000 k	30.000 M	10.00 k	164.925000 k	-37.37	-200.00
30.000 M	1.000 G	100.00 k	366.493000 M	-34.82	-200.00
1.000 G	5.000 G	100.00 k	2.465600 G	13.80	-200.00
5.000 G	10.000 G	100.00 k	7.618000 G	-33.58	-200.00
10.000 G	15.000 G	100.00 k	12.610500 G	-33.62	-200.00
15.000 G	20.000 G	100.00 k	17.080500 G	-33.04	-200.00
20.000 G	25.000 G	100.00 k	24.651000 G	-32.34	-200.00

Modulation: 802.11g; Data rate: 54Mbps – 2462MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Significant Emissions Within 20 dB of Limit						PASS



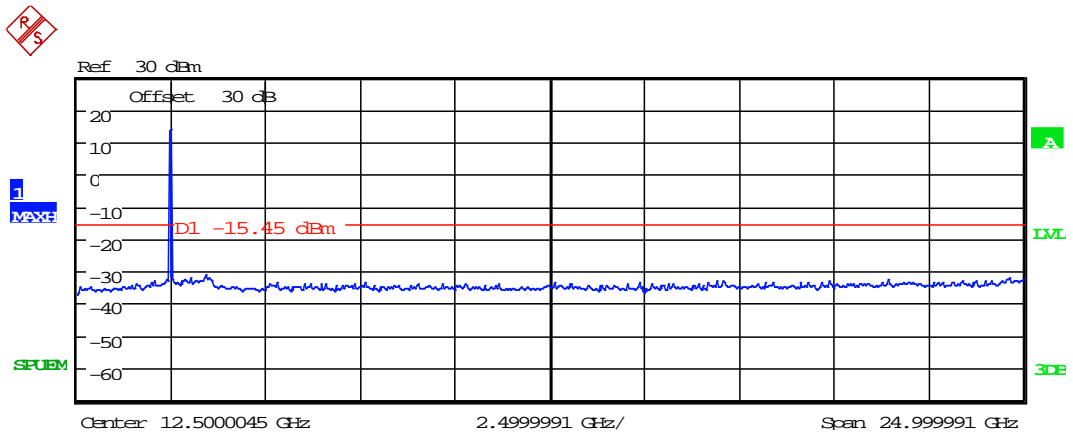
Date: 15.OCT.2015 16:20:42

Reference



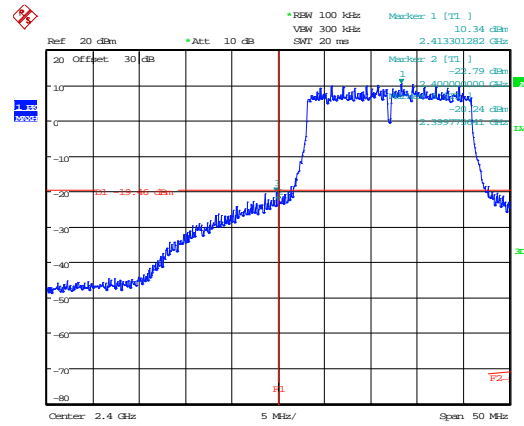
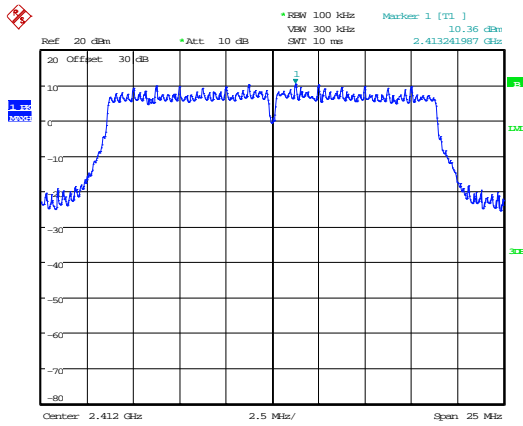
Date: 15.OCT.2015 16:21:14

