FCC RF Test Report

APPLICANT	:	Hangzhou Tuya Information Technology Co., Ltd
EQUIPMENT	:	WIFI-BT module
MODEL NAME	:	WBR2L
FCC ID	:	2ANDL-WBR2L
STANDARD	:	FCC Part 15 Subpart C §15.247
CLASSIFICATION	:	(DTS) Digital Transmission System

The product was received on Mar. 25, 2020 and testing was completed on Aug. 21, 2020. We, Sporton International (Kunshan) Inc., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International (Kunshan) Inc., the test report shall not be reproduced except in full.

Jason Jia

Reviewed by: Jason Jia / Supervisor

James Huang

Approved by: James Huang / Manager

ACCREDITED
Cert #5145.02

Sporton International (Kunshan) Inc.
No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China

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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR032513B	Rev. 01	Initial issue of report	Sep. 21, 2020

SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result	Remark
3.1	15.247(a)(2)	6dB Bandwidth	≥ 0.5MHz	Pass	-
3.2	15.247(b)	Power Output Measurement	≤ 30dBm	Pass	-
3.3	15.247(e)	Power Spectral Density	≤ 8dBm/3kHz	Pass	-
3.4	15.247(d)	Conducted Band Edges	≤ 20dBc	Pass	-
		Conducted Spurious Emission		Pass	-
3.5	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 3.11 dB at 2483.500 MHz
3.6	15.207	AC Conducted Emission	15.207(a)	Pass	Under limit 12.33 dB at 0.494 MHz
3.7	15.203 & 15.247(b)	Antenna Requirement	N/A	Pass	-

Declaration of Conformity:
The test results with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers.
Comments and Explanations:
The declared of product specification for EUT presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.

1 General Description

1.1 Applicant

Hangzhou Tuya Information Technology Co., Ltd
Room701, Building3, More Center, No.87 GuDun Road, Hangzhou, Zhejiang, China

1.2 Manufacturer

Hangzhou Tuya Information Technology Co., Ltd
Room701, Building3, More Center, No.87 GuDun Road, Hangzhou, Zhejiang, China

1.3 Product Feature of Equipment Under Test

Product Feature	
Equipment	WIFI-BT module
Model Name	WBR2L
FCC ID	2ANDL-WBR2L
EUT supports Radios application	WLAN 2.4GHz 802.11b/g/n HT20 Bluetooth LE
HW Version	V1.0.0
SW Version	V2.1.6

Remark: The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

1.4 Product Specification of Equipment Under Test

Standards-related Product Specification	
Tx/Rx Channel Frequency Range	2412 MHz ~ 2462 MHz
Maximum (Peak) Output Power to antenna	802.11b : 19.76 dBm (0.0946 W) 802.11g : 26.00 dBm (0.3981 W) 802.11n HT20 : 26.11 dBm (0.4083 W)
Antenna Type / Gain	PCB Antenna type with gain 1.73 dBi
Type of Modulation	802.11b : DSSS (DBPSK / DQPSK / CCK) 802.11g/n : OFDM (BPSK / QPSK / 16QAM / 64QAM)

1.5 Modification of EUT

No modifications are made to the EUT during all test items.

1.6 Testing Location

Sporton International (Kunshan) Inc. is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

Test Firm	Sporton International (Kunshan) Inc.		
Test Site Location	No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China TEL : +86-512-57900158 FAX : +86-512-57900958		
Test Site No.	**Sporton Site No.**	**FCC Designation No.**	**FCC Test Firm Registration No.**
	CO01-KS 03CH06-KS TH01-KS	CN1257	314309

1.7 Test Software

Item	Site	Manufacture	Name	Version
1.	03CH06-KS	AUDIX	E3	6.2009-8-24al
2.	CO01-KS	AUDIX	E3	6.2009-8-24

1.8 Applicable Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- 47 CFR Part 15 Subpart C §15.247
- FCC KDB 558074 D01 15.247 Meas Guidance v05r02
- ANSI C63.10-2013

Remark: All test items were verified and recorded according to the standards and without any deviation during the test.

2 Test Configuration of Equipment Under Test

a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: conduction emission (150 kHz to 30 MHz), radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (X plane) were recorded in this report.

b. AC power line Conducted Emission was tested under maximum output power.

2.1 Carrier Frequency and Channel

Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)
2400-2483.5 MHz	1	2412	7	2442
	2	2417	8	2447
	3	2422	9	2452
	4	2427	10	2457
	5	2432	11	2462
	6	2437		

2.2 Test Mode

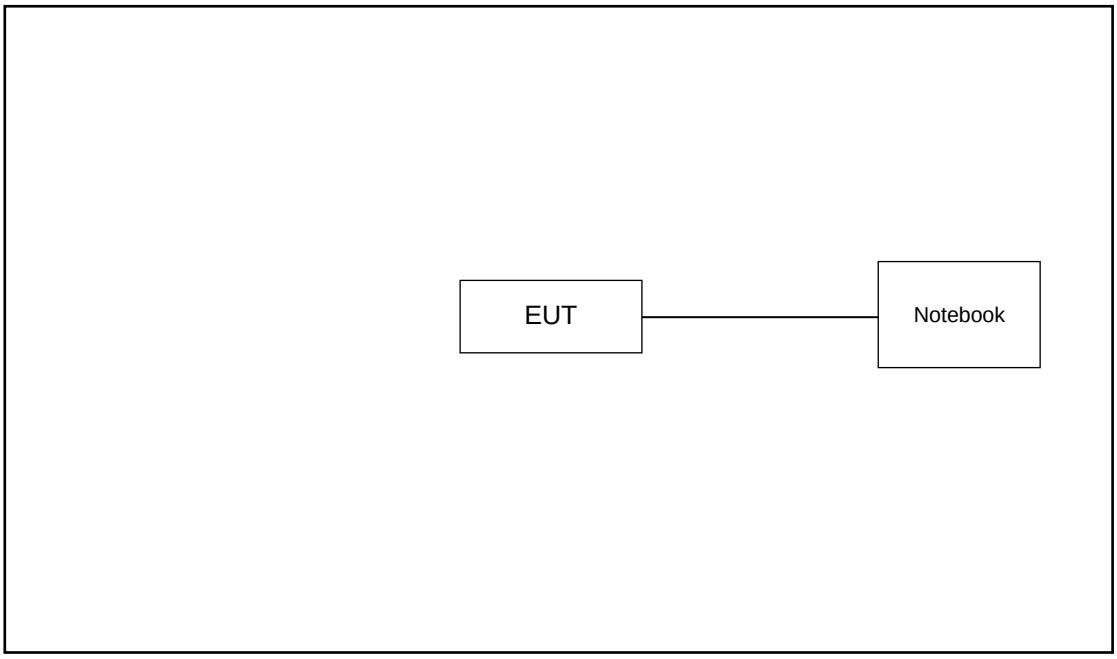
Final test modes are considering the modulation and worse data rates as below table.

Modulation	Data Rate
802.11b	1 Mbps
802.11g	6 Mbps
802.11n HT20	MCS0

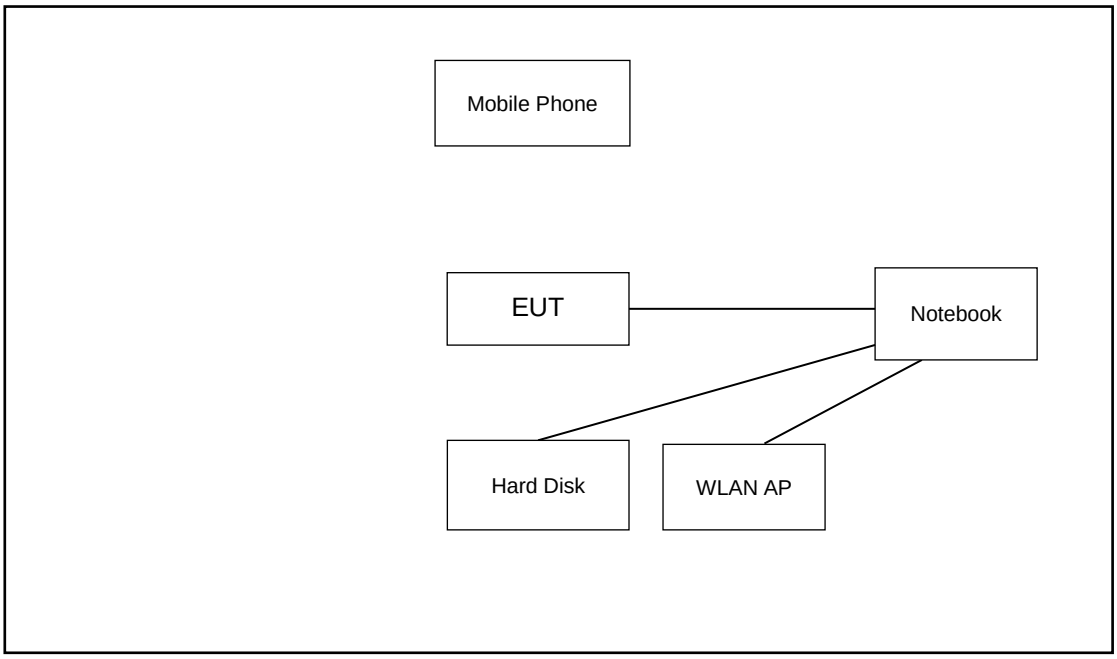
Test Cases	
AC Conducted Emission	Mode 1 :Bluetooth Link + Charging from Notebook Mode 2 :**WLAN Link(2.4G) + Charging from Notebook**
Remark: The worst case of conducted emission is mode 2; only the test data of it was reported.	

2.3 Connection Diagram of Test System

For Radiation



For Conducted Emission



2.4 Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	WLAN AP	D-link	DIR-655	KA21R655B1	N/A	Unshielded,1.8m
2.	Notebook	Lenovo	G480	QDS-BRCM1050I	N/A	AC I/P: Unshielded, 1.8 m DC O/P: Shielded, 1.8 m
3.	Phone	Apple	Iphone 6s	BCG-E2946A	N/A	N/A
4.	Hard Disk	Lenovo	F310	DoC	Shielded, 1.2m	N/A

2.5 EUT Operation Test Setup

For WLAN RF test items, an engineering test program was provided and enabled to make EUT continuous transmit/receive.

For AC power line conducted emissions, the EUT was set to connect with the WLAN AP under large package sizes transmission.

2.6 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example:

The spectrum analyzer offset is derived from RF cable loss.

Offset = RF cable loss.

Following shows an offset computation example with cable loss 6.3 dB.

Offset(dB) = RF cable loss(dB).

= 6.3 (dB)

3 Test Result

3.1 6dB Bandwidth Measurement

3.1.1 Limit of 6dB Bandwidth

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

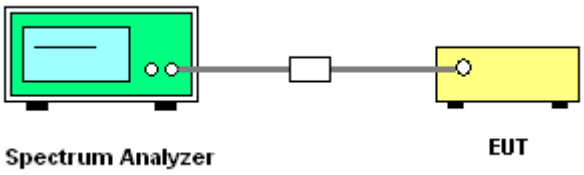
3.1.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.1.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 11.8
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. Set the Video bandwidth (VBW) = 300 kHz. In order to make an accurate measurement. The 6 dB bandwidth must be greater than 500 kHz.
5. Measure and record the results in the test report.

