

Nemko Korea Co., Ltd.

155 & 159, Osan-Ro, Mohyeon-Eup, Cheoin-Gu, Yongin-Si, Gyeonggi-Do 16885 KOREA, REPUBLIC OF
TEL:+82 31 330-1700 FAX:+82 31 322 2332

FCC and IC EVALUATION REPORT FOR CERTIFICATION

Applicant :

Anam Electronics Co., Ltd.
27, Digital-ro 27ga-gil, Guro-gu, Seoul,
08375, Republic of Korea.
Attn. : Byeong-Seob, Lee

Dates of Issue : March 14, 2019
Test Report No. : NK-19-R-008
Test Site : Nemko Korea Co., Ltd.

FCC ID
IC

MBBA118
11657A-A118

Brand Name

Linkplay

Contact Person

Anam Electronics Co., Ltd.
27, Digital-ro 27ga-gil, Guro-gu, Seoul, 08375,
Republic of Korea.
Byeong-Seob, Lee
Telephone No. : +82-2-6424-4881

Applied Standard: FCC 47 CFR Part 15.247 and IC RSS-247 Issue 2
Classification: Digital Transmission System (DTS)
EUT Type: Linkplay Wireless Smart Audio Module

The device bearing the brand name and model specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10-2013. The client should not use it to claim product endorsement by TAF or any government agencies. The test results in the report only apply to the tested sample.

I attest to the accuracy of data and all measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

 Mar 14, 2019

Tested By : Yonghwan Kim
Engineer

 Mar. 14, 2019

Reviewed By : Seungyong Shin
Technical Manager

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1. SCOPE

Measurement and determination of electromagnetic emissions (EME) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission under FCC part 15 and IC RSS-247 Issue2.

Responsible Party :	Anam Electronics Co., Ltd. 27, Digital-ro 27ga-gil, Guro-gu, Seoul, 08375, Republic of Korea
Contact Person :	Byeong Seob, Lee
Manufacturer :	Linkplay Technology, Inc. 5225 Canyon Crest Dr. Riverside, CA 92507, USA

- FCC ID: MBBA118
- IC: 11657A-A118
- Model: A118
- HVIN: A118
- Brand Name: Linkplay
- EUT Type: Linkplay Wireless Smart Audio Module
- Classification: Digital Transmission System (DTS)
- Applied Standard: FCC 47 CFR Part 15.247 and IC RSS-247 Issue 2
- Test Procedure(s): ANSI C63.10-2013
KDB 558074 D01 15.247 Meas Guidance v05
- Dates of Test: January 28, 2019 ~ February 19, 2019
- Place of Test: Nemko Korea Co., Ltd.

2. INTRODUCTION

2.1 Test facility

The measurement procedure described in 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 (ANSI C63.4-2014), the American National Standard for Testing Unlicensed Wireless Devices (ANSI C63.10-2013) was used in determining radiated and conducted emissions emanating from **Anam Electronics Co., Ltd. FCC ID : MBBA118** and **IC : 11657A-A118**.

These measurement tests were conducted at **Nemko Korea Co., Ltd. EMC Laboratory**.

The site address 155 & 159, Osan-Ro, Mohyeon-Eup, Cheoin-Gu, Yongin-Si, Gyeonggi-Do 16885 KOREA, REPUBLIC OF.

The area of Nemko Korea Corporation Ltd. EMC Test Site is located in a mountain area at 80 km (48 miles) southeast and Incheon International Airport (Incheon Airport), 30 km (18miles) south-southeast from central Seoul.

It is located in the valley surrounded by mountains in all directions where ambient radio signal conditions are quiet and a favorable area to measure the radio frequency interference on open field test site for the computing and ISM devices manufactures.

The detailed description of the measurement facility was found to be in compliance with the requirements of ANSI C63.4-2014 according to §2.948.



Nemko Korea Co., Ltd.
EMC Lab.
155 & 159, Osan-Ro, Mohyeon-Eup,
Cheoin-Gu, Yongin-Si, Gyeonggi-Do
16885 KOREA, REPUBLIC OF
Tel)+82-31-330-1700
Fax)+82-31-322-2332

Fig. 1. The map above shows the Seoul in Korea vicinity area.

The map also shows Nemko Korea Corporation Ltd. EMC Lab. and Incheon Airport.

2.2 Accreditation and listing

Accreditation type		Accreditation number
	CAB Accreditation for DOC	Designation No. KR0026
	KOLAS Accredited Lab. (Korea Laboratory Accreditation Scheme)	Registration No. 155
	Canada IC Registered site	Site No. 2040E
	VCCI registration site(RE/CE/Telecom CE)	Member No. 2118
	EMC CBTL	-
	KCC(RRL)Designated Lab.	Registration No. KR0026

3. TEST CONDITIONS & EUT INFORMATION

3.1 Operation During Test

The EUT is the transceiver which is module supporting the 802.11b/g/n mode (802.11b/g/n(20MHz) : 1TX/1RX).

The Laptop was used to control the EUT to transmit the wanted TX channel continuously (duty cycle< 98%) by the testing program (ADB) supported by manufacturer.

The operating voltage of EUT was 3.4 Vdc supplied from jig board connected to USB port on Laptop PC.

The EUT was tested at the lowest, middle and the highest channels with the maximum output power in accordance with the manufacturer's specifications. The worst data were recorded in the report.

3.1.1 Table of test power setting

Frequency	Mode	Power setting Level
2412 MHz ~ 2462 MHz	802.11b	17
	802.11g	15
	802.11n (20 MHz)	14

3.1.2 Table of test channels

Frequency band	Mode	Test Channel (CH)	Frequency (MHz)
2.4 GHz	802.11b,g,n (20 MHz)	1	2412
		6	2437
		11	2462

3.1.3 Antenna information

Frequency band	Mode	Data rate	Antenna TX mode	Support CDD	Support MIMO
2.4 GHz	802.11b,g	All	■ 1TX, □ 2TX	□ Yes, ■ No	□ Yes, ■ No
	802.11n (20MHz)	MCS 0~7	■ 1TX, □ 2TX	□ Yes, ■ No	□ Yes, ■ No

3.1.4 Additional Information Related to Testing

The cable and attenuator loss from 30MHz to 26.5GHz was reflected in spectrum analyzer with correction factor for all conducted testing.

3.1.5 Table of test modes

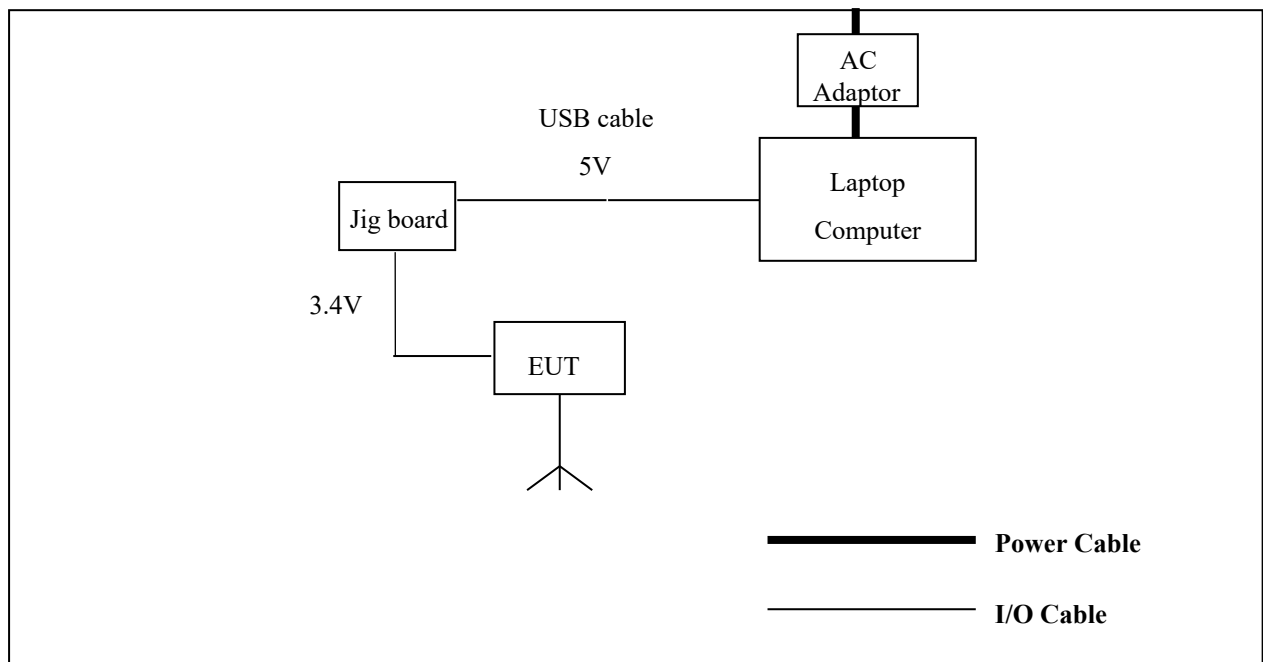
Test Items	Mode	*Data rate (Mbps)	Test Channel (CH)
Conducted Emissions	802.11b	5.5	13
Radiated Emissions	802.11b	5.5	6
6 dB Bandwidth	802.11b	5.5	1/6/11
	802.11g	36	1/6/11
	802.11n (20 MHz)	MCS4	1/6/11
Maximum Conducted Output Power	802.11b	5.5	1/6/11
	802.11g	36	1/6/11
	802.11n (20 MHz)	MCS4	1/6/11
Power Spectral Density	802.11b	5.5	1/6/11
	802.11g	36	1/6/11
	802.11n (20 MHz)	MCS4	1/6/11
Conducted Spurious Emission, Radiated Spurious Emission, Band edge Emission	802.11b	5.5	1/6/11
	802.11g	36	1/6/11
	802.11n (20 MHz)	MCS4	1/6/11

*The worst data rate was determined by the conducted output power that generates the highest emission performing pre-scan testing in all data rates of each mode.

3.2 Support Equipment

EUT	Anam Electronics Co., Ltd. Model : A118	S/N: N/A
Laptop Computer	HP Model : G62-355TU	FCC DOC S/N : CNF0489WDT
AC/DC Adapter	HP Model : PPP009D 1.5 m unshielded power cable	FCC DOC S/N : WBGSV0ACXZH162

3.3 Setup Drawing



3.4 EUT Information

The EUT is the **Anam Electronics Co., Ltd. Linkplay Wireless Smart Audio Module FCC ID: MBBA118, IC: 11657A-A118.**

Specifications:

EUT Type	Linkplay Wireless Smart Audio Module
Model Name	A118
Brand Name	Linkplay
Frequency of Operation	802.11b,g,n (20 MHz) : 2412 MHz ~ 2462 MHz
Maximum Conducted Output Power	802.11b : 16.44 dBm 802.11g : 14.10 dBm 802.11n (20 MHz) : 13.02 dBm
FCC Classification	Digital Transmission System (DTS)
Number of Channels	802.11b,g,n (20 MHz): 11 CH
Modulations	DSSS(BPSK,QPSK,CCK) for 802.11b OFDM(BPSK,QPSK,16QAM,64QAM) for 802.11g/n
Antenna Gain (peak)	5.6 dBi
Antenna Setup	802.11b/g/n (20MHz) : 1TX / 1RX
Voltage	3.4 Vdc
Temperature Range	-20 °C ~ +55 °C
Size (W x H x D)	About 42 mm x 10 mm x 54 mm
Weight	About 18 g
HVIN (Hardware Version Number)	A118
FVIN (Firmware Version Identification Number)	V3.6.6720
Remarks	-

4. SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specification:

Name of Test	FCC Paragraph No.	IC Paragraph No.	Result	Remark
Conducted Emission	15.207	RSS-GEN Issue 4 8.8	Complies	
Radiated Emission	15.209	RSS-GEN Issue 4 8.9	Complies	
6 dB Bandwidth	15.247(a)(2)	RSS-247 Issue 2 5.2	Complies	
Maximum Conducted Output Power	15.247(b)(3)	RSS-247 Issue 2 5.4	Complies	
Power Spectral Density	15.247(e)	RSS-247 Issue 2 5.2	Complies	
Conducted Spurious Emission	15.247(d)	RSS-247 Issue 2 5.5	Complies	
Radiated Spurious Emission	15.247(d)	RSS-247 Issue 2 5.5	Complies	
Maximum Permissible Exposure	1.1307(b)	RSS-102 Issue 5	Complies	

5. RECOMMENDATION/CONCLUSION

The data collected shows that the **Anam Electronics Co., Ltd. Linkplay Wireless Smart Audio Module FCC ID: MBBA118, IC: 11657A-A118** is in compliance with Part 15.247 of the FCC Rule and RSS-247 Issue 2 of the IC Specification.

6. ANTENNA REQUIREMENTS

§15.203 of the FCC Rules part 15 Subpart C

: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

The antenna of the **Anam Electronics Co., Ltd. Linkplay Wireless Smart Audio Module FCC ID: MBBA118, IC: 11657A-A118** is **permanently attached** and there are no provisions for connection to an external antenna. It complies with the requirement of §15.203.

Used Antenna	
Model name	Max. gain (dBi)
W619-1B235B-A	5.60
W619-1B110B-A2	4.87
W619-1B170B-A	5.60
W548-1G240B-A	5.42

7. DESCRIPTION OF TESTS

7.1 Conducted Emissions

The Line conducted emission test facility is located inside a 4 x 7 x 2.5 meter shielded enclosure. It is manufactured by EM engineering. The shielding effectiveness of the shielded room is in accordance with MIL-STD-285 or NSA 65-6. A 1 m x 1.5 m wooden table 0.8 m height is placed 0.4 m away from the vertical wall and 1.5 m away from the side of wall of the shielded room. Rohde & Schwarz (ESH3-Z5) and (ESH2-Z5) of the 50 ohm/50 μ H Line Impedance Stabilization Network (LISN) are bonded to the shielded room. The EUT is powered from the Rohde & Schwarz LISN (ESH3-Z5) and the support equipment is powered from the Rohde & Schwarz LISN (ESH2-Z5). Power to the LISNs are filtered by high-current high insertion loss Power line filters. The purpose of filter is to attenuate ambient signal interference and this filter is also bonded to shielded enclosure. All electrical cables are shielded by tinned copper zipper tubing with inner diameter of 1 / 2 ". If DC power device, power will be derived from the source power supply it normally will be powered from and this supply lines will be connected to the LISNs, All interconnecting cables more than 1 meter were shortened by non-inductive bundling (serpentine fashion) to a 1 meter length. Sufficient time for EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer to determine the frequency producing the maximum EME from the EUT. The spectrum was scanned from 150 kHz to 30 MHz with 200 msec sweep time. The frequency producing the maximum level was re-examined using the EMI test receiver. (Rohde & Schwarz ESCS30). The detector functions were set to CISPR quasi-peak mode & average mode. The bandwidth of receiver was set to 9 kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each EME emission. Each emission was maximized by; switching power lines; varying the mode of operation or resolution; clock or data exchange speed; scrolling H pattern to the EUT and of support equipment, and powering the monitor from the floor mounted outlet box and computer aux AC outlet, if applicable; whichever determined the worst case emission. Each EME reported was calibrated using the R&S signal generator.

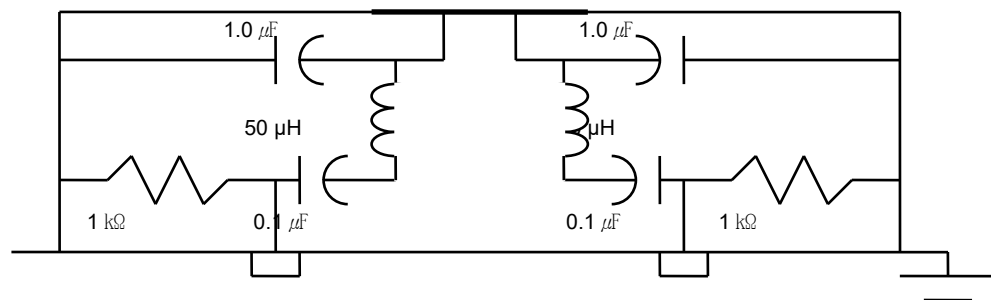


Fig. 2. LISN Schematic Diagram

7.2 Radiated Emissions

The measurement was performed at the test site that is specified in accordance with ANSI C63.10-2013.

The spurious emission was scanned from 9 kHz to 30 MHz using Loop Antenna(Rohde&Schwarz, HFH2-Z2) and 30 to 1000 MHz using Trilog broadband test antenna(Schwarzbeck, VULB 9163). Above 1 GHz, Horn antenna (Schwarzbeck BBHA 9120D: up to 18 GHz, Q-par Angus QSH20S20 : 18 to 26.5 GHz) was used.

For emissions testing at below 1GHz, The test equipment was placed on turntable with 0.8 m above ground. For emission measurements above 1 GHz, The test equipment was placed on turntable with 1.5 m above ground. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The EUT, cable, wire arrangement and mode of operation that has the highest amplitude relative to the limit was selected. Then, the turn table was rotated from 0° to 360° and an antenna mast was moved from 1 m to 4 m height to maximize the suspected highest amplitude signal. The final maximized level was recorded.

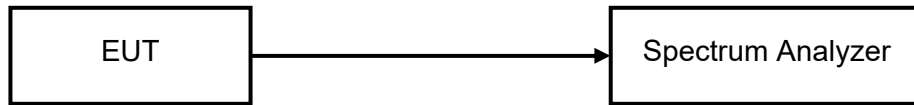
At frequencies below 1000 MHz, measurements performed using the CISPR quasi-peak detection. At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in ANSI 63.10-2013 section 11.12. Peak emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Trace mode = max hold. Average emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 1kHz, Detector = Peak, Trace mode = max hold. Allow max hold to run for at least 50 times (1/duty cycle) traces.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30
30–88	100	3
88–216	150	3
216–960	200	3
Above 960	500	3

Radiated Emissions Limits per 47 CFR 15.209(a) and RSS-GEN Issue 4 8.9

7.3 6 dB Bandwidth

Test Setup



Test Procedure

EUTs 6 dB bandwidth is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level. The spectrum analyzer setting is as follows.

RBW = 100 kHz

VBW > 3 x RBW

Detector = Peak

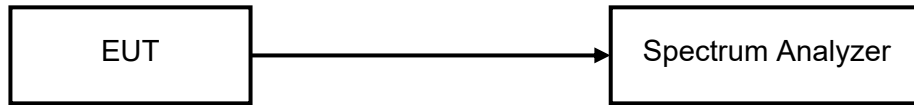
Trace mode = max hold

Sweep = auto couple

The bandwidth measurement function on the spectrum analyzer is used to measure the 6 dB bandwidth.

7.4 Maximum Conducted Output Power (average)

Test Setup



Test Procedure

EUTs Maximum Conducted Output Power (average) is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

Measure the duty cycle, x , of the transmitter output signal

Span to at least 1.5 times the OBW.

RBW = 1 – 5 % of the OBW, not to exceed 1MHz

VBW $\geq 3 \times$ RBW.

Number of points in sweep $\geq 2 \times$ span / RBW

Sweep time = auto couple

Detector = RMS

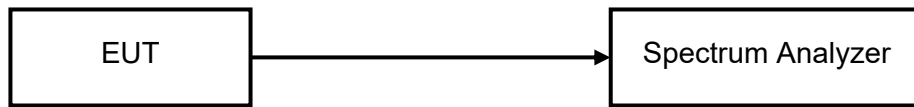
Trace average at least 100 traces in power averaging mode.

Add $10 \log (1/x)$, where x is the duty cycle

Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function, with band limits set equal to the OBW band edges.

7.5 Maximum Power Spectral Density (average)

Test Setup



Test Procedure

EUTs Maximum Power Spectral Density (average) is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

Center frequency = DTS channel center frequency

Span = at least 1.5 times the DTS bandwidth

RBW : 3 kHz $\leq$ RBW $\leq$ 100 kHz

VBW $\geq$ 3 x RBW

Detector = power averaging (RMS)

Ensure that the number of measurement points = sweep $\geq$ 2 x span / RBW

Sweep time = auto couple

Employ trace averaging (RMS) = minimum of 100 traces

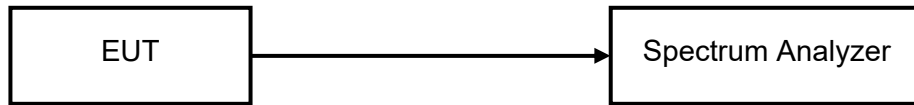
Add 10 log (1/x), where x is the duty cycle

Use the peak marker function to determine the maximum amplitude level.

If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

7.6 Conducted Spurious Emissions

Test Setup



Test Procedure

EUTs Conducted spurious emissions are measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level. The spectrum analyzer setting is as follows.

1) Reference Level

Center frequency = DTS channel center frequency

Span $\geq 1.5 \times$ DTS bandwidth

RBW = 100 kHz

VBW $\geq 3 \times$ RBW

Detector = peak

Sweep time = auto couple

Trace mode = max hold

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum PSD level.

Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

2) Unwanted Emissions

Set the center frequency and span to encompass frequency range to be measured.

RBW = 100 kHz

VBW $\geq 3 \times$ RBW

Detector = peak

Sweep time = auto couple

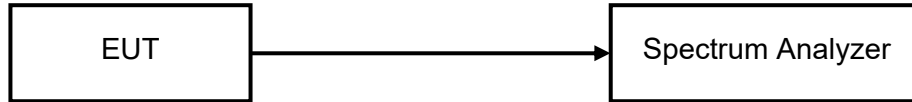
Trace mode = max hold

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum amplitude level.

7.7 Duty Cycle

Test Setup



Test Procedure

EUTs duty cycle are measured at middle channel with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level. The spectrum analyzer setting is as follows.

Center frequency = Center frequency of the transmission

Span = zero

RBW = 8 MHz

VBW = 8 MHz

Detector = peak

Sweep time = at least 3 ms

Sweep mode = Single

The marker function on the spectrum analyzer is used to determine the duty cycle.

The results of the duty cycle measurement according to the above test procedure.

