

Prüfbericht-Nr.: Test Report No.:	50058587 001	Auftrags-Nr.: Order No.:	114054306	Seite 1 von 57 Page 1 of 57
Kunden-Referenz-Nr.: Client Reference No.:	N/A	Auftragsdatum: Order date:	25-Jul-2016	
Auftraggeber: Client:	Lenovo (Beijing) Limited, No.6 Chuang Ye Road, Shangdi Information Industry Base, Haidian District, Beijing, China 100085			
Prüfgegenstand: Test item:	ThinkPad Stack Mobile Projector			
Bezeichnung / Typ-Nr.: Identification / Type No.:	M123			
Auftrags-Inhalt: Order content:	FCC Part 15C / IC RSS-247 Test report (WiFi 2.4GHz)			
Prüfgrundlage: Test specification:	FCC 47CFR Part 15: Subpart C Section 15.247 RSS-247 (05-2015)			
Wareneingangsdatum: Date of receipt:	9-Aug-2016			
Prüfmuster-Nr.: Test sample No.:	A00040610-002			
Prüfzeitraum: Testing period:	22-Aug-2016 - 19-Oct-2016			
Ort der Prüfung: Place of testing:	EMC Laboratory Taipei			
Prüflaboratorium: Testing laboratory:	TUV Rheinland Taiwan Ltd.			
Prüfergebnis*: Test result*:	Pass			
geprüft von / tested by:		kontrolliert von / reviewed by:		
2016-11-01 Amy S.R.Hsu /Engineer		2016-11-01 Rene Charton/Senior Project Manager		
Datum Date	Name / Stellung Name / Position	Unterschrift Signature	Datum Date	Name / Stellung Name / Position
				Unterschrift Signature
Sonstiges / Other:				
Zustand des Prüfgegenstandes bei Anlieferung: Condition of the test item at delivery:		Prüfmuster vollständig und unbeschädigt Test item complete and undamaged		
* Legende:	1 = sehr gut P(ass) = entspricht o.g. Prüfgrundlage(n)	2 = gut F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	3 = befriedigend N/A = nicht anwendbar	4 = ausreichend N/T = nicht getestet
Legend:	1 = very good P(ass) = passed a.m. test specification(s)	2 = good F(ail) = failed a.m. test specification(s)	3 = satisfactory N/A = not applicable	4 = sufficient N/T = not tested
Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.				

TEST SUMMARY

5.1.1 ANTENNA REQUIREMENT

RESULT: *Passed*

5.1.2 PEAK OUTPUT POWER

RESULT: *Passed*

5.1.3 6dB BANDWIDTH AND 99% BANDWIDTH

RESULT: *Passed*

5.1.4 POWER DENSITY

RESULT: *Passed*

5.1.5 CONDUCTED SPURIOUS EMISSIONS AND FREQUENCY BAND EDGE MEASURED IN 100KHZ BANDWIDTH

RESULT: *Passed*

5.1.6 SPURIOUS EMISSION

RESULT: *Passed*

5.2.1 MAINS CONDUCTED EMISSIONS

RESULT: *Passed*

6.1.1 ELECTROMAGNETIC FIELDS

RESULT: *Passed*

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1. General Remarks

1.1 Complementary Materials

The following attachments are integral parts of this test report:

Appendix P: Photo Documentation
(File Name: 50058587APPENDIX P)

Appendix D: Test Result of Radiated Emissions
(File Name: 50058587APPENDIX D)

Test Specifications

The following standards were applied (in bold: product standards, otherwise: basic standards).

Table 1: Applied Standard and Test Levels

Radio
FCC CFR47 Part 15: Subpart C Section 15.247 RSS-247 Issue 1 May 2015 RSS-Gen, Issue 4, November 2014 ANSI C63.10:2013 KDB558074 D01 DTS Meas Guidance v03r05

2. Test Sites

2.1 Test Laboratory

TUV Rheinland Taiwan Ltd.
Taichung Branch Office

No.9, Lane 36, Minsheng Rd., Sec. 3, Daya District,
Taichung City 428
Taiwan (R.O.C.)

2.2 Test Facilities

TUV Rheinland Taiwan Ltd.
Taipei Office

11F. No.758, Sec. 4, Bade Rd., Songshan Dist.
Taipei City 105
Taiwan (R.O.C.)

FCC RegistrationNo.: 365730
IC Canada Registration No.: 9465A-1
TAF Accredited NCC Test Lab. No.:0759
TAF ISO17025 Certification effective periods: 2016-Jul-1st to 2019-Jun-30th



Testing Laboratory
0759

2.3 List of Test and Measurement Instruments

Table 2: List of Test and Measurement Equipment

Kind of Equipment	Manu-facturer	Type	S/N	Last Calibration	Next Calibration
Test Software	Farad	EZ_EMCC	Ver. TUV3A1	N/A	N/A
EMI Test Receiver	R&S	ESR7	101062	2016/09/12	2017/09/12
Spectrum Analyzer	R&S	FSV 40	100921	2016/04/21	2017/04/21
Spectrum Analyzer	Agilent	N9010A	MY53470241	2016/04/25	2017/04/24
Preamplifier (30MHz -1GHz)	HP	8447F	2805A03335	2016/07/29	2017/07/29
Preamplifier (18 GHz -40 GHz)	COM-POWER	PAM-840	461257	2015/11/19	2016/11/19
Pre-Amplifier (1GHz~18GHz)	EM Electronics	EM01G18G	060558	2015/11/19	2016/11/19
Bilog Antenna	TESEQ	CBL6111D	29804	2016/06/23	2017/06/23
Horn Antenna	ETS-Lindgren	3117	138160	2016/05/03	2017/05/03
Horn Antenna (18GHz~40GHz)	COM-POWER	AH840	101031	2015/11/02	2016/11/02
EMI Test Receiver	R&S	ESCI7	100797	2015/12/28	2016/12/27
Temp. & Humid. Chamber	Giant Force	GCT-099-40-S	MAF0103-007	2015/07/13	2017/07/12
LISN (1 phase)	R&S	ENV216	101243	2016/06/02	2017/06/02
LISN	R&S	ENV216	101262	2016/06/16	2017/06/16
Test Software	Audix	e3	Ver. 9	N/A	N/A
Test Software	Agilent	300328 testsystem	V1.9.1	N/A	N/A
Power sensor	Agilent	U2021XA	MY53480013	2016/03/11	2017/03/10

2.4 Traceability

All measurement equipment calibrations are traceable to NML(Taiwan)/NIST(USA) or where calibration is performed outside Taiwan, to equivalent nationally recognized standards organizations.

2.5 Calibration

Equipment requiring calibration is calibrated periodically by the manufacturer or according to manufacturer's specifications. Additionally all equipment is verified for proper performance on a regular basis using in house standards or comparisons.

2.6 Measurement Uncertainty

The estimated combined standard uncertainty for radiated emissions and conducted emissions measurements are $\pm 3\text{dB}$.

Table 3: Emission Measurement Uncertainty

Parameter	Uncertainty
RF power, conducted	$\pm 1.5 \text{ dB}$
Adjacent channel power	$\pm 3 \text{ dB}$
Radiated emission of transmitter, valid up to 26 GHz	$\pm 6 \text{ dB}$
Radiated emission of receiver, valid up to 26 GHz	$\pm 6 \text{ dB}$
Temperature	$\pm 2 \text{ }^\circ\text{C}$
Humidity	$\pm 10 \text{ \%}$

3. General Product Information

3.1 Product Function and Intended Use

The EUT is a Mobile Projector. It contains a WiFi and Bluetooth compatible module enabling the user to communicate data through a Wireless interface.
 For details refer to the User Guide, Data Sheet and Circuit Diagram.

3.2 System Details and Ratings

Table 4: Basic Information of EUT

Item	EUT information
Kind of Equipment	ThinkPad Stack Mobile Projector
Type Designation	M123
FCC ID	A5MM123
Canada ID	5903G-M123
Canada HVIN	M123

Table 5: Technical Specification of EUT

Technical Specification	Value
Operating Frequencies	2412 MHz ~ 2462 MHz
Channel Spacing	5 MHz
Channel number	802.11b/g/n : 11 (2412 MHz ~ 2462 MHz)
Operation Voltage	Power Adapter: Input:100-240v 1.5A ; Output: 20V 3.25A
Modulation	802.11b: DSSS ; 802.11g/n: OFDM
Antenna gain	2.16 dBi max@2.400 GHz Main ANT 0.29 dBi max@2.400 GHz Aux ANT

3.3 Independent Operation Modes

Basic operation modes are:

- A. Transmitting
 - 1. Low channel
 - 2. Middle channel
 - 3. High channel
- B. Receiving
- C. Standby
- D. Off

3.4 Noise Generating and Noise Suppressing Parts

Refer to the Circuit Diagram.

3.5 Submitted Documents

- Bill of Material
- PCB Layout
- Photo Document
- Technical Description
- Circuit Diagram
- Instruction Manual
- Rating Label

4. Test Set-up and Operation Modes

4.1 Principle of Configuration Selection

The equipment under test (EUT) was configured to measure its maximum power level. The test modes were adapted accordingly in reference to the instructions for use.

4.2 Test Operation and Test Software

Setup for testing: Test samples are provided with a USB to RJ45 interface which makes it possible to control them through a test software installed on a notebook computer.

This software was running on the laptop computer connected to the EUT. It was used to enable the operation modes listed in section 3.3 as appropriate.

The samples were used as follows:

Conducted: A00040610-001

Radiation: A00040610-001

Full test was applied on all test modes, but only worst case was shown

Spe: TX1 stands for Main Antenna

TX2 stands for Aux Antenna

4.3 Additional Accessories and Auxiliary Equipment

The product has been tested together with the following additional accessories:

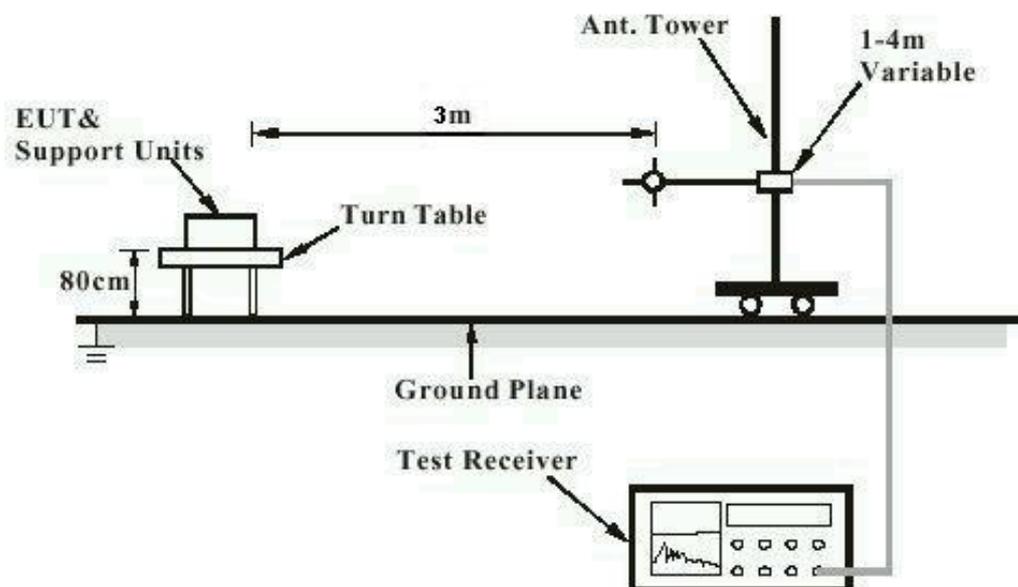
Description	Manufacturer	Model No.	Serial No.
Notebook(EMC-06)	Lenovo	TP00048A	PB-0F8B2

4.4 Countermeasures to achieve EMC Compliance

The test sample which has been tested contained the noise suppression parts as described in the Constructional Data Form or the Technical Construction File. No additional measures were employed to achieve compliance.

4.5 Test Setup Diagram

Diagram of Measurement Configuration for Radiation Test



Note: Measurements above 1 GHz are done with a table height of 1.5m.

Diagram of Measurement Equipment Configuration for Mains Conduction Measurement (if applicable)

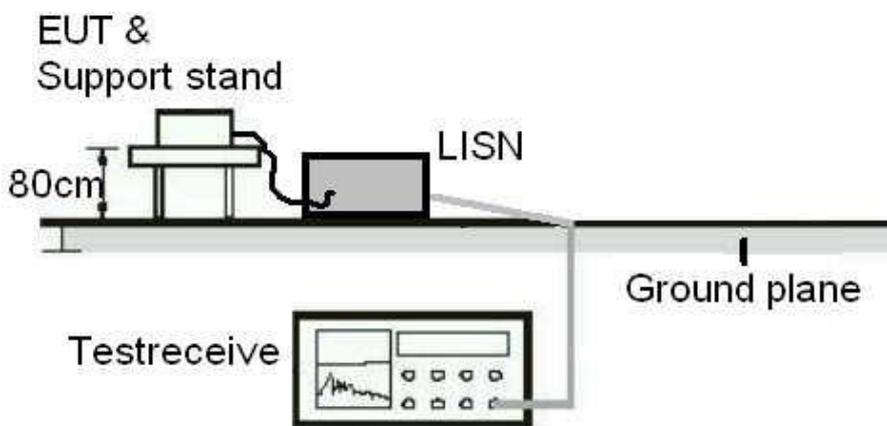
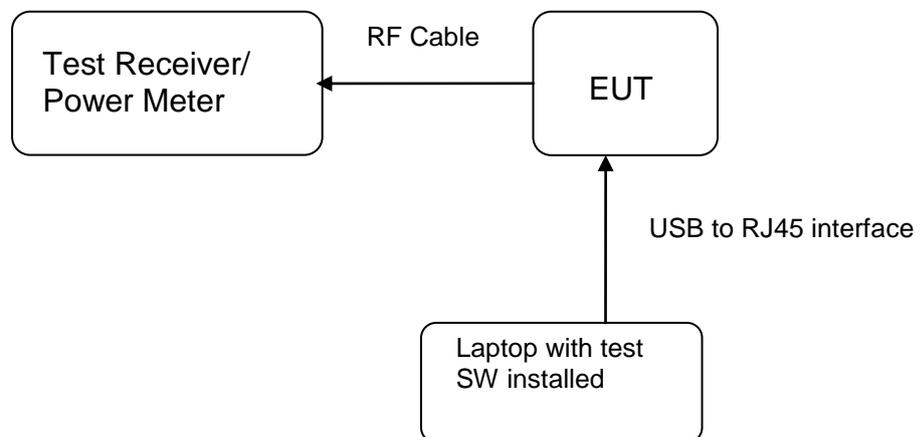


Diagram of Measurement Equipment Configuration for Conducted Transmitter Measurement



5. Test Results

5.1 Transmitter Requirement & Test Suites

5.1.1 Antenna Requirement

RESULT: **Passed**

Test standard : LP0002(2016): 3.10.1, (3)
FCC Part 15.247(b)(4), Part 15.203 and RSS-
Gen 8.3

Limit : the use of antennas with directional gains that do not
exceed 6 dBi

According to the manufacturer declaration, the EUT has an antenna with a directional gain of Main ANT:2.26dBi ; Aux ANT: 0.29 dBi .The antenna is a printed PCB trace with no possibility of replacement with a non-approved antenna by the end-user. Therefore, the EUT is considered to comply with this provision.

