EMC TEST REPORT for Intentional Radiator (Wi-Fi Function)
No. 131000486SHA-001

Applicant	:	Ecovacs Robotics Co.,Ltd. No.108 Shihu Road (West), Wuzhong Zone, Suzhou , China l215168
Manufacturer	:	Ecovacs Robotics Co.,Ltd. No.108 Shihu Road (West), Wuzhong Zone, Suzhou , China l215168
Product Name	:	wifi module
Type/Model	:	RAK310

SUMMARY
The equipment complies with the requirements according to the following standard(s):

47CFR Part 15 (2013): Radio Frequency Devices

ANSI C63.4 (2009): 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

RSS-210 Issue 8 (December 2010): Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment

RSS-Gen Issue 3 (December 2010): General Requirements and Information for the Certification of Radiocommunication Equipment

Date of issue: August 18, 2014

Prepared by: Reviewed by:

Jackson Huang (*Project Engineer*) Daniel Zhao (*Reviewer*)

Description of Test Facility

Name: Intertek Testing Services Limited Shanghai
Address: Building No.86, 1198 Qinzhou Road(North), Shanghai 200233, P.R. China

FCC Registration Number: 236597

Name of contact: Steve Li
Tel: +86 21 64956565 ext. 214
Fax: +86 21 54262335 ext. 214

Content

1. General Information

1.1 Applicant Information

Applicant	:	Ecovacs Robotics Co.,Ltd. No.108 Shihu Road (West), Wuzhong Zone, Suzhou , China |215168
Name of contact	:	Ms. Geng Hongxia
Tel	:	86 0512 67072006
Fax	:	86 0512 65274820
Manufacturer	:	Ecovacs Robotics Co.,Ltd. No.108 Shihu Road (West), Wuzhong Zone, Suzhou , China |215168

1.2 Identification of the EUT

Equipment:	wifi module
Type/model:	RAK310
FCC ID:	2AAL3-RAK310
IC ID:	12253A-RAK310

1.3 Technical specification

Frequency Range:	2412 - 2462 MHz
Modulation:	CCK,BPSK,QPSK,DSSS,OFDM
Gain of Antenna:	with antenna connector, 3.5 dBi
Rating:	3.3VDC
Description of EUT:	The EUT is a 802.11b/g/n(HT20) wifi module .
Channel Description:	11Channel for 2412MHz~2462MHz.

1.4 Mode of operation during the test / Test peripherals used

While testing transmitting mode of EUT, the internal modulation and continuously transmission was applied.

The lowest, middle and highest channel were tested as representatives.

Freq. Band	Modulation	Lowest(MHz)	Middle(MHz)	Highest(MHz)
2412-2462MHz	802.11b	2412	2437	2462
	802.11g	2412	2437	2462
	802.11n(HT20)	2412	2437	2462

Test software setting:
The test setting software for 802.11b/g/n(HT20) is offered by the manufactory.
Test hardware setting:

Product	Model	Manufactory
WIFI Module Test Board Information	RAK310-TEB	ShenZhen RAK wireless Co.,Ltd

Data rate VS Power

The pre-scan for the conducted power with all rates in each modulation and bands was used, and the worst case was found and used in all test cases.

2.4GHz Band:
After this pre-scan, we choose the following table of the data rata as the worst case.

Freq. Band	Modulation	Worst case data rate
2400-2483.5MHz	802.11b	11Mbps
	802.11g	54Mbps
	802.11 n(HT20)	65Mbp

2. Test Specification

2.1 Instrument list

Equipment	Type	Manu.	Internal no.	Cal. Date	Due date
Test Receiver	ESCS 30	R&S	EC 2107	2013-10-21	2014-10-20
Test Receiver	ESIB 26	R&S	EC 3045	2013-10-21	2014-10-20
Test Receiver	ESCI 7	R&S	EC4501	2013-12-29	2014-12-28
Spectrum Analyzer	N9010	Agilent	EC4890	2013-10-21	2014-10-20
Power meter	ML 2495A	Anritsu	EC 4895	2013-10-21	2014-10-20
A.M.N.	ESH2-Z5	R&S	EC 3119	2014-1-9	2015-1-8
Bilog Antenna	CBL 6112D	TESEQ	EC 4206	2014-5-16	2015-5-15
Horn antenna	HF 906	R&S	EC 3049	2014-5-13	2015-5-12
Pre-amplifier	Pre-amp 18	R&S	EC 3222	2014-4-12	2015-4-11
Pre-amplifier	Tpa0118-40	R&S	EC 4792-2	2014-4-12	2015-4-11
Log-period antenna	AT 1080	AR	EC 3044-7	2014-5-22	2015-5-21
Biconical antenna	3109PX	ETS	EC3564	2013-8-25	2014-8-24
Semi-anechoic chamber	-	Albatross project	EC 3048	2014-5-21	2015-5-20
Shielded room	-	Zhongyu	EC 2838	2014-1-12	2016-1-11
Shielded room	-	Zhongyu	EC 2839	2014-1-12	2016-1-11
High Pass Filter	WHKX 1.0/15G-10SS	Wainwright	EC4297-1	2014-2-1	2015-1-31
High Pass Filter	WHKX 2.8/18G-12SS	Wainwright	EC4297-2	2014-2-1	2015-1-31
High Pass Filter	WHKX 7.0/1.8G-8SS	Wainwright	EC4297-3	2014-2-1	2015-1-31
Band Reject Filter	WRCGV 2400/2483-2390/2493-35/10SS	Wainwright	EC4297-4	2014-2-1	2015-1-31

2.2 Test Standard

47CFR Part 15 (2013)
ANSI C63.4 (2009)
RSS-210 Issue 8 (December 2010)
RSS-Gen Issue 3 (December 2010)

2.3 Test Summary

This report applies to tested sample only. This report shall not be reproduced in part without written approval of Intertek Testing Service Shanghai.

TEST ITEM	FCC REFERANCE	FCC REFERANCE	RESULT
Minimum 6dB Bandwidth	15.247(a)(2)	RSS-210 Issue 8 Annex 8	Pass
Maximum peak output power	15.247(b)	RSS-210 Issue 8 Annex 8	Pass
Power spectrum density	15.247(e)	RSS-210 Issue 8 Annex 8	Pass
Radiated emission	15.205 & 15.209	RSS-210 Issue 8 Clause 2	Pass
Emission outside the frequency band	15.247(d)	RSS-210 Issue 8 Annex 8	Pass
Power line conducted emission	15.207	RSS-Gen Issue 3 Clause 7.2.4	Pass
Occupied bandwidth	-	RSS-Gen Issue 3 Clause 4.6.1	Tested

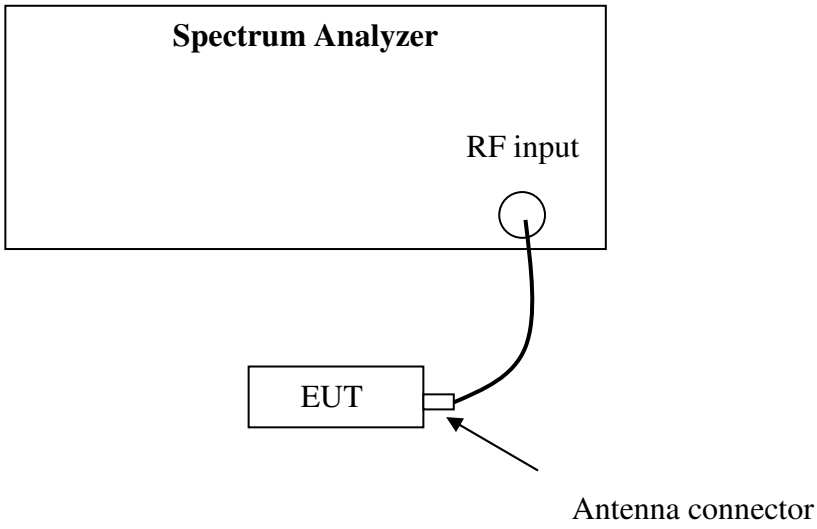
3. Minimum 6dB Bandwidth

Test result: PASS

3.1 Limit

For systems using digital modulation techniques that may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz bands, the minimum 6 dB bandwidth shall be at least 500 kHz.

3.2 Test Configuration



3.3 Test Procedure and test setup

The minimum 6dB bandwidth per FCC §15.247(a)(2) is measured using the Spectrum Analyzer according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r01" for compliance to FCC 47CFR 15.247 requirements.

