



FCC PART 15.247

TEST REPORT

For

Signify (China) Investment Co., Ltd.

Building no.9, Lane 888, Tianlin Road, Minhang District, Shanghai, 200233, China

FCC ID: 2AGBW9290023351X

Report Type: Original Report	Product Type: LED Lamp
Report Number: RXM200119050-00A	
Report Date: 2020-03-31	
Jimmy Xiao 	
Reviewed By: RF Engineer	
Prepared By: Bay Area Compliance Laboratories Corp. (Shenzhen) 6/F., West Wing, Third Phase of Wanli Industrial Building, Shihua Road, Futian Free Trade Zone, Shenzhen, Guangdong, China Tel: +86-755-33320018 Fax: +86-755-33320008 www.baclcorp.com.cn	

Note: This report must not be used by the customer to claim product certification, approval, or endorsement by A2LA* or any agency of the Federal Government. This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk “★”.

BACL is not responsible for the authenticity of any test data provided by the applicant. Data included from the applicant that may affect test results are marked with an asterisk “*”. Customer model name, addresses, names, trademarks etc. are not considered data.

This report cannot be reproduced except in full, without prior written approval of the Company. Unless otherwise stated the results shown in this test report refer only to the sample(s) tested. This report is valid only with a valid digital signature. The digital signature may be available only under the Adobe software above version 7.0.

TABLE OF CONTENTS

GENERAL INFORMATION.....	4
PRODUCT DESCRIPTION FOR EQUIPMENT UNDER TEST (EUT)	4
OBJECTIVE	4
RELATED SUBMITTAL(S)/GRANT(S).....	4
TEST METHODOLOGY	4
MEASUREMENT UNCERTAINTY	5
SYSTEM TEST CONFIGURATION.....	6
DESCRIPTION OF TEST CONFIGURATION	6
EQUIPMENT MODIFICATIONS	6
EUT EXERCISE SOFTWARE	7
DUTY CYCLE	7
SUPPORT EQUIPMENT LIST AND DETAILS	10
EXTERNAL I/O CABLE.....	10
BLOCK DIAGRAM OF TEST SETUP	11
SUMMARY OF TEST RESULTS.....	12
TEST EQUIPMENT LIST	13
FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE).....	14
APPLICABLE STANDARD	14
RESULT	14
FCC §15.203 - ANTENNA REQUIREMENT.....	15
APPLICABLE STANDARD	15
ANTENNA CONNECTOR CONSTRUCTION	15
FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS	16
APPLICABLE STANDARD	16
EUT SETUP.....	16
EMI TEST RECEIVER SETUP.....	16
TEST PROCEDURE	16
CORRECTED FACTOR & MARGIN CALCULATION	17
TEST RESULTS SUMMARY	17
TEST DATA	17
FCC §15.209, §15.205 & §15.247(d) - SPURIOUS EMISSIONS.....	24
APPLICABLE STANDARD	24
EUT SETUP	24
EMI TEST RECEIVER & SPECTRUM ANALYZER SETUP	25
TEST PROCEDURE	25
CORRECTED AMPLITUDE & MARGIN CALCULATION	25
TEST RESULTS SUMMARY	25
TEST DATA	25
FCC §15.247(a) (2) – 6 dB EMISSION BANDWIDTH.....	36
APPLICABLE STANDARD	36
TEST PROCEDURE	36
TEST DATA	36

FCC §15.247(b) (3) - MAXIMUM CONDUCTED OUTPUT POWER.....	40
APPLICABLE STANDARD	40
TEST PROCEDURE	40
TEST DATA	40
FCC §15.247(d) – 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE.....	41
APPLICABLE STANDARD	41
TEST PROCEDURE	41
TEST DATA	41
FCC §15.247(e) - POWER SPECTRAL DENSITY	44
APPLICABLE STANDARD	44
TEST PROCEDURE	44
TEST DATA	44

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	LED Lamp
Model	9290023351
Frequency Range	Bluetooth LE: 2402~2480MHz ZigBee: 2405~2480MHz
Maximum conducted peak output power	Bluetooth LE 1M: 10.52dBm Bluetooth LE 2M: 9.34dBm ZigBee: 10.14dBm
Modulation Technique	Bluetooth LE: GFSK ZigBee: OQPSK
Antenna Specification	Bluetooth LE/ZigBee: -3dBi
Voltage	110-130Vac, 50-60Hz
Date of Test	2020/02/02~2020/03/30
Sample serial number	68CA07 (Assigned by applicant)
Received date	2020/01/19
Sample/EUT Status	Good condition

Objective

This report is prepared on behalf of *Signify (China) Investment Co., Ltd.* in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission's rules.

The tests were performed in order to determine compliance with FCC Part 15, Subpart C, and section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

Related Submittal(s)/Grant(s)

No Related Submittals.