Refer to EUT photo for details.

5.1.2 Peak Output Power

RESULT:
Passed

Test standard : LP0002(2016): 3.10.1, (2)
 FCC Part 15.247(b)(3), RSS-247 5.4(4)
 Basic standard : ANSI C63.10:2009, KDB558074
 Limit : 1 Watt
 Kind of test site : Shielded room

Test setup

Test Channel : Low/ Middle/ High
 Operation Mode : A
 Ambient temperature : 22-26 °C
 Relative humidity : 50-65 %
 Atmospheric pressure : 100-103 kPa

Table 6: Test result of Peak Output Power (802.11b)

Channel	Channel Frequency (MHz)	Output Power		Limit
		(dBm)	(W)	(W)
Low Channel	2412	24.11	0.2576	1
Middle Channel	2437	24.26	0.2667	1
High Channel	2462	24.34	0.2716	1

Table 7: Test result of AVG Output Power (802.11b)

Channel	Channel Frequency (MHz)	Output Power		
		(dBm)	(W)	(mw)
Low Channel	2412	21.20	0.1318	131.8
Middle Channel	2437	21.35	0.1365	136.5
High Channel	2462	21.46	0.1400	140.0

Table 8: Test result of Peak Output Power (802.11g)

Channel	Channel Frequency (MHz)	Output Power		Limit (W)
		(dBm)	(W)	
Low Channel	2412	23.56	0.2270	1
Middle Channel	2437	23.62	0.2301	1
High Channel	2462	23.46	0.2218	1

Table 9: Test result of AVG Output Power (802.11g)

Channel	Channel Frequency (MHz)	Output Power		
		(dBm)	(W)	(mw)
Low Channel	2412	14.36	0.0273	27.3
Middle Channel	2437	14.42	0.0277	27.7
High Channel	2462	14.37	0.0274	27.4

Table 10: Test result of Peak Output Power (802.11n HT20)

Channel	Channel Frequency (MHz)	Output Power			Limit (mW)	Result
		Power TX1 (dBm)	PowerTX2 (dBm)	Power TX + TX2 (mW)		
Low Channel	2412	20.14	19.97	202.6	1000	Pass
Middle Channel	2437	20.35	20.13	211	1000	Pass
High Channel	2462	20.02	19.79	196	1000	Pass

Table 11: Test result of AVG Output Power (802.11n HT20)

Channel	Channel Frequency (MHz)	Output Power		
		Power TX1 (dBm)	PowerTX2(dBm)	Power TX + TX2 (mW)
Low Channel	2412	9.14	8.77	15.7
Middle Channel	2437	9.06	8.82	16
High Channel	2462	9.01	8.87	16

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5.1.3 6dB Bandwidth and 99% Bandwidth

RESULT:**Passed**

Test standard : LP0002(2016): 3.10.1, (5)
FCC Part 15.247(a)(2), RSS-247 5.2(1)
Basic standard : ANSI C63.10:2009, KDB558074
Kind of test site : Shielded room

Test setup

Test Channel : Low/ Middle/ High
Operation Mode : A
Ambient temperature : 22-26°C
Relative humidity : 50-65%
Atmospheric pressure : 100-103 kPa

Table 12: Test result of 6dB Bandwidth (802.11b)

Channel	Channel Frequency (MHz)	6dB Bandwidth (MHz)	Limit (MHz)	Result
Low Channel	2412	9.196	0.5	Pass
Mid Channel	2437	8.843	0.5	Pass
High Channel	2462	9.500	0.5	Pass

Table 13: Test result of 6dB Bandwidth (802.11g)

Channel	Channel Frequency (MHz)	6dB Bandwidth (MHz)	Limit (MHz)	Result
Low Channel	2412	16.42	0.5	Pass
Mid Channel	2437	16.40	0.5	Pass
High Channel	2462	16.40	0.5	Pass

Table 14: Test result of 6dB Bandwidth (802.11n HT20)

Channel	Channel Frequency (MHz)	6dB Bandwidth (MHz)	Limit (MHz)	Result
Low Channel	2412	17.76	0.5	Pass
Mid Channel	2437	17.75	0.5	Pass
High Channel	2462	17.74	0.5	Pass

Table 15: Test result of 99% Bandwidth (802.11b)

Channel	Channel Frequency (MHz)	99% Bandwidth (MHz)
Low Channel	2412	12.363
Mid Channel	2437	12.296
High Channel	2462	12.315

Table 16: Test result of 99% Bandwidth (802.11g)

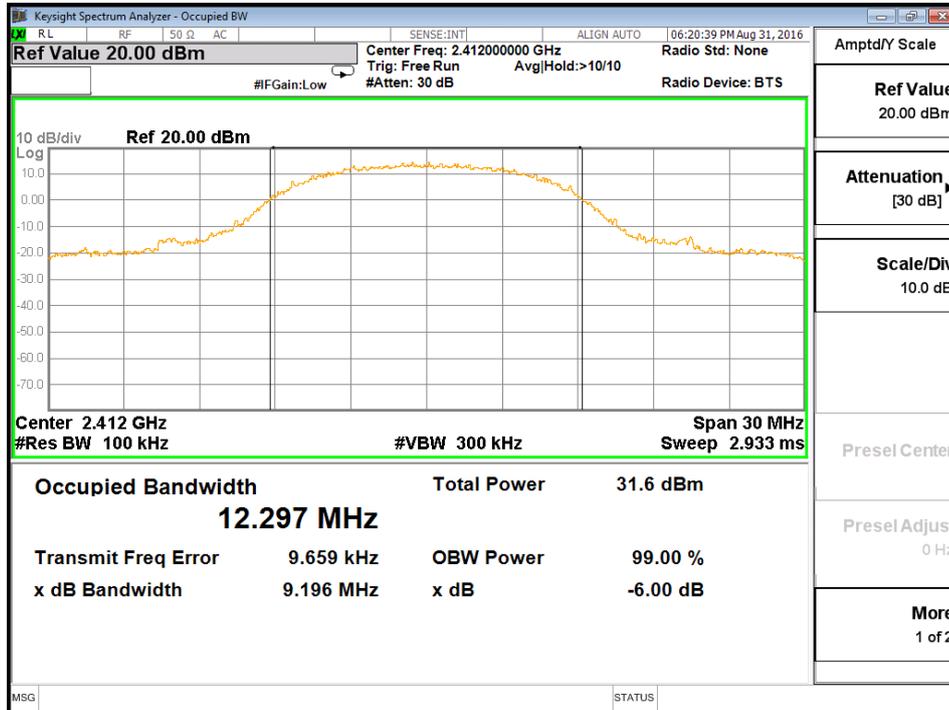
Channel	Channel Frequency (MHz)	99% Bandwidth (MHz)
Low Channel	2412	16.718
Mid Channel	2437	16.707
High Channel	2462	16.700

Table 17: Test result of 99% Bandwidth (802.11n HT20)

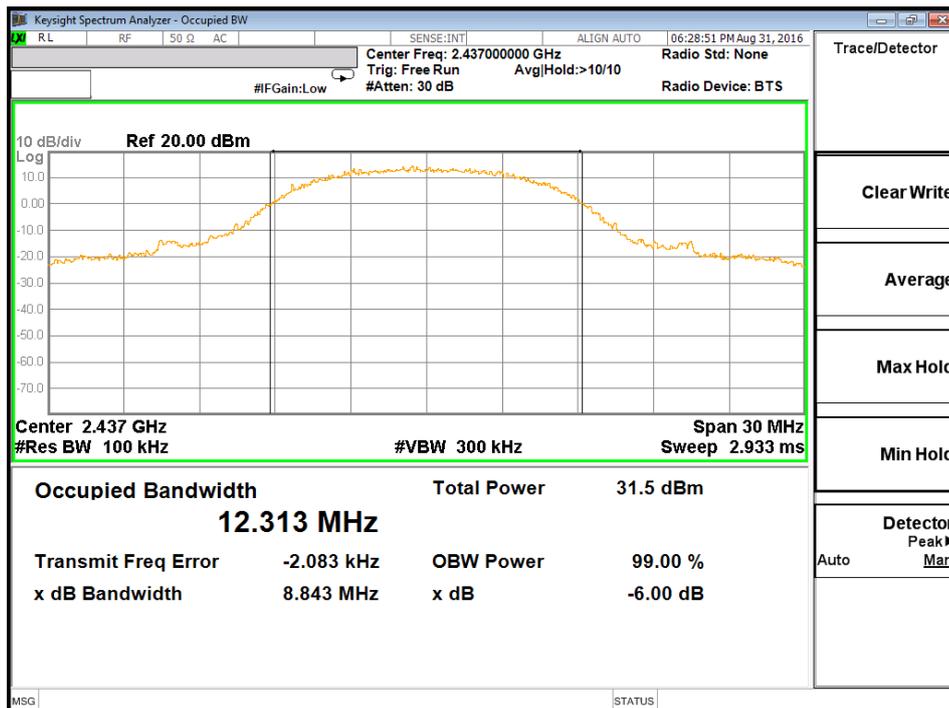
Channel	Channel Frequency (MHz)	99% Bandwidth (MHz)
Low Channel	2412	18.00
Mid Channel	2437	17.956
High Channel	2462	17.978

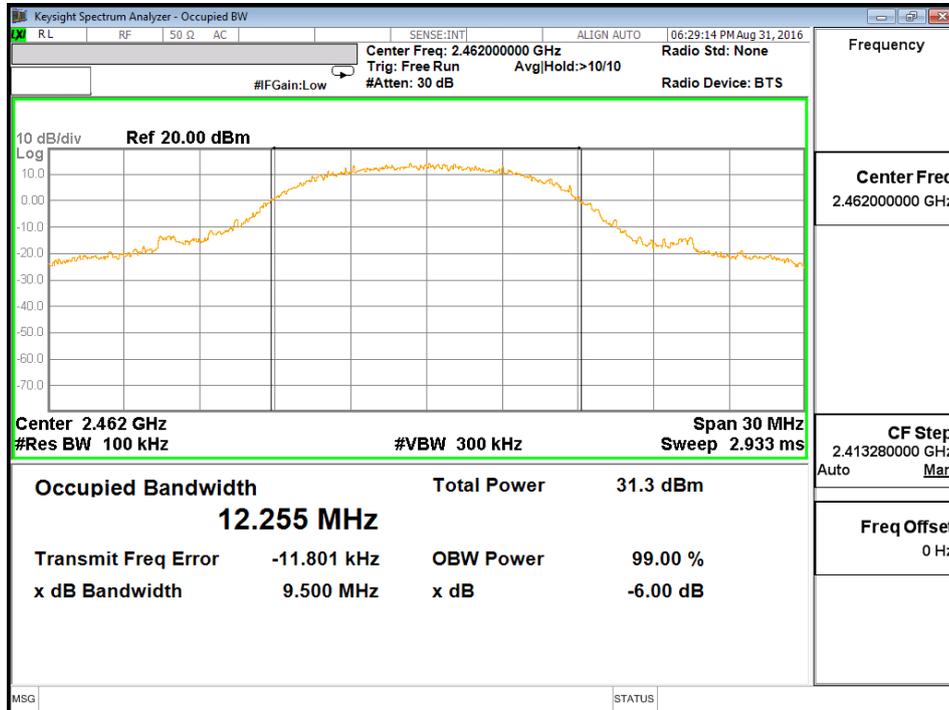
Test Plot of 6dB Bandwidth (802.11b)