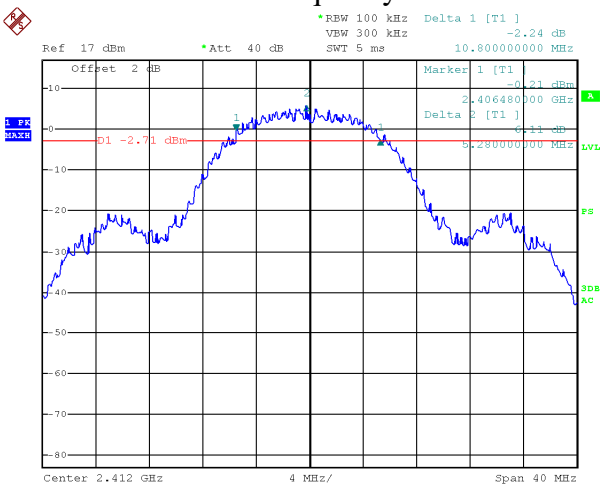
3.4 Test Protocol

Temperature : 25°C

Relative Humidity : 55%

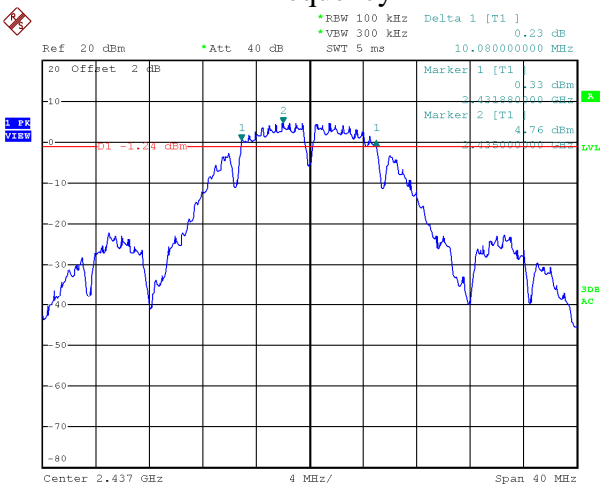
Mode	CH	Bandwidth (MHz)	Limit (MHz)
802.11b	L	10.80	≥0.5
	M	10.08	
	H	10.08	

Frequency L



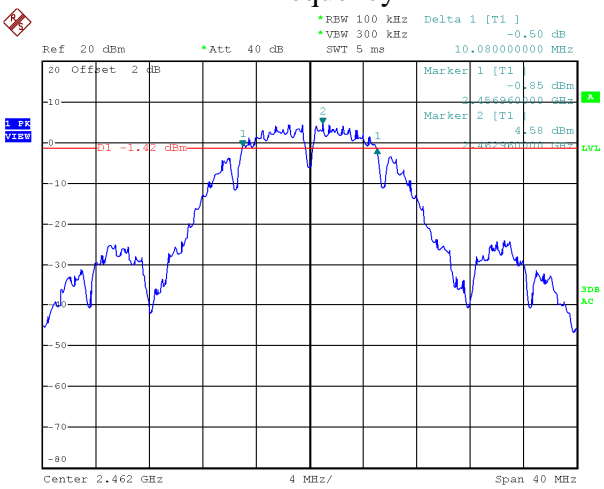
Date: 24.JAN.2014 16:09:46

Frequency M



Date: 4.NOV.2014 14:14:46

Frequency H



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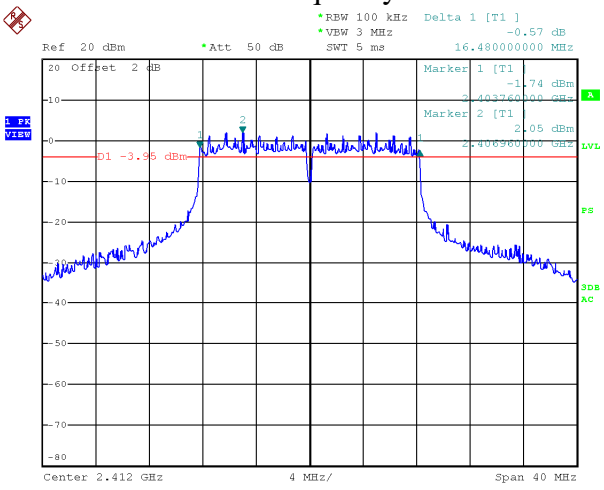
Mode	CH	Bandwidth (MHz)	Limit (MHz)
802.11g	L	16.48	≥0.5
	M	16.36	
	H	16.36	

Frequency L



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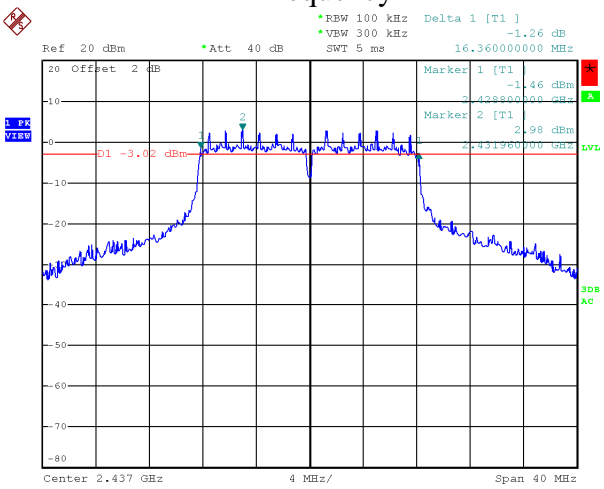
Frequency M



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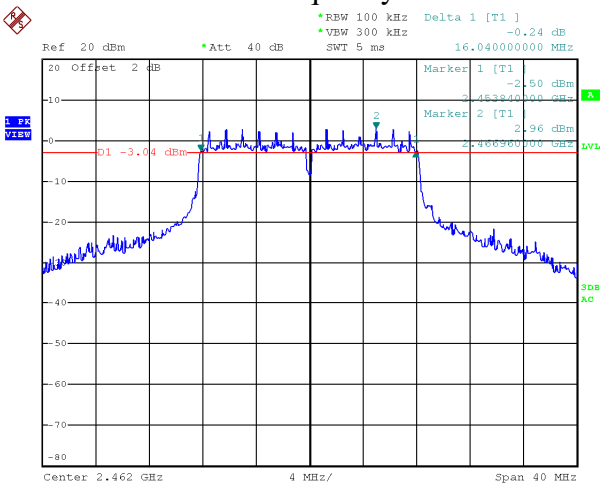
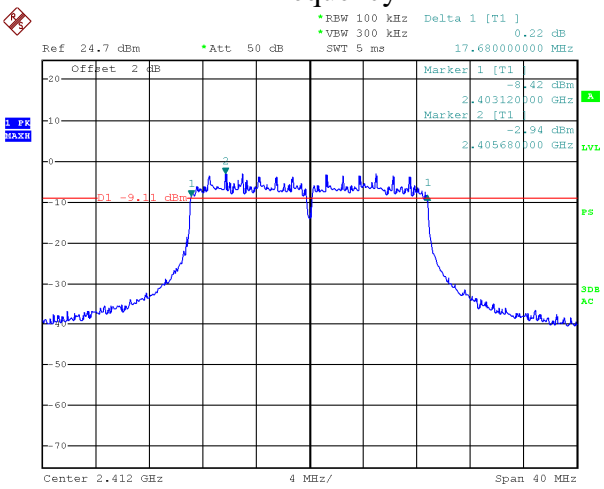
Frequency H



Date: 4.NOV.2014 14:43:55

Mode	CH	Bandwidth (MHz)	Limit (MHz)
802.11n(HT20)	L	17.68	≥0.5
	M	17.40	
	H	17.64	

Frequency L



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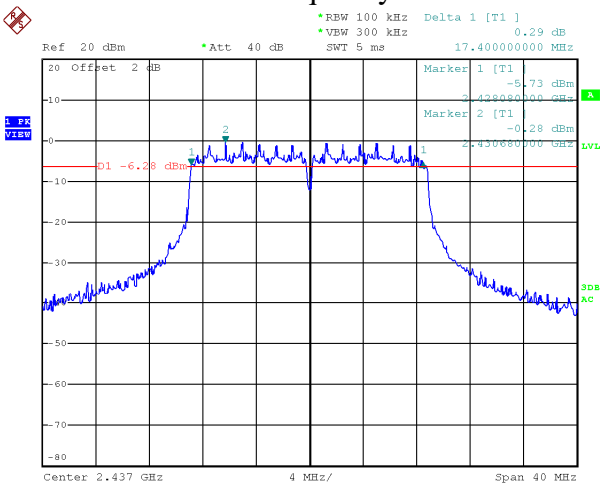
Frequency M