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

And KDB 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed at Bay Area Compliance Laboratories Corp. (Shenzhen). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		±5%
RF Output Power with Power meter		±0.73dB
RF conducted test with spectrum		±1.6dB
AC Power Lines Conducted Emissions		±1.95dB
Emissions, Radiated	Below 1GHz	±4.75dB
	Above 1GHz	±4.88dB
Temperature		±1 °C
Humidity		±6%
Supply voltages		±0.4%

Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Facility

The test site used by Bay Area Compliance Laboratories Corp. (Shenzhen) to collect test data is located on the 6/F., West Wing, Third Phase of Wanli Industrial Building, Shihua Road, Futian Free Trade Zone, Shenzhen, Guangdong, China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 342867, the FCC Designation No.: CN1221.

The test site has been registered with ISED Canada under ISED Canada Registration Number 3062B.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

For BLE 1M & BLE 2M mode, 40 channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	20	2442
1	2404	21	2444
2	2406	22	2446
3	2408	23	2448
4	2410	24	2450
5	2412	25	2452
6	2414	26	2454
7	2416	27	2456
8	2418	28	2458
9	2420	29	2460
10	2422	30	2462
11	2424	31	2464
12	2426	32	2466
13	2428	33	2468
14	2430	34	2470
15	2432	35	2472
16	2434	36	2474
17	2436	37	2476
18	2438	38	2478
19	2440	39	2480

EUT was tested with Channel 0, 20 and 39.

For ZigBee mode, 16 channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
11	2405	19	2445
12	2410	...	...
...	...	...	...
...	...	...	...
...	...	25	2475
18	2440	26	2480

EUT was tested with Channel 11, 19 and 26.

Equipment Modifications

No modification was made to the EUT tested.

EUT Exercise Software

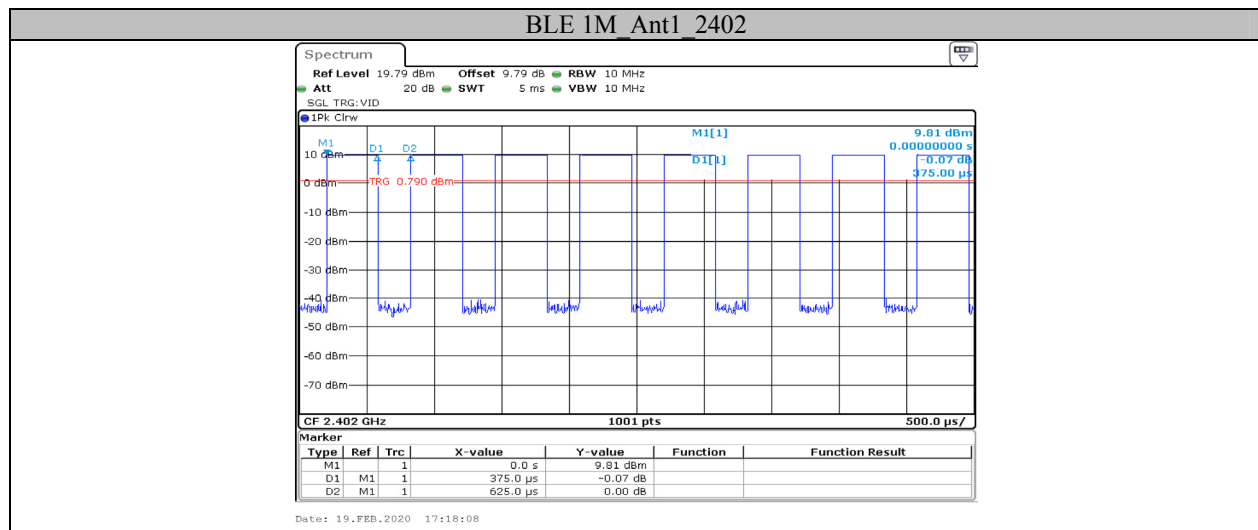
“UartAssistV4.2.3” software was used for testing.

The device was tested with the worst case was performed as below:

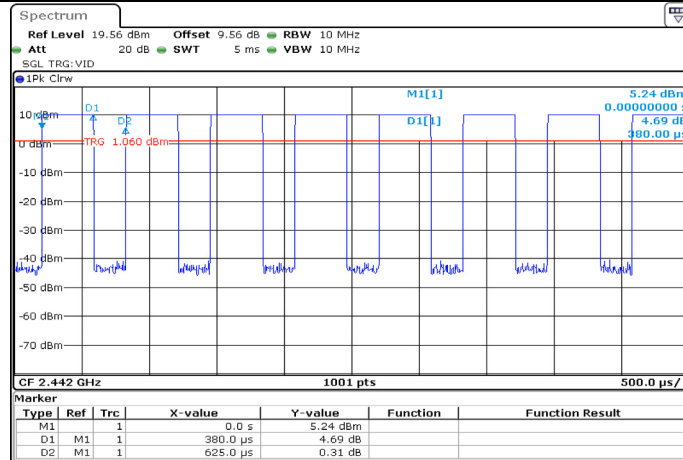
Mode	Power level		
	Low channel	Middle channel	High channel
BLE 1M	Default	Default	Default
BLE 2M	Default	Default	Default
ZigBee	Default	Default	Default