Low Channel



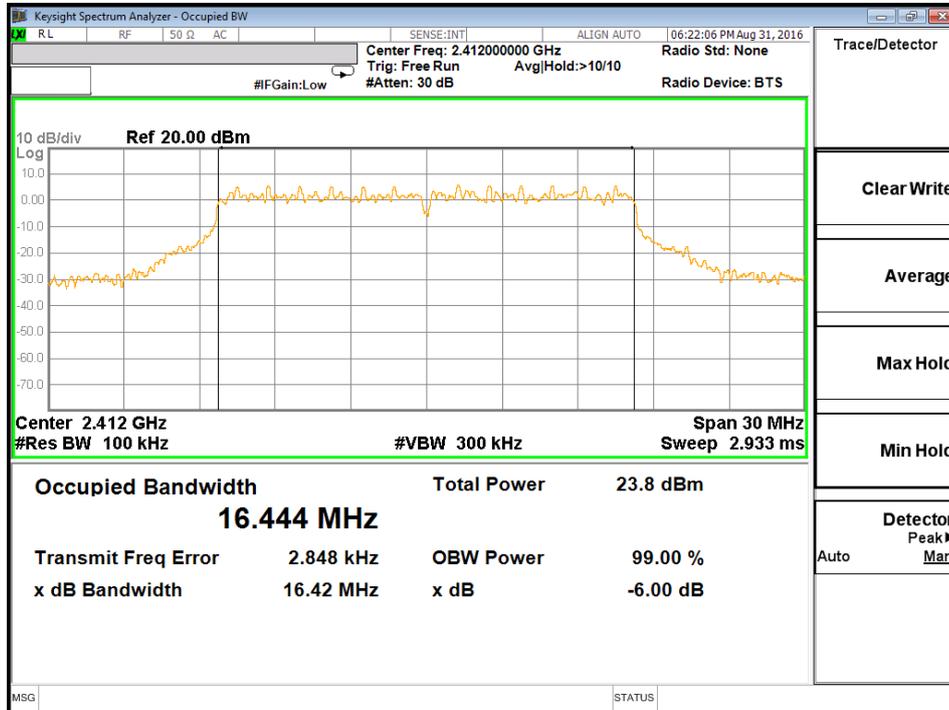
Middle Channel



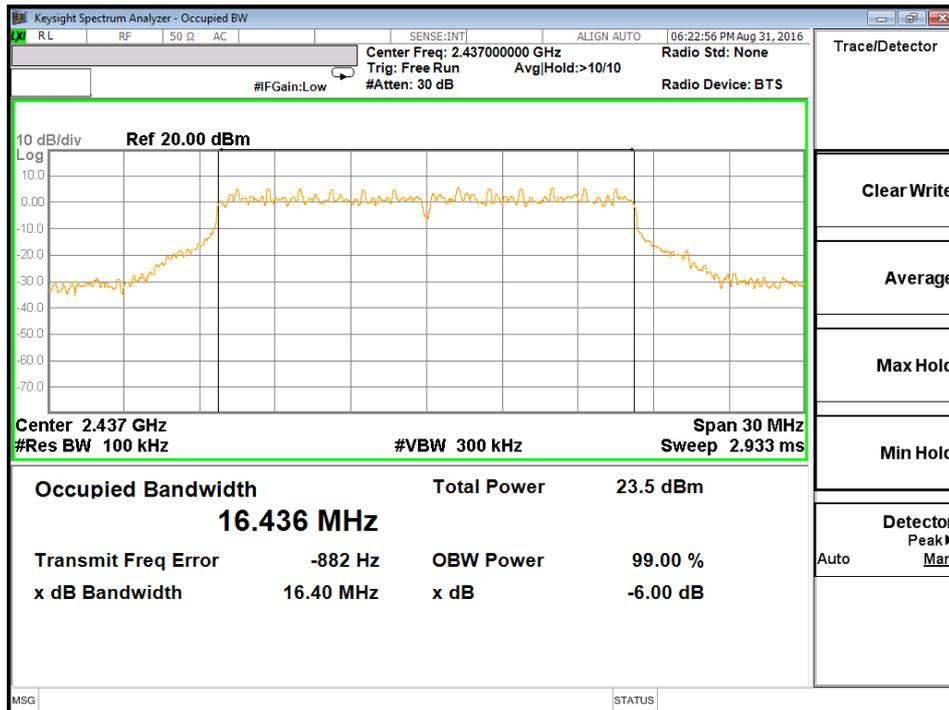
High Channel


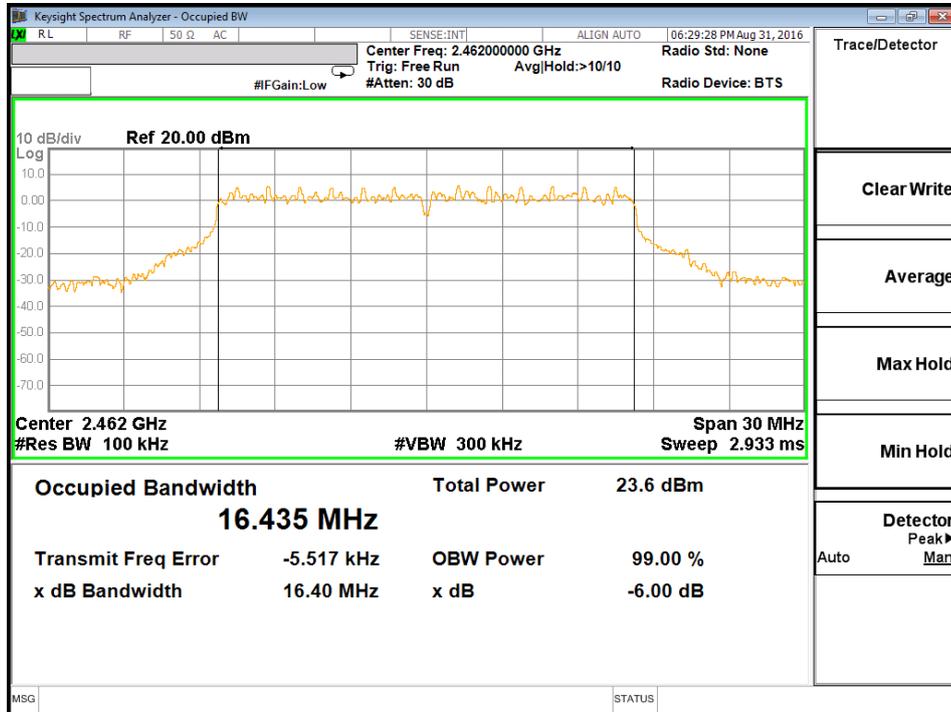
Test Plot of 6dB Bandwidth (802.11g)

Low Channel



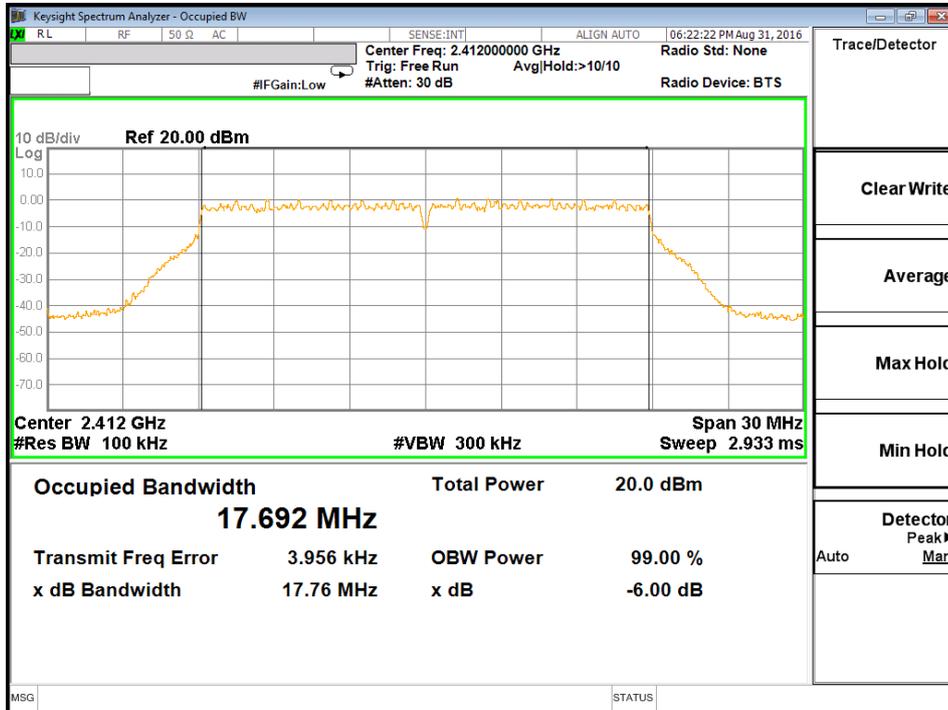
Middle Channel



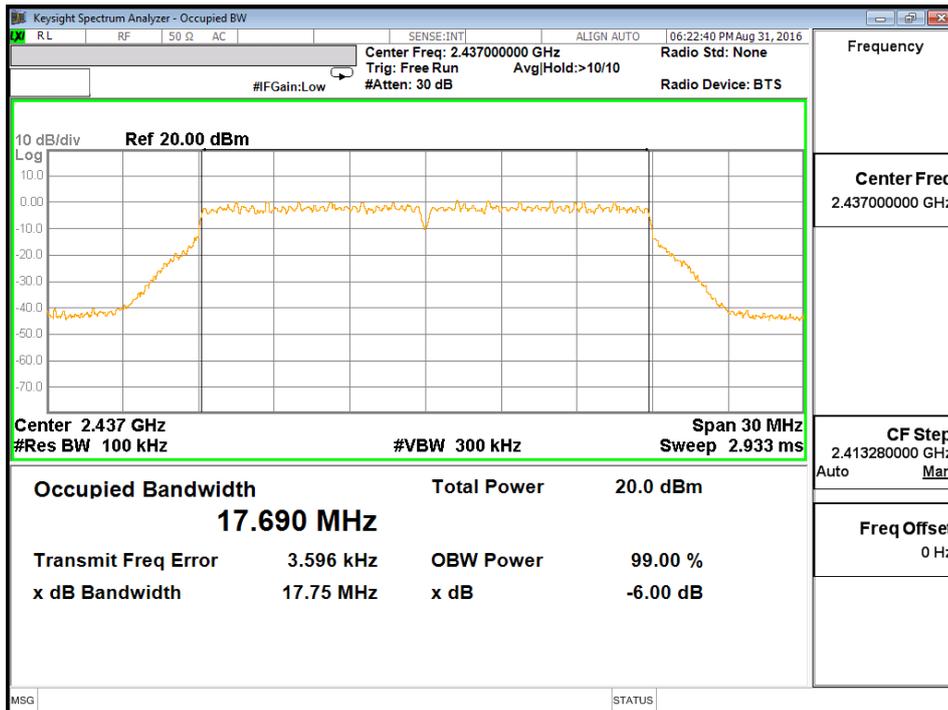
High Channel


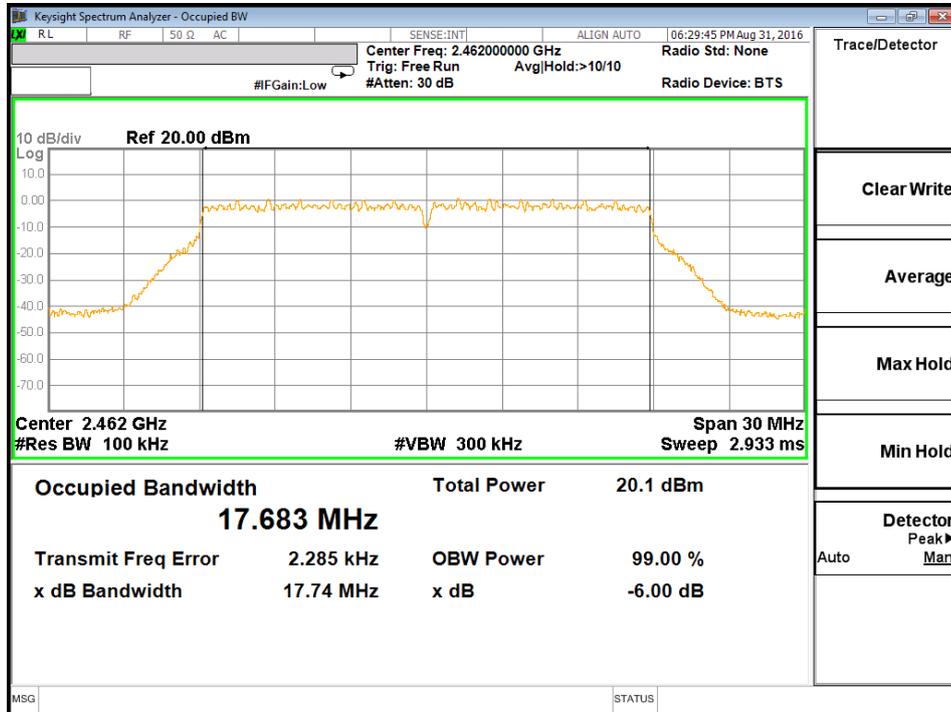
Test Plot of 6dB Bandwidth (802.11n HT20)

