

TEST REPORT

FCC/IC DTS Test for ADB10DWAN&ADB10DWKN
Certification

APPLICANT
HYUNDAI MOBIS CO., LTD.

REPORT NO.
HCT-RF-1907-FI007

DATE OF ISSUE
July 24, 2019

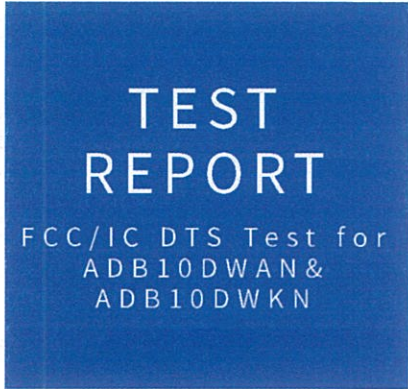
HCT Co., Ltd.

74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, 17383 KOREA
Tel. +82 31 634 6300 F ax. +82 31 645 6401



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Other Model
FCC: ATB41D WAN, ADB10D WAU
IC: ATB41D WKN

Applicant

HYUNDAI MOBIS CO., LTD.
203, Teheran-ro, Gangnam-gu, Seoul, 135-977, South Korea

Eut Type	Car Audio System
FCC Model Name	ADB10D WAN
IC Model Name	ADB10D WKN
FCC ID	TQ8-ADB10D WAN
IC	5074A-ADB10D WKN
Max. RF Output Power	802.11b : 14.89 dBm / 802.11g : 17.86 dBm / 802.11n(HT20) : 18.16 dBm
Modulation type	CCK/DSSS/OFDM
FCC Classification	Digital Transmission System(DTS)
FCC Rule Part(s)	Part 15.247
ISED Rule Part(s)	RSS-247 Issue 2 (February 2017), RSS-Gen Issue 5(April 2018)

This test results were applied only to the test methods required by the standard.

Tested by
Se Wook Park

(signature)

Technical Manager
Kwon Jeong

(signature)

HCT CO., LTD.

SooChan Lee / CEO

REVISION HISTORY

The revision history for this test report is shown in table.

Revision No.	Date of Issue	Description
0	July 24, 2019	Initial Release

The result shown in this test report refer only to the sample(s) tested unless otherwise stated.

Engineering Statement:

The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC / IC Rules under normal use and maintenance

CONTENTS

1. EUT DESCRIPTION	5
2. TEST METHODOLOGY	6
EUT CONFIGURATION	6
EUT EXERCISE	6
GENERAL TEST PROCEDURES	6
DESCRIPTION OF TEST MODES	7
3. INSTRUMENT CALIBRATION	7
4. FACILITIES AND ACCREDITATIONS	7
FACILITIES	7
EQUIPMENT	7
5. ANTENNA REQUIREMENTS	8
6. MEASUREMENT UNCERTAINTY	8
7. DESCRIPTION OF TESTS	9
7.1. Duty Cycle	9
7.2. 6dB Bandwidth & 99 % Bandwidth	10
7.3. Output Power	11
7.4. Power Spectral Density	12
7.5. Conducted Band Edge(Out of Band Emissions) & Conducted Spurious Emissions	13
7.6. Radiated Test	15
7.7. AC Power line Conducted Emissions	23
7.8. Receiver Spurious Emissions	24
7.9. Worst case configuration and mode	27
8. SUMMARY TEST OF RESULTS	28
9. TEST RESULT	30
9.1 DUTY CYCLE	30
9.2 6dB BANDWIDTH & 99 % BANDWIDTH	33
9.3 OUTPUT POWER	39
9.4 POWER SPECTRAL DENSITY	45
9.5 BAND EDGE/ CONDUCTED SPURIOUS EMISSIONS	48
9.6 RADIATED SPURIOUS EMISSIONS	59
9.7 RADIATED RESTRICTED BAND EDGES	69
10. LIST OF TEST EQUIPMENT	72
11. ANNEX A_ TEST SETUP PHOTO	74

1. EUT DESCRIPTION

FCC Model	ADB10DWAN
IC Model	ADB10DWKN
FCC Additional Model	ATB41DWAN, ADB10DWAU
IC Additional Model	ATB41DWKN
EUT Type	Car Audio System
Power Supply	DC 14.4 V
Frequency Range	2412 MHz - 2462 MHz
Max. RF Output Power	Peak Power 802.11b : 14.89 dBm 802.11g : 17.86 dBm 802.11n(HT20) : 18.16 dBm Average Power 802.11b : 9.72 dBm 802.11g : 10.05 dBm 802.11n(HT20) : 9.94 dBm
Modulation Type	DSSS/CCK : 802.11b OFDM : 802.11g, 802.11n
Number of Channels	11 Channels
Antenna Specification	Antenna type: Pattern Antenna Peak Gain : -0.01 dBi
Date(s) of Tests	May 28, 2019~ June 02, 2019
PMN (Product Marketing Number)	ADB10DWKN, ATB41DWKN
HVIN (Hardware Version Identification Number)	ADB10DWKN, ATB41DWKN
FVIN (Firmware Version Identification Number)	N/A
HMN (Host Marketing Name)	N/A

2. TEST METHODOLOGY

FCC KDB 558074 D01 15.247 Meas Guidance v05r02 dated April 02, 2019 entitled “guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices and the measurement procedure described in ANSI C63.10(Version : 2013) ‘the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices’.

EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C.

GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1GHz. Above 1GHz with 1.5m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3.75 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 6.6.5 of ANSI C63.10. (Version: 2013)

DESCRIPTION OF TEST MODES

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.

3. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment's, which is traceable to recognized national standards.

Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2017).

4. FACILITIES AND ACCREDITATIONS

FACILITIES

The SAC(Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at the 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, 17383, Rep. of KOREA. The site is constructed in conformance with the requirements of A NSI C63.4. (Version :2014) and CISPR Publication 22.

Detailed description of test facility was submitted to the Commission and accepted dated April 02, 2018 (Registration Number: KR0032).

For ISED, test facility was accepted dated February 14, 2019 (CAB identifier: KR0032).

EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements.

Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.

All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

5. ANTENNA REQUIREMENTS

According to FCC 47 CFR § 15.203:

“An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can 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 antennas of this E.U.T are permanently attached.

* The E.U.T Complies with the requirement of § 15.203

6. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of

ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of $k = 2$ to indicate a 95 % level of confidence.

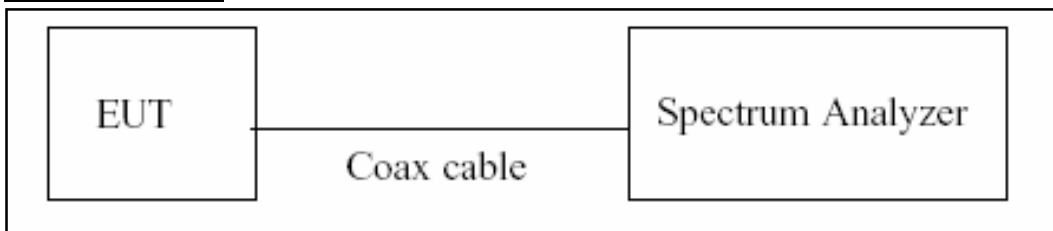
The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded Uncertainty (\pm dB)
Conducted Disturbance (150 kHz ~ 30 MHz)	1.82
Radiated Disturbance (9 kHz ~ 30 MHz)	3.40
Radiated Disturbance (30 MHz ~ 1 GHz)	4.80
Radiated Disturbance (1 GHz ~ 18 GHz)	5.70
Radiated Disturbance (18 GHz ~ 40 GHz)	5.05

7. DESCRIPTION OF TESTS

7.1. Duty Cycle

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

We tested according to the zero-span measurement method.

The largest available value of RBW is 8 MHz and VBW is 50 MHz.

The zero-span method of measuring duty cycle shall not be used if $T \leq 6.25$ microseconds. ($50/6.25 = 8$)

The zero-span method was used because all measured T data are > 6.25 microseconds and both RBW and VBW are $> 50/T$.

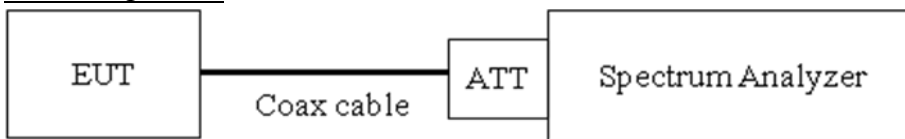
1. RBW = 8 MHz (the largest available value)
2. VBW = 8 MHz (\geq RBW)
3. SPAN = 0 Hz
4. Detector = Peak
5. Number of points in sweep > 100
6. Trace mode = Clear write
7. Measure T_{total} and T_{on}
8. Calculate Duty Cycle = T_{on}/T_{total} and Duty Cycle Factor = $10 \cdot \log(1/\text{Duty Cycle})$

7.2. 6dB Bandwidth & 99 % Bandwidth

Limit

The minimum permissible 6 dB bandwidth is 500 kHz.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

The Spectrum Analyzer is set to (Procedure 8.2 in KDB 558074 v05r01,

Procedure 11.8.1 in ANSI 63.10-2013)

- 1) RBW = 100 kHz
- 2) VBW \geq 3 x RBW
- 3) Detector = Peak
- 4) Trace mode = max hold
- 5) Sweep = auto couple
- 6) Allow the trace to stabilize
- 7) We tested 6 dB bandwidth using the automatic bandwidth measurement capability of a spectrum analyzer. X dB is set 6 dB.

Test Procedure (99 % Bandwidth for IC)

The transmitter output is connected to the spectrum analyzer.

RBW = 1% ~ 5% of the occupied bandwidth

VBW \approx 3 x RBW

Detector = Peak

Trace mode = max hold

Sweep = auto couple

Allow the trace to stabilize

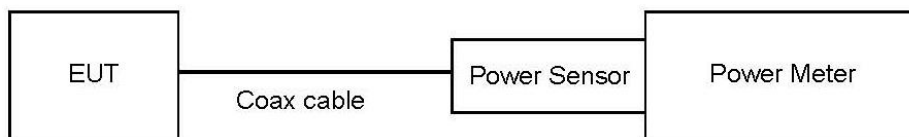
Note : We tested OBW using the automatic bandwidth measurement capability of a spectrum analyzer.

7.3. Output Power

Limit

The maximum permissible conducted output power is 1 Watt.

Test Configuration



Test Procedure

The transmitter output is connected to the Power Meter.

- Peak Power (Procedure 11.9.1.3 in ANSI 63.10-2013)
: Measure the peak power of the transmitter.

- Average Power (Procedure 11.9.2.3 in ANSI 63.10-2013)
 - 1) Measure the duty cycle.
 - 2) Measure the average power of the transmitter. This measurement is an average over both the on and off periods of the transmitter.
 - 3) Add $10 \log(1/x)$, where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times.

Sample Calculation

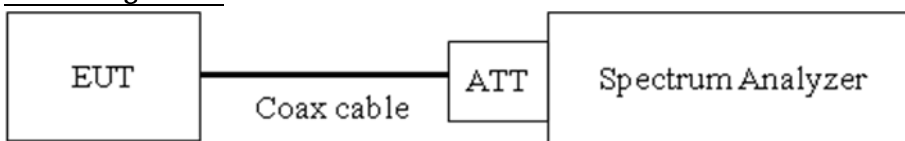
- Conducted Output Power(Peak) = Reading Value + ATT loss + Cable loss
- Conducted Output Power(Average) = Reading Value + ATT loss + Cable loss + Duty Cycle Factor

7.4. Power Spectral Density

Limit

The transmitter power density average over 1-second interval shall not be greater than 8dBm in any 3kHz BW.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

We tested according to Procedure 8.4 in KDB 558074 v05r02, Procedure 11.10 in ANSI 63.10-2013.

The spectrum analyzer is set to :

- 1) Set analyzer center frequency to DTS channel center frequency.
- 2) Set span to at least 1.5 times the OBW.
- 3) $RBW = 3 \text{ kHz} \leq RBW \leq 100 \text{ kHz}$.
- 4) $VBW \geq 3 \times RBW$.
- 5) Sweep = auto couple
- 6) Detector = power averaging (rms) or sample detector (when rms not available).
- 7) Ensure that the number of measurement points in the sweep $\geq [2 \times \text{span} / RBW]$.
- 8) Employ trace averaging (rms) mode over a minimum of 100 traces
- 9) Use the peak marker function to determine the maximum amplitude level.
- 10) Use the peak marker function to determine the maximum amplitude level within the RBW.

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

Sample Calculation

- Power Spectral Density = Reading Value + ATT loss + Cable loss

7.5. Conducted Band Edge(Out of Band Emissions) & Conducted Spurious Emissions

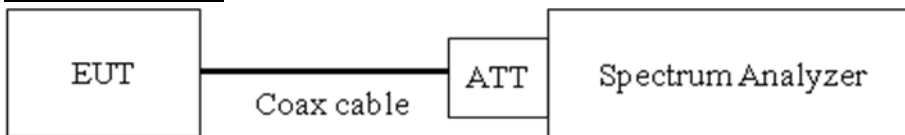
Limit

The maximum conducted (Average) output power was used to demonstrate compliance, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least

30 dB relative to the maximum in-band peak PSD level in 100 kHz.

[Conducted > 30 dBc]

Test Configuration



Test Procedure

The transmitter output is connected to the spectrum analyzer.

