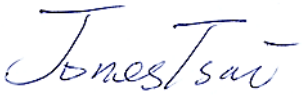
FCC RF Test Report

APPLICANT	**:**	**Nest Labs Inc.**
EQUIPMENT	**:**	**Nest Cam IQ**
MODEL NAME	**:**	**A0053**
FCC ID	**:**	**ZQANC31**
STANDARD	**:**	**FCC Part 15 Subpart C §15.247**
CLASSIFICATION	**:**	**(DTS) Digital Transmission System**

The testing was completed on Mar. 16, 2017. We, SPORTON INTERNATIONAL 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 INC., the test report shall not be reproduced except in full.

Reviewed by: Joseph Lin / Supervisor



Approved by: Jones Tsai / Manager

SPORTON INTERNATIONAL INC.
No. 52, Hwa Ya 1st Rd., Hwa Ya Technology Park, Kwei-Shan District, Tao Yuan City, Taiwan, R.O.C.

TABLE OF CONTENTS

REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR630207-02A	Rev. 01	Initial issue of report	Apr. 19, 2017
FR630207-02A	Rev. 02	Revising the test procedures description of peak output power in section 3.2.3, and antenna information in section 1.2, and add loop antenna information in section 4, and add description of radiated spurious emissions below 30MHz in section 3.1.5.	May 05, 2017
FR630207-02A	Rev. 03	Add Zigbee information in section 1.2 and revising connection diagram of test system in section 2.3.	May 09, 2017

SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result
3.1	15.247(a)(2)	6dB Bandwidth	≥ 0.5MHz	Pass
3.1	-	99% Bandwidth	-	Pass
3.2	15.247(b)(3)	Peak Output Power	≤ 30dBm	Pass
3.3	15.247(e)	Power Spectral Density	≤ 8dBm/3kHz	Pass
3.4	15.247(d)	Conducted Band Edges and Spurious Emission	≤ 20dBc	Pass
3.5	15.247(d)	Radiated Band Edges and Spurious Emission	15.209(a) & 15.247(d)	Pass
3.6	15.207	AC Conducted Emission	15.207(a)	Pass
3.7	15.203 & 15.247(b)	Antenna Requirement	N/A	Pass

1 General Description

1.1 Applicant

Nest Labs Inc.
3400 Hillview Ave.Palo Alto, CA 94304 USA

1.2 Product Feature of Equipment Under Test

Bluetooth- LE, Wi-Fi 2.4GHz 802.11b/g/n/ac, Wi-Fi 5GHz 802.11a/n/ac, Zigbee

Product Specification subjective to this standard	
Antenna Type	ANT FPC 1 2.4G/5G : Fixed Internal Antenna ANT FPC 2 2.4G/5G : Fixed Internal Antenna ANT FPC 15.4 2.4G : Fixed Internal Antenna

1.3 Modification of EUT

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

1.4 Testing Location

Sporton Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code : 1190) and the FCC designation No. TW0007 under the FCC 2.948(e) by Mutual Recognition Agreement (MRA) in FCC Test.

Test Site	SPORTON INTERNATIONAL INC.	
Test Site Location	No. 52, Hwa Ya 1st Rd., Hwa Ya Technology Park, Kwei-Shan District, Tao Yuan City, Taiwan, R.O.C. TEL: +886-3-327-3456 FAX: +886-3-328-4978	
Test Site No.	**Sporton Site No.**	
	TH05-HY	CO05-HY

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

Test Site	SPORTON INTERNATIONAL INC.	
Test Site Location	No.58, Aly. 75, Ln. 564, Wenhua 3rd Rd. Guishan Dist, Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-0868 FAX: +886-3-327-0855	
Test Site No.	**Sporton Site No.**	
	03CH10-HY	03CH13-HY

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

1.5 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

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

2.1 Descriptions of Test Mode

The RF output power was recorded in the following table:

Channel	Frequency	Zigbee RF Output Power
		Data Rate / Modulation
		BPSK/QPSK
		250kbps
Ch11	2405MHz	**21.18 dBm**
Ch18	2440MHz	20.60 dBm
Ch25	2475MHz	14.01 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). Pre-scanned tests, X, Y, Z in three orthogonal panels to determine the final configuration (Y plane as worst plane) from all possible combinations.

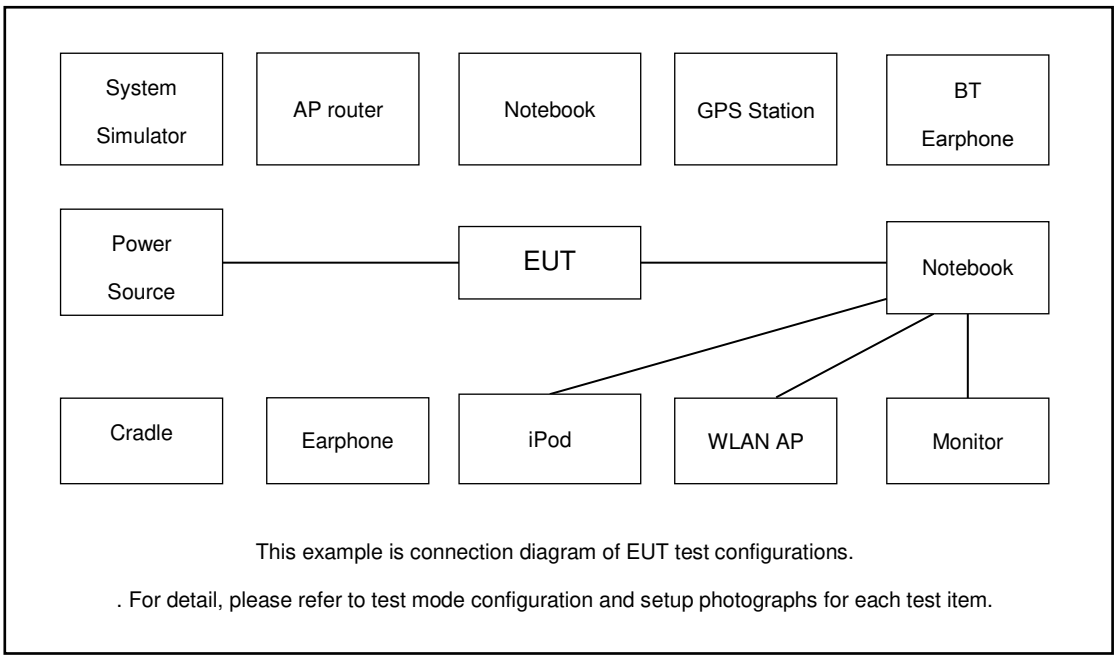
b. AC power line Conducted Emission was tested under maximum output power.

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 / Zigbee
Conducted TCs	Mode 1: Zigbee Tx CH11_2405 MHz Mode 2: Zigbee Tx CH18_2440 MHz Mode 3: Zigbee Tx CH25_2475 MHz
Radiated TCs	Mode 1: Zigbee Tx CH11_2405 MHz Mode 2: Zigbee Tx CH18_2440 MHz Mode 3: Zigbee Tx CH25_2475 MHz
AC Conducted Emission	Mode 1 :WLAN Tx + Bluetooth Tx + Zigbee Idle + Y Cable + USB Cable (Charging from Adapter 1) Mode 2 : WLAN Tx + Bluetooth Idle + Zigbee Tx + Y Cable + USB Cable (Charging from Adapter 1)
Remark: The worst case of conducted emission is mode 1; only the test data of it was reported.	

2.3 Connection Diagram of Test System



This example is connection diagram of EUT test configurations.

. For detail, please refer to test mode configuration and setup photographs for each test item.

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	ASUS	RT-AC66U	MSQ-RTAC66U	N/A	Unshielded, 1.8 m
2.	Notebook	DELL	Latitude E3340	FCC DoC/ Contains FCC ID: PD97260NGU	N/A	AC I/P: Unshielded, 1.2 m DC O/P: Shielded, 1.8 m
3.	iPod	Apple	A1285	FCC DoC	Shielded, 1.0 m	N/A

2.5 EUT Operation Test Setup

For Zigbee function, programmed RF utility, “CMD” installed in the notebook make the EUT provide functions like channel selection and power level for continuous transmitting and receiving signals.

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 4.2 dB and 10dB attenuator.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB).
= 4.2 + 10 = 14.2 (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.

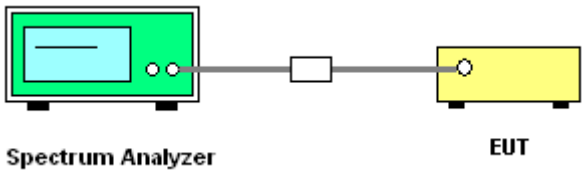
3.1.2 Measuring Instruments

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.

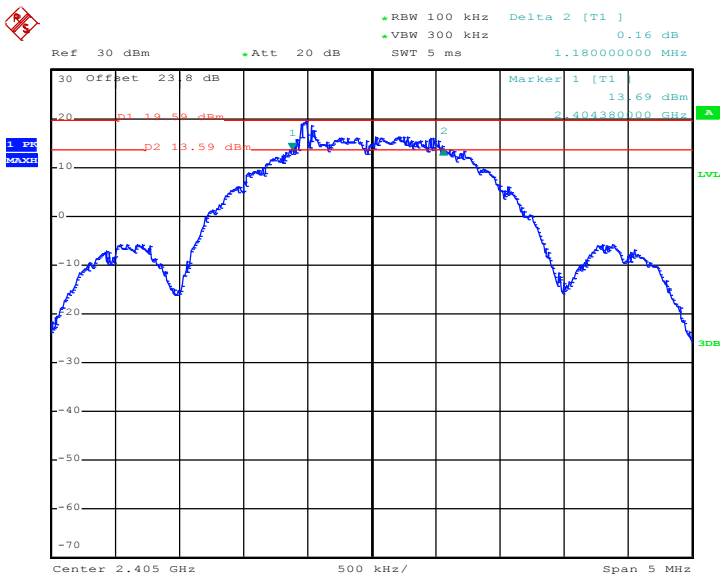
3.1.4 Test Setup



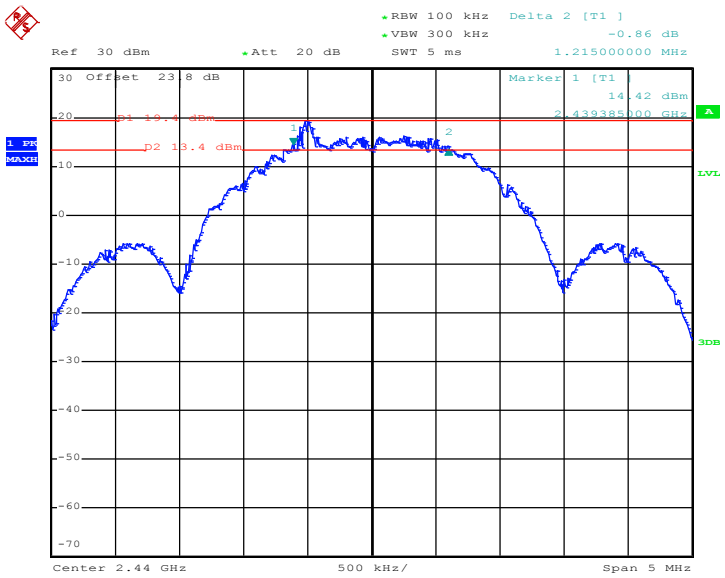
3.1.5 Test Result of 6dB Bandwidth

Test data refer to Appendix A.