Bandedge



Start [Hz]	Stop [Hz]	REW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.677885 k	-38.92	-200.00
150.000 k	30.000 M	10.00 k	164.925000 k	-37.37	-200.00
30.000 M	1.000 G	100.00 k	366.493000 M	-34.82	-200.00
1.000 G	5.000 G	100.00 k	2.465600 G	13.80	-200.00
5.000 G	10.000 G	100.00 k	7.618000 G	-33.58	-200.00
10.000 G	15.000 G	100.00 k	12.610500 G	-33.62	-200.00
15.000 G	20.000 G	100.00 k	17.080500 G	-33.04	-200.00
20.000 G	25.000 G	100.00 k	24.651000 G	-32.34	-200.00

Modulation: 802.11n HT20; Data rate: MCS7 – 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 Limit						PASS

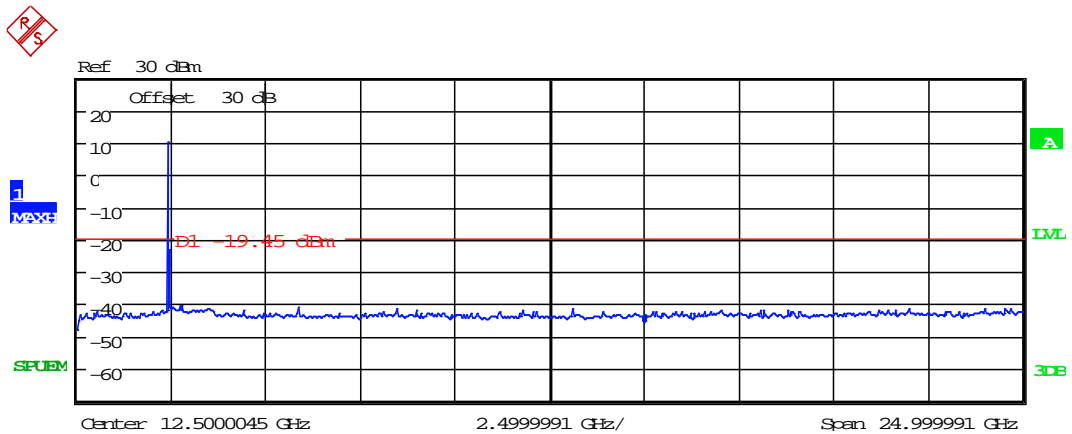


Date: 15.OCT.2015 15:21:19

Date: 15.OCT.2015 15:22:02

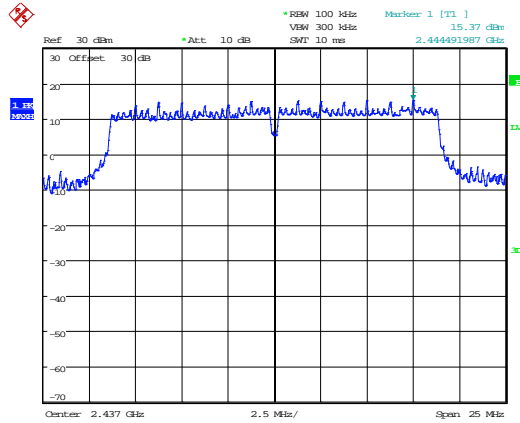
Reference

Bandedge



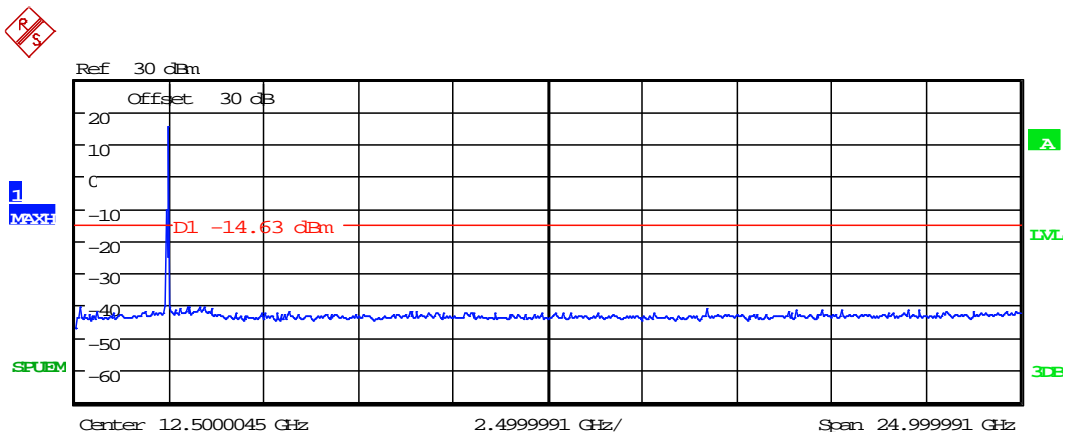
Start [Hz]	Stop [Hz]	REW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	10.355769 k	-49.24	-200.00
150.000 k	30.000 M	10.00 k	167.910000 k	-48.33	-200.00
30.000 M	1.000 G	100.00 k	517.716000 M	-42.76	-200.00
1.000 G	5.000 G	100.00 k	2.414400 G	9.88	-200.00
5.000 G	10.000 G	100.00 k	5.838000 G	-41.20	-200.00
10.000 G	15.000 G	100.00 k	13.107500 G	-41.61	-200.00
15.000 G	20.000 G	100.00 k	18.146500 G	-41.93	-200.00
20.000 G	25.000 G	100.00 k	24.523500 G	-41.49	-200.00