(Procedure 11.11 in ANSI 63.10-2013)

- 1) RBW = 100 kHz
- 2) VBW $\geq 3 \times$ RBW
- 3) Set span to encompass the spectrum to be examined
- 4) Detector = Peak
- 5) Trace Mode = max hold
- 6) Sweep time = auto couple
- 7) Ensure that the number of measurement points $\geq 2 \times$ Span/RBW
- 8) Allow trace to fully stabilize.
- 9) Use peak marker function to determine the maximum amplitude level.

Measurements are made over the 30 MHz to 25 GHz range with the transmitter set to the lowest, middle, and highest channels.

Factors for frequency

Freq(MHz)	Factor(dB)
30	11.17
100	9.7
200	10.06
300	10
400	10.1
500	10.12
600	10.19
700	10.22
800	10.22
900	10.21
1000	10.26
2000	10.51
2400*	10.52
2500*	10.54
3000	10.55
4000	10.76
5000	10.94
6000	10.93
7000	11.22
8000	11.19
9000	11.35
10000	11.43
11000	11.43
12000	11.55
13000	11.7
14000	11.77
15000	11.85
16000	11.91
17000	11.89
18000	11.95
19000	11.94
20000	12.01
21000	12.04
22000	12.18
23000	12.47
24000	12.21
25000	12.4
26000	11.89

Note : 1. ‘*’ is fundamental frequency range.
 2. Factor = Attenuator loss + Cable loss

7.6. Radiated Test

Limit

FCC

Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30	30

IC

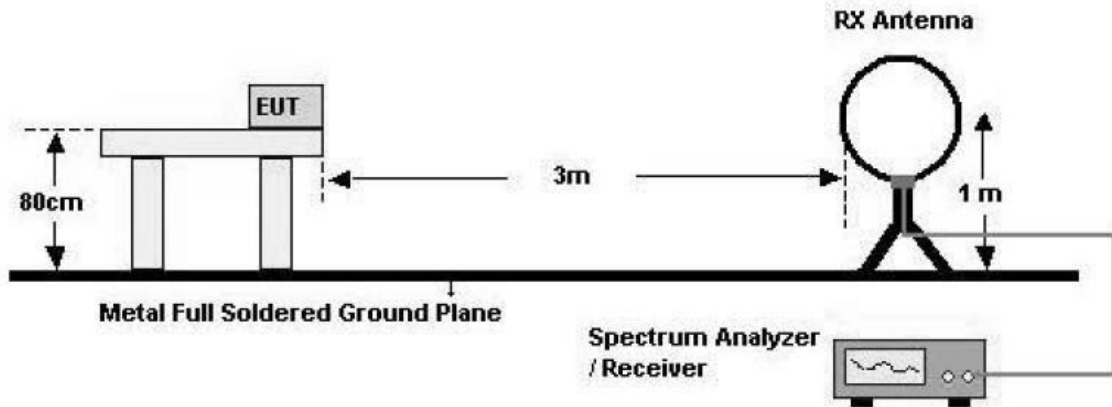
Frequency (MHz)	Field Strength (uA/m)	Measurement Distance (m)
0.009 – 0.490	6.37/F(kHz)	300
0.490 – 1.705	63.7/F(kHz)	30
1.705 – 30	0.08	30

FCC&IC

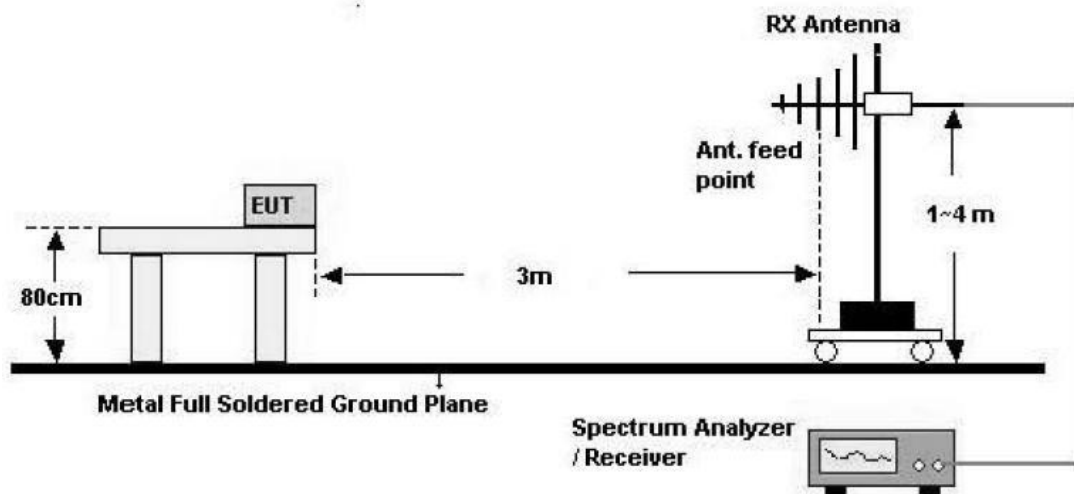
Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Test Configuration

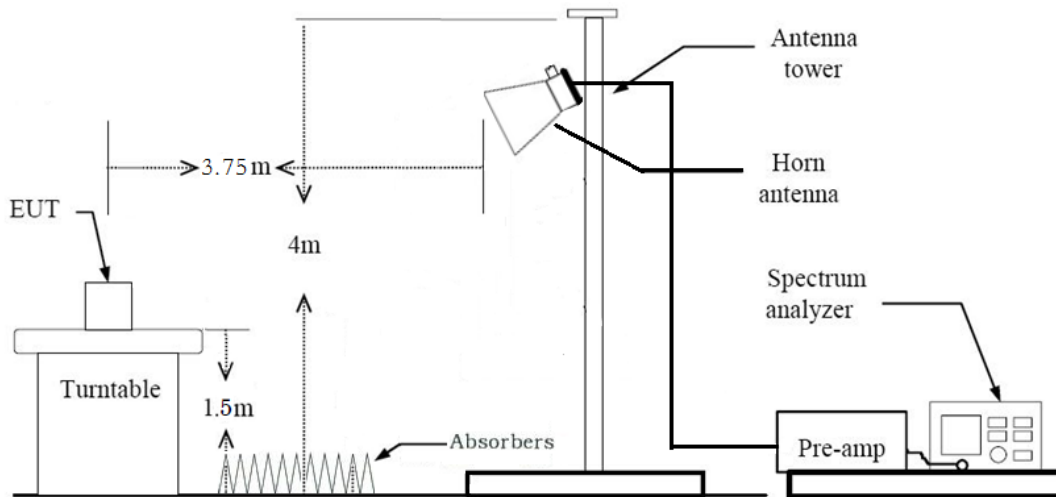
Below 30 MHz



30 MHz - 1 GHz



Above 1 GHz



Test Procedure of Radiated spurious emissions(Below 30 MHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The loop antenna was placed at a location 3m from the EUT
3. The EUT is placed on a turntable, which is 0.8m above ground plane.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
6. Distance Correction Factor(0.009 MHz – 0.490 MHz) = $40 \cdot \log(3 \text{ m}/300 \text{ m}) = -80 \text{ dB}$
Measurement Distance : 3 m
7. Distance Correction Factor(0.490 MHz – 30 MHz) = $40 \cdot \log(3 \text{ m}/30 \text{ m}) = -40 \text{ dB}$
Measurement Distance : 3 m
8. Spectrum Setting
 - Frequency Range = 9 kHz ~ 30 MHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 9 kHz
 - VBW $\geq 3 \cdot$ RBW
9. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

KDB 414788 OFS and Chamber Correlation Justification

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

(Worst case: semi-anechoic chamber(10 m chamber))

Test Procedure of Radiated spurious emissions(Below 1GHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The EUT is placed on a turntable, which is 0.8m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

5. Spectrum Setting

(1) Measurement Type(Peak):

- Measured Frequency Range : 30 MHz – 1 GHz
- Detector = Peak
- Trace = Maxhold
- RBW = 100 kHz
- VBW \geq 3*RBW

(2) Measurement Type(Quasi-peak):

- Measured Frequency Range : 30 MHz – 1 GHz
- Detector = Quasi-Peak
- RBW = 120 kHz

*In general, (1) is used mainly

6. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L)

Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
*Distance extrapolation factor = $20 \cdot \log(\text{test distance} / \text{specific distance})$ (dB)
6. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
8. The unit was tested with its standard battery.
9. Spectrum Setting (Method 8.6 in KDB 558074 v05r02, Procedure 11.12 in ANSI 63.10-2013)

(1) Measurement Type(Peak):

- Measured Frequency Range : 1 GHz – 25 GHz
- Detector = Peak
- Trace = Maxhold
- RBW = 1 MHz
- VBW $\geq 3 \cdot$ RBW

(2) Measurement Type(Average): Duty cycle $\geq 98\%$

- Measured Frequency Range : 1 GHz – 25 GHz
- Detector = RMS
- Averaging type = power (*i.e.*, RMS)
- RBW = 1 MHz
- VBW $\geq 3 \cdot$ RBW
- Sweep time = auto.
- Trace mode = average (at least 100 traces).

(3) Measurement Type(Average): Duty cycle $< 98\%$, duty cycle variations are less than $\pm 2\%$

- Measured Frequency Range : 1 GHz – 25 GHz
- Detector = RMS
- Averaging type = power (*i.e.*, RMS)
- RBW = 1 MHz

- $VBW \geq 3 * RBW$
- Sweep time = auto.
- Trace mode = average (at least 100 traces).
- Correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle.
- Duty Cycle Factor (dB) : Please refer to the please refer to section 9.1.

10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

11. Total(Measurement Type : Peak)

= Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Distance Factor(D.F)

Total(Measurement Type : Average, Duty cycle \geq 98%)

= Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Distance Factor(D.F)

Total(Measurement Type : Average, Duty cycle < 98%)

= Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Distance Factor(D.F)

+ Duty Cycle Factor

Test Procedure of Radiated Restricted Band Edge

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
*Distance extrapolation factor = $20 \cdot \log(\text{test distance} / \text{specific distance})$ (dB)
6. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
8. The unit was tested with its standard battery.
9. Spectrum Setting

(1) Measurement Type(Peak):

- Measured Frequency Range : 2310 MHz ~ 2390 MHz/ 2483.5 MHz ~ 2500 MHz
- Detector = Peak
- Trace = Maxhold
- RBW = 1 MHz
- VBW \geq 3*RBW

(2) Measurement Type(Average): Duty cycle \geq 98%,

- Measured Frequency Range : 2310 MHz ~ 2390 MHz/ 2483.5 MHz ~ 2500 MHz
- Detector = RMS
- Averaging type = power (*i.e.*, RMS)
- RBW = 1 MHz
- VBW \geq 3*RBW
- Sweep time = auto.
- Trace mode = average (at least 100 traces).

(3) Measurement Type(Average): Duty cycle < 98%, duty cycle variations are less than $\pm 2\%$

- Measured Frequency Range : 2310 MHz ~ 2390 MHz/ 2483.5 MHz ~ 2500 MHz
- Detector = RMS
- Averaging type = power (*i.e.*, RMS)
- RBW = 1 MHz
- VBW \geq 3*RBW

- Sweep time = auto.
- Trace mode = average (at least 100 traces).
- Correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle.
- Duty Cycle Factor (dB) : Please refer to the please refer to section 9.1.

10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

11. Total(Measurement Type : Peak)

= Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

Total(Measurement Type : Average, Duty cycle \geq 98%)

= Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

Total(Measurement Type : Average, Duty cycle < 98%)

= Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

+ Duty Cycle Factor

7.7. AC Power line Conducted Emissions

Limit

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN).

Frequency Range (MHz)	Limits (dBμV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56*	56 to 46*
0.50 to 5	56	46
5 to 30	60	50

*Decreases with the logarithm of the frequency.

Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

Test Configuration

See test photographs attached in Annex A for the actual connections between EUT and support equipment.

Test Procedure

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to a test power supply.
3. The measurement results are obtained as described below:
4. Detectors : Quasi Peak and Average Detector.