Duty cycle

Test Mode	Antenna	Channel	Transmission Duration [ms]	Transmission Period [ms]	Duty Cycle [%]
BLE 1M	Ant1	2402	0.37	0.63	60.00
		2442	0.38	0.63	60.80
		2480	0.37	0.63	60.00
BLE 2M	Ant1	2442	0.19	0.63	30.40
Zigbee	Ant1	2405	2.8	20.9	13.4
		2445	2.8	20.9	13.4
		2480	2.775	20.9	13.3

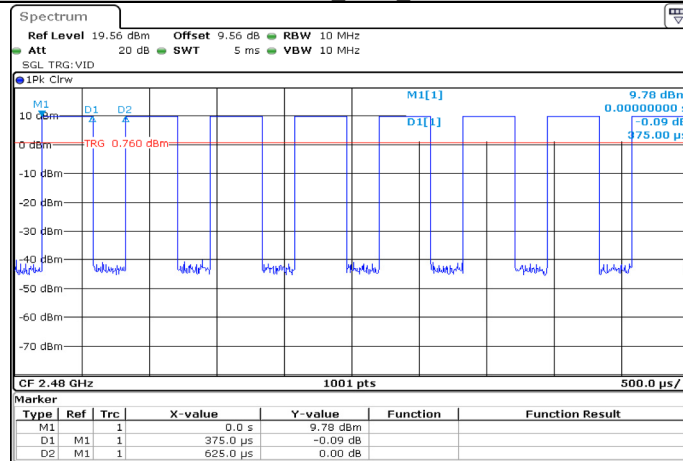


BLE 1M_Ant1_2442



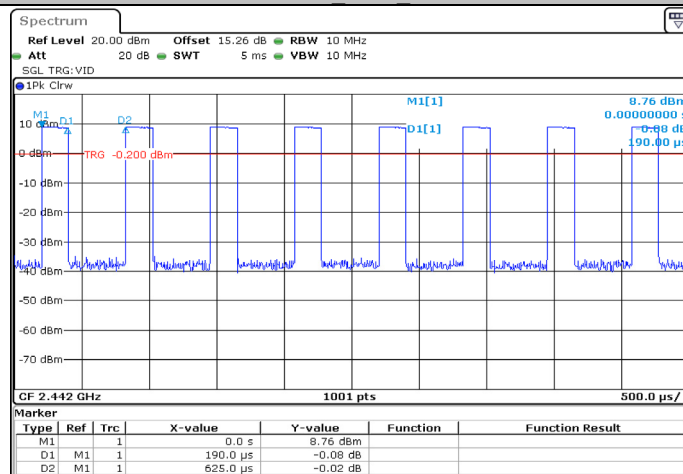
Date: 19.FEB.2020 17:23:40

BLE 1M_Ant1_2480



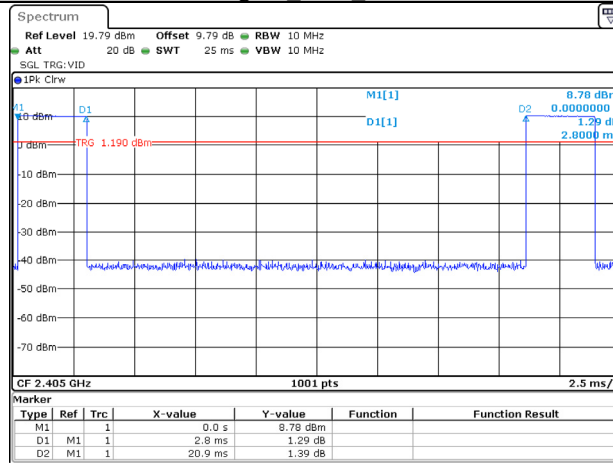
Date: 19.FEB.2020 17:25:49

BLE 2M_Ant1_2442



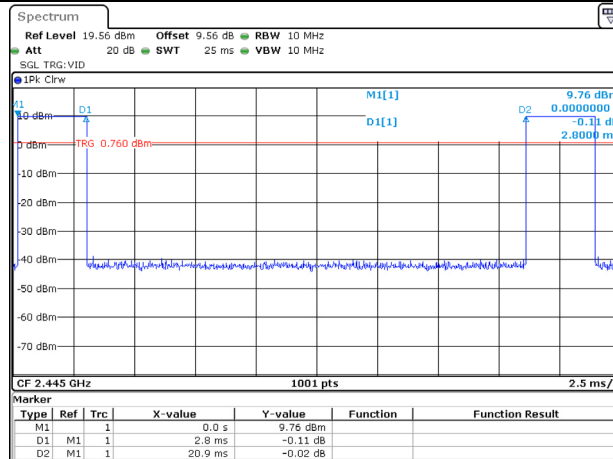
Date: 26.MAR.2020 17:40:02

Zigbee Ant1 2405



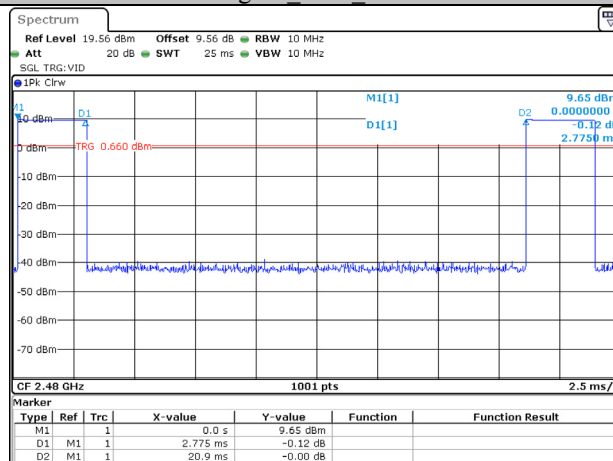
Date: 20.FEB.2020 09:31:15

Zigbee Ant1 2445

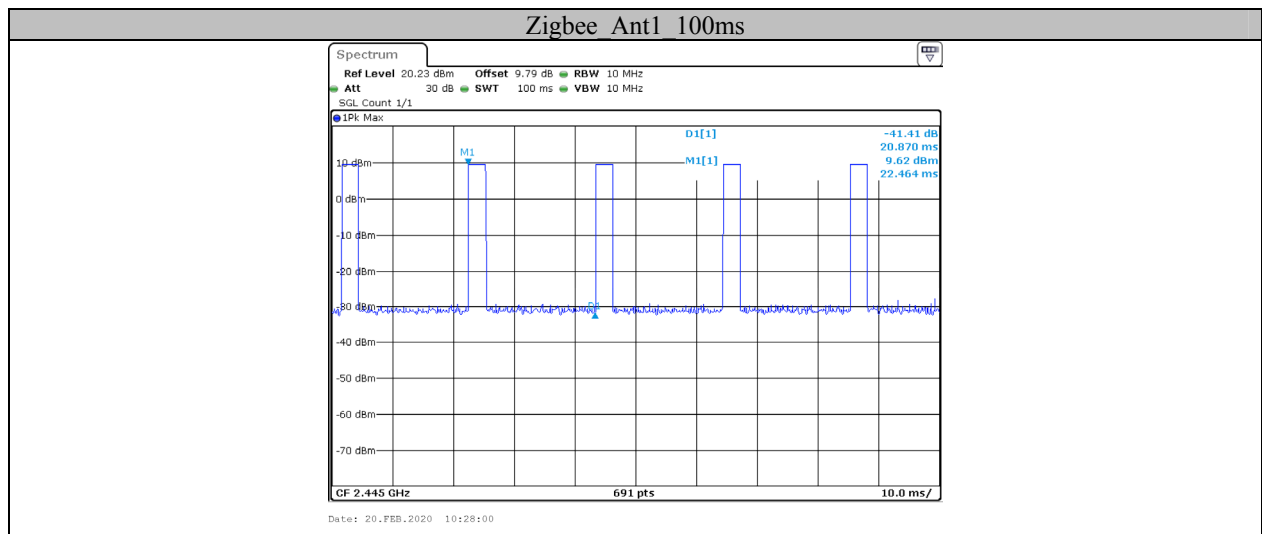


Date: 20.FEB.2020 09:37:19

Zigbee Ant1 2480



Date: 20.FEB.2020 09:39:29



Support Equipment List and Details

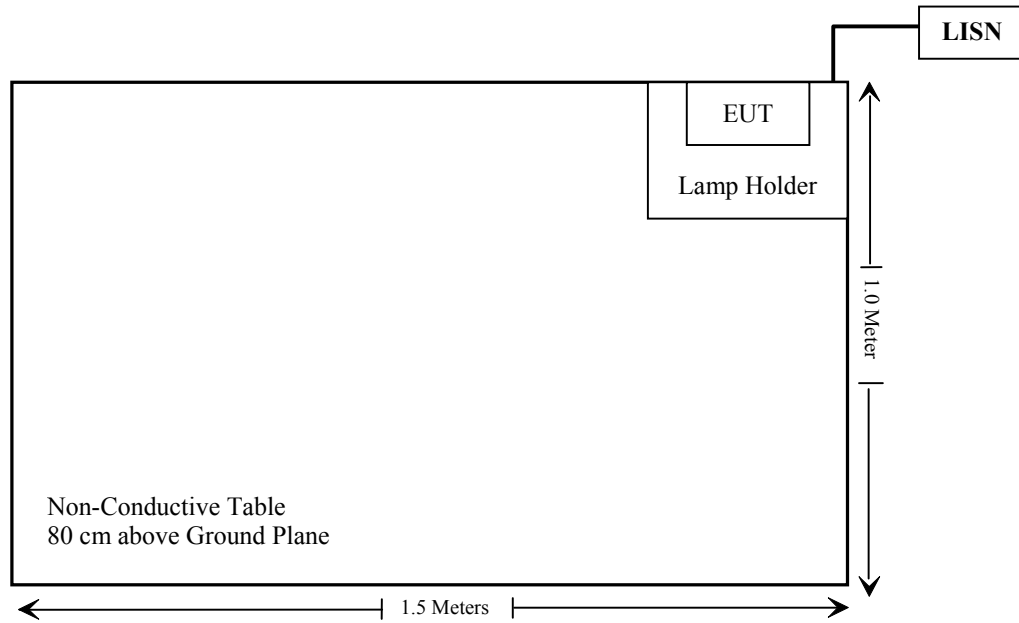
Manufacturer	Description	Model	Serial Number
Unknown	Lamp Holder	Unknown	Unknown

External I/O Cable

Cable Description	Length (m)	From Port	To
Un-shielded Un-detachable AC Cable	1.2	LISN	Lamp Holder

Block Diagram of Test Setup

For conducted emission



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (i), §2.1091	MPE	Compliance