6 dB Bandwidth Plot on Channel 11

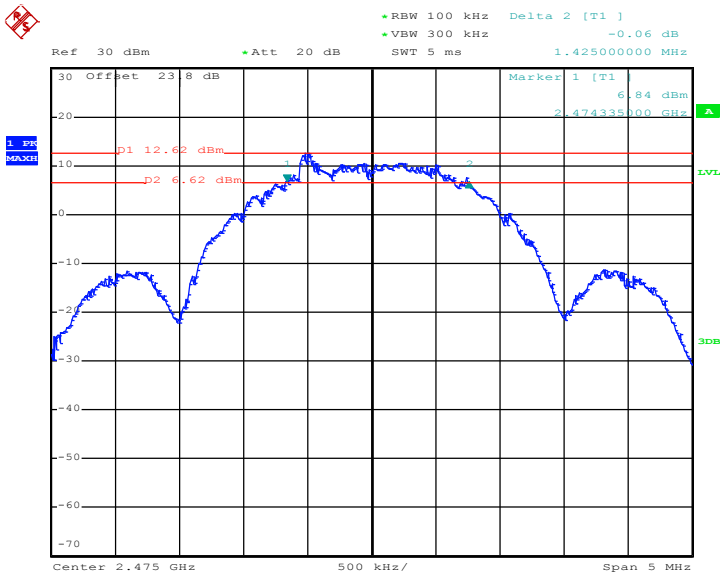


6 dB Bandwidth Plot on Channel 18



Date: 12.JAN.2017 00:08:09

6 dB Bandwidth Plot on Channel 25

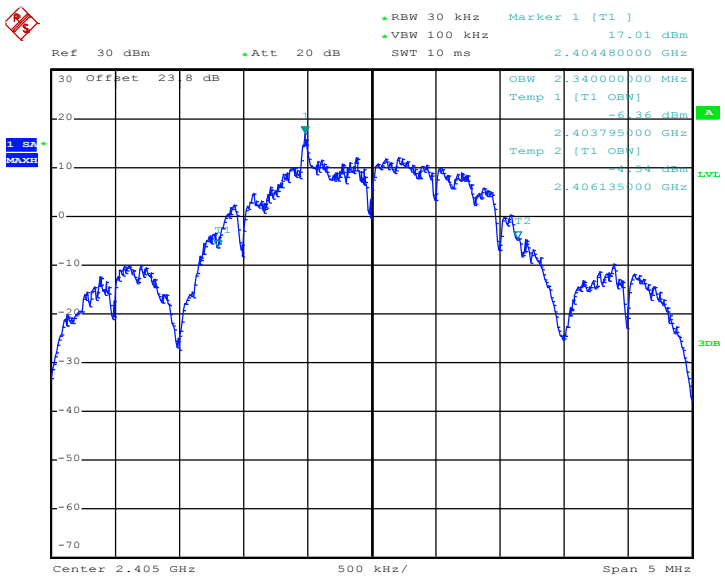


Date: 12.JAN.2017 00:38:32

3.1.6 Test Result of 99% Occupied Bandwidth

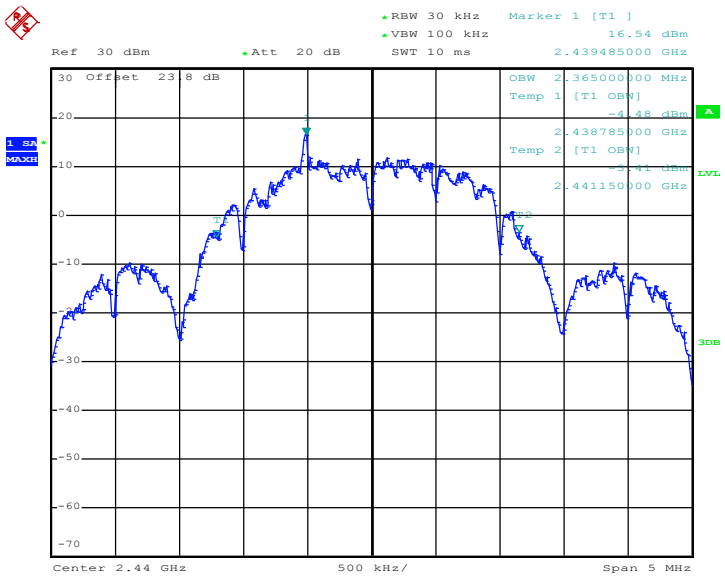
Test data refer to Appendix A.

99% Bandwidth Plot on Channel 11



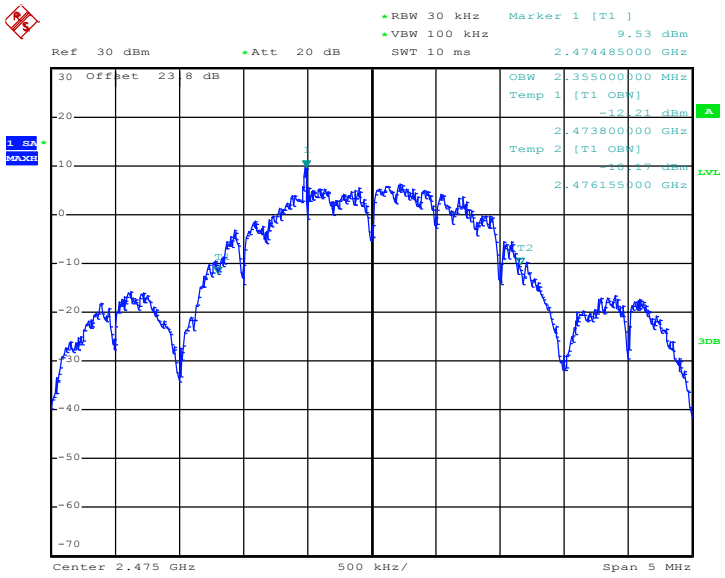
Date: 12.JAN.2017 00:27:44

99% Occupied Bandwidth Plot on Channel 18



Date: 12.JAN.2017 00:19:23

99% Occupied Bandwidth Plot on Channel 25



Date: 12.JAN.2017 00:54:54

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.

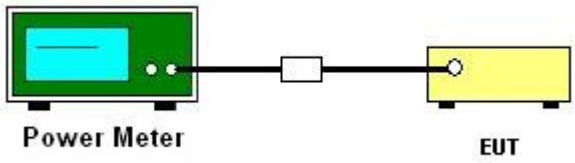
3.2.2 Measuring Instruments

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 9.1.3 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.

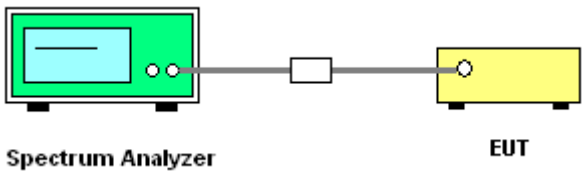
3.3.2 Measuring Instruments

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

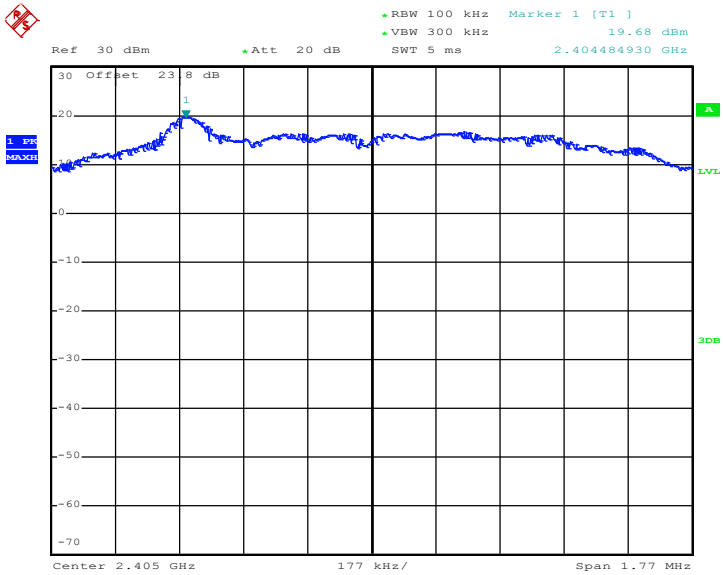


3.3.5 Test Result of Power Spectral Density

Test data refers to Appendix A.

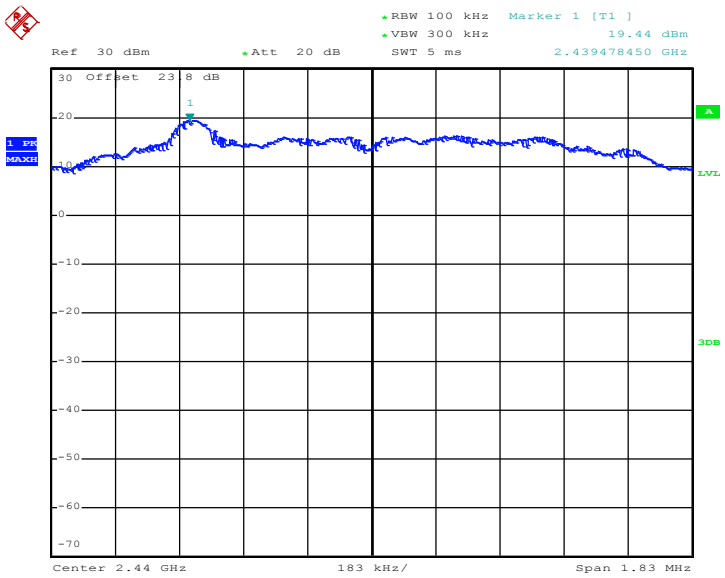
3.3.6 Test Result of Power Spectral Density Plots (100kHz)