Modulation: 802.11n HT20; Data rate: MCS7 – 2437 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 Limit						PASS



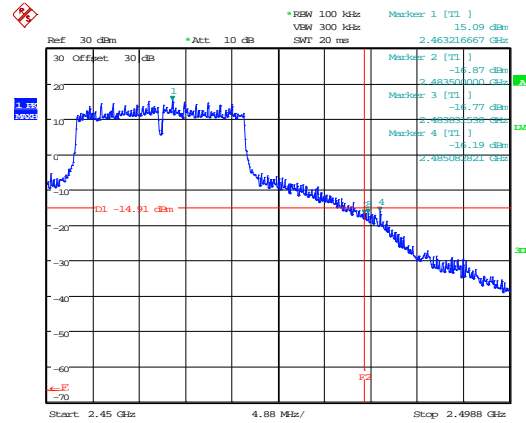
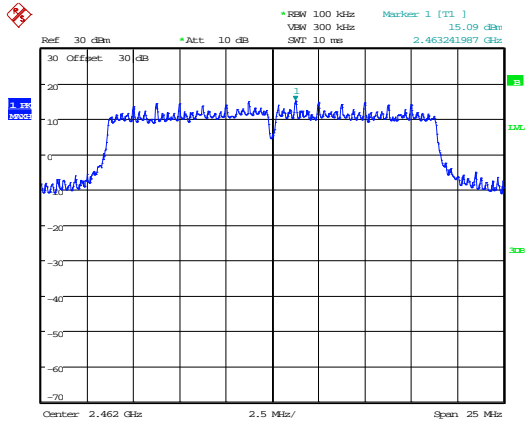
Date: 16.OCT.2015 14:31:55

Reference



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.000000 k	-49.79	-200.00
150.000 k	30.000 M	10.00 k	188.805000 k	-47.37	-200.00
30.000 M	1.000 G	100.00 k	123.411000 M	-40.58	-200.00
1.000 G	5.000 G	100.00 k	2.438400 G	15.36	-200.00
5.000 G	10.000 G	100.00 k	9.022000 G	-42.08	-200.00
10.000 G	15.000 G	100.00 k	10.440500 G	-42.36	-200.00
15.000 G	20.000 G	100.00 k	16.704000 G	-41.29	-200.00
20.000 G	25.000 G	100.00 k	22.330000 G	-41.50	-200.00

Modulation: 802.11n HT20; Data rate: MCS7 – 2462MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Significant Emissions Within 20 dB of Limit						PASS