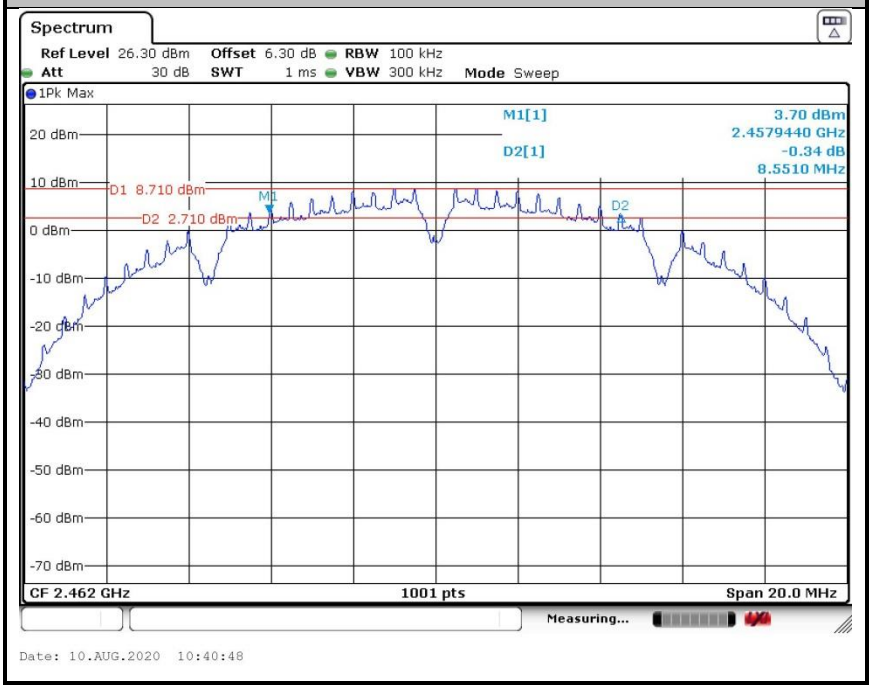
3.1.4 Test Setup



3.1.5 Test Result of 6dB Occupied Bandwidth

Please refer to Appendix A.

Minimum 6dB Bandwidth



3.2 Output Power Measurement

3.2.1 Limit of Output Power

For systems using digital modulation in the 2400-2483.5MHz, the limit for peak output power is 30dBm. If transmitting antenna with directional gain greater than 6dBi is used, the peak output power from the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi. In case of point-to-point operation, the limit has to be reduced by 1dB for every 3dB that the directional gain of the antenna exceeds 6dBi.

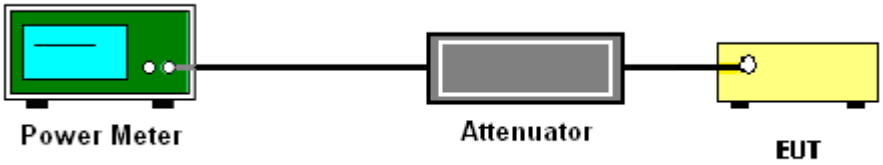
3.2.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.2.3 Test Procedures

1. The testing follows the Measurement Procedure of ANSI C63.10-2013 clause 11.9.1.3 PKPM1 Peak power meter or ANSI C63.10-2013 clause 11.9.2.3.2 Method AVGPM-G method.
2. The RF output of EUT was connected to the power meter by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Measure the conducted output power and record the results in the test report.

3.2.4 Test Setup



3.2.5 Test Result of Peak Output Power

Please refer to Appendix A.

3.2.6 Test Result of Average output Power (Reporting Only)

Please refer to Appendix A.

3.3 Power Spectral Density Measurement

3.3.1 Limit of Power Spectral Density

The peak power spectral density shall not be greater than 8dBm in any 3kHz band at any time interval of continuous transmission.

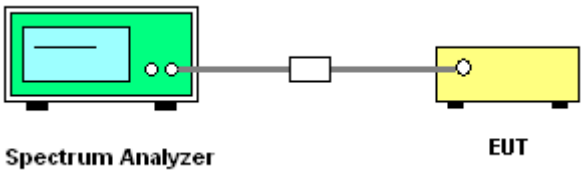
3.3.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.3.3 Test Procedures

1. The testing follows Measurement Procedure of ANSI C63.10-2013 clause 11.10.2 Method PKPSD.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 3 kHz. Video bandwidth VBW = 10 kHz In order to make an accurate measurement, set the span to 1.5 times DTS Channel Bandwidth. (6dB BW)
5. Detector = peak, Sweep time = auto couple, Trace mode = max hold, Allow trace to fully stabilize. Use the peak marker function to determine the maximum power level.
6. Measure and record the results in the test report.

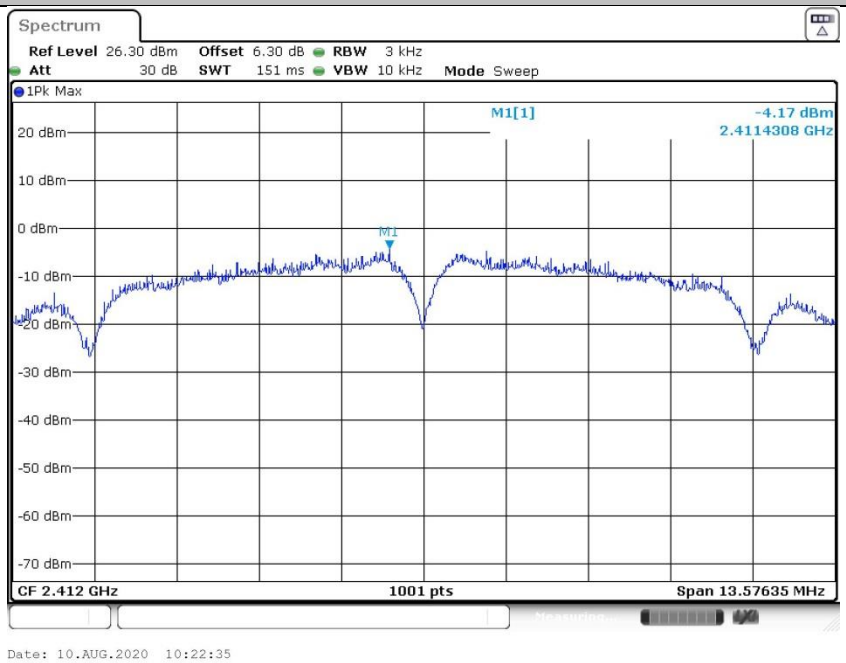
3.3.4 Test Setup



3.3.5 Test Result of Power Spectral Density

Please refer to Appendix A.

Worst Case Power Density (dBm/3kHz)



3.4 Conducted Band Edges and Spurious Emission Measurement

3.4.1 Limit of Conducted Band Edges and Spurious Emission Measurement

In any 100 kHz bandwidth outside of the authorized frequency band, the emissions which fall in the non-restricted bands shall be attenuated at least 20 dB / 30dB relative to the maximum PSD level in 100 kHz by RF conducted measurement.

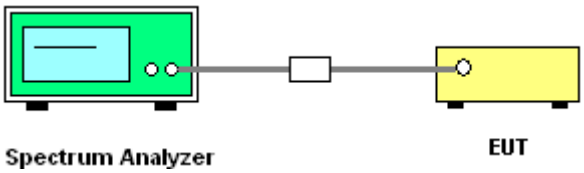
3.4.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.4.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 11.13
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Set RBW = 100 kHz, VBW=300 kHz, Peak Detector. Unwanted Emissions measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz when maximum peak conducted output power procedure is used. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB per 15.247(d).
5. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

3.4.4 Test Setup

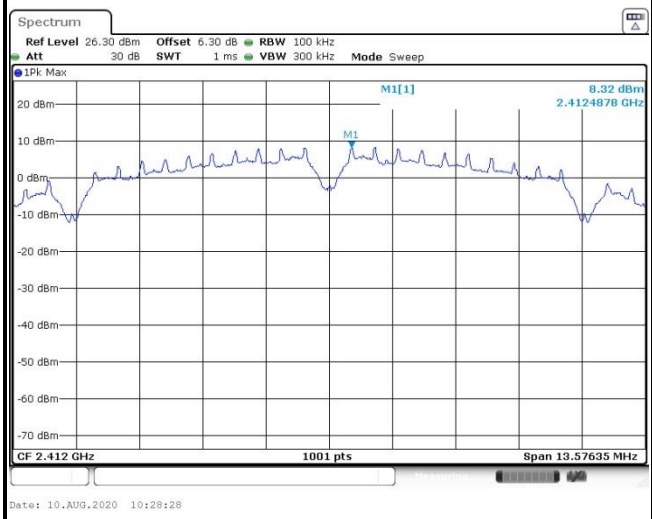


3.4.5 Test Result of Conducted Band Edges and Spurious Emission

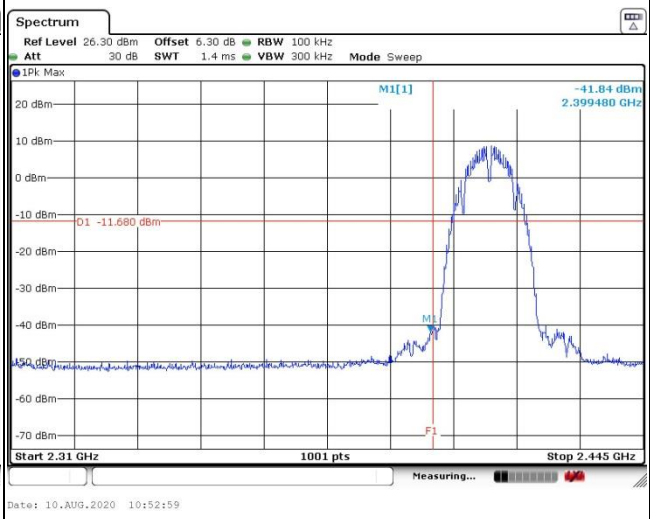
Test Engineer :	Kib Shi	**Temperature :**	21~25℃
		Relative Humidity :	51~54%