PSD 100kHz Plot on Channel 11



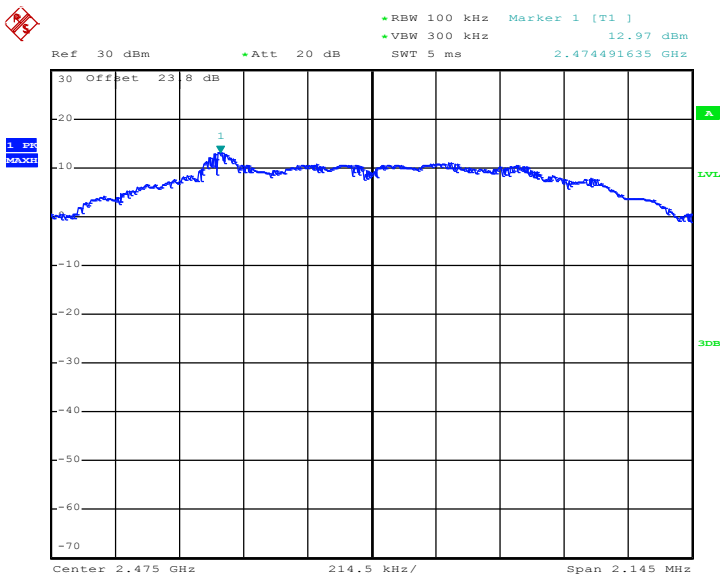
Date: 11.JAN.2017 23:49:24

PSD 100kHz Plot on Channel 18



Date: 12.JAN.2017 00:12:14

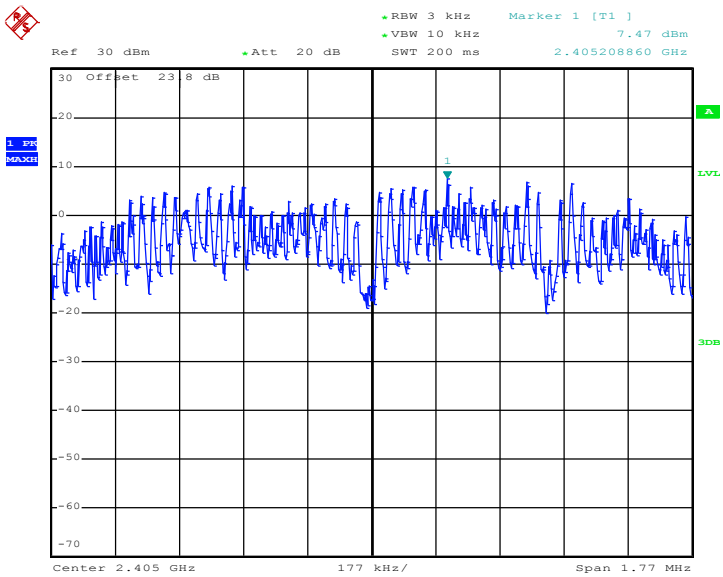
PSD 100kHz Plot on Channel 25



Date: 12.JAN.2017 00:44:08

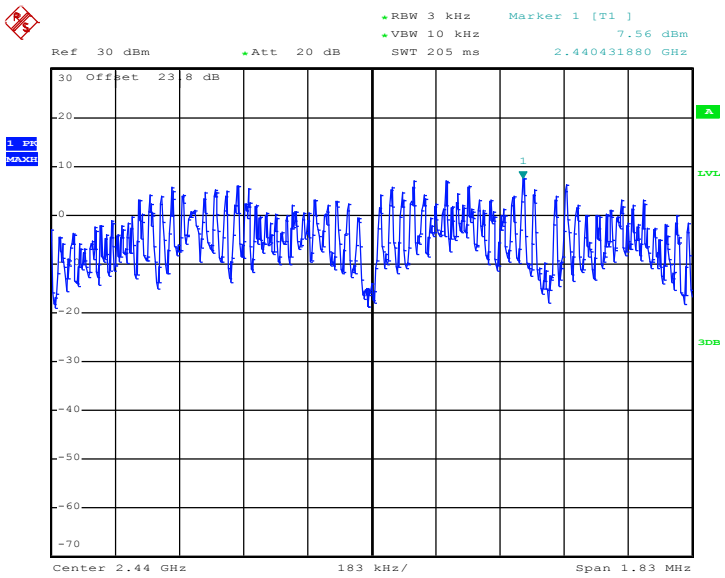
3.3.7 Test Result of Power Spectral Density Plots (3kHz)

PSD 3kHz Plot on Channel 11



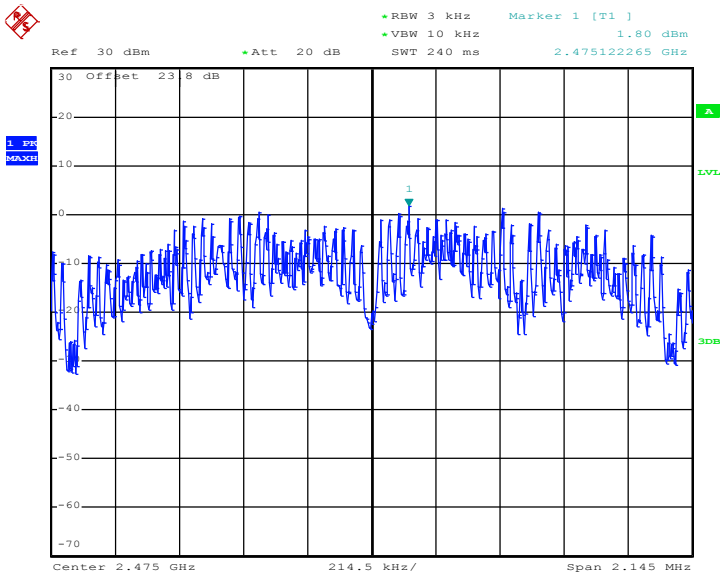
Date: 11.JAN.2017 23:50:36

PSD 3kHz Plot on Channel 18



Date: 12.JAN.2017 00:30:16

PSD 3kHz Plot on Channel 25



Date: 12.JAN.2017 00:42:40

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.

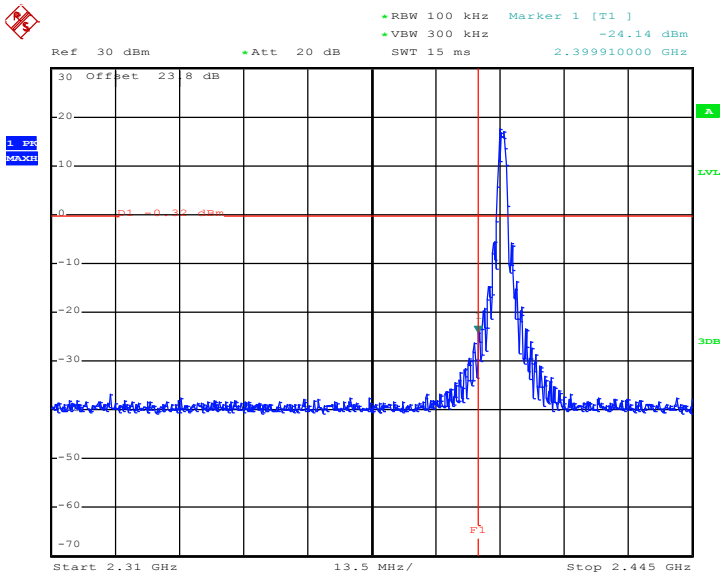
3.4.3 Test Procedure

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

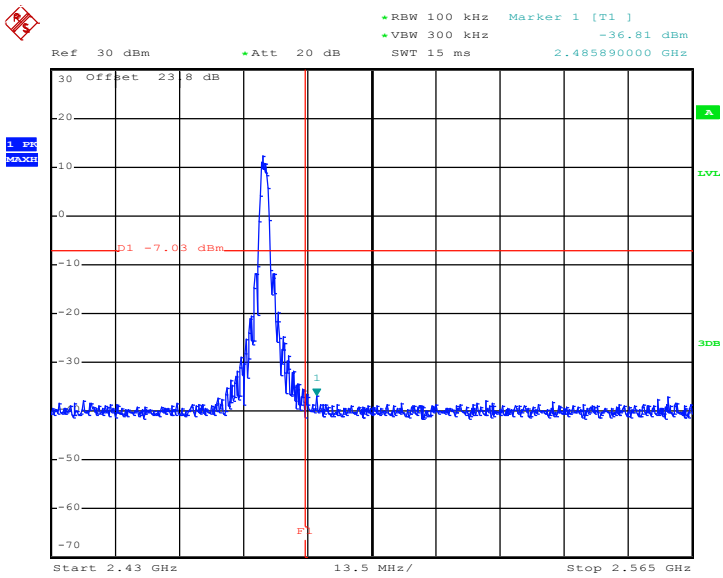
3.4.5 Test Result of Conducted Band Edges Plots

