FCC RF Test Report

APPLICANT	:	Volansys Technologies Pvt Ltd.
EQUIPMENT	:	Modular IoT Gateway
BRAND NAME	:	Volansys
MODEL NAME	:	VT-GTWY-6UL01-M2-M4
MARKETING NAME	:	Modular IoT Gateway
FCC ID	:	2AKNO-GW6UL01M2M4
STANDARD	:	FCC Part 15 Subpart C §15.247
CLASSIFICATION	:	(DTS) Digital Transmission System

The product was received on Jul. 12, 2017 and testing was completed on Aug. 22, 2017. We, Sporton International (Shenzhen) 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 (Shenzhen) Inc., the test report shall not be reproduced except in full.

Eric Shih

Approved by: Eric Shih / Manager

NVLAP®
TESTING
NVLAP LAB CODE 600156-0

Sporton International (Shenzhen) Inc.
1/F, 2/F, Bldg 5, Shiling Industrial Zone, Xinwei Village, Xili, Nanshan Shenzhen City
Guangdong Province 518055 China

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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR771202E	Rev. 01	Initial issue of report	Aug. 24, 2017

SUMMARY OF TEST RESULT

Report Section	FCC Rule	IC Rule	Description	Limit	Result	Remark
3.1	15.247(a)(2)	RSS-247 5.2(a)	6dB Bandwidth	≥ 0.5MHz	Pass	-
3.1	-	RSS-Gen 6.6	99% Bandwidth	-	Pass	-
3.2	15.247(b)(3)	RSS-247 5.4(d)	Peak Output Power	≤ 30dBm	Pass	-
3.3	15.247(e)	RSS-247 5.2(b)	Power Spectral Density	≤ 8dBm/3kHz	Pass	-
3.4	15.247(d)	RSS-247 5.5	Conducted Band Edges and Spurious Emission	≤ 20dBc	Pass	-
3.5	15.247(d)	RSS-247 5.5	Radiated Band Edges and Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 12.22 dB at 2483.520 MHz
3.6	15.207	RSS-GEN 8.8	AC Conducted Emission	15.207(a)	Pass	Under limit 11.26 dB at 0.440 MHz
3.7	15.203 & 15.247(b)	N/A	Antenna Requirement	N/A	Pass	-

1 General Description

1.1 Applicant

Volansys Technologies Pvt Ltd.
Block A-7th Floor, Safal Profitaire, Corporate Road, Prahaladnagar, Ahmedabad-380 015, Gujarat. India

1.2 Manufacturer

Volansys Technologies Pvt Ltd.
Block A-7th Floor, Safal Profitaire, Corporate Road, Prahaladnagar, Ahmedabad-380 015, Gujarat. India

1.3 Product Feature of Equipment Under Test

Product Feature	
Equipment	Modular IoT Gateway
Brand Name	Volansys
Model Name	VT-GTWY-6UL01-M2-M4
Marketing Name	Modular IoT Gateway
FCC ID	2AKNO-GW6UL01M2M4
EUT supports Radios application	NFC WLAN 2.4G 802.11b/g/n HT20/ Bluetooth 4.1 LE / v4.2 LE Zigbee/Thread: 250kpbs
HW Version	1.0
SW Version	test 1.2.0
EUT Stage	Production Unit

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 Frequency Range	2405 MHz ~ 2480 MHz
Number of Channels	16
Carrier Frequency of Each Channel	2405 MHz, 2410MHz, …, 2480MHz
Maximum Output Power to Antenna	2.83 dBm (0.0019 W)
99% Occupied Bandwidth	2.23MHz
Antenna Type / Gain	Chip Antenna with gain 2.00 dBi
Type of Modulation	Thread: BPSK/QPSK

1.5 Modification of EUT

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

1.6 Testing Location

Sporton Lab is accredited to ISO 17025 by National Voluntary Laboratory Accreditation Program (NVLAP code: 600156-0) and the FCC designation No are CN5018 and CN5019.

Test Site	Sporton International (Shenzhen) Inc.		
Test Site Location	1/F, 2/F, Bldg 5, Shiling Industrial Zone, Xinwei Village, Xili, Nanshan Shenzhen City Guangdong Province 518055 China TEL: +86-755-8637-9589 FAX: +86-755-8637-9595		
Test Site No.	**Sporton Site No.**		**FCC Test Firm Registration No.**
	TH01-SZ	CO01-SZ	251365

Test Site	SPORTON International (ShenZhen) INC.	
Test Site Location	No. 3 Bldg the third floor of south, Shahe River west, Fengzeyuan Warehouse, Nanshan District Shenzhen City Guangdong Province 518055 China TEL: +86-755-3320-2398	
Test Site No.	**Sporton Site No.**	**FCC Test Firm Registration No.**
	03CH01-SZ	577730

Note: The test site complies with ANSI C63.4 2014 requirement.

1.7 Applicable Standards

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

- FCC Part 15 Subpart C §15.247
- FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v04
- ANSI C63.10-2013
- IC RSS-247 Issue 2
- IC RSS-Gen Issue 4

Remark:

1. All test items were verified and recorded according to the standards and without any deviation during the test.
2. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.

2 Test Configuration of Equipment Under Test

2.1 Descriptions of Test Mode

The RF output power was recorded in the following table:

Channel	Frequency	Thread
		Data Rate / Modulation
		BPSK/QPSK
		250kbps
Ch11	2405MHz	2.59 dBm
Ch18	2440MHz	2.67 dBm
Ch25	2475MHz	2.82 dBm
CH26	2480MHz	**2.83** dBm

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 (150 kHz to 30 MHz), radiation (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower).

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

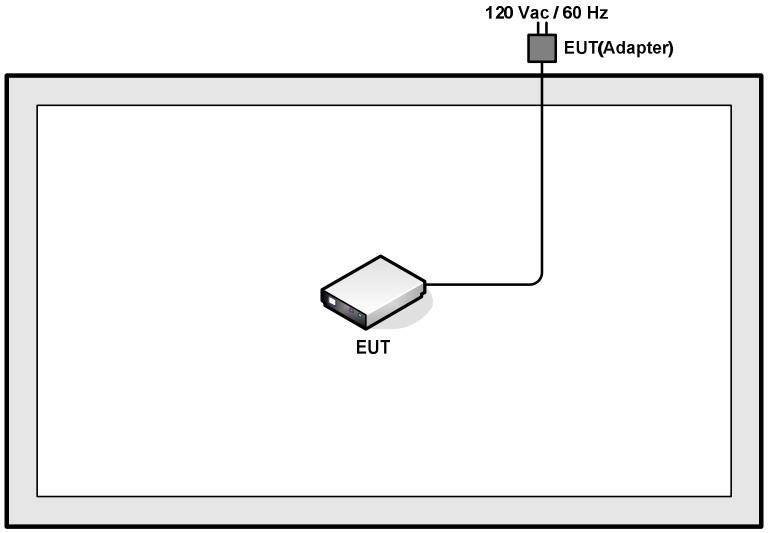
2.2 Test Mode

The following summary table is showing all test modes to demonstrate in compliance with the standard.

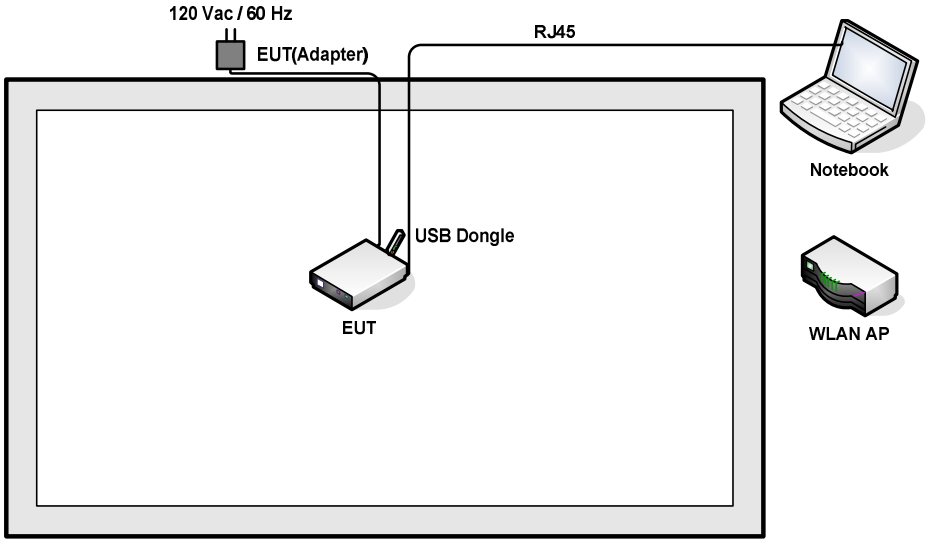
Summary table of Test Cases	
Test Item	**Data Rate / Modulation**
	250kbps / Thread
Conducted TCs	Mode 1: Thread Tx CH11_2405 MHz Mode 2: Thread Tx CH18_2440 MHz Mode 3: Thread Tx CH25_2475 MHz Mode 4: Thread Tx CH26_2480 MHz
Radiated TCs	Mode 1: Thread Tx CH11_2405 MHz Mode 2: Thread Tx CH18_2440 MHz Mode 3: Thread Tx CH25_2475 MHz Mode 4: Thread Tx CH26_2480 MHz
AC Conducted Emission	Mode 1: WLAN Link + Bluetooth Link + Zigbee Link + Thread Link + Adapter + USB Dongle (Data Link) + RJ-45 Link + SD Card (Data Link) + NFC On

2.3 Connection Diagram of Test System

<Thread Tx Mode>



<AC Conducted Emission Mode>



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-855	KA2DIR855A2	N/A	Unshielded, 1.8 m
2.	Notebook	Lenovo	E450	FCC DoC	N/A	AC I/P: Unshielded, 1.8 m DC O/P: Shielded, 1.8 m
3.	SD Card	Kingstone	8G	N/A	N/A	N/A
4.	USB Dongle	N/A	N/A	N/A	N/A	N/A

2.5 EUT Operation Test Setup

For Thread function, the 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 and attenuator factor 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 and attenuator factor.
Offset = RF cable loss + attenuator factor.
Following shows an offset computation example with cable loss 4.5 dB and 10dB attenuator.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB).
= 4.5 + 10 = 14.5 (dB)

3 Test Result

3.1 6dB and 99% Bandwidth Measurement

3.1.1 Limit of 6dB and 99% Bandwidth

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

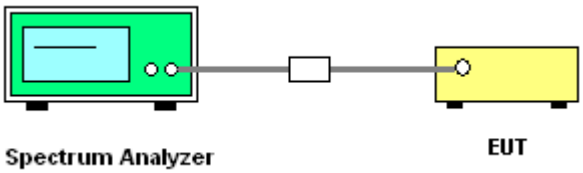
3.1.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.1.3 Test Procedures

1. The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v04.
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. For 99% Bandwidth Measurement, the spectrum analyzer's resolution bandwidth (RBW) is set 30kHz and set the Video bandwidth (VBW) = 100kHz.
6. Measure and record the results in the test report.