Test Mode :	802.11b	**Test Channel :**	01

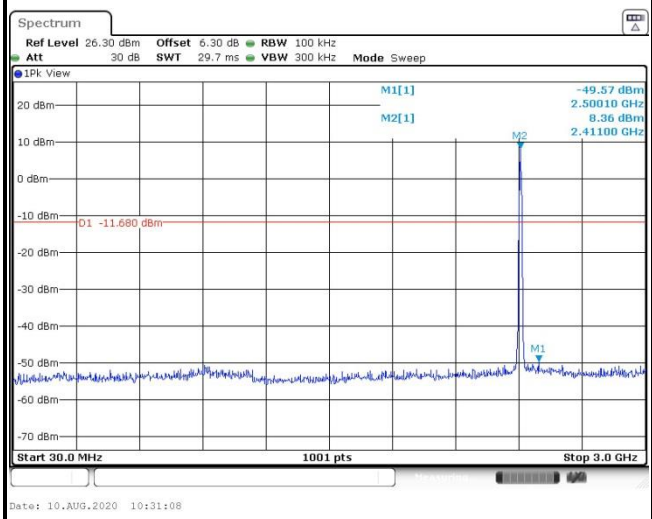
100kHz PSD reference Level



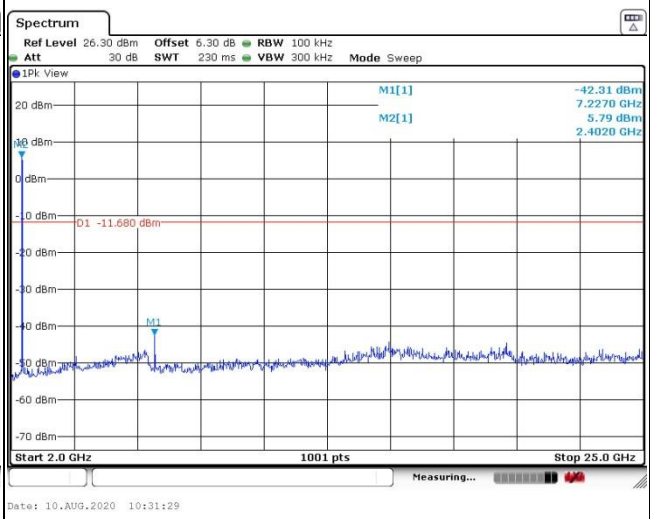
Channel Plot



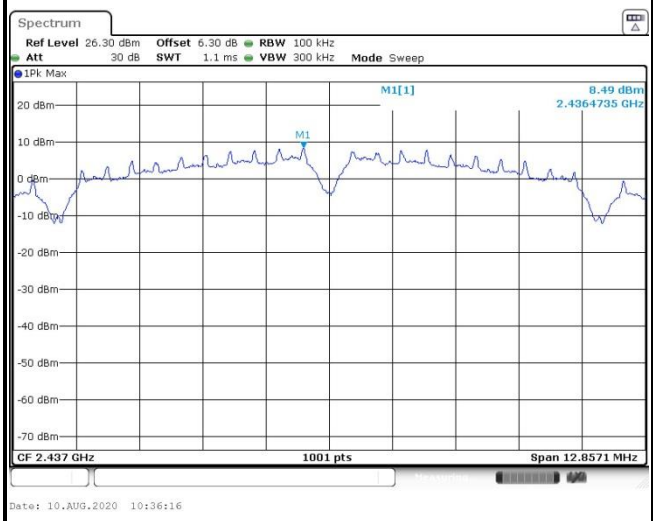
Spurious Emission 30MHz~3GHz

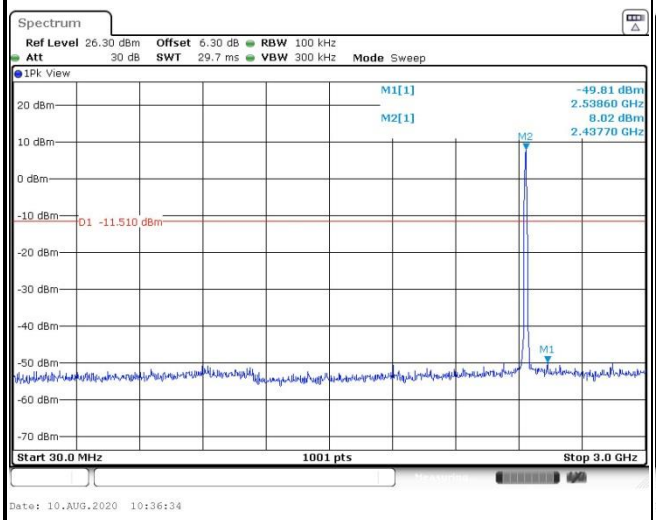
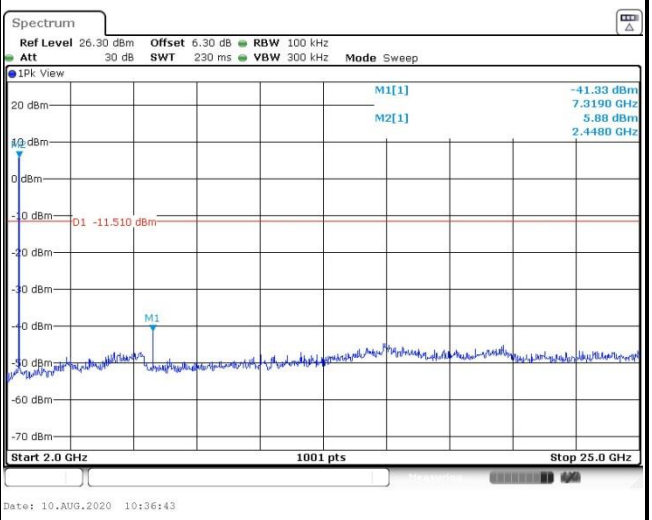


Spurious Emission 2GHz~25GHz

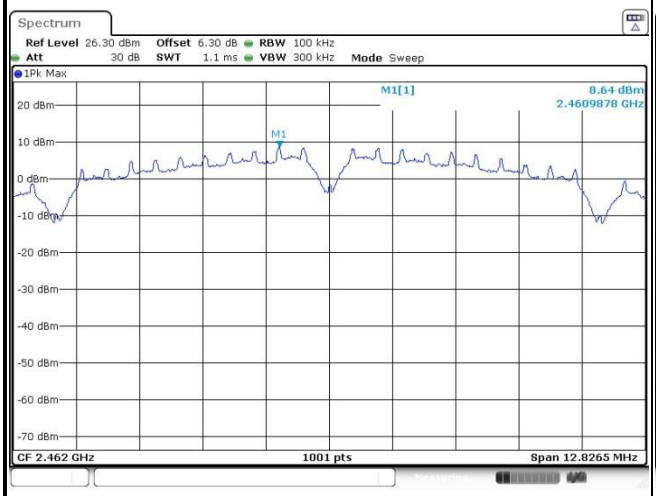
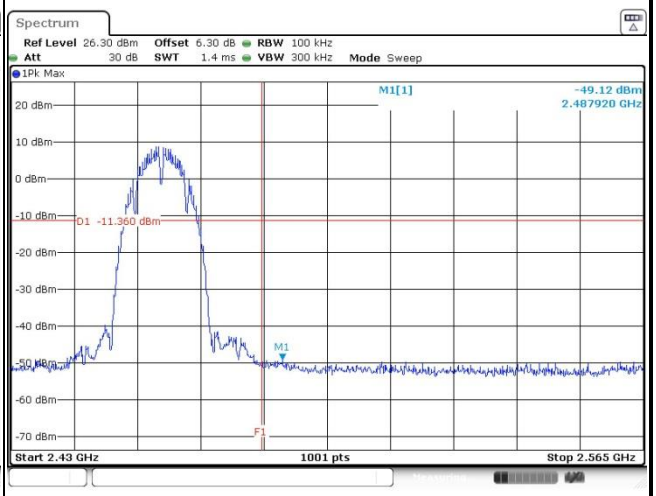
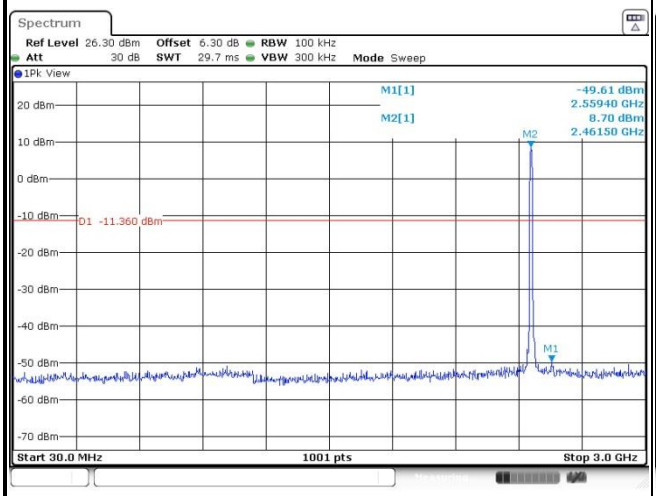
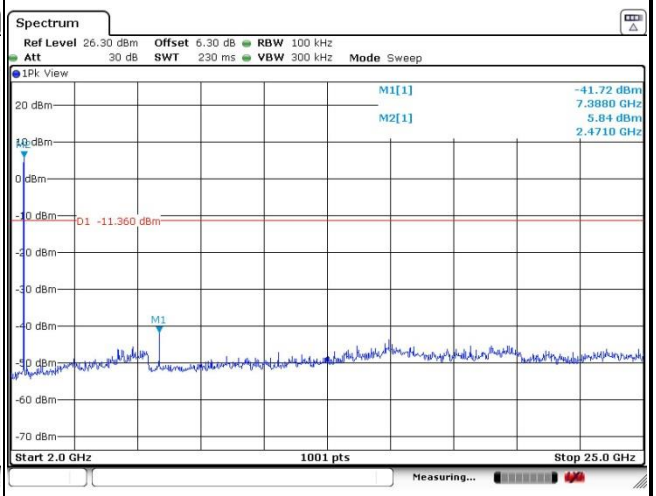


Test Mode :	802.11b	Test Channel :	06

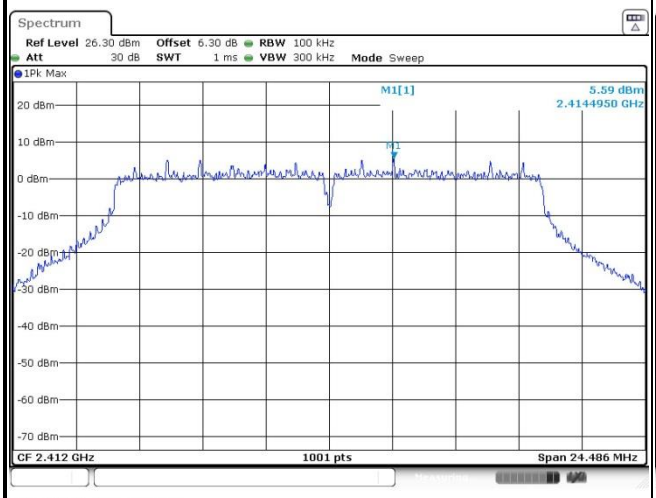
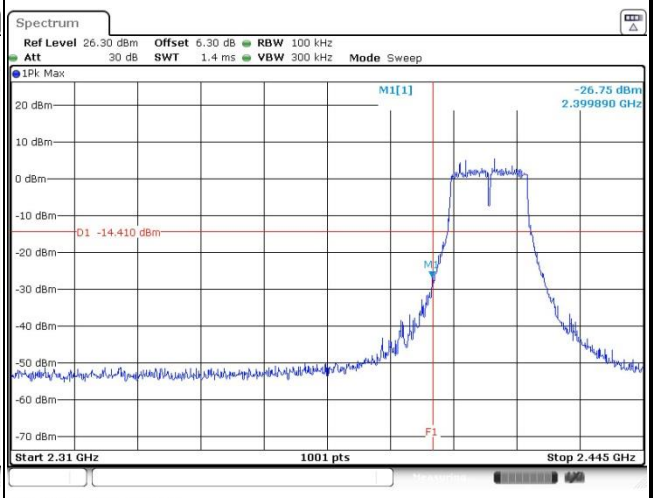
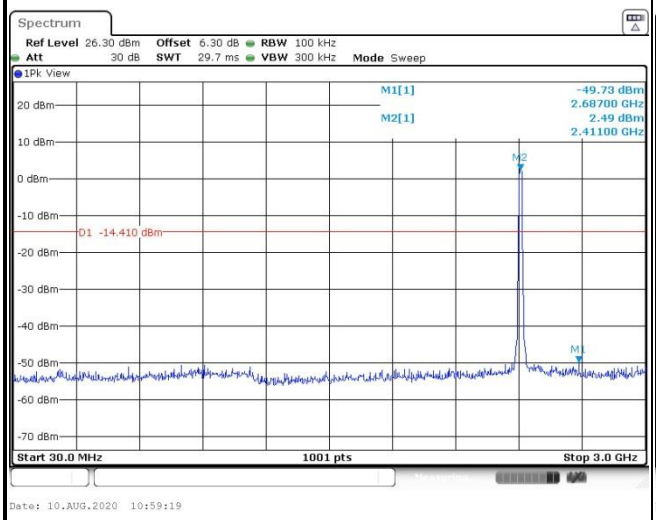
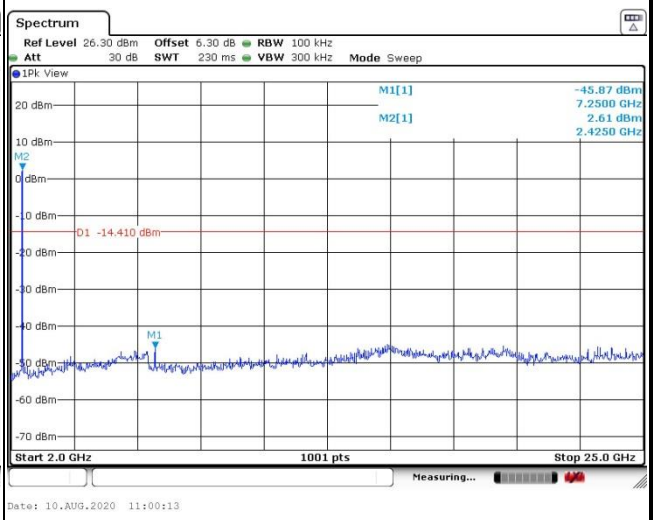
100kHz PSD reference Level	
	