Low Band Edge Plot on Channel 11



Date: 12.JAN.2017 00:22:50

High Band Edge Plot on Channel 25

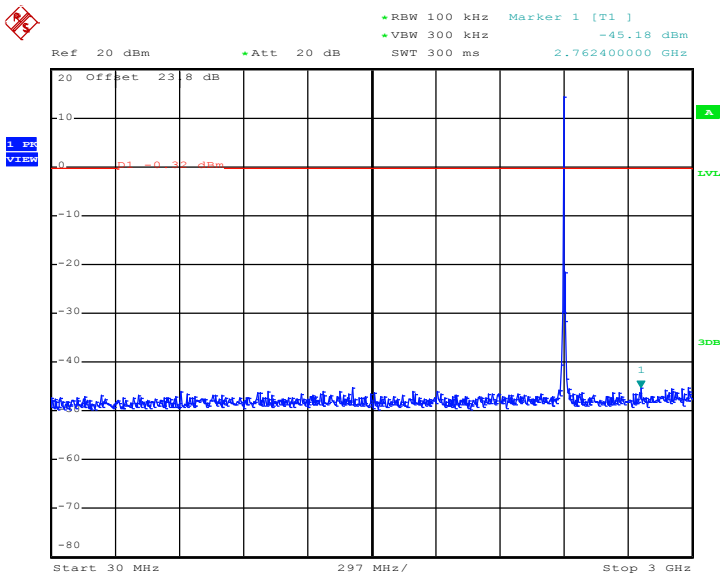


Date: 12.JAN.2017 00:46:56

3.4.6 Test Result of Conducted Spurious Emission Plots

Conducted Spurious Emission Plot on Zigbee

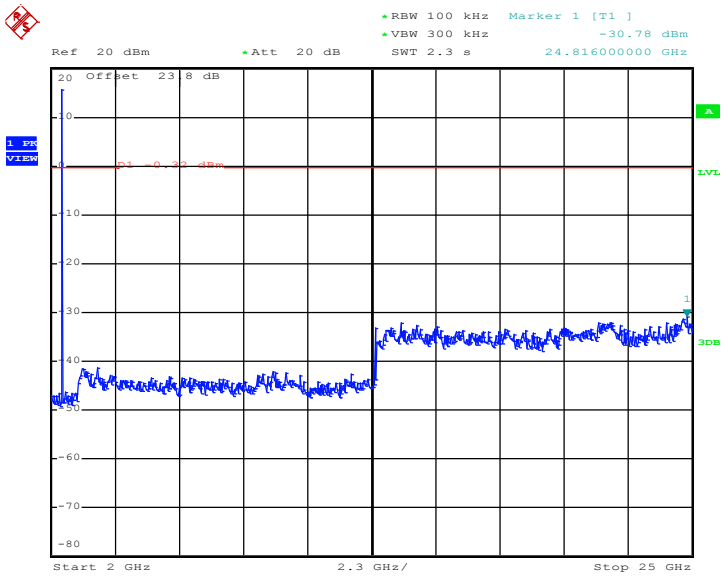
Channel 11



Date: 12.JAN.2017 00:25:12

Conducted Spurious Emission Plot on Zigbee

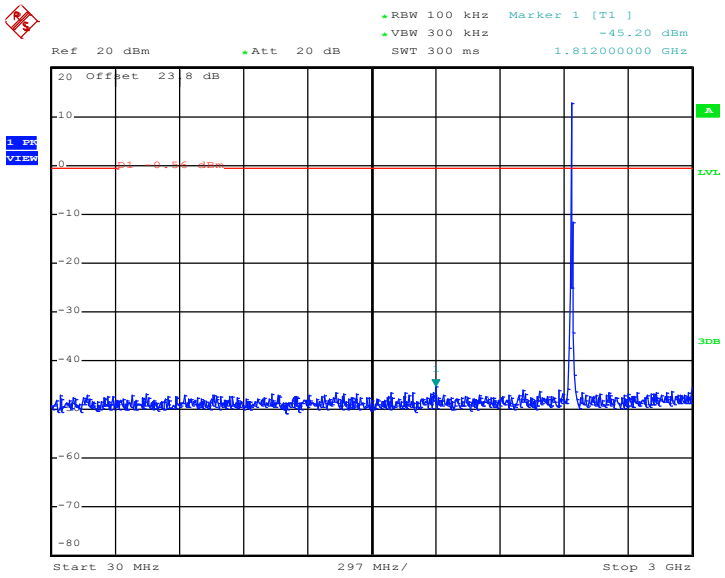
Channel 11



Date: 12.JAN.2017 00:24:25

Conducted Spurious Emission Plot on Zigbee

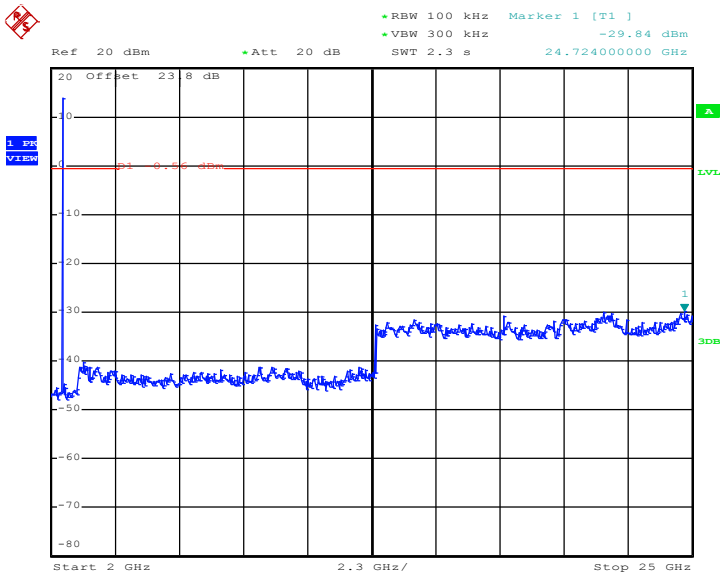
Channel 18



Date: 12.JAN.2017 00:15:51

Conducted Spurious Emission Plot on Zigbee

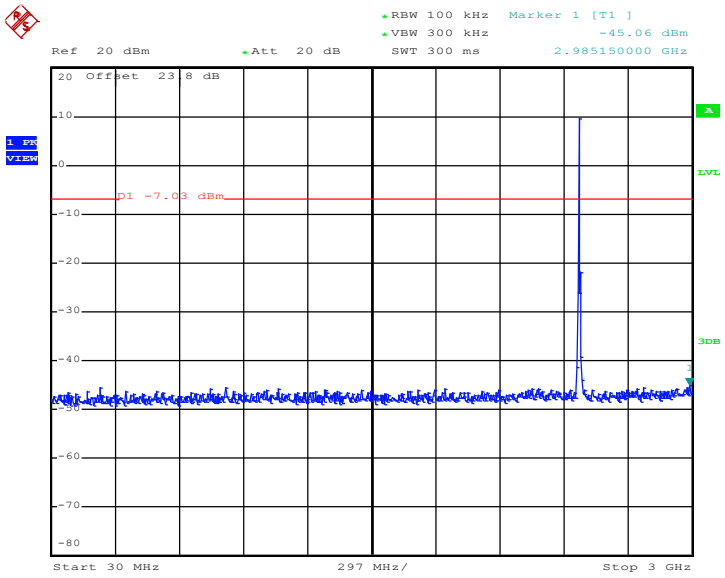
Channel 18



Date: 12.JAN.2017 00:17:31

Conducted Spurious Emission Plot on Zigbee

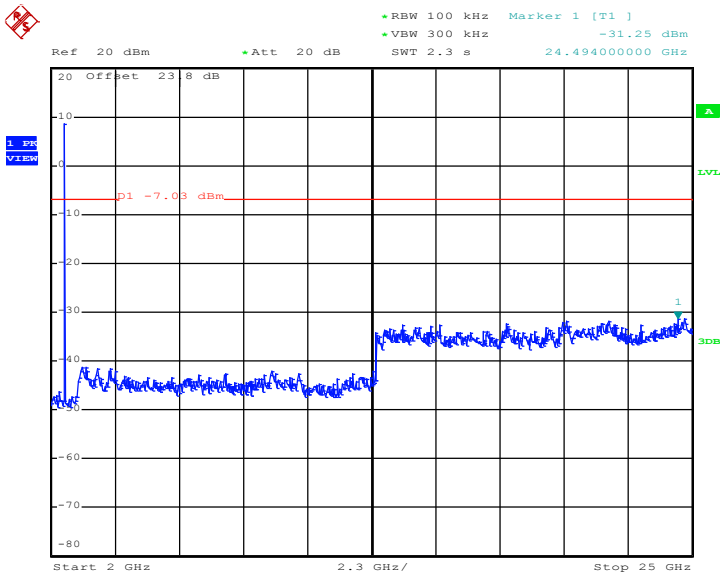
Channel 25



Date: 12.JAN.2017 00:50:10

Conducted Spurious Emission Plot on Zigbee

Channel 25



Date: 12.JAN.2017 00:48:57

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

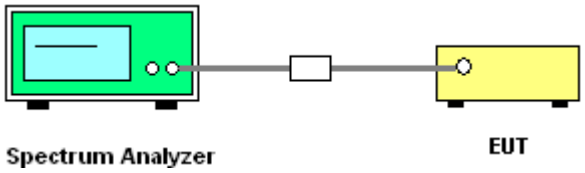
The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.5.3 Test Procedures

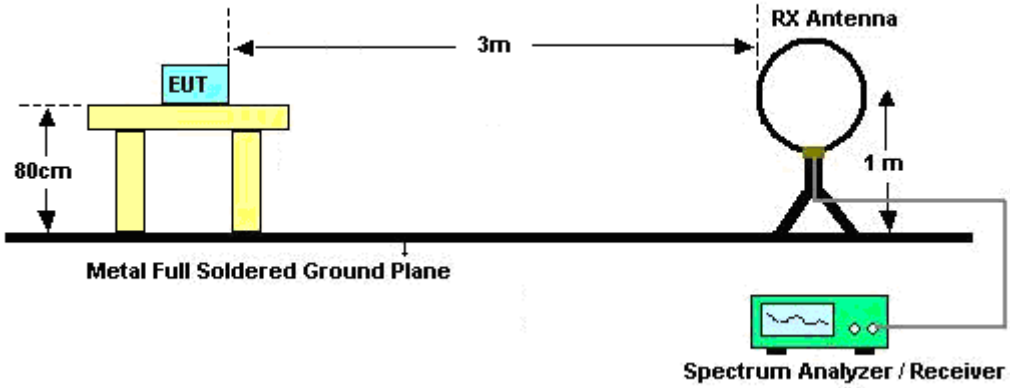
1. The testing follows FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v04
2. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test 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 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.
8. 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.
9. 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

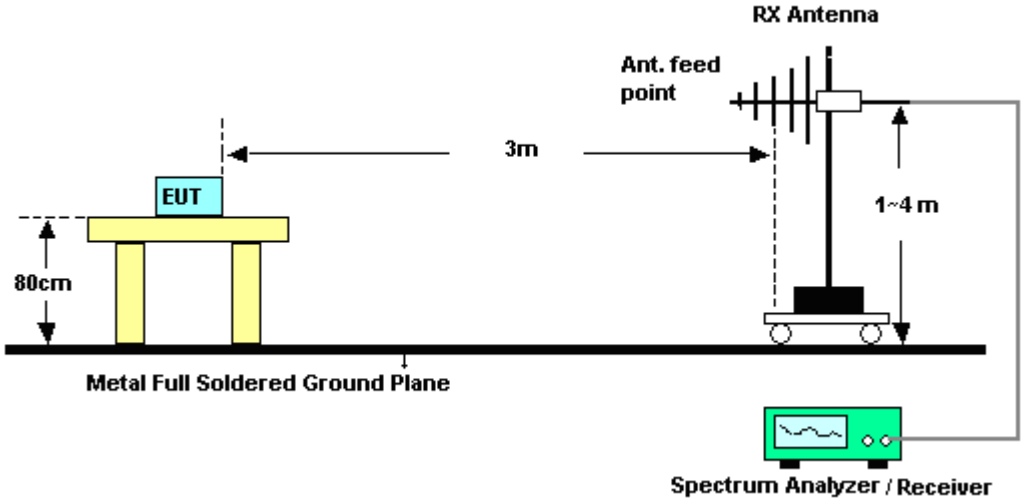
For Conducted Measurement:



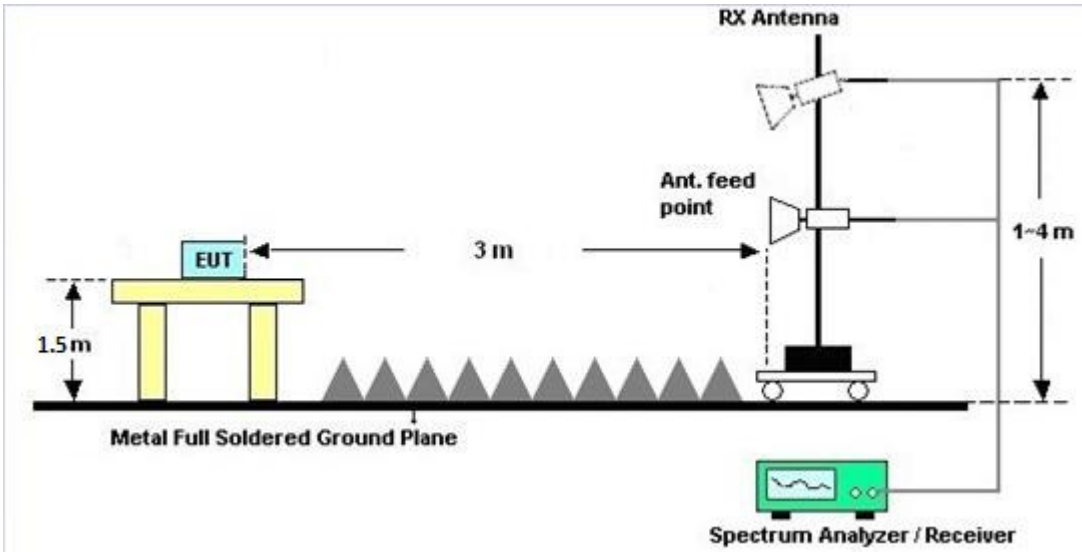
For radiated emissions below 30MHz



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.