	Data rate	On time (ms)	On + Off time (ms)	Duty Cycle (%)	Duty Factor (dB)
b mode	5.5Mbps	1.681	1.846	91.1	0.407
g mode	36Mbps	0.252	0.423	59.6	2.249
n(20MHz)mode	MCS4	0.247	0.419	58.9	2.295

8. TEST DATA

8.1 Conducted Emissions

FCC §15.207, RSS-GEN Issue 4 8.8

Result

Frequency (MHz)	Level (dB μ V)		*) Factor (dB)	**) Line	Limit (dB μ V)		Margin (dB)	
	Q-Peak	Average			Q-Peak	Average	Q-Peak	Average
0.15	55.0	44.4	10.50	N	65.8	55.8	10.8	11.4
0.16	55.9	45.2	10.50	N	65.4	55.4	9.5	10.2
0.23	46.6	38.5	10.50	L	62.3	52.3	15.7	13.8
0.31	37.0	30.4	10.50	L	60.0	50.0	23.0	19.6
0.39	29.9	17.9	10.50	N	58.1	48.1	28.2	30.2
11.39	36.2	29.0	11.00	L	60.0	50.0	23.8	21.0

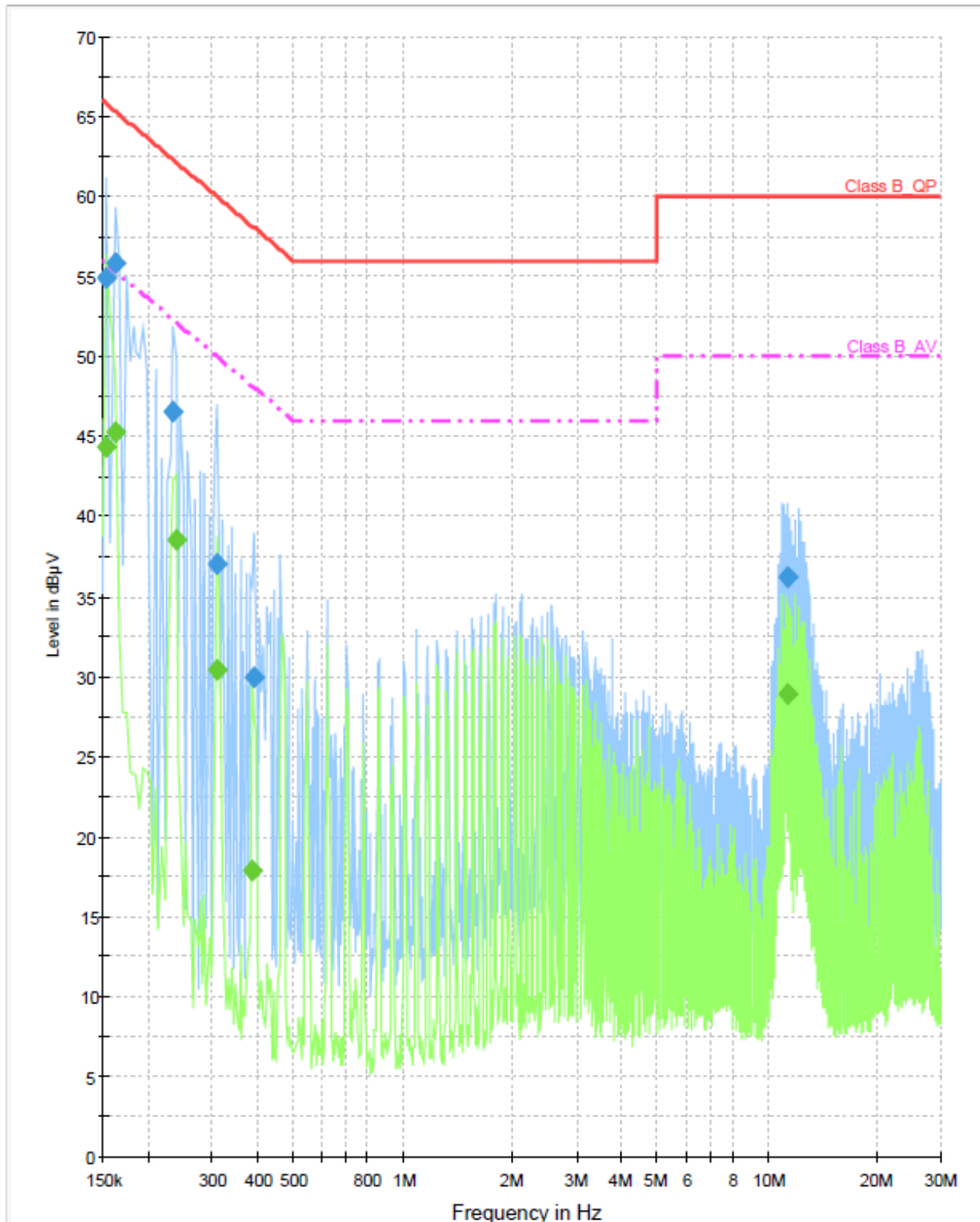
Line Conducted Emissions Tabulated Data

Notes:

1. Measurements using CISPR quasi-peak mode & average mode.
2. All modes of operation were investigated and the worst -case emission are reported. See attached Plots.
3. *) Factor = LISN + Cable Loss
4. **) LINE : L = Line , N = Neutral
5. The limit is on the FCC §15.207(a) and IC RSS-GEN issue4 8.8.

PLOTS OF EMISSIONS

Conducted Emission at the Mains port (Line + Neutral)_b mode 2472MHz



TEST DATA

8.2 Radiated Emissions

FCC §15.209, IC RSS-Gen Issue 4 8.9

Result

Frequency	Reading	Pol*	Antenna Heights	Turntable	AF+CL+Amp	Result	Limit	Margin
(MHz)	(dBμV/m)	(H/V)	(cm)	Angles (°)	(dB)**	(dBμV/m)	(dBμV/m)	(dB)
104.47	53.56	H	277	248	-23.6	30.0	43.5	13.5
110.94	56.69	H	230	272	-23.9	32.8	43.5	10.7
111.86	56.23	H	211	250	-24.0	32.2	43.5	11.3
122.10	67.28	H	296	246	-25.9	41.4	43.5	2.1
141.60	60.43	H	226	6	-27.2	33.2	43.5	10.3
143.44	59.69	H	230	1	-27.3	32.4	43.5	11.1

Radiated Measurements at 3meters

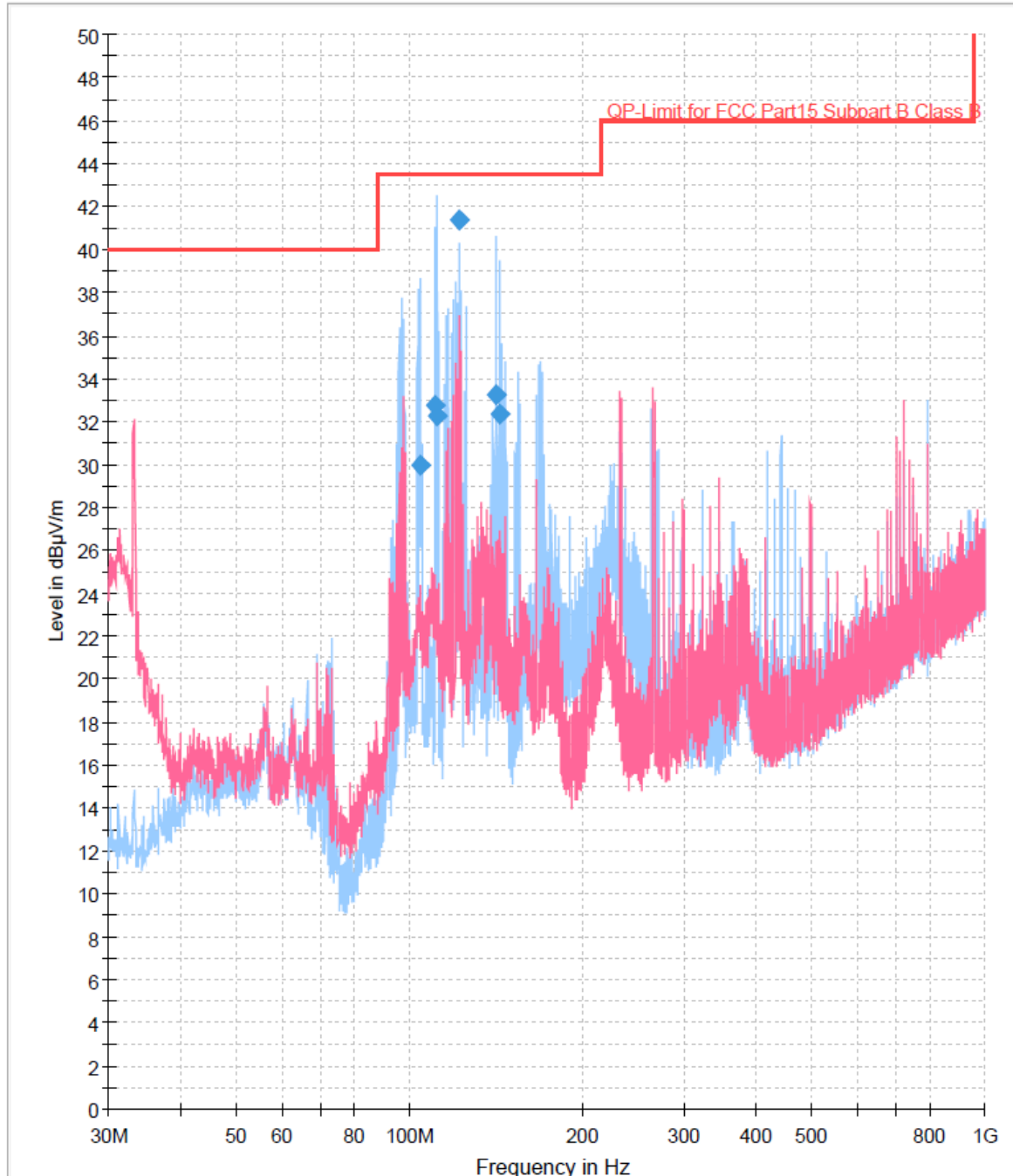
Notes:

1. All modes were measured and the worst-case emission was reported.
2. *Pol. H = Horizontal, V = Vertical
3. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
4. Measurements using CISPR quasi-peak mode below 1 GHz.
5. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.
6. 6 channel (2437MHz) in b mode is the worst case.
7. No emission found between lowest internal used/generated frequency to 30MHz (9kHz~30MHz).
8. The limit is on the FCC §15.209 and RSS-Gen Issue4 8.9.

PLOTS OF EMISSIONS

Worst Case

Radiated emission below 1GHz_ b mode 2437 MHz



TEST DATA

8.3 6 dB Bandwidth

FCC §15.247(a)(2), IC RSS-247 Issue 2 5.2

Test Mode : Set to Lowest channel, Middle channel and Highest channel,

802.11b mode

Channel	Frequency (MHz)	6 dB modulated bandwidth (MHz)	Limit (MHz)	Margin (MHz)	99% emission bandwidth (MHz)
Lowest	2412	9.78	0.50	9.28	12.41
Middle	2442	9.85	0.50	9.35	12.44
Highest	2462	9.89	0.50	9.39	12.53

802.11g mode

Channel	Frequency (MHz)	6 dB modulated bandwidth (MHz)	Limit (MHz)	Margin (MHz)	99% emission bandwidth (MHz)
Lowest	2412	16.02	0.50	15.52	16.35
Middle	2442	15.88	0.50	15.38	16.35
Highest	2462	15.95	0.50	15.45	16.35

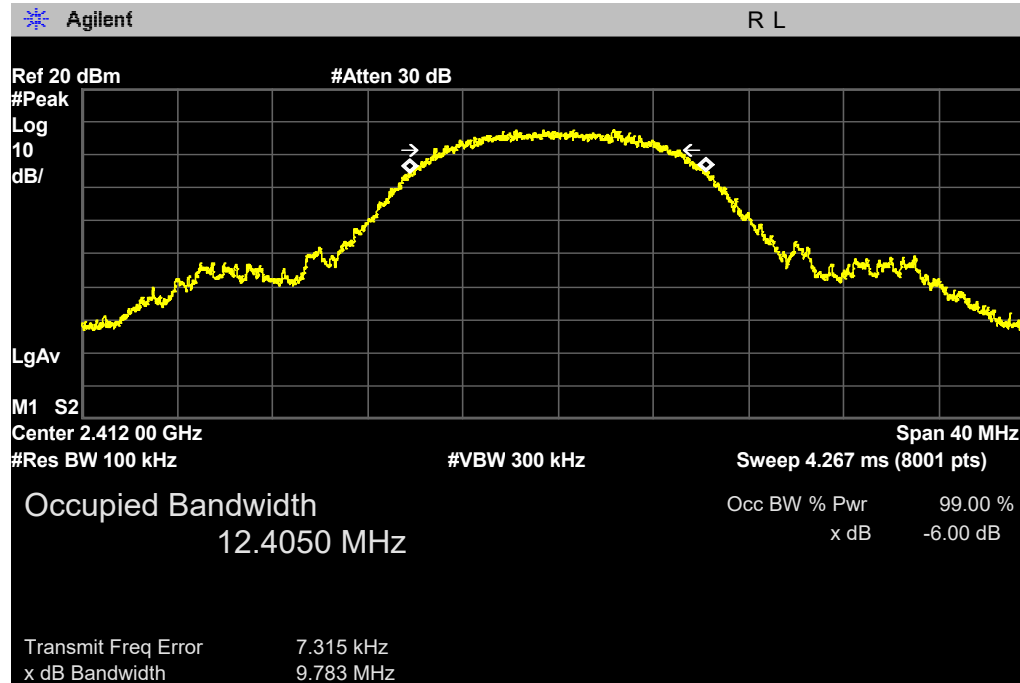
802.11n (20 MHz) mode

Channel	Frequency (MHz)	6 dB modulated bandwidth (MHz)	Limit (MHz)	Margin (MHz)	99% emission bandwidth (MHz)
Lowest	2412	16.30	0.50	15.80	17.52
Middle	2442	16.34	0.50	15.84	17.51
Highest	2462	15.40	0.50	14.90	17.53

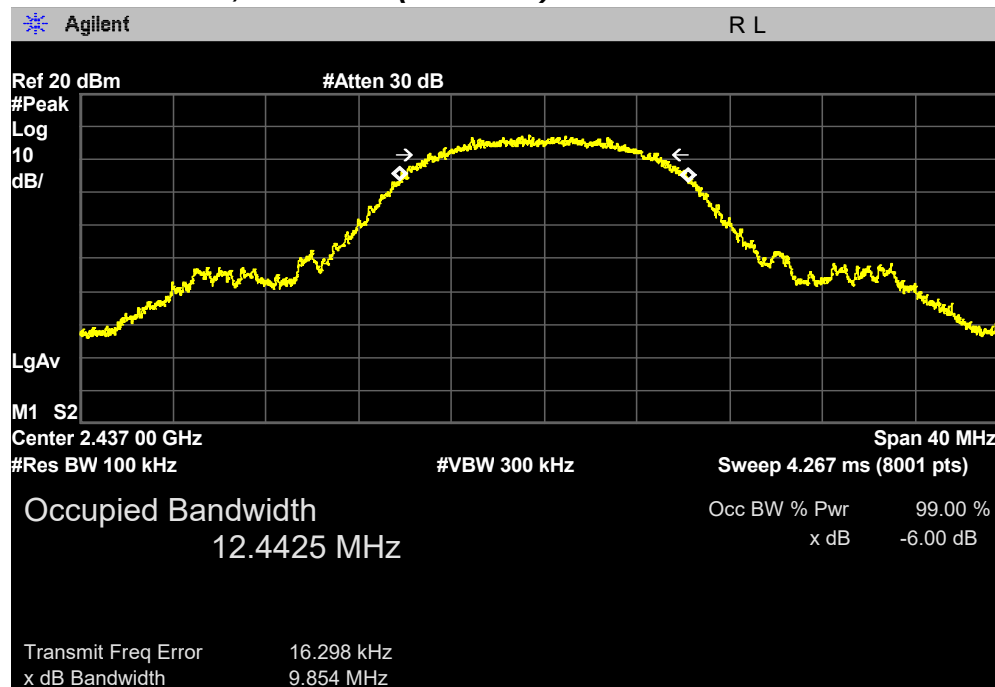
PLOTS OF EMISSIONS

802.11b mode

6 dB Bandwidth, 1 Channel (2412 MHz)

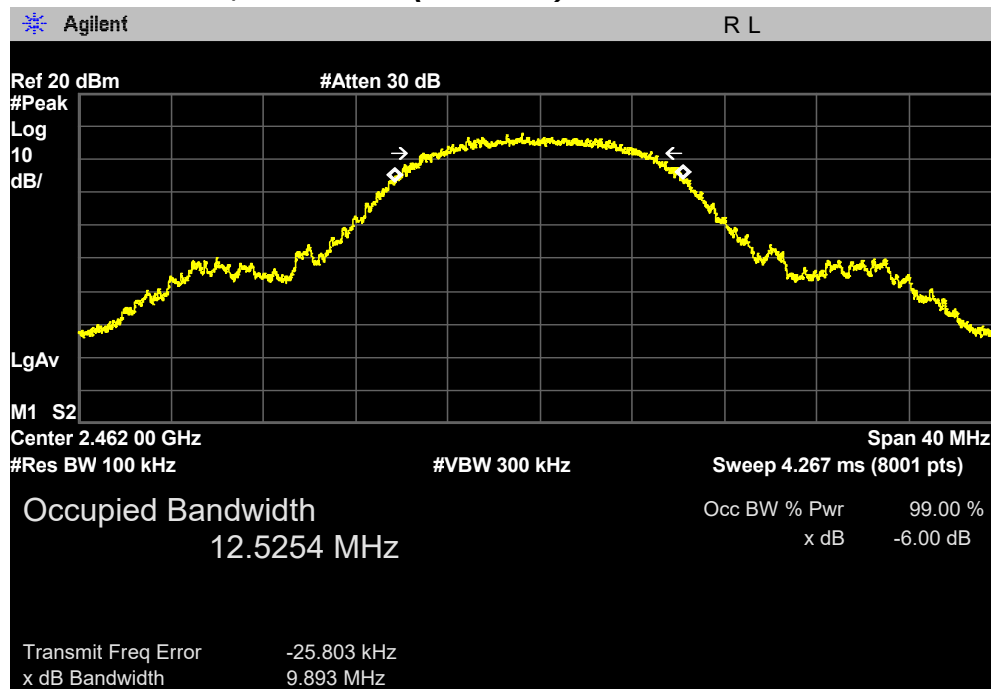


6 dB Bandwidth, 6 Channel (2437 MHz)



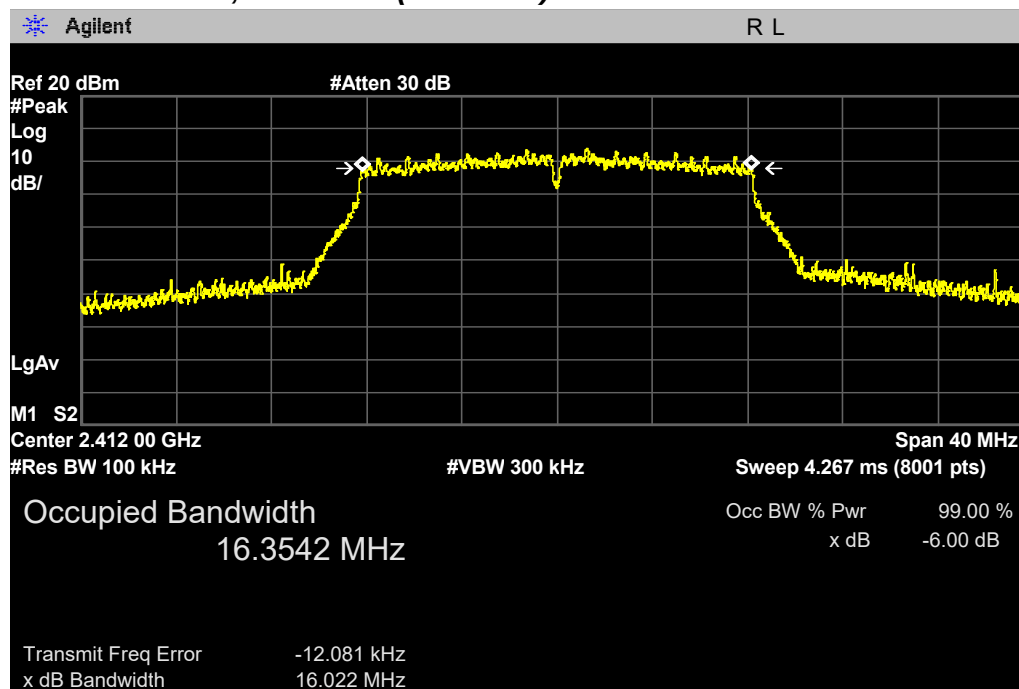
PLOTS OF EMISSIONS

6 dB Bandwidth, 11 Channel (2462 MHz)



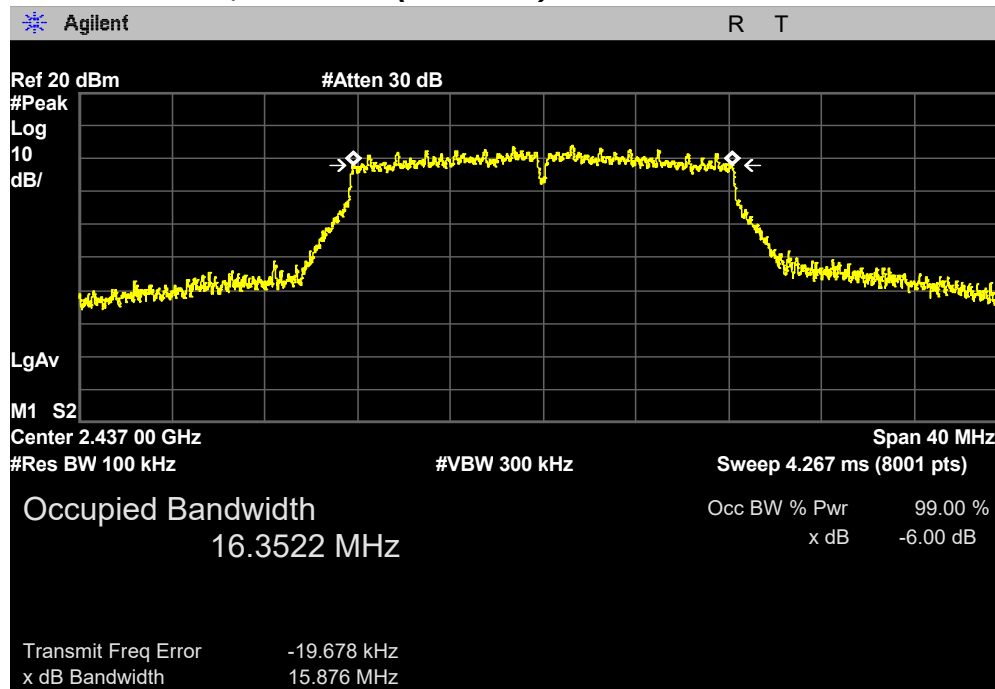
802.11g mode

6 dB Bandwidth, 1 Channel (2412 MHz)