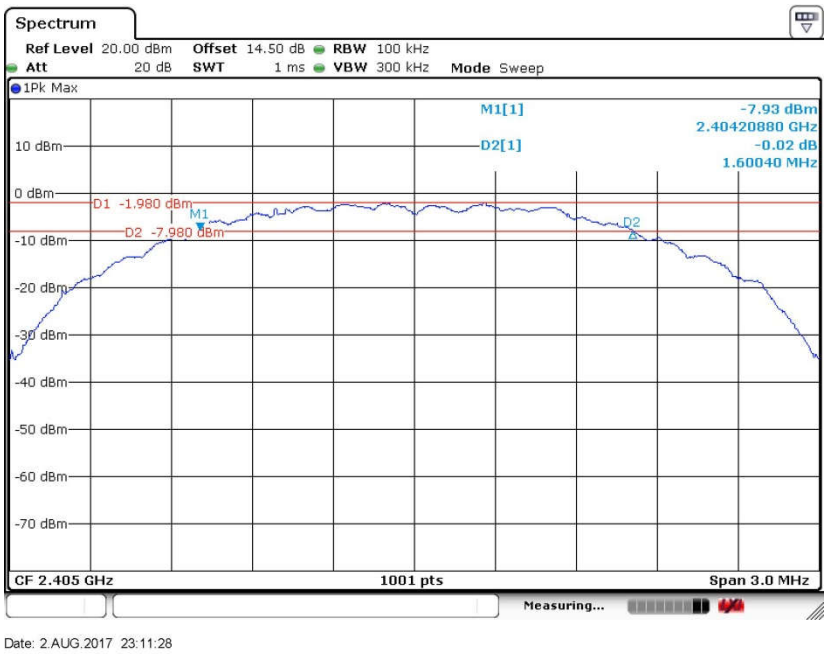
3.1.4 Test Setup



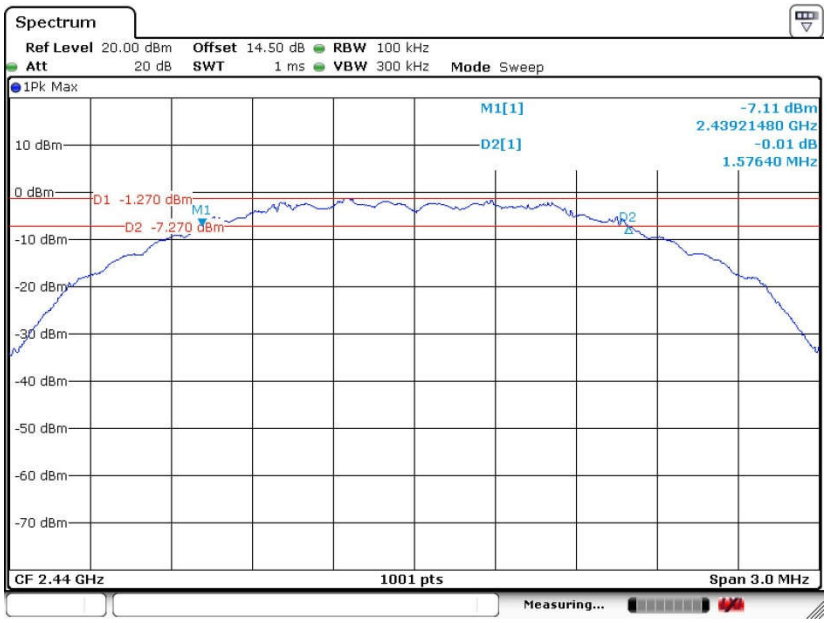
3.1.5 Test Result of 6dB Bandwidth

Test data refer to Appendix A.

6 dB Bandwidth Plot on Channel 11



6 dB Bandwidth Plot on Channel 18



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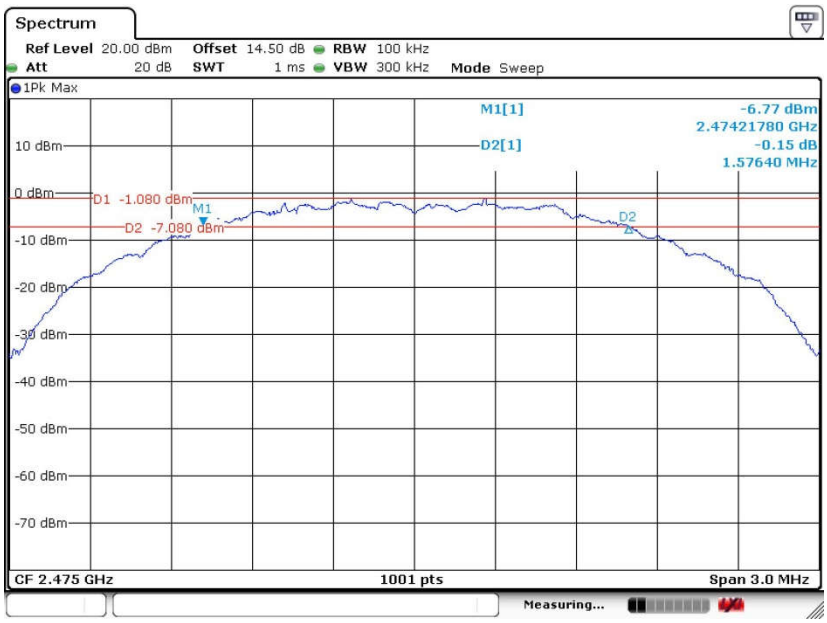
6 dB Bandwidth Plot on Channel 25



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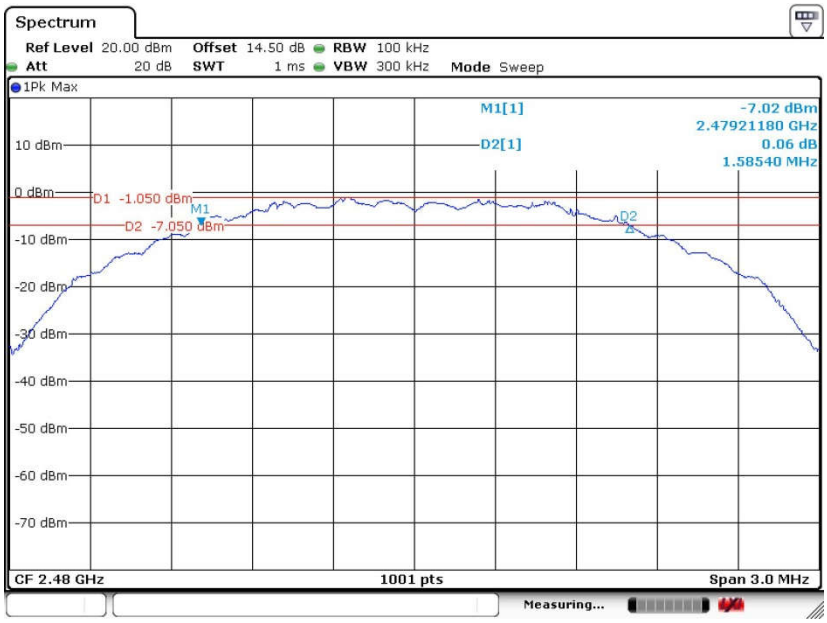
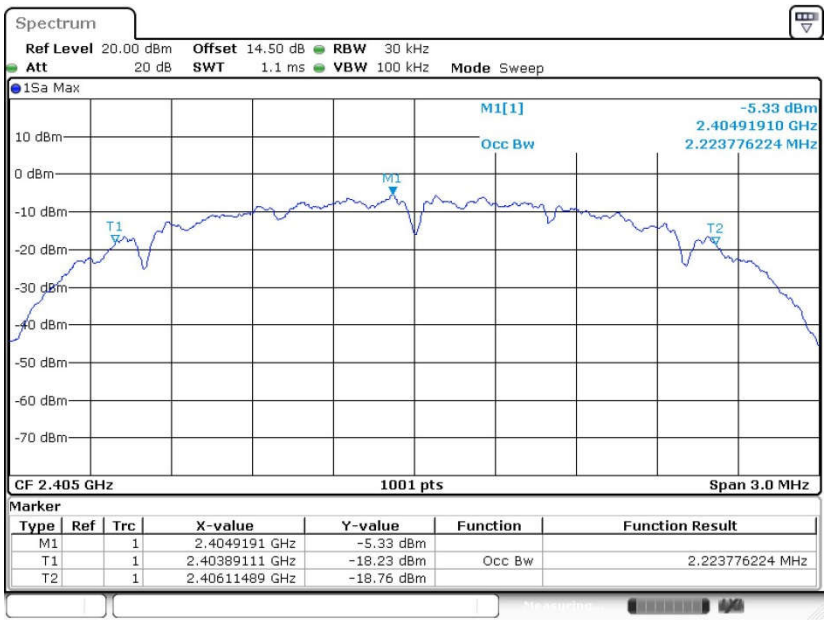
6 dB Bandwidth Plot on Channel 26



3.1.6 Test Result of 99% Occupied Bandwidth

Test data refer to Appendix A.

99% Bandwidth Plot on Channel 11



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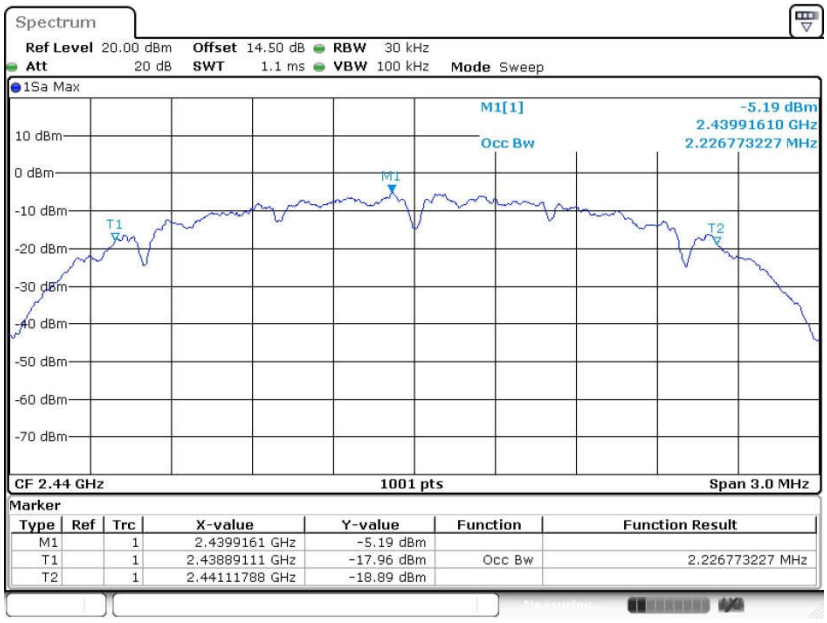
99% Occupied Bandwidth Plot on Channel 18