Low Channel



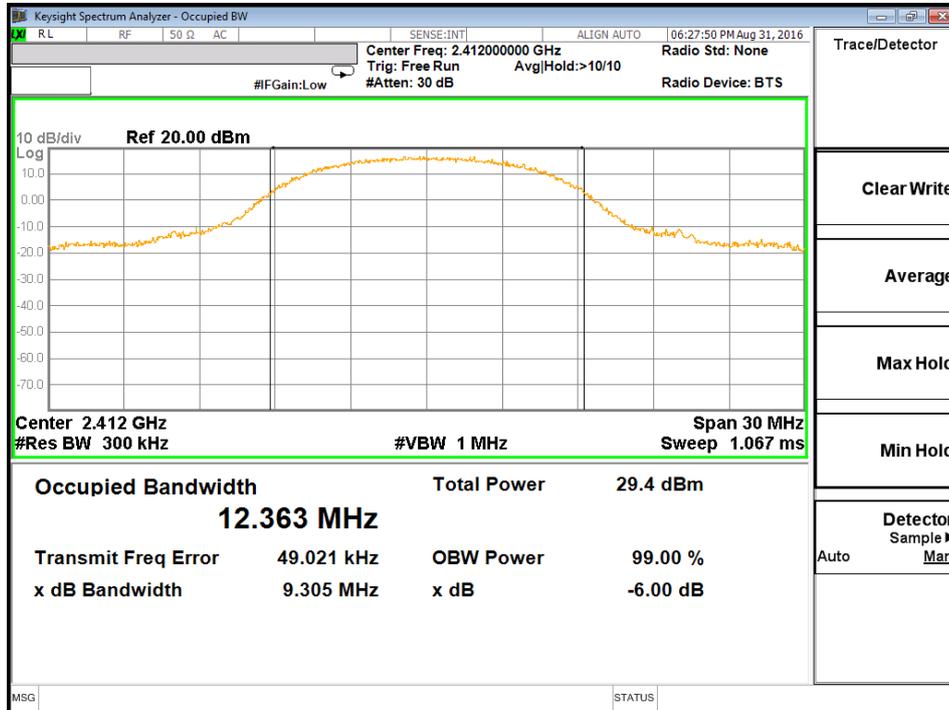
Middle Channel



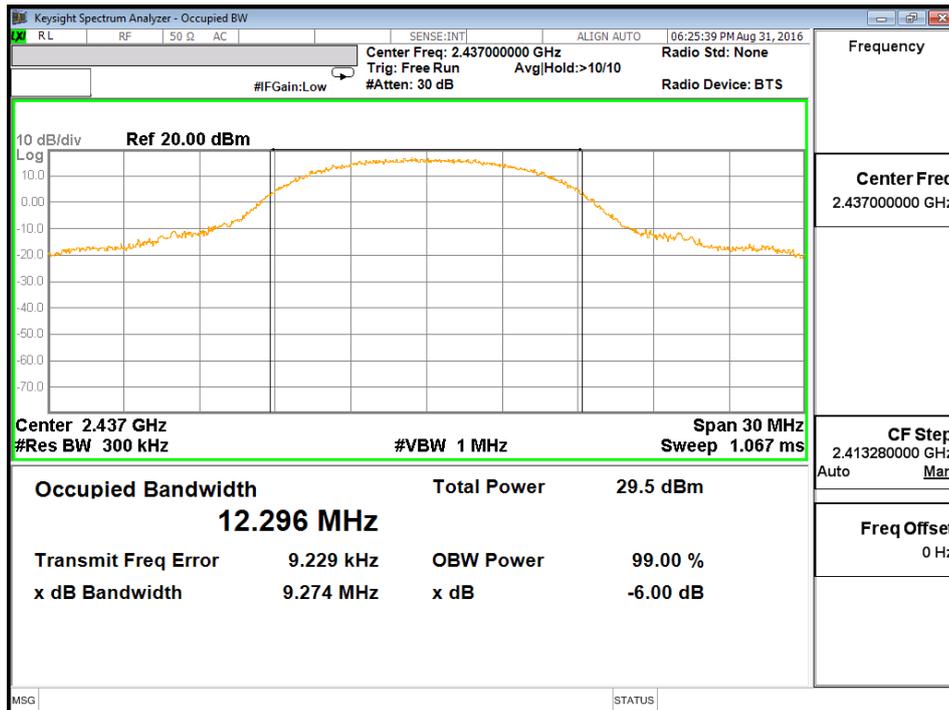
High Channel


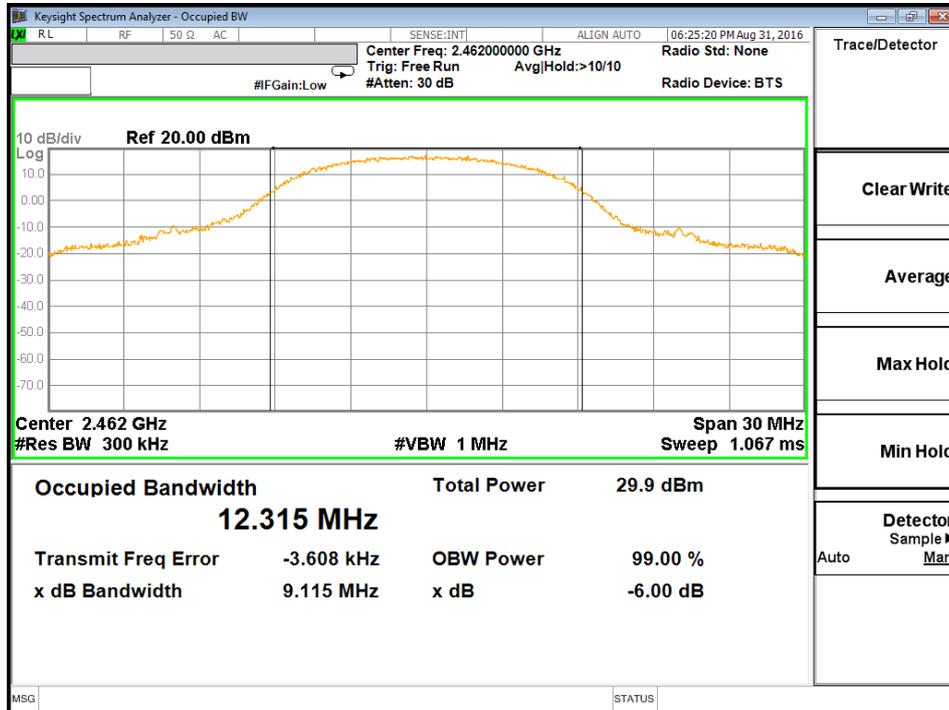
Test Plot of 99% Bandwidth (802.11b)

Low Channel



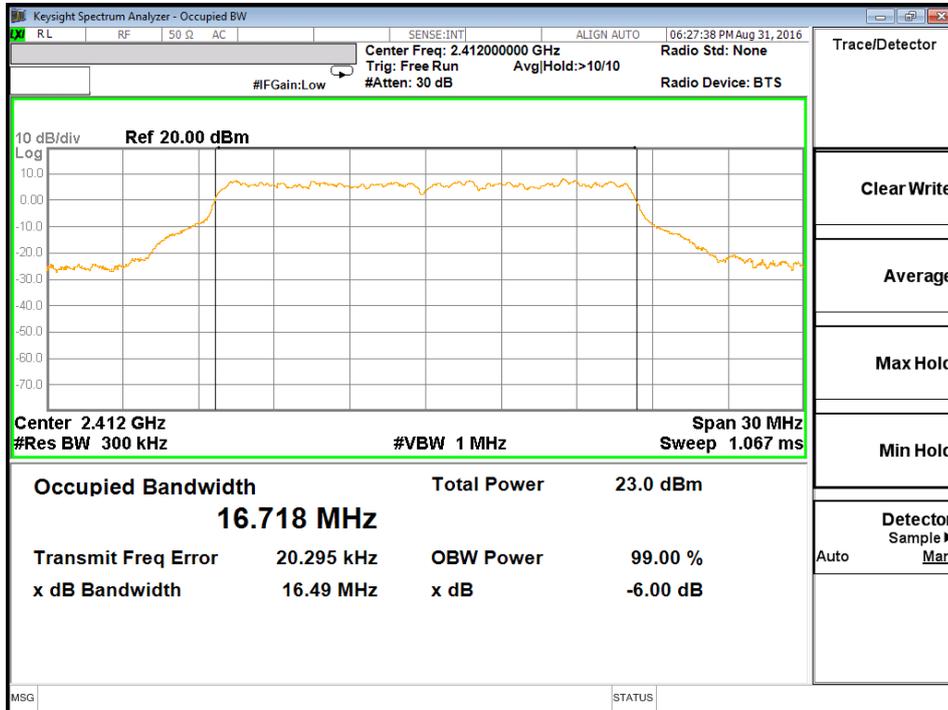
Middle Channel



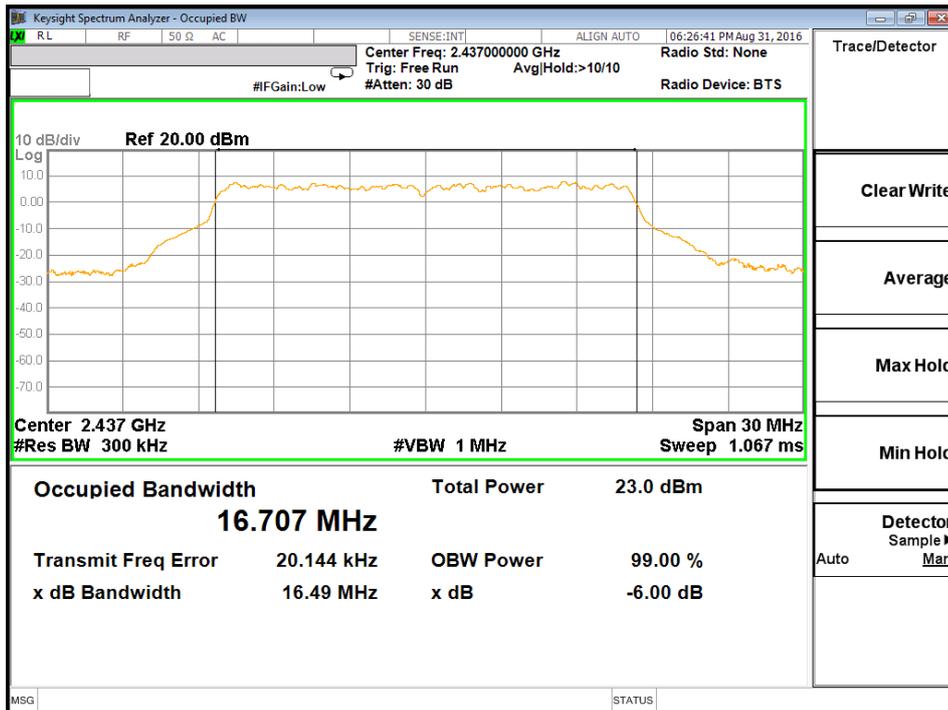
High Channel


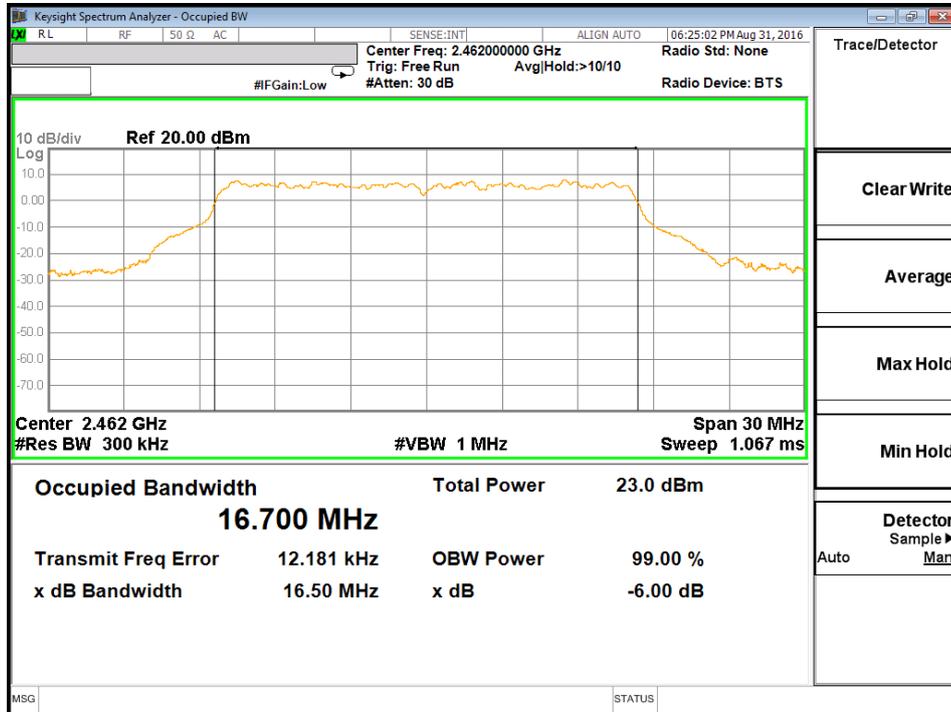
Test Plot of 99% Bandwidth (802.11g)