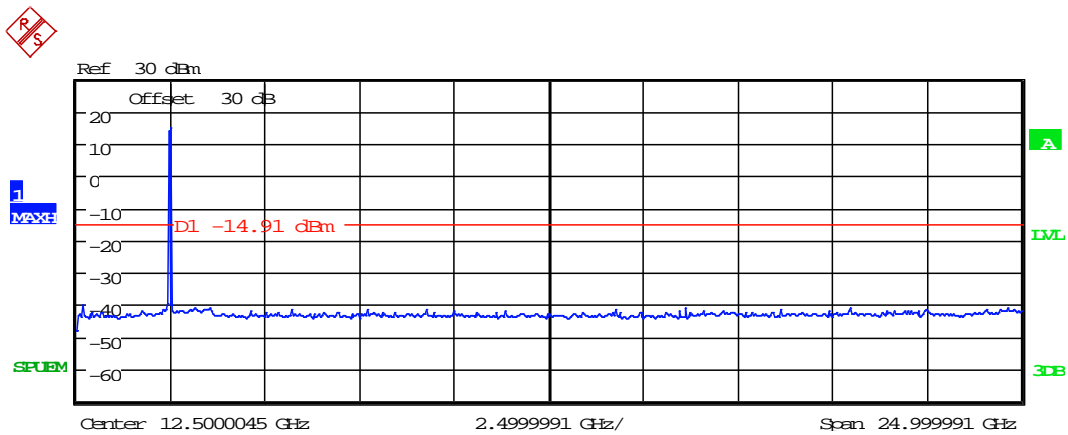


Date: 15.OCT.2015 16:15:13

Date: 15.OCT.2015 16:16:38

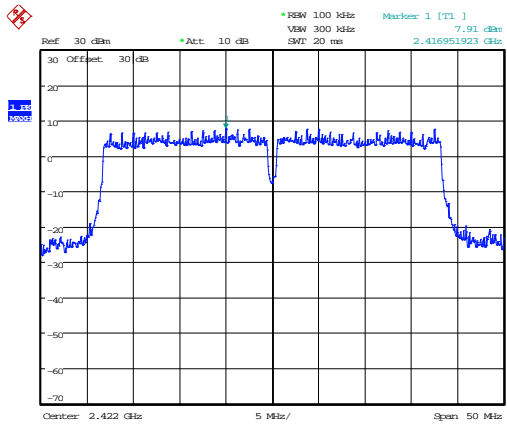
Reference

Bandedge

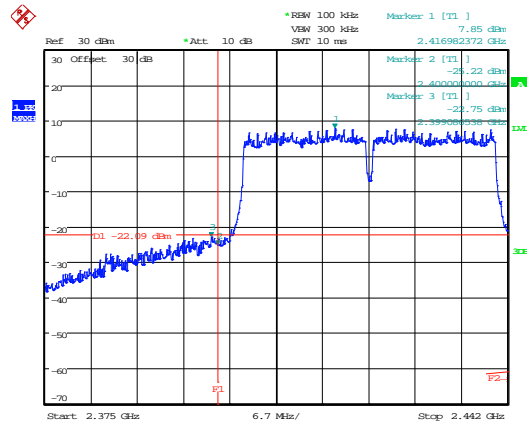


Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.225962 k	-49.51	-200.00
150.000 k	30.000 M	10.00 k	197.760000 k	-48.33	-200.00
30.000 M	1.000 G	100.00 k	147.176000 M	-39.99	-200.00
1.000 G	5.000 G	100.00 k	2.466800 G	14.53	-200.00
5.000 G	10.000 G	100.00 k	5.677500 G	-41.39	-200.00
10.000 G	15.000 G	100.00 k	14.273000 G	-41.39	-200.00
15.000 G	20.000 G	100.00 k	16.105500 G	-41.22	-200.00
20.000 G	25.000 G	100.00 k	24.625500 G	-41.16	-200.00

Modulation: 802.11n HT40; Data rate: MCS23 – 2422 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 Limit						PASS