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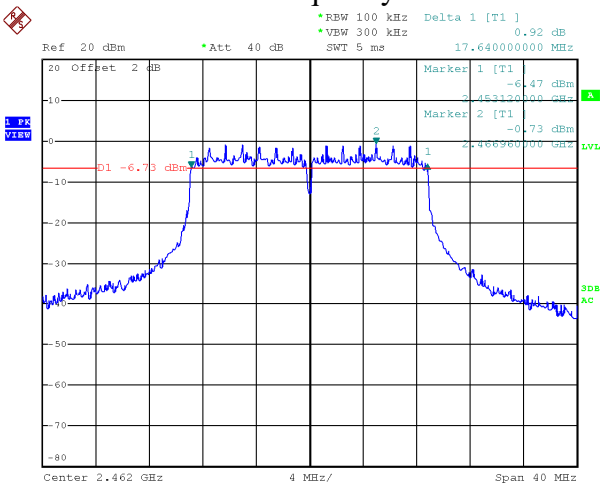
Frequency H



Date: 4.NOV.2014 14:39:23

4. Maximum peak output power

Test result: Pass

4.1 Test limit

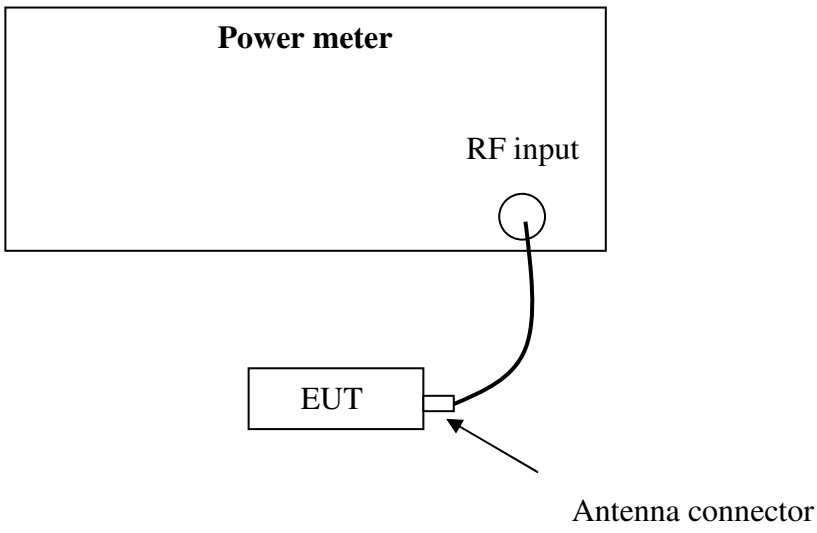
☐ For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt

☐ For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts

☒ For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

If the transmitting antenna of directional gain greater than 6dBi is used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

4.2 Test Configuration



4.3 Test procedure and test setup

The EUT was tested according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r01" for compliance to FCC 47CFR 15.247 requirements (clause 9.1.2).

4.4 Test protocol

Temperature : 25 ℃

Relative Humidity : 55 %

Mode	Freq. (MHz)	Reading (dBm)	Limit (dBm)	Margin (dB)
802.11b	2412	16.97	30.00	13.03
	2437	16.46	30.00	13.54
	2462	16.54	30.00	13.46
802.11g	2412	19.51	30.00	10.49
	2437	19.55	30.00	10.45
	2462	19.33	30.00	10.67
802.11n(HT20)	2412	17.51	30.00	12.49
	2437	17.20	30.00	12.80
	2462	17.60	30.00	12.40

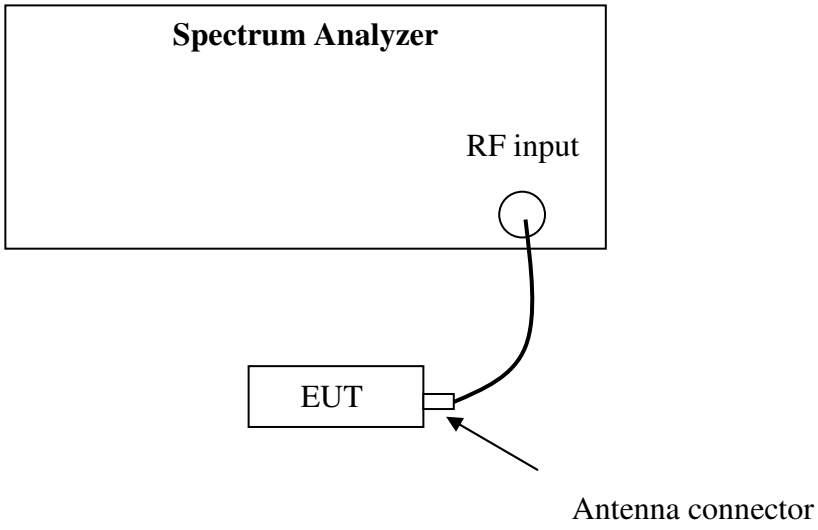
5. Power spectrum density

Test result: **Pass**

5.1 Test limit

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

5.2 Test Configuration



5.3 Test procedure and test setup

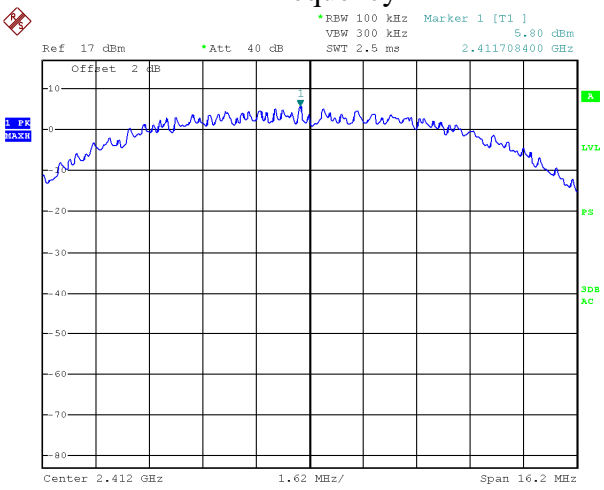
The power output per FCC §15.247(e) was tested according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r01" (clause 10.2) for compliance to FCC 47CFR 15.247 requirements.

5.4 Test Protocol

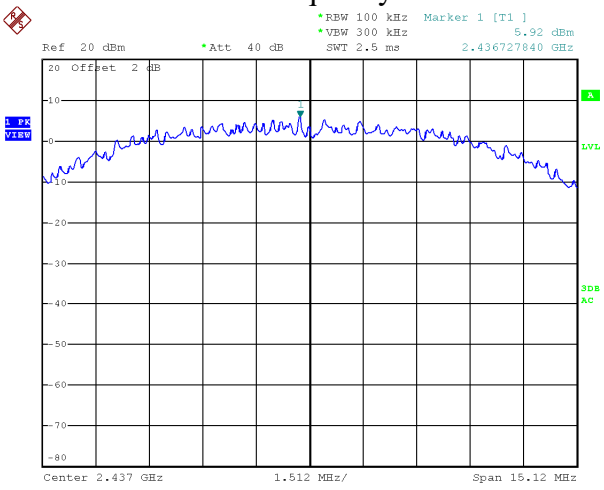
Temperature : 25 ℃
Relative Humidity: 55 %

Mode	CH	Cable loss (dB)	PSD (dBm/100kHz)	Limit (dBm/3kHz)
802.11b	L	2.00	5.80	≤8.00
	M	2.00	5.92	
	H	2.00	5.94	