Low Channel



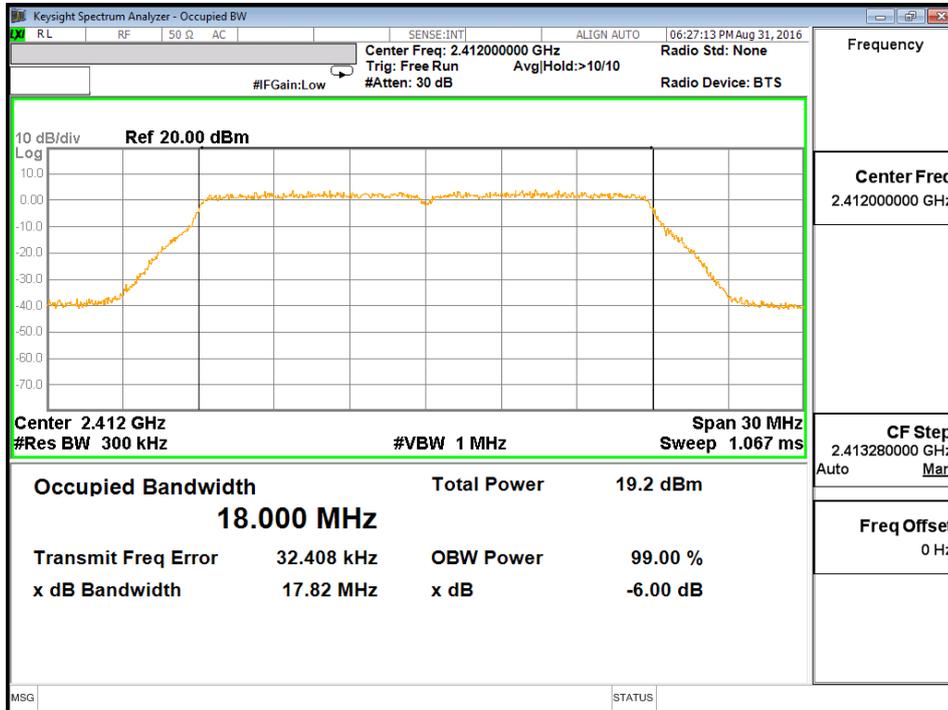
Middle Channel



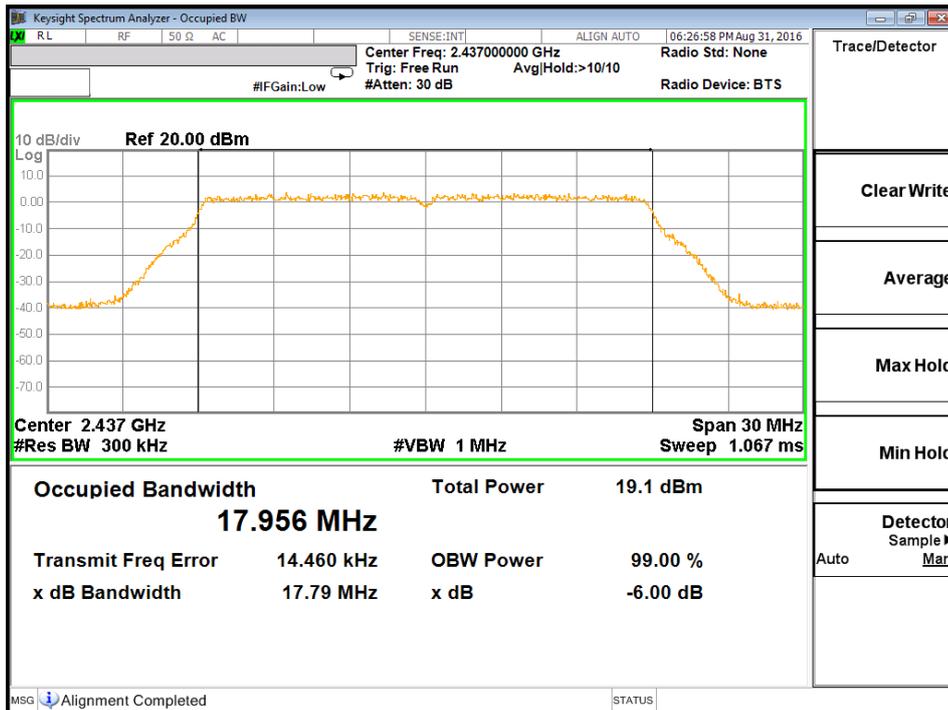
High Channel


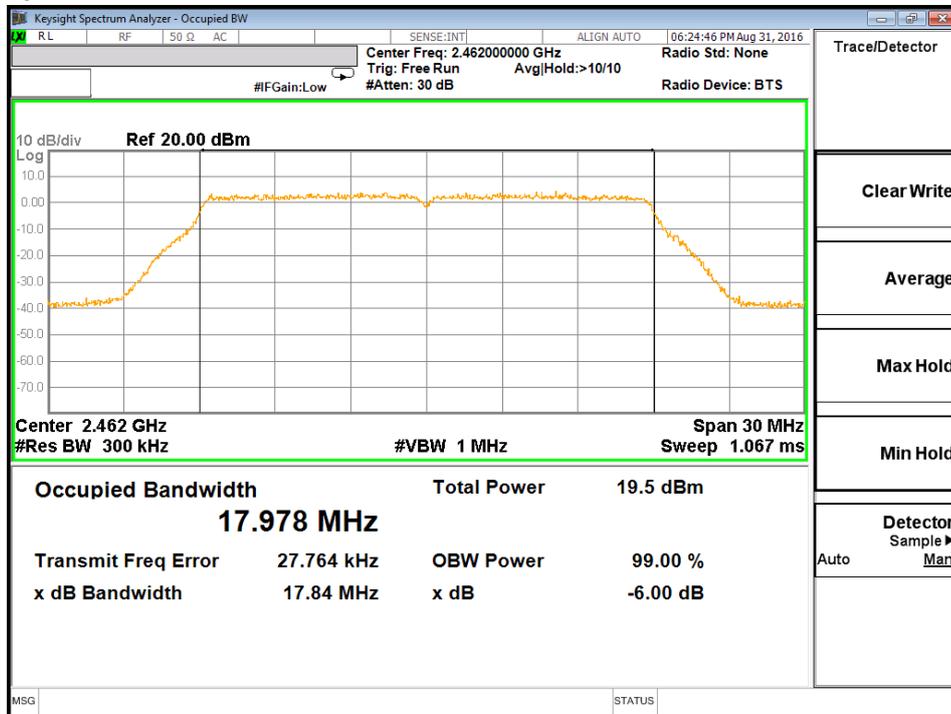
Test Plot of 99% Bandwidth (802.11n HT20)

Low Channel



Middle Channel



High Channel


5.1.4 Power Density

RESULT:
Passed

Test standard : LP0002(2016): 3.10.1, (6.2.2)
 FCC Part 15.247(e) , RSS-247 5.2(2)
 Basic standard : ANSI C63.10:2009, KDB558074
 Kind of test site : Shielded room

Test setup

Test Channel : Low/ Middle/ High
 Operation Mode : A
 Ambient temperature : 22-26°C
 Relative humidity : 50-65%
 Atmospheric pressure : 100-103 kPa

Table 18: Test result of Power Density (802.11b)

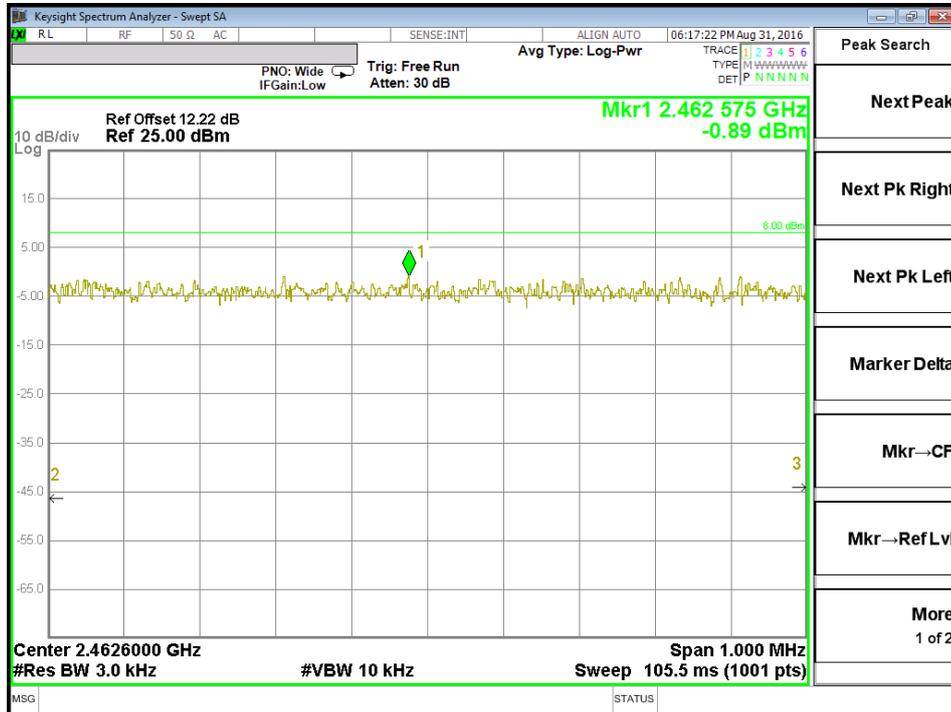
Channel	Channel Frequency (MHz)	Power Density	Limit
		(dBm)	(dBm)
Low Channel	2412	-1.09	8
Middle Channel	2437	-1.32	8
High Channel	2462	-0.89	8

Table 19: Test result of Power Density (802.11g)

Channel	Channel Frequency (MHz)	Power Density	Limit
		(dBm)	(dBm)
Low Channel	2412	-11.72	8
Middle Channel	2437	-11.90	8
High Channel	2462	-11.83	8

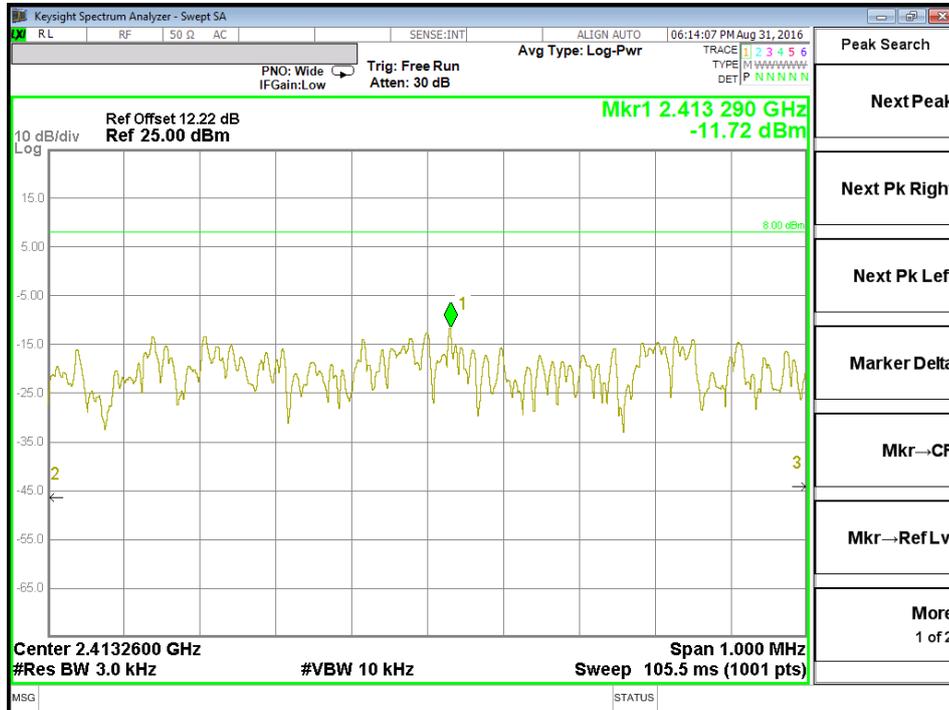
Table 20: Test result of Power Density (802.11n HT20)

Channel	Channel Frequency (MHz)	Power Density		Total Power Density (dBm)	Limit (dBm)
		TX1(dBm)	TX2(dBm)		
Low Channel	2412	-14.22	-14.52	-11.36	8
Middle Channel	2437	-14.65	-14.93	-11.78	8
High Channel	2462	-13.28	-14.64	-10.90	8

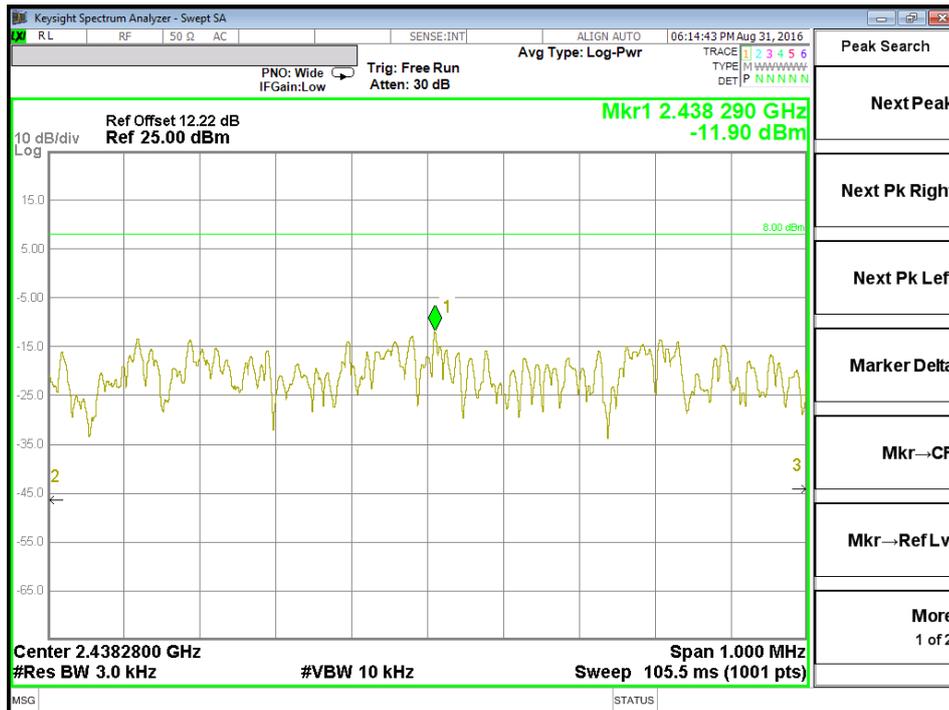
High Channel


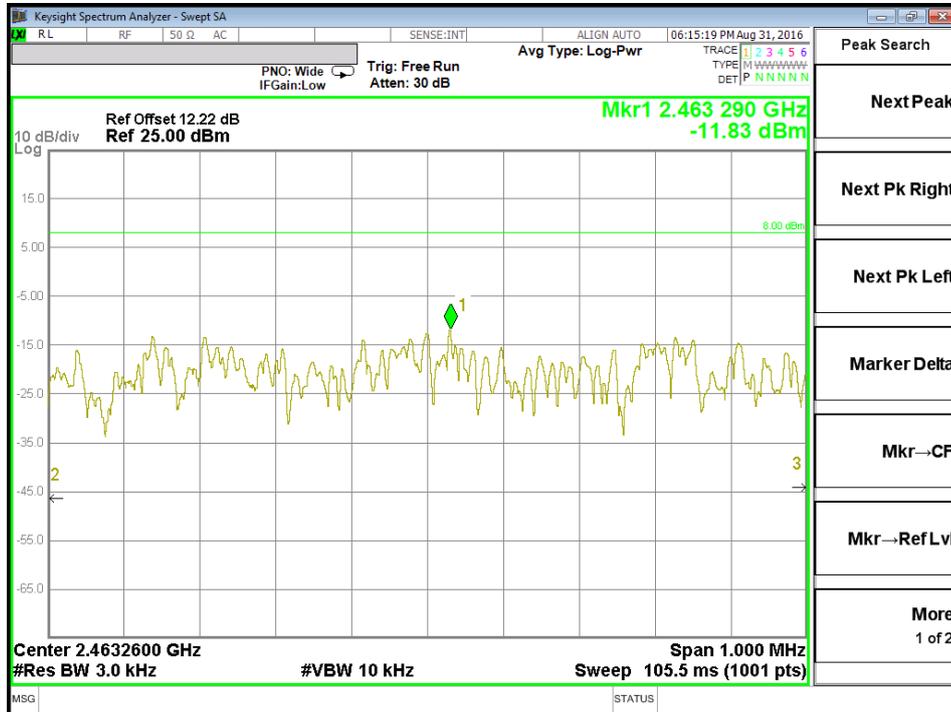
Test Plot of Power Density (802.11g)