Sample Calculation

Quasi-peak(Final Result) = Reading Value + Correction Factor

7.8. Receiver Spurious Emissions

Limit

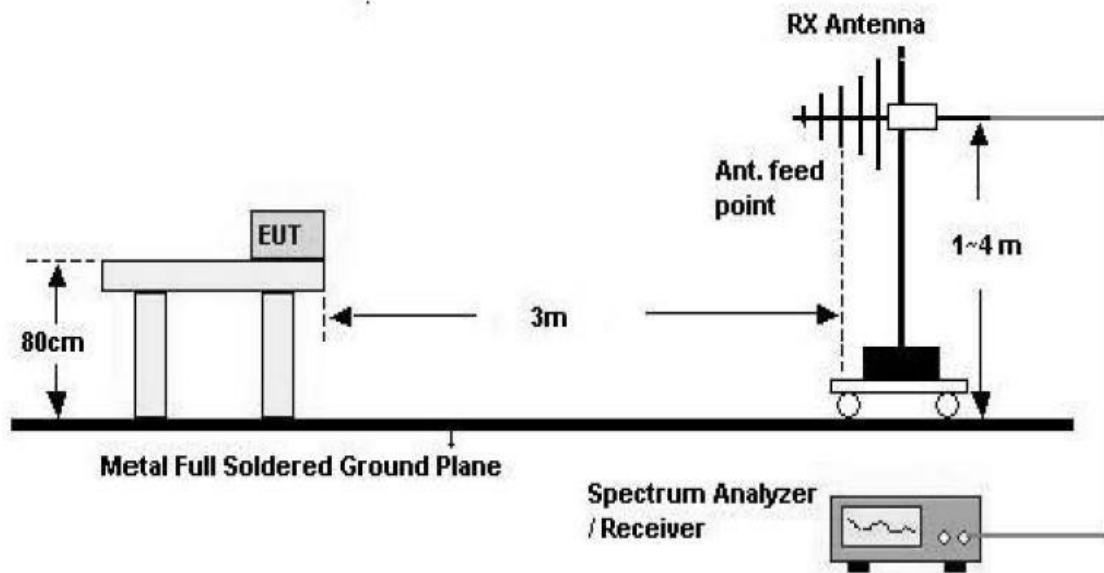
Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Note:

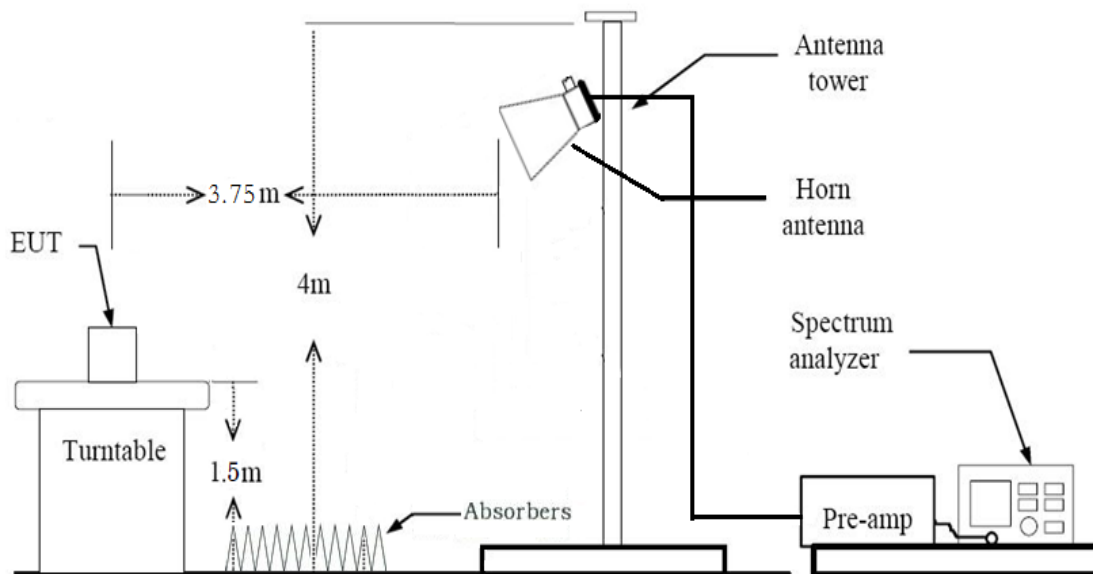
Measurements for compliance with the limits in table may be performed at distances other than 3 meters.

Test Configuration

30 MHz - 1 GHz



Above 1 GHz



Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
*Distance extrapolation factor = $20 \cdot \log(\text{test distance} / \text{specific distance})$ (dB)
6. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
8. The unit was tested with its standard battery.
9. Spectrum Setting
 - (1) Measurement Type(Peak):
 - Measured Frequency Range : 1 GHz – 25 GHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW $\geq 3 \cdot$ RBW
 - (2) Measurement Type(Average):
 - We performed using a reduced video BW method was done with the analyzer in linear mode
 - Measured Frequency Range : 1 GHz – 25 GHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW $\geq 1/\tau$ Hz, where τ = pulse width in secondsThe actual setting value of VBW = 1 kHz
10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
11. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Distance Factor(D.F)

7.9. Worst case configuration and mode

Radiated test

1. All modes of operation were investigated and the worst case configuration results are reported.
 - Mode : Stand alone
 - Worstcase : Stand alone
2. EUT Axis
 - Radiated Spurious Emissions : X
 - Radiated Restricted Band Edge : X
3. Duty cycle factor applies only 802.11g/n(Duty cycle < 98%).
4. All data rate of operation were investigated and the test results are worst case in lowest datarate of each mode.
 - 802.11b : 1Mbps
 - 802.11g : 6Mbps
 - 802.11n_HT20 : MCS0

AC Power line Conducted Emissions

1. We don't perform powerline conducted emission test. Because this EUT is used with vehicle.

Conducted test

1. The EUT was configured with data rate of highest power.

*

8. SUMMARY TEST OF RESULTS

FCC Part

Test Description	FCC Part Section(s)	Test Limit	Test Condition	Test Result
6 dB Bandwidth	§ 15.247(a)(2)	> 500 kHz	Conducted	PASS
Conducted Maximum Peak Output Power	§ 15.247(b)(3)	< 1 Watt		PASS
Power Spectral Density	§ 15.247(e)	< 8 dBm / 3 kHz Band		PASS
Band Edge (Out of Band Emissions)	§ 15.247(d)	Conducted > 30 dBc		PASS
AC Power line Conducted Emissions	§ 15.207	cf. Section 7.7		N/A
Radiated Spurious Emissions	§ 15.247(d), 15.205, 15.209	cf. Section 7.6	Radiated	PASS
Radiated Restricted Band Edge	§ 15.247(d), 15.205, 15.209	cf. Section 7.6		PASS

IC Part

Test Description	IC Part Section(s)	Test Limit	Test Condition	Test Result
6 dB Bandwidth	RSS-247, 5.2	> 500 kHz	Conducted	PASS
99% Bandwidth	RSS-GEN, 6.7	N/A		PASS
Conducted Maximum Peak Output Power And e.i.r.p.	RSS-247, 5.4.	< 1 Watt <4 Watt(e.i.r.p.)		PASS
Power Spectral Density	RSS-247, 5.2	< 8 dBm / 3 kHz Band		PASS
Band Edge(Out of Band Emissions)	RSS-247, 5.5	Conducted > 30 dBc		PASS
AC Power line Conducted Emissions	RSS-GEN, 8.8	cf. Section 7.7		N/A (Note1)
Radiated Spurious Emissions	RSS-GEN, 8.9	cf. Section 7.6		Radiated
Receiver Spurious Emissions	RSS-GEN, 7	cf. Section 7.8	PASS	
Radiated Restricted Band Edge	RSS-GEN, 8.10	cf. Section 7.6	PASS	

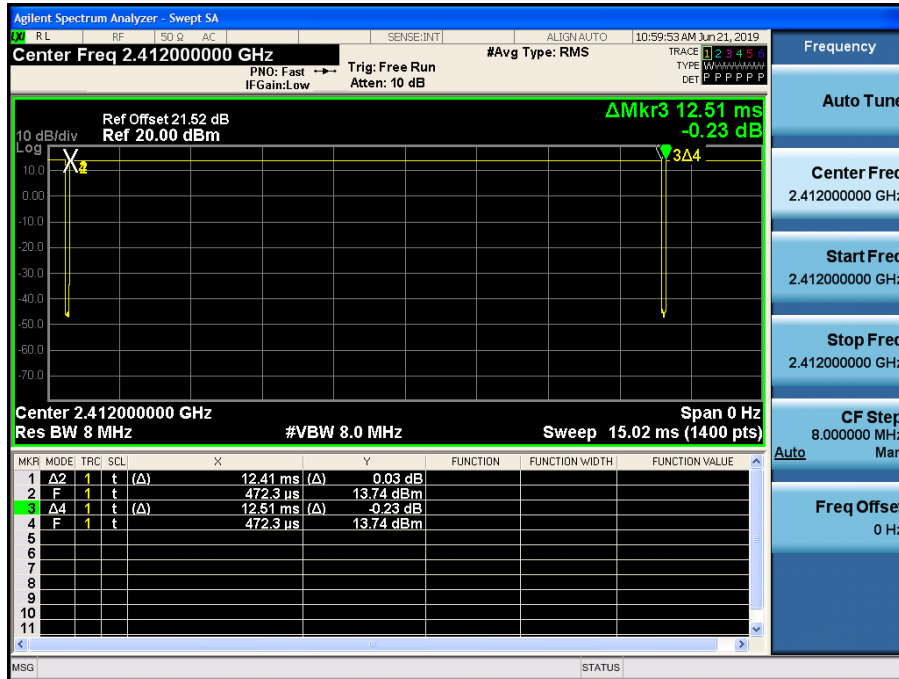
9. TEST RESULT

9.1 DUTY CYCLE

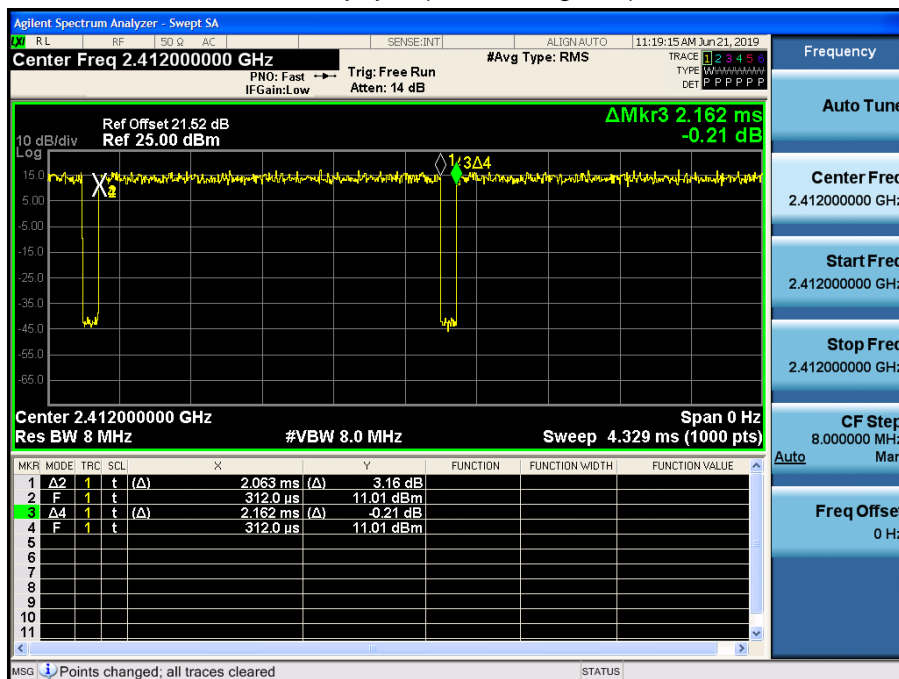
Mode	Data Rate (Mbps)	T _{on} (ms)	T _{total} (ms)	Duty Cycle	Duty Cycle Factor (dB)
802.11b	1	12.410	12.510	0.99200639	0.035
	2	6.209	6.310	0.98399366	0.070
	5.5	2.317	2.414	0.95981773	0.178
	11	1.206	1.302	0.92626728	0.333
802.11g	6	2.063	2.162	0.95391083	0.205
	9	1.382	1.485	0.93050177	0.313
	12	1.044	1.146	0.91062130	0.407
	18	0.704	0.805	0.87417255	0.584
	24	0.532	0.633	0.84000044	0.757
	36	0.365	0.465	0.78398582	1.057
	48	0.276	0.377	0.73103448	1.361
	54	0.248	0.349	0.70967770	1.489
802.11n (HT20)	6.5 (MCS0)	1.919	2.021	0.94970140	0.224
	13 (MCS1)	0.980	1.081	0.90630696	0.427
	19.5 (MCS2)	0.663	0.765	0.86756719	0.617
	26 (MCS3)	0.509	0.610	0.83391654	0.789
	39 (MCS4)	0.352	0.454	0.77544483	1.104
	52 (MCS5)	0.272	0.373	0.72888040	1.373
	58.5 (MCS6)	0.248	0.349	0.71008431	1.487
	65 (MCS7)	0.228	0.329	0.69265065	1.595

Test Plots

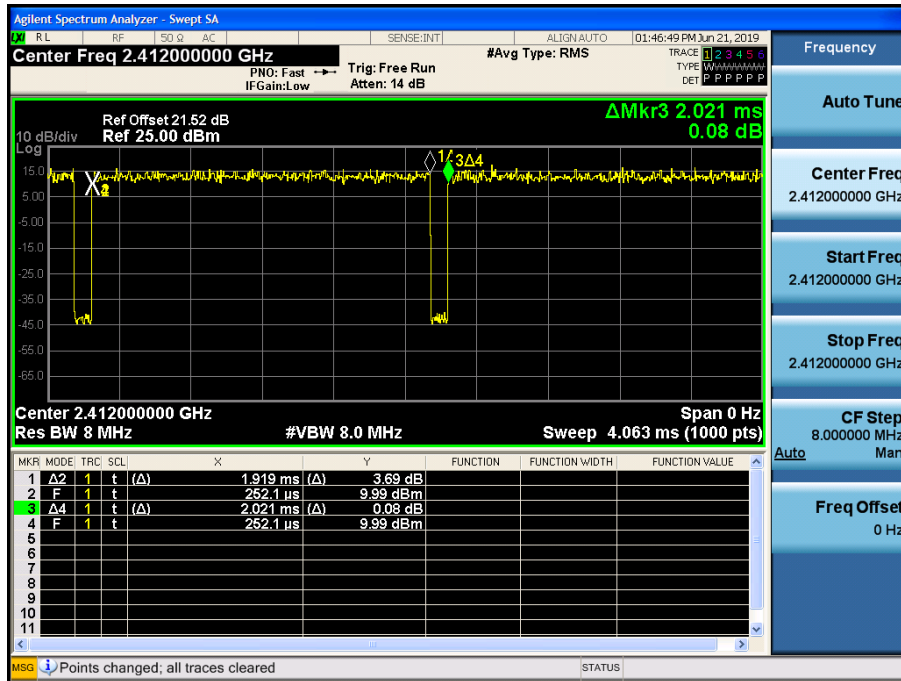
Duty cycle plot (802.11b(1Mbps))



Duty cycle plot (802.11g(6Mbps))



Duty cycle plot (802.11n(MCS0))



Note:

In order to simplify the report, attached plots were only the most lowest datarate.