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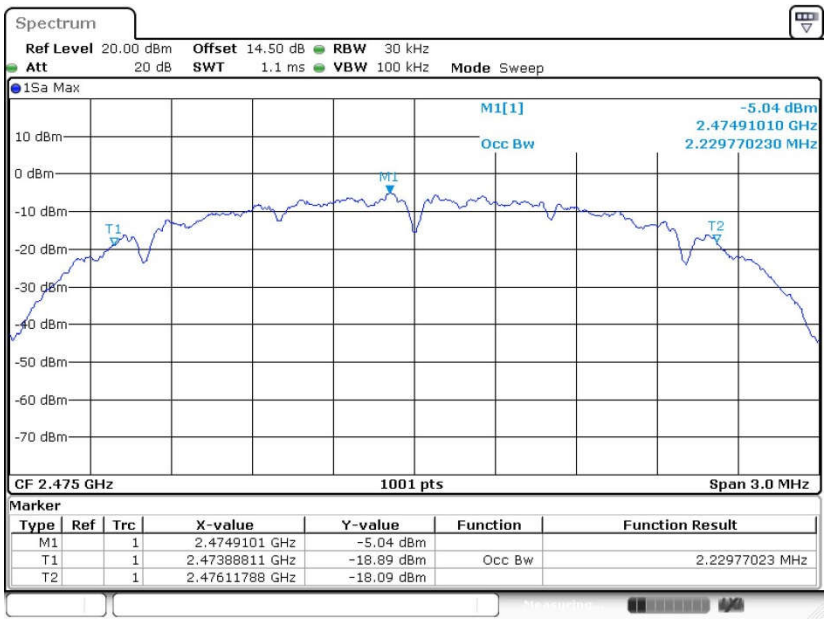
99% Occupied Bandwidth Plot on Channel 25



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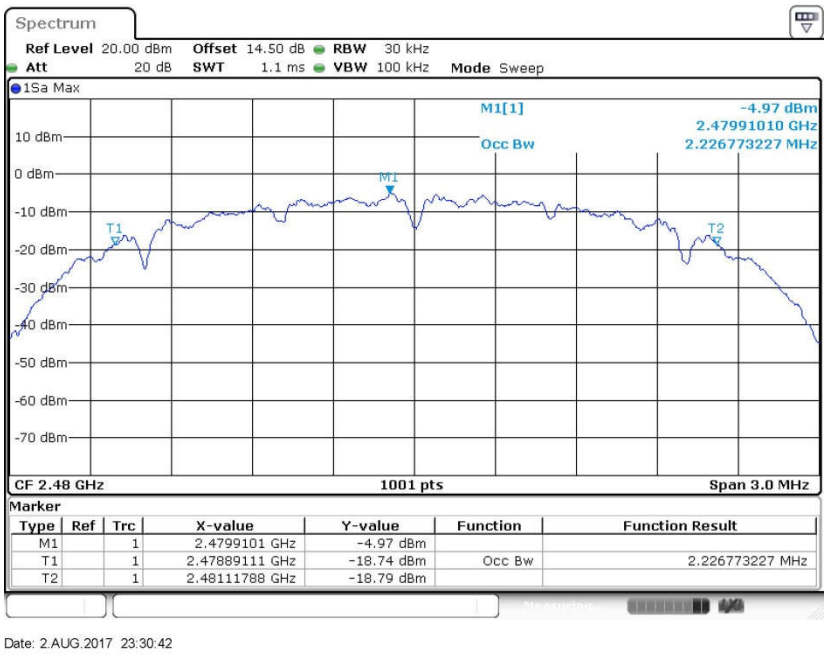
99% Occupied Bandwidth Plot on Channel 26



Note : The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

3.2 Peak Output Power Measurement

3.2.1 Limit of Peak Output Power

For systems using digital modulation in the 2400-2483.5MHz, the limit for peak output power is 30dBm. If transmitting antenna of 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.

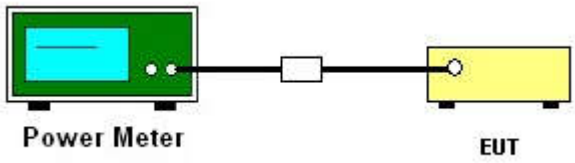
3.2.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.2.3 Test Procedures

1. The testing follows the Measurement Procedure of FCC KDB No. 558074 DTS D01 Meas. Guidance v04 section 9.1.2 PKPM1 Peak power meter 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

Test data refers 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.

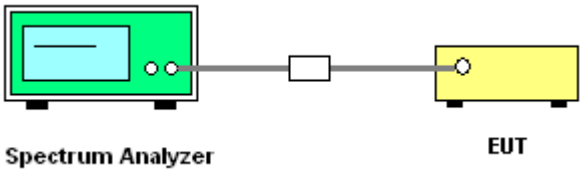
3.3.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.3.3 Test Procedures

1. The testing follows Measurement Procedure 10.2 Method PKPSD of FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v04
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.
7. The Measured power density (dBm)/ 100kHz is a reference level and used as 20dBc down limit line for Conducted Band Edges and Conducted Spurious Emission.

3.3.4 Test Setup

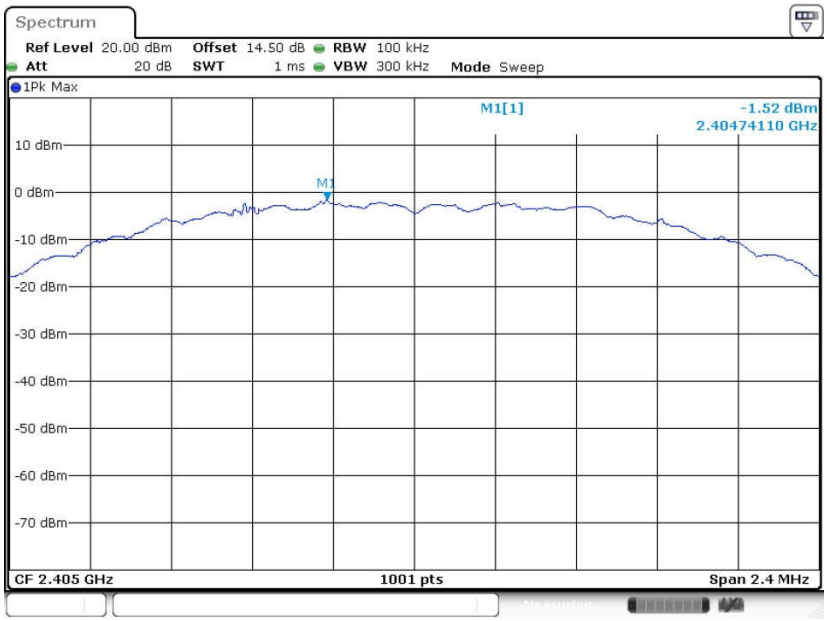


3.3.5 Test Result of Power Spectral Density

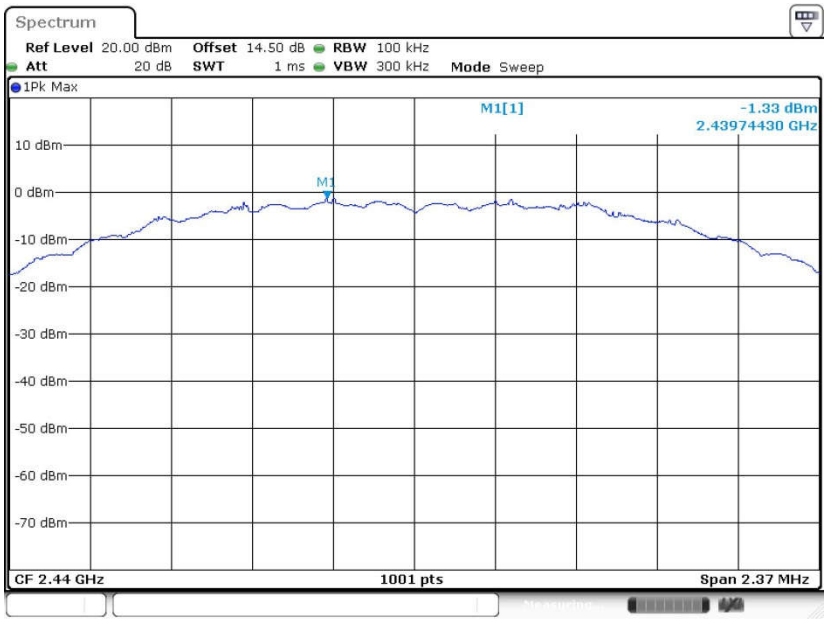
Test data refers to Appendix A.

3.3.6 Test Result of Power Spectral Density Plots (100kHz)

PSD 100kHz Plot on Channel 11



PSD 100kHz Plot on Channel 18



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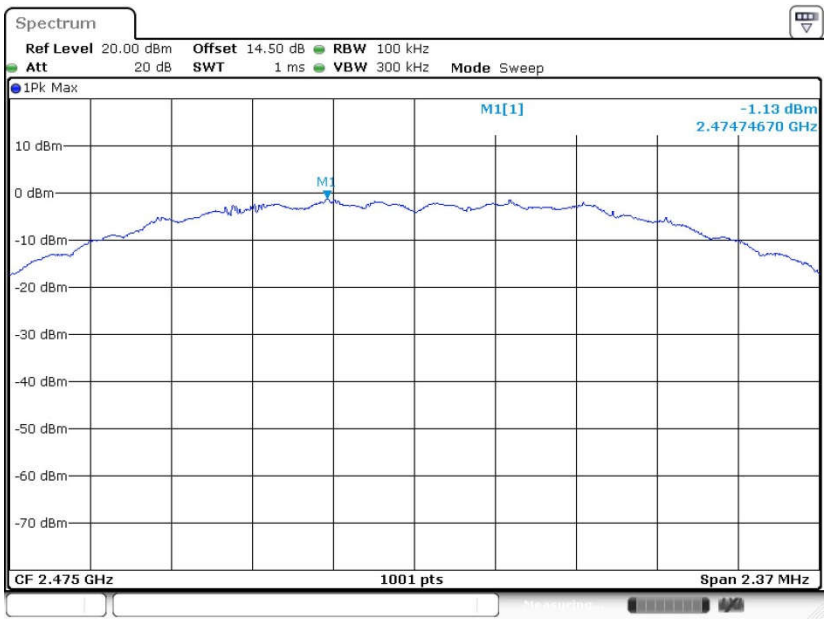
PSD 100kHz Plot on Channel 25