Low Channel



Middle Channel



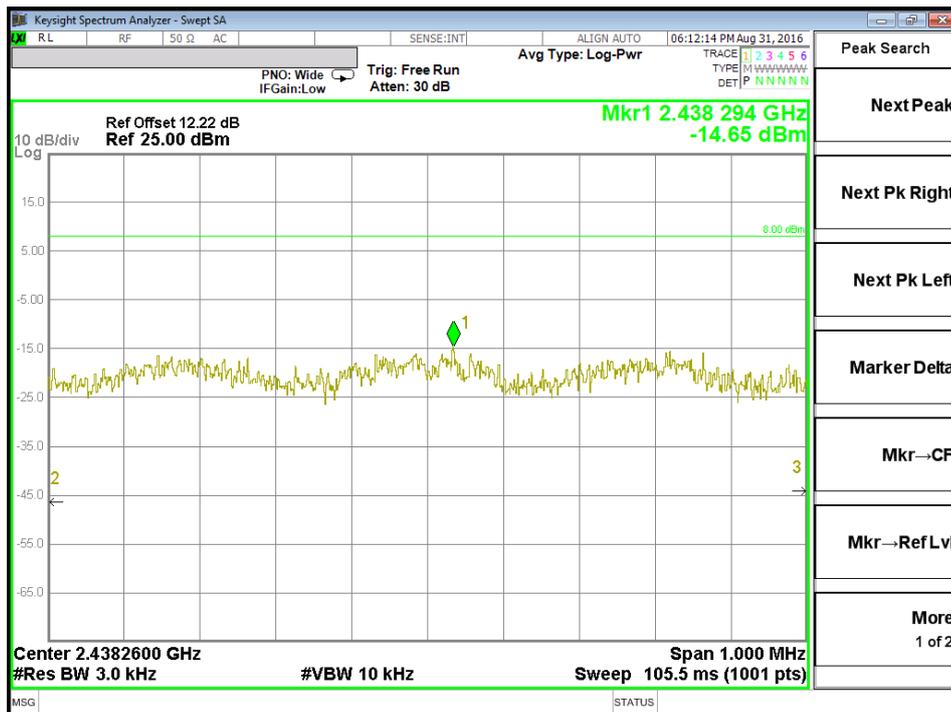
High Channel


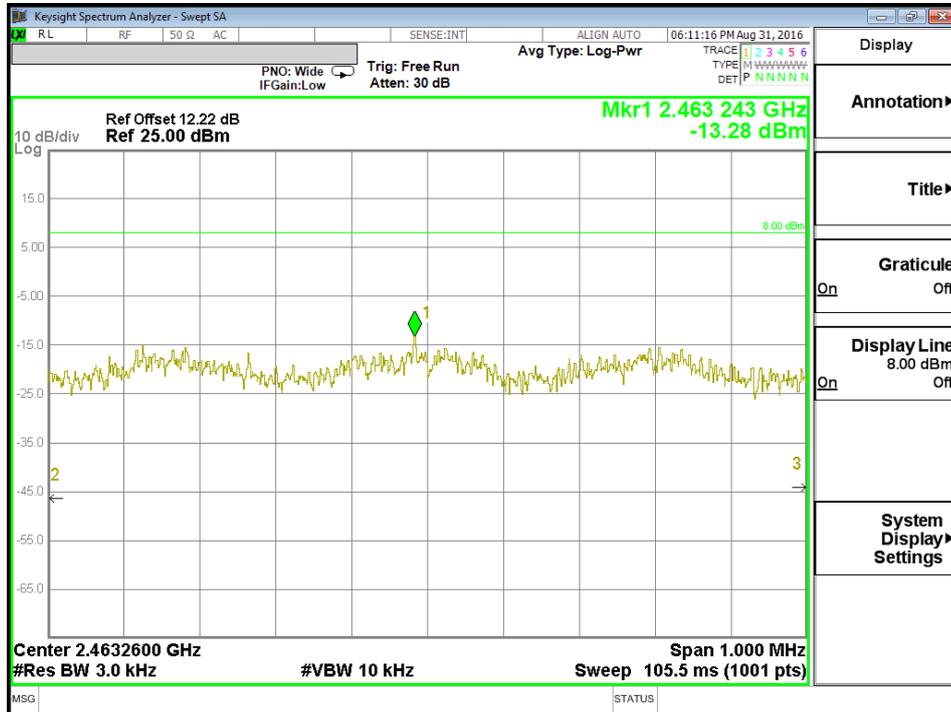
Test Plot of Power Density (802.11n HT20) TX1

Low Channel



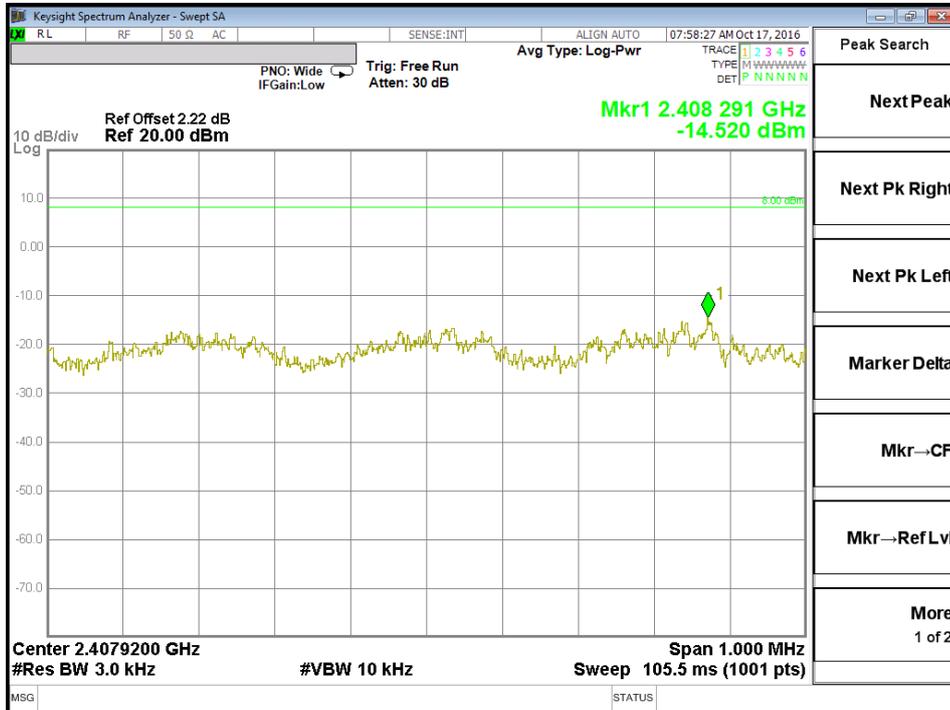
Middle Channel



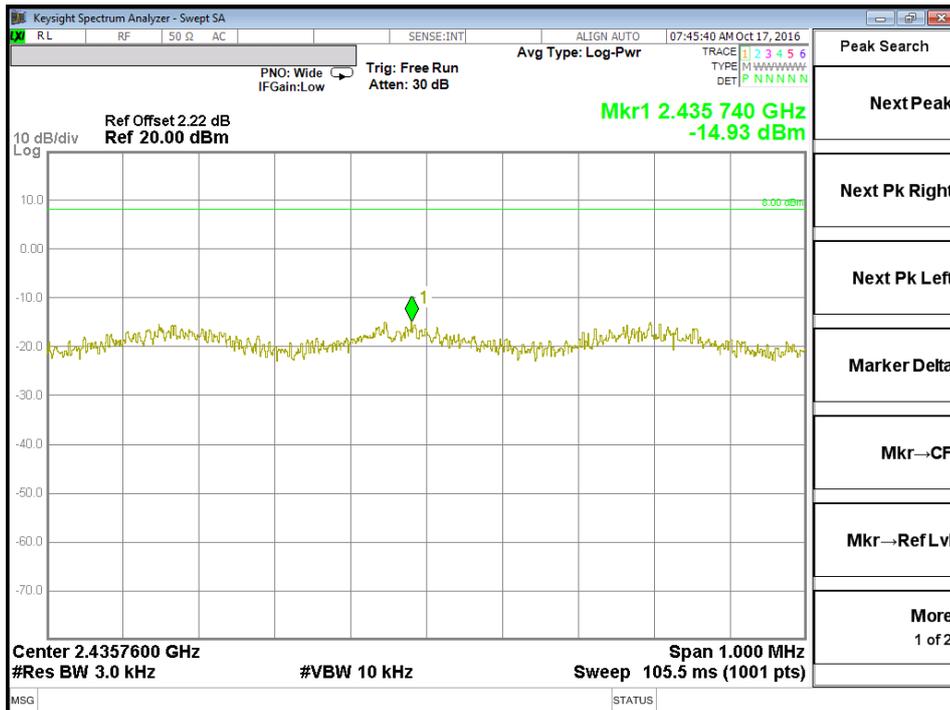
High Channel


Test Plot of Power Density (802.11n HT20) TX2

Low Channel



Middle Channel



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5.1.5 Conducted spurious emissions and Frequency Band Edge measured in 100kHz Bandwidth

RESULT:**Passed**

Test standard : LP0002(2016): 3.10.1, (5)
FCC part 15.247(d), RSS-247 5.5
Basic standard : ANSI C63.10:2009, KDB558074
Limit : 20dB (below that in the 100kHz bandwidth within the
band that contains the highest level of the desired power)
Kind of test site : Shielded room

Test setup

Test Channel : Low/ High
Operation mode : A
Ambient temperature : 22-26°C
Relative humidity : 50-65%
Atmospheric pressure : 100-103 kPa

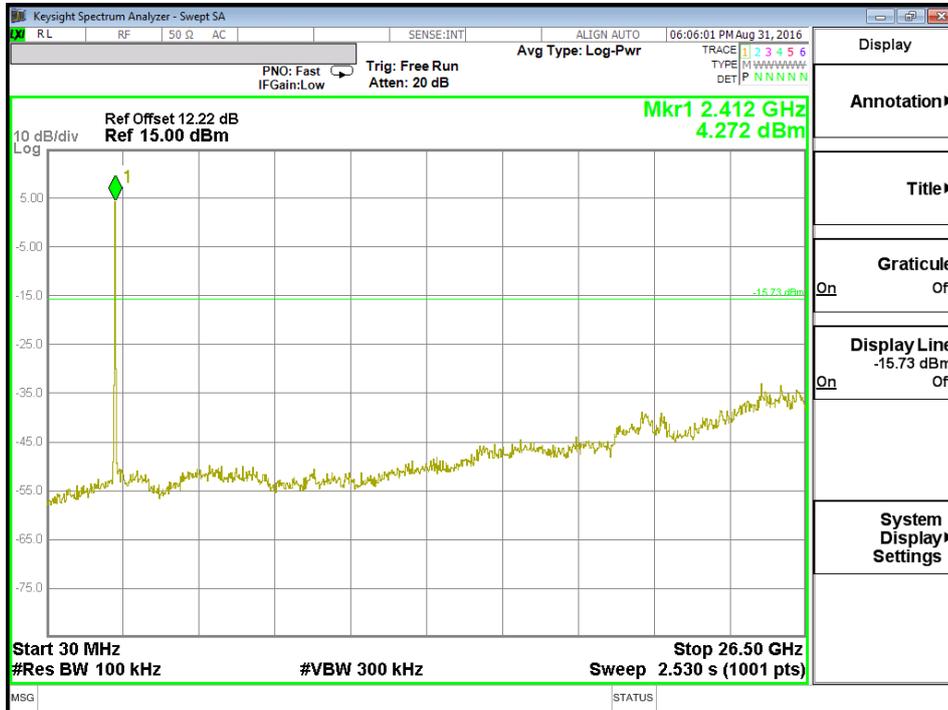
All emissions are more than 20dB below fundamental, details refer to following test plot, and compliance is achieved as well.

Due to the small size of the product and that there are no inductive components of significant size, 9kHz to 30MHz frequency range is not tested based on technical judgment.