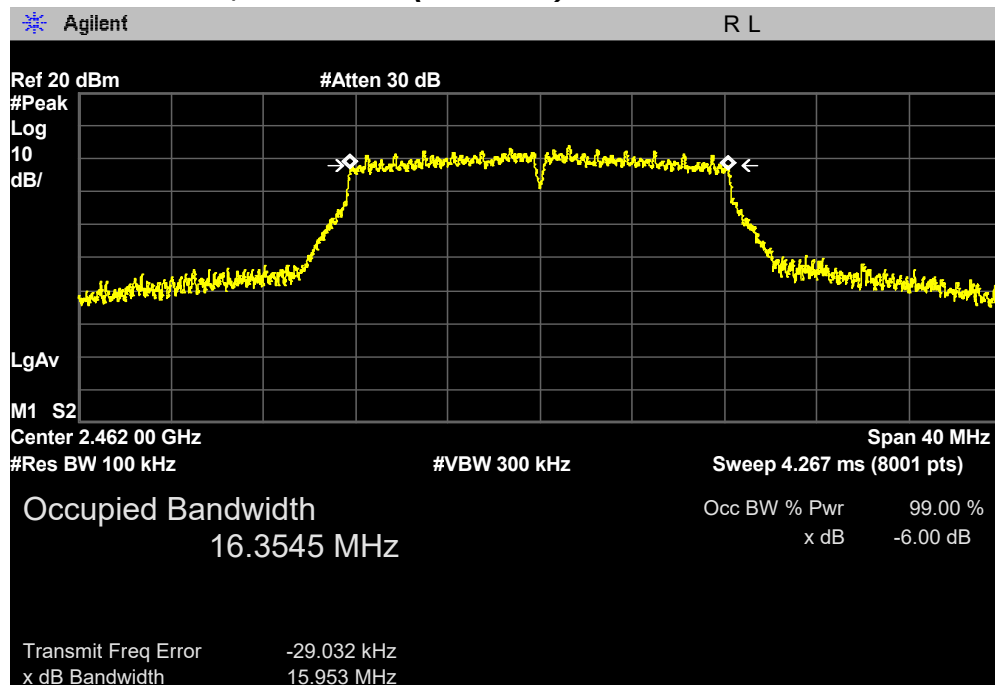


PLOTS OF EMISSIONS

6 dB Bandwidth, 6 Channel (2437 MHz)



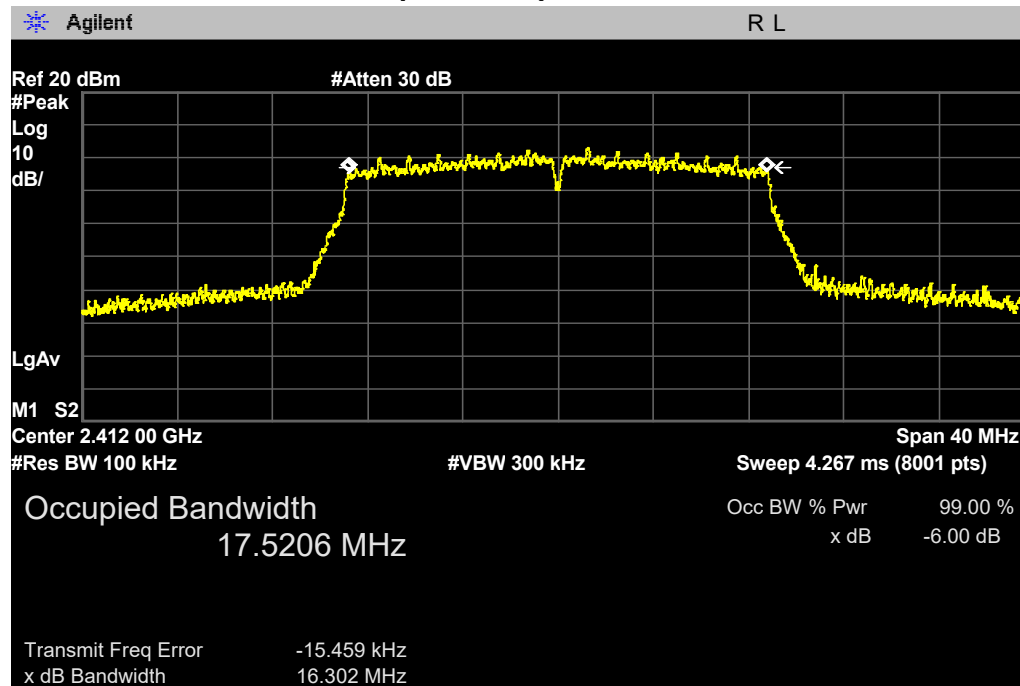
6 dB Bandwidth, 11 Channel (2462 MHz)



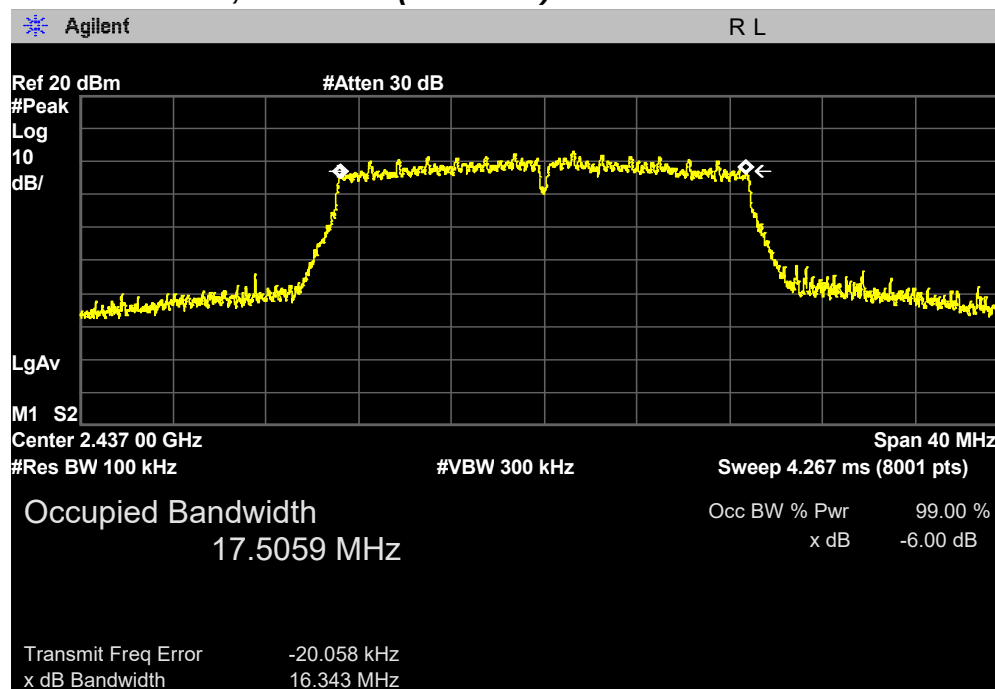
PLOTS OF EMISSIONS

802.11n (20 MHz) mode

6 dB Bandwidth, 1 Channel (2412 MHz)

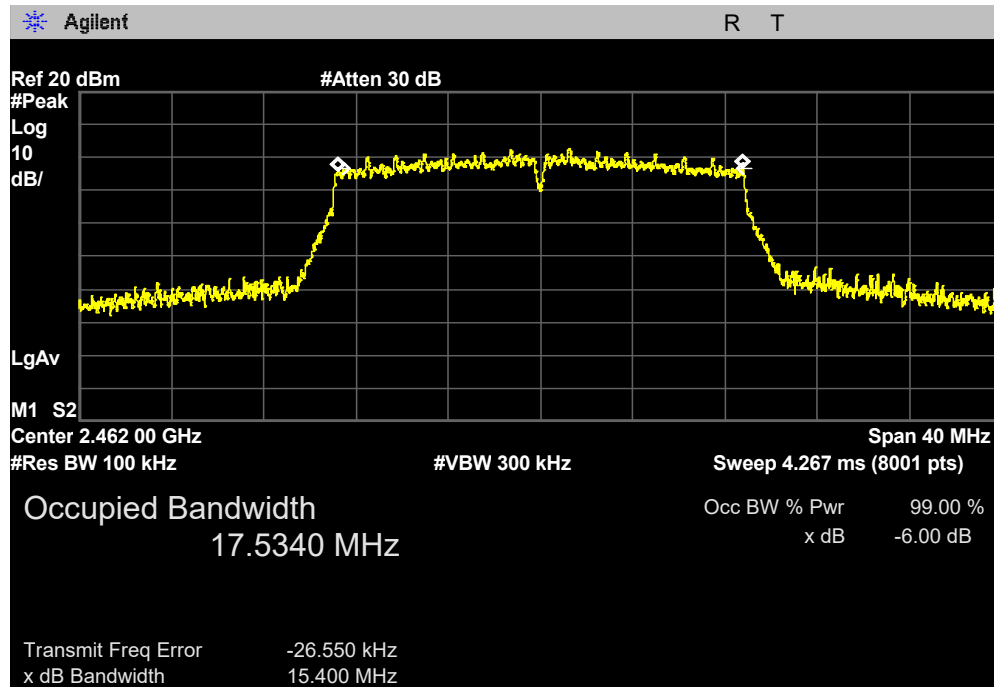


6 dB Bandwidth, 6 Channel (2437 MHz)



PLOTS OF EMISSIONS

6 dB Bandwidth, 11 Channel (2462 MHz)



TEST DATA

8.4 Maximum Conducted Output Power (average) and E.I.R.P

FCC §15.247(b)(3), IC RSS-247 Issue 2 5.4

Test Mode : Set to Lowest channel, Middle channel and Highest channel,

802.11b mode

Channel	Frequency (MHz)	Measured conducted power (dBm)	Duty Factor (dB)	*Maximum Conducted Power (dBm)	Limit (dBm)	E.I.R.P (dBm)	E.I.R.P Limit (dBm)
1	2412	16.03	0.41	16.44	30.00	22.04	36.00
6	2437	15.74	0.41	16.15	30.00	21.75	36.00
11	2462	15.86	0.41	16.27	30.00	21.87	36.00

802.11g mode

Channel	Frequency (MHz)	Measured conducted power (dBm)	Duty Factor (dB)	*Maximum Conducted Power (dBm)	Limit (dBm)	E.I.R.P (dBm)	E.I.R.P Limit (dBm)
1	2412	11.80	2.25	14.05	30.00	19.65	36.00
6	2437	11.85	2.25	14.10	30.00	19.70	36.00
11	2462	11.60	2.25	13.85	30.00	19.45	36.00

TEST DATA

802.11n (20MHz) mode

Channel	Frequency (MHz)	Measured conducted power (dBm)	Duty Factor (dB)	*Maximum Conducted Power (dBm)	Limit (dBm)	E.I.R.P (dBm)	E.I.R.P Limit (dBm)
1	2412	10.72	2.30	13.02	30.00	18.62	36.00
6	2437	10.65	2.30	12.95	30.00	18.55	36.00
11	2462	10.42	2.30	12.72	30.00	18.32	36.00

Note:

1. *Maximum Conducted (average) Power = Measured conducted power + Duty Factor

2. E.I.R.P was calculated by following equation according to KDB412172 D01 Determining ERP and EIRP v01r01.

$$E.I.R.P = P_T + G_T - L_C$$

P_T = Peak output power (dBm)

G_T = Gain of the transmitting antenna in dBi, Directional antenna gain is **5.6 dBi**.

L_C = Signal attenuation in the connecting cable between the transmitter and antenna in dB. This factor of an integral antenna is negligible.

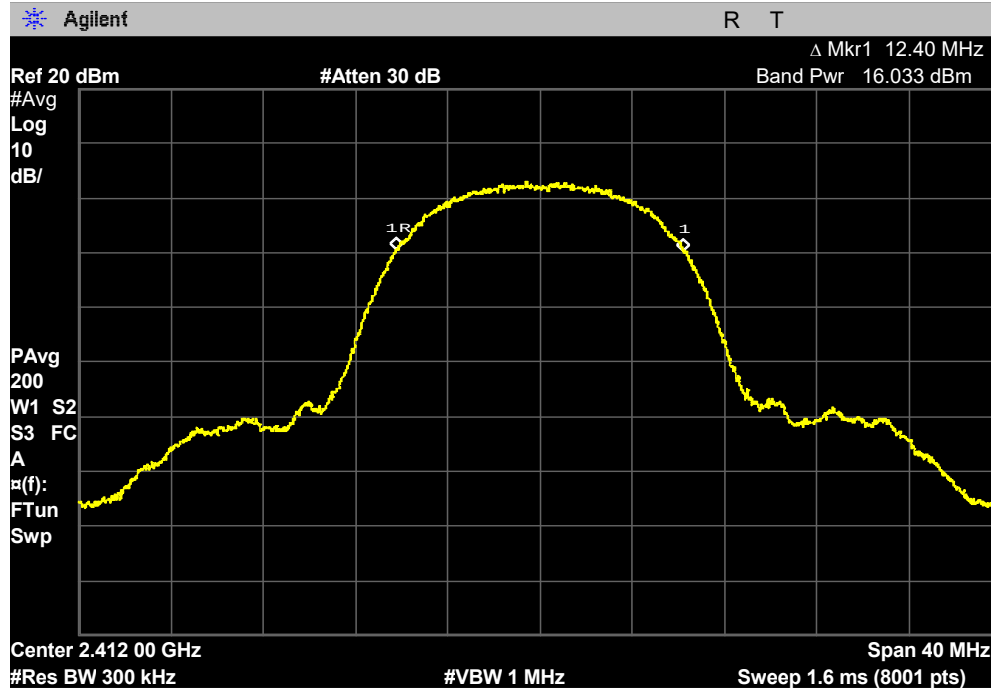
5. The following equation was used for spectrum offset:

$$\text{Spectrum offset (dB)} = \text{Attenuator (dB)} + \text{Cable Loss (dB)} + \text{SMA Type Connector Loss (dB)}$$

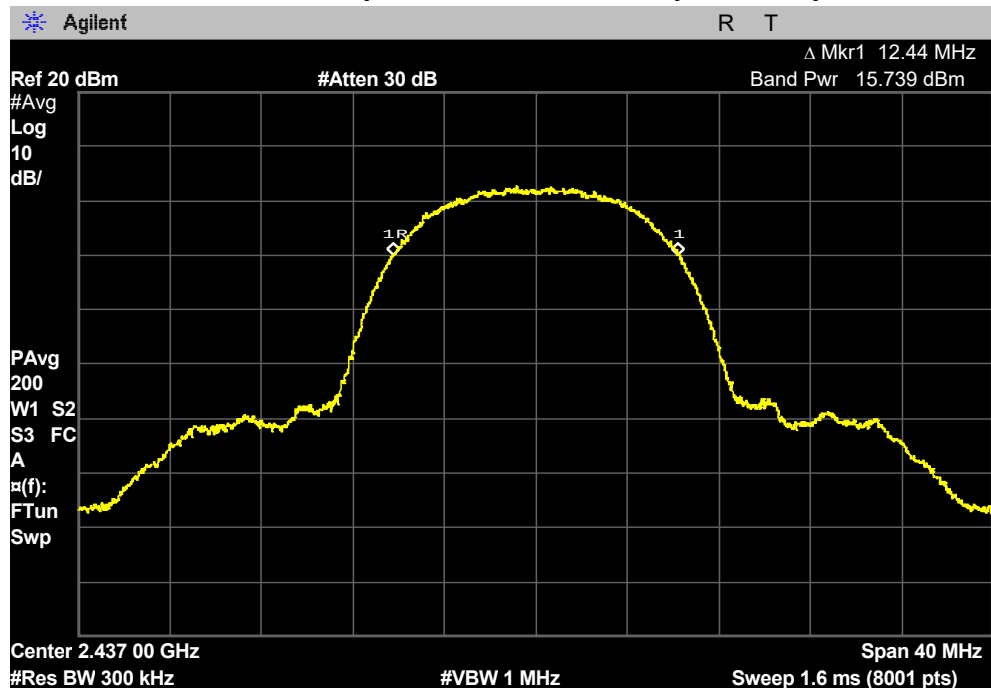
PLOTS OF EMISSIONS

802.11b mode

Maximum Conducted Output Power, 1 Channel (2412 MHz)

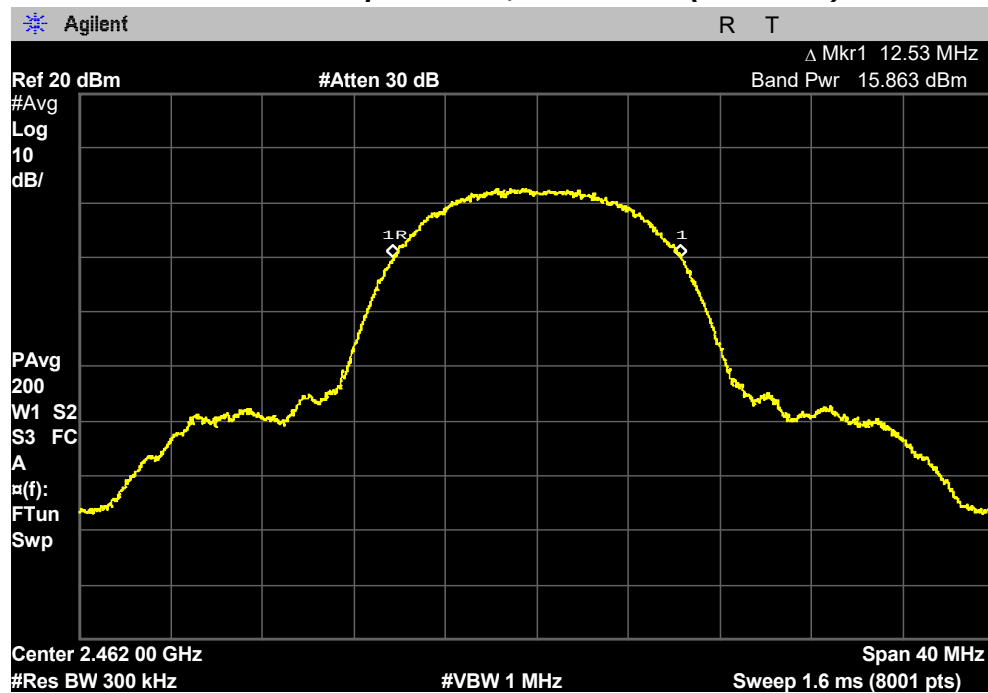


Maximum Conducted Output Power, 6 Channel (2437 MHz)



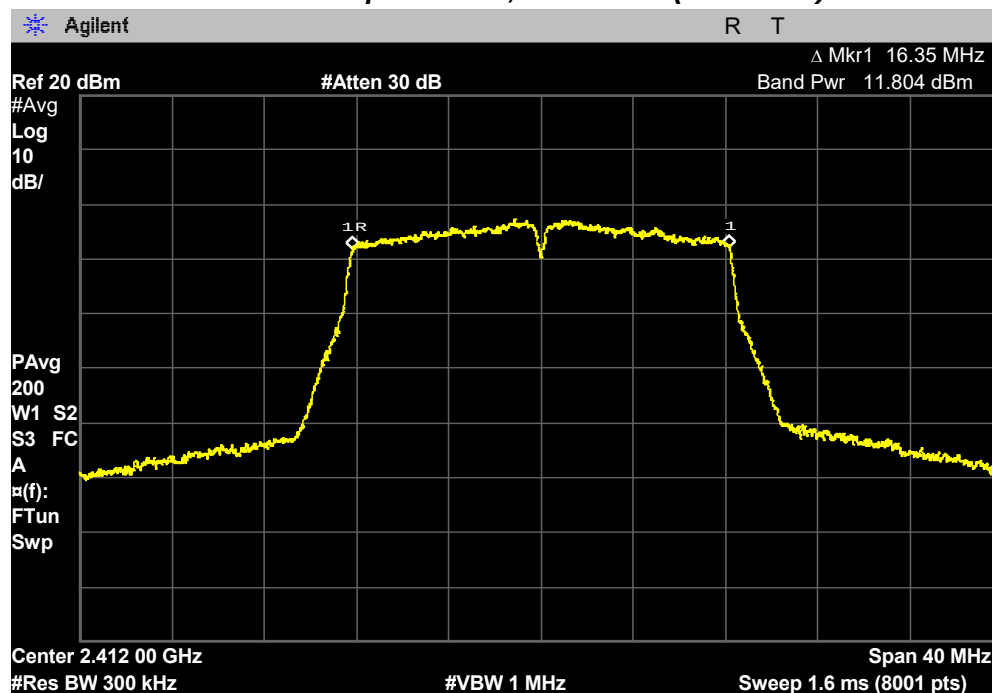
PLOTS OF EMISSIONS

Maximum Conducted Output Power, 11 Channel (2462 MHz)



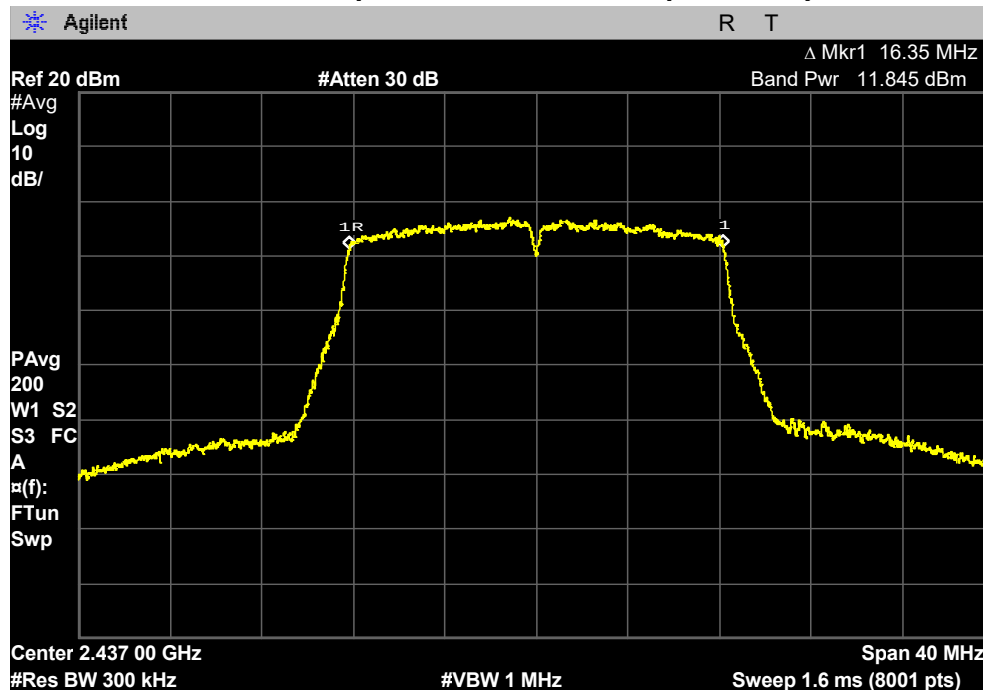
802.11g mode

Maximum Conducted Output Power, 1 Channel (2412 MHz)