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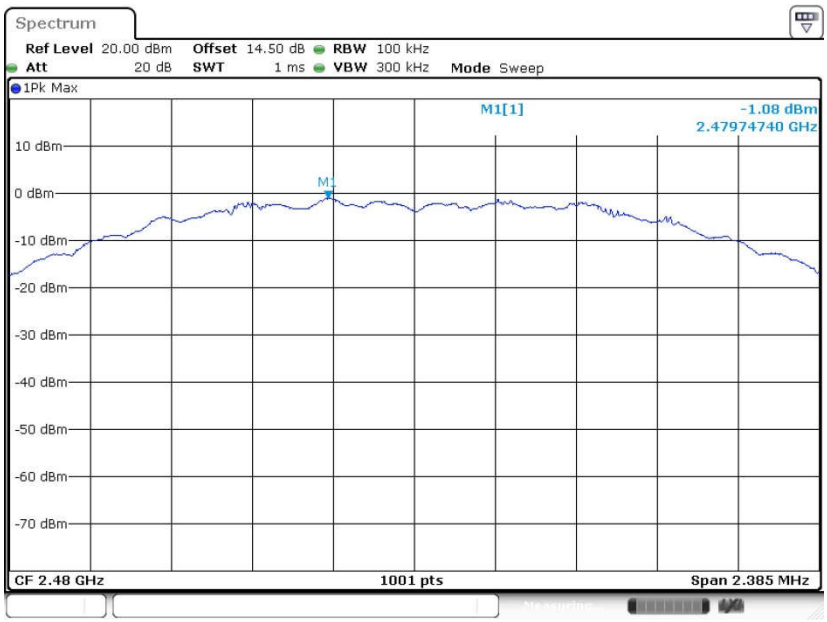
PSD 100kHz Plot on Channel 26



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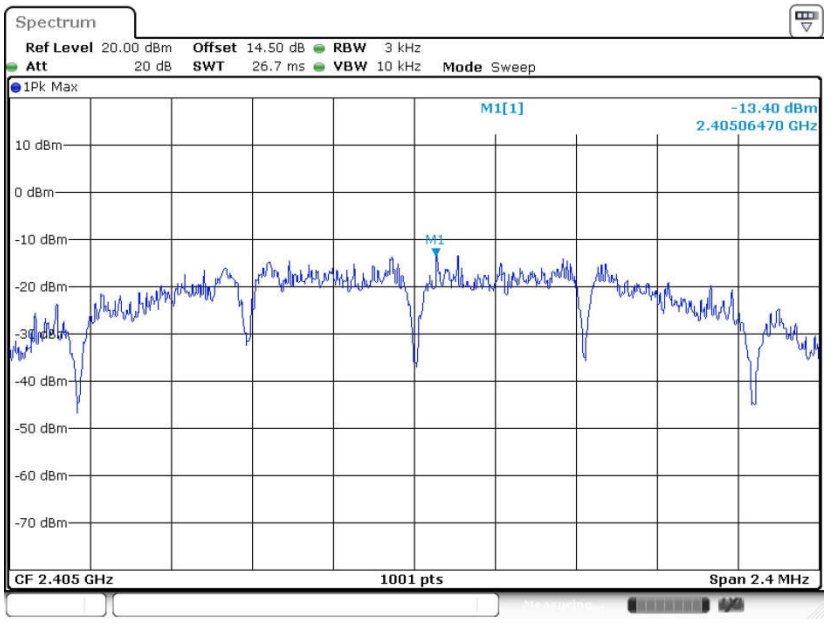
3.3.7 Test Result of Power Spectral Density Plots (3kHz)

PSD 3kHz Plot on Channel 11



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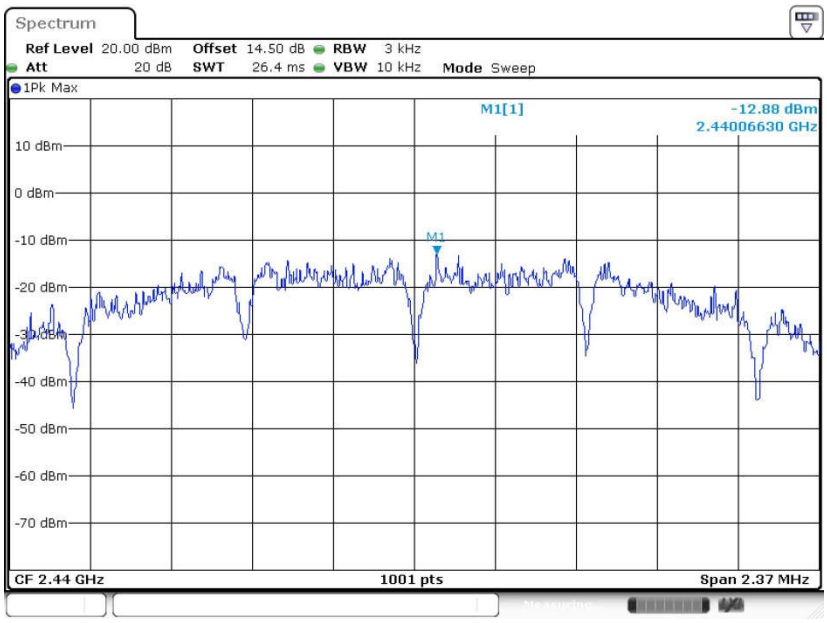
PSD 3kHz Plot on Channel 18



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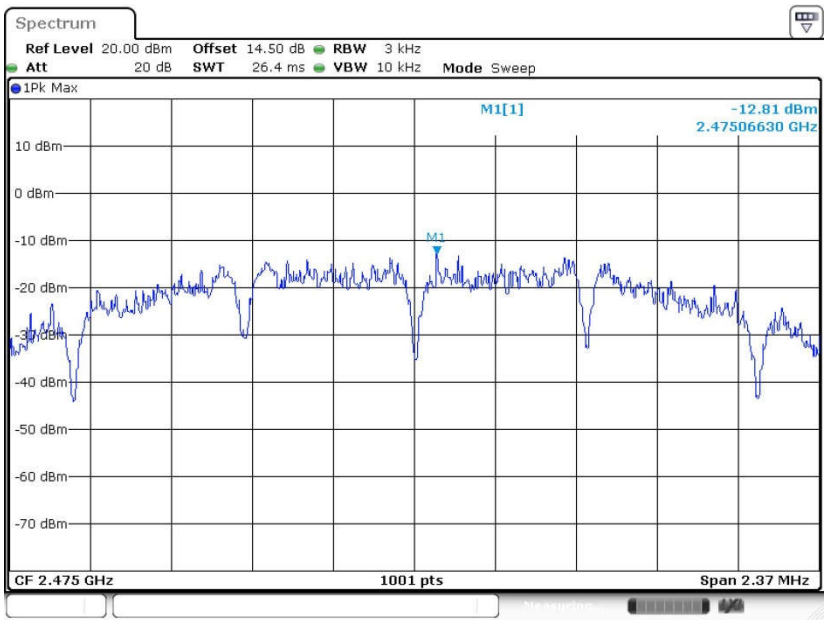
PSD 3kHz Plot on Channel 25



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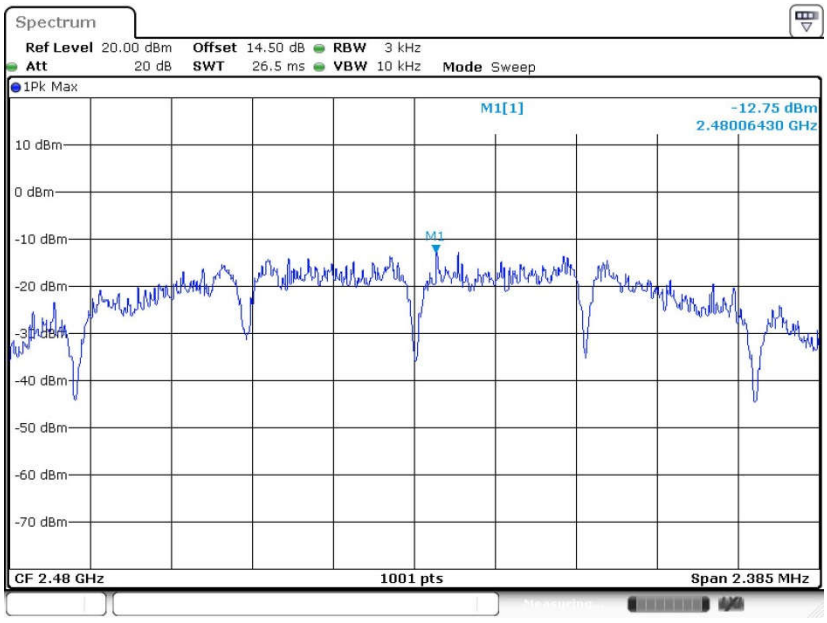
PSD 3kHz Plot on Channel 26



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3.4 Conducted Band Edges and Spurious Emission Measurement

3.4.1 Limit of Conducted Band Edges and Spurious Emission

All harmonics/spurious must be at least 20 dB down from the highest emission level within the authorized band.

3.4.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

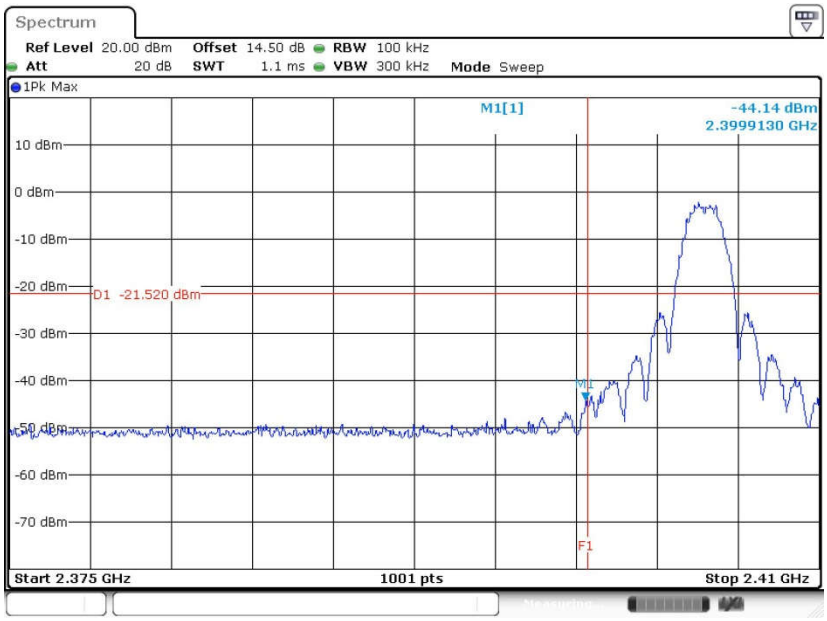
3.4.3 Test Procedure

1. The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v04.
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.
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 Plots