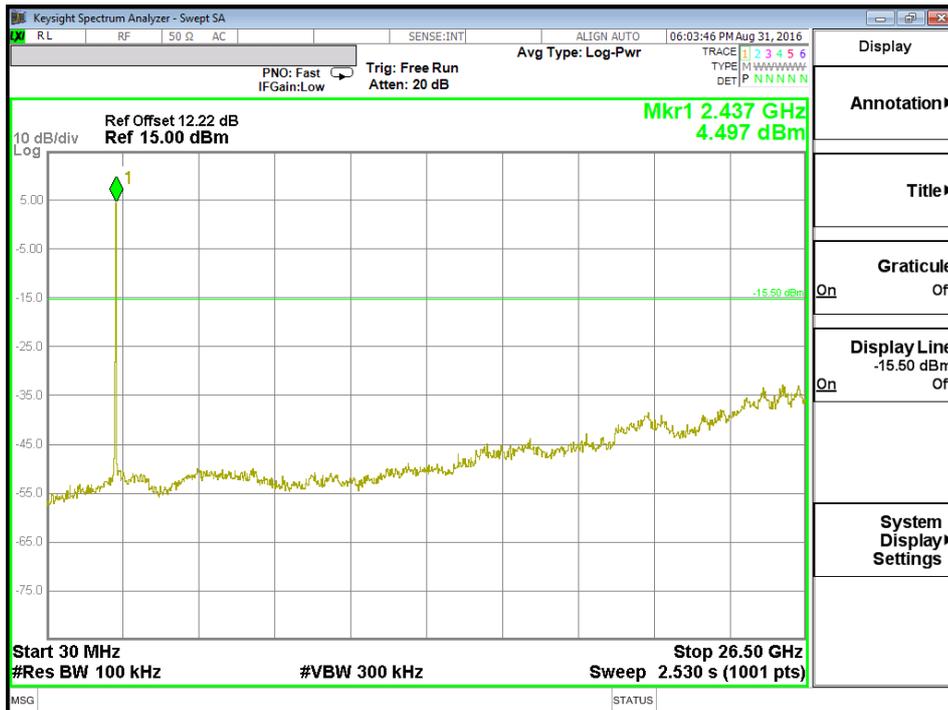
High Channel

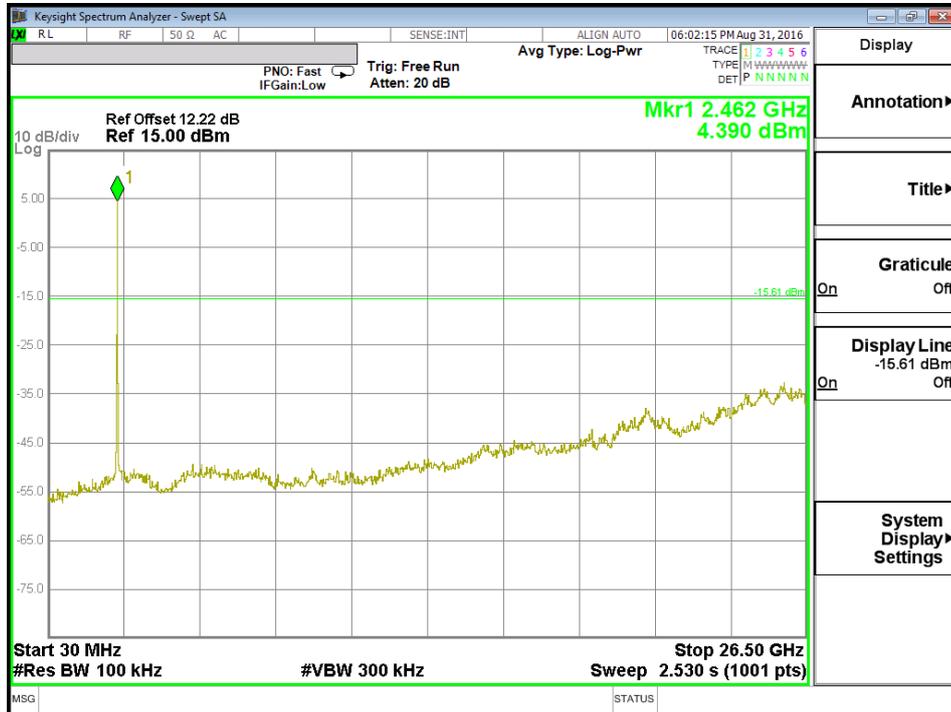

Test Plot 100kHz Conducted Emissions (802.11g)

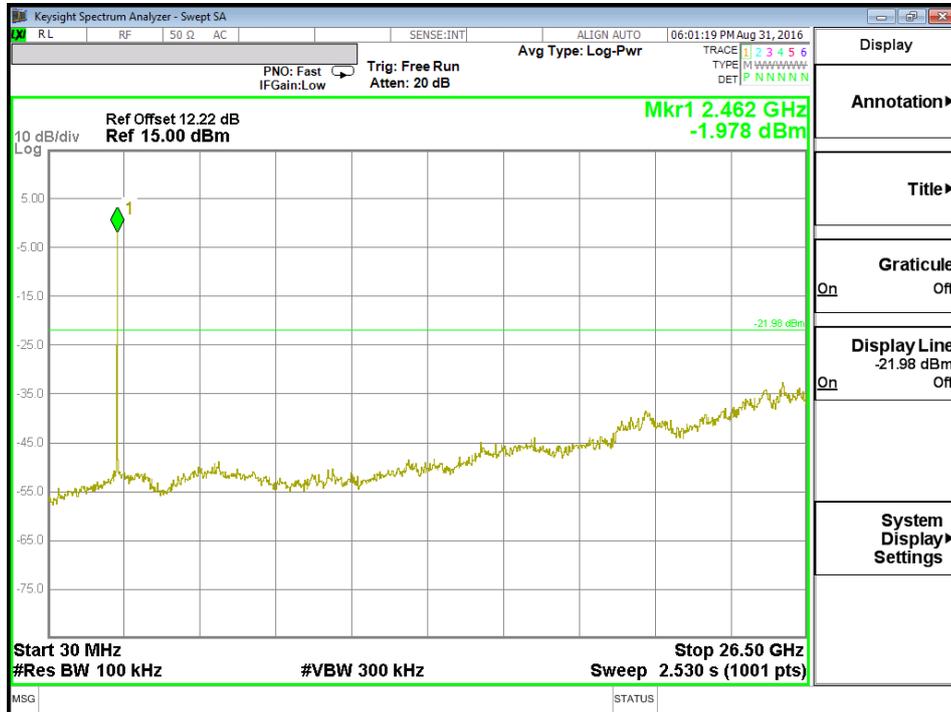
Low Channel



Middle Channel

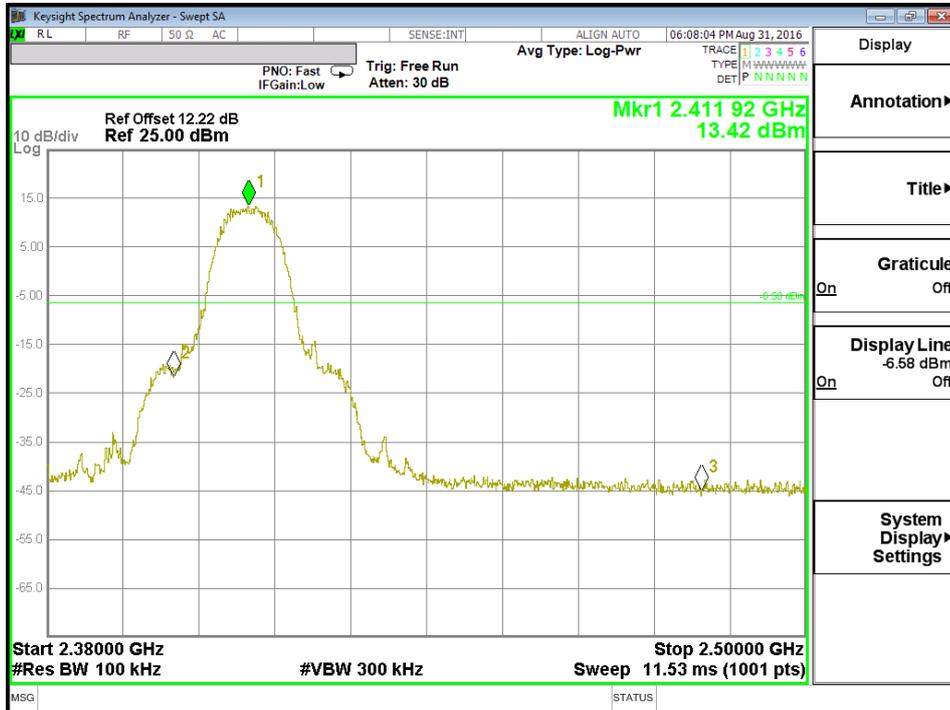


High Channel


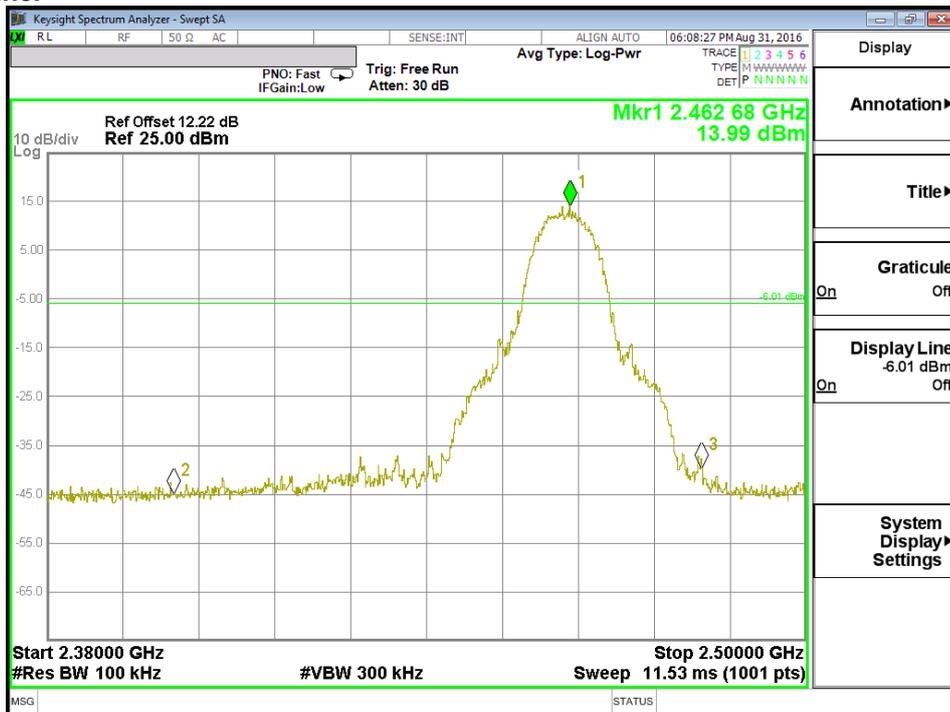
High Channel


Test Plot 100kHz RBW of Band Edge (802.11b)

Low Channel

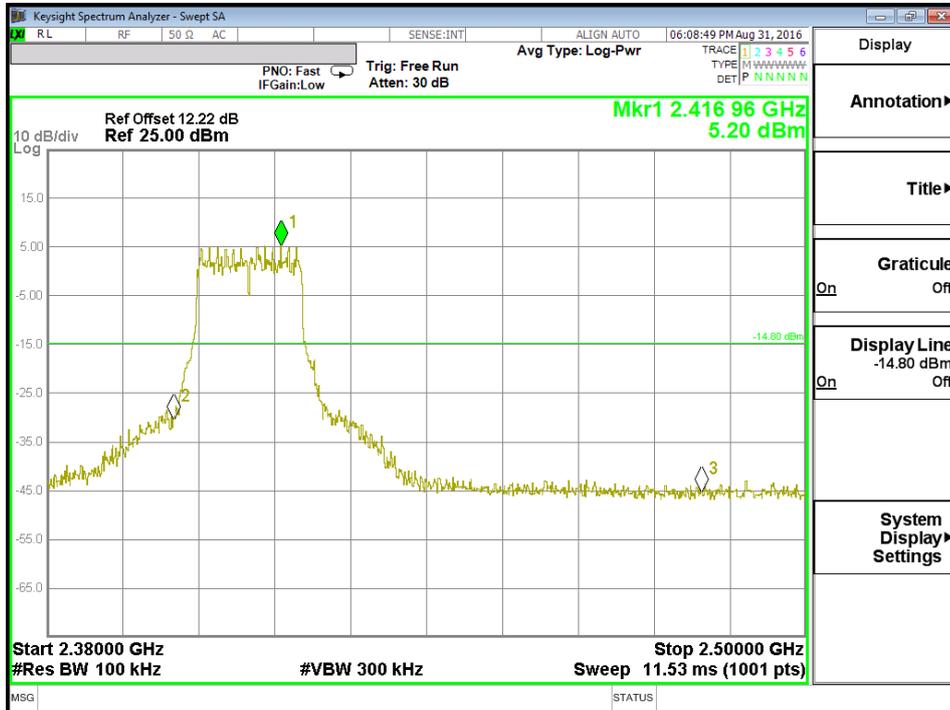


High Channel

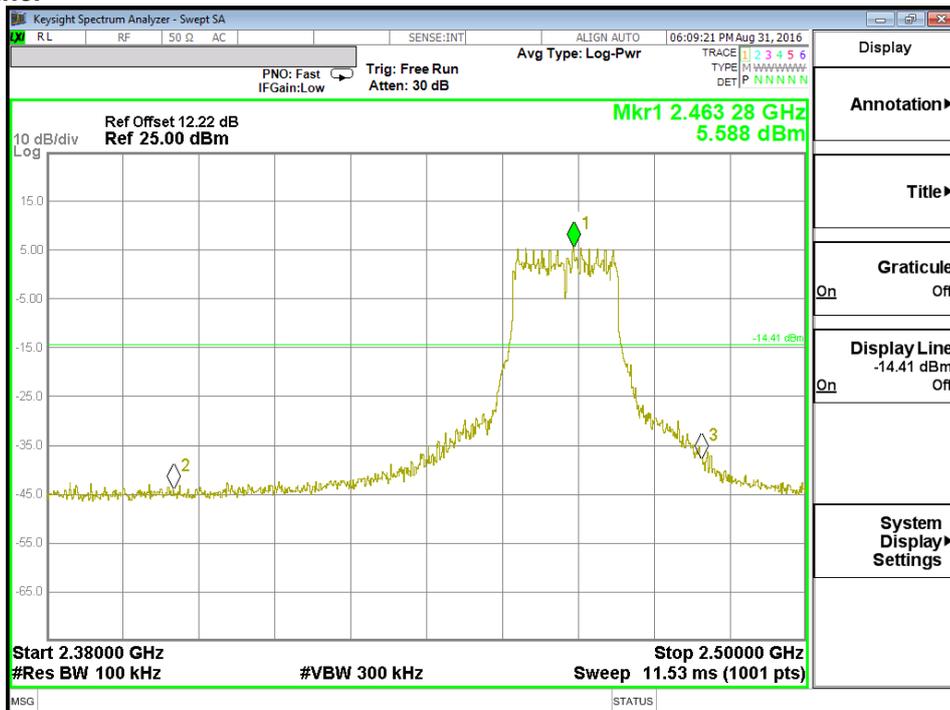


Test Plot 100kHz RBW of Band Edge (802.11g)

Low Channel



High Channel



5.1.6 Spurious Emission

RESULT:**Passed**

Test standard	:	FCC part 15.247(d), FCC 15.205, FCC 15.209, RSS-210 2.2, RSS-247 5.5 and RSS-Gen 8.9 LP0002(2016): 3.10.1, (5)
Basic standard	:	ANSI C63.10: 2009
Limits	:	Radiated emissions which fall in the restricted bands, as defined in FCC 15.205(a) and RSS-Gen i4, 8.9 (Table 6), must comply with the radiated emission limits specified in FCC 15.209(a) and RSS-Gen i4, 8.9 (Table 4 and 5). Radiated emissions which fall in the restricted bands, as defined in LP0002(2016): 2.7 , must comply with the radiated emission limits specified in LP0002(2016): 2.8 Emission radiated outside the specified frequency bands must comply with the radiated emission limits specified in FCC 15.209(a) and FCC 15.249(a), RSS-Gen i4, 8.9 (Table 4 and 5) and RSS-210 A2.9(a). Emission radiated outside the specified frequency bands must comply with the radiated emission limits specified in LP0002(2016): 2.8
Kind of test site	:	3m Semi-Anechoic Chamber
Test setup		
Test Channel	:	Low/ Middle/ High
Operation mode	:	A, B

Remark: Testing was carried out within frequency range 30MHz to the tenth harmonic.