9.2 6dB BANDWIDTH & 99 % BANDWIDTH

FCC

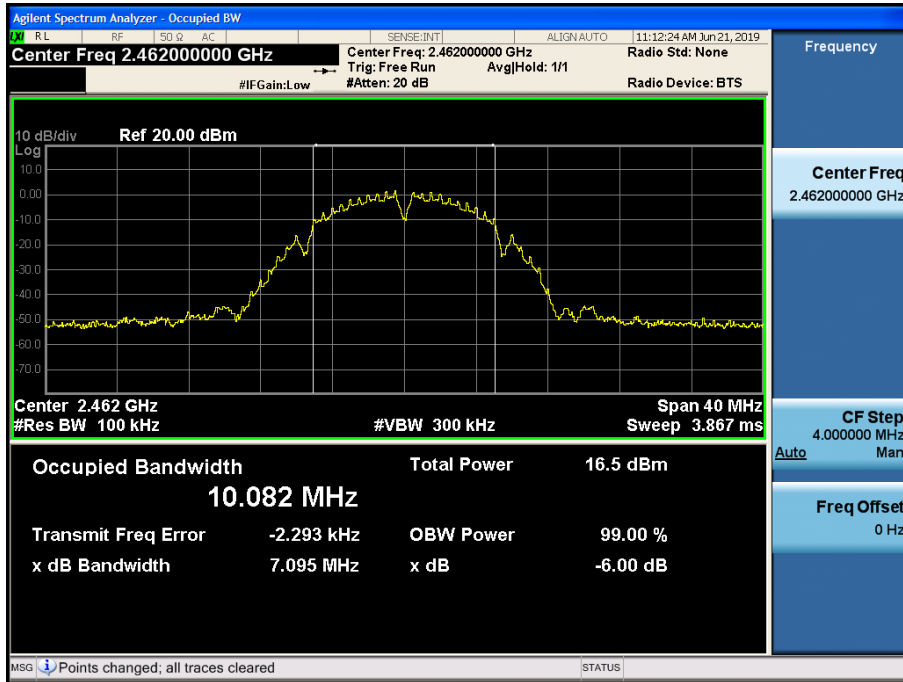
802.11b Mode		Measured Bandwidth [MHz]	Minimum Bandwidth [MHz]
Frequency [MHz]	Channel No.		
2412	1	7.117	0.5
2437	6	7.112	0.5
2462	11	7.095	0.5

802.11g Mode		Measured Bandwidth [MHz]	Minimum Bandwidth [MHz]
Frequency [MHz]	Channel No.		
2412	1	16.33	0.5
2437	6	16.28	0.5
2462	11	16.34	0.5

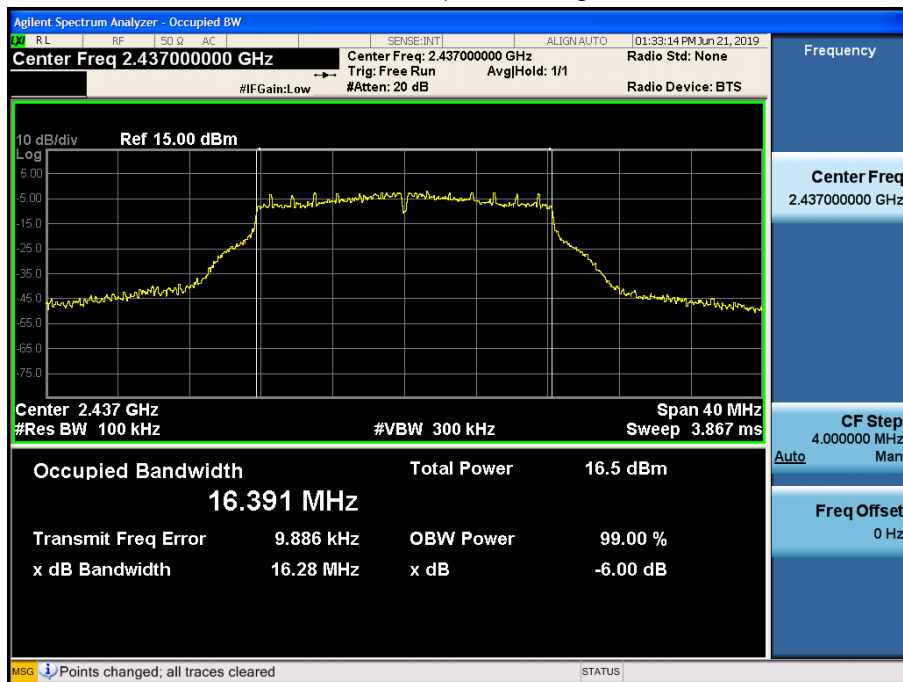
802.11n Mode		Measured Bandwidth [MHz]	Minimum Bandwidth [MHz]
Frequency [MHz]	Channel No.		
2412	1	17.32	0.5
2437	6	17.56	0.5
2462	11	17.56	0.5

Test Plots

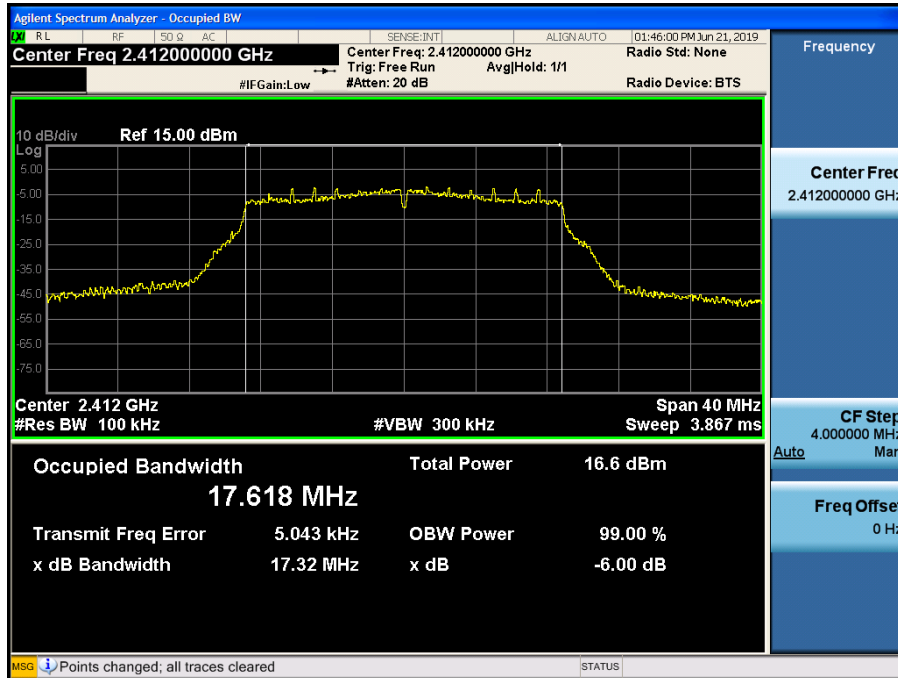
6dB Bandwidth plot (802.11b-CH 11)



6dB Bandwidth plot (802.11g-CH 6)



6dB Bandwidth plot (802.11n_HT20-CH 1)



Note:

In order to simplify the report, attached plots were only the most narrow 6 dB BW channel.

IC

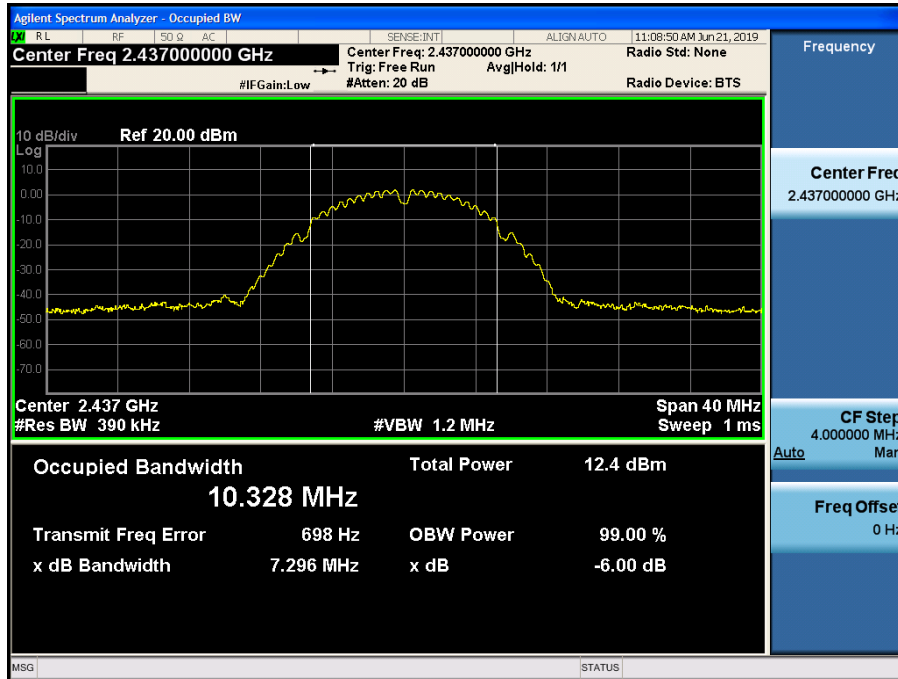
802.11b Mode		OBW Bandwidth [MHz]	Limit [MHz]
Frequency [MHz]	Channel No.		
2412	1	10.324	N/A
2437	6	10.328	N/A
2462	11	10.303	N/A

802.11g Mode		OBW Bandwidth [MHz]	Limit [MHz]
Frequency [MHz]	Channel No.		
2412	1	17.075	N/A
2437	6	17.057	N/A
2462	11	17.076	N/A

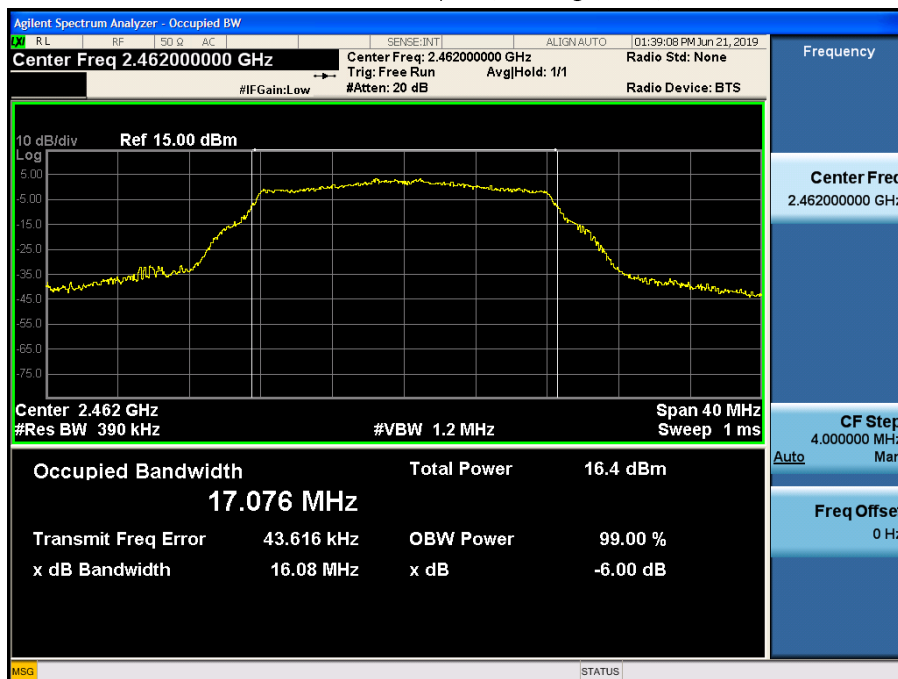
802.11n(HT20) Mode		OBW Bandwidth [MHz]	Limit [MHz]
Frequency [MHz]	Channel No.		
2412	1	18.133	N/A
2437	6	18.092	N/A
2462	11	18.157	N/A

Test Plots

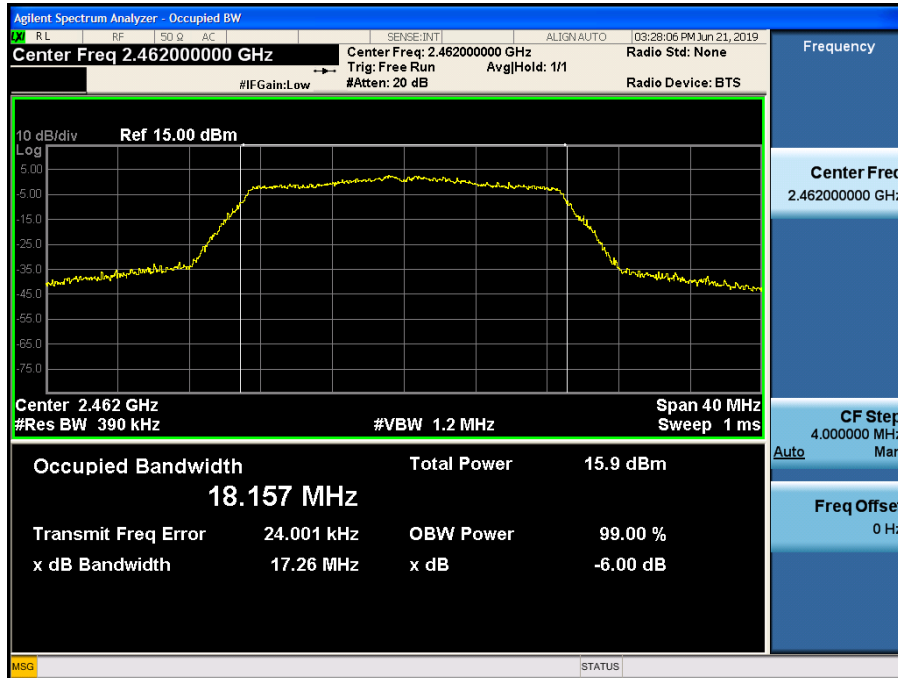
99% Bandwidth plot (802.11b-CH 6)



99% Bandwidth plot (802.11g-CH 11)



99% Bandwidth plot (802.11n_HT20-CH 11)



Note:

In order to simplify the report, attached plots were only the most wide 99% Bandwidth channel.