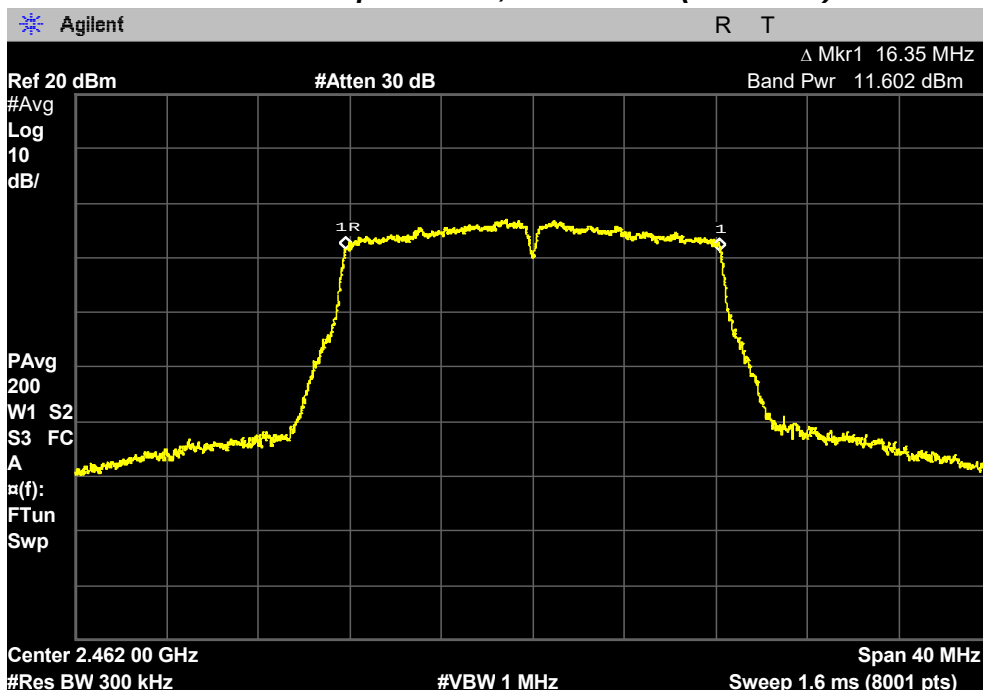


PLOTS OF EMISSIONS

Maximum Conducted Output Power, 6 Channel (2437 MHz)



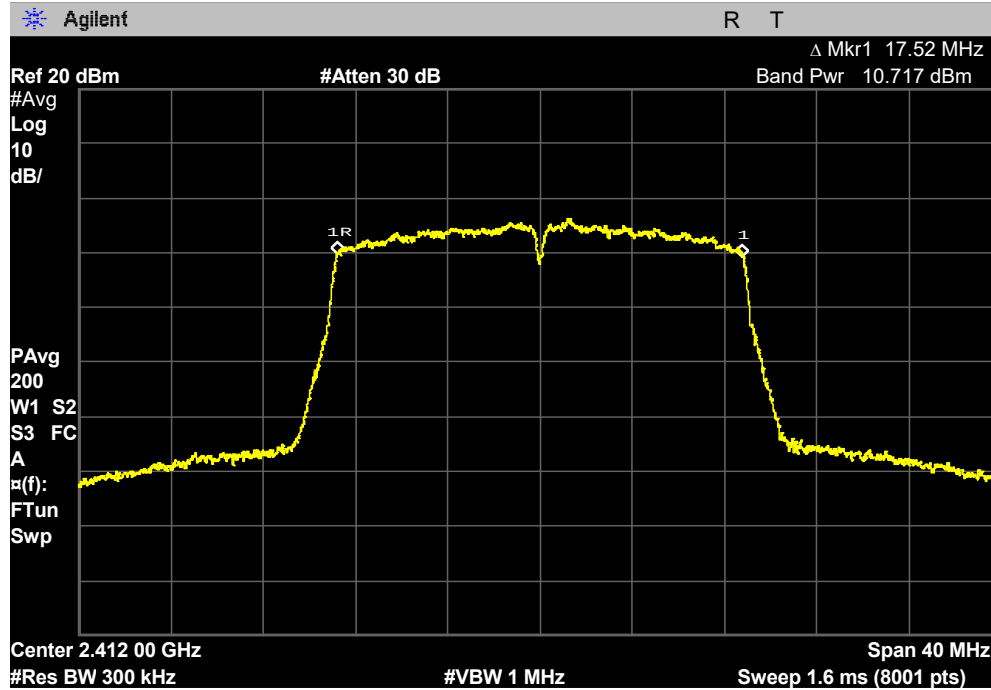
Maximum Conducted Output Power, 11 Channel (2462 MHz)



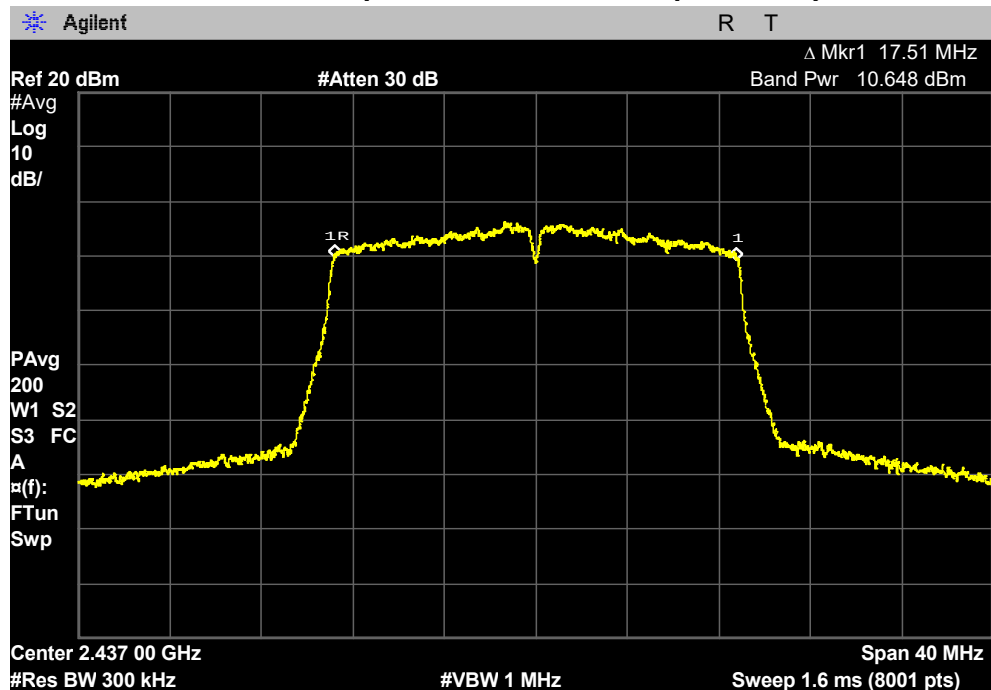
PLOTS OF EMISSIONS

802.11n (20 MHz) mode

Maximum Conducted Output Power, 1 Channel (2412 MHz)

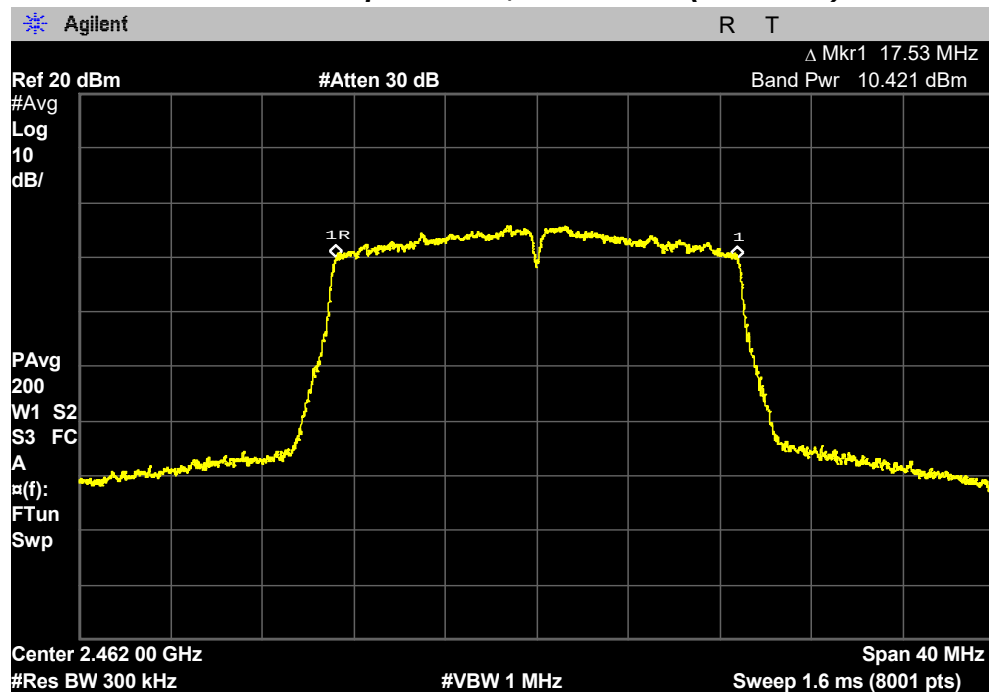


Maximum Conducted Output Power, 6 Channel (2437 MHz)



PLOTS OF EMISSIONS

Maximum Conducted Output Power, 11 Channel (2462 MHz)



TEST DATA

8.5 Maximum Power Spectral Density (average)

FCC §15.247(e), IC RSS-247 Issue 2 5.2

Test Mode : Set to Lowest channel, Middle channel and Highest channel.

802.11b mode

Channel	Frequency (MHz)	Measured PSD (dBm/100kHz)	Duty Factor (dB)	*Maximum PSD (dBm/100kHz)	Limit (dBm/3kHz)
1	2412	-1.52	0.41	-1.11	8.00
6	2437	-2.43	0.41	-2.02	8.00
11	2462	-1.89	0.41	-1.48	8.00

802.11g mode

Channel	Frequency (MHz)	Measured PSD (dBm/100kHz)	Duty Factor (dB)	*Maximum PSD (dBm/100kHz)	Limit (dBm/3kHz)
1	2412	-6.49	2.25	-4.24	8.00
6	2437	-6.26	2.25	-4.01	8.00
11	2462	-6.34	2.25	-4.09	8.00

TEST DATA

802.11n (20 MHz) mode

Channel	Frequency (MHz)	Measured PSD (dBm/100kHz)	Duty Factor (dB)	*Maximum PSD (dBm/100kHz)	Limit (dBm/3kHz)
1	2412	-7.31	2.30	-5.02	8.00
6	2437	-7.31	2.30	-5.02	8.00
11	2462	-7.75	2.30	-5.46	8.00

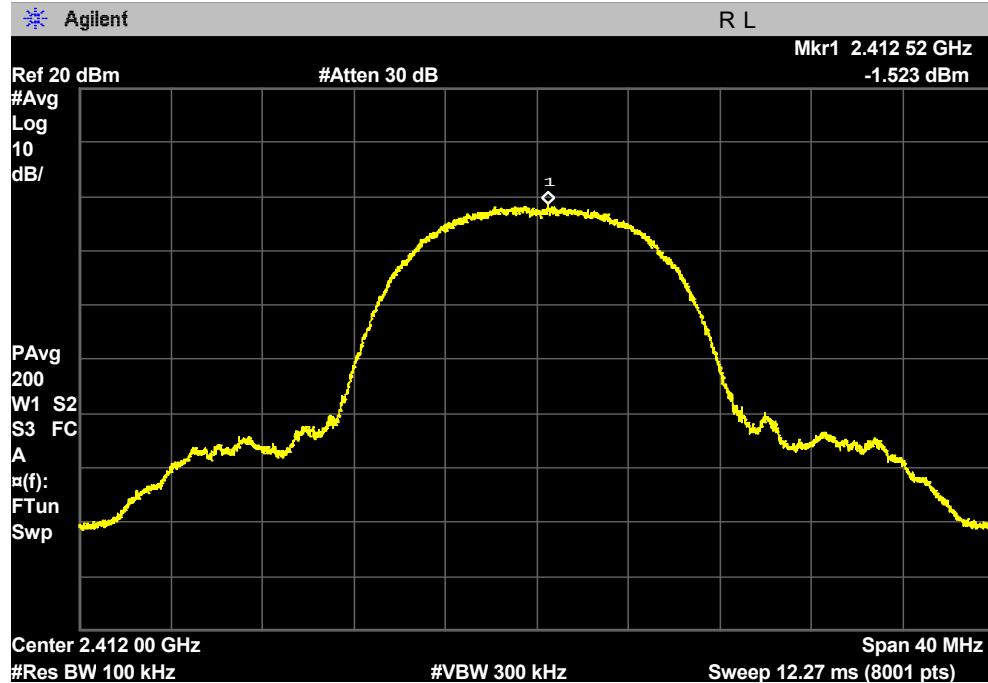
Note:

1. *Maximum PSD = Measured PSD + Duty Factor
2. The following equation was used for spectrum offset:
$$\text{Spectrum offset (dB)} = \text{Attenuator (dB)} + \text{Cable Loss (dB)} + \text{SMA Type Connector Loss (dB)}$$

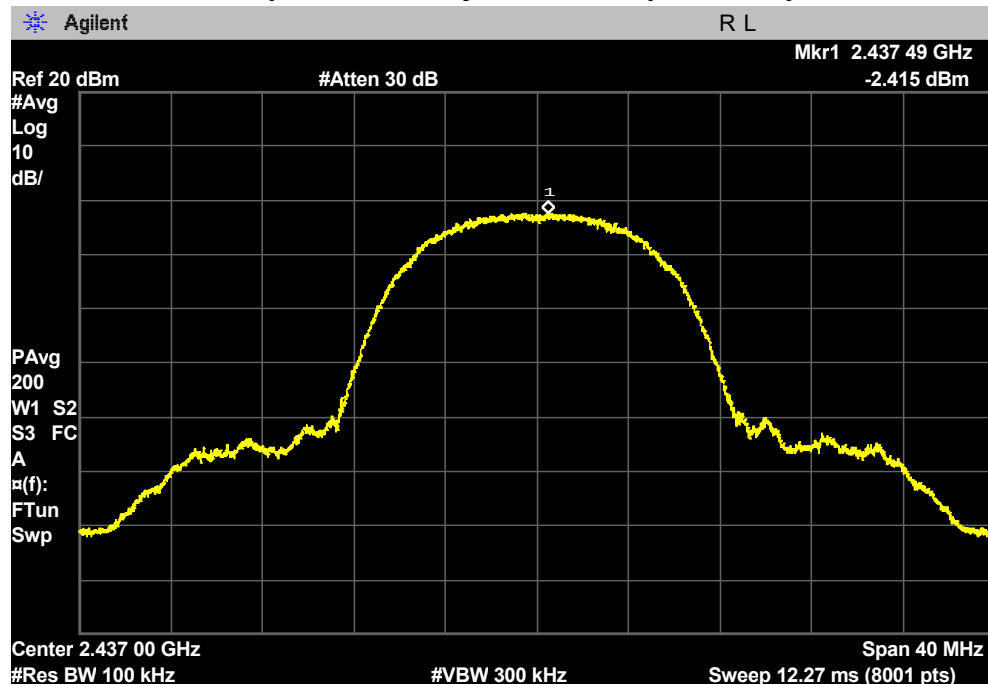
PLOTS OF EMISSIONS

802.11b mode

Maximum Power Spectral Density, 1 Channel (2412 MHz)

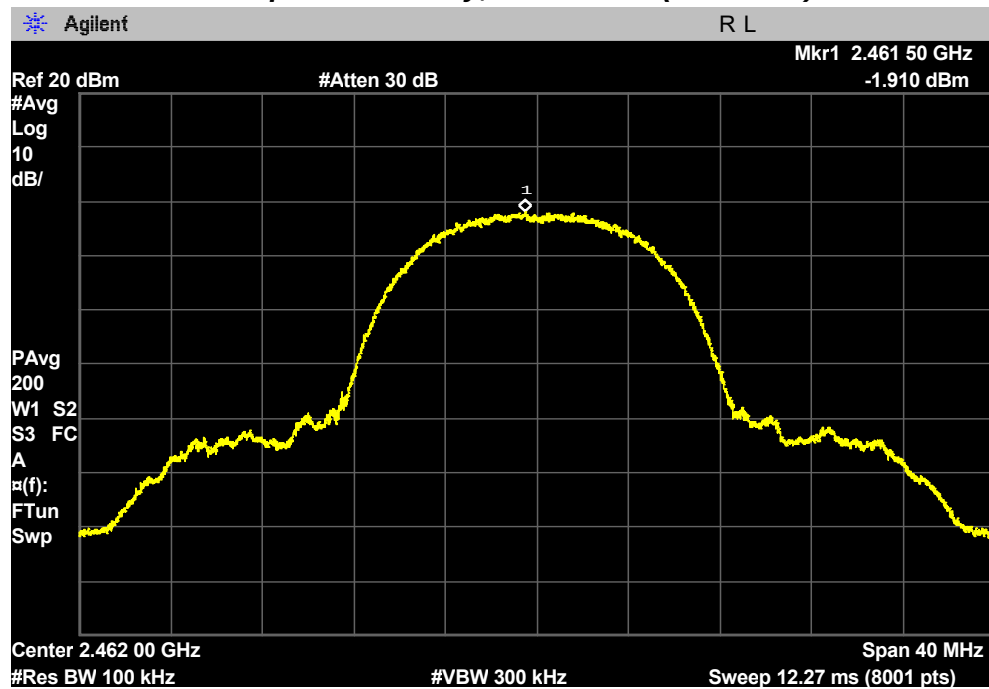


Maximum Power Spectral Density, 6 Channel (2437 MHz)



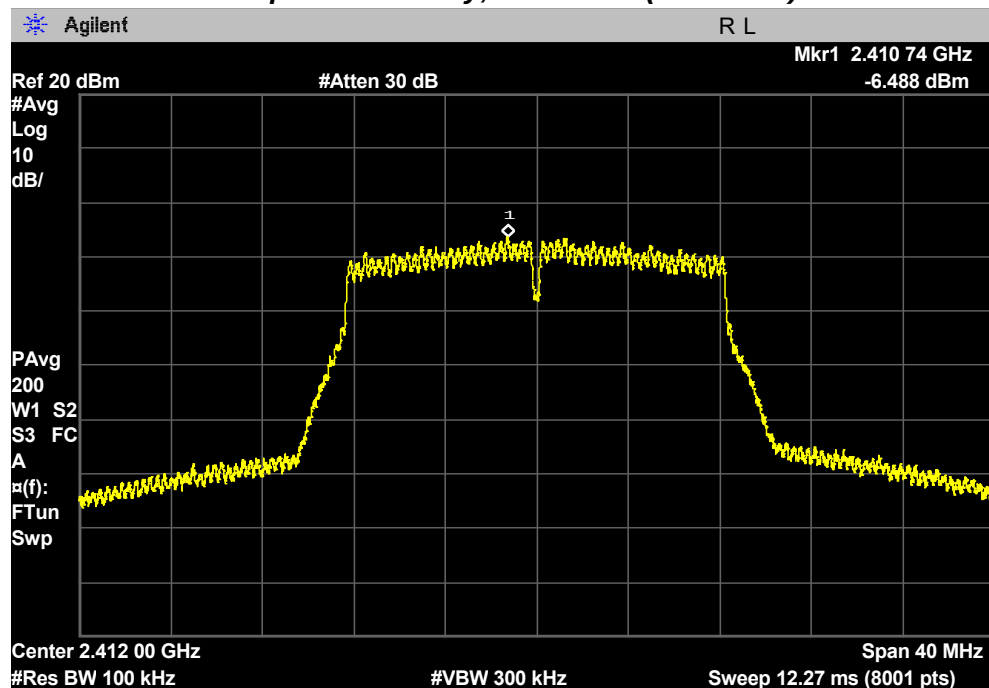
PLOTS OF EMISSIONS

Maximum Power Spectral Density, 11 Channel (2462 MHz)



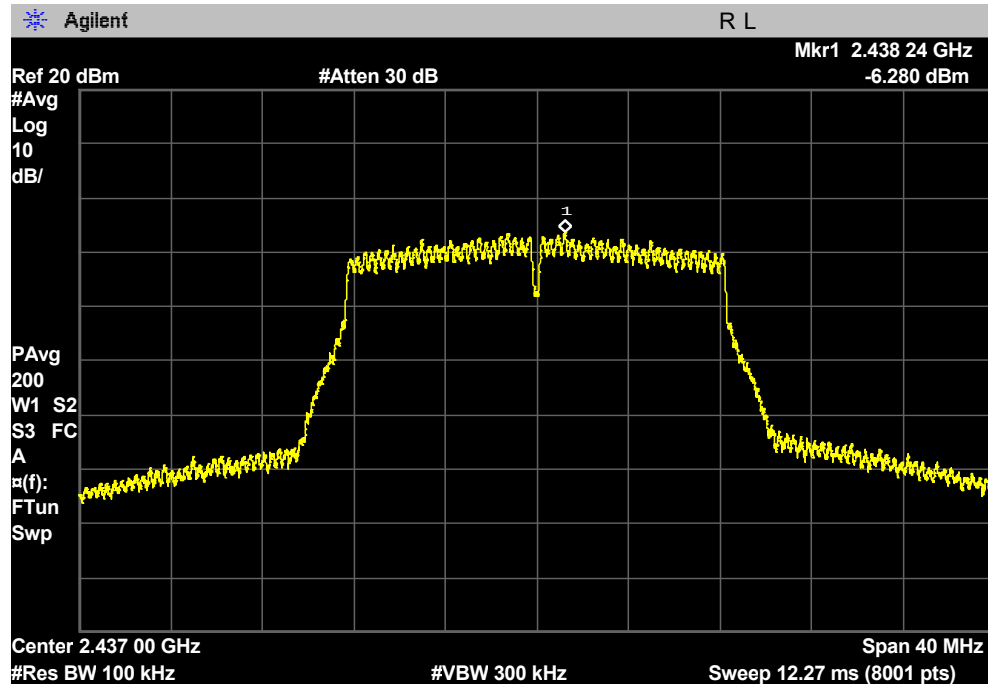
802.11g mode

Maximum Power Spectral Density, 1 Channel (2412 MHz)

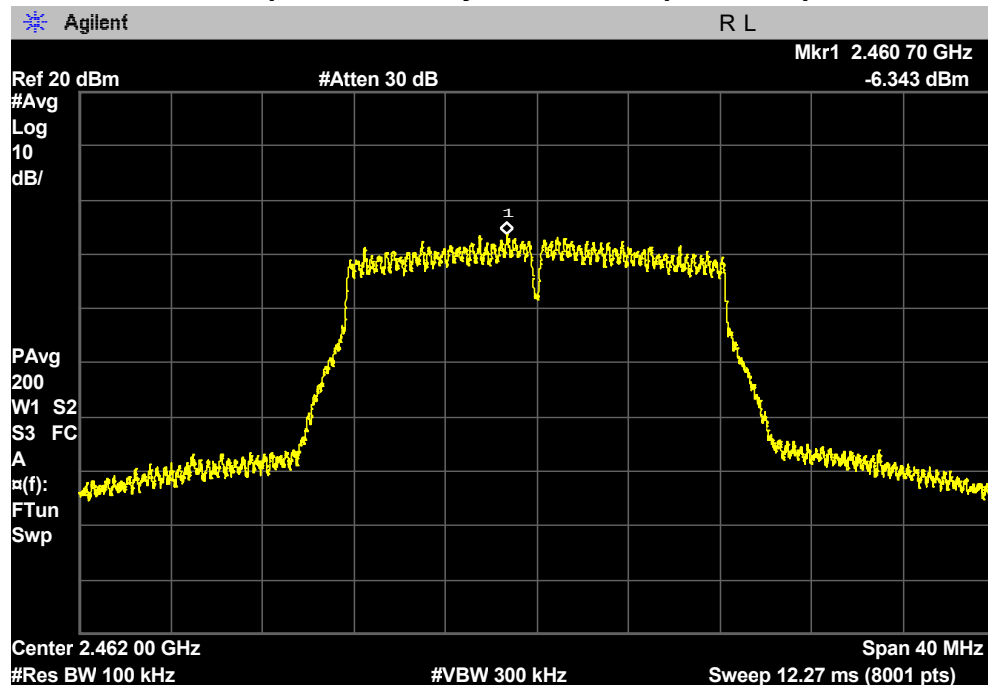


PLOTS OF EMISSIONS

Maximum Power Spectral Density, 6 Channel (2437 MHz)