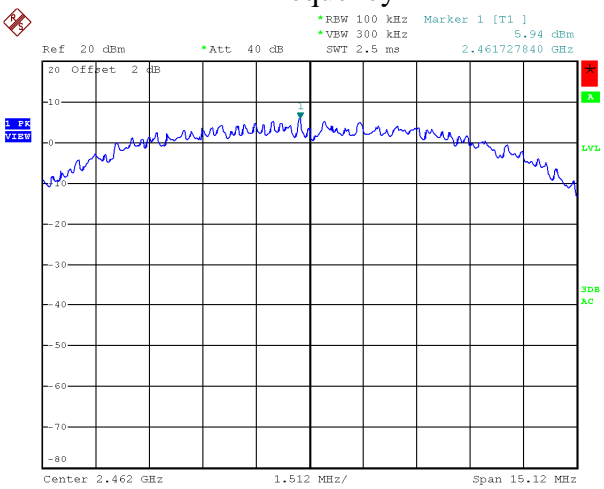
Frequency L



Frequency M



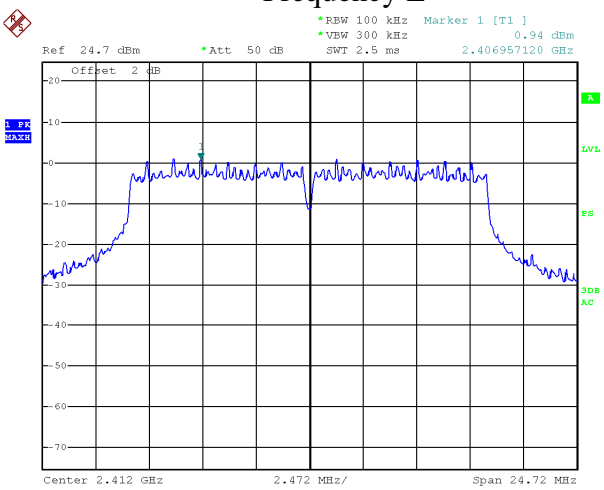
Frequency H



Date: 4.NOV.2014 14:52:43

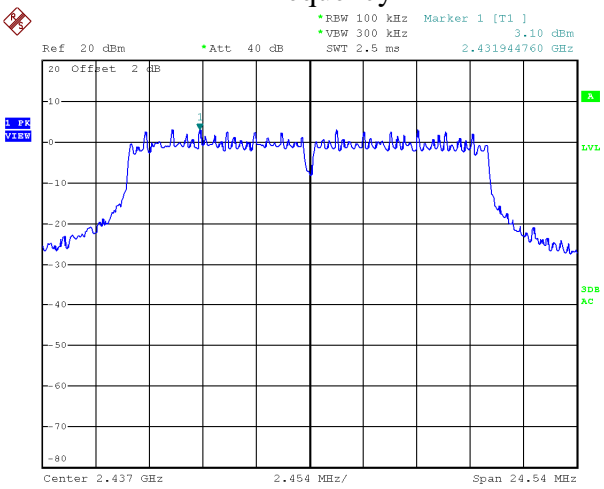
Mode	CH	Cable loss (dB)	PSD (dBm/100kHz)	Limit (dBm/3kHz)
802.11g	L	2.00	0.94	≤8.00
	M	2.00	3.10	
	H	2.00	2.59	

Frequency L



Date: 28.JAN.2014 10:27:54

Frequency M



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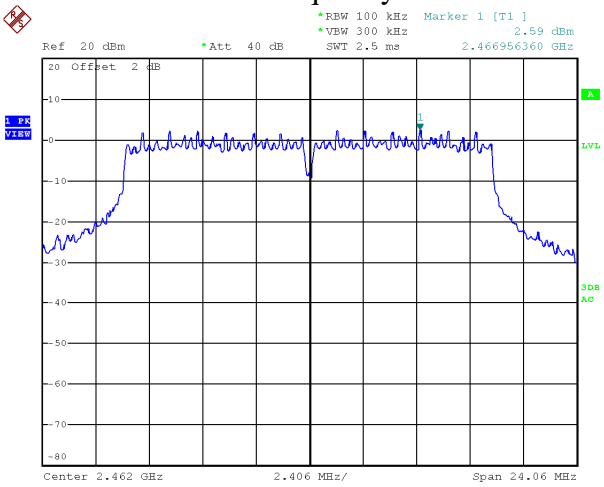
Frequency H



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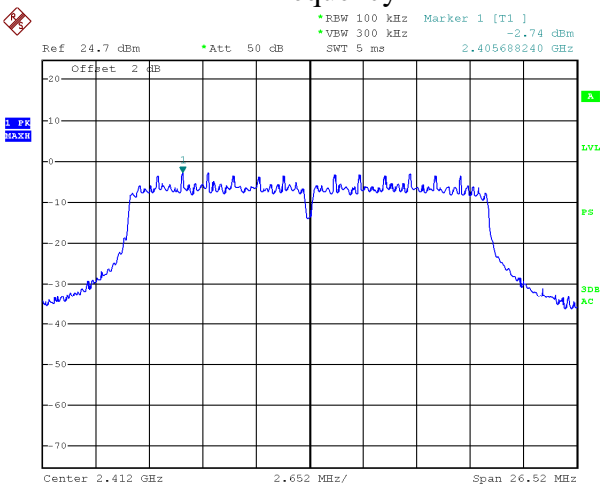
Mode	CH	Cable loss (dB)	PSD (dBm/100kHz)	Limit (dBm/3kHz)
802.11n (HT20)	L	2.00	-2.74	≤8.00
	M	2.00	-0.40	
	H	2.00	-0.34	

Frequency L



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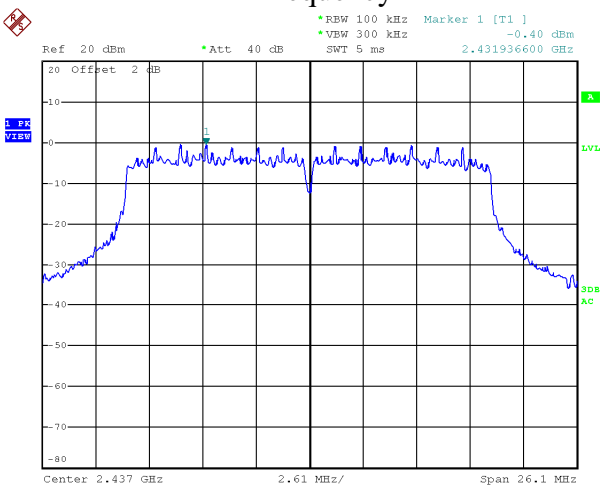
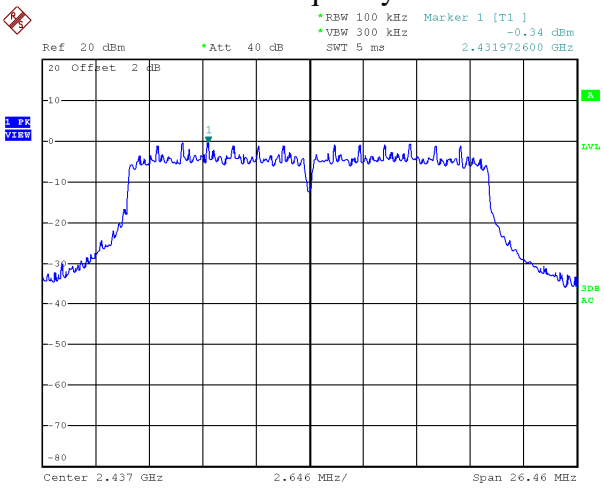
Frequency M



Date: 4.NOV.2014 14:58:15

Frequency H



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6. Radiated emission

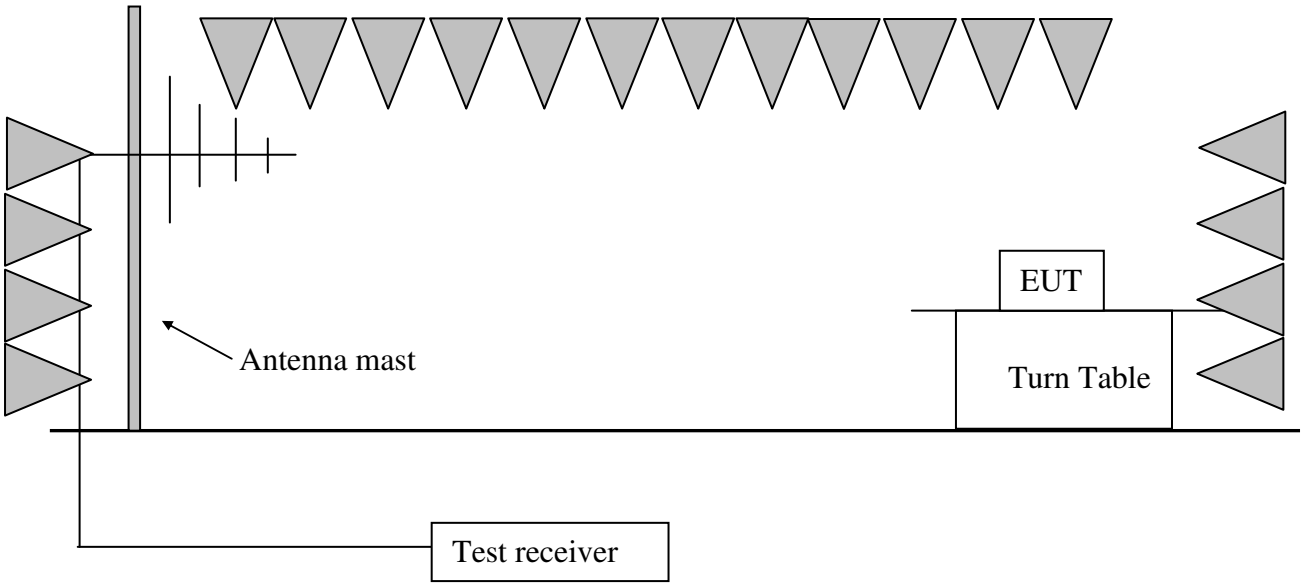
Test result: PASS

6.1 Test limit

The radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) showed as below:

Frequency (MHz)	Field Strength (dBuV/m)	Measurement Distance (m)
30 - 88	40.0	3
88 - 216	43.5	3
216 - 960	46.0	3
Above 960	54.0	3

6.2 Test Configuration



6.3 Test procedure and test setup

The measurement was applied in a semi-anechoic chamber. While testing for spurious emission higher than 1GHz, if applied, the pre-amplifier would be equipped just at the output terminal of the antenna.
The EUT and simulators were placed on a 0.8m high wooden turntable above the horizontal metal ground plane. The turn table rotated 360 degrees to determine the position of the maximum emission level. The EUT was set 3 meters away from the receiving antenna which was mounted on an antenna mast. The antenna moved up and down between from 1meter to 4 meters to find out the maximum emission level.
The EUT was tested according to DTS test procedure of KDB558074 D01 DTS “Meas Guidance v03r01” (clause 12.1) for compliance to FCC 47CFR 15.247 requirements.