9.3 OUTPUT POWER

Peak Power

1. Power Meter offset = Attenuator loss + Cable loss
2. We apply to the offset in the 2.4 GHz range that was rounded off to the closest tenth dB.

802.11b Mode		Rate (Mbps)	Measured Power(dBm)	Limit (dBm)
Frequency[MHz]	Channel No.			
2412	1	1	12.13	30.00
		2	12.34	30.00
		5.5	13.76	30.00
		11	13.76	30.00
2437	6	1	11.63	30.00
		2	11.96	30.00
		5.5	13.42	30.00
		11	14.89	30.00
2462	11	1	11.44	30.00
		2	11.64	30.00
		5.5	13.06	30.00
		11	14.54	30.00

802.11g Mode		Rate (Mbps)	Measured Power(dBm)	Limit (dBm)
Frequency[MHz]	Channel No.			
2412	1	6	17.86	30.00
		9	17.72	30.00
		12	17.63	30.00
		18	17.27	30.00
		24	17.33	30.00
		36	17.48	30.00
		48	17.51	30.00
		54	17.43	30.00
2437	6	6	17.31	30.00
		9	17.22	30.00
		12	17.10	30.00
		18	16.72	30.00
		24	17.24	30.00
		36	17.02	30.00
		48	17.03	30.00
		54	16.94	30.00
2462	11	6	17.13	30.00
		9	17.04	30.00
		12	16.86	30.00
		18	16.53	30.00
		24	16.86	30.00
		36	16.66	30.00
		48	17.01	30.00
		54	16.97	30.00

802.11n Mode		MCS Index	Measured Power(dBm)	Limit (dBm)
Frequency[MHz]	Channel No.			
2412	1	0	17.33	30.00
		1	17.29	30.00
		2	17.33	30.00
		3	18.05	30.00
		4	18.08	30.00
		5	17.79	30.00
		6	18.16	30.00
		7	18.11	30.00
2437	6	0	16.79	30.00
		1	16.80	30.00
		2	16.83	30.00
		3	17.39	30.00
		4	17.67	30.00
		5	17.30	30.00
		6	18.16	30.00
		7	17.70	30.00
2462	11	0	16.62	30.00
		1	17.04	30.00
		2	16.97	30.00
		3	17.22	30.00
		4	17.20	30.00
		5	17.24	30.00
		6	17.69	30.00
		7	17.25	30.00

Average Power

1. Power Meter offset = Attenuator loss + Cable loss
2. We apply to the offset in the 2.4 GHz range that was rounded off to the closest tenth dB.

802.11b Mode		Rate (Mbps)	Measured Power (dBm)	Duty Cycle Factor	Measured Power(dBm) + Duty Cycle Factor	Limit (dBm)
Frequency [MHz]	Channel No.					
2412	1	1	9.69	0.035	9.72	30.00
		2	9.60	0.070	9.67	30.00
		5.5	9.39	0.178	9.56	30.00
		11	9.38	0.333	9.72	30.00
2437	6	1	9.18	0.035	9.22	30.00
		2	9.23	0.070	9.30	30.00
		5.5	9.06	0.178	9.24	30.00
		11	8.61	0.333	8.94	30.00
2462	11	1	8.97	0.035	9.01	30.00
		2	8.93	0.070	9.00	30.00
		5.5	8.72	0.178	8.90	30.00
		11	8.24	0.333	8.57	30.00

802.11g Mode		Rate (Mbps)	Measured Power (dBm)	Duty Cycle Factor	Measured Power(dBm) + Duty Cycle Factor	Limit (dBm)
Frequency [MHz]	Channel No.					
2412	1	6	9.79	0.205	10.00	30.00
		9	9.69	0.313	10.00	30.00
		12	9.64	0.407	10.05	30.00
		18	8.93	0.584	9.51	30.00
		24	8.70	0.757	9.46	30.00
		36	8.40	1.057	9.45	30.00
		48	8.24	1.361	9.60	30.00
		54	8.00	1.489	9.49	30.00
2437	6	6	9.30	0.205	9.51	30.00
		9	9.20	0.313	9.52	30.00
		12	9.12	0.407	9.53	30.00
		18	8.45	0.584	9.03	30.00
		24	8.53	0.757	9.29	30.00
		36	7.91	1.057	8.97	30.00
		48	7.70	1.361	9.06	30.00
		54	7.52	1.489	9.01	30.00
2462	11	6	9.03	0.205	9.23	30.00
		9	8.95	0.313	9.26	30.00
		12	8.90	0.407	9.31	30.00
		18	8.25	0.584	8.83	30.00
		24	8.19	0.757	8.95	30.00
		36	7.59	1.057	8.65	30.00
		48	7.74	1.361	9.10	30.00
		54	7.54	1.489	9.03	30.00

802.11n Mode		MCS Index	Measured Power (dBm)	Duty Cycle Factor	Measured Power(dBm) + Duty Cycle Factor	Limit (dBm)
Frequency [MHz]	Channel No.					
2412	1	0	9.24	0.224	9.47	30.00
		1	9.07	0.427	9.50	30.00
		2	8.83	0.617	9.45	30.00
		3	8.97	0.789	9.75	30.00
		4	8.73	1.104	9.84	30.00
		5	8.20	1.373	9.57	30.00
		6	8.43	1.487	9.91	30.00
		7	8.34	1.595	9.94	30.00
2437	6	0	8.68	0.224	8.91	30.00
		1	8.52	0.427	8.95	30.00
		2	8.40	0.617	9.01	30.00
		3	8.24	0.789	9.03	30.00
		4	8.23	1.104	9.34	30.00
		5	7.75	1.373	9.13	30.00
		6	8.26	1.487	9.75	30.00
		7	7.79	1.595	9.38	30.00
2462	11	0	8.46	0.224	8.68	30.00
		1	8.69	0.427	9.12	30.00
		2	8.55	0.617	9.17	30.00
		3	8.07	0.789	8.86	30.00
		4	7.83	1.104	8.94	30.00
		5	7.61	1.373	8.98	30.00
		6	7.87	1.487	9.36	30.00
		7	7.41	1.595	9.01	30.00

9.4 POWER SPECTRAL DENSITY

Mode	Frequency (MHz)	Channel No.	Test Result			
			Measured PSD (dBm)	Duty Cycle Factor	Measured PSD(dBm) + Duty Cycle Factor	Limit (dBm)
802.11b	2412	1	-12.800	0.035	-12.765	8
	2437	6	-13.727	0.070	-13.657	8
	2462	11	-12.943	0.035	-12.908	8
802.11g	2412	1	-13.192	0.407	-12.785	8
	2437	6	-13.695	0.407	-13.288	8
	2462	11	-13.846	0.407	-13.439	8
802.11n	2412	1	-15.704	1.595	-14.109	8
	2437	6	-16.039	1.487	-14.552	8
	2462	11	-16.049	1.487	-14.562	8

Note :

1. Spectrum reading values are not plot data.

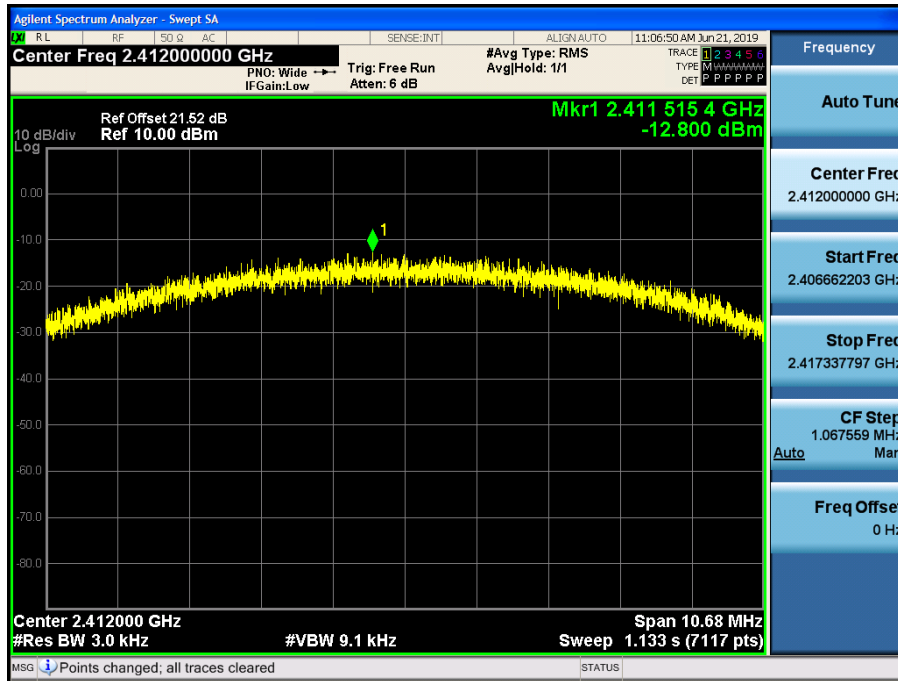
The PSD results in plot is already including the actual values of loss for the attenuator and cable combination.

2. Spectrum offset = Attenuator loss + Cable loss

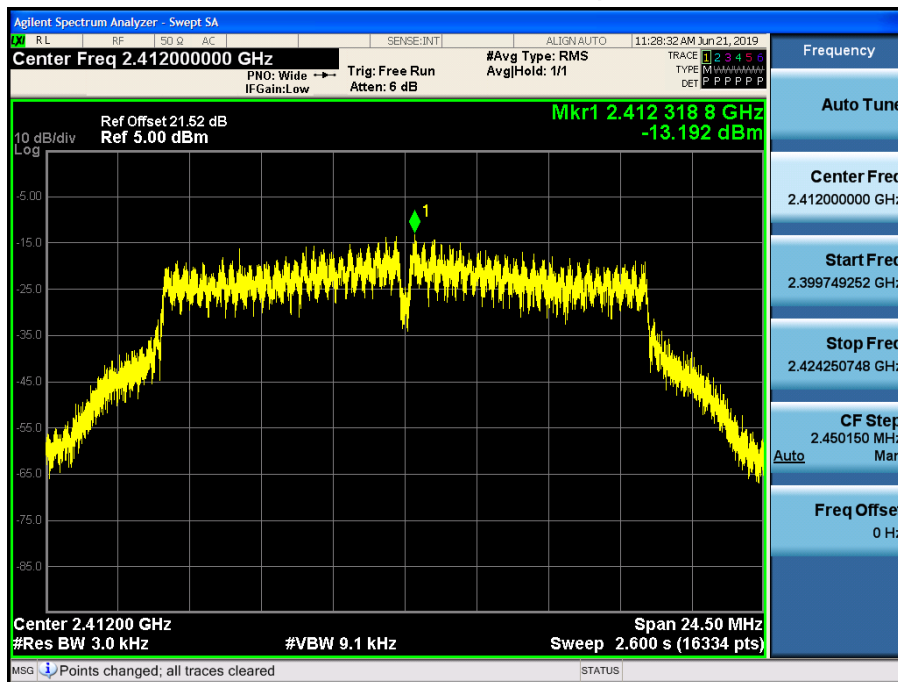
3. 21.52 dB is offset for 2.4 GHz Band.