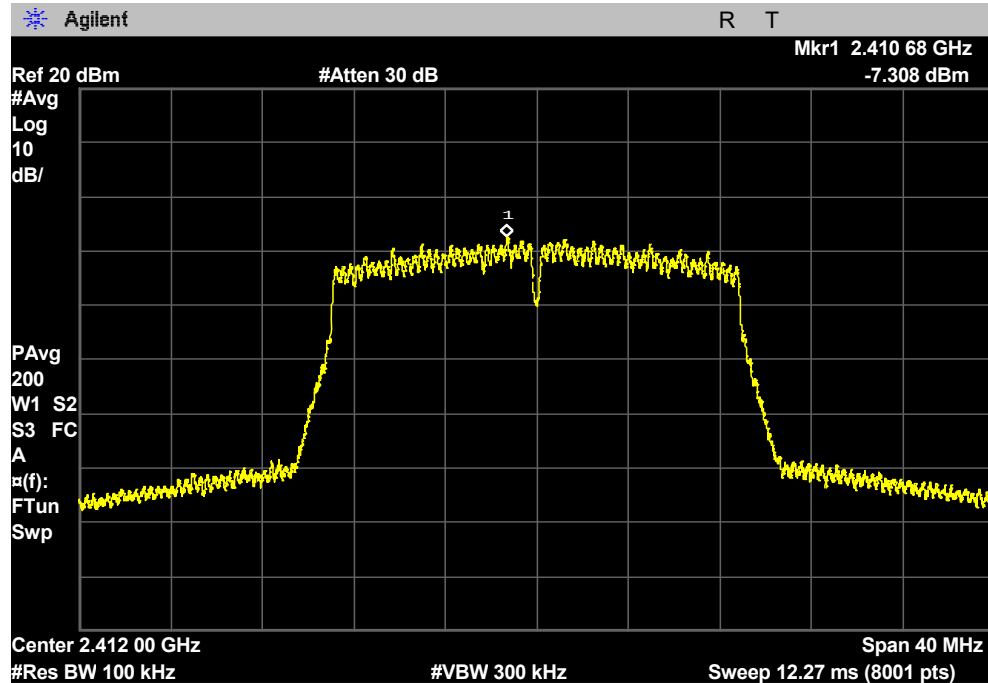
Maximum Power Spectral Density, 11 Channel (2462 MHz)



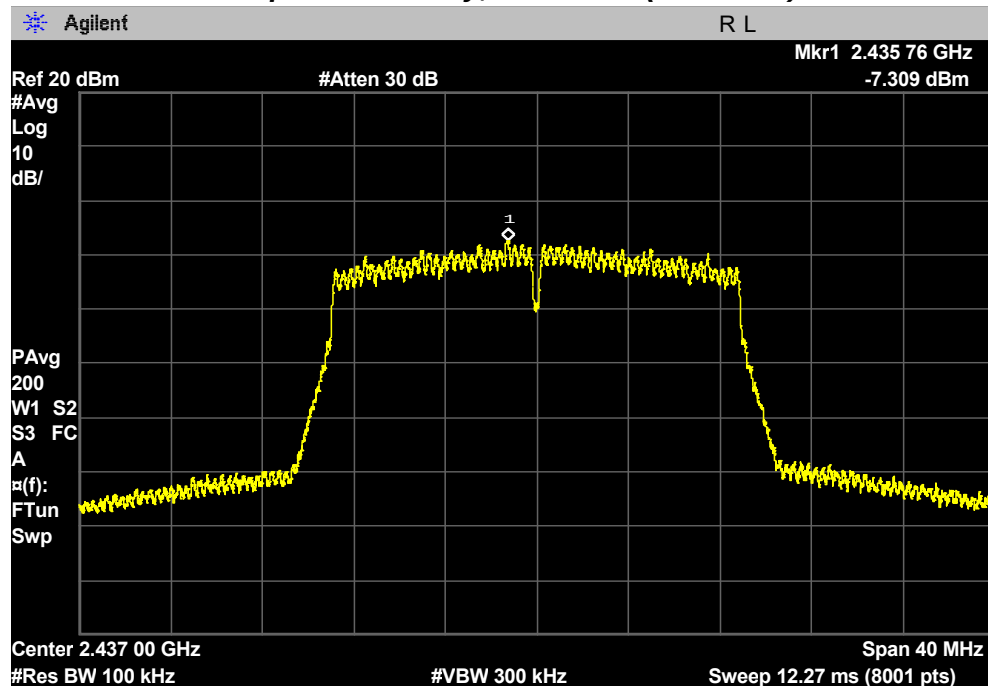
PLOTS OF EMISSIONS

802.11n (20 MHz) mode

Maximum Power Spectral Density, 1 Channel (2412 MHz)

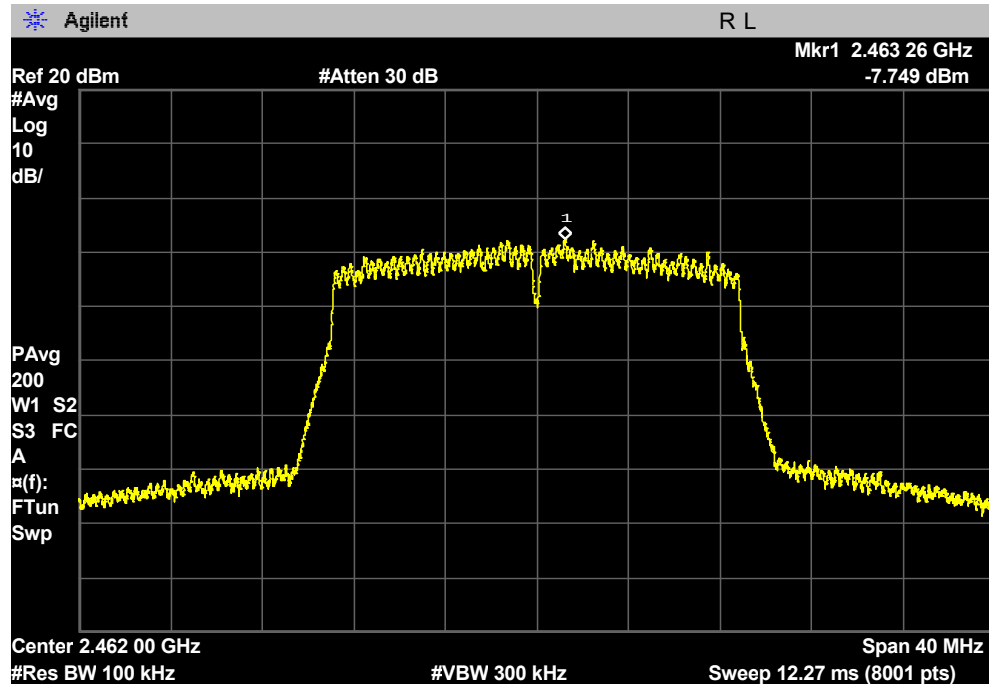


Maximum Power Spectral Density, 6 Channel (2437 MHz)



PLOT OF TEST DATA

Maximum Power Spectral Density, 11 Channel (2462 MHz)



TEST DATA

8.6 Conducted Spurious Emissions

FCC §15.247(d), IC RSS-247 Issue 2 5.5

Test Mode : Set to Lowest channel, Middle channel and Highest channel,

802.11b mode

Channel	Frequency (MHz)	Reference Level (dBm/100kHz)	Conducted Spurious Emissions (dBc)	Limit (dBc)
1	2412	7.96	More than 30 dBc	30
6	2437	8.18	More than 30 dBc	30
11	2462	7.65	More than 30 dBc	30

802.11g mode

Channel	Frequency (MHz)	Reference Level (dBm/100kHz)	Conducted Spurious Emissions (dBc)	Limit (dBc)
1	2412	4.10	More than 30 dBc	30
6	2437	4.12	More than 30 dBc	30
11	2462	3.80	More than 30 dBc	30

TEST DATA

802.11n (20 MHz) mode

Channel	Frequency (MHz)	Reference Level (dBm/100kHz)	Conducted Spurious Emissions (dBc)	Limit (dBc)
1	2412	3.01	More than 30 dBc	30
6	2437	3.03	More than 30 dBc	30
11	2462	2.73	More than 30 dBc	30

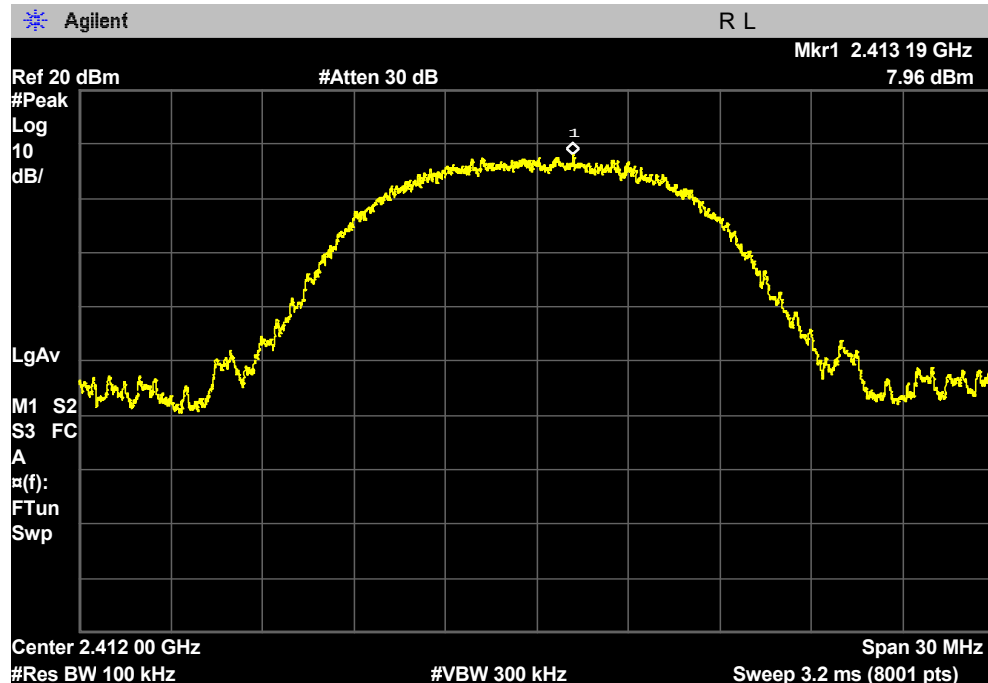
Notes:

The cable and attenuator loss from 30 MHz to 26.5 GHz was reflected in spectrum analyzer with correction factor for the spurious emissions test.

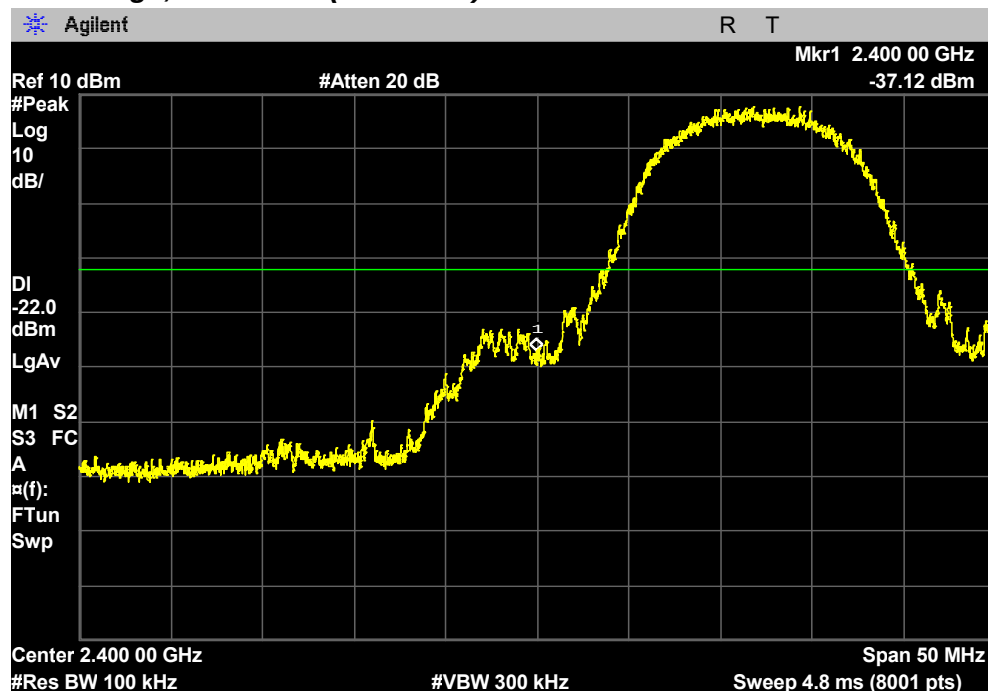
PLOTS OF EMISSIONS

802.11b mode

Reference Power Spectral Density, 1 Channel (2412 MHz)

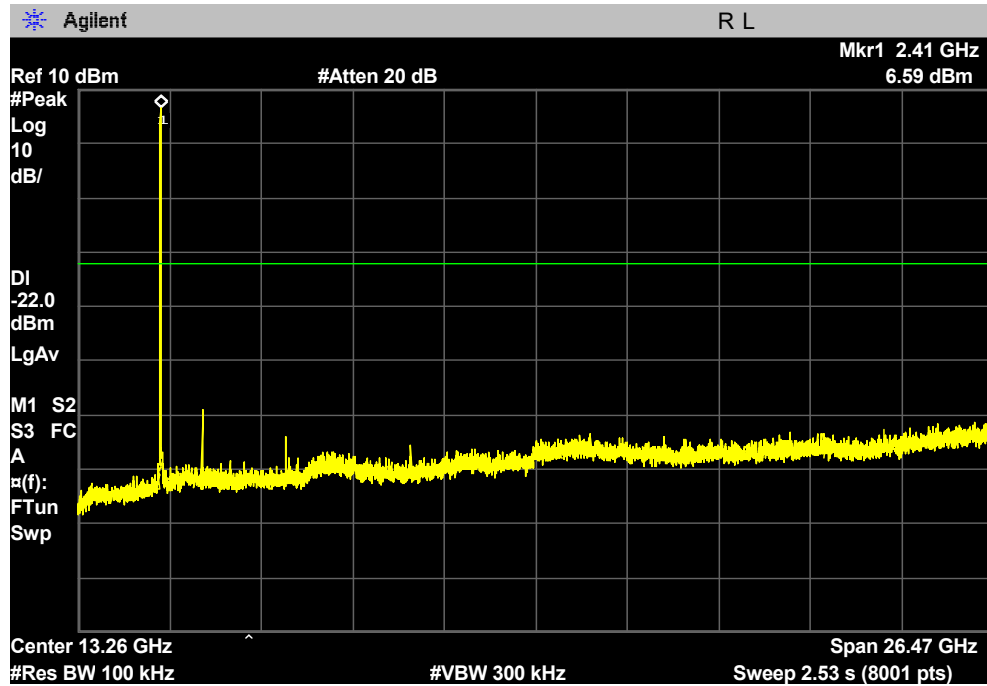


Band Edge, 1 Channel (2412 MHz)

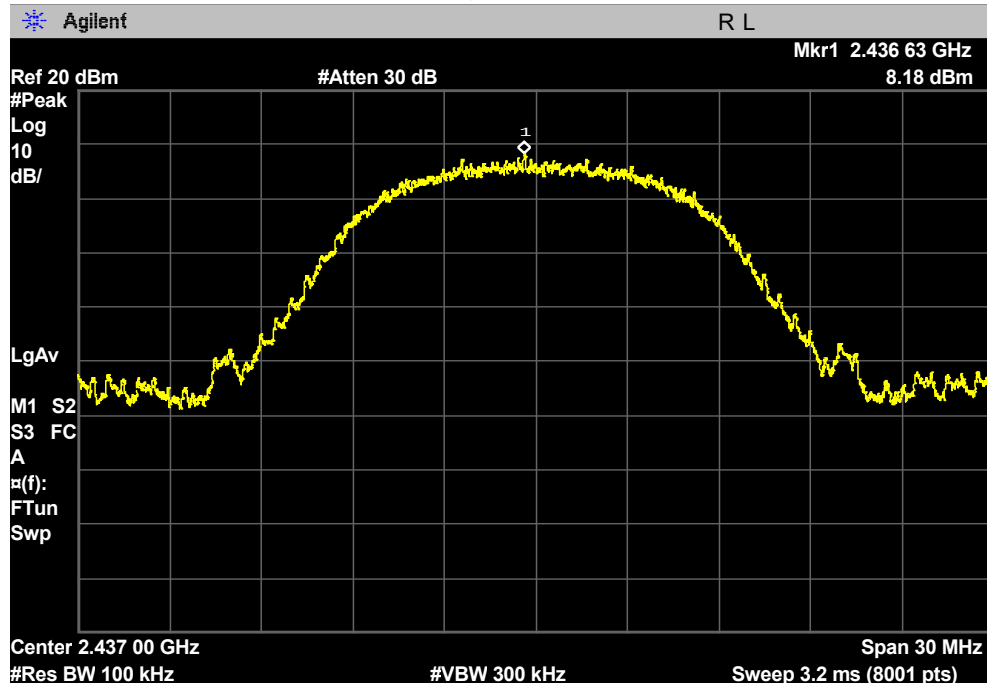


PLOTS OF EMISSIONS

Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2412 MHz)

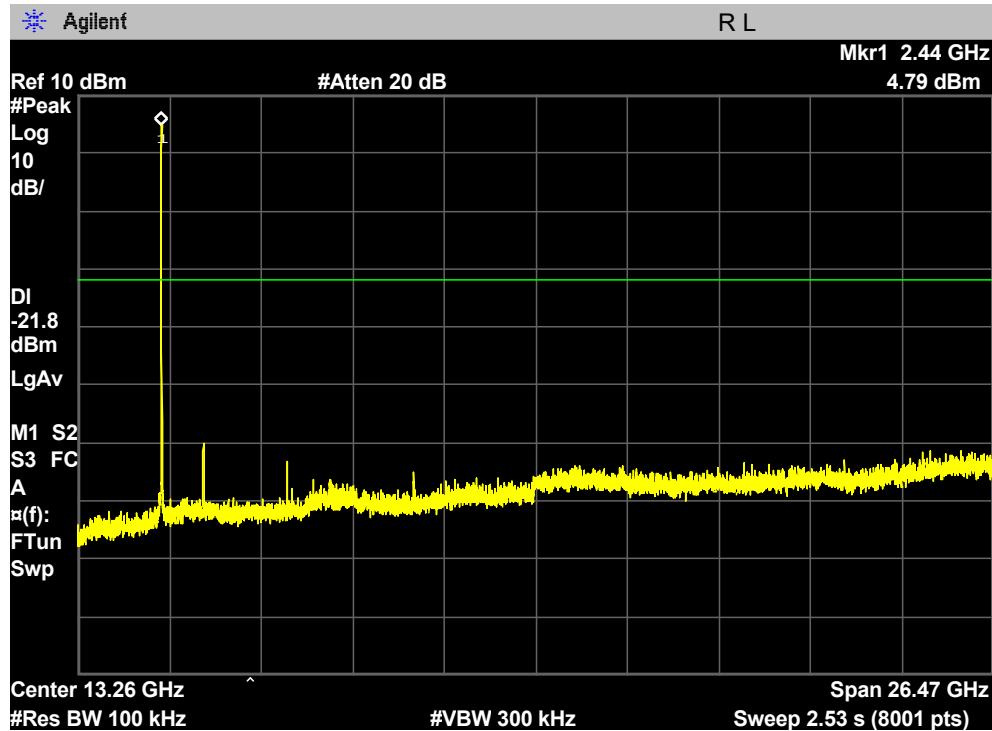


Reference Power Spectral Density, 6 Channel (2437 MHz)

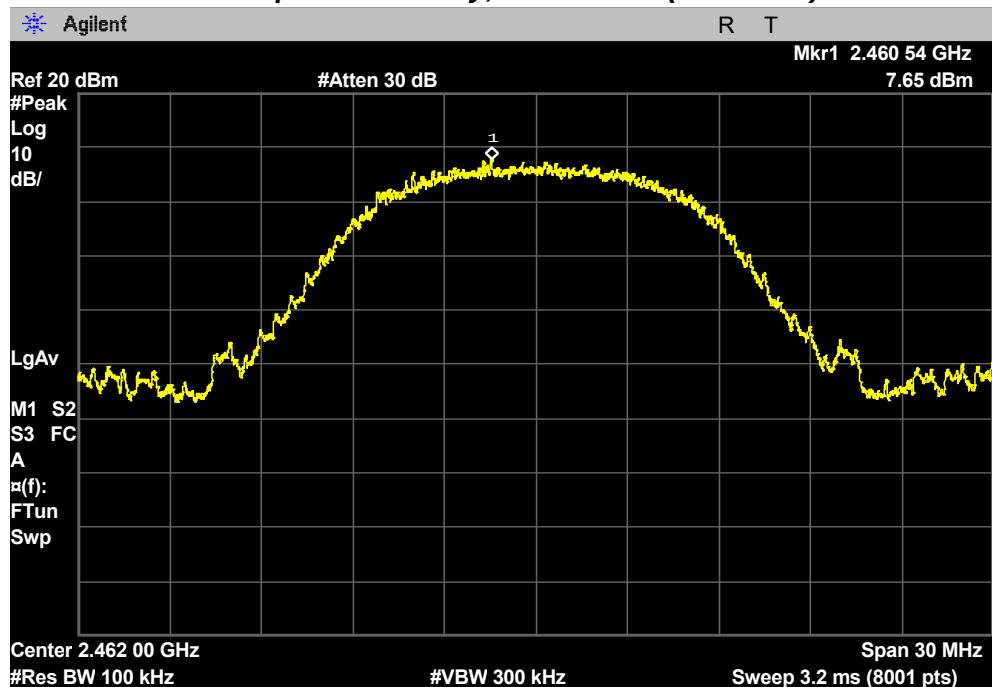


PLOTS OF EMISSIONS

Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2437 MHz)