6.4 Test protocol

Temperature : 18 °C
Relative Humidity : 54 %

Mode 802.11b

CH	Polarization	Frequency (MHz)	Factor	Measure Level (dBuV/m)	Limit (dBuV/m)	Over Limit (dB)	Type
L	H	2412.0	28.5	99.8	Fundamental	/	PK
	H	168.0	13.1	37.3	43.5	-6.2	QP
	H	2719.4	29.2	57.9	74.0	-16.1	PK
	H	2719.4	29.2	46.5	54.0	-7.5	AV
	H	4824.0	-3.6	61.5	74.0	-12.5	PK
	H	4824.0	-3.6	44.1	54.0	-9.9	AV
	H	7238.5	2.2	53.8	54.0	-0.2	PK
M	H	2437.0	28.6	99.5	Fundamental	/	PK
	H	4874.0	-3.5	58.3	74.0	-15.7	PK
	H	4874.0	-3.5	43.0	54.0	-11.0	AV
H	V	2462.0	28.6	102.0	Fundamental	/	PK
	H	168.0	13.1	37.0	43.5	-6.5	QP
	V	2819.7	29.5	57.7	74.0	-16.3	PK
	V	2839.7	29.5	45.5	54.0	-8.5	AV
	H	7386.0	2.7	64.1	74.0	-9.9	PK
	H	7386.0	2.7	50.5	54.0	-3.5	AV

Mode 802.11g

CH	Polarization	Frequency (MHz)	Factor	Measure Level (dBuV/m)	Limit (dBuV/m)	Over Limit (dB)	Type
L	V	2412.0	28.5	90.9	Fundamental	/	PK
	V	2400.0	29.1	52.7	54.0	-1.3	AV
	H	168.0	13.1	37.3	43.5	-6.2	QP
	H	2070.1	27.7	58.6	74.0	-15.4	PK
	H	2070.1	27.7	47.1	54.0	-6.9	AV
	H	4824.0	-3.6	65.4	74.0	-8.6	PK
	H	4824.0	-3.6	49.3	54.0	-4.7	AV
M	V	2437.0	28.6	95.1	Fundamental	/	PK
	H	4874.0	-3.5	60.7	74.0	-13.3	PK
	H	4874.0	-3.5	46.3	54.0	-7.7	AV
H	V	2462.0	28.6	94.2	Fundamental	/	PK
	H	168.0	13.1	37.0	43.5	-6.5	QP
	V	4944.0	-3.3	60.6	74.0	-13.4	PK
	V	4944.0	-3.3	49.3	54.0	-4.7	AV
	V	7386.0	2.7	67.3	74.0	-6.7	PK
	V	7386.0	2.7	51.4	54.0	-2.6	AV

Mode 802.11n(HT20)

CH	Polarization	Frequency (MHz)	Factor	Measure Level (dBuV/m)	Limit (dBuV/m)	Over Limit (dB)	Type
L	V	2412.0	28.5	97.4	Fundamental	/	PK
	H	168.02	13.1	37.3	43.5	-6.2	QP
	H	2086.2	27.7	57.6	74.0	-16.4	PK
	H	2086.2	27.7	47.1	54.0	-6.9	AV
	H	4824.0	-3.6	66.7	74.0	-7.3	PK
	H	4824.0	-3.6	51.7	54.0	-2.3	AV
M	V	2437.0	28.6	97.9	Fundamental	/	PK
	H	4874.0	-3.5	65.6	74.0	-8.4	PK
	H	4874.0	-3.5	52.0	54.0	-2.0	AV
H	V	2462.0	28.6	100.0	Fundamental	/	PK
	H	168.02	13.1	37.0	43.5	-6.5	QP
	V	2483.5	28.7	52.5	54.0	-1.5	AV
	H	4924.0	-3.3	63.0	74.0	-11.0	PK
	H	4924.0	-3.3	47.2	54.0	-6.8	AV
	H	7386.0	2.7	54.8	74.0	-19.2	PK
	H	7386.0	2.7	36.2	54.0	-17.8	AV

Remark: 1. Factor = Antenna Factor + Cable Loss (-Amplifier, is employed)
2. Measure level = Original Receiver Reading Level+ Correct Factor
3. Over Limit = Measure level - limit
4. If the PK reading is lower than AV limit, the AV test can be elided.

Example: Assuming Antenna Factor = 30.20dB/m, Cable Loss = 2.00dB,
Gain of Preamplifier = 32.00dB, Original Receiver Reading level = 10dBuV.
Then Factor = 30.20 + 2.00 – 32.00 = 0.20dB/m; Measure level = 10dBuV + 0.20dB/m = 10.20dBuV/m
Assuming limit = 54dBuV/m, Measure level = 10.20dBuV/m, then Over Limit = 10.20 - 54= -43.80dBuV/m

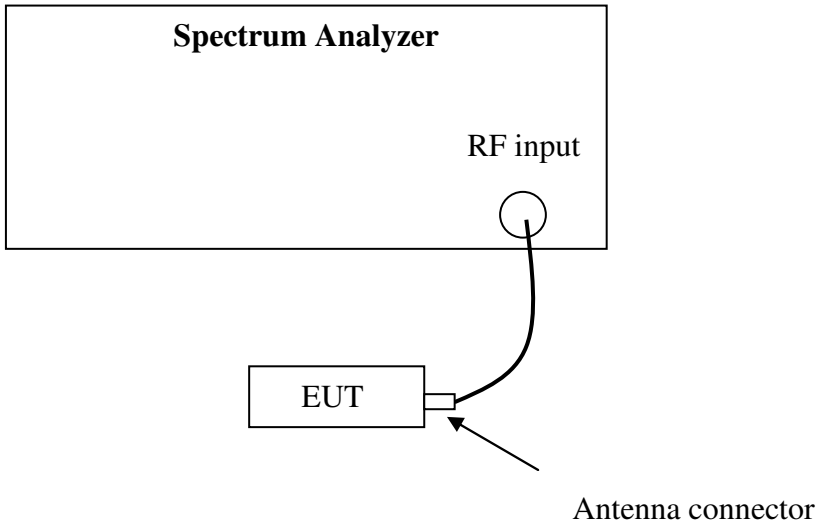
7. Emission outside the frequency Band

Test result: **PASS**

7.1 Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator 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.

7.2 Test Configuration



7.3 Test procedure and test setup

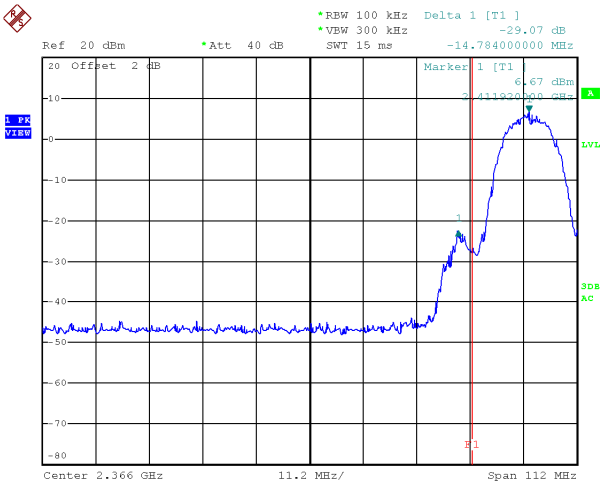
The Emission outside the frequency Band per FCC §15.247(d) is measured using the Spectrum Analyzer with the resolutions bandwidth set at 100kHz, the video bandwidth set at 300kHz, and the SPAN>>RBW.
The EUT was tested according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r01" (clause 11.0) for compliance to FCC 47CFR 15.247 requirements.