Spurious Emission 30MHz~3GHz	Spurious Emission 2GHz~25GHz
	

Test Mode :	802.11b	Test Channel :	11

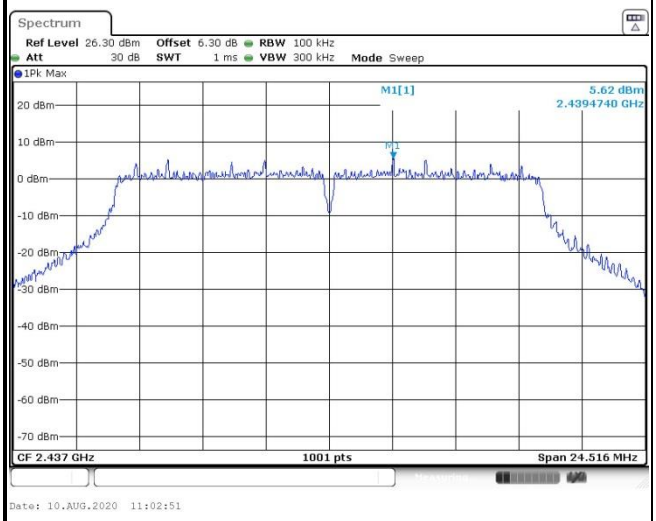
100kHz PSD reference Level	Channel Plot
	
Spurious Emission 30MHz~3GHz	**Spurious Emission 2GHz~25GHz**
	

Test Mode :	802.11g	Test Channel :	01

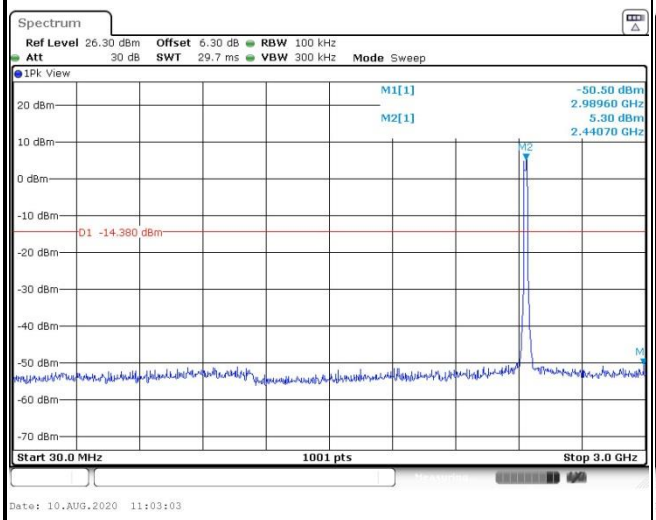
100kHz PSD reference Level	Channel Plot
	
Spurious Emission 30MHz~3GHz	**Spurious Emission 2GHz~25GHz**
	

Test Mode :	802.11g	Test Channel :	06

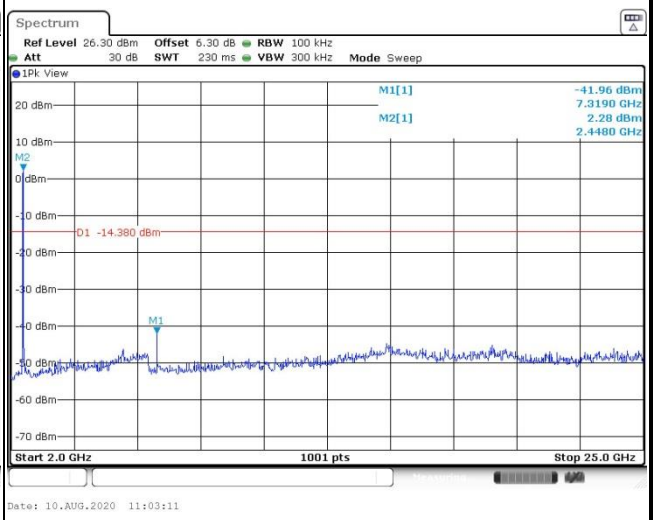
100kHz PSD reference Level



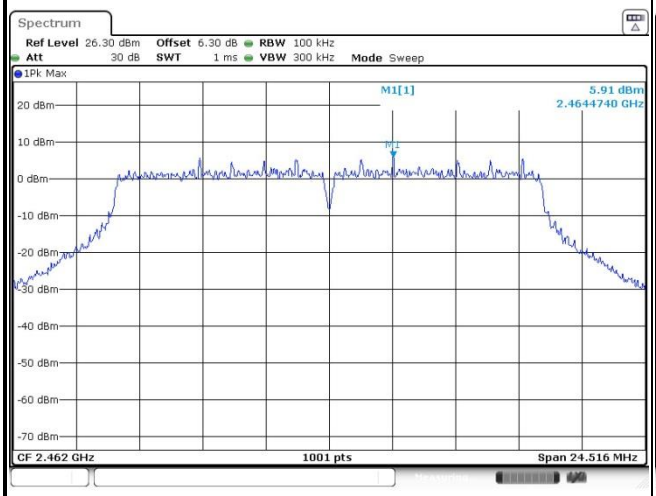
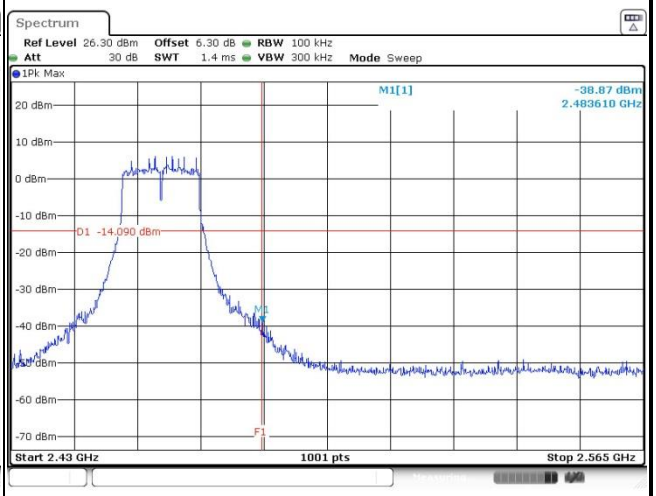
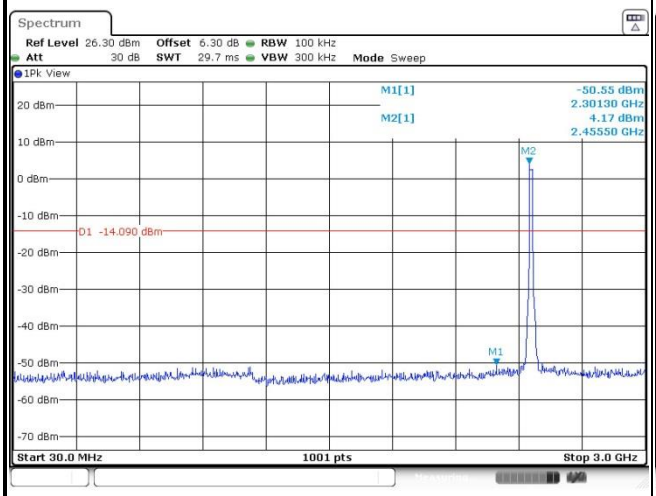
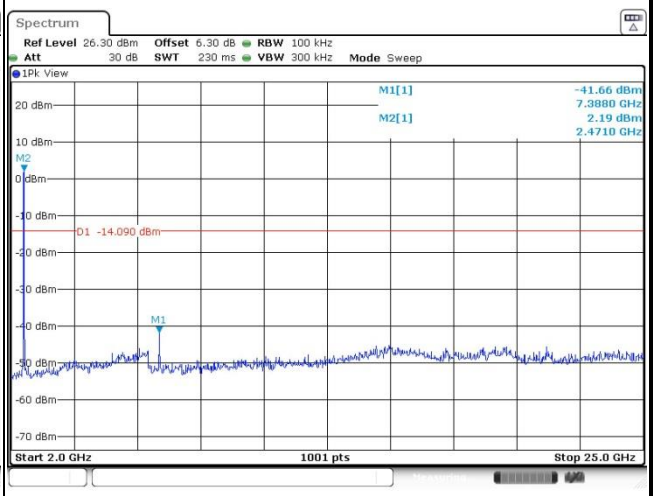
Spurious Emission 30MHz~3GHz



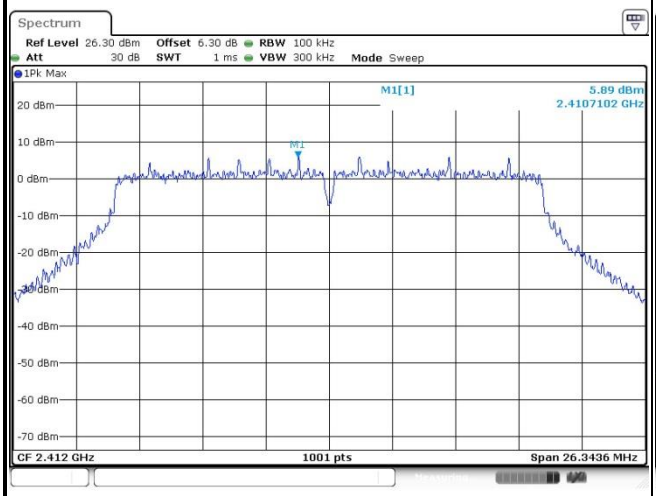
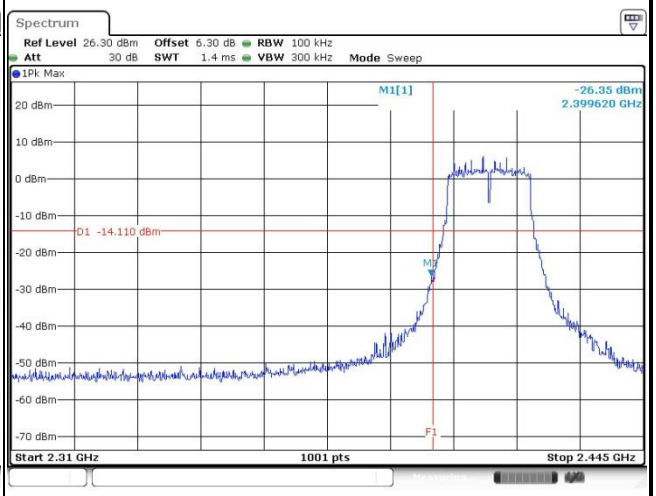
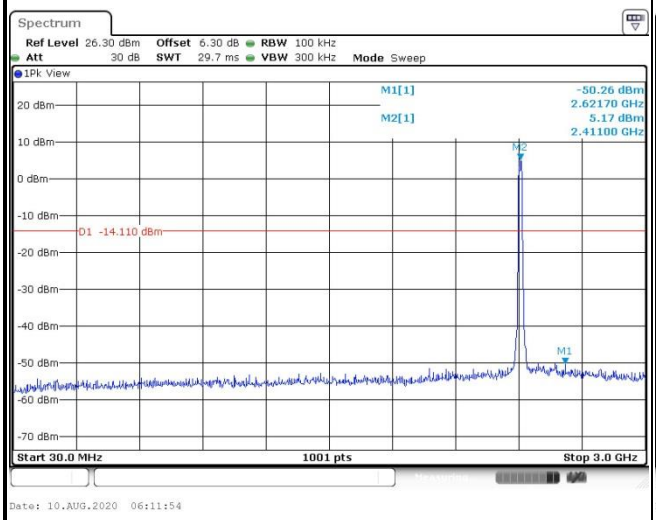
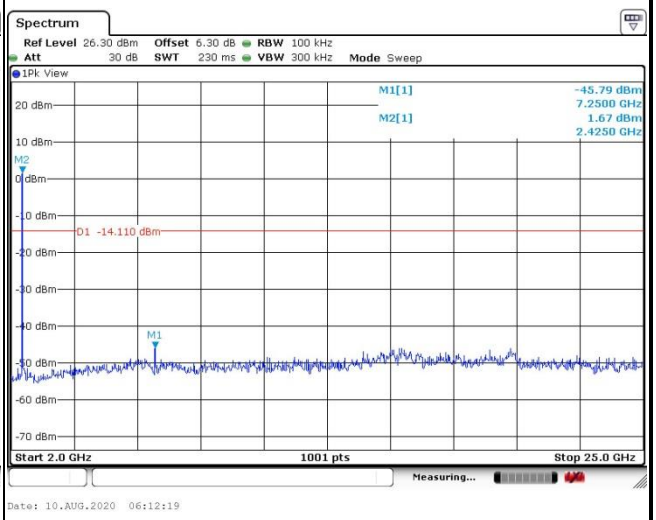
Spurious Emission 2GHz~25GHz