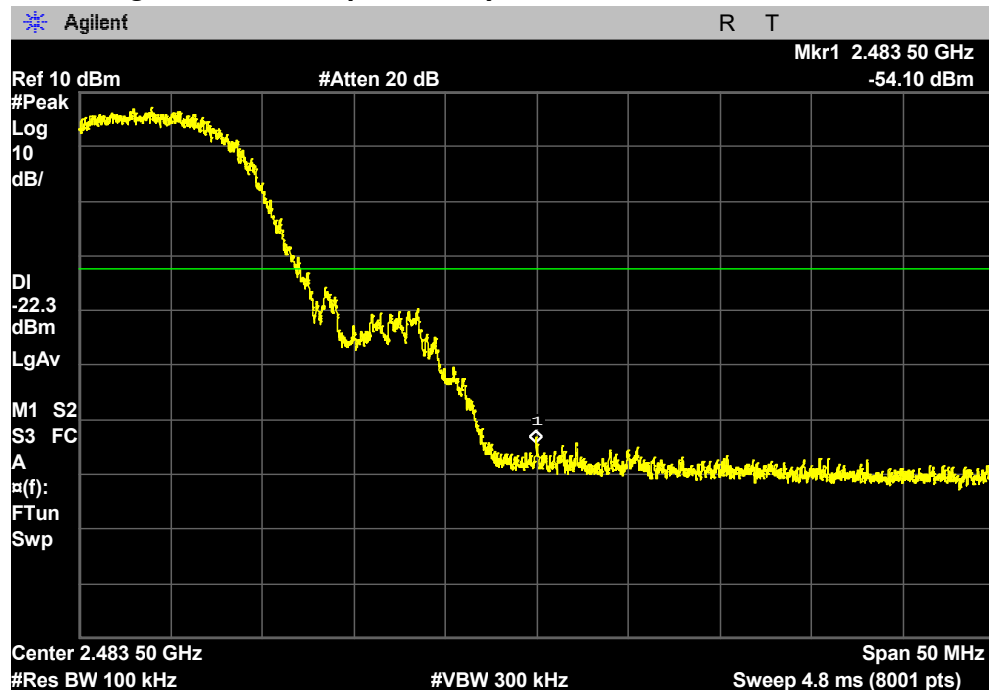


Reference Power Spectral Density, 11 Channel (2462 MHz)

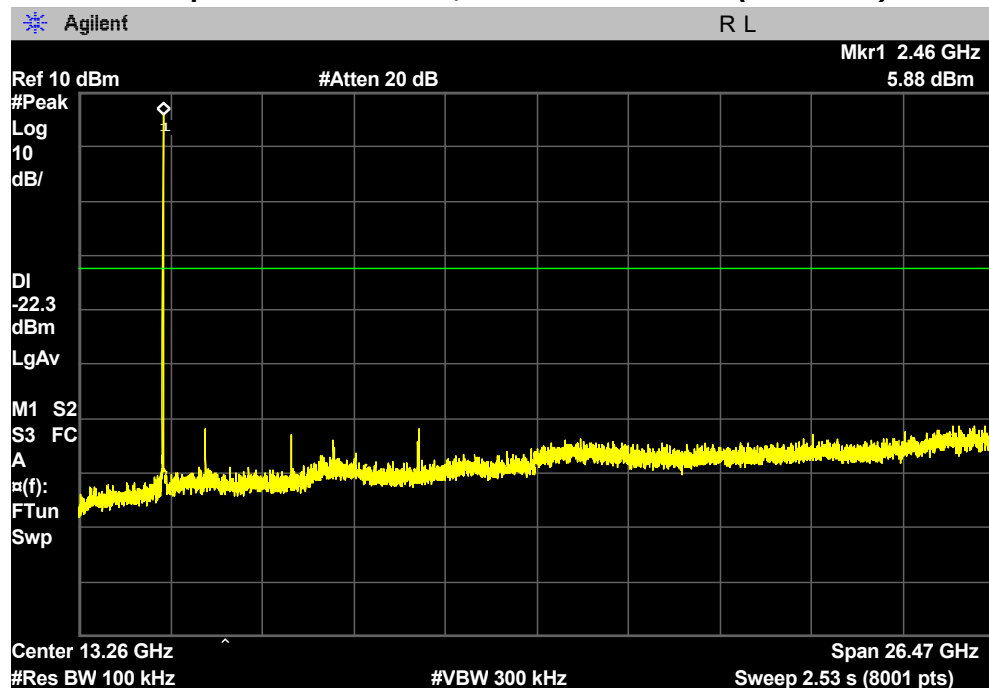


PLOTS OF EMISSIONS

Band Edge, 11 Channel (2462 MHz)



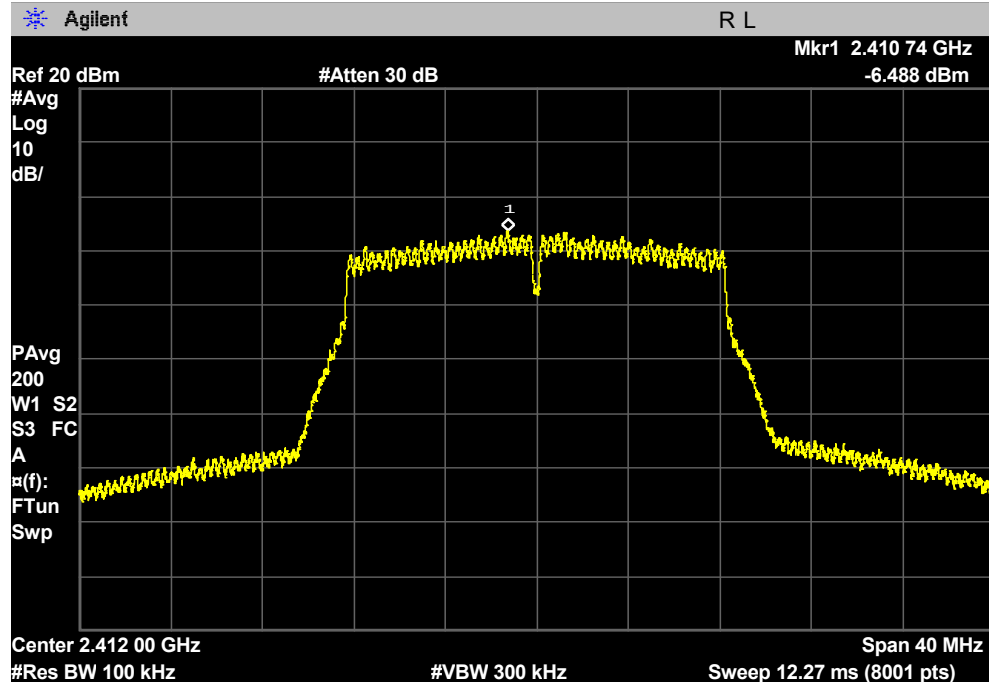
Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2462 MHz)



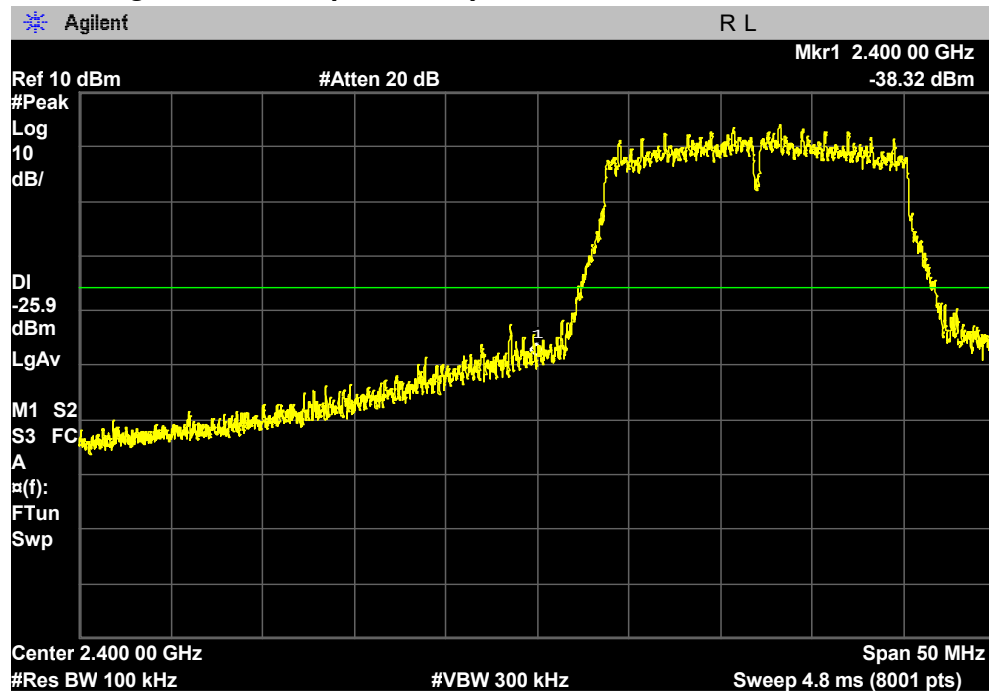
PLOTS OF EMISSIONS

802.11g mode

Reference Power Spectral Density, 1 Channel (2412 MHz)

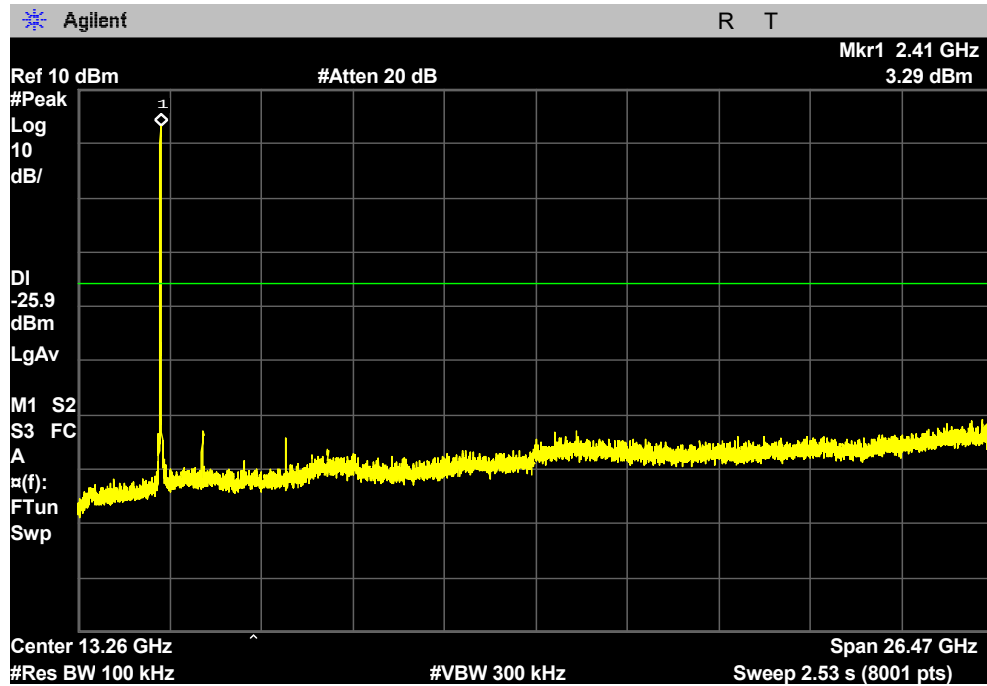


Band Edge, 1 Channel (2412 MHz)

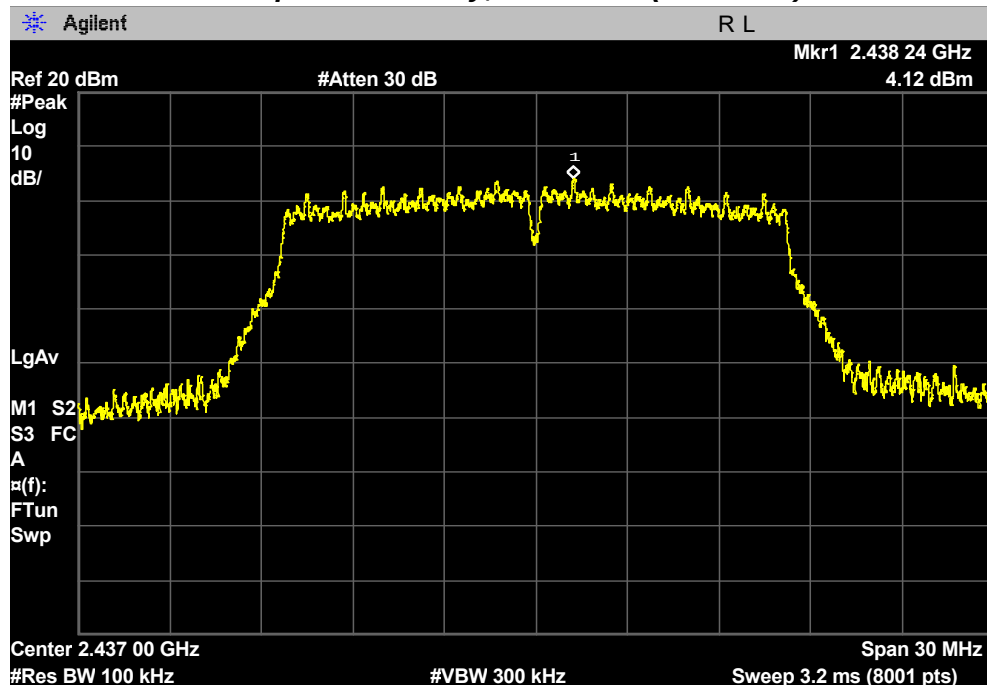


PLOTS OF EMISSIONS

Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2412 MHz)

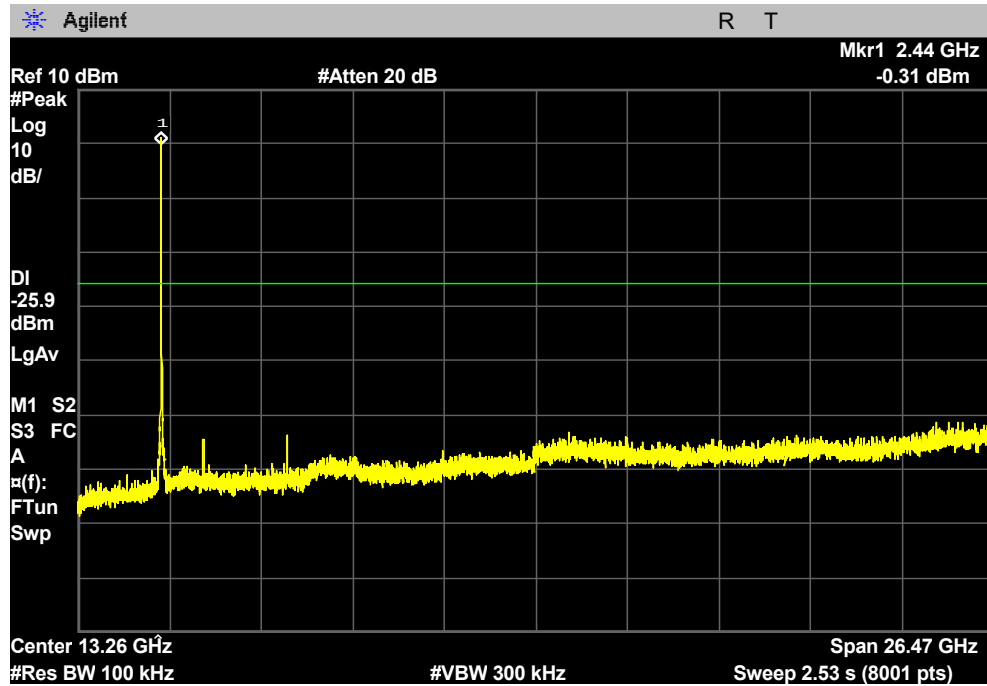


Reference Power Spectral Density, 6 Channel (2437 MHz)

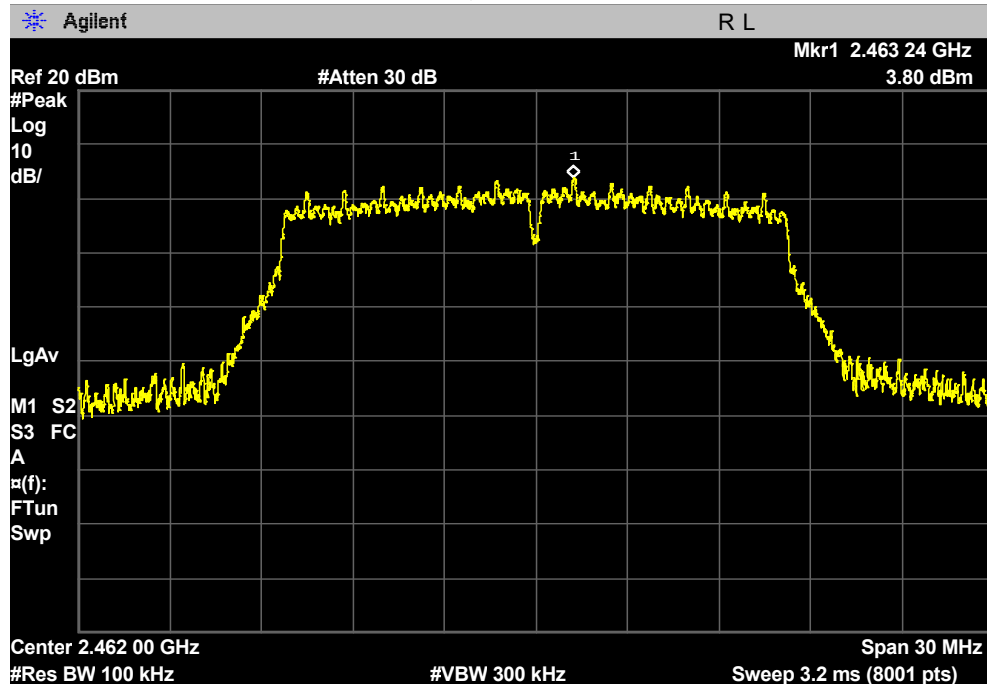


PLOTS OF EMISSIONS

Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2437 MHz)

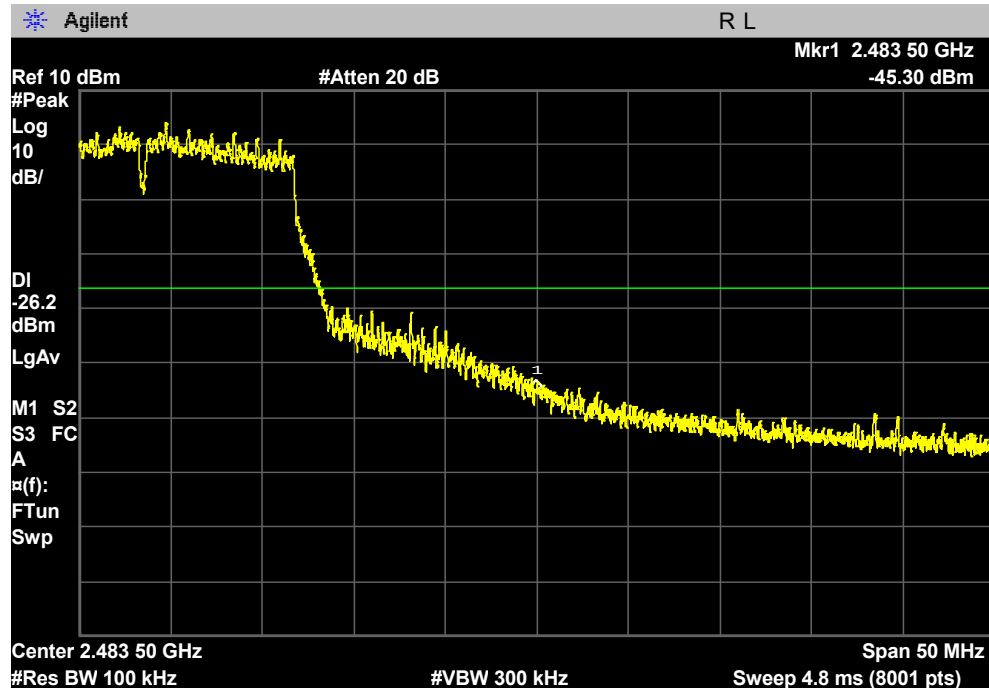


Reference Power Spectral Density, 11 Channel (2462 MHz)

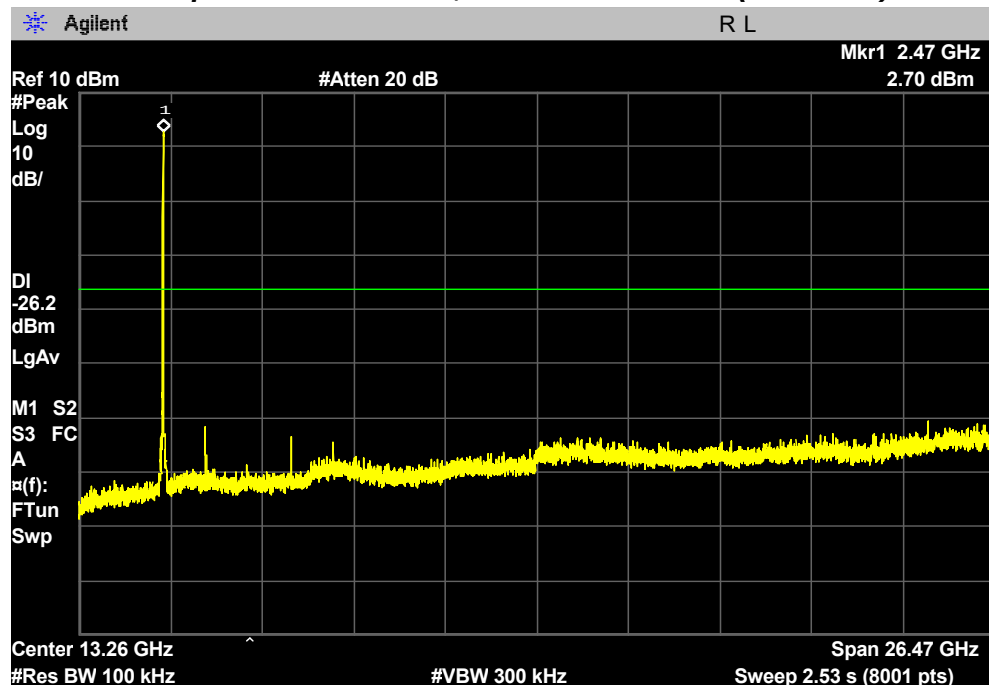


PLOTS OF EMISSIONS

Band Edge, 11 Channel (2462 MHz)



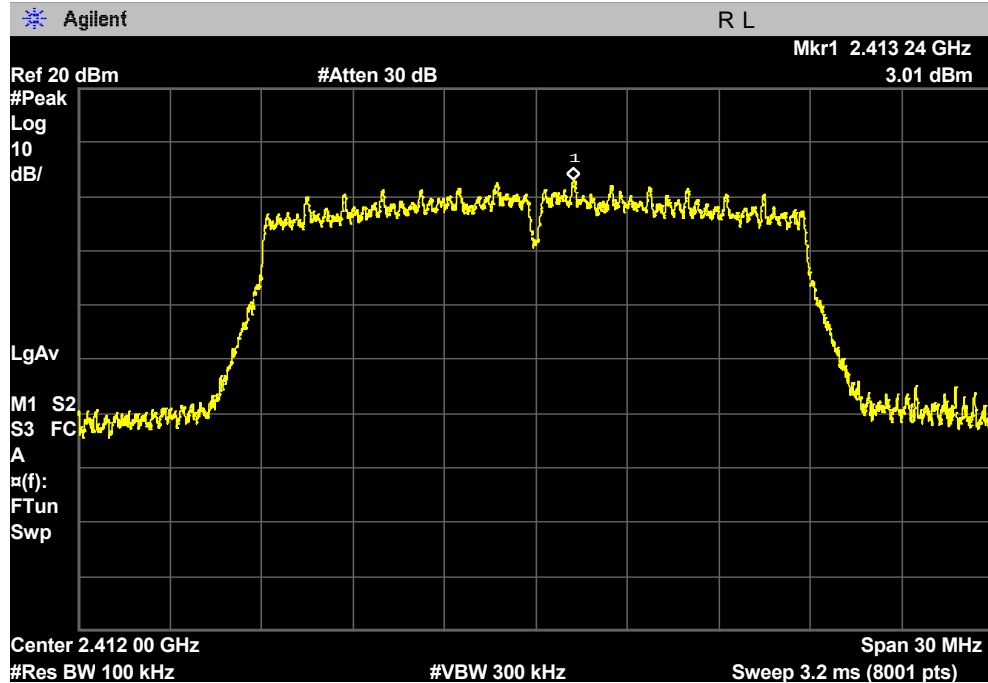
Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2462 MHz)