Low Band Edge Plot on Channel 11



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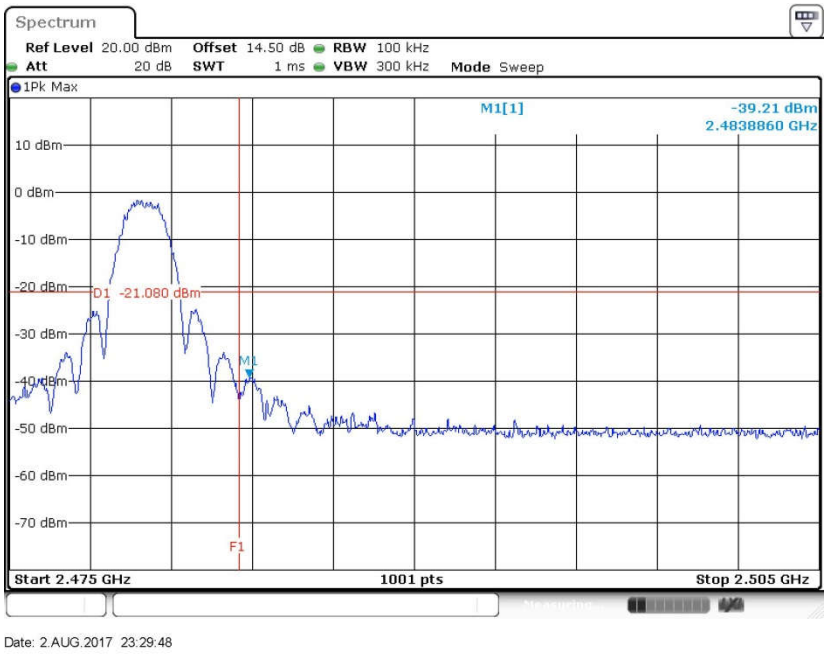
High Band Edge Plot on Channel 26



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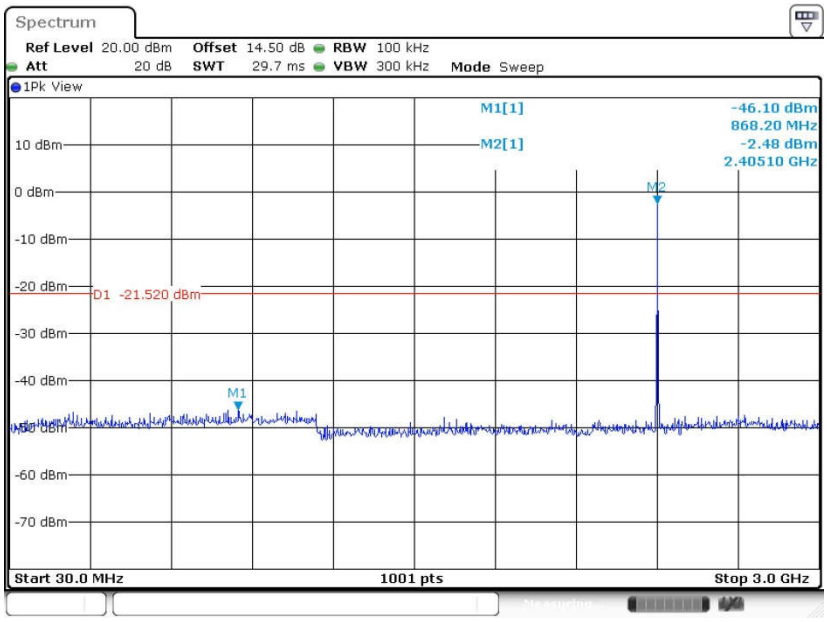
3.4.6 Test Result of Conducted Spurious Emission Plots

Conducted Spurious Emission Plot on

Thread Channel 11



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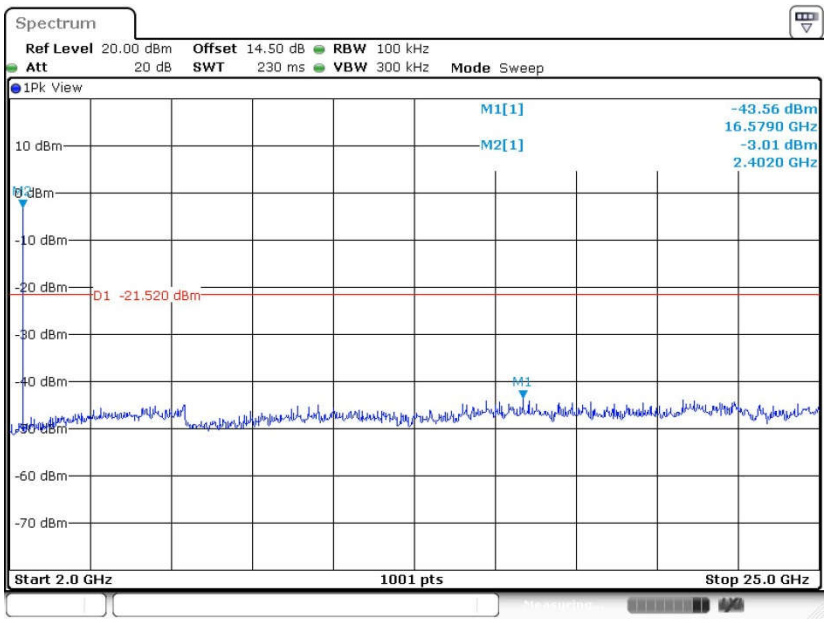

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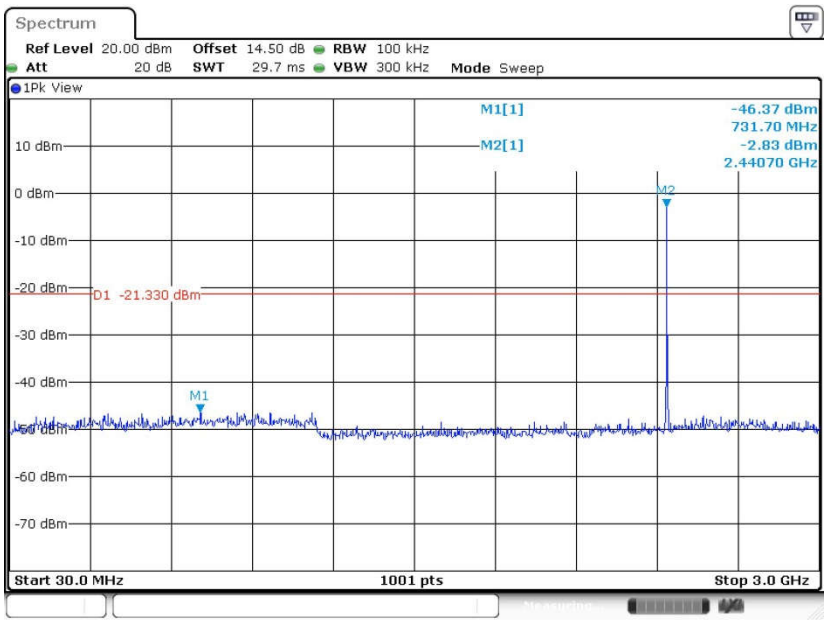
Conducted Spurious Emission Plot on

Thread Channel 18



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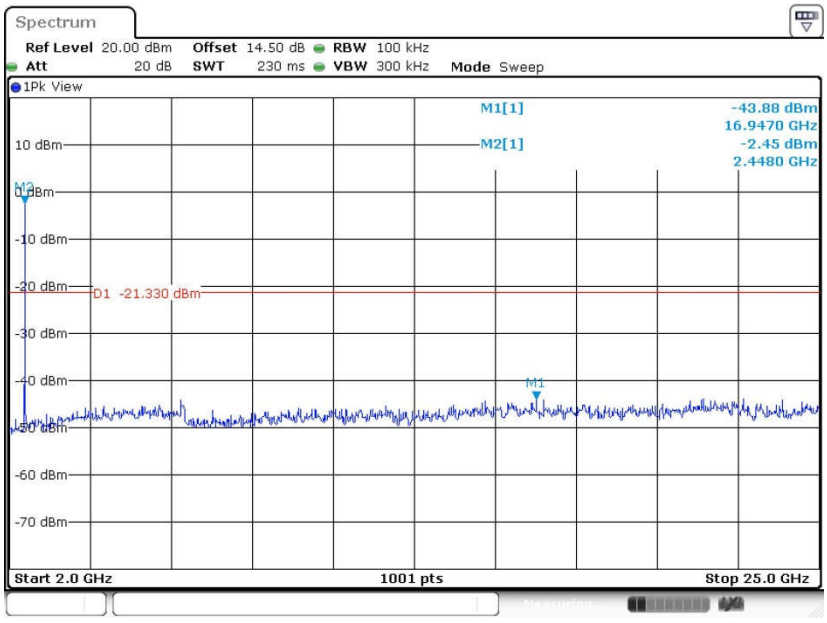

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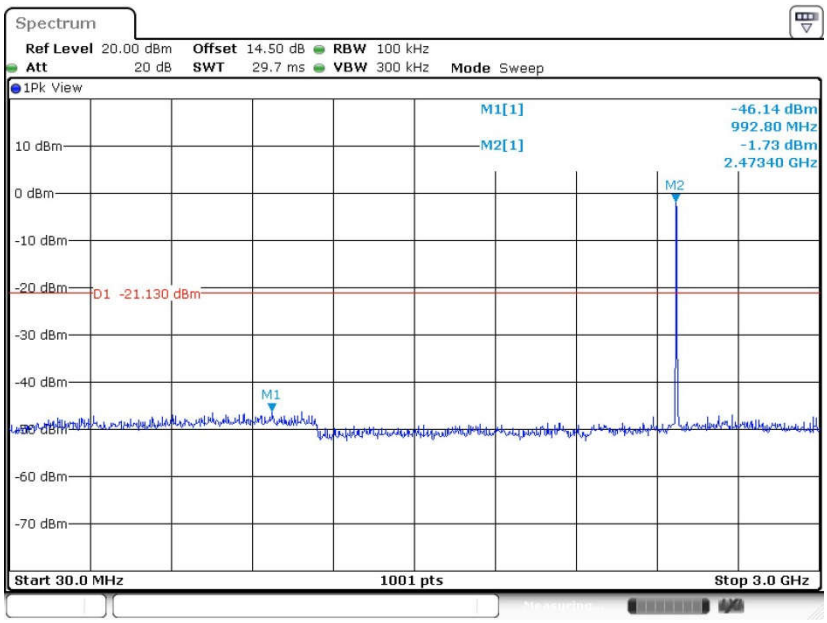
Conducted Spurious Emission Plot on