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 Conducted Spurious at Band Edges in the Restricted Band

Please refer to Appendix B and C.

3.5.7 Test Result of Conducted Spurious Emission in the Restricted Band

Please refer to Appendix B and C.

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

Please refer to Appendix D and E.

3.5.9 Duty Cycle

Please refer to Appendix F.

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.

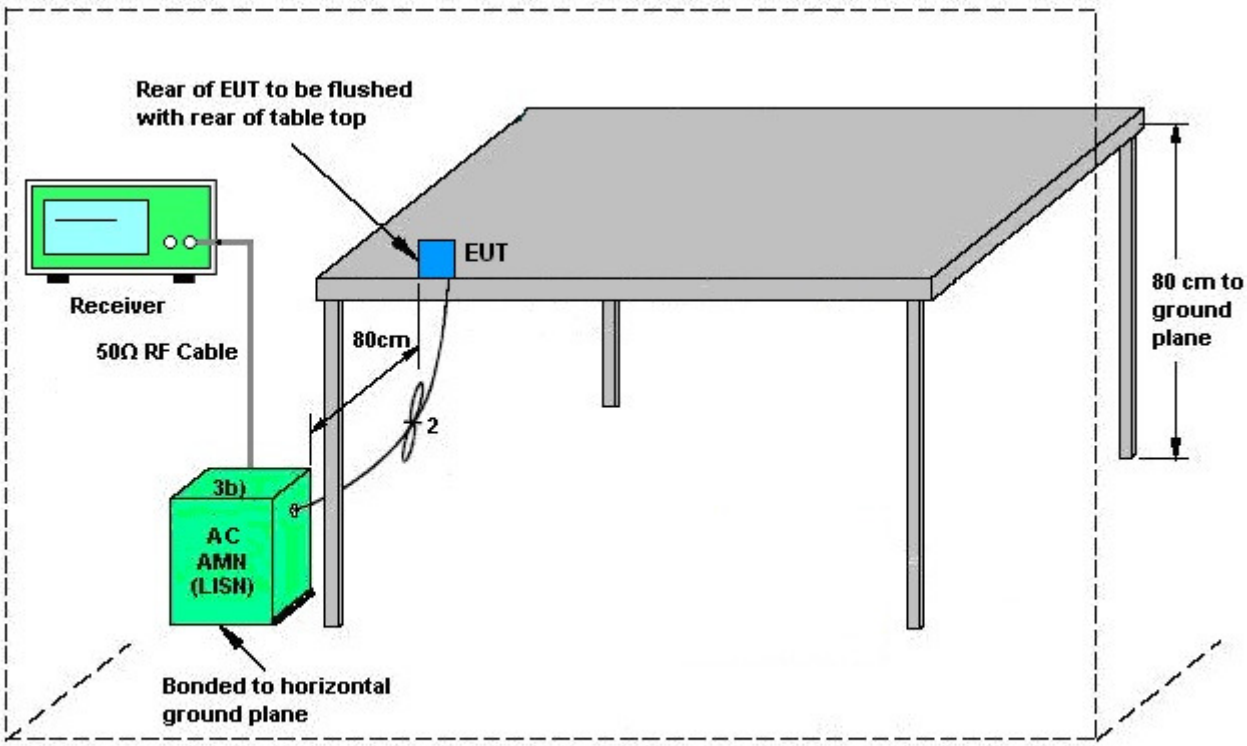
3.6.2 Measuring Instruments

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.

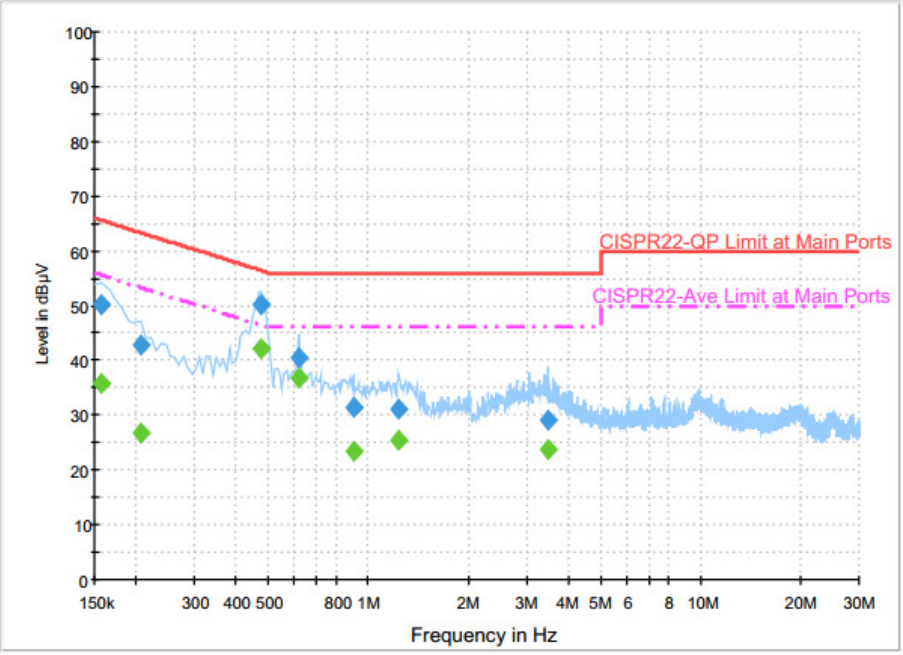
3.6.4 Test Setup



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 :	21~22℃
Test Engineer :	Kai-Chun Chu	Relative Humidity :	48~49%
Test Voltage :	120Vac / 60Hz	Phase :	Line
Function Type :	WLAN Tx + Bluetooth Tx + Zigbee Idle + Y Cable + USB Cable (Charging from Adapter 1)		



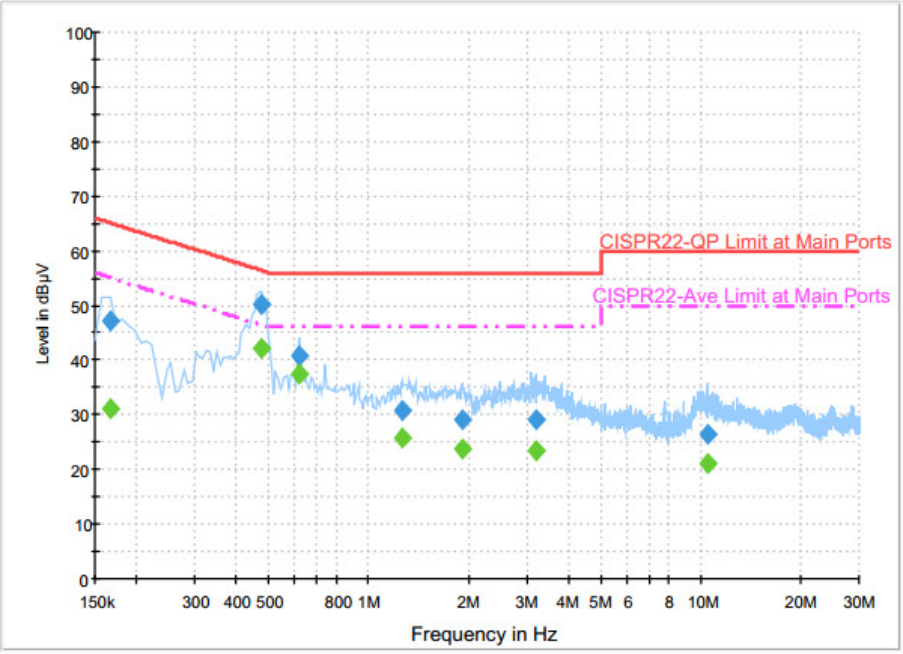
Final Result : QuasiPeak

Frequency (MHz)	QuasiPeak (dBµV)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.158000	50.3	Off	L1	19.6	15.3	65.6
0.206000	42.6	Off	L1	19.6	20.8	63.4
0.478000	50.3	Off	L1	19.6	6.1	56.4
0.622000	40.6	Off	L1	19.6	15.4	56.0
0.902000	31.6	Off	L1	19.6	24.4	56.0
1.238000	31.0	Off	L1	19.6	25.0	56.0
3.470000	29.0	Off	L1	19.6	27.0	56.0

Final Result : Average

Frequency (MHz)	Average (dBµV)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.158000	35.7	Off	L1	19.6	19.9	55.6
0.206000	26.7	Off	L1	19.6	26.7	53.4
0.478000	42.0	Off	L1	19.6	4.4	46.4
0.622000	36.8	Off	L1	19.6	9.2	46.0
0.902000	23.4	Off	L1	19.6	22.6	46.0
1.238000	25.3	Off	L1	19.6	20.7	46.0
3.470000	23.6	Off	L1	19.6	22.4	46.0

Test Mode :	Mode 1	Temperature :	21~22℃
Test Engineer :	Kai-Chun Chu	Relative Humidity :	48~49%
Test Voltage :	120Vac / 60Hz	Phase :	Neutral
Function Type :	WLAN Tx + Bluetooth Tx + Zigbee Idle + Y Cable + USB Cable (Charging from Adapter 1)		



Final Result : QuasiPeak

Frequency (MHz)	QuasiPeak (dBµV)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.166000	47.0	Off	N	19.6	18.2	65.2
0.478000	50.3	Off	N	19.6	6.1	56.4
0.622000	41.0	Off	N	19.6	15.0	56.0
1.262000	30.9	Off	N	19.6	25.1	56.0
1.910000	29.2	Off	N	19.6	26.8	56.0
3.190000	29.0	Off	N	19.6	27.0	56.0
10.526000	26.3	Off	N	20.1	33.7	60.0

Final Result : Average

Frequency (MHz)	Average (dBµV)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.166000	31.0	Off	N	19.6	24.2	55.2
0.478000	42.1	Off	N	19.6	4.3	46.4
0.622000	37.6	Off	N	19.6	8.4	46.0
1.262000	25.9	Off	N	19.6	20.1	46.0
1.910000	23.8	Off	N	19.6	22.2	46.0
3.190000	23.5	Off	N	19.6	22.5	46.0
10.526000	21.2	Off	N	20.1	28.8	50.0