§15.203	Antenna Requirement	Compliance
§15.207 (a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209, §15.247(d)	Spurious Emissions	Compliance
§15.247 (a)(2)	6 dB Emission Bandwidth	Compliance
§15.247(b)(3)	Maximum Conducted Output Power	Compliance
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliance
§15.247(e)	Power Spectral Density	Compliance

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Emissions Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	101120	2019/7/9	2020/7/8
Rohde & Schwarz	LISN	ENV216	101613	2020/1/22	2021/1/21
Rohde & Schwarz	Transient Limitor	ESH3Z2	DE25985	2019/11/29	2020/11/28
Unknown	CE Cable	CE Cable	UF A210B-1-0720-504504	2019/11/29	2020/11/28
Rohde & Schwarz	CE Test software	EMC 32	V8.53.0	NCR	NCR
Radiated Emission Test					
R&S	EMI Test Receiver	ESR3	102455	2019/7/9	2020/7/8
Sonoma instrument	Pre-amplifier	310 N	186238	2019/4/20	2020/4/20
Sunol Sciences	Broadband Antenna	JB1	A040904-1	2017/12/22	2020/12/21
Unknown	Cable 2	RF Cable 2	F-03-EM197	2019/11/29	2020/11/28
Unknown	Cable	Chamber Cable 1	F-03-EM236	2019/11/29	2020/11/28
Rohde & Schwarz	Auto test software	EMC 32	V9.10	NCR	NCR
Rohde & Schwarz	Spectrum Analyzer	FSV40-N	102259	2019/7/22	2020/07/21
COM-POWER	Pre-amplifier	PA-122	181919	2019/11/29	2020/11/28
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2019/11/29	2020/11/28
Sunol Sciences	Horn Antenna	DRH-118	A052604	2017/12/22	2020/12/21
Insulated Wire Inc.	RF Cable	SPS-2503-3150	02222010	2019/11/29	2020/11/28
Unknown	RF Cable	W1101-EQ1 OUT	F-19-EM005	2019/11/29	2020/11/28
SNSD	Band Reject filter	BSF2402-2480MN-0898-001	2.4G filter	2019/4/20	2020/4/20
Ducommun Technologies	Horn antenna	ARH-4223-02	1007726-021304	2017/12/6	2020/12/5
RF Conducted Test					
Tonscend Corporation	RF control Unit	JS0806-2	19D8060154	2019/7/10	2020/7/9
Rohde & Schwarz	Signal and Spectrum Analyzer	FSV40	101473	2019/7/22	2020/7/21
Unknown	RF Cable	Unknown	2301 276	2019/11/29	2020/11/28

* **Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Shenzhen) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

Limits for General Population/Uncontrolled Exposure

Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (Minutes)
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

Result

Calculated Formulary:

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = power density (in appropriate units, e.g. mW/cm²)

P = power input to the antenna (in appropriate units, e.g., mW).

G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain.