Test Plots

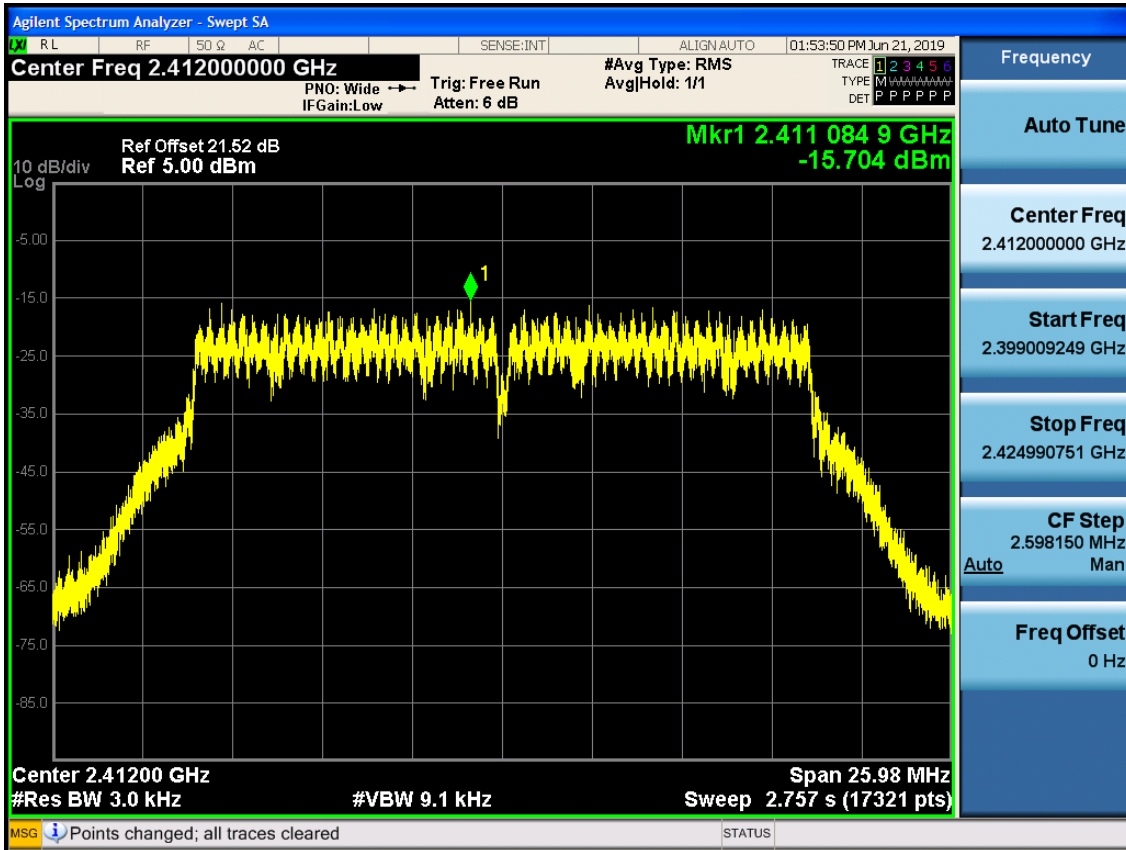
Power Spectral Density (802.11b-CH 1)



Power Spectral Density (802.11g-CH 1)



Power Spectral Density (802.11n_HT20 -CH 1)



Note :

In order to simplify the report, attached plots were only the worstcase PSD channel.

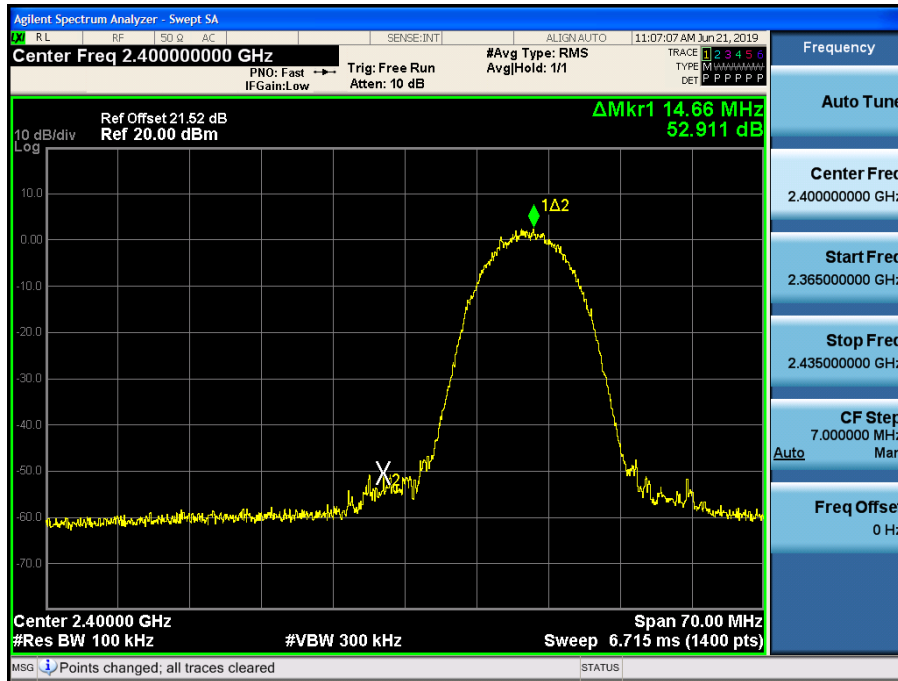
9.5 BAND EDGE/ CONDUCTED SPURIOUS EMISSIONS

Test Result : please refer to the plot below.

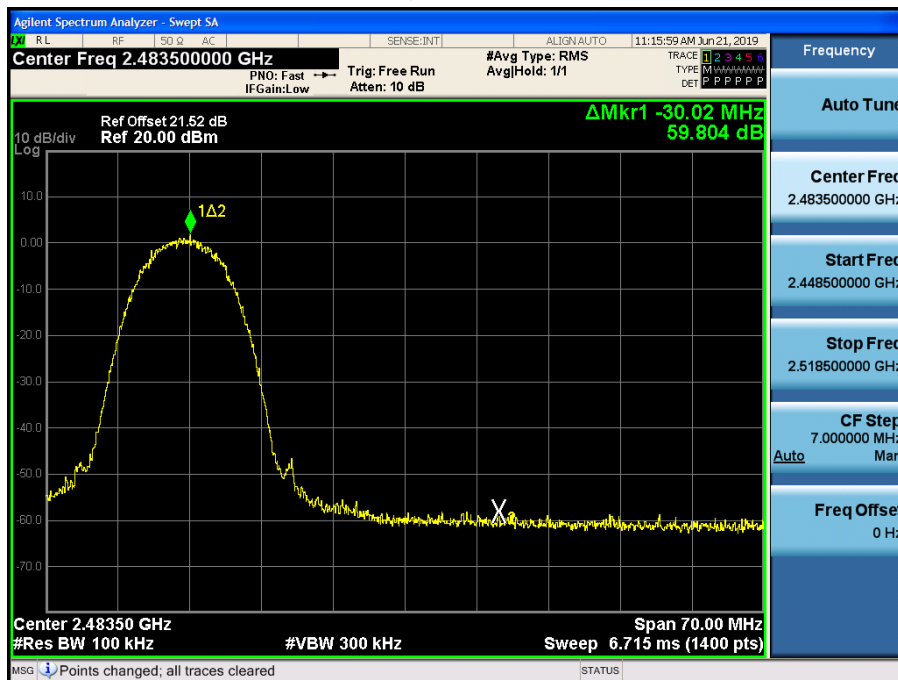
In order to simplify the report, attached plots were only the worst case channel and data rate.

Test Plots(BandEdge)

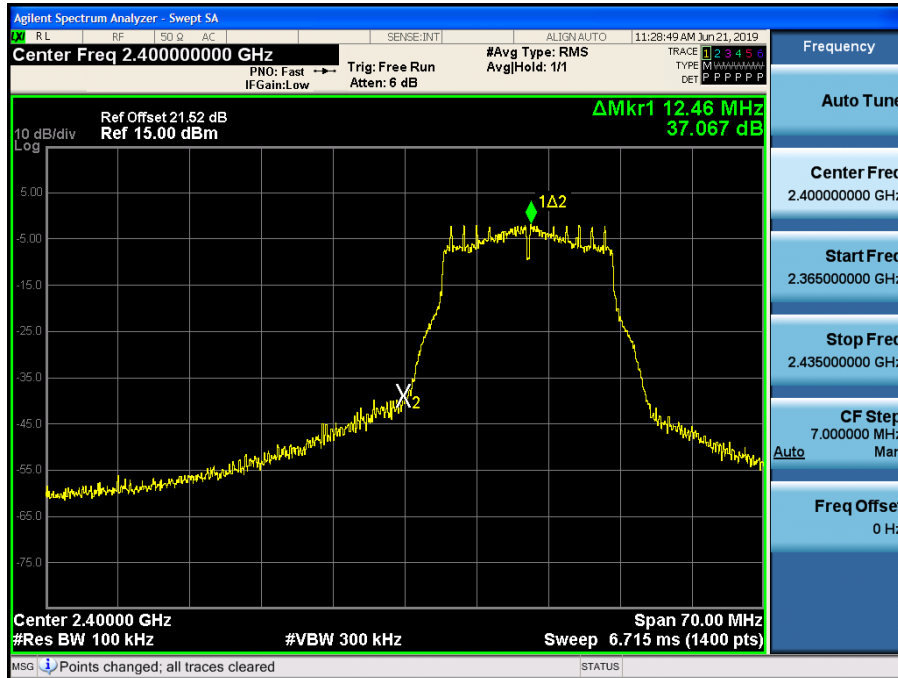
Band Edge (802.11b-CH1)



Band Edge (802.11b-CH11)



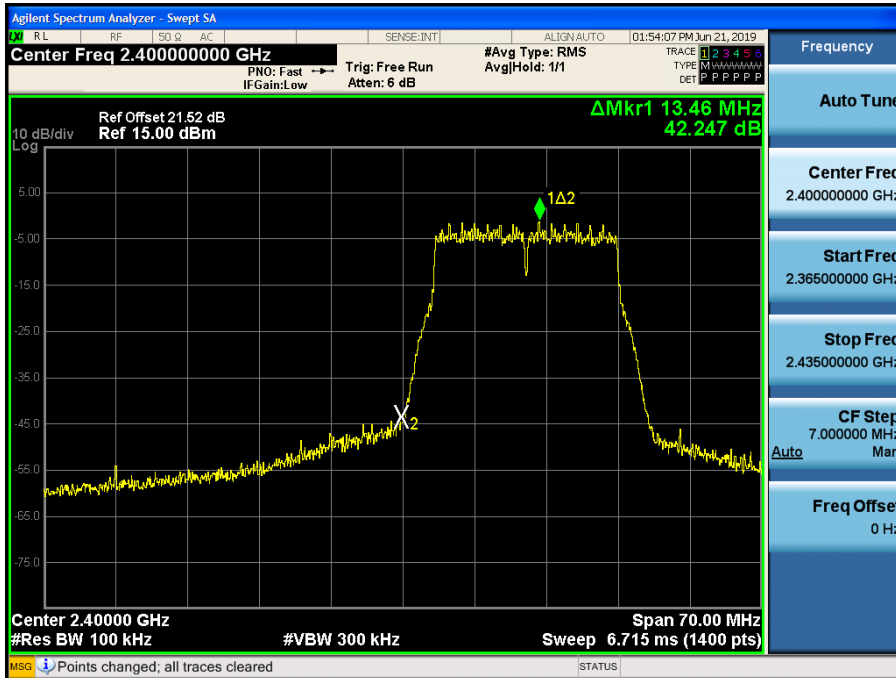
Band Edge (802.11g-CH1)



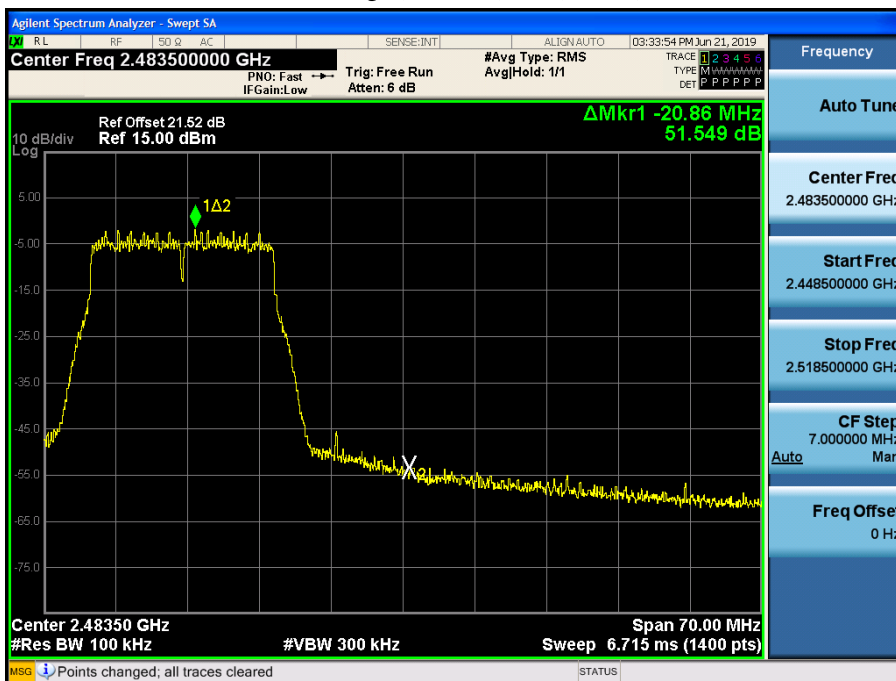
Band Edge (802.11g-CH11)



Band Edge (802.11n(HT20)-CH1)