For details refer to Appendix D.

The Radiated Emissions testing was performed in the X, Y and Z axis orientation. The X Axis orientation is the worst-case and recorded in this test report. Due to the small size of the product and that there are no inductive components of significant size, 9kHz to 30MHz frequency range is not tested based on technical judgment.

5.2 Mains Emissions

5.2.1 Mains Conducted Emissions

RESULT:**Passed**

Test standard : FCC Part 15.207
FCC Part 15.107
RSS-Gen 8.8
LP0002(2016): 2.3

Limits : Mains Conducted emissions as defined in
above standards

Kind of test site : Shielded Room

Test setup

Test Channel : Middle
Operation mode : A

Remark: For details refer to Appendix D.

6. Safety Human exposure

6.1 Radio Frequency Exposure Compliance

6.1.1 Electromagnetic Fields

RESULT:
Passed

Test standard : FCC KDB Publication 447498 D01 v06
 RSS--102

Separation distance is more than 20 cm, thus mobile device exposure limits can be applied

Maximum Exposure:

Power to Antenna (mW)	140 mW
Power to Antenna (dBm)	21.5 dBm
Antenna Gain	2.16 dBi
Power+Ant Gain	230.2 mW
Distance	20 cm
S=	0.046 mW/cm ²

Limit FCC:

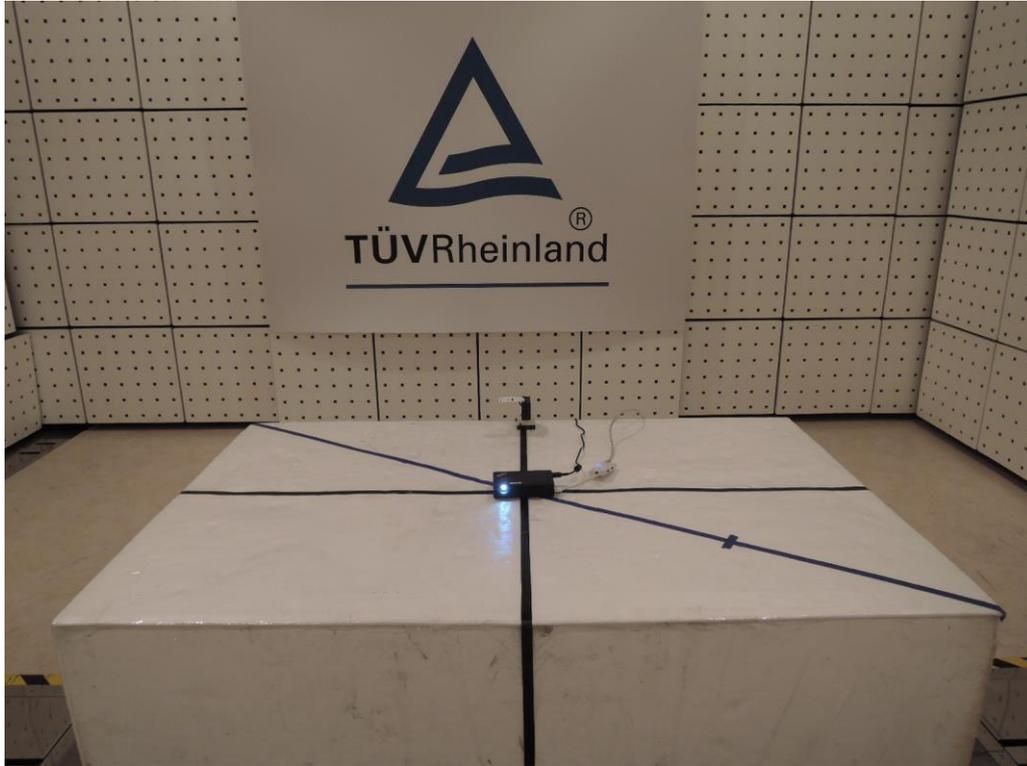
0.3-1.34 MHz (100) mW/cm²
 1.34-30 MHz (180/f²) mW/cm²
 30-300 MHz 0.2 mW/cm²
 300-1500 MHz f/1500 mW/cm²
1500-100,000 MHz 1.0 mW/cm²

Limit Canada: $0.02619f^{0.6834}$

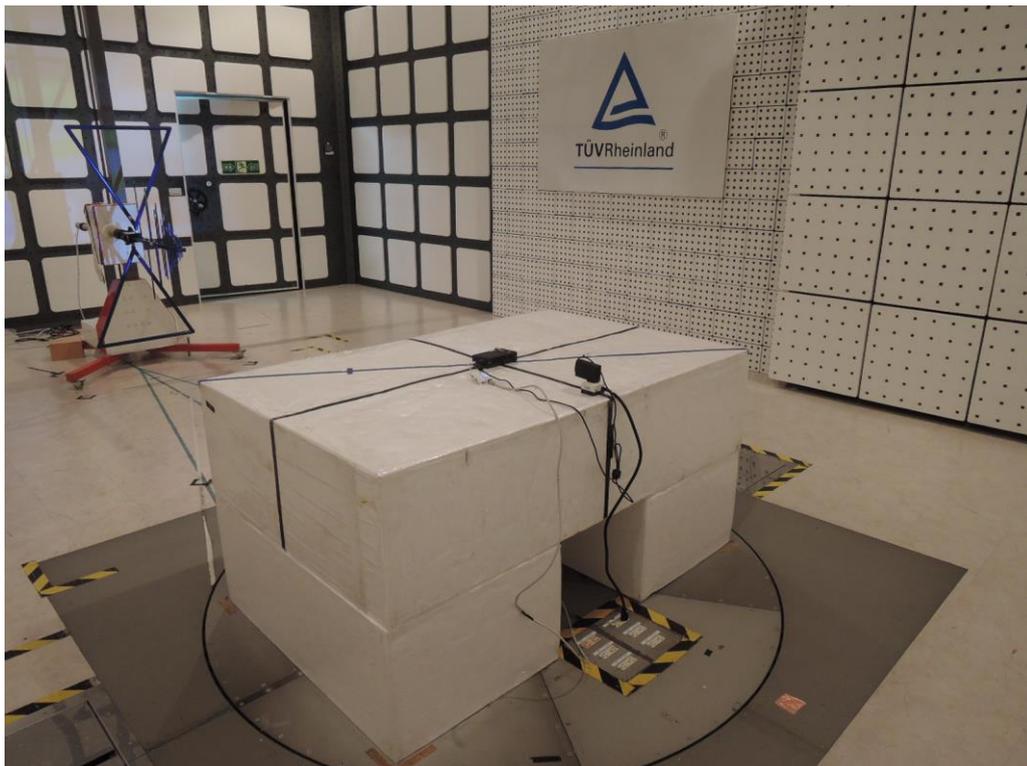
---End---

Photographs of the Test Set-Up

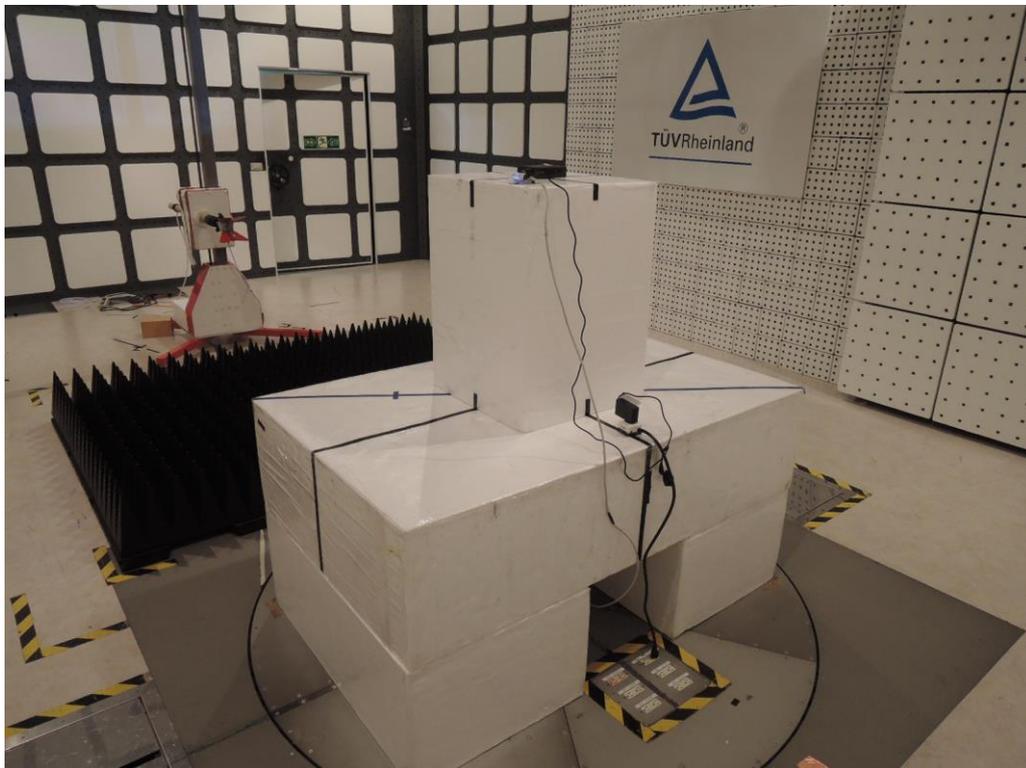
Photograph 1: Set-up for Spurious Emissions (Front View)



Photograph 2: Set-up for Spurious Emissions (Back View 1)



Photograph 3: Set-up for Spurious Emissions (Back View 2)



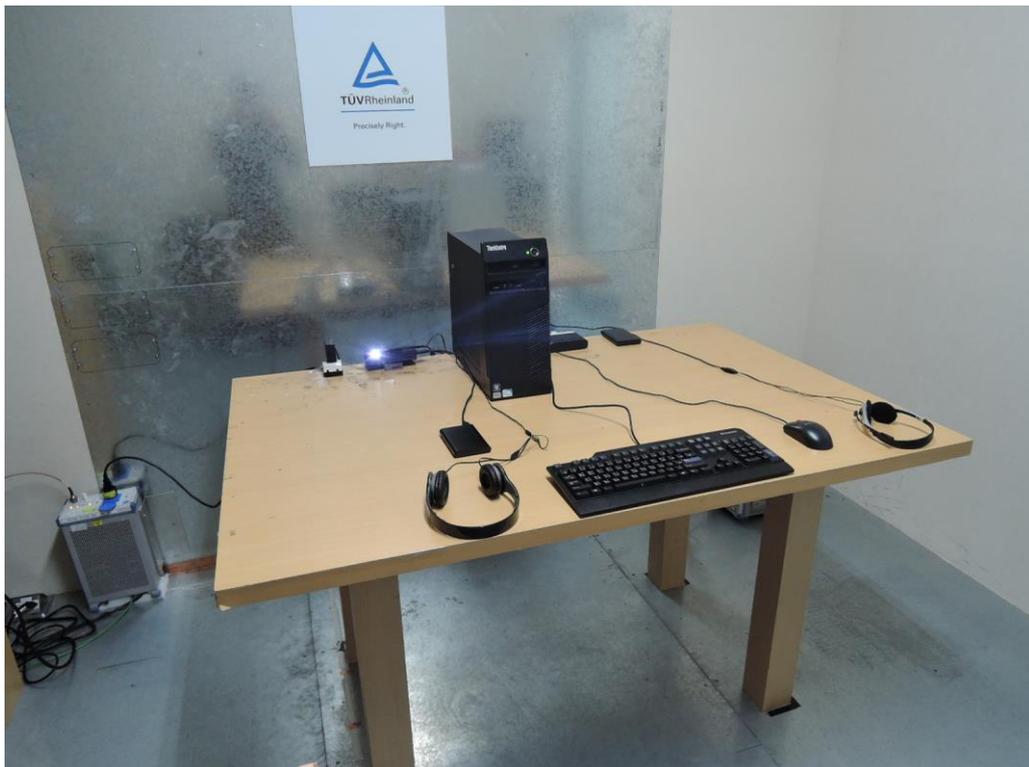
Photograph 4: Set-up for Conducted testing



Photograph 5: Set-up for for Mains Conducted testing Back



Photograph 6: Set-up for for Mains Conducted testing Front



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