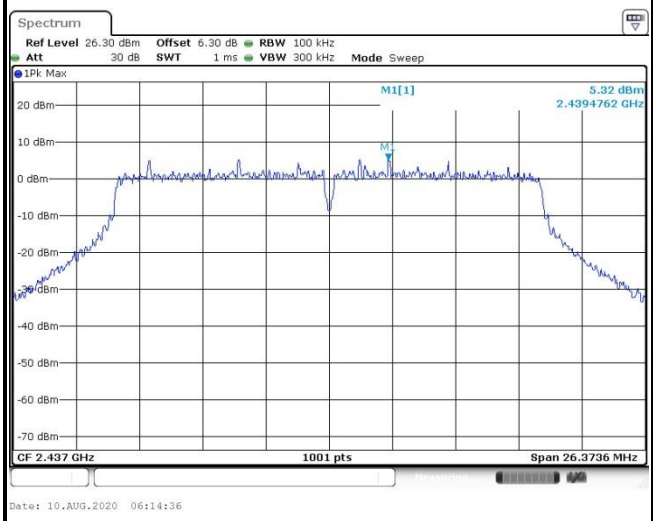
Test Mode :	802.11g	Test Channel :	11

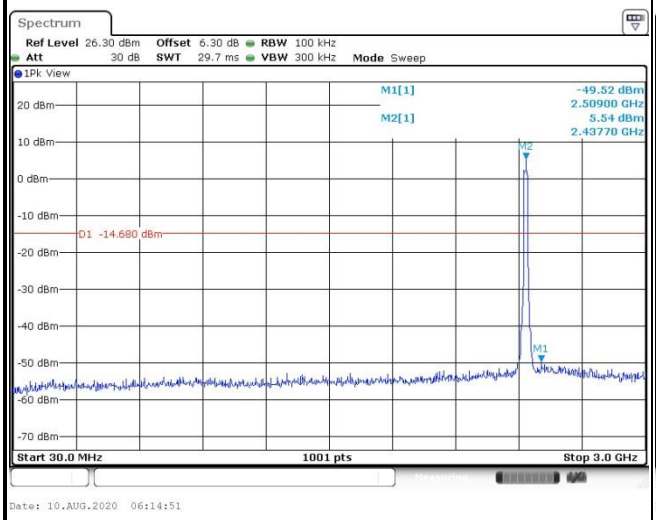
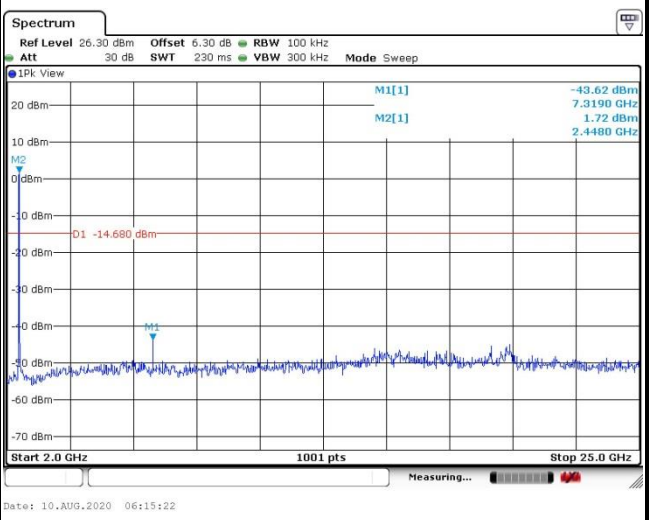
100kHz PSD reference Level	Channel Plot
	
Spurious Emission 30MHz~3GHz	Spurious Emission 2GHz~25GHz
	

Test Mode :	802.11n HT20	Test Channel :	01

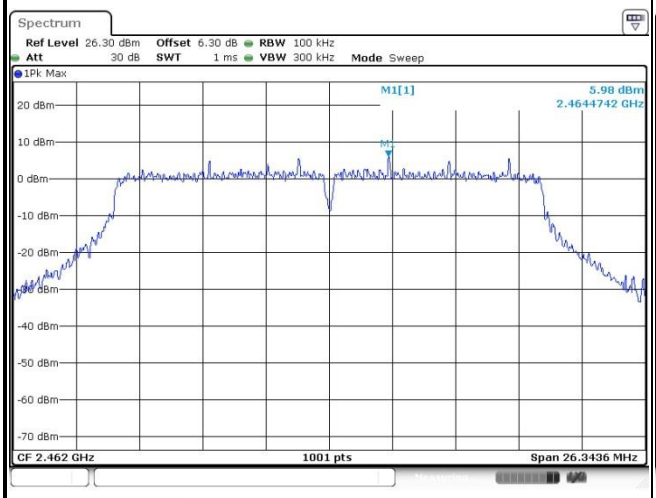
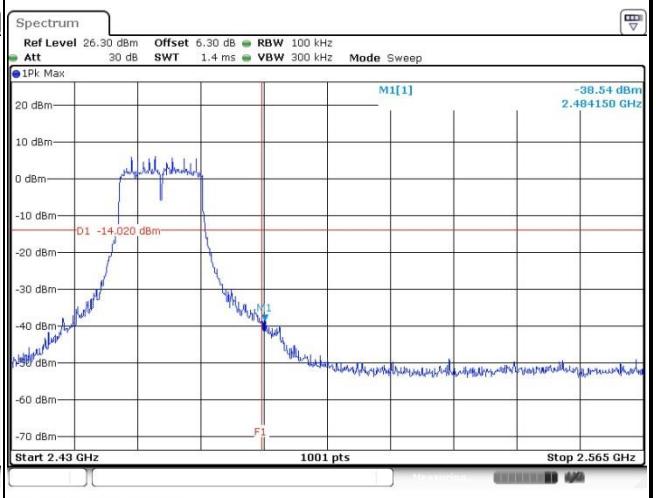
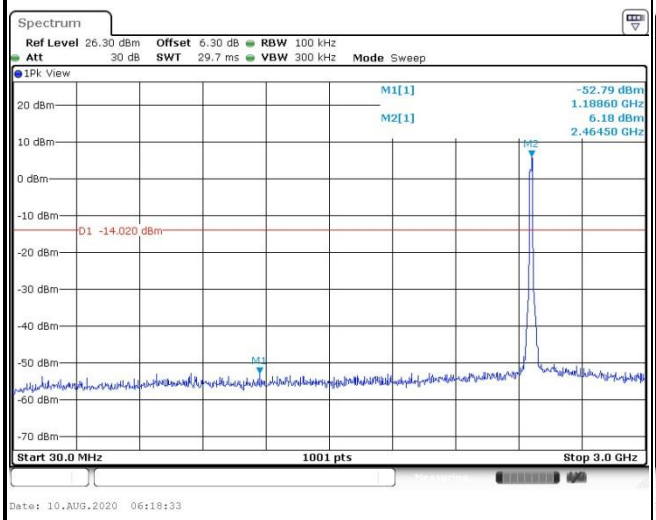
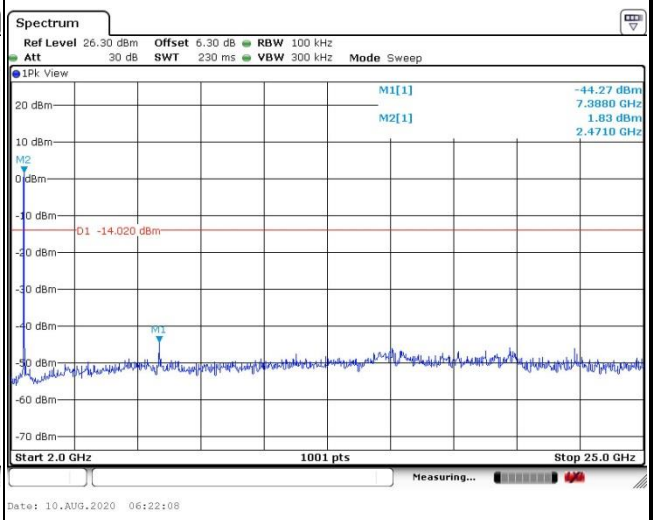
100kHz PSD reference Level	Channel Plot
	
Spurious Emission 30MHz~3GHz	**Spurious Emission 2GHz~25GHz**
	

Test Mode :	802.11n HT20	Test Channel :	06

100kHz PSD reference Level	
	

Spurious Emission 30MHz~3GHz	Spurious Emission 2GHz~25GHz
	

Test Mode :	802.11n HT20	Test Channel :	11

100kHz PSD reference Level	Channel Plot
	
Spurious Emission 30MHz~3GHz	**Spurious Emission 2GHz~25GHz**
	

3.5 Radiated Band Edges and Spurious Emission Measurement

3.5.1 Limit of Radiated band edge and Spurious Emission Measurement

In any 100 kHz bandwidth outside the intentional radiator frequency band, all harmonics/spurious must be at least 20 dB below the highest emission level within the authorized band. If the output power of this device was measured by spectrum analyzer, the attenuation under this paragraph shall be 30 dB instead of 20 dB. In addition, radiated emissions which fall in the restricted bands must also comply with the limits as below.

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

3.5.2 Measuring Instruments

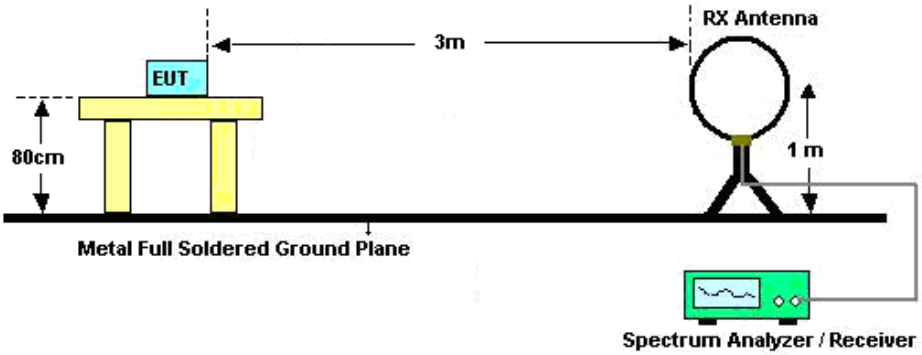
The measuring equipment is listed in the section 4 of this test report.

3.5.3 Test Procedures

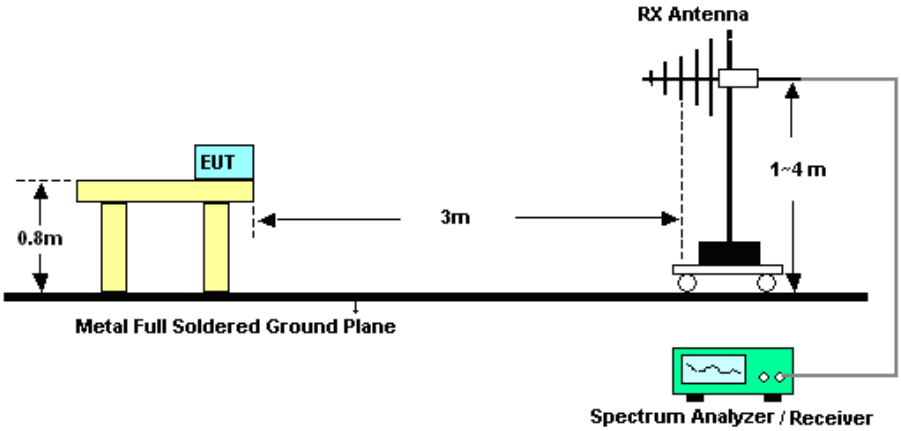
1. The testing follows ANSI C63.10-2013 clause 11.11 & 11.12
2. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level.
3. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
4. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
6. For testing below 1GHz, if the emission level of the EUT in peak mode was 3 dB lower than the limit specified, then peak values of EUT will be reported, otherwise, the emissions will be repeated one by one using the CISPR quasi-peak method and reported.
7. For testing above 1GHz, the emission level of the EUT in peak mode was 20dB lower than average limit (that means the emission level in average mode also complies with the limit in average mode), then peak values of EUT will be reported, otherwise, the emissions will be measured in average mode again and reported.
8. Use the following spectrum analyzer settings:
   (1) Span shall wide enough to fully capture the emission being measured;
   (2) Set RBW=100 kHz for f < 1 GHz; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold;
   (3) Set RBW = 1 MHz, VBW= 3MHz for f ≥ 1 GHz for peak measurement.
   For average measurement:
   - VBW = 10 Hz, when duty cycle is no less than 98 percent.
   - VBW ≥ 1/T, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

3.5.4 Test Setup

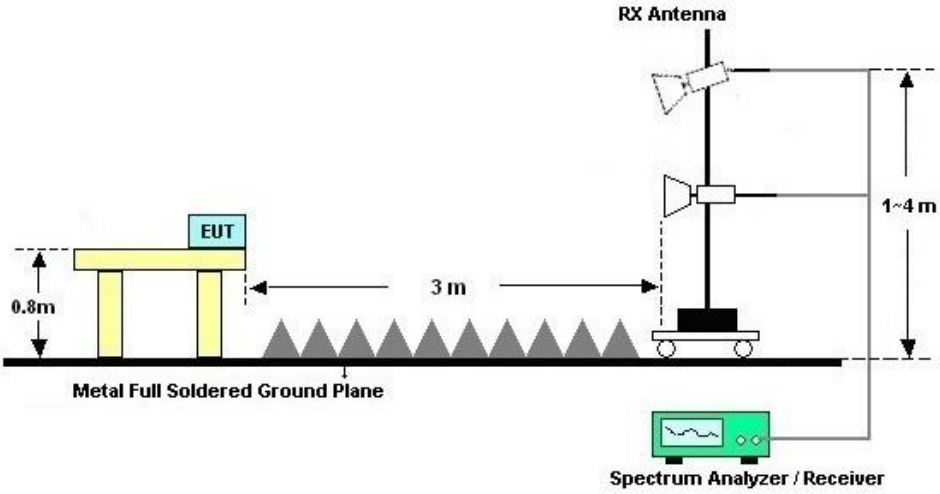
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



3.5.5 Test Results of Radiated Spurious Emissions (9kHz ~ 30MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line was not reported.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

3.5.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix C.