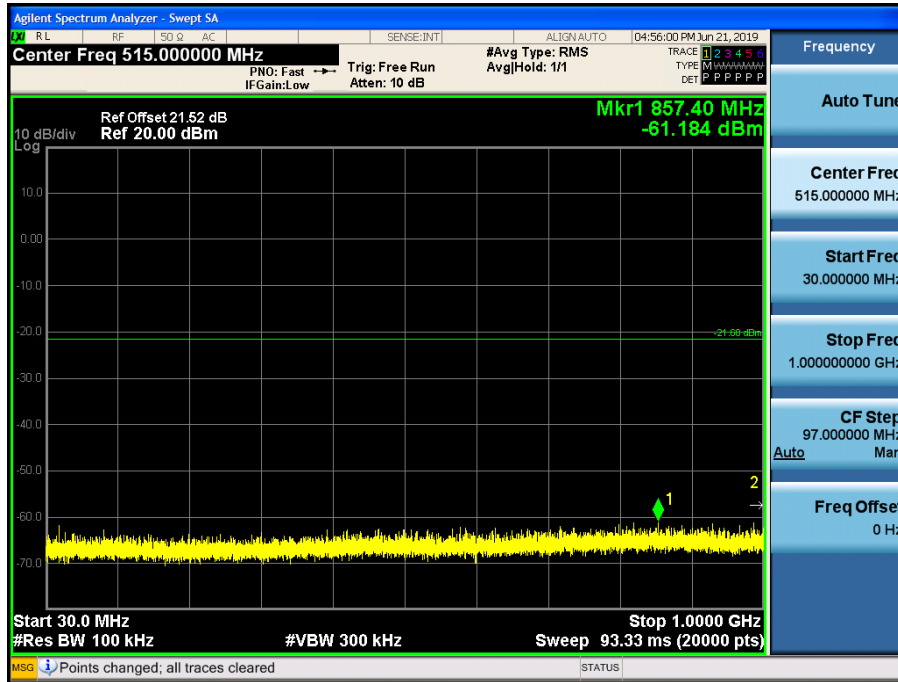
Band Edge (802.11n(HT20)-CH11)



Test Plots(Conducted Spurious Emission)

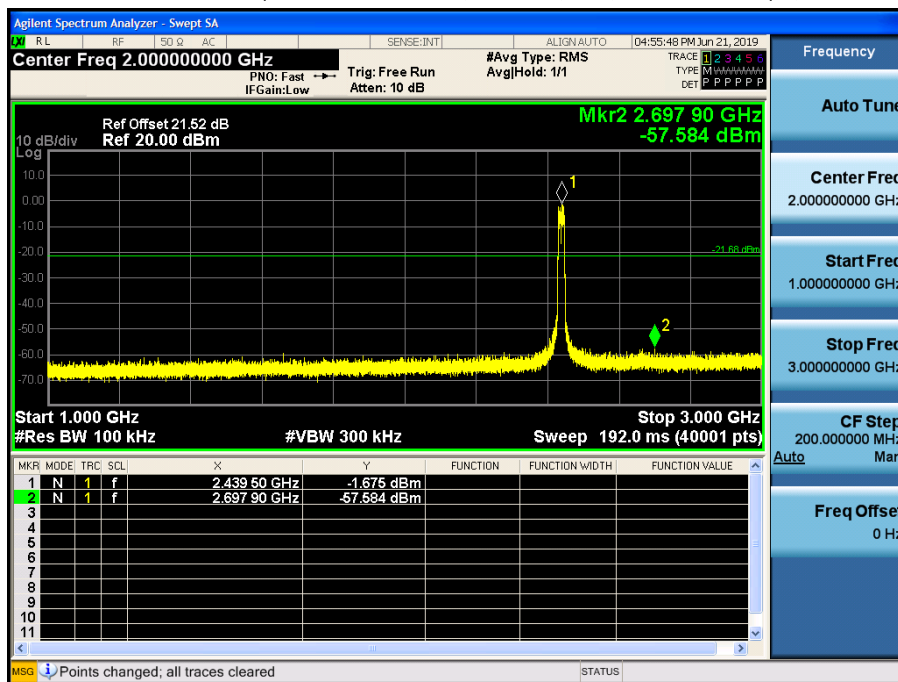
30 MHz ~ 1 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



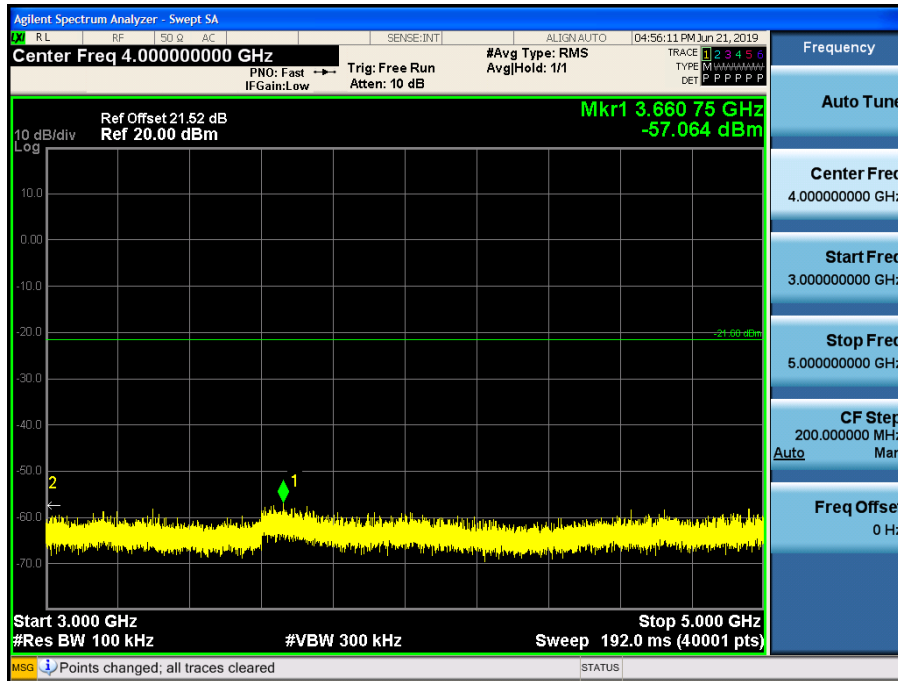
1 GHz ~ 3 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



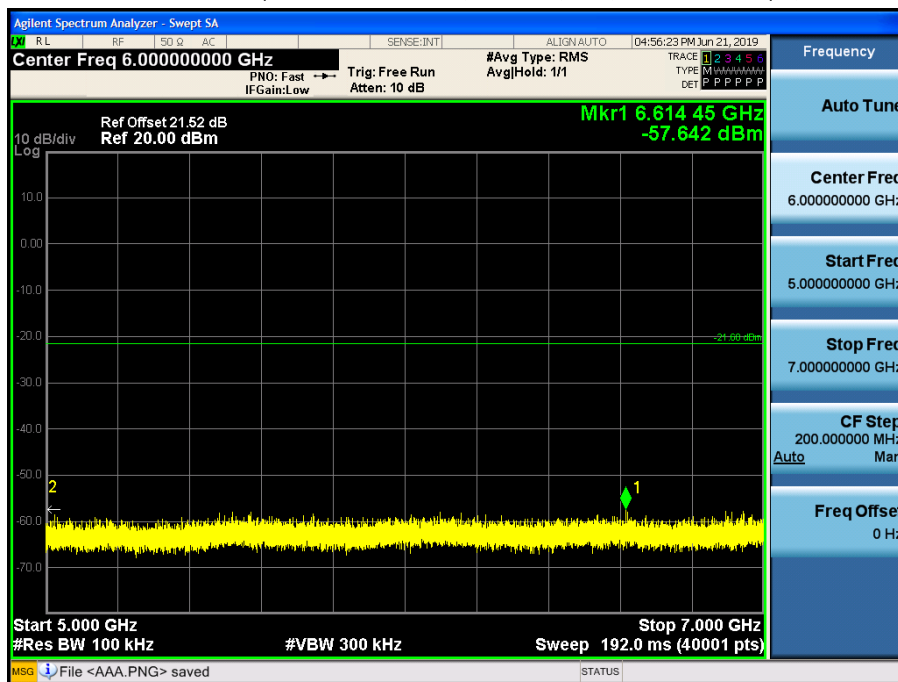
3 GHz ~ 5 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



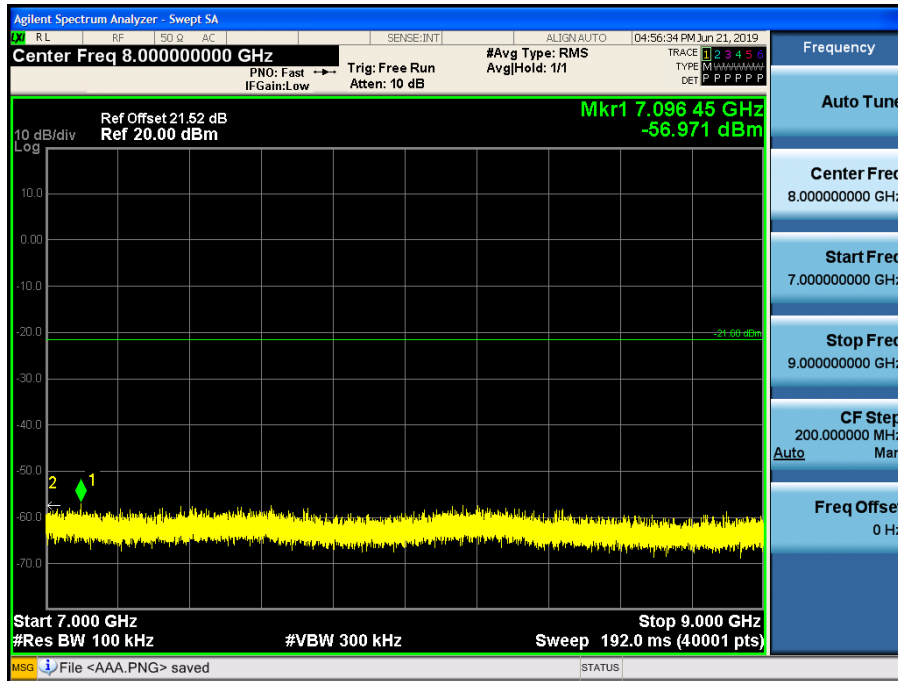
5 GHz ~ 7 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



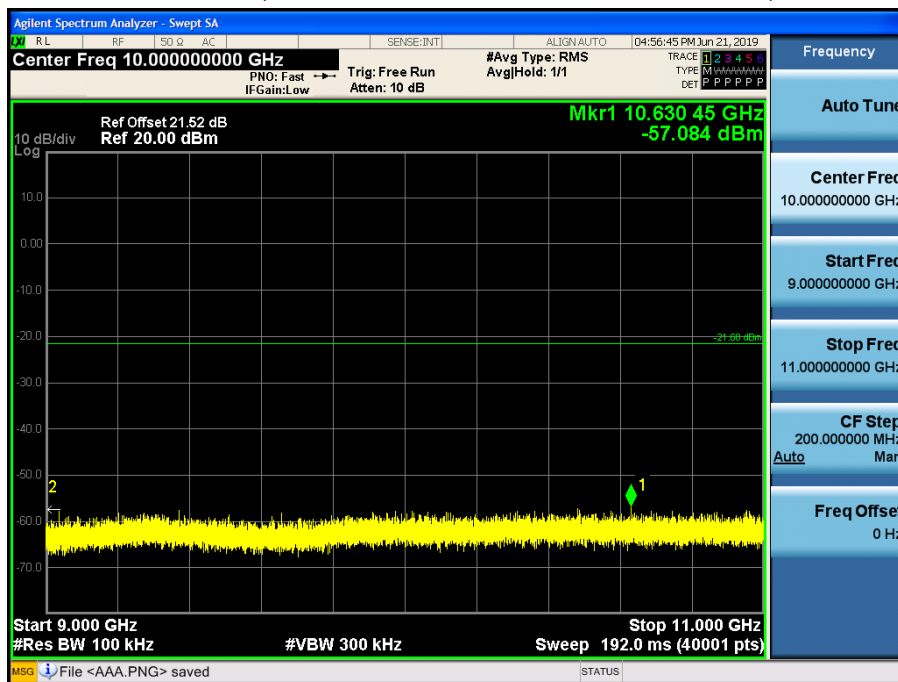
7 GHz ~ 9 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



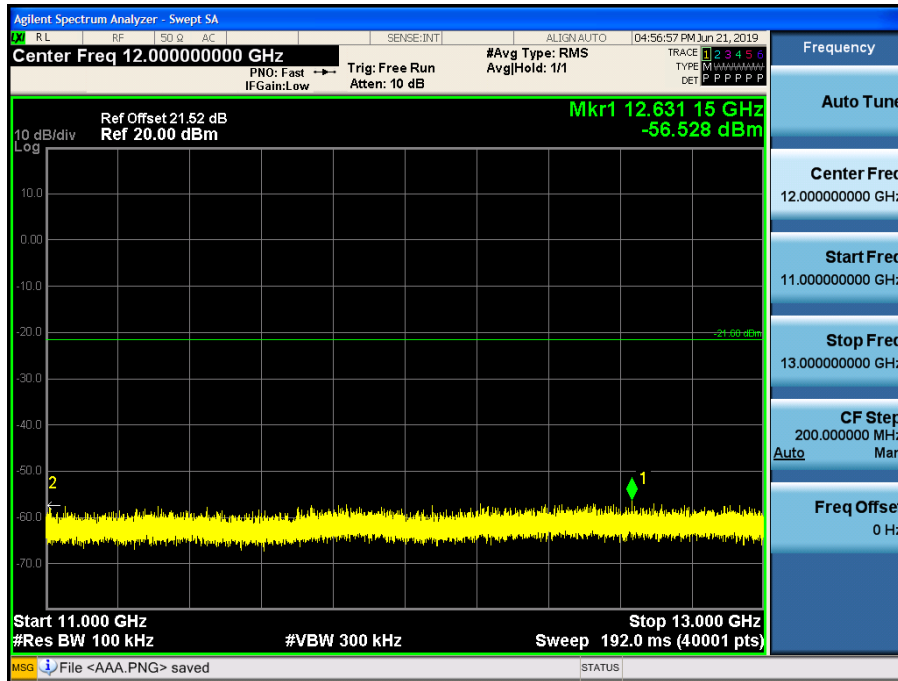
9 GHz ~ 11 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