7.4 Test protocol

Mode	CH	Max reading among band (dBm)	The most restrict Attenuation outside band (dB)	Limit (dB)
802.11b	L	6.67	29.07	≥20
	M	-35.15	40.48	
	H	6.33	50.99	

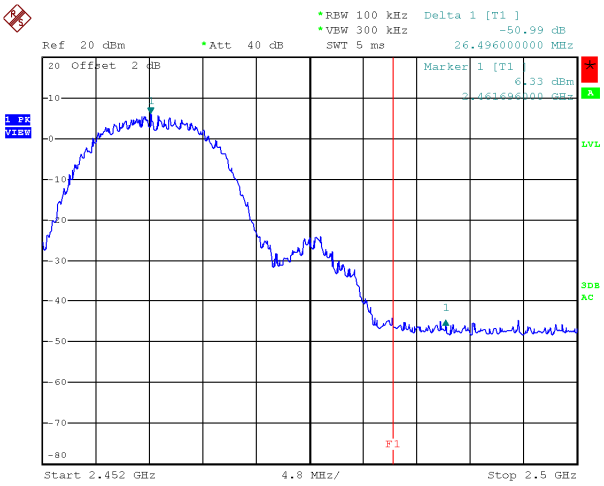
Note: The test was performed from 9kHz to 26GHz and the graph of band edge emission is listed below.

Low Band Edge - Frequency L



Date: 4.NOV.2014 15:09:16

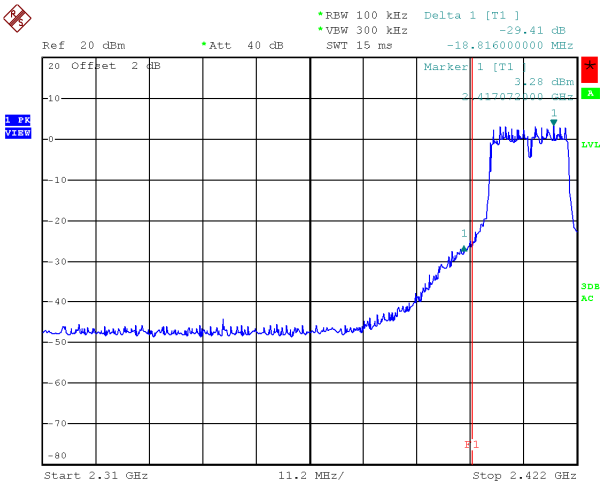
High Band Edge - Frequency H



Date: 4.NOV.2014 15:13:19

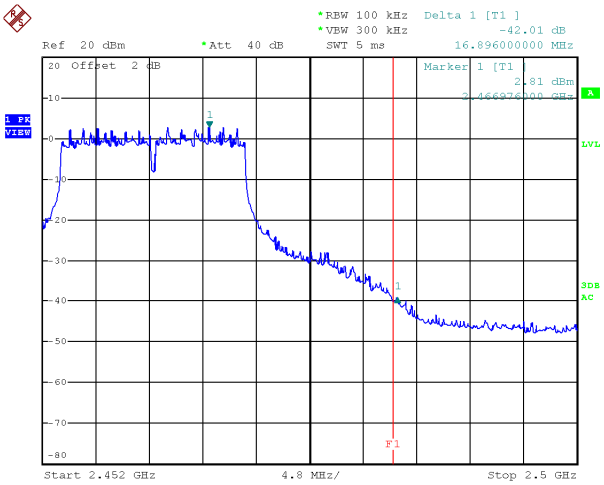
Mode	CH	Max reading among band (dBm)	The most restrict Attenuation outside band (dB)	Limit (dB)
802.11g	L	3.28	29.41	≥20
	M	-38.78	40.21	
	H	2.81	42.01	

Low Band Edge - Frequency L



Date: 4.NOV.2014 15:16:24

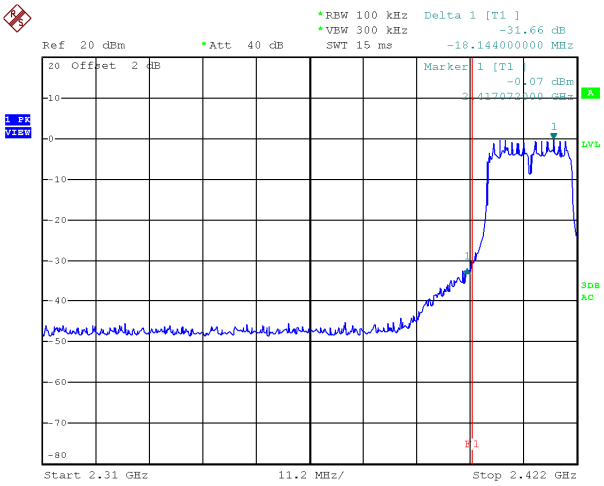
High Band Edge - Frequency H



Date: 4.NOV.2014 15:14:43

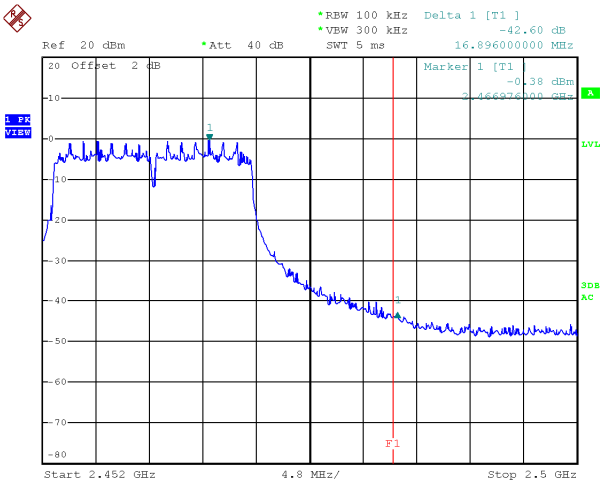
Mode	CH	Max reading among band (dBm)	The most restrict Attenuation outside band (dB)	Limit (dB)
802.11n (HT20)	L	-0.07	31.66	≥20
	M	-44.51	43.58	
	H	-0.38	42.60	

Low Band Edge - Frequency L



Date: 4.NOV.2014 15:17:30

High Band Edge - Frequency H



Date: 4.NOV.2014 15:19:22

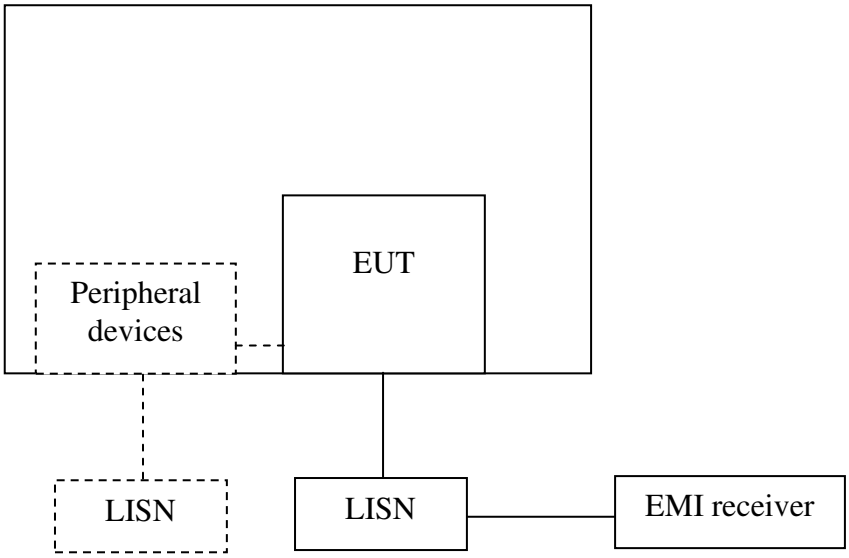
8. Power line conducted emission

Test result: **NA**

8.1 Limit

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	QP	AV
0.15-0.5	66 to 56*	56 to 46 *
0.5-5	56	46
5-30	60	50
* Decreases with the logarithm of the frequency.		

8.2 Test configuration



☒ For table top equipment, wooden support is 0.8m height table

☐ For floor standing equipment, wooden support is 0.1m height rack.

8.3 Test procedure and test set up

The EUT are connected to the main power through a line impedance stabilization network (LISN). This provides a 50Ω/50uH coupling impedance for the measuring equipment. The peripheral devices are also connected to the main power through a LISN that provides a 50Ω/50uH coupling impedance with 50Ω termination.
Both sides (Line and Neutral) of AC line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.4 on conducted measurement.
The bandwidth of the test receiver is set at 9 kHz.