R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

Mode	Frequency (MHz)	Antenna Gain		Max Tune-up Conducted Power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		(dBi)	(numeric)	(dBm)	(mW)			
BLE 1M	2402-2480	-3.0	0.50	11	12.59	20	0.0013	1
BLE 2M	2402-2480	-3.0	0.50	10	10.00	20	0.0010	1
ZigBee	2405-2480	-3.0	0.50	11	12.59	20	0.0013	1

Note: To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Compliance

FCC §15.203 - ANTENNA REQUIREMENT

Applicable Standard

According to § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the user of a standard antenna jack or electrical connector is prohibited. The structure and application of the EUT were analyzed to determine compliance with section §15.203 of the rules. §15.203 state that the subject device must meet the following criteria:

- a. Antenna must be permanently attached to the unit.
 - b. Antenna must use a unique type of connector to attach to the EUT.
- Unit must be professionally installed, and installer shall be responsible for verifying that the correct antenna is employed with the unit.

And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Antenna Connector Construction

The EUT has an internal antenna arrangement for BLE & ZigBee, which was permanently attached and the antenna gain is -3 dBi, fulfill the requirement of this section. Please refer to the EUT photos.

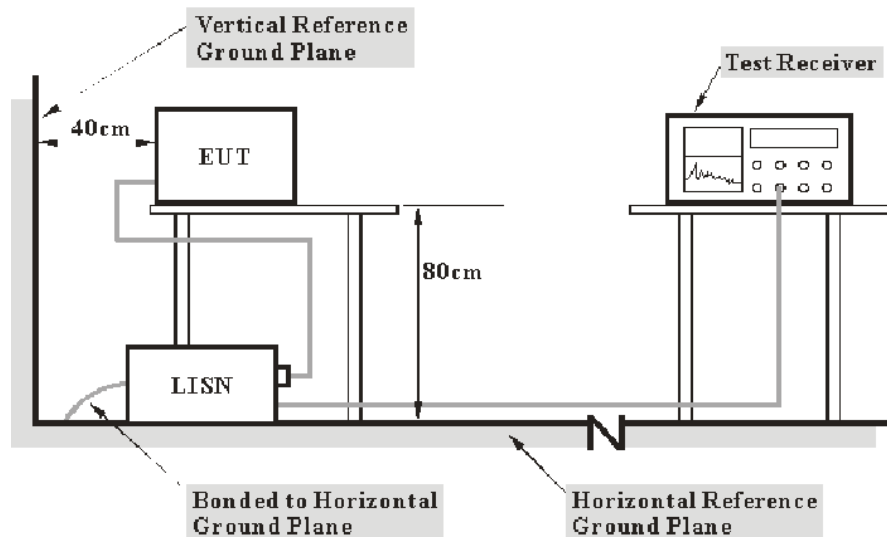
Result: Compliance.

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC§15.207

EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 limits.

The spacing between the peripherals was 10 cm.

EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

Corrected Factor & Margin Calculation

The Corrected factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

$$\text{Correction Factor} = \text{LISN VDF} + \text{Cable Loss} + \text{Transient Limiter Attenuation}$$

The “**Margin**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7 dB means the emission is 7 dB below the limit. The equation for margin calculation is as follows:

$$\text{Margin} = \text{Limit} - \text{Corrected Amplitude}$$

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Part 15.207.