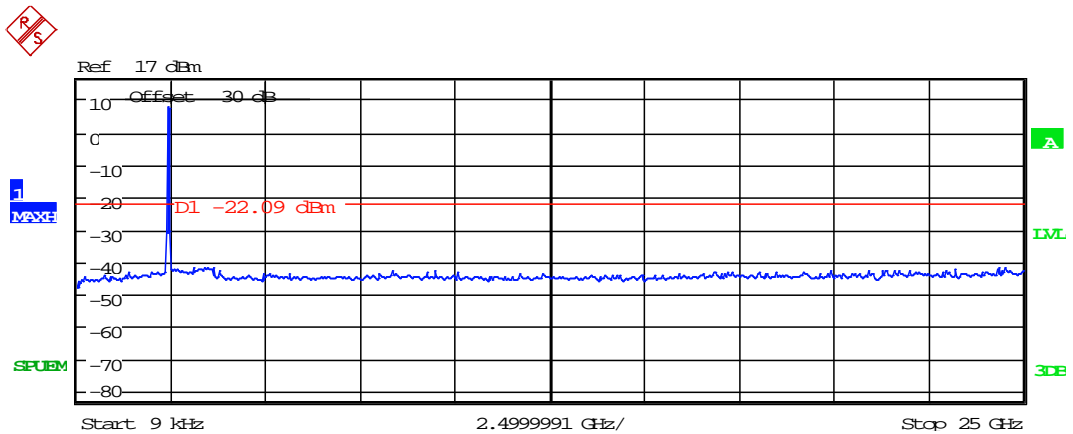
Date: 15.OCT.2015 15:44:23



Date: 15.OCT.2015 15:44:57

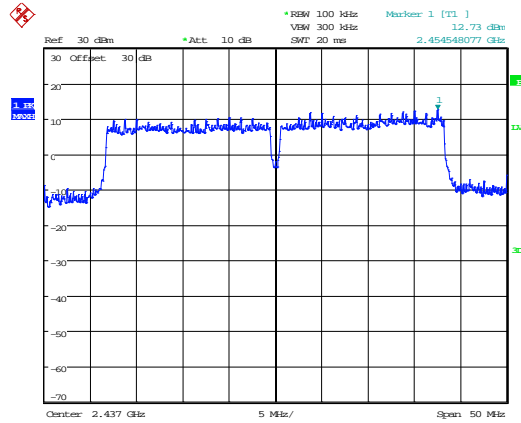
Reference

Bandedge



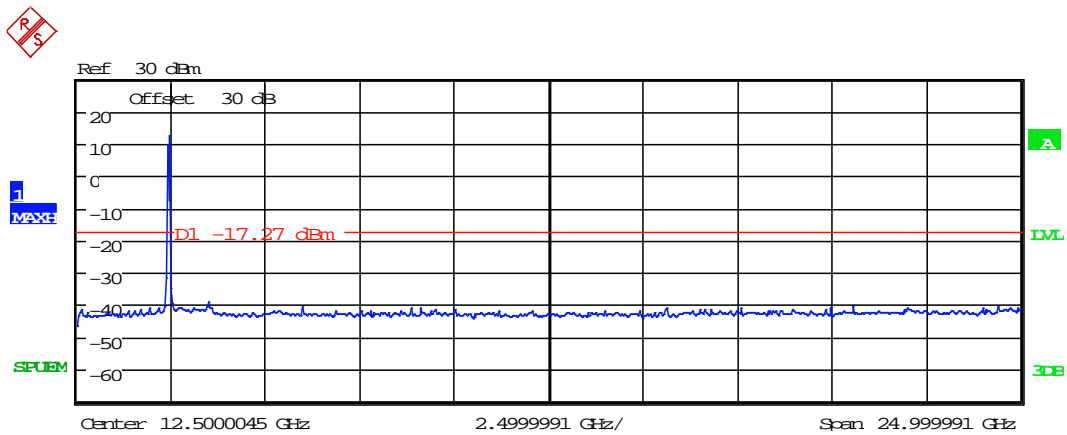
Start [Hz]	Stop [Hz]	REW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	11.033654 k	-49.34	-200.00
150.000 k	30.000 M	10.00 k	150.000000 k	-47.81	-200.00
30.000 M	1.000 G	100.00 k	714.044000 M	-44.41	-200.00
1.000 G	5.000 G	100.00 k	2.416800 G	7.98	-200.00
5.000 G	10.000 G	100.00 k	8.317000 G	-42.98	-200.00
10.000 G	15.000 G	100.00 k	10.047500 G	-43.27	-200.00
15.000 G	20.000 G	100.00 k	19.926000 G	-42.95	-200.00
20.000 G	25.000 G	100.00 k	24.510000 G	-41.76	-200.00

Modulation: 802.11n HT40; Data rate: MCS23 – 2437 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 Limit						PASS