8.4 Test protocol

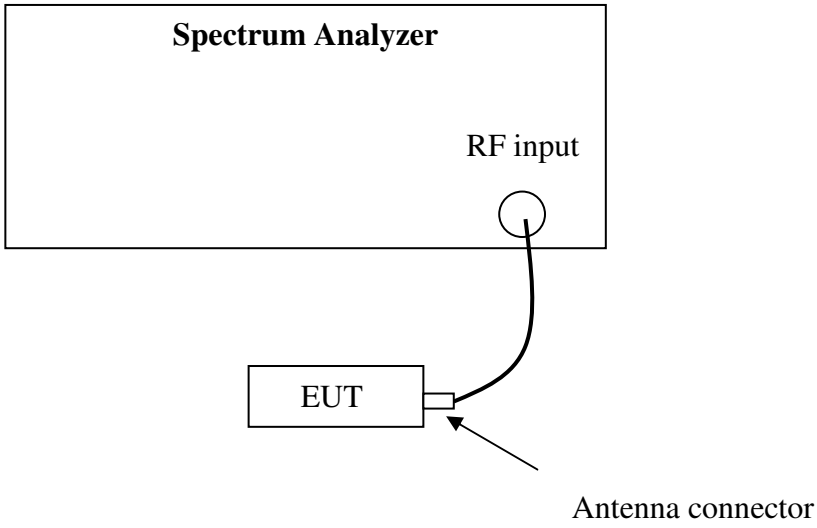
9. Occupied Bandwidth

Test Status: Tested

9.1 Test limit

None

9.2 Test Configuration



9.3 Test procedure and test setup

The occupied bandwidth per RSS-Gen Issue 3 Clause 4.6.1 was measured using the Spectrum Analyzer.

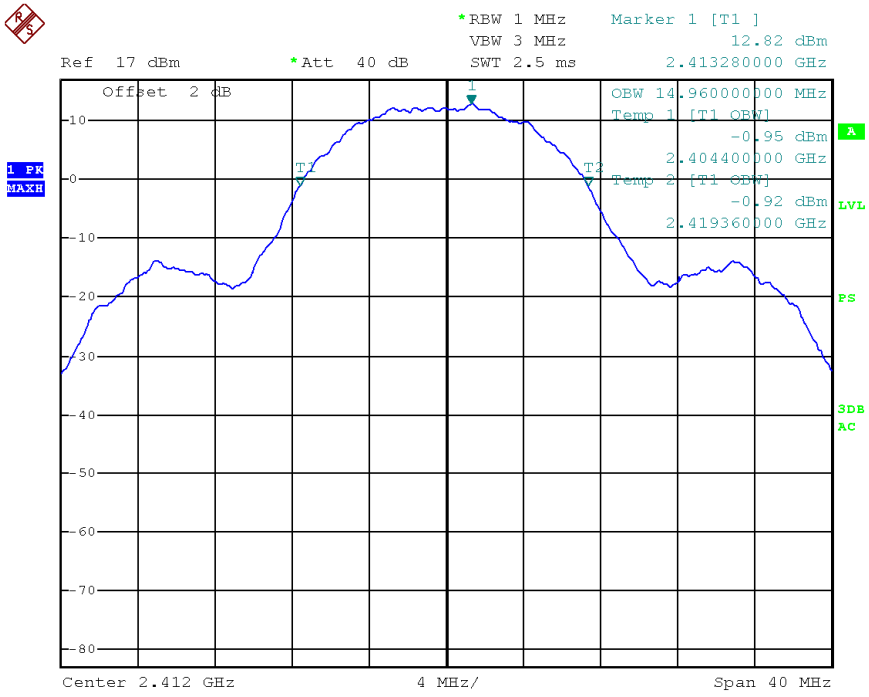
9.4 Test protocol

Temperature : 25 °C

Relative Humidity : 55 %

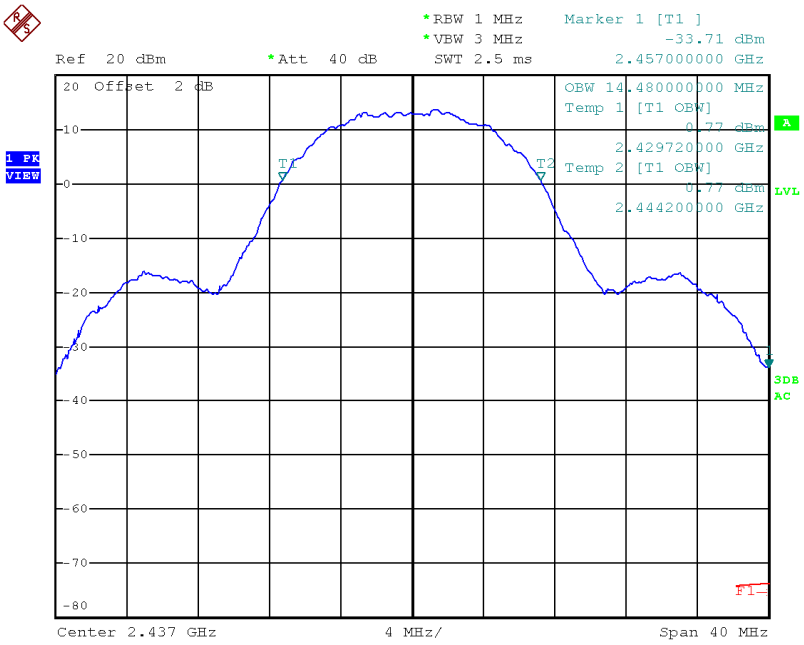
Mode	CH	99% Bandwidth (MHz)
802.11b	L	14.96
	M	14.48
	H	14.48