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	Rohde & Schwarz	FSP40	100055	9kHz-40GHz	Jul. 17, 2016	Dec. 30, 2016 ~ Mar. 08, 2017	Jul. 16, 2017	Conducted (TH05-HY)
Power Sensor	DARE	RPR3006W	13I00030SNO32	9kHz~6GHz	Sep. 21, 2016	Dec. 30, 2016 ~ Mar. 08, 2017	Sep. 20, 2017	Conducted (TH05-HY)
AC Power Source	ChainTek	APC-1000W	N/A	N/A	N/A	Jan. 24, 2017	N/A	Conduction (CO05-HY)
EMI Test Receiver	Rohde & Schwarz	ESCI 7	100724	9kHz~7GHz	Aug. 30, 2016	Jan. 24, 2017	Aug. 29, 2017	Conduction (CO05-HY)
LISN	Rohde & Schwarz	ENV216	100080	9kHz~30MHz	Nov. 29, 2016	Jan. 24, 2017	Nov. 28, 2017	Conduction (CO05-HY)
LISN	Rohde & Schwarz	ENV216	100081	9kHz~30MHz	Dec. 06, 2016	Jan. 24, 2017	Dec. 05, 2017	Conduction (CO05-HY)
Amplifier	SONOMA	310N	187311	9kHz~1GHz	Oct. 26, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Oct. 25, 2017	Radiation (03CH10-HY)
Bilog Antenna	TESEQ	CBL 6111D&00800N1D01N-06	35413&02	30MHz~1GHz	Jan. 07, 2017	Feb. 13, 2017 ~ Mar. 03, 2017	Jan. 06, 2018	Radiation (03CH10-HY)
Horn Antenna	SCHWARZBECK	BBHA 9120 D	9120D-1325	1GHz ~ 18GHz	Sep. 30, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Sep. 29, 2017	Radiation (03CH10-HY)
Preamplifier	Keysight	83017A	MY53270078	1GHz~26.5GHz	Oct. 26, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Oct. 25, 2017	Radiation (03CH10-HY)
Spectrum Analyzer	Keysight	N9010A	MY54200485	10Hz ~ 44GHz	Oct. 17, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Oct. 16, 2017	Radiation (03CH10-HY)
Antenna Mast	EMEC	AM-BS-4500-B	N/A	1~4m	N/A	Feb. 13, 2017 ~ Mar. 03, 2017	N/A	Radiation (03CH10-HY)
Turn Table	EMEC	TT 2200	N/A	0~360 Degree	N/A	Feb. 13, 2017 ~ Mar. 03, 2017	N/A	Radiation (03CH10-HY)
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100488	9 kHz~30 MHz	Oct. 20, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Oct. 19, 2018	Radiation (03CH10-HY)
Preamplifier	MITEQ	AMF-7D-00101800-30-10P	1815698	1GHz~18GHz	Dec. 01, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Nov. 30, 2017	Radiation (03CH10-HY)
SHF-EHF Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170576	18GHz ~ 40GHz	Apr. 15, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Apr. 14, 2017	Radiation (03CH10-HY)
EMI Test Receiver	Keysight	N9038A (MXE)	MY55420170	N/A	Mar. 10, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Mar. 09, 2017	Radiation (03CH10-HY)
Preamplifier	MITEQ	JS44-18004000-33-8P	1840917	18GHz ~ 40GHz	Jun. 14, 2016	Feb. 13, 2017 ~ Mar. 03, 2017	Jun. 13, 2017	Radiation (03CH10-HY)
Preamplifier	MITEQ	AMF-7D-00101800	2025787	1GHZ~18GHZ	Feb. 13, 2017	Feb. 13, 2017 ~ Mar. 03, 2017	Feb. 12, 2018	Radiation (03CH10-HY)
Spectrum Analyzer	Keysight	N9010A	MY54200485	10Hz ~ 44GHz	Oct. 17, 2016	Mar. 16, 2017	Oct. 16, 2017	CSE (03CH13-HY)
EMI Test Receiver	Agilent	N9038A (MXE)	MY53290053	20Hz to 26.5GHz	Jan. 12, 2017	Mar. 16, 2017	Jan. 11, 2018	CSE (03CH13-HY)

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))	**2.7**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.6**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.9**

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

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

Appendix A. Conducted Test Results

Bluetooth Low Energy

Test Engineer:	Derek Hsu	Temperature:	21~25	°C
Test Date:	2016/12/30~2017/03/08	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
Zigbee	250kbps	1	11	2405	2.34	1.18	0.50	Pass
Zigbee	250kbps	1	18	2440	2.37	1.22	0.50	Pass
Zigbee	250kbps	1	25	2475	2.36	1.43	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
Zigbee	250kbps	1	11	2405	21.18	30.00	-0.04	21.14	36.00	Pass
Zigbee	250kbps	1	18	2440	20.60	30.00	-0.04	20.56	36.00	Pass
Zigbee	250kbps	1	25	2475	14.01	30.00	-0.04	13.97	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)
Zigbee	250kbps	1	11	2405	9.68	20.54
Zigbee	250kbps	1	18	2440	9.68	20.23
Zigbee	250kbps	1	25	2475	9.68	13.40

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
Zigbee	250kbps	1	11	2405	19.68	7.47	-0.04	8.00	Pass
Zigbee	250kbps	1	18	2440	19.44	7.56	-0.04	8.00	Pass
Zigbee	250kbps	1	25	2475	12.97	1.80	-0.04	8.00	Pass

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

Appendix B. Conducted Spurious Emission

Test Engineer :	Stan Hsieh	Temperature :	22~24°C
		Relative Humidity :	44~46%

2.4GHz 2400~2483.5MHz

Zigbee (Band Edge @ Conducted)

Zigbee Ant.	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
3		(MHz)	(dBm)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
Zigbee CH 11 2405MHz		2389.11	-32.51	-11.31	-21.2	-37.49	2	2.98	-	-	-	P	-
		2389.92	-44.16	-2.96	-41.2	-49.14	2	2.98	-	-	-	A	-
	*	2406	20.98	42.18	-21.2	15.98	2	3	-	-	-	P	-
	*	2406	19.14	60.34	-41.2	14.14	2	3	-	-	-	A	-
		2484.65	-32.41	-11.21	-21.2	-37.46	2	3.05	-	-	-	P	-
		2485.65	-54.94	-13.74	-41.2	-59.99	2	3.05	-	-	-	A	-
Zigbee CH 18 2440MHz		2386.815	-32	-10.8	-21.2	-36.98	2	2.98	-	-	-	P	-
		2389.11	-54.15	-12.95	-41.2	-59.13	2	2.98	-	-	-	A	-
	*	2440	20.76	41.96	-21.2	15.74	2	3.02	-	-	-	P	-
	*	2440	18.96	60.16	-41.2	13.94	2	3.02	-	-	-	A	-
		2488.73	-30.09	-8.89	-21.2	-35.14	2	3.05	-	-	-	P	-
		2486.28	-52.01	-10.81	-41.2	-57.06	2	3.05	-	-	-	A	-
Zigbee CH 25 2475MHz		2388.435	-48.16	-26.96	-21.2	-53.14	2	2.98	-	-	-	P	-
		2389.11	-63.58	-22.38	-41.2	-68.56	2	2.98	-	-	-	A	-
	*	2476	13.53	34.73	-21.2	8.49	2	3.04	-	-	-	P	-
	*	2476	11.47	52.67	-41.2	6.43	2	3.04	-	-	-	A	-
		2484.18	-32.46	-11.26	-21.2	-37.51	2	3.05	-	-	-	P	-
		2483.48	-41.71	-0.51	-41.2	-46.76	2	3.05	-	-	-	A	-
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

Zigbee (Harmonic @ Conducted)

Zigbee Ant. 3	Note	Frequency (MHz)	Level (dBm)	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)
Zigbee CH 11 2405MHz		4810	-69.77	-48.57	-21.2	-76.17	2	4.4	-	-	-	P	-
Zigbee CH 18 2440MHz		4880	-67.13	-45.93	-21.2	-73.57	2	4.44	-	-	-	P	-
		7320	-73.06	-51.86	-21.2	-80.93	2	5.87	-	-	-	P	-
Zigbee CH 25 2475MHz		4950	-71.28	-50.08	-21.2	-77.77	2	4.49	-	-	-	P	-
		7428	-74.23	-53.03	-21.2	-82.13	2	5.9	-	-	-	P	-
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Emission below 1GHz

2.4GHz Zigbee (LF)

Zigbee Ant. 3	Note	Frequency (MHz)	Level (dBm)	Over Limit (dB)	Limit Line (dBµV/m)	Read Level (dBµV)	Antenna Factor (dB/m)	Cable Loss (dB)	Aux Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
2.4GHz Zigbee LF		55.38	-70.73	-15.53	-55.2	-77.72	2	0.29	4.7	-	-	P	-
		123.15	-68.44	-16.74	-51.7	-75.69	2	0.55	4.7	-	-	P	-
		255.45	-79.24	-30.04	-49.2	-86.8	2	0.86	4.7	-	-	P	-
		404.3	-77.24	-28.04	-49.2	-85.01	2	1.07	4.7	-	-	P	-
		654.2	-77.44	-28.24	-49.2	-85.56	2	1.42	4.7	-	-	P	-
		899.2	-73.81	-24.61	-49.2	-82.23	2	1.72	4.7	-	-	P	-
Remark	1. No other spurious found. 2. All results are PASS against limit line.												

Appendix C. Conducted Spurious Emission Plots

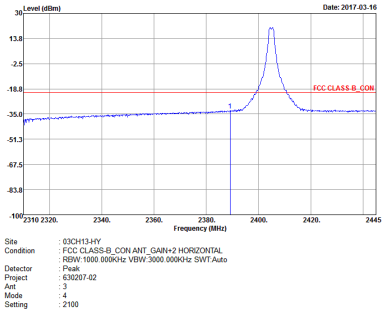
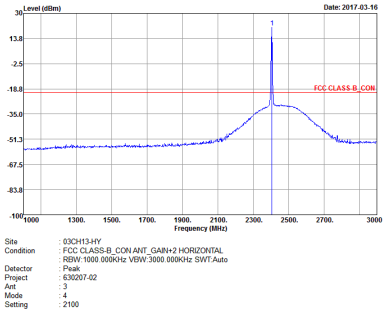
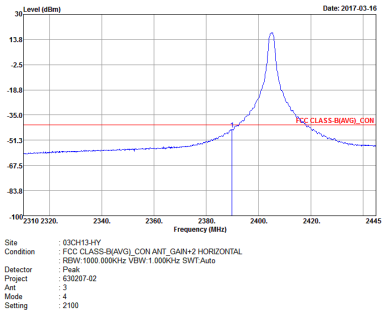
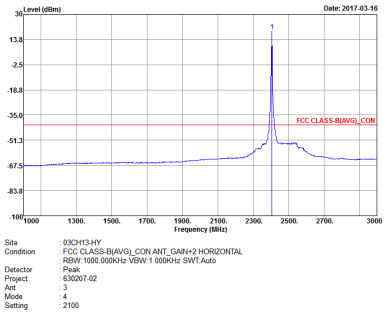
Test Engineer :	Stan Hsieh	**Temperature :**	22~24°C
		Relative Humidity :	44~46%

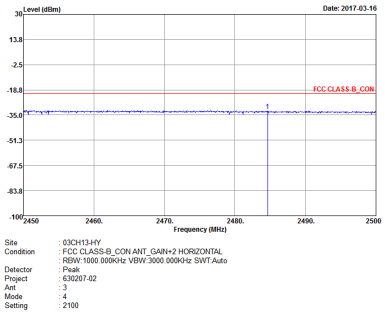
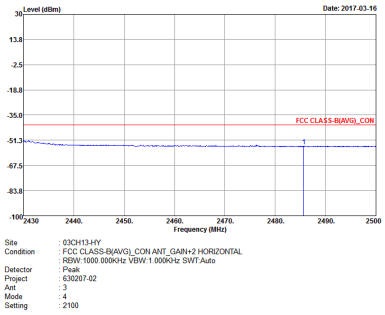
Note symbol