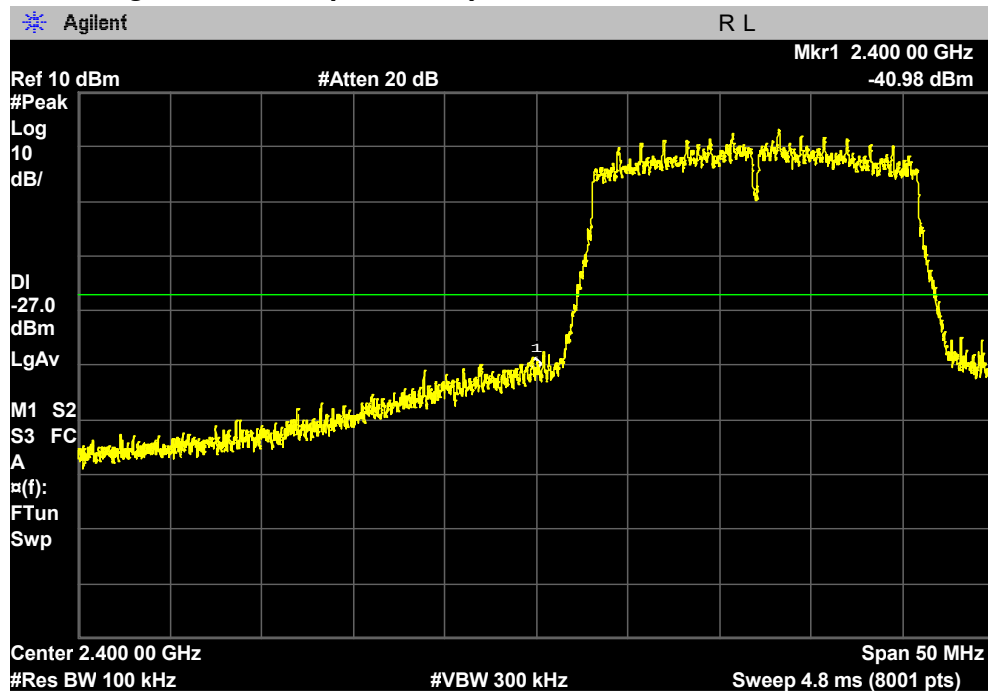
PLOTS OF EMISSIONS

802.11n (20MHz) mode

Reference Power Spectral Density, 1 Channel (2412 MHz)

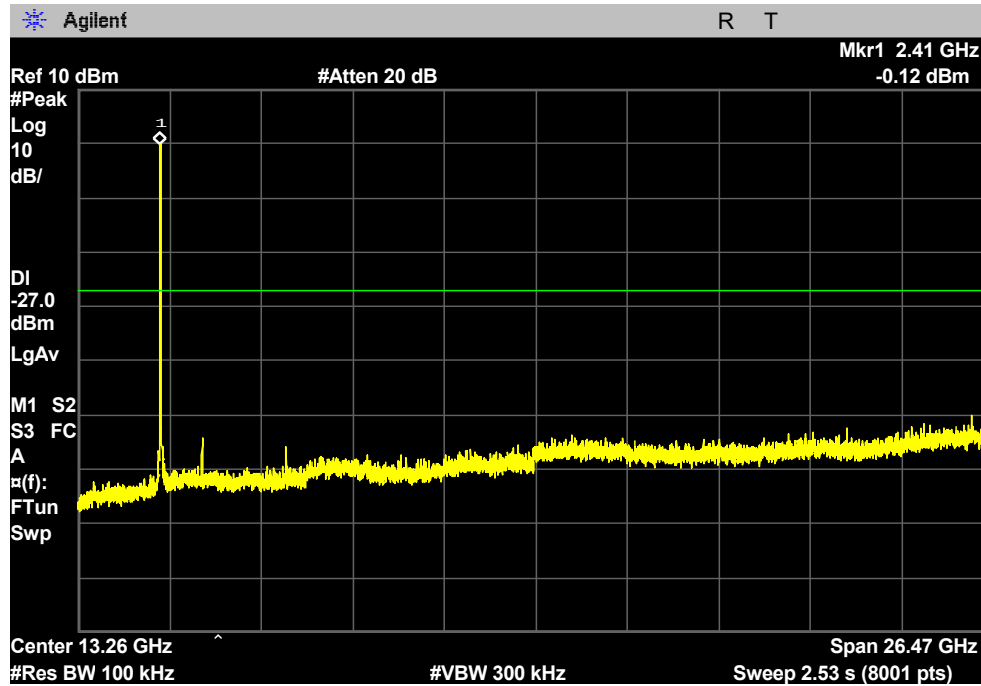


Band Edge, 1 Channel (2412 MHz)

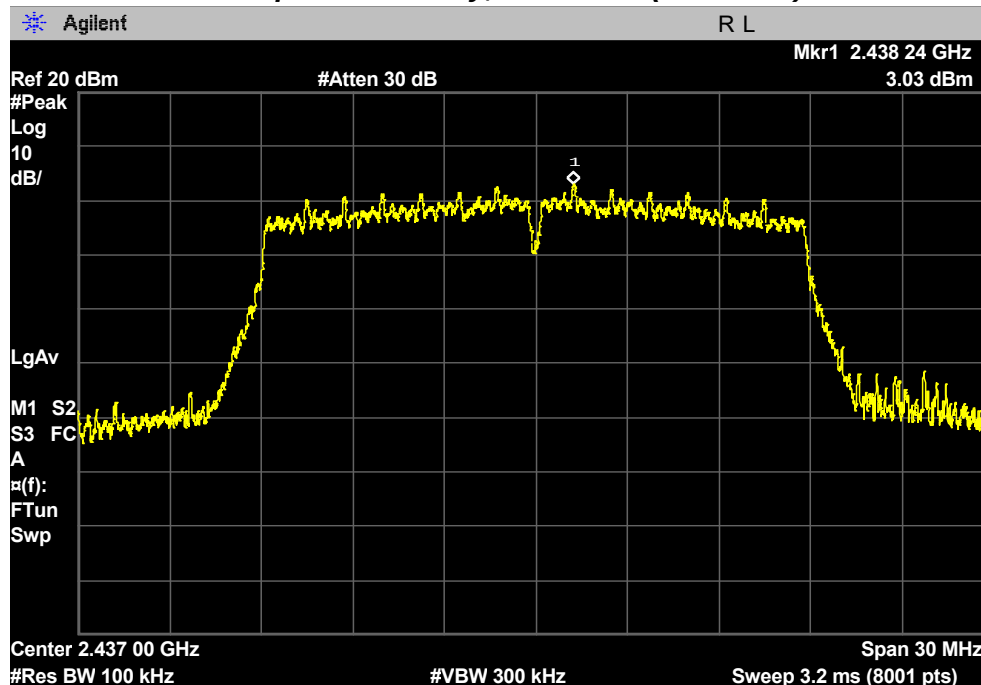


PLOTS OF EMISSIONS

Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2412 MHz)

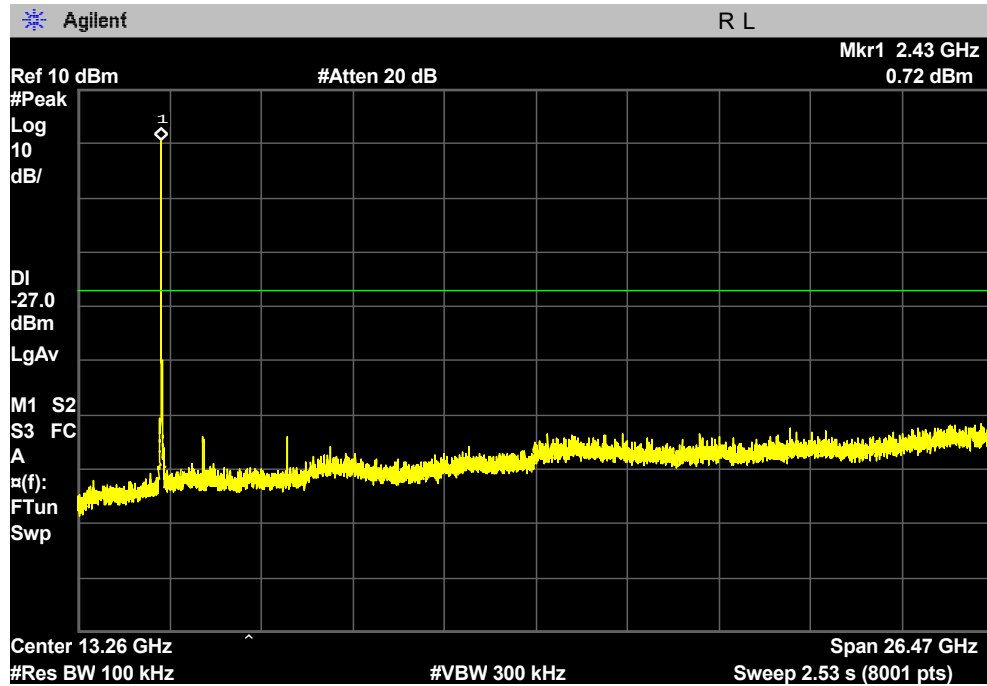


Reference Power Spectral Density, 6 Channel (2437 MHz)

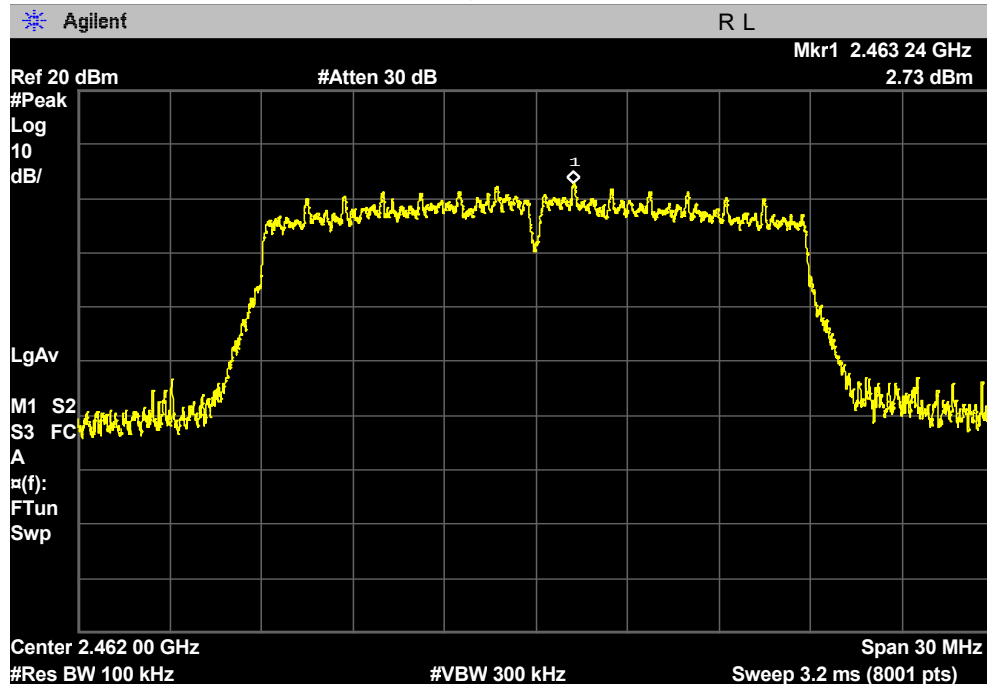


PLOTS OF EMISSIONS

Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2437 MHz)

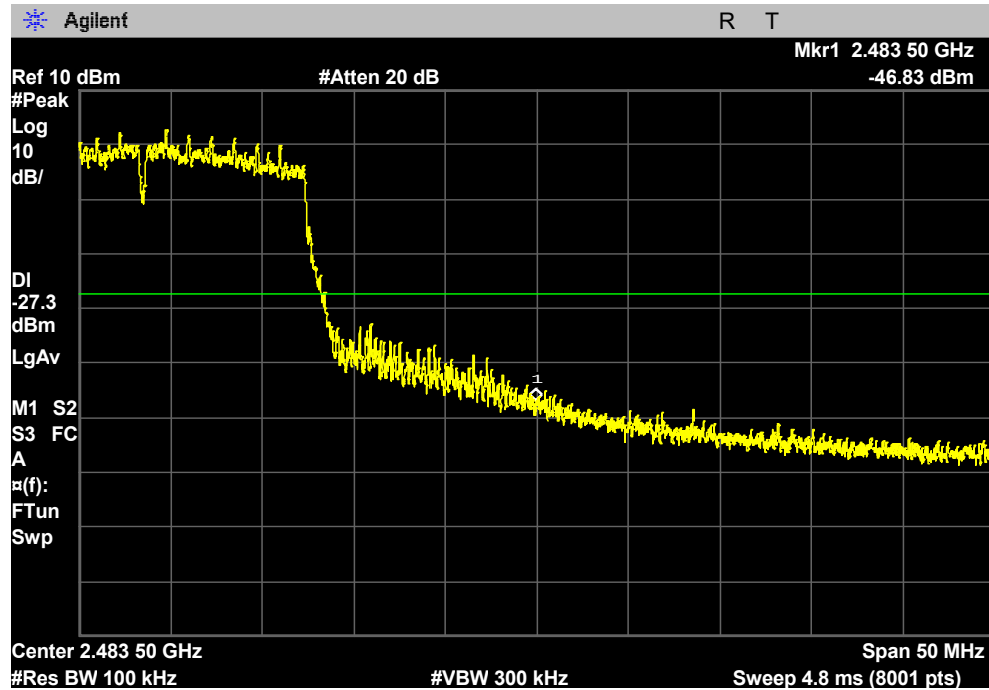


Reference Power Spectral Density, 11 Channel (2462 MHz)

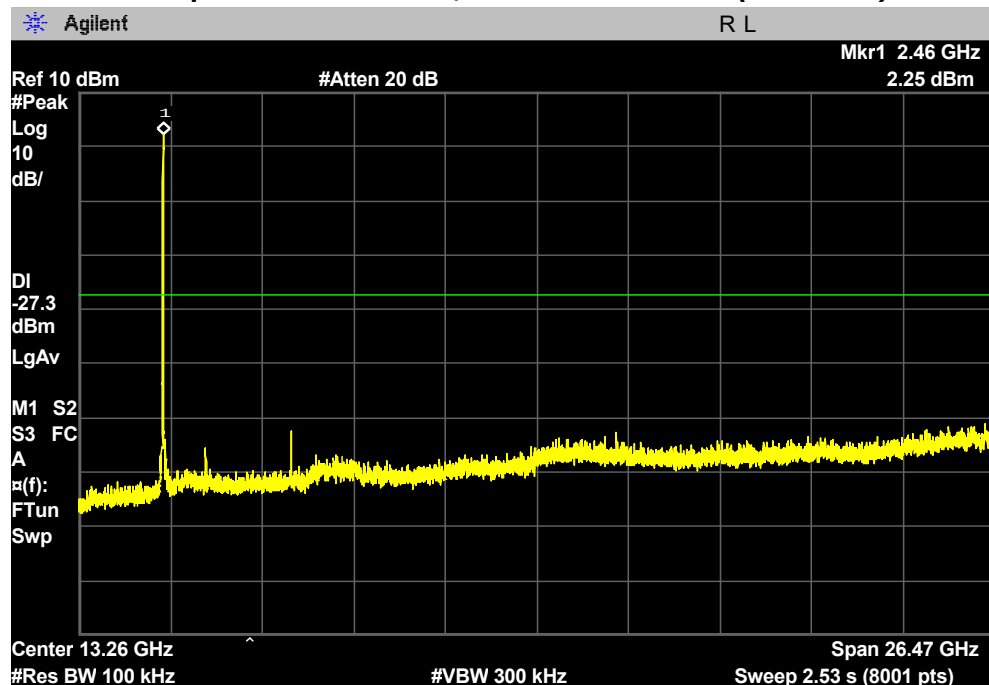


PLOTS OF EMISSIONS

Band Edge, 11 Channel (2462 MHz)



Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2462 MHz)



TEST DATA

8.7 Radiated Spurious Emissions

FCC §15.247(d), IC RSS-247 Issue 2 5.5

Test Mode : Set to Lowest channel, Middle channel and Highest channel,

802.11b mode

1 Channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4823.83	56.1	V	peak	1.1	57.2	74.0	16.8
4829.02	50.1	V	average	1.2	51.3	54.0	2.7
7244.50	35.0	V	peak	7.2	56.5	74.0	17.5
7228.30	35.0	V	average	7.2	47.2	54.0	6.8

6 Channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4873.67	55.8	V	peak	1.4	57.2	74.0	16.8
4829.02	50.1	V	average	1.2	51.3	54.0	2.7
7312.33	35.0	V	peak	7.2	55.5	74.0	18.5
7228.30	35.0	V	average	7.2	47.2	54.0	6.8

11 Channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4929.00	53.2	V	peak	1.3	54.5	74.0	19.5
4929.02	50.1	V	average	1.3	51.4	54.0	2.6
7377.67	35.0	V	peak	7.8	52.7	74.0	21.3

TEST DATA

Note:

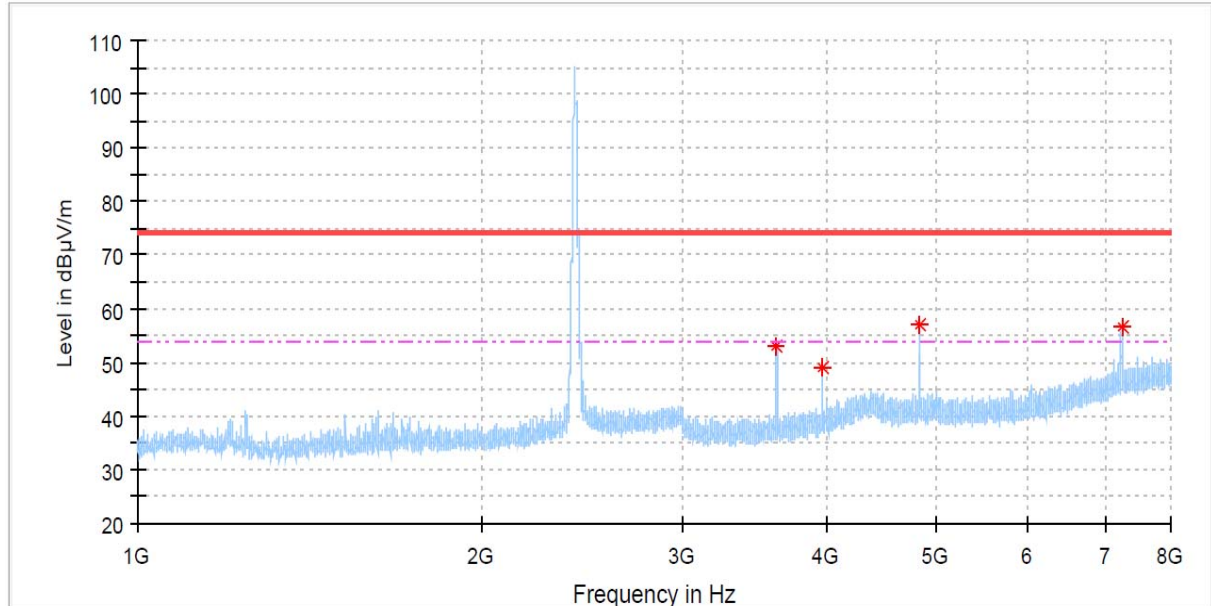
1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. Average measurement was not performed when peak-detected emission complies with the average limit.
4. Other spurious was under 30 dB below Fundamental.
5. 11 channel (2462MHz) in b mode was the worst condition. For other modes, peak-detected emissions have enough margin more than 20dBc, therefore the results were not recorded in this report
6. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.
7. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
8. Average emissions were measured using RBW = 1 MHz, VBW = 1 kHz, Detector = Peak.
9. The spectrum was measured from 9 kHz to 10th harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 3rd harmonic for this device.