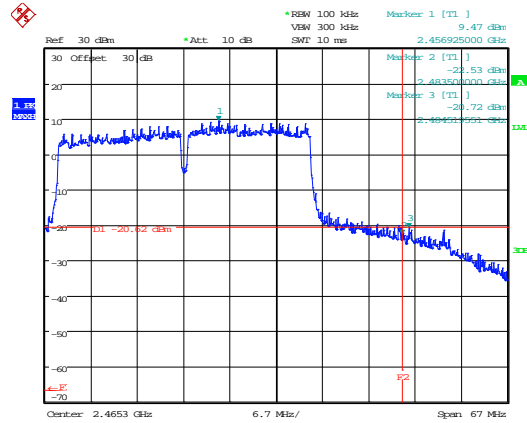
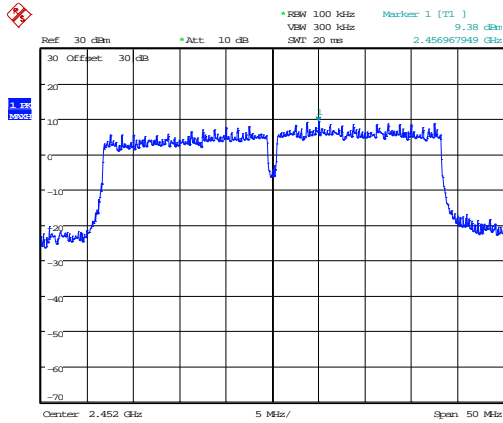
Date: 16.OCT.2015 14:37:45

Reference



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.225962 k	-48.42	-200.00
150.000 k	30.000 M	10.00 k	197.760000 k	-46.95	-200.00
30.000 M	1.000 G	100.00 k	122.150000 M	-41.67	-200.00
1.000 G	5.000 G	100.00 k	2.454400 G	12.41	-200.00
5.000 G	10.000 G	100.00 k	5.984000 G	-40.72	-200.00
10.000 G	15.000 G	100.00 k	10.009000 G	-41.71	-200.00
15.000 G	20.000 G	100.00 k	19.940000 G	-41.25	-200.00
20.000 G	25.000 G	100.00 k	20.563500 G	-40.48	-200.00

Modulation: 802.11n HT40; Data rate: MCS23 – 2452MHz						
Channel Frequency (MHz)	Emission Frequency (MHz)	Analyzer Level (dBm)	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Significant Emissions Within 20 dB of Limit						PASS

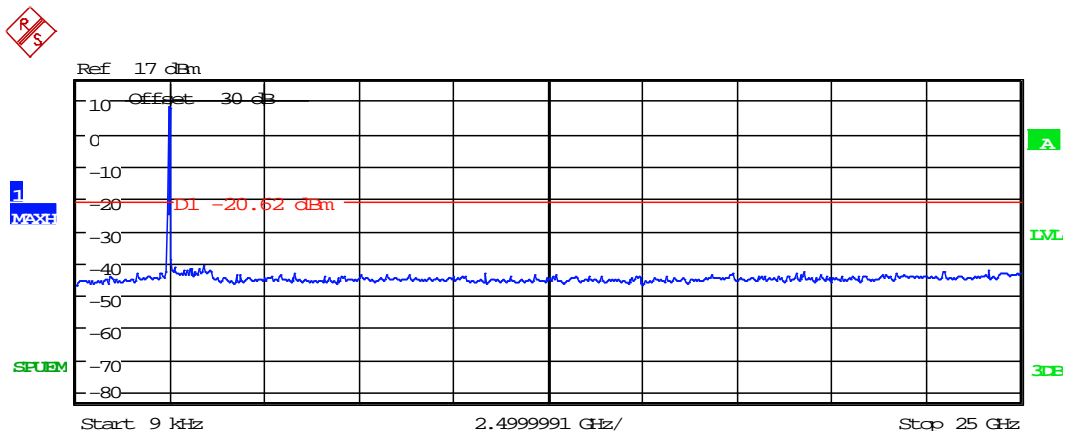


Date: 15.OCT.2015 16:06:28

Date: 15.OCT.2015 16:07:55

Reference

Bandedge



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.225962 k	-47.20	-200.00
150.000 k	30.000 M	10.00 k	152.985000 k	-47.37	-200.00
30.000 M	1.000 G	100.00 k	891.457000 M	-44.24	-200.00
1.000 G	5.000 G	100.00 k	2.455600 G	8.51	-200.00
5.000 G	10.000 G	100.00 k	5.783500 G	-43.13	-200.00
10.000 G	15.000 G	100.00 k	10.800500 G	-43.15	-200.00
15.000 G	20.000 G	100.00 k	19.252000 G	-43.05	-200.00
20.000 G	25.000 G	100.00 k	24.139000 G	-42.51	-200.00

14 Power spectral density

14.1 Definition

The power per unit bandwidth.