Thread Channel 25



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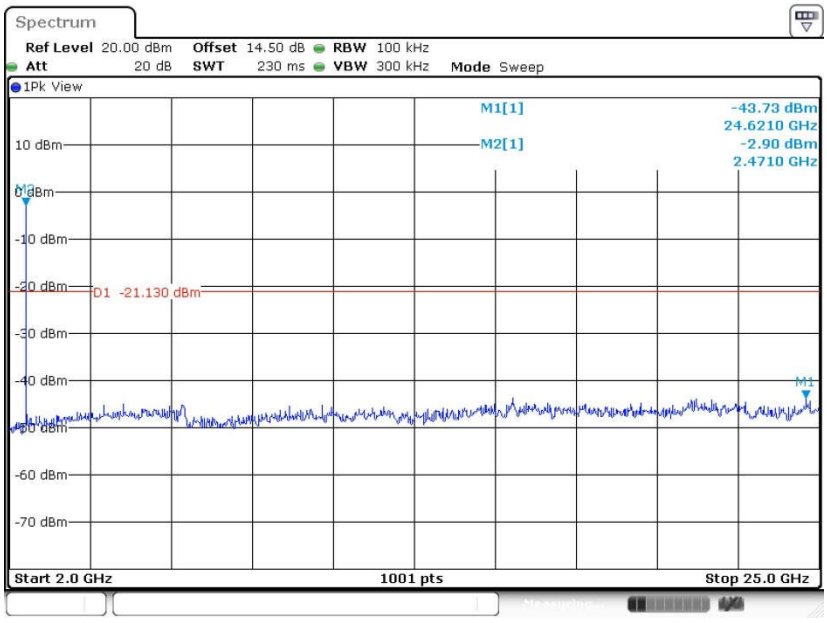
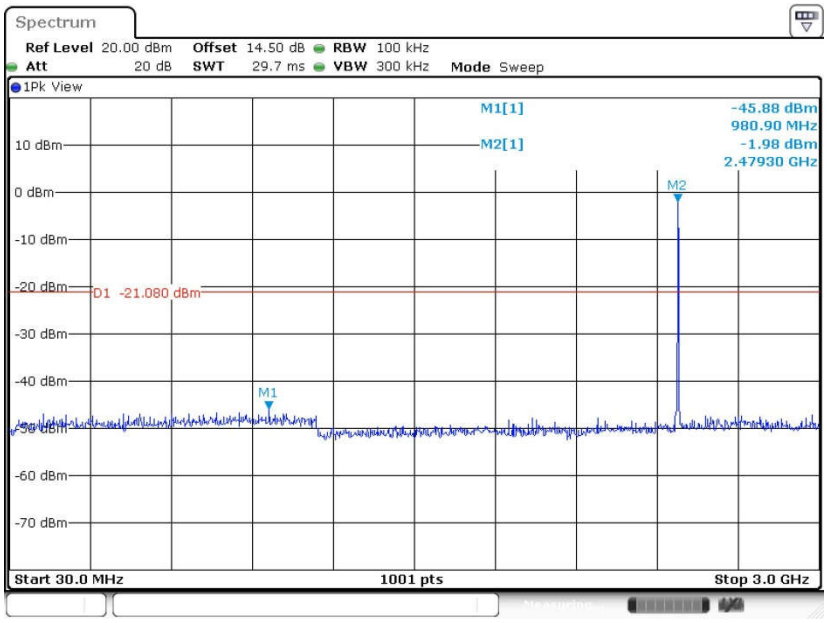


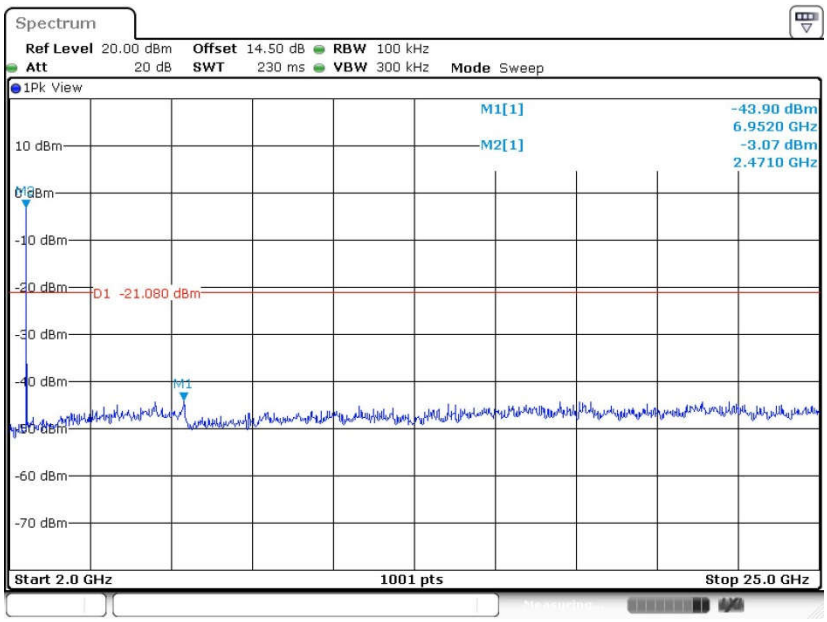
Date: 2.AUG.2017 23:24:35

Conducted Spurious Emission Plot on

Thread Channel 26



Date: 2.AUG.2017 23:30:03



Date: 2.AUG.2017 23:30:11

3.5 Spurious Emission Measurement in the Restricted Band

3.5.1 Limit of Spurious Emission Measurement in the Restricted Band

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

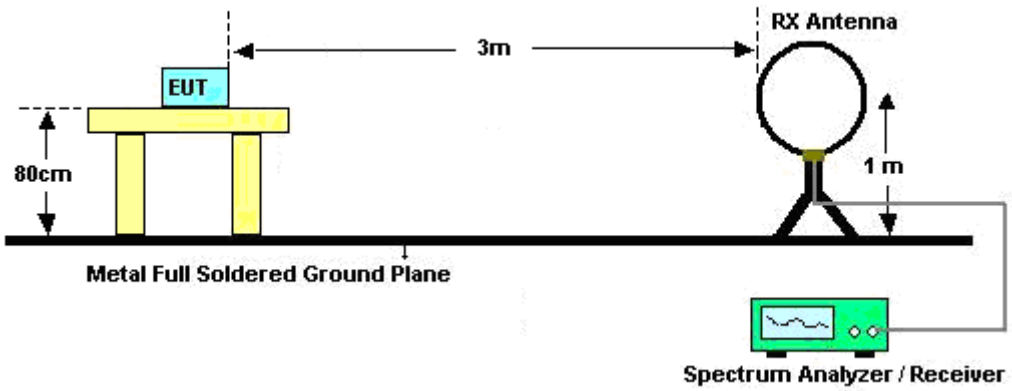
The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.5.3 Test Procedures

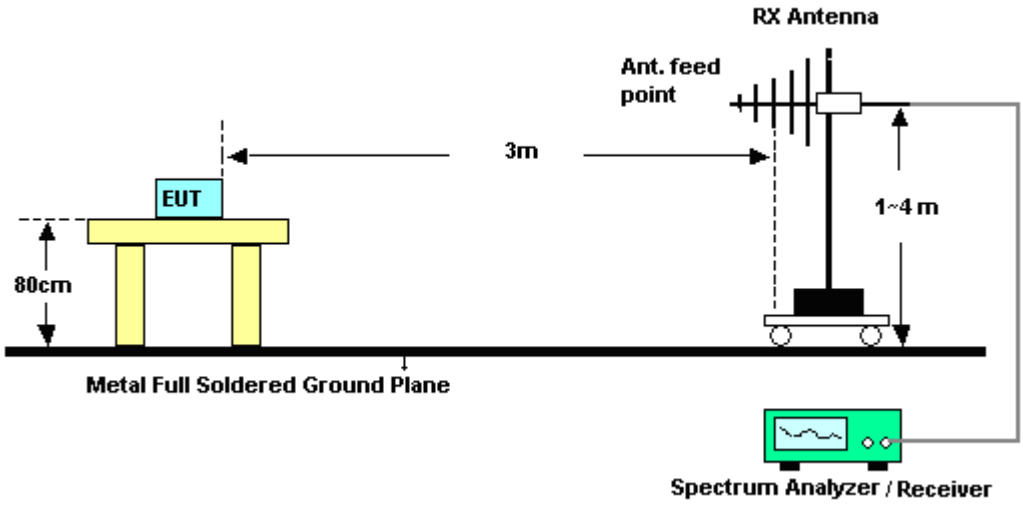
1. The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v04.
2. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test 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 conducted spurious emission measurement in the restricted band, 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.
7. For measurement below 1GHz, if the emission level of the EUT measured by the peak detector is 3 dB lower than the applicable limit, the peak emission level will be reported. Otherwise, the emission measurement will be repeated using the quasi-peak detector 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

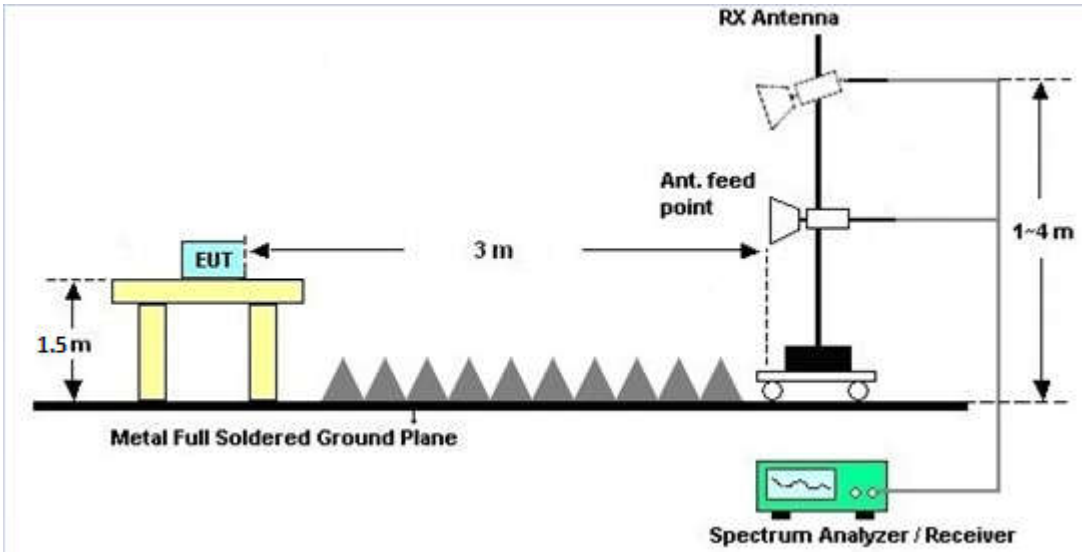
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



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

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.

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

Please refer to Appendix B.

3.5.7 Duty Cycle

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.