PLOTS OF EMISSIONS

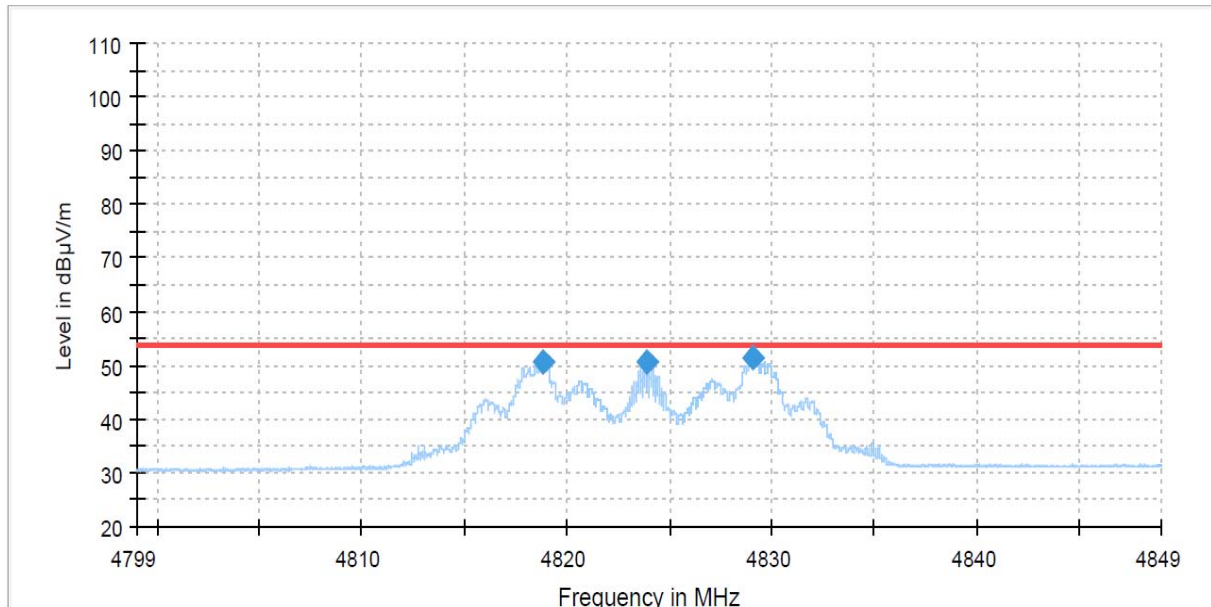
Worst Case

802.11b mode

11 channel : 1 GHz to 8 GHz_Peak

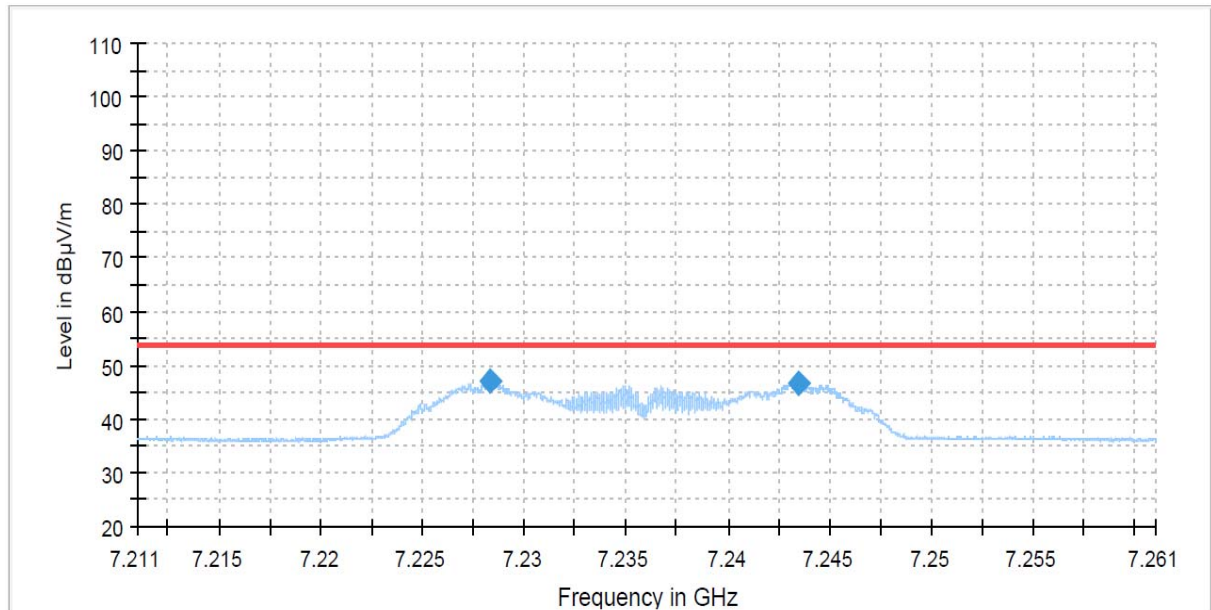


11 channel : 2nd harmonic_Average

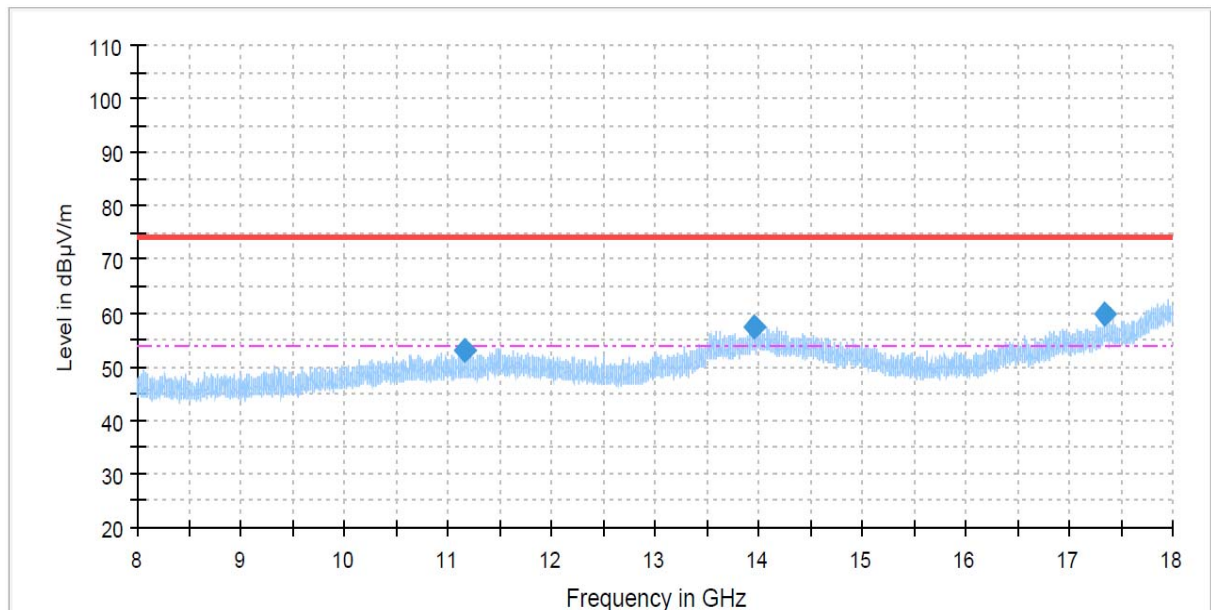


PLOTS OF EMISSIONS

11 channel : 3rd harmonic_Average

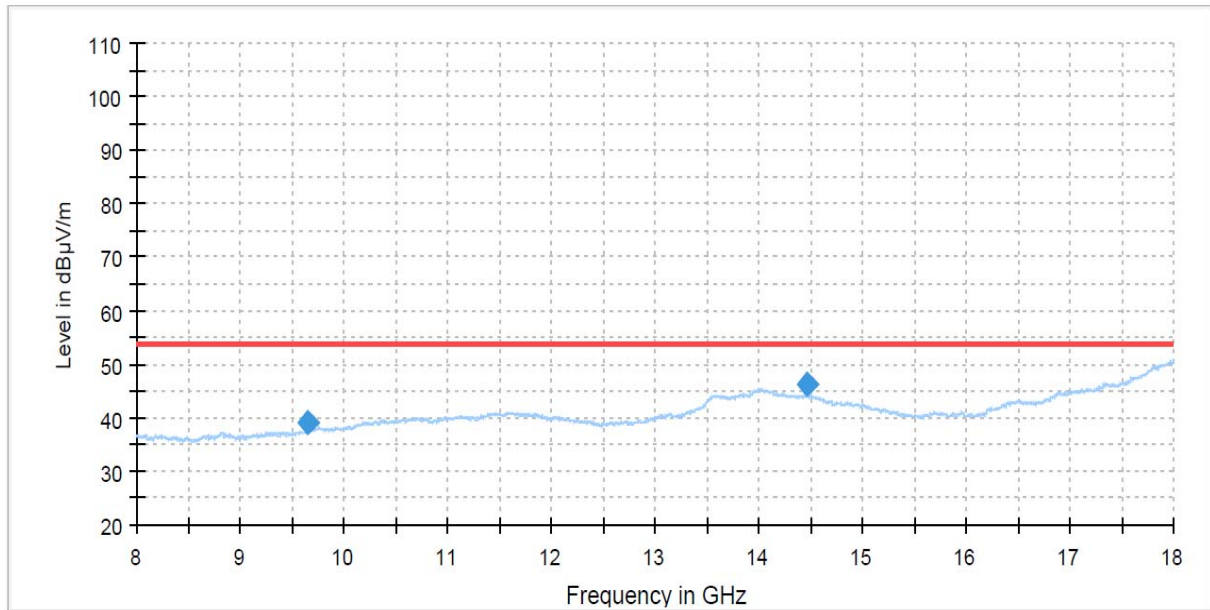


11 channel : 8 GHz to 18 GHz_Peak

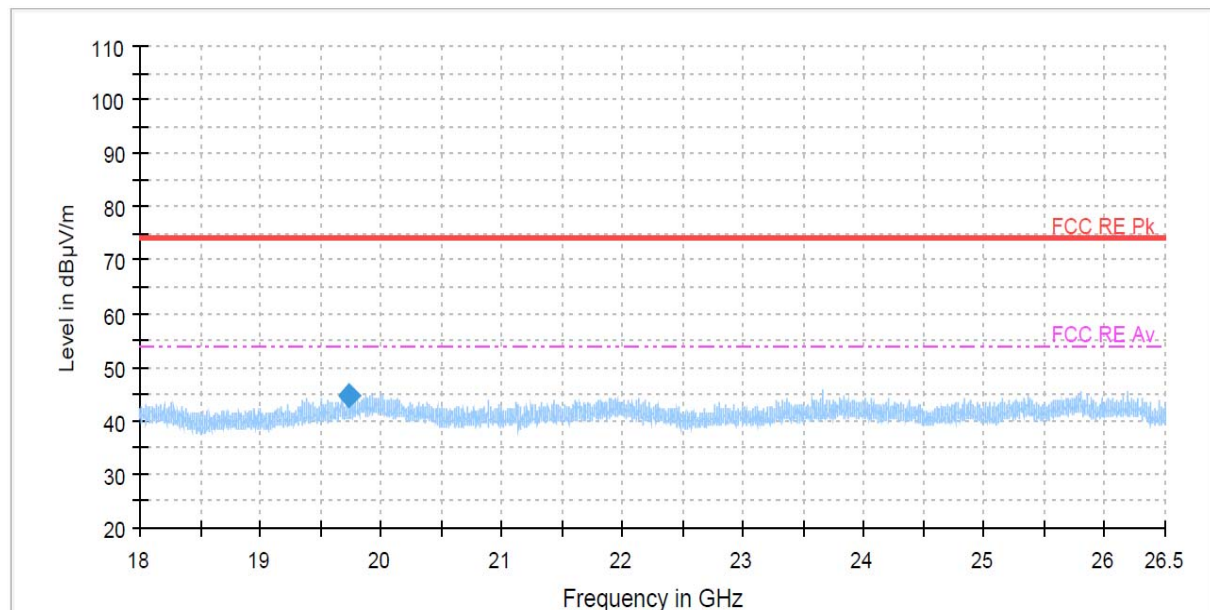


PLOTS OF EMISSIONS

11 channel : 8 GHz to 18 GHz_Average



11 channel : 18 GHz to 26.5 GHz_Peak



TEST DATA

8.8 Radiated Band Edge

FCC §15.247(d), IC RSS-247 Issue 2 5.5

Test Mode : Set to Lowest channel and Highest channel

802.11n(20MHz) mode

1 Channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2389.81	72.5	V	peak	-7.9	64.6	74.0	9.4
2389.96	54.0	H	average	-7.9	46.1	54.0	7.9

11 Channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2383.50	66.8	V	peak	-7.6	59.2	74.0	14.8
2383.50	55.9	V	average	-7.6	48.3	54.0	5.7
2484.11	73.6	V	peak	-7.6	66.0	74.0	8.0
2483.76	57.3	V	average	-7.6	49.7	54.0	4.3

Note:

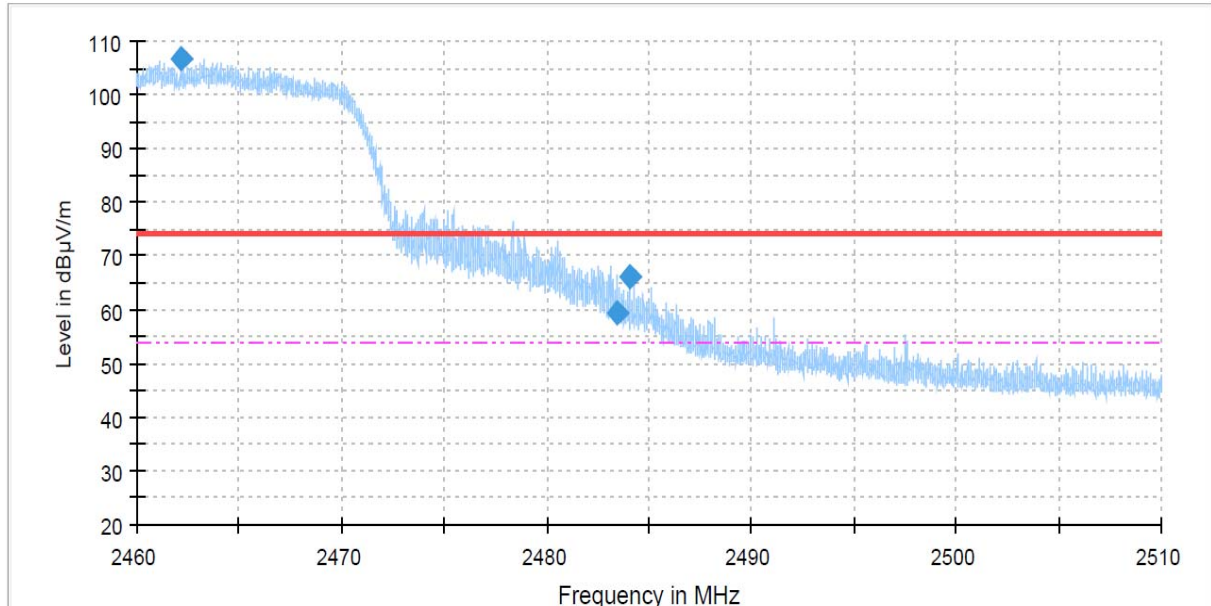
- *Pol. H = Horizontal V = Vertical
- **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
- Other spurious was under 30 dB below Fundamental.
- Highest channel (2462MHz) in n(20MHz) mode was the worst condition.
- The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.
- Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
- Average emissions were measured using RBW = 1 MHz, VBW = 5 kHz, Detector = Peak.

PLOT OF TEST DATA

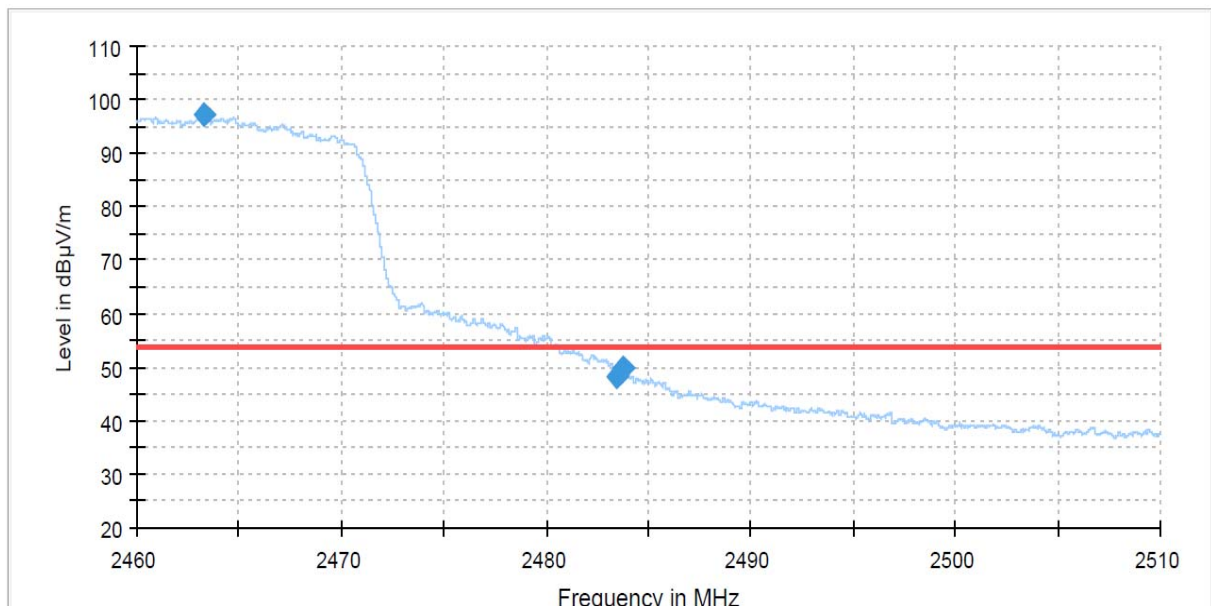
Worst Case

802.11n (20 MHz) mode

11 channel_Peak



11 channel_Average



9. TEST EQUIPMENT

No.	Instrument	Manufacturer	Model	Serial No.	Calibration Date	Calibration Interval
1	*Test Receiver	R & S	ESU 40	100202	May. 24 2018	1 year
2	*Test Receiver	R & S	ESCS30	100302	Oct. 11 2018	1 year
3	*Attenuator	PASTERNAK	PE7395-10	1441-1	Jul. 07 2018	1 year
4	*Attenuator	FAIRVIEW	SA3N5W-06	N/A	Jul. 14 2018	1 year
5	*Attenuator	FAIRVIEW	SA3N5W-10	N/A	Apr. 04 2018	1 year
6	*Attenuator	WEINSCHEL	56-10	58765	Oct. 12 2018	1 year
7	*Amplifier	R & S	SCU 01	10029	Apr. 02 2018	1 year
8	*Amplifier	R & S	SCU18F	180025	Apr. 02 2018	1 year
9	*Amplifier	R & S	SCU26	10011	Jul. 16 2018	1 year
10	*Amplifier	R & S	SCU40	100380	Jul. 16 2018	1 year
11	Spectrum Analyzer	R & S	FSW43	100732	Apr. 02 2018	1 year
12	*Spectrum Analyzer	Agilent	E4440A	MY44022567	Oct. 11 2018	1 year
13	*Spectrum Analyzer	R & S	FSW43	104084	Apr. 02 2018	1 year
14	*Loop Antenna	R & S	HFH2-Z2	100279	Feb. 13 2019	2 year
15	*Horn Antenna	SCHWARZBECK	BBHA9120D	9120D-474	Jun. 28 2017	2 year
16	*Horn Antenna	Q-par Angus	QSH20S20	8179	Aug. 01 2017	2 year
17	*Horn Antenna	Q-par Angus	QSH22K20	8180	Aug. 02 2017	2 year
18	*Trilog-Broadband Antenna	SCHWARZBECK	VULB 9163	946	May. 18 2017	2 year
19	*LISN	R & S	ESH3-Z5	833874/006	Oct. 12 2018	1 year
20	*ESH2-Z5 Artificial Mains Network	R & S	ESH2-Z5	100227	Apr. 03 2018	1 year
21	*Position Controller	INNCO	CO2000	12480406/L	N/A	N/A
22	*Controller	INNCO	CO3000	CO3000/937/38330516/L	N/A	N/A
23	*Turn Table	INNCO	DS1200S	N/A	N/A	N/A
24	*Turn Table	INNCO	DT2000-2t	N/A	N/A	N/A
25	*Antenna Mast	INNCO	MA4000	N/A	N/A	N/A
26	*TILT Antenna Mast	INNCO	MA4640-XP-EP	N/A	N/A	N/A
27	*Open Switch And Control Unit	R & S	OSP-120	100081	N/A	N/A
28	*Open Switch And Control Unit	R & S	OSP-120	101766	N/A	N/A
29	*Shielded Room	Seo-Young EMC	N/A	N/A	N/A	N/A
30	*Anechoic Chamber	Seo-Young EMC	N/A	N/A	N/A	N/A
31	*WiFi Filter Bank	R & S	U083	N/A	N/A	N/A
32	*WiFi Filter Bank	R & S	U082	N/A	N/A	N/A

*) Test equipment used during the test

10. ACCURACY OF MEASUREMENT

The Measurement Uncertainties stated were calculated in accordance with the requirements of measurement uncertainty contained in CISPR 16-4-2 with the confidence level of 95%

1. Conducted Uncertainty Calculation

Source of Uncertainty	X_i	Uncertainty of X_i		Coverage factor k	$u(X_i)$ (dB)	C_i	$C_i u(X_i)$ (dB)
		Value (dB)	Probability Distribution				
Receiver reading	R_I	± 0.1	normal 1	1.000	0.1	1	0.1
Attenuation AMN-Receiver	LC	± 0.08	normal 2	2.000	0.04	1	0.04
AMN Voltage division factor	$LAMN$	± 0.8	normal 2	2.000	0.4	1	0.4
Sine wave voltage	$dVSW$	± 2.00	normal 2	2.000	1.00	1	1.00
Pulse amplitude response	$dVPA$	± 1.50	rectangular	1.732	0.87	1	0.87
Pulse repetition rate response	$dVPR$	± 1.50	rectangular	1.732	0.87	1	0.87
Noise floor proximity	$dVNF$	± 0.00	-	-	0.00	1	0.00
AMN Impedance	dZ	± 1.80	triangular	2.449	0.73	1	0.73
Ⓐ Mismatch	M	+ 0.70	U-Shaped	1.414	0.49	1	0.49
Ⓑ Mismatch	M	- 0.80	U-Shaped	1.414	- 0.56	1	- 0.56
Measurement System Repeatability	RS	0.05	normal 1	1.000	0.05	1	0.05
Remark	Ⓐ: AMN-Receiver Mismatch : + Ⓑ: AMN-Receiver Mismatch : -						
Combined Standard Uncertainty	Normal			± 1.88			
Expanded Uncertainty U	Normal ($k = 2$)			± 3.76			

2. Radiation Uncertainty Calculation

Source of Uncertainty	X_i	Uncertainty of X_i		Coverage factor k	$u(X_i)$ (dB)	C_i	$C_i u(X_i)$ (dB)
		Value (dB)	Probability Distribution				
Measurement System Repeatability	RS	0.34	normal 1	1.00	0.34	1	0.34
Receiver reading	Ri	± 0.02	normal 2	2.00	0.01	1	0.01
Sine wave voltage	dVsw	± 0.17	normal 2	2.00	0.09	1	0.09
Pulse amplitude response	dVpa	± 0.92	normal 2	2.00	0.46	1	0.46
Pulse repetition rate response	dVpr	± 0.35	normal 2	2.00	0.18	1	0.18
Noise floor proximity	dVnf	± 0.50	normal 2	2.00	0.25	1	0.25
Antenna Factor Calibration	AF	± 2.00	rectangular	$\sqrt{3}$	1.15	1	1.15
Cable Loss	CL	± 1.00	normal 2	2.00	0.50	1	0.50
Antenna Directivity	AD	± 0.00	rectangular	$\sqrt{3}$	0.00	1	0.00
Antenna Factor Height Dependence	AH	± 2.00	rectangular	$\sqrt{3}$	1.15	1	1.15
Antenna Phase Centre Variation	AP	± 0.20	rectangular	$\sqrt{3}$	0.12	1	0.12
Antenna Factor Frequency Interpolation	Ai	± 0.25	rectangular	$\sqrt{3}$	0.14	1	0.14
Site Imperfections	Si	± 4.00	triangular	$\sqrt{6}$	1.63	1	1.63
Measurement Distance Variation	DV	± 0.60	rectangular	$\sqrt{3}$	0.35	1	0.35
Antenna Balance	Dbal	± 0.90	rectangular	$\sqrt{3}$	0.52	1	0.52
Cross Polarisation	DCross	± 0.00	rectangular	$\sqrt{3}$	0.00	1	0.18
Mismatch	M	+ 0.98 - 1.11	U-Shaped	$\sqrt{2}$	0.74	1	0.74
EUT Volume Diameter	Vd	0.33	normal 1	1.00	0.33	1	0.11
Remark							
Combined Standard Uncertainty	Normal						
Expanded Uncertainty U	Normal ($k = 2$)						