3.5.7 Duty Cycle

Please refer to Appendix D.

3.5.8 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic)

Please refer to Appendix C.

3.6 AC Conducted Emission Measurement

3.6.1 Limit of AC Conducted Emission

For equipment 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.

Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

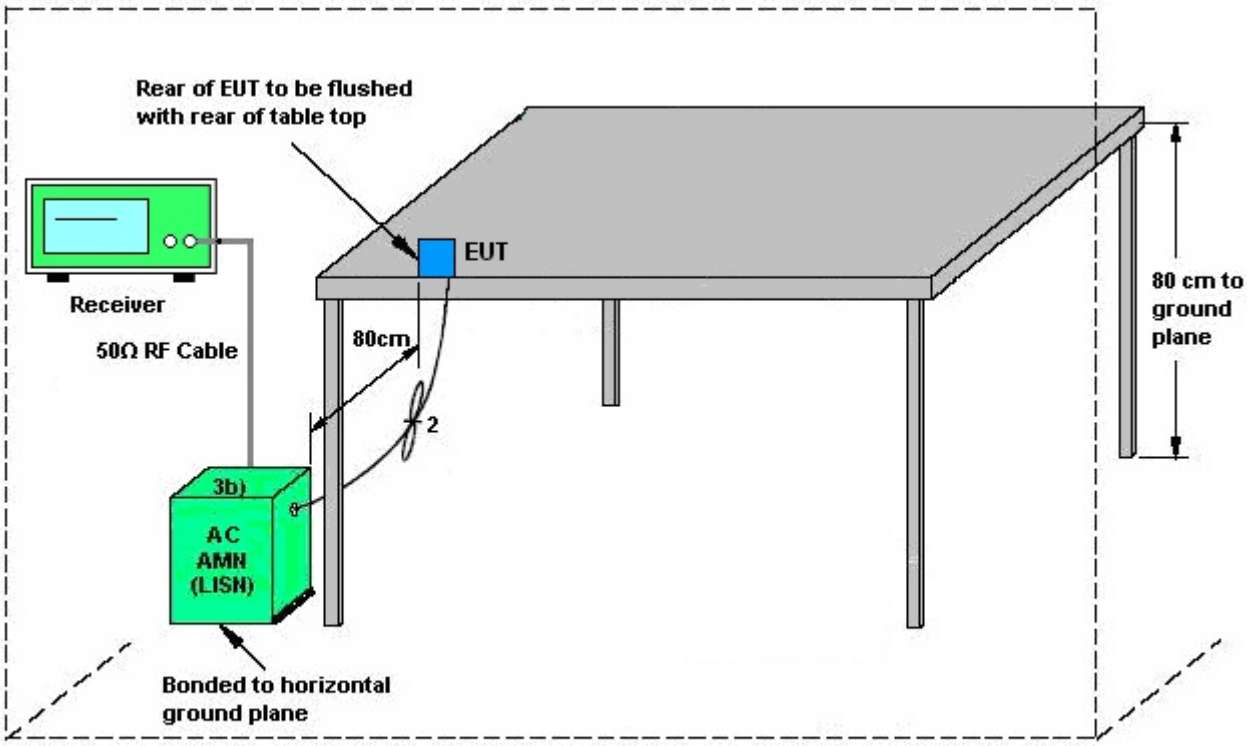
3.6.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.6.3 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room, and it was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
6. Both sides of AC line were checked for maximum conducted interference.
7. The frequency range from 150 kHz to 30 MHz was searched.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF bandwidth = 9kHz) with Maximum Hold Mode.

3.6.4 Test Setup



AMN = Artificial mains network (LISN)
AE = Associated equipment
EUT = Equipment under test
ISN = Impedance stabilization network

3.6.5 Test Result of AC Conducted Emission

Please refer to Appendix B.

3.7 Antenna Requirements

3.7.1 Standard Applicable

If directional gain of transmitting Antennas is greater than 6dBi, the power shall be reduced by the same level in dB comparing to gain minus 6dBi. 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 rule.

3.7.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.7.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.

4 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV40	101040	10Hz~40GHz	Nov. 02, 2019	Aug. 10, 2020	Nov. 01, 2020	Conducted (TH01-KS)
Pulse Power Senor	Anritsu	MA2411B	0917070	300MHz~40GHz	Jan. 13, 2020	Aug. 10, 2020	Jan. 12, 2021	Conducted (TH01-KS)
Power Meter	Anritsu	ML2495A	1005002	50MHz Bandwidth	Jan. 13, 2020	Aug. 10, 2020	Jan. 12, 2021	Conducted (TH01-KS)
EMI Test Receiver	Keysight	N9038A	MY56400004	3Hz~8.5GHz;Max 30dBm	Oct. 18, 2019	Aug. 21, 2020	Oct. 17, 2020	Radiation (03CH06-KS)
EXA Spectrum Analyzer	Keysight	N9010A	MY55150208	10Hz-44GHz	Apr. 15, 2020	Aug. 21, 2020	Apr. 16, 2021	Radiation (03CH06-KS)
Loop Antenna	R&S	HFH2-Z2	100321	9kHz~30MHz	Nov. 10, 2019	Aug. 21, 2020	Nov. 09, 2020	Radiation (03CH06-KS)
Bilog Antenna	TeseQ	CBL6111D	49921	30MHz-1GHz	May 29, 2020	Aug. 21, 2020	May 28, 2021	Radiation (03CH06-KS)
Double Ridge Horn Antenna	ETS-Lindgren	3117	00218652	1GHz~18GHz	Apr. 27, 2020	Aug. 21, 2020	Apr. 26, 2021	Radiation (03CH06-KS)
SHF-EHF Horn	Com-power	AH-840	101115	18GHz~40GHz	Nov. 10, 2019	Aug. 21, 2020	Nov. 09, 2020	Radiation (03CH06-KS)
Amplifier	SONOMA	310N	187289	9KHz ~1GHZ	Apr. 14, 2020	Aug. 21, 2020	Apr. 13, 2021	Radiation (03CH06-KS)
Amplifier	MITEQ	EM18G40GGA	060728	18~40GHz	Jan. 08, 2020	Aug. 21, 2020	Jan. 07, 2021	Radiation (03CH06-KS)
high gain Amplifier	MITEQ	AMF-7D-00101800-30-10P	2025788	1Ghz-18Ghz	Jan. 02, 2020	Aug. 21, 2020	Jan. 01, 2021	Radiation (03CH06-KS)
Amplifier	Keysight	83017A	MY53270203	500MHz~26.5GHz	Apr. 15, 2020	Aug. 21, 2020	Apr. 14, 2021	Radiation (03CH06-KS)
AC Power Source	Chroma	61601	F104090004	N/A	NCR	Aug. 21, 2020	NCR	Radiation (03CH06-KS)
Turn Table	ChamPro	EM 1000-T	060762-T	0~360 degree	NCR	Aug. 21, 2020	NCR	Radiation (03CH06-KS)
Antenna Mast	ChamPro	EM 1000-A	060762-A	1 m~4 m	NCR	Aug. 21, 2020	NCR	Radiation (03CH06-KS)
EMI Receiver	R&S	ESCI7	100768	9kHz~7GHz;	Apr. 14, 2020	Aug. 20, 2020	Apr. 13, 2021	Conduction (CO01-KS)
AC LISN (for auxiliary equipment)	MessTec	AN3016	060103	9kHz~30MHz	Oct. 18, 2019	Aug. 20, 2020	Oct. 17, 2020	Conduction (CO01-KS)
AC LISN	MessTec	AN3016	060105	9kHz~30MHz	Oct. 28, 2019	Aug. 20, 2020	Oct. 27, 2020	Conduction (CO01-KS)
AC Power Source	Chroma	61602	ABP000000811	AC 0V~300V, 45Hz~1000Hz	Oct. 18, 2019	Aug. 20, 2020	Oct. 17, 2020	Conduction (CO01-KS)

NCR: No Calibration Required

5 Uncertainty of Evaluation

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI 63.10-2013. All the measurement uncertainty value were shown with a coverage K=2 to indicate 95% level of confidence. The measurement data show herein meets or exceeds the CISPR measurement uncertainty values specified in CISPR 16-4-2 and can be compared directly to specified limit to determine compliance.

Uncertainty of Conducted Emission Measurement (150 kHz ~ 30 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**2.94dB**

Uncertainty of Radiated Emission Measurement (30 MHz ~ 1000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.0dB**

Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.0dB**

Uncertainty of Radiated Emission Measurement (18000 MHz ~ 40000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.0dB**

Appendix A. Conducted Test Results

Report Number : FR032513B

A1 - DTS Part

Test Engineer:	Kib Shi	Temperature:	21~25	°C
Test Date:	2020/8/10	Relative Humidity:	51~54	%

TEST RESULTS DATA
6dB and 99% Occupied Bandwidth

2.4GHz Band								
Mod.	Data Rate	NTX	CH.	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
11b	1Mbps	1	1	2412	14.19	9.05	0.50	Pass
11b	1Mbps	1	6	2437	14.19	8.57	0.50	Pass
11b	1Mbps	1	11	2462	14.24	8.55	0.50	Pass
11g	6Mbps	1	1	2412	18.43	16.32	0.50	Pass
11g	6Mbps	1	6	2437	18.53	16.34	0.50	Pass
11g	6Mbps	1	11	2462	18.28	16.34	0.50	Pass
HT20	MCS0	1	1	2412	19.43	17.56	0.50	Pass
HT20	MCS0	1	6	2437	19.13	17.58	0.50	Pass
HT20	MCS0	1	11	2462	19.23	17.56	0.50	Pass

Report Number : FR032513B

TEST RESULTS DATA
Peak Power Table

2.4GHz Band										
Mod.	Data Rate	NTX	CH.	Freq. (MHz)	Peak Conducted Power (dBm)	Conducted Power Limit (dBm)	DG (dBi)	EIRP Power (dBm)	EIRP Power Limit (dBm)	Pass /Fail
11b	1Mbps	1	1	2412	19.55	30.00	1.73	21.28	36.00	Pass
11b	1Mbps	1	6	2437	19.76	30.00	1.73	21.49	36.00	Pass
11b	1Mbps	1	11	2462	19.62	30.00	1.73	21.35	36.00	Pass
11g	6Mbps	1	1	2412	25.94	30.00	1.73	27.67	36.00	Pass
11g	6Mbps	1	6	2437	26.00	30.00	1.73	27.73	36.00	Pass
11g	6Mbps	1	11	2462	25.86	30.00	1.73	27.59	36.00	Pass
HT20	MCS0	1	1	2412	25.97	30.00	1.73	27.70	36.00	Pass
HT20	MCS0	1	6	2437	26.11	30.00	1.73	27.84	36.00	Pass
HT20	MCS0	1	11	2462	25.88	30.00	1.73	27.61	36.00	Pass

TEST RESULTS DATA
Average Power Table
(Reporting Only)