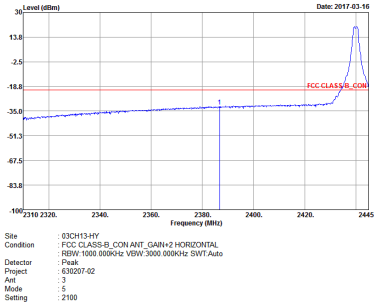
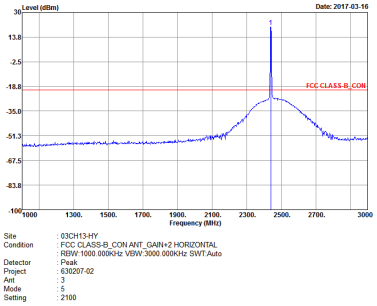
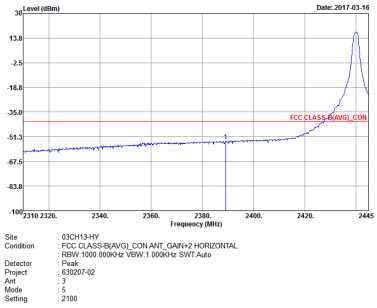
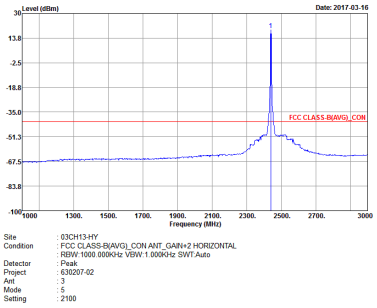
-L	**Low channel location**
-R	**High channel location**

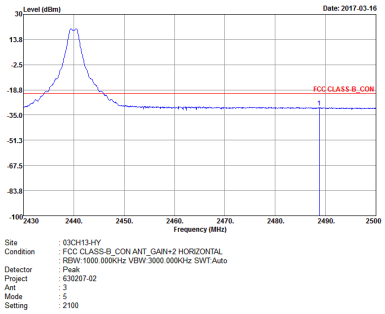
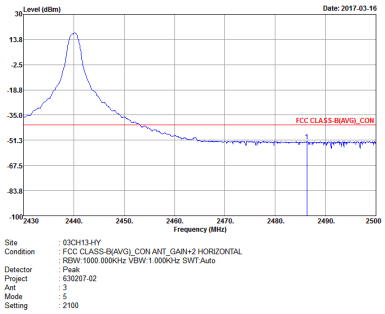
2.4GHz 2400~2483.5MHz

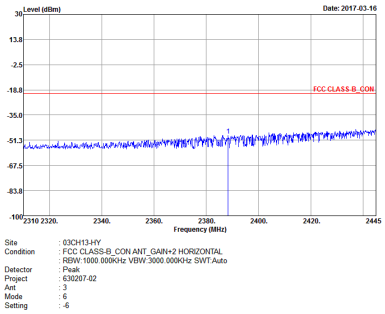
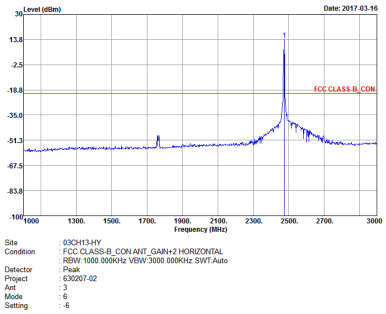
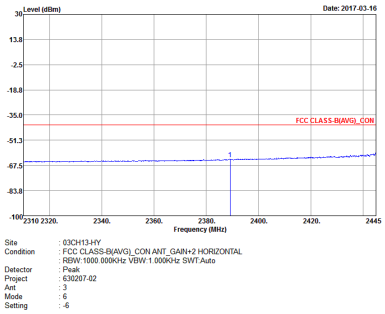
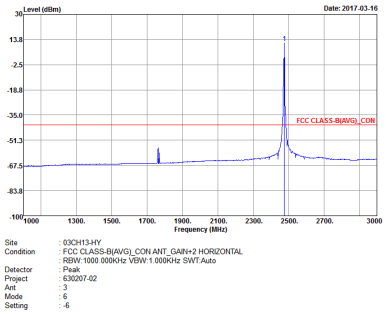
Zigbee (Band Edge @ Conducted)

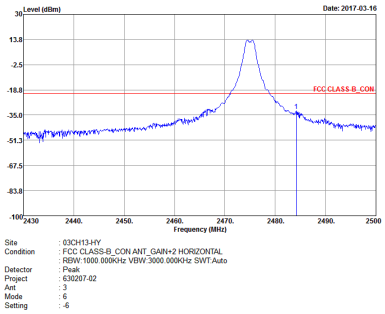
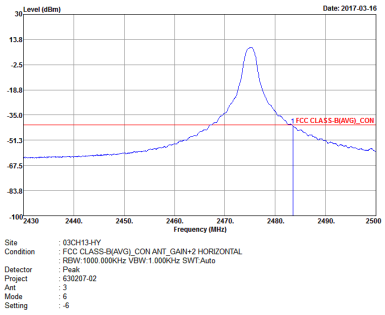
Zigbee	2.4GHz 2400~2483.5MHz Band Edge @ Conducted	
ANT	Zigbee CH11 2405MHz	
3	Band Edge - L	Fundamental
Peak		
Avg.		

Zigbee	2.4GHz 2400~2483.5MHz Band Edge @ Conducted	
ANT	Zigbee CH11 2405MHz	
3	Band Edge - R	
Peak		
Avg		

Zigbee	2.4GHz 2400~2483.5MHz Band Edge @ Conducted	
ANT	Zigbee CH18 2440MHz	
3	Band Edge - L	Fundamental
Peak		
Avg.		

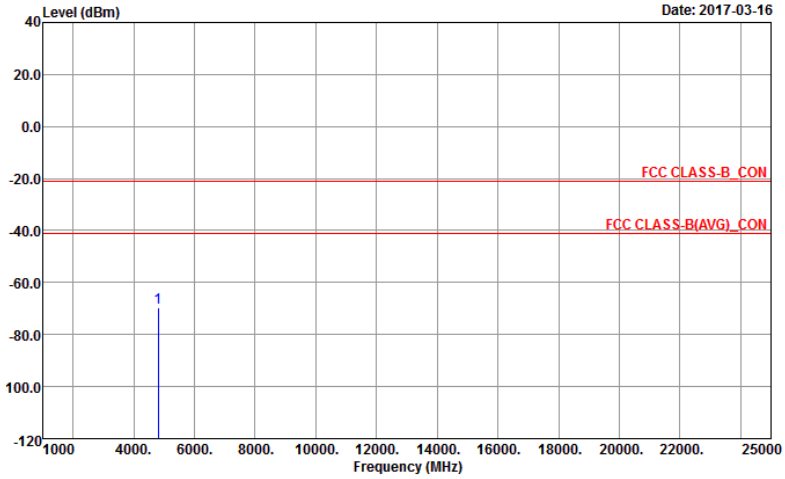
Zigbee	2.4GHz 2400~2483.5MHz Band Edge @ Conducted	
ANT	Zigbee CH18 2440MHz	
3	Band Edge - R	Fundamental
Peak		
Avg.		

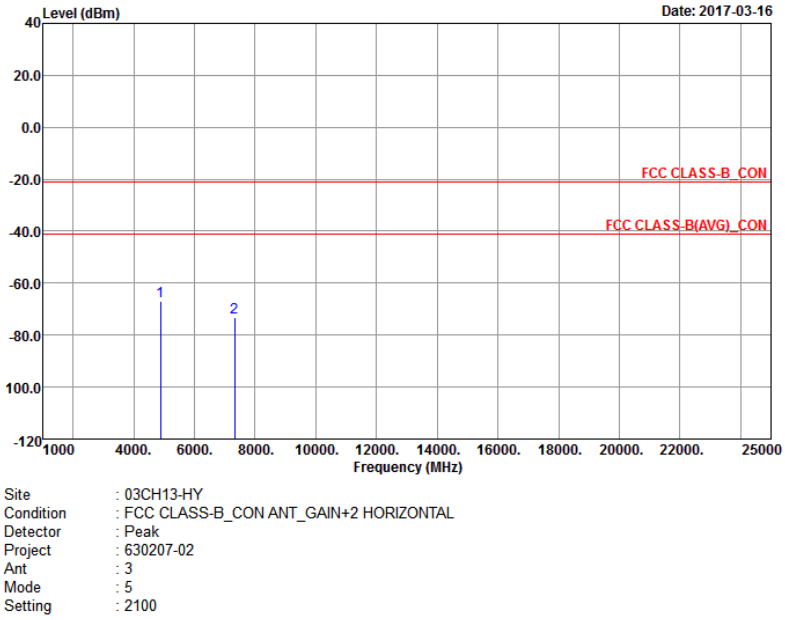
Zigbee	2.4GHz 2400~2483.5MHz Band Edge @ Conducted	
ANT	Zigbee CH25 2475MHz	
3	Band Edge - L	Fundamental
Peak		
Avg.		

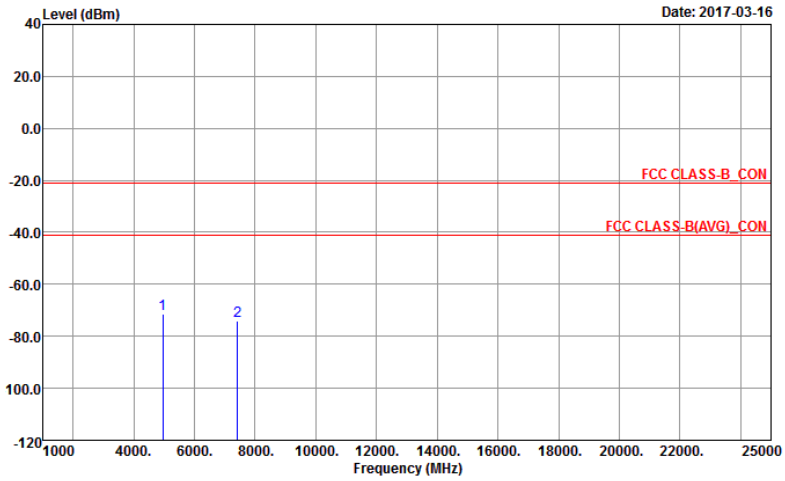
Zigbee	2.4GHz 2400~2483.5MHz Band Edge @ Conducted	
ANT	Zigbee CH25 2475MHz	
3	Band Edge - R	Fundamental
Peak		
Avg.		