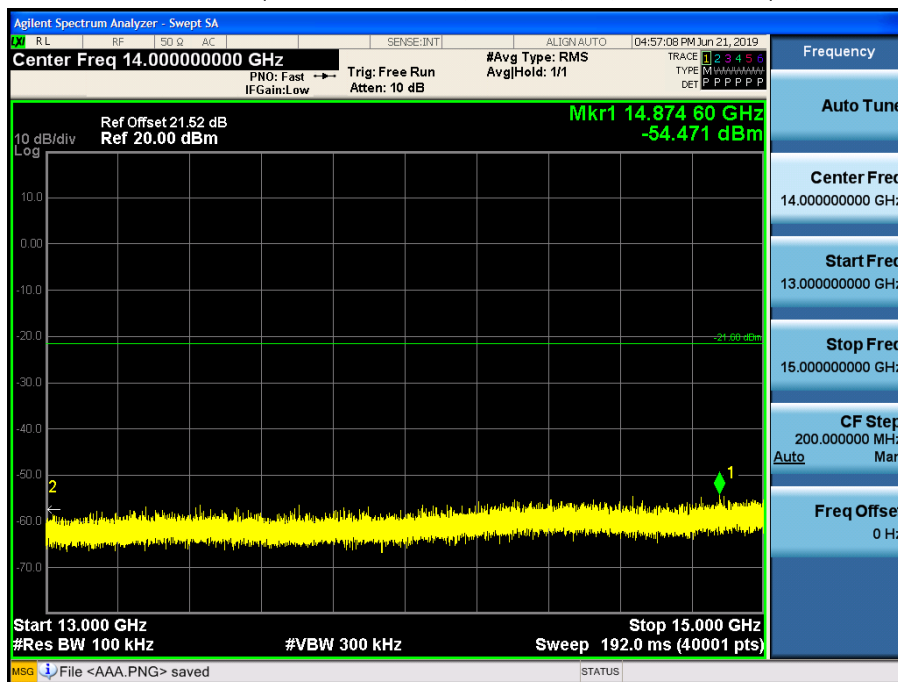
11 GHz ~ 13 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



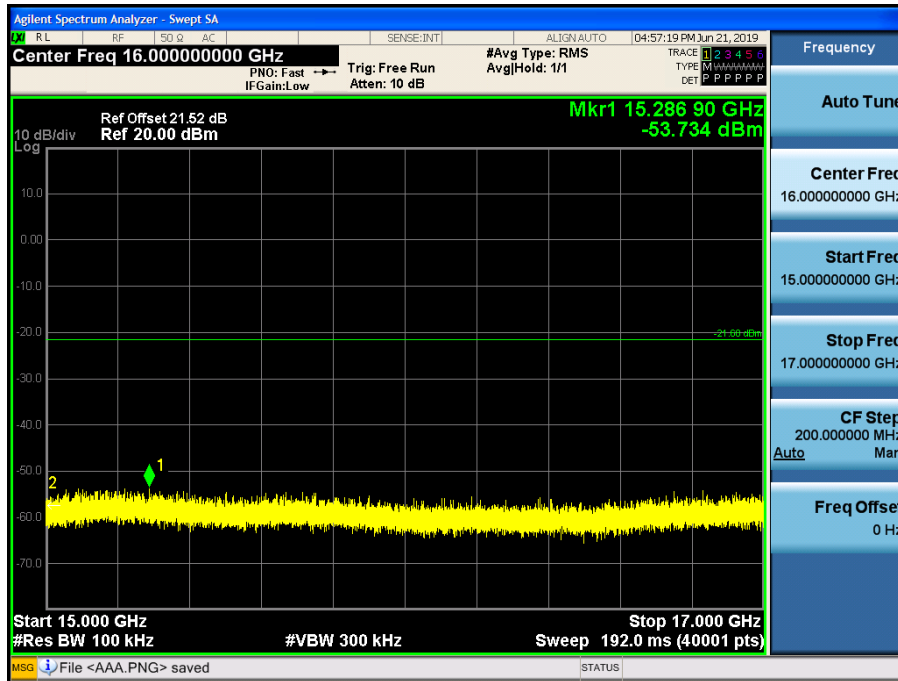
13 GHz ~ 15 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



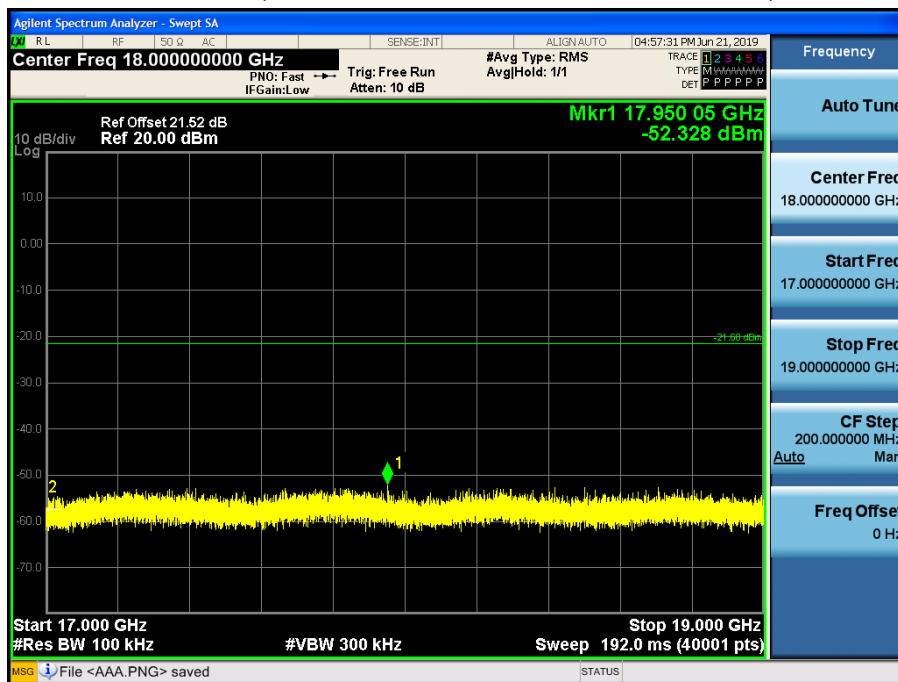
15 GHz ~ 17 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



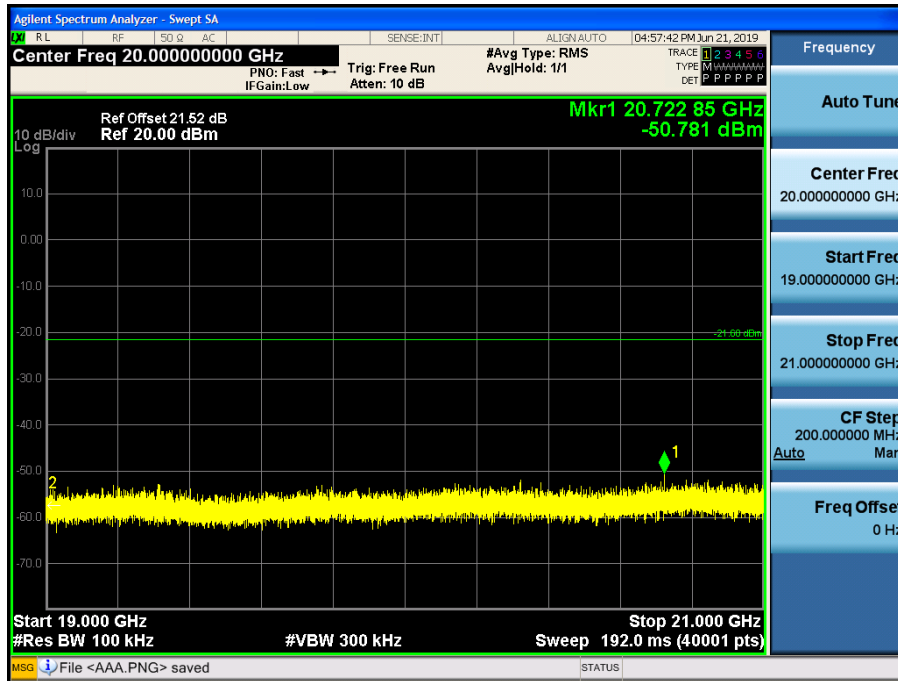
17 GHz ~ 19 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



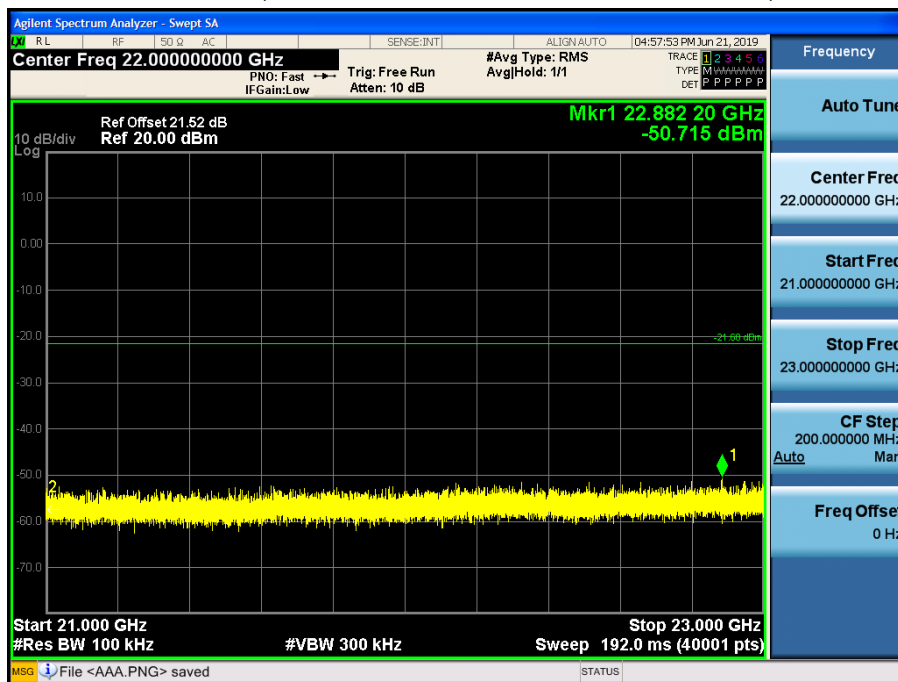
19 GHz ~ 21 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



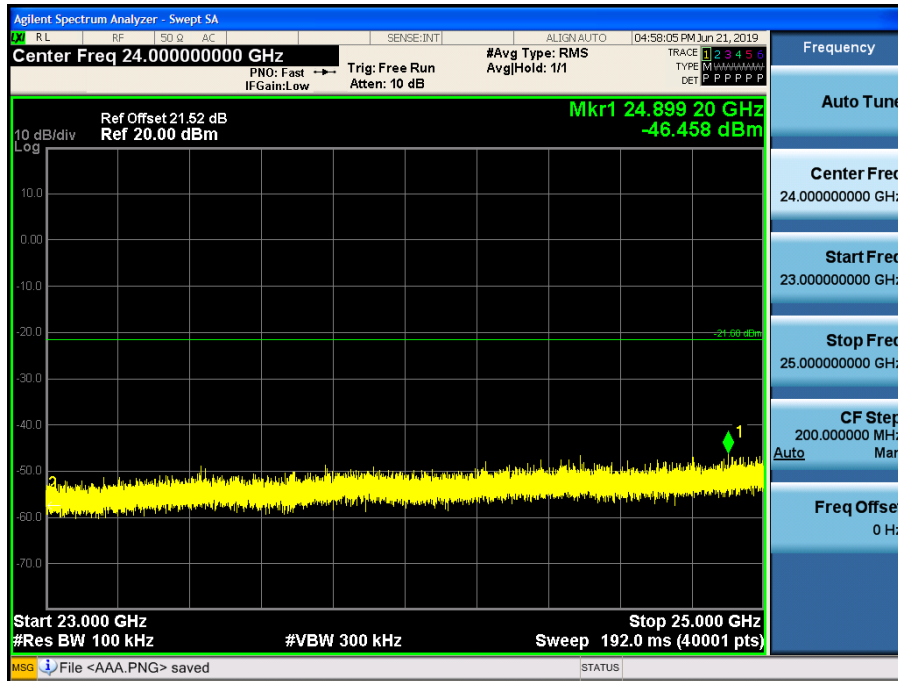
21 GHz ~ 23 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



23 GHz ~ 25 GHz

Conducted Spurious Emission (802.11n(20M)_Ch.6_6.5 Mbps)



9.6 RADIATED SPURIOUS EMISSIONS

Frequency Range : 9 kHz – 30MHz

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Note:

1. The reading of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to be measured.
2. Distance extrapolation factor = $40 \cdot \log(\text{specific distance} / \text{test distance})$ (dB)
3. Limit line = specific Limits (dBuV) + Distance extrapolation factor
4. Radiated test is performed with hopping off.
5. The test results for below 30 MHz is correlated to an open site.
The result on OFS is about 2 dB higher than semi-anechoic chamber(10 m chamber)

Frequency Range : Below 1 GHz

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Note:

1. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.