2.4GHz Band						
Mod.	Data Rate	N_{TX}	CH.	Freq. (MHz)	Duty Factor (dB)	Average Conducted Power (dBm)
11b	1Mbps	1	1	2412	0.00	16.85
11b	1Mbps	1	6	2437	0.00	17.08
11b	1Mbps	1	11	2462	0.00	17.03
11g	6Mbps	1	1	2412	0.27	16.92
11g	6Mbps	1	6	2437	0.27	17.09
11g	6Mbps	1	11	2462	0.27	17.05
HT20	MCS0	1	1	2412	0.29	16.94
HT20	MCS0	1	6	2437	0.29	17.08
HT20	MCS0	1	11	2462	0.29	16.91

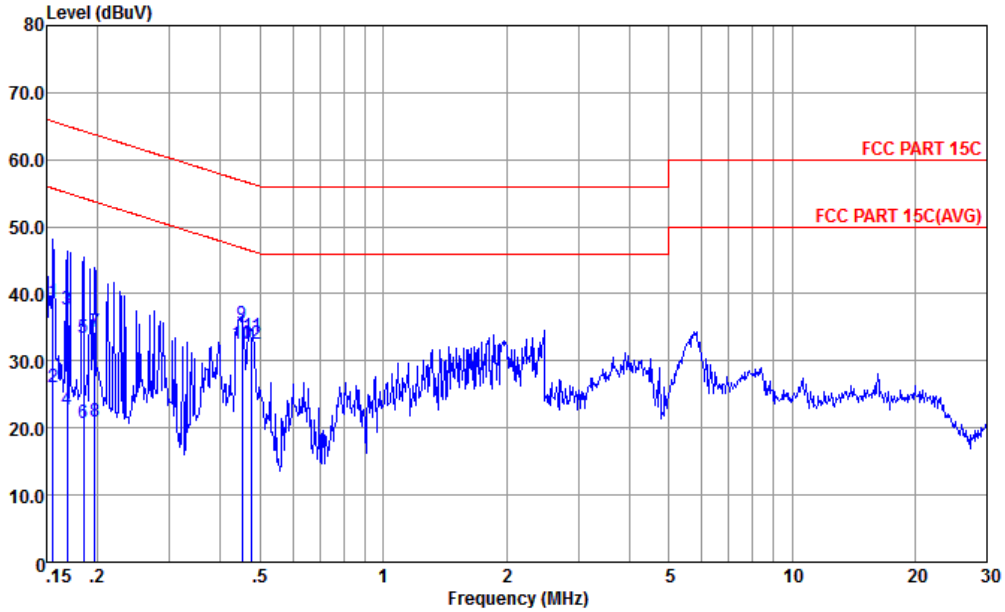
Report Number : FR032513B

TEST RESULTS DATA
Peak Power Density

2.4GHz Band								
Mod.	Data Rate	N_{TX}	CH.	Freq. (MHz)	Peak PSD (dBm /3kHz)	DG (dBi)	Peak PSD Limit (dBm /3kHz)	Pass/Fail
11b	1Mbps	1	1	2412	-4.17	1.73	8.00	Pass
11b	1Mbps	1	6	2437	-5.89	1.73	8.00	Pass
11b	1Mbps	1	11	2462	-4.99	1.73	8.00	Pass
11g	6Mbps	1	1	2412	-8.73	1.73	8.00	Pass
11g	6Mbps	1	6	2437	-7.92	1.73	8.00	Pass
11g	6Mbps	1	11	2462	-8.59	1.73	8.00	Pass
HT20	MCS0	1	1	2412	-8.86	1.73	8.00	Pass
HT20	MCS0	1	6	2437	-8.48	1.73	8.00	Pass
HT20	MCS0	1	11	2462	-8.44	1.73	8.00	Pass

Appendix B. AC Conducted Emission Test Results

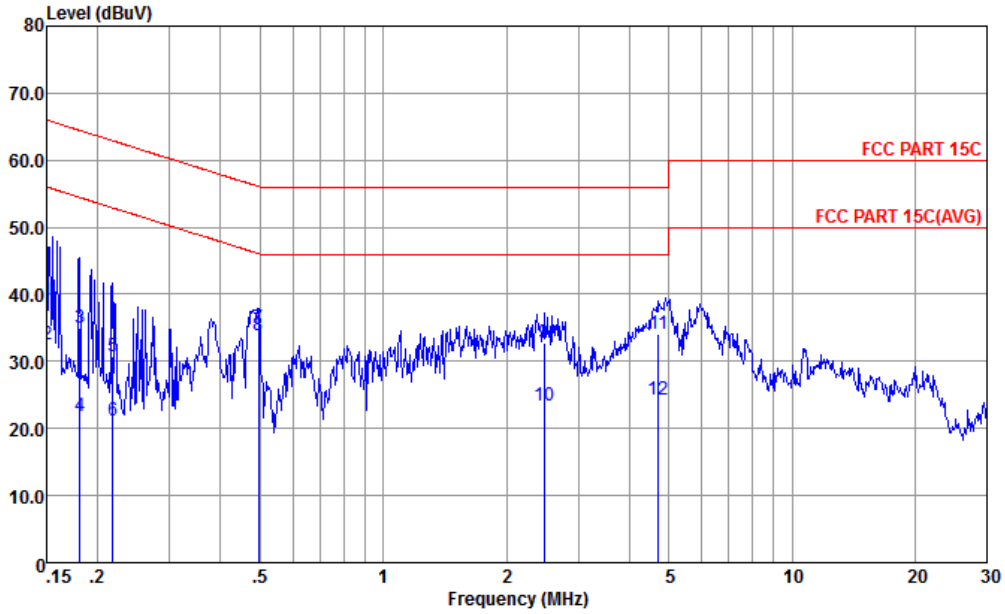
Test Engineer :	Amos Zhang	**Temperature :**	25.3~26.2℃
		Relative Humidity :	38~40%
Test Voltage :	120Vac / 60Hz	**Phase :**	Line



Site : CO01-KS
Condition : FCC PART 15C LISN-L-191028-060105 LINE

	Freq	Level	Over Limit	Limit Line	Read Level	LISN Factor	Cable Loss	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	dB	
1	0.156	38.74	-26.95	65.69	28.24	0.03	10.47	QP
2	0.156	26.04	-29.65	55.69	15.54	0.03	10.47	Average
3	0.169	37.71	-27.32	65.03	27.25	0.03	10.43	QP
4	0.169	22.71	-32.32	55.03	12.25	0.03	10.43	Average
5	0.184	33.38	-30.90	64.28	22.94	0.04	10.40	QP
6	0.184	20.78	-33.50	54.28	10.34	0.04	10.40	Average
7	0.197	34.36	-29.40	63.76	23.95	0.04	10.37	QP
8	0.197	21.06	-32.70	53.76	10.65	0.04	10.37	Average
9	0.452	35.47	-21.38	56.85	25.16	0.06	10.25	QP
10	0.452	32.47	-14.38	46.85	22.16	0.06	10.25	Average
11	0.476	33.67	-22.74	56.41	23.37	0.06	10.24	QP
12 *	0.476	32.57	-13.84	46.41	22.27	0.06	10.24	Average

Test Engineer :	Amos Zhang	**Temperature :**	25.3~26.2℃
		Relative Humidity :	38~40%
Test Voltage :	120Vac / 60Hz	**Phase :**	Neutral



Site : CO01-KS
Condition : FCC PART 15C LISN-N-191028-060105 NEUTRAL

		Freq	Level	Over Limit	Limit Line	Read Level	LISN Factor	Cable Loss	Remark
		MHz	dBuV	dB	dBuV	dBuV	dB	dB	
1		0.150	38.93	-27.07	66.00	28.37	0.08	10.48	QP
2		0.150	32.53	-23.47	56.00	21.97	0.08	10.48	Average
3		0.181	35.07	-29.39	64.46	24.59	0.08	10.40	QP
4		0.181	21.87	-32.59	54.46	11.39	0.08	10.40	Average
5		0.217	30.73	-32.19	62.92	20.30	0.08	10.35	QP
6		0.217	21.13	-31.79	52.92	10.70	0.08	10.35	Average
7		0.494	34.97	-21.13	56.10	24.63	0.10	10.24	QP
8	*	0.494	33.77	-12.33	46.10	23.43	0.10	10.24	Average
9		2.474	32.73	-23.27	56.00	22.36	0.14	10.23	QP
10		2.474	23.43	-22.57	46.00	13.06	0.14	10.23	Average
11		4.721	34.17	-21.83	56.00	23.74	0.16	10.27	QP
12		4.721	24.37	-21.63	46.00	13.94	0.16	10.27	Average

Note:

1. Level(dBμV) = Read Level(dBμV) + LISN Factor(dB) + Cable Loss(dB)
2. Over Limit(dB) = Level(dBμV) – Limit Line(dBμV)

Appendix C. Radiated Spurious Emission

2.4GHz 2400~2483.5MHz

WIFI 802.11b (Band Edge @ 3m)

WIFI Ant.	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
1		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
802.11b CH 01 2412MHz		2368.5	55.04	-18.96	74	49.36	32	7.68	34	112	291	P	H
		2386.57	44.24	-9.76	54	38.29	32.2	7.74	33.99	112	291	A	H
	*	2412	105.96	-	-	100.01	32.16	7.77	33.98	112	291	P	H
	*	2410	102.28	-	-	96.33	32.16	7.77	33.98	112	291	A	H
		2372.01	55.11	-18.89	74	49.3	32.1	7.71	34	100	268	P	V
		2386.18	43.83	-10.17	54	37.88	32.2	7.74	33.99	100	268	A	V
	*	2412	103.28	-	-	97.33	32.16	7.77	33.98	100	268	P	V
	*	2410	99.44	-	-	93.49	32.16	7.77	33.98	100	268	A	V
802.11b CH 11 2462MHz		2493.52	54.69	-19.31	74	48.75	31.94	7.93	33.93	141	292	P	H
		2483.5	43.7	-10.3	54	37.76	31.99	7.89	33.94	141	292	A	H
	*	2462	104.9	-	-	98.96	32.03	7.86	33.95	141	292	P	H
	*	2460	101.04	-	-	95.1	32.03	7.86	33.95	141	292	A	H
		2498.8	54.39	-19.61	74	48.45	31.94	7.93	33.93	100	272	P	V
		2483.5	43.38	-10.62	54	37.44	31.99	7.89	33.94	100	272	A	V
	*	2462	101.92	-	-	95.98	32.03	7.86	33.95	100	272	P	V
	*	2464	98.09	-	-	92.15	32.03	7.86	33.95	100	272	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

WIFI 802.11b (Harmonic @ 3m)

WIFI Ant. 1	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
802.11b CH 01 2412MHz		4824	47	-27	74	63.36	35.16	10.96	62.48	300	0	P	H
		4824	44.67	-29.33	74	61.03	35.16	10.96	62.48	300	360	P	V
802.11b CH 06 2437MHz		4872	44.03	-29.97	74	60.02	35.17	11.04	62.2	300	0	P	H
		7308	43.48	-30.52	74	55.27	36.86	13.46	62.11	300	0	P	H
		4872	43.55	-30.45	74	59.54	35.17	11.04	62.2	300	360	P	V
		7308	43.6	-30.4	74	55.39	36.86	13.46	62.11	300	360	P	V
802.11b CH 11 2462MHz		4926	44.51	-29.49	74	60.3	35.18	11.1	62.07	300	0	P	H
		7386	44.33	-29.67	74	56.17	36.88	13.54	62.26	300	0	P	H
		4926	44.11	-29.89	74	59.9	35.18	11.1	62.07	300	360	P	V
		7386	42.7	-31.3	74	54.54	36.88	13.54	62.26	300	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

WIFI 802.11g (Band Edge @ 3m)

WIFI Ant. 1	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
802.11g CH 01 2412MHz		2389.17	65.77	-8.23	74	59.82	32.2	7.74	33.99	110	291	P	H
		2389.95	50.15	-3.85	54	44.2	32.2	7.74	33.99	110	291	A	H
	*	2408	107.77	-	-	101.82	32.16	7.77	33.98	110	291	P	H
	*	2408	99.87	-	-	93.92	32.16	7.77	33.98	110	291	A	H
		2389.04	63.93	-10.07	74	57.98	32.2	7.74	33.99	100	287	P	V
		2389.95	49.68	-4.32	54	43.73	32.2	7.74	33.99	100	287	A	V
	*	2412	104.8	-	-	98.85	32.16	7.77	33.98	100	287	P	V
	*	2410	96.61	-	-	90.66	32.16	7.77	33.98	100	287	A	V
802.11g CH 11 2462MHz		2483.5	68.65	-5.35	74	62.71	31.99	7.89	33.94	139	290	P	H
		2483.5	50.89	-3.11	54	44.95	31.99	7.89	33.94	139	290	A	H
	*	2460	105.58	-	-	99.64	32.03	7.86	33.95	139	290	P	H
	*	2460	97.24	-	-	91.3	32.03	7.86	33.95	139	290	A	H
		2483.5	66.26	-7.74	74	60.32	31.99	7.89	33.94	102	275	P	V
		2483.5	49.42	-4.58	54	43.48	31.99	7.89	33.94	102	275	A	V
	*	2468	103.01	-	-	97.07	32.03	7.86	33.95	102	275	P	V
	*	2464	94.74	-	-	88.8	32.03	7.86	33.95	102	275	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