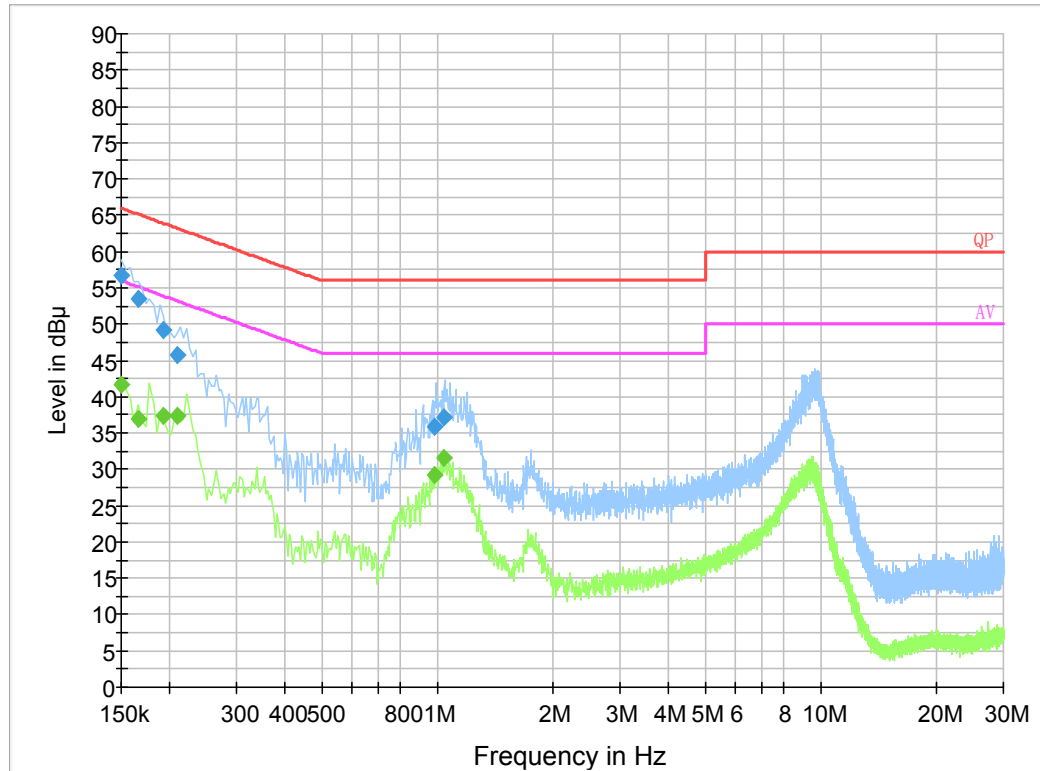
Test Data

Environmental Conditions

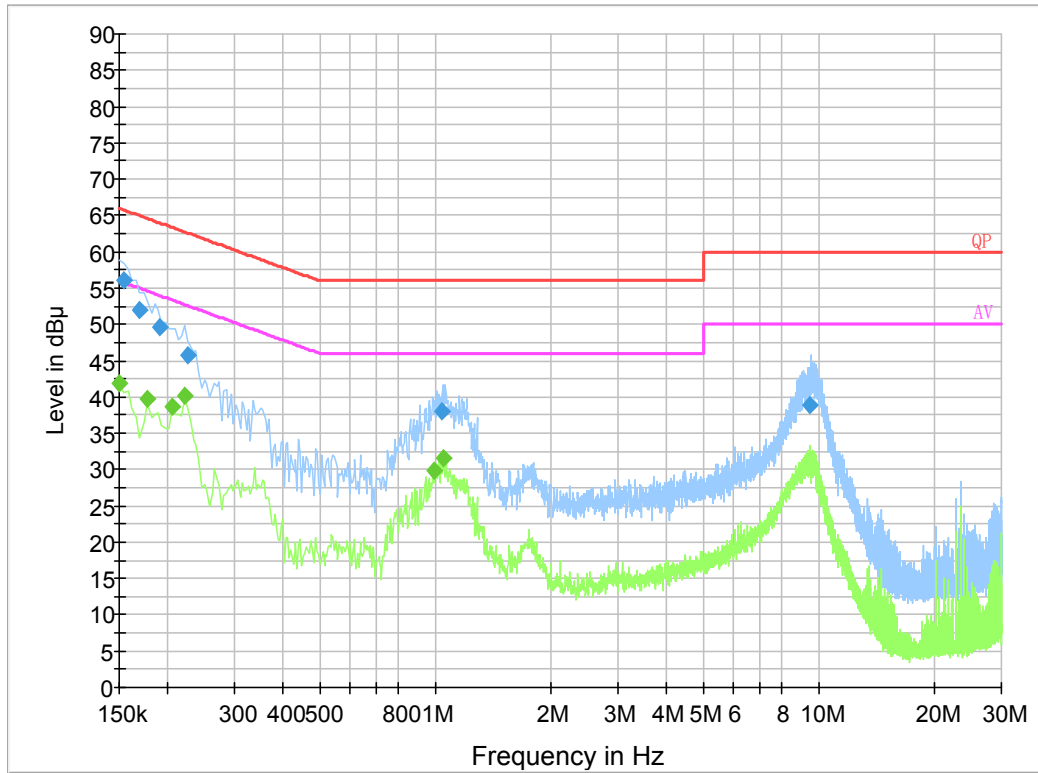
Temperature:	25 °C
Relative Humidity:	65 %
ATM Pressure:	101.0 kPa

The testing was performed by Haiguo Li on 2020-03-14 & 2020-03-30.