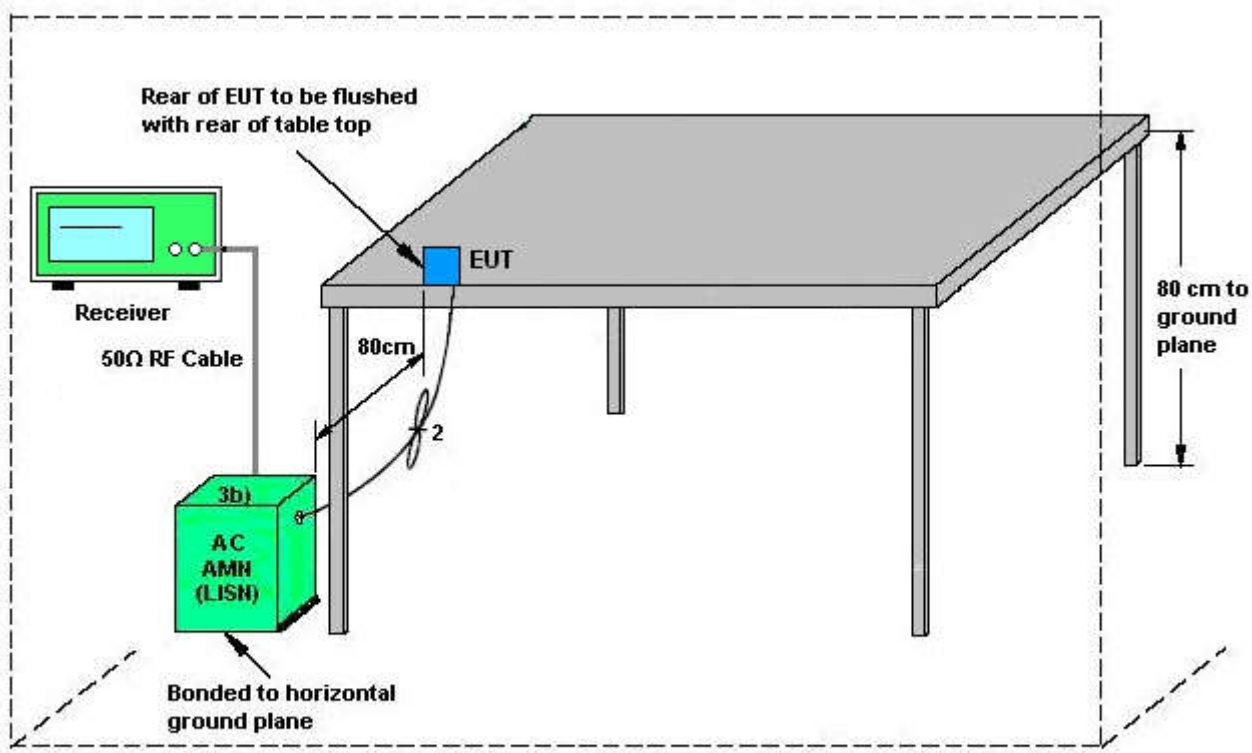
3.6.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.6.3 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room 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. Then measurement is also conducted by Average Detector and Quasi-Peak Detector Function respectively.

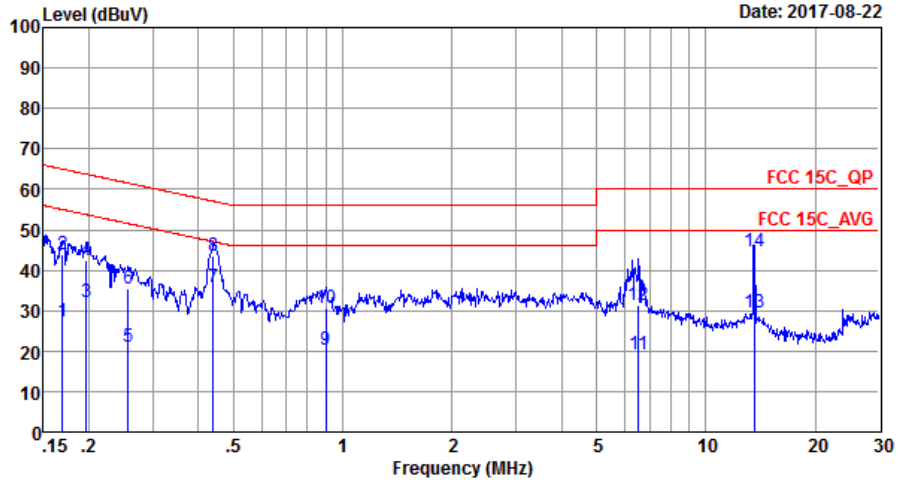
3.6.4 Test Setup



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

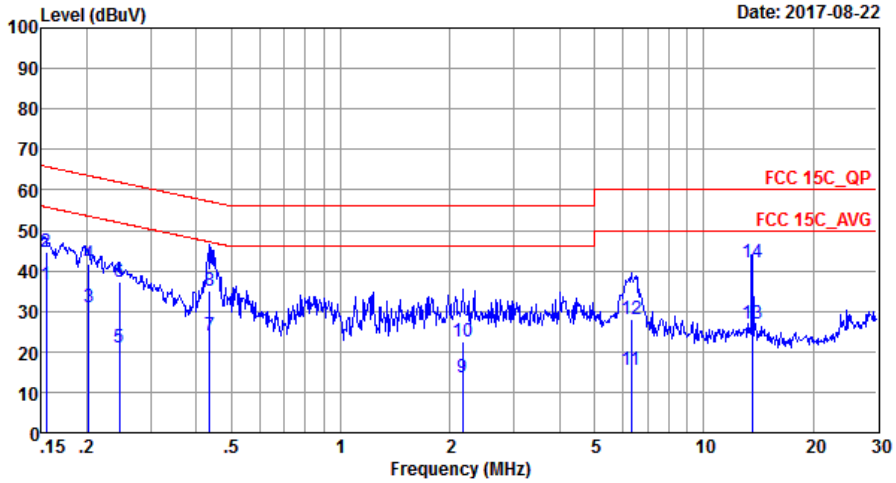
Test Mode :	Mode 1	Temperature :	22~25℃
Test Engineer :	Haohai Ye	Relative Humidity :	50~55%
Test Voltage :	120Vac / 60Hz	Phase :	Line
Function Type :	WLAN Link + Bluetooth Link + Zigbee Link + Thread Link + Adapter + USB Dongle (Data Link) + RJ-45 Link + SD Card (Data Link) + NFC On		



Site : CO01-SZ
Condition: FCC 15C_QP LISN_20170301_L LINE

		Freq	Level	Over Limit	Limit Line	Read Level	LISN Factor	Cable Loss	Remark
		MHz	dBuV	dB	dBuV	dBuV	dB	dB	
1		0.17	27.26	-27.73	54.99	16.90	0.03	10.33	Average
2		0.17	43.96	-21.03	64.99	33.60	0.03	10.33	QP
3		0.20	32.16	-21.60	53.76	21.90	0.03	10.23	Average
4		0.20	42.26	-21.50	63.76	32.00	0.03	10.23	QP
5		0.26	20.85	-30.71	51.56	10.60	0.03	10.22	Average
6		0.26	35.55	-26.01	61.56	25.30	0.03	10.22	QP
7	*	0.44	35.81	-11.26	47.07	25.59	0.03	10.19	Average
8		0.44	43.71	-13.36	57.07	33.49	0.03	10.19	QP
9		0.90	20.31	-25.69	46.00	10.10	0.06	10.15	Average
10		0.90	30.51	-25.49	56.00	20.30	0.06	10.15	QP
11		6.52	19.17	-30.83	50.00	8.64	0.22	10.31	Average
12		6.52	31.34	-28.66	60.00	20.81	0.22	10.31	QP
13		13.56	29.50	-20.50	50.00	18.70	0.47	10.33	Average
14		13.56	44.60	-15.40	60.00	33.80	0.47	10.33	QP

Test Mode :	Mode 1	Temperature :	22~25℃
Test Engineer :	Haohai Ye	Relative Humidity :	50~55%
Test Voltage :	120Vac / 60Hz	Phase :	Neutral
Function Type :	WLAN Link + Bluetooth Link + Zigbee Link + Thread Link + Adapter + USB Dongle (Data Link) + RJ-45 Link + SD Card (Data Link) + NFC On		



Site : CO01-SZ
Condition: FCC 15C_QP LISN_20170301_N NEUTRAL

		Freq	Level	Over Limit	Limit Line	Read Level	LISN Factor	Cable Loss	Remark
		MHz	dBuV	dB	dBuV	dBuV	dB	dB	
1		0.15	36.42	-19.32	55.74	26.00	0.03	10.39	Average
2		0.15	44.62	-21.12	65.74	34.20	0.03	10.39	QP
3		0.20	31.15	-22.34	53.49	20.90	0.03	10.22	Average
4		0.20	41.65	-21.84	63.49	31.40	0.03	10.22	QP
5		0.25	21.15	-30.76	51.91	10.90	0.03	10.22	Average
6		0.25	37.15	-24.76	61.91	26.90	0.03	10.22	QP
7		0.44	23.81	-23.34	47.15	13.60	0.02	10.19	Average
8		0.44	34.91	-22.24	57.15	24.70	0.02	10.19	QP
9		2.17	13.62	-32.38	46.00	3.40	0.05	10.17	Average
10		2.17	22.62	-33.38	56.00	12.40	0.05	10.17	QP
11		6.32	15.68	-34.32	50.00	5.30	0.07	10.31	Average
12		6.32	27.98	-32.02	60.00	17.60	0.07	10.31	QP
13		13.56	27.01	-22.99	50.00	16.39	0.29	10.33	Average
14	*	13.56	42.01	-17.99	60.00	31.39	0.29	10.33	QP

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	101078	9kHz~40GHz	Apr. 20, 2017	Aug. 02, 2017	Apr. 19, 2018	Conducted (TH01-SZ)
Pulse Power Senor	Anritsu	MA2411B	1207253	30MHz~40GHz	Jan. 06, 2017	Aug. 02, 2017	Jan. 05, 2018	Conducted (TH01-SZ)
Power Meter	Anritsu	ML2495A	1218010	50MHz Bandwidth	Jan. 06, 2017	Aug. 02, 2017	Jan. 05, 2018	Conducted (TH01-SZ)
EMI Test Receiver&SA	Agilent	N9038A	MY52260185	20Hz~26.5GHz	Apr. 20, 2017	Aug. 09, 2017	Apr. 19, 2018	Radiation (03CH01-SZ)
Loop Antenna	R&S	HFH2-Z2	100354	9kHz~30MHz	May 14, 2017	Aug. 09, 2017	May 13, 2018	Radiation (03CH01-SZ)
Bilog Antenna	TeseQ	CBL6112D	23188	30MHz-2GHz	Apr. 25, 2017	Aug. 09, 2017	Apr. 24, 2018	Radiation (03CH01-SZ)
Double Ridge Horn Antenna	ETS Lindgren	3117	00119436	1GHz~18GHz	Nov. 19, 2016	Aug. 09, 2017	Nov. 18, 2017	Radiation (03CH01-SZ)
SHF-EHF Horn	com-power	AH-840	101071	18Ghz-40GHz	Aug.10, 2016	Aug. 09, 2017	Aug. 09, 2017	Radiation (03CH01-SZ)
LF Amplifier	Burgeon	BPA-530	102209	0.01~3000Mhz	Apr. 20, 2017	Aug. 09, 2017	Apr. 19, 2018	Radiation (03CH01-SZ)
HF Amplifier	MITEQ	AMF-7D-00101800-30-10P-R	1707137	1GHz~18GHz	Oct. 11, 2016	Aug. 09, 2017	Oct. 10, 2017	Radiation (03CH01-SZ)
HF Amplifier	KEYSIGHT	83017A	MY53270104	0.5GHz~26.5Ghz	Oct. 11, 2016	Aug. 09, 2017	Oct. 10, 2017	Radiation (03CH01-SZ)
AC Power Source	Chroma	61601	616010001985	N/A	NCR	Aug. 09, 2017	NCR	Radiation (03CH01-SZ)
Turn Table	EM	EM1000	N/A	0~360 degree	NCR	Aug. 09, 2017	NCR	Radiation (03CH01-SZ)
Antenna Mast	EM	EM1000	N/A	1 m~4 m	NCR	Aug. 09, 2017	NCR	Radiation (03CH01-SZ)
EMI Receiver	R&S	ESR7	101630	9kHz~7GHz;	Jan. 06, 2017	Aug. 22, 2017	Jan. 05, 2018	Conduction (CO01-SZ)
AC LISN	EMCO	3816/2SH	00103912	9kHz~30MHz	Jan. 05, 2017	Aug. 22, 2017	Jan. 04, 2018	Conduction (CO01-SZ)
AC LISN (for auxiliary equipment)	MessTec	3816/2SH	00103892	9kHz~30MHz	Jan. 05, 2017	Aug. 22, 2017	Jan. 04, 2018	Conduction (CO01-SZ)
AC Power Source	Chroma	61602	616020000891	100Vac~250Vac	Jul. 19, 2017	Aug. 22, 2017	Jul. 18, 2018	Conduction (CO01-SZ)