WIFI 802.11g (Harmonic @ 3m)

WIFI Ant. 1	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
802.11g CH 01 2412MHz		4824	44.13	-29.87	74	60.49	35.16	10.96	62.48	300	0	P	H
		4824	41.53	-32.47	74	57.89	35.16	10.96	62.48	300	360	P	V
802.11g CH 06 2437MHz		4872	42.27	-31.73	74	58.26	35.17	11.04	62.2	100	360	P	H
		7308	44.32	-29.68	74	56.11	36.86	13.46	62.11	100	360	P	H
		4872	41.24	-32.76	74	57.23	35.17	11.04	62.2	100	360	P	V
		7308	42.62	-31.38	74	54.41	36.86	13.46	62.11	100	360	P	V
802.11g CH 11 2462MHz		4926	44.19	-29.81	74	59.98	35.18	11.1	62.07	300	0	P	H
		7386	43.24	-30.76	74	55.08	36.88	13.54	62.26	300	0	P	H
		4926	42.48	-31.52	74	58.27	35.18	11.1	62.07	300	360	P	V
		7386	42.39	-31.61	74	54.23	36.88	13.54	62.26	300	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

WIFI 802.11n HT20 (Band Edge @ 3m)

WIFI Ant. 1	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
802.11n HT20 CH 01 2412MHz		2389.95	65.08	-8.92	74	59.13	32.2	7.74	33.99	112	292	P	H
		2389.95	50.16	-3.84	54	44.21	32.2	7.74	33.99	112	292	A	H
	*	2410	106.78	-	-	100.83	32.16	7.77	33.98	112	292	P	H
	*	2410	98.89	-	-	92.94	32.16	7.77	33.98	112	292	A	H
		2388.91	63.22	-10.78	74	57.27	32.2	7.74	33.99	100	269	P	V
		2389.95	48.95	-5.05	54	43	32.2	7.74	33.99	100	269	A	V
	*	2412	105.11	-	-	99.16	32.16	7.77	33.98	100	269	P	V
	*	2410	96.11	-	-	90.16	32.16	7.77	33.98	100	269	A	V
802.11n HT20 CH 11 2462MHz		2484.46	65.41	-8.59	74	59.47	31.99	7.89	33.94	102	293	P	H
		2483.56	50.22	-3.78	54	44.28	31.99	7.89	33.94	102	293	A	H
	*	2462	104.03	-	-	98.09	32.03	7.86	33.95	102	293	P	H
	*	2464	95.72	-	-	89.78	32.03	7.86	33.95	102	293	A	H
		2483.68	64.38	-9.62	74	58.44	31.99	7.89	33.94	100	273	P	V
		2483.5	48.15	-5.85	54	42.21	31.99	7.89	33.94	100	273	A	V
	*	2462	101.58	-	-	95.64	32.03	7.86	33.95	100	273	P	V
	*	2464	93.17	-	-	87.23	32.03	7.86	33.95	100	273	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

WIFI 802.11n HT20 (Harmonic @ 3m)

WIFI Ant. 1	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
802.11n HT20 CH 01 2412MHz		4824	43.36	-30.64	74	59.72	35.16	10.96	62.48	100	360	P	H
		4824	41.69	-32.31	74	58.05	35.16	10.96	62.48	100	360	P	V
802.11n HT20 CH 06 2437MHz		4872	42.56	-31.44	74	58.55	35.17	11.04	62.2	300	0	P	H
		7308	43.53	-30.47	74	55.32	36.86	13.46	62.11	300	0	P	H
		4872	42.26	-31.74	74	58.25	35.17	11.04	62.2	300	360	P	V
		7308	43.27	-30.73	74	55.06	36.86	13.46	62.11	300	360	P	V
802.11n HT20 CH 11 2462MHz		4926	42.38	-31.62	74	58.17	35.18	11.1	62.07	100	360	P	H
		7386	43.04	-30.96	74	54.88	36.88	13.54	62.26	100	360	P	H
		4926	41.62	-32.38	74	57.41	35.18	11.1	62.07	100	360	P	V
		7386	42.5	-31.5	74	54.34	36.88	13.54	62.26	100	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

Emission below 1GHz

2.4GHz WIFI 802.11g (LF)

WIFI Ant.	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
1		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
2.4GHz 802.11g LF		64.92	18.83	-21.17	40	37.06	13.3	1.37	32.9	-	-	P	H
		167.74	20.33	-23.17	43.5	34.15	17.08	2.06	32.96	-	-	P	H
		216.24	23.44	-22.56	46	36.68	17.31	2.32	32.87	-	-	P	H
		263.77	26.46	-19.54	46	37.05	19.62	2.56	32.77	-	-	P	H
		385.99	22.95	-23.05	46	29.99	22.34	3.06	32.44	-	-	P	H
		576.11	27.05	-18.95	46	30.79	25.69	3.42	32.85	200	0	P	H
		64.92	23.02	-16.98	40	41.25	13.3	1.37	32.9	100	360	P	V
		167.74	22.31	-21.19	43.5	36.13	17.08	2.06	32.96	-	-	P	V
		263.77	22.5	-23.5	46	33.09	19.62	2.56	32.77	-	-	P	V
		332.64	21.79	-24.21	46	30.74	20.98	2.84	32.77	-	-	P	V
		504.33	22.2	-23.8	46	26.71	24.61	3.41	32.53	-	-	P	V
		599.39	27.52	-18.48	46	31.05	25.51	3.76	32.8	-	-	P	V
Remark	1. No other spurious found. 2. All results are PASS against limit line.												

Note symbol

*	**Fundamental Frequency** which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is **over limit** line.
P/A	**P**eak or **A**verage
H/V	**H**orizontal or **V**ertical

A calculation example for radiated spurious emission is shown as below:

WIFI	Note	Frequency	Level	Over	Limit	Read	Antenna	Cable	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
2		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
802.11b CH 01 2412MHz		2390	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
		2390	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Level(dBμV/m) =

Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

2. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

For Peak Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)

= 55.45 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 55.45(dBμV/m) – 74(dBμV/m)

= -18.55(dB)

For Average Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)

= 43.54 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 43.54(dBμV/m) – 54(dBμV/m)

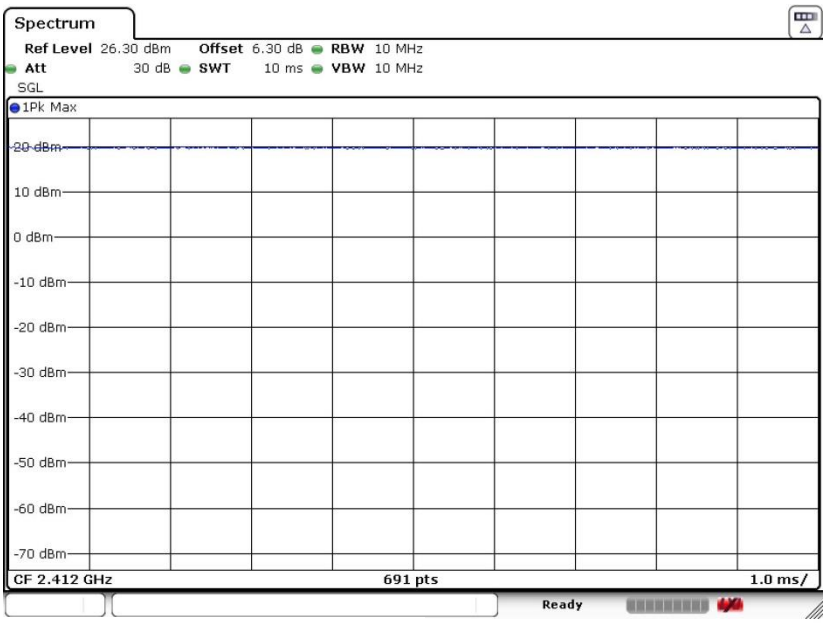
= -10.46(dB)

Both peak and average measured complies with the limit line, so test result is “PASS”.

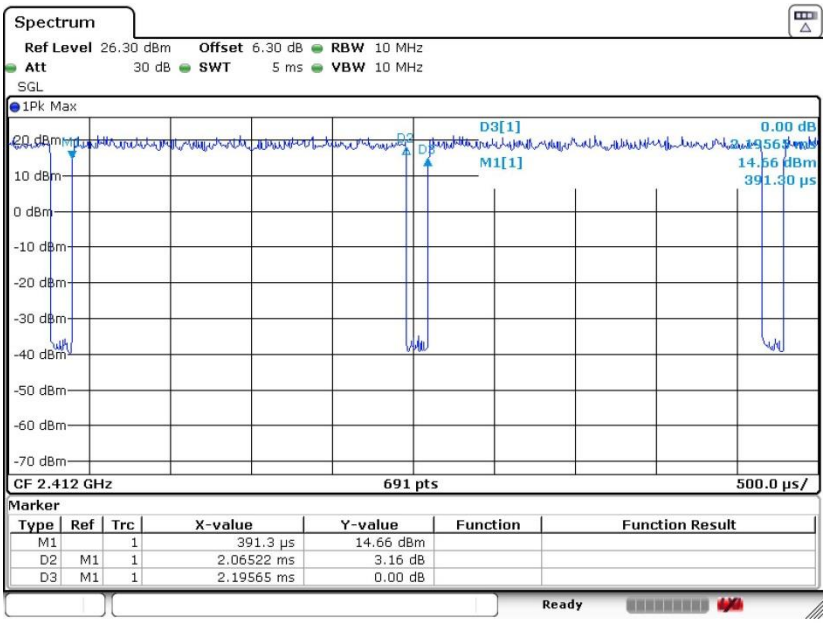
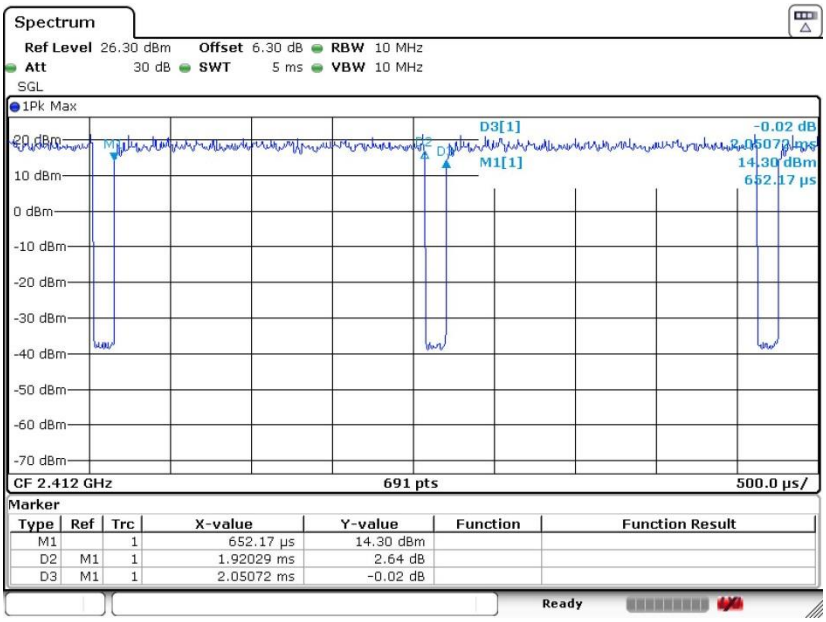
Appendix D. Duty Cycle Plots

Band	Duty Cycle(%)	T(ms)	1/T(kHz)	VBW Setting
802.11b	100	-	-	10Hz
802.11g	94.06	2.065	0.484	0.51KHz
802.11n HT20	93.64	1.920	0.521	0.56KHz

802.11b



802.11g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