Channel L



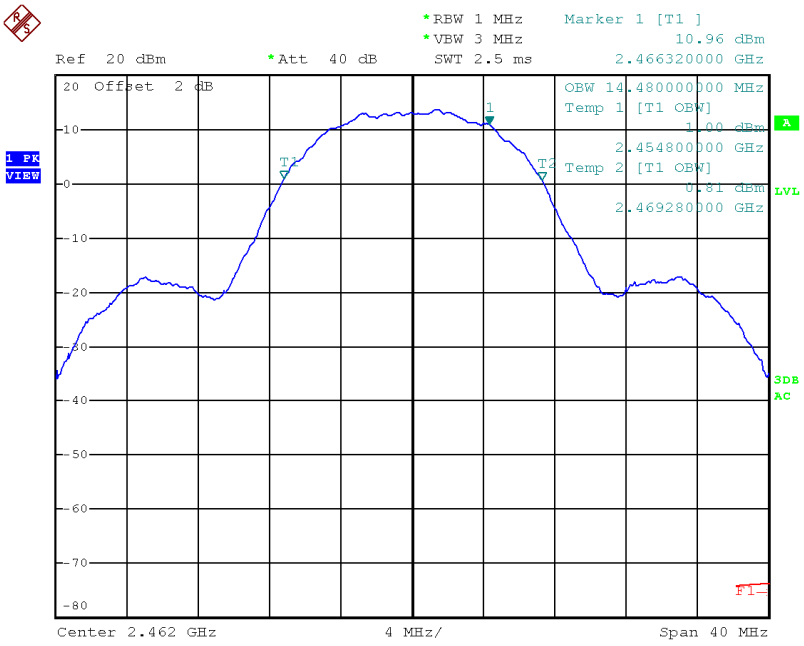
Date: 24.JAN.2014 16:17:10

Channel M



Date: 4.NOV.2014 15:24:44

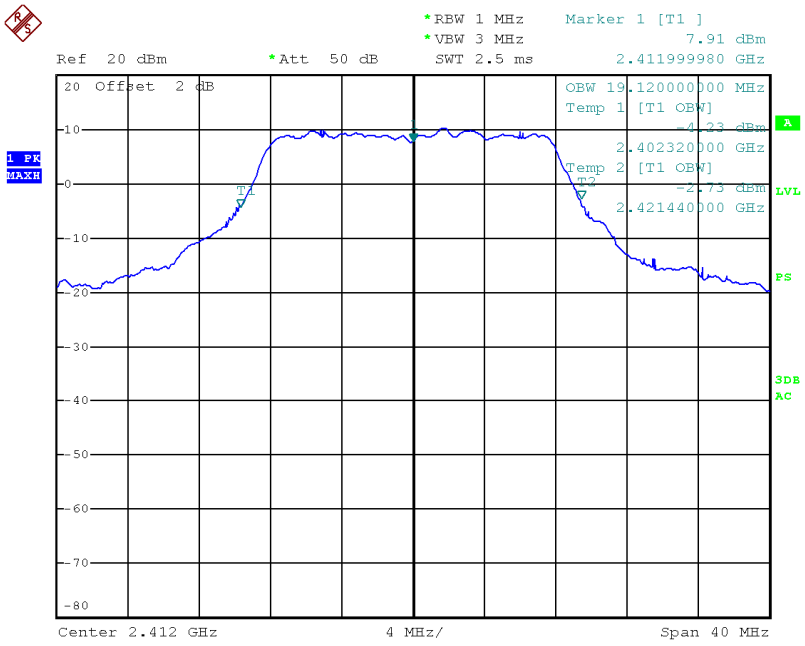
Channel H



Date: 4.NOV.2014 15:24:02

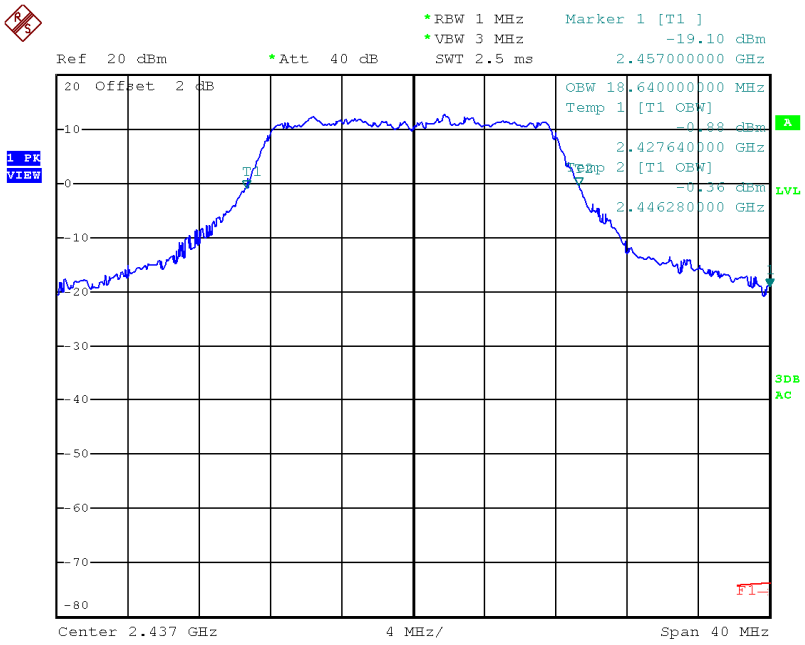
Mode	CH	99% Bandwidth (MHz)
802.11g	L	19.12
	M	18.72
	H	18.48

Channel L



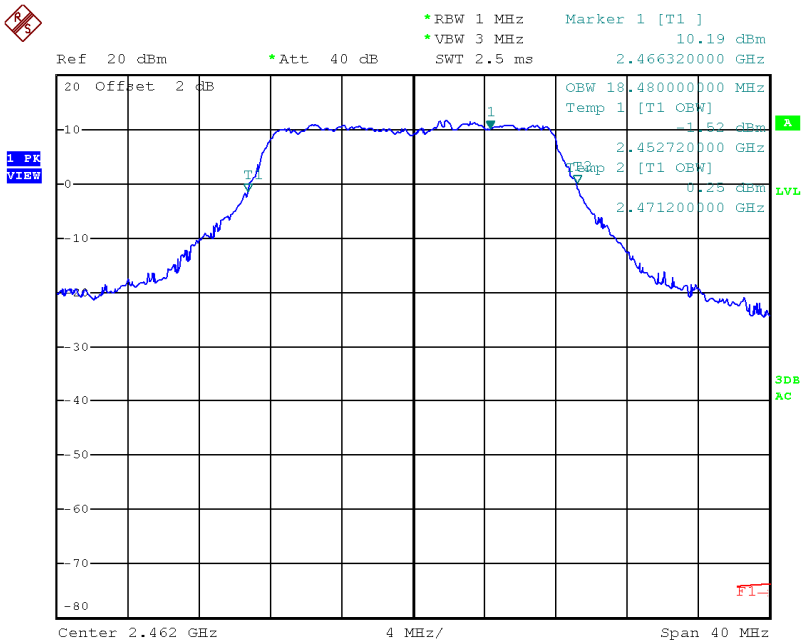
Date: 28.JAN.2014 10:15:15

Channel M



Date: 4.NOV.2014 15:25:26

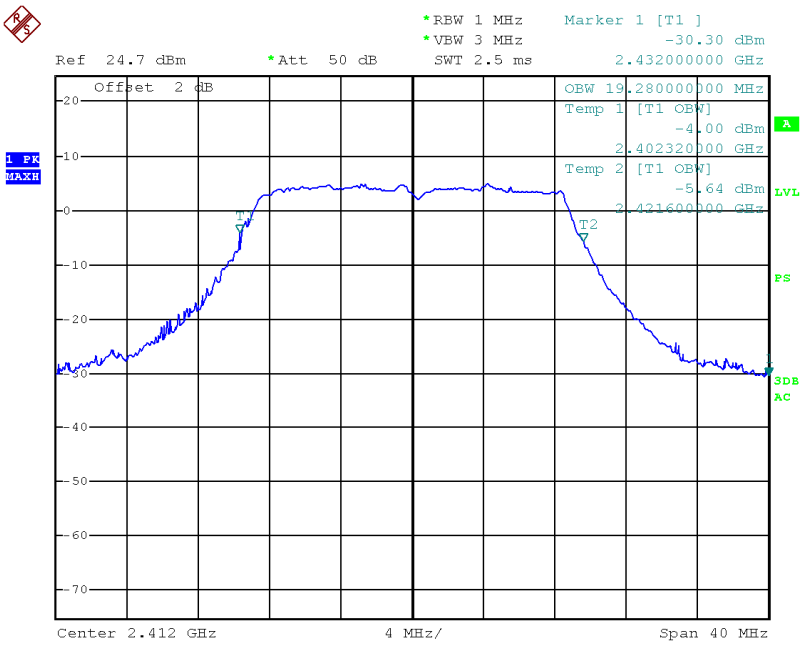
Channel H



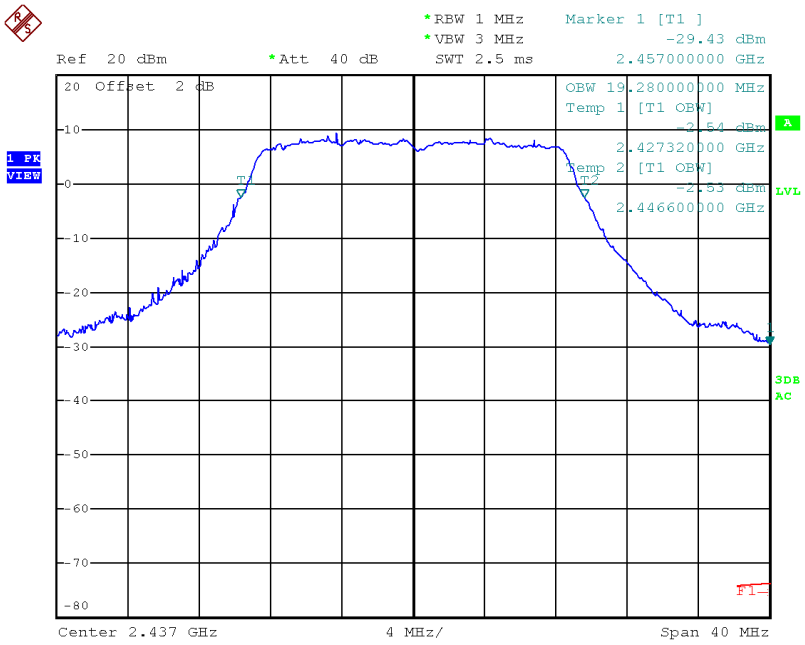
Date: 4.NOV.2014 15:23:10

Mode	CH	99% Bandwidth (MHz)
802.11n (HT20)	L	19.28
	M	19.28
	H	19.28

Channel L

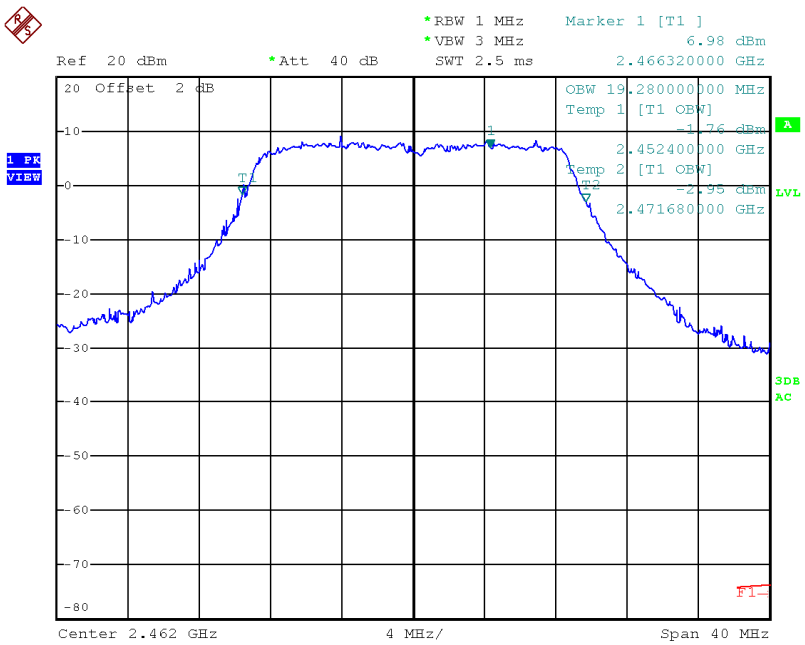


Channel M



Date: 4.NOV.2014 15:26:09

Channel H



Date: 4.NOV.2014 15:22:13