2.4GHz 2400~2483.5MHz

Zigbee (Harmonic @ Conducted)

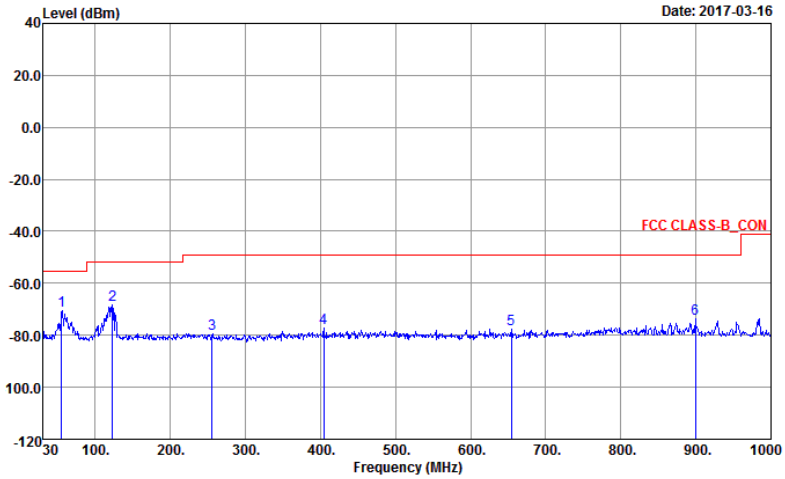
Zigbee	2.4GHz 2400~2483.5MHz Harmonic @ Conducted
ANT	Zigbee CH11 2405MHz
3	
Peak Avg.	 Site : 03CH13-HY Condition : FCC CLASS-B_CON ANT_GAIN+2 HORIZONTAL Detector : Peak Project : 630207-02 Ant : 3 Mode : 4 Setting : 2100

Zigbee	2.4GHz 2400~2483.5MHz Harmonic @ Conducted
ANT	Zigbee CH18 2440MHz
3	
Peak Avg.	 Site : 03CH13-HY Condition : FCC CLASS-B_CON ANT_GAIN+2 HORIZONTAL Detector : Peak Project : 630207-02 Ant : 3 Mode : 5 Setting : 2100

Zigbee	2.4GHz 2400~2483.5MHz Harmonic @ Conducted
ANT	Zigbee CH25 2475MHz
3	
Peak	 Site : 03CH13-HY Condition : FCC CLASS-B_CON ANT_GAIN+2 HORIZONTAL Detector : Peak Project : 630207-02 Ant : 3 Mode : 6 Setting : -6

Emission below 1GHz

2.4GHz Zigbee (LF)

Zigbee	2.4GHz 2400~2483.5MHz
ANT	Zigbee LF
3	
QP / Peak	

Site : 03CH13-HY
Condition : FCC CLASS-B_CON ANT_GAIN+2 HORIZONTAL
: RBW:120.000KHz VBW:300.000KHz SWT:0.500sec
Detector : Peak
Project : 630207-02
Ant : 3
Mode : 6
Setting : -6

Appendix D. Cabinet Radiation Data

Test Engineer :	Taigong Lin	**Temperature :**	20~24°C
		Relative Humidity :	48~50%

Emission Above 1GHz

2.4GHz Zigbee (HF)

Zigbee	Note	Frequency	Level	Over	Limit	Read	Antenna	Cable	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
3		(MHz)	(dBm)	(dB)	(dBm)	(dBm)	(dBi)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
Zigbee CH 11 2405MHz		4810	35.79	-38.21	74	61.54	31.42	7.58	64.75	100	0	P	H
													H
													H
													H
		4810	35.71	-38.29	74	53.7	39.18	7.58	64.75	100	0	P	V
													V
													V
													V
Zigbee CH 18 2440MHz		4880	35.35	-38.65	74	54.33	31.56	7.7	58.24	100	0	P	H
		7320	41.04	-32.96	74	54.43	36.22	9.49	59.1	100	0	P	H
													H
													H
		4880	34.72	-39.28	74	53.7	31.56	7.7	58.24	100	0	P	V
		7320	39.28	-34.72	74	52.67	36.22	9.49	59.1	100	0	P	V
													V
													V
Zigbee CH 25 2475MHz		4950	36.57	-37.43	74	61.58	31.7	7.93	64.64	100	0	P	H
		7425	41.01	-32.99	74	59.82	36.45	9.61	64.87	100	0	P	H
													H
													H
		4950	37.09	-36.91	74	62.1	31.7	7.93	64.64	100	0	P	V
		7425	39.89	-34.11	74	58.7	36.45	9.61	64.87	100	0	P	V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Emission below 1GHz

2.4GHz Zigbee (LF)

Zigbee	Note	Frequency	Level	Over	Limit	Read	Antenna	Cable	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
3		(MHz)	(dBm)	(dB)	(dBm)	(dBm)	(dBi)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
2.4GHz Zigbee LF		40.26	33.74	-6.26	40	45.9	19.94	0.65	32.75	100	0	P	H
		49.44	24.89	-15.11	40	41.08	15.62	0.93	32.74	-	-	P	H
		98.31	27.52	-15.98	43.5	43.01	16.14	1.14	32.77	-	-	P	H
		409.9	27.62	-18.38	46	35.66	22.57	2.16	32.77	-	-	P	H
		820.1	29.37	-16.63	46	30.85	28.23	3.07	32.78	-	-	P	H
		949.6	31.33	-14.67	46	29.79	30	3.29	31.75	-	-	P	H
		30	29.81	-10.19	40	35.82	26.1	0.65	32.76	100	0	P	V
		47.01	29.78	-10.22	40	45.14	16.45	0.93	32.74	-	-	P	V
		77.52	27.98	-12.02	40	46.26	13.55	0.93	32.76	-	-	P	V
		118.83	31.92	-11.58	43.5	45.8	17.75	1.14	32.77	-	-	P	V
		135.84	30.34	-13.16	43.5	43.77	18	1.33	32.76	-	-	P	V
		943.3	31.49	-14.51	46	30.18	29.85	3.29	31.83	-	-	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.	
1		(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 E. Cabinet Radiation Plots

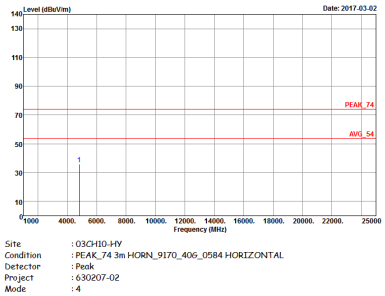
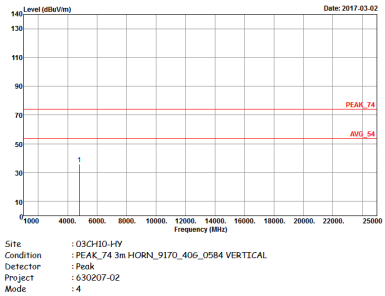
Test Engineer :	Taigong Lin	Temperature :	20~24°C
		Relative Humidity :	48~50%

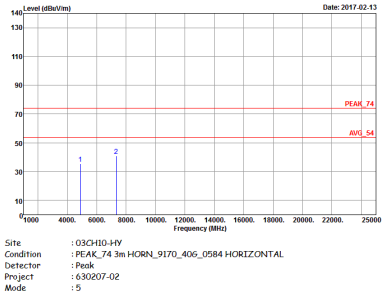
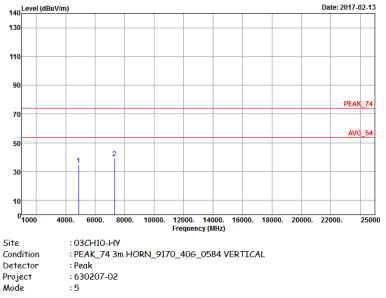
Note symbol

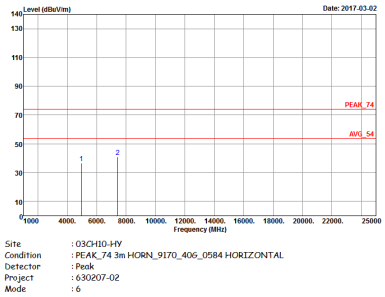
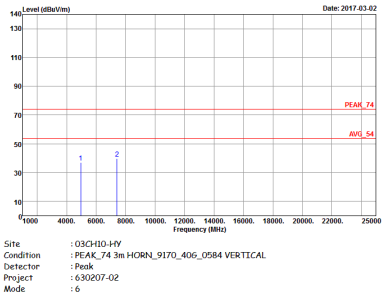
-L	**Low channel location**
-R	**High channel location**

Emission Above 1GHz

2.4GHz Zigbee (HF)

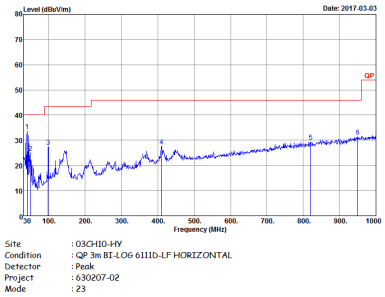
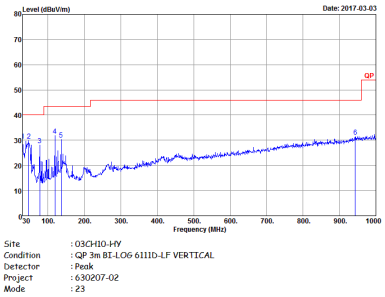
Zigbee	2.4GHz 2400~2483.5MHz cabinet radiation above 1GHz @ 3m	
ANT	Zigbee CH11 2405MHz	
3	Horizontal	Vertical
Peak Avg.		

Zigbee	2.4GHz 2400~2483.5MHz cabinet radiation above 1GHz @ 3m	
ANT	Zigbee CH18 2440MHz	
3	Horizontal	Vertical
Peak Avg.		

Zigbee	2.4GHz 2400~2483.5MHz cabinet radiation above 1GHz @ 3m	
ANT	Zigbee CH25 2475MHz	
3	Horizontal	Vertical
Peak		

Emission below 1GHz

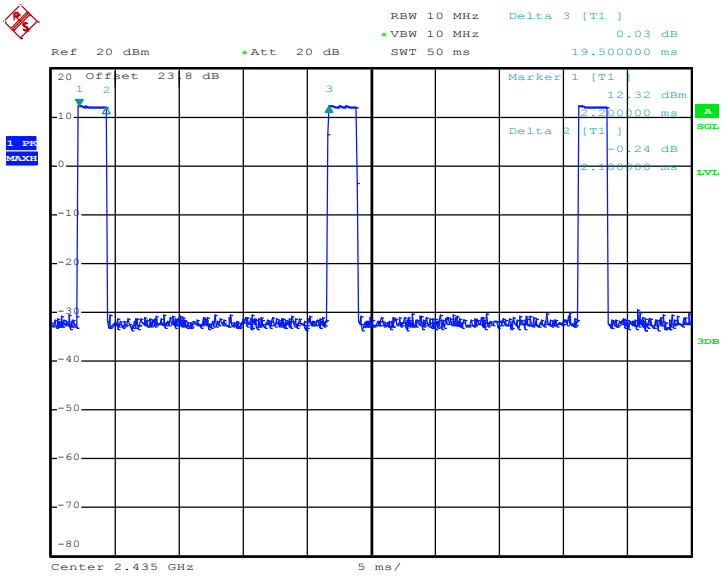
2.4GHz Zigbee (LF)

Zigbee	2.4GHz 2400~2483.5MHz	
ANT	Zigbee LF	
3	Horizontal	Vertical
QP / Peak		

Appendix F. Duty Cycle Plots

Band	Duty Cycle(%)	T(μs)	1/T(kHz)	VBW Setting
Zigbee 2.4 GHz Band	10.77	2100	0.48	1kHz

Zigbee 2.4 GHz



Date: 30.DEC.2016 04:22:32