NCR: No Calibration Required

5 Uncertainty of Evaluation

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**2.5 dB**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.1 dB**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.2 dB**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.1 dB**

Appendix A. Conducted Test Results

Report Number : FR771202E

Thread Low Energy

Test Engineer:	Wilson Chen	Temperature:	21~25	°C
Test Date:	2017/8/2	Relative Humidity:	51~54	%

TEST RESULTS DATA
6dB and 99% Occupied Bandwidth

Mod.	Data Rate	NTX	CH.	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
Thread	250 Kbps	1	11	2405	2.22	1.60	0.50	Pass
Thread	250 Kbps	1	18	2440	2.23	1.58	0.50	Pass
Thread	250 Kbps	1	25	2475	2.23	1.58	0.50	Pass
Thread	250 Kbps	1	26	2480	2.23	1.59	0.50	Pass

TEST RESULTS DATA
Peak Power Table

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
Thread	250 Kbps	1	11	2405	2.59	30.00	2.00	4.59	36.00	Pass
Thread	250 Kbps	1	18	2440	2.67	30.00	2.00	4.67	36.00	Pass
Thread	250 Kbps	1	25	2475	2.82	30.00	2.00	4.82	36.00	Pass
Thread	250 Kbps	1	26	2480	2.83	30.00	2.00	4.83	36.00	Pass

TEST RESULTS DATA
Average Power Table
(Reporting Only)

Mod.	Data Rate	NTX	CH.	Freq. (MHz)	Duty Factor (dB)	Average Conducted Power (dBm)
Thread	250 Kbps	1	11	2405	0.67	2.18
Thread	250 Kbps	1	18	2440	0.67	2.30
Thread	250 Kbps	1	25	2475	0.67	2.40
Thread	250 Kbps	1	26	2480	0.67	2.44

TEST RESULTS DATA
Peak Power Density

Mod.	Data Rate	NTX	CH.	Freq. (MHz)	Peak PSD (dBm /100kHz)	Peak PSD (dBm /3kHz)	DG (dBi)	Peak PSD Limit (dBm /3kHz)	Pass/Fail
Thread	250 Kbps	1	11	2405	-1.52	-13.40	2.00	8.00	Pass
Thread	250 Kbps	1	18	2440	-1.33	-12.88	2.00	8.00	Pass
Thread	250 Kbps	1	25	2475	-1.13	-12.81	2.00	8.00	Pass
Thread	250 Kbps	1	26	2480	-1.08	-12.75	2.00	8.00	Pass

Note: PSD (dBm/ 100kHz) is a reference level used for Conducted Band Edges and Conducted Spurious Emission 20dBc limit.

Appendix B. Radiated Spurious Emission

15C 2.4GHz 2400~2483.5MHz

Thread (Band Edge @ 3m)

Thread	Note	Frequency	Level	Over	Limit	Read	Antenna	Cable	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
1		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
Thread *CH11* 2405MHz		2375.415	40.85	-33.15	74	40.16	27.19	6.73	33.23	157	282	P	H
		2380.56	31.66	-22.34	54	30.97	27.19	6.73	33.23	157	282	A	H
	*	2405	74.14	-	-	73.24	27.28	6.81	33.19	157	282	P	H
	*	2405	70.97	-	-	70.07	27.28	6.81	33.19	157	282	A	H
		2380.665	46.32	-27.68	74	41.56	31.26	6.73	33.23	157	282	P	V
		2381.4	35.81	-18.19	54	31.05	31.26	6.73	33.23	157	282	A	V
	*	2405	77.88	-	-	72.76	31.5	6.81	33.19	157	282	P	V
	*	2405	74.9	-	-	69.78	31.5	6.81	33.19	157	282	A	V
Thread *CH18* 2440MHz		2380.28	45.14	-28.86	74	40.38	31.26	6.73	33.23	138	274	P	H
		2382.1	35.8	-18.2	54	31.04	31.26	6.73	33.23	138	274	A	H
	*	2440	80.02	-	-	74.57	31.74	6.86	33.15	138	274	P	H
	*	2440	77.15	-	-	71.7	31.74	6.86	33.15	138	274	A	H
		2497.13	46.59	-27.41	74	40.68	32.1	6.91	33.1	138	274	P	H
		2495.8	36.96	-17.04	54	31.05	32.1	6.91	33.1	138	2495.8	A	H
		2315.6	47.72	-26.28	74	43.6	30.77	6.65	33.3	331	359	P	V
		2389.8	35.86	-18.14	54	30.88	31.38	6.81	33.21	331	359	A	V
	*	2440	80.51	-	-	75.06	31.74	6.86	33.15	331	359	P	V
	*	2440	77.64	-	-	72.19	31.74	6.86	33.15	331	359	A	V
		2489.29	50.43	-23.57	74	44.52	32.1	6.91	33.1	331	359	P	V
		2495.66	38.52	-15.48	54	32.61	32.1	6.91	33.1	331	359	A	V

Thread *CH25* 2475MHz	*	2475	80.64	-	-	74.87	31.98	6.91	33.12	118	274	P	H
	*	2475	77.51	-	-	71.74	31.98	6.91	33.12	118	274	A	H
		2490.04	47.13	-26.87	74	41.22	32.1	6.91	33.1	118	274	P	H
		2495.92	37.44	-16.56	54	31.53	32.1	6.91	33.1	118	274	A	H
	*	2475	79.53	-	-	73.76	31.98	6.91	33.12	100	300	P	V
	*	2475	76.7	-	-	70.93	31.98	6.91	33.12	100	300	A	V
		2489.32	52.22	-21.78	74	46.31	32.1	6.91	33.1	100	300	P	V
		2492.76	40.26	-13.74	54	34.35	32.1	6.91	33.1	100	300	A	V
Thread *CH26* 2480MHz	*	2480	81.17	-	-	75.4	31.98	6.91	33.12	116	275	P	H
	*	2480	78.25	-	-	72.48	31.98	6.91	33.12	116	275	A	H
		2483.68	51.48	-22.52	74	45.71	31.98	6.91	33.12	116	275	P	H
		2483.52	41.78	-12.22	54	36.01	31.98	6.91	33.12	116	275	A	H
	*	2480	79.73	-	-	73.96	31.98	6.91	33.12	127	300	P	V
	*	2480	76.82	-	-	71.05	31.98	6.91	33.12	127	300	A	V
		2497.64	51.97	-22.03	74	46.06	32.1	6.91	33.1	127	300	P	V
		2483.52	41.74	-12.26	54	35.97	31.98	6.91	33.12	127	300	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

15C 2.4GHz 2400~2483.5MHz

Thread (Harmonic @ 3m)

Thread	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
Thread CH 11 2405MHz		4810	44.24	-29.76	74	58.28	31.71	10.89	56.64	163	360	P	H
		4810	45.8	-28.2	74	59.84	31.71	10.89	56.64	163	360	P	V
Thread CH 18 2440MHz		4880	44.93	-29.07	74	59.14	31.78	10.92	56.91	163	360	P	H
		7320	49.56	-24.44	74	58.44	35.69	13.29	57.86	163	360	P	H
		4880	48.27	-25.73	74	62.48	31.78	10.92	56.91	163	360	P	V
		7320	49.48	-24.52	74	58.36	35.69	13.29	57.86	163	360	P	V
Thread CH 25 2475MHz		4950	46.8	-27.2	74	60.13	31.85	10.99	56.17	163	360	P	H
		7425	47.43	-26.57	74	56.35	35.88	13.06	57.86	163	360	P	H
		4950	46.11	-27.89	74	59.44	31.85	10.99	56.17	163	360	P	V
		7425	48.04	-25.96	74	56.96	35.88	13.06	57.86	163	360	P	V
Thread CH 26 2480MHz		4960	48.62	-25.38	74	61.98	31.87	11.02	56.25	163	360	P	H
		7440	49.2	-24.8	74	58.01	35.91	13.06	57.78	163	360	P	H
		4960	48.79	-25.21	74	62.15	31.87	11.02	56.25	163	360	P	V
		7440	48.91	-25.09	74	57.72	35.91	13.06	57.78	163	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

15C Emission below 1GHz

2.4GHz Thread *CH26*

(LF)

Thread	Note	Frequency	Level	Over	Limit	Read	Antenna	Cable	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
1		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
2.4GHz Thread *CH26* LF		31.94	24.36	-15.64	40	30.46	25.28	0.27	31.65	-	-	P	H
		199.75	23.24	-20.26	43.5	36.72	16.1	1.62	31.2	-	-	P	H
		399.57	31.73	-14.27	46	39.24	21.4	2.39	31.3	-	-	P	H
		500.45	32.66	-13.34	46	38.05	23.3	2.71	31.4	100	155	P	H
		816.67	31.42	-14.58	46	32.05	27.23	3.64	31.5	-	-	P	H
		994.18	32.28	-21.72	54	30.65	28.95	4.18	31.5	-	-	P	H
		38.73	25.89	-14.11	40	34.32	22.8	0.37	31.6	100	255	P	V
		199.75	19.74	-23.76	43.5	33.22	16.1	1.62	31.2	-	-	P	V
		299.66	23.54	-22.46	46	34.6	18.2	2.04	31.3	-	-	P	V
		500.45	30.19	-15.81	46	35.58	23.3	2.71	31.4	-	-	P	V
		765.26	29.88	-16.12	46	31.08	26.79	3.51	31.5	-	-	P	V
		944.71	31.64	-14.36	46	30.65	28.56	3.93	31.5	-	-	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 per 15.209(c).
!	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.	
1+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 C. Duty Cycle Plots

Band	Duty Cycle(%)	T(ms)	1/T(kHz)	VBW Setting
Thread 2.4GHz	85.72	2.661	0.376	1KHz

Thread 2.4GHz