14.2 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 MHz / 2437 MHz / 2462 MHz
EUT Channel Bandwidths:	20 MHz / 40 MHz
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 kHz, 20 kHz, 30 kHz, 50 kHz
Measurement Span: (requirement 1.5 times Channel BW)	13MHz, 25MHz, 50MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 110V ac	230 V ac \pm 10% (as declared)

14.3 Test Limit

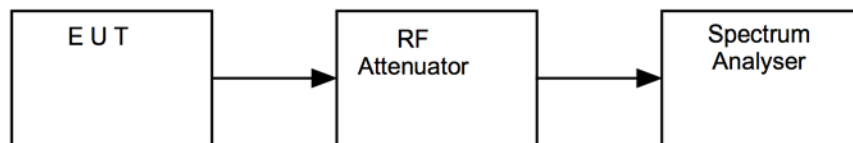
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

14.4 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



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>
Spectrum Analyser	R&S	FSU26	REF909	13/02/2016
Spectrum Analyser	R&S	FSU26	UH405	11/05/2016
10 dB Attenuator	Radiall	R411820121	N/A	In Use
20 dB Attenuator	Radiall	R411810121	N/A	In Use

14.6 Test Results

Modulation: 802.11b; Data rate: 11Mbps					
Channel (MHz)	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2412	106	0	-30.81	30.00	0.83
		1	-30.28	30.00	0.94
		2	-29.99	30.00	1.00
Total (dBm):					4.42
Result:					Pass
2437	106	0	-30.79	30.00	0.83
		1	-30.70	30.00	0.85
		2	-30.95	30.00	0.80
Total (dBm):					3.96
Result:					Pass
2462	106	0	-30.62	30.00	0.87
		1	-30.59	30.00	0.87
		2	-30.29	30.00	0.94
Total (dBm):					4.27
Result:					Pass

Modulation: 802.11g; Data rate: 54Mbps					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2412	90	0	-25.25	23.00	0.60
		1	-24.70	23.00	0.68
		2	-24.78	23.00	0.66
Total (dBm):					2.87
Result:					Pass
2437	107	0	-22.97	23.00	1.01
		1	-22.81	23.00	1.04
		2	-22.38	23.00	1.15
Total (dBm):					5.06
Result:					Pass
2462	106	0	-22.74	23.00	1.06
		1	-22.09	23.00	1.23
		2	-22.24	23.00	1.19
Total (dBm):					5.42
Result:					Pass

Modulation: 802.11n HT20; Data rate: MCS7					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2412	95	0	-26.75	23.00	0.42
		1	-26.21	23.00	0.48
		2	-26.19	23.00	0.48
Total (dBm):					1.40
Result:					Pass
2437	104	0	-22.40	23.00	1.15
		1	-21.87	23.00	1.30
		2	-21.89	23.00	1.29
Total (dBm):					5.72
Result:					Pass
2462	104	0	-22.87	23.00	1.03
		1	-21.71	23.00	1.35
		2	-22.01	23.00	1.26
Total (dBm):					5.60
Result:					Pass

Modulation: 802.11n HT40; Data rate: MCS23					
Channel MHz	Power setting	Antenna Chain	Analyzer Level (dBm)	Cable loss (dB)	Power (mW)
2422	88	0	-27.23	23.00	0.38
		1	-26.68	23.00	0.43
		2	-26.60	23.00	0.44
Total (dBm):					0.94
Result:					Pass
2437	103	0	-23.32	23.00	0.93
		1	-22.81	23.00	1.04
		2	-21.93	23.00	1.28
Total (dBm):					5.12
Result:					Pass
2452	91	0	-26.38	23.00	0.46
		1	-25.49	23.00	0.56
		2	-25.28	23.00	0.59
Total (dBm):					2.08
Result:					Pass

15 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**