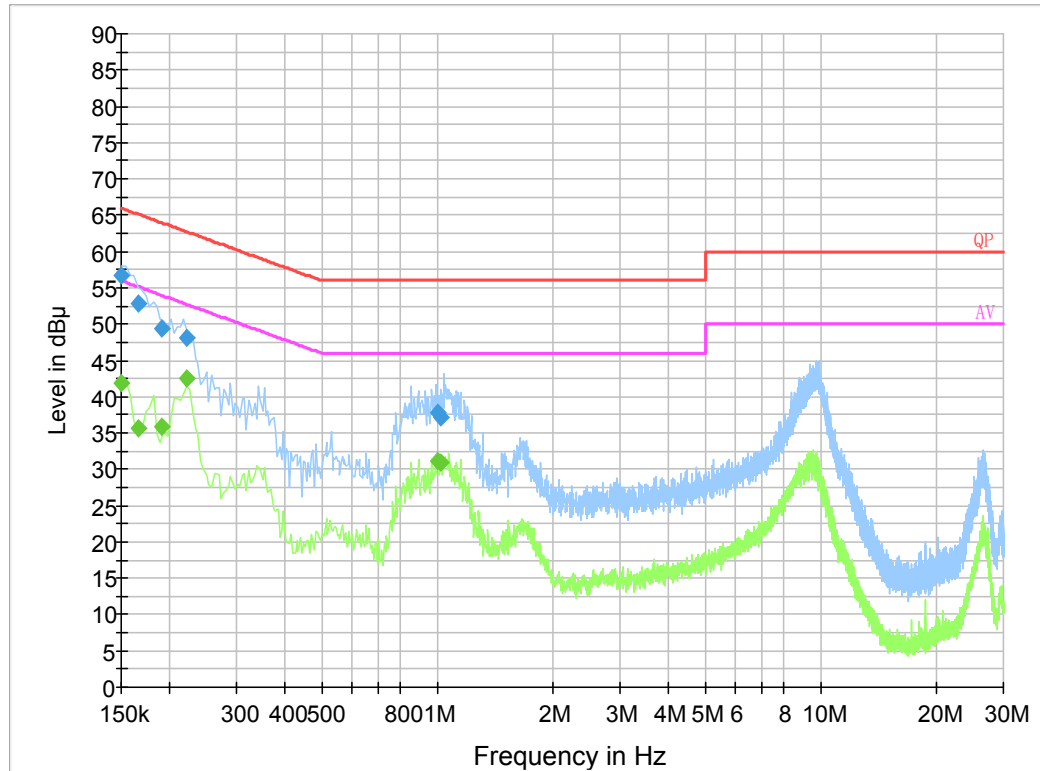
EUT operation mode: Transmitting

BLE 1M Mode: (Middle channel was worst case)**AC 120 V/60 Hz, Line**

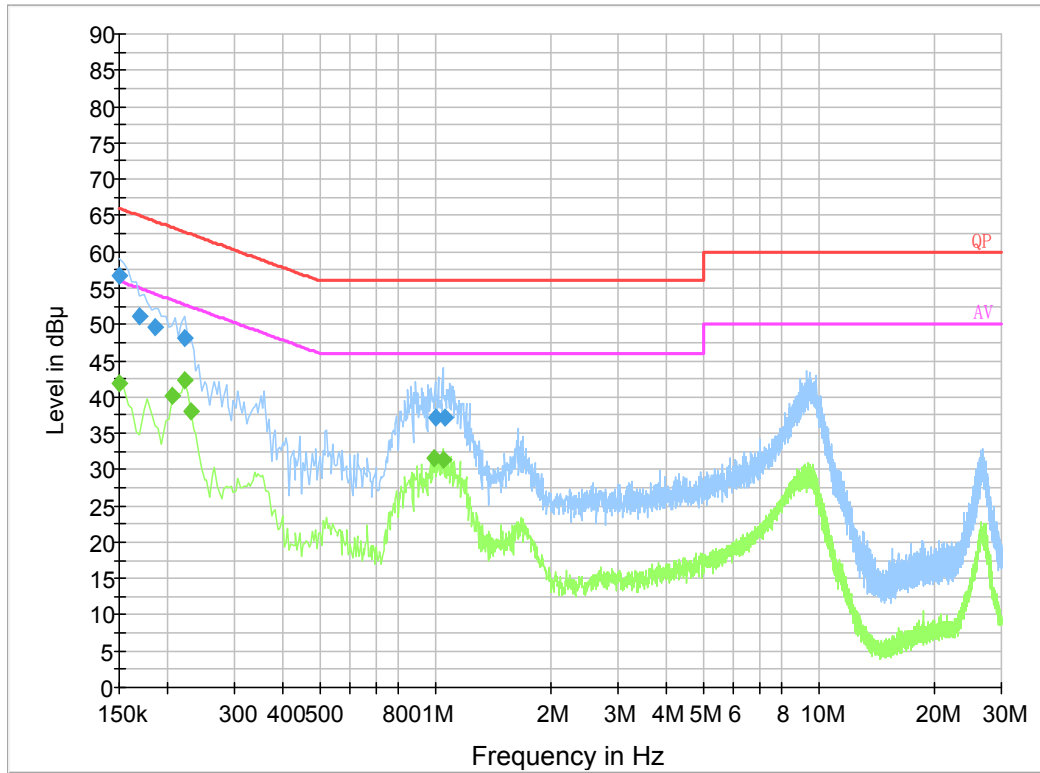
Frequency (MHz)	Corrected Amplitude (dBμV)	Correction Factor (dB)	Limit (dBμV)	Margin (dB)	Detector (PK/Ave./QP)
0.150000	56.7	19.8	66.0	9.3	QP
0.165500	53.4	19.9	65.2	11.8	QP
0.193500	49.2	19.8	63.9	14.7	QP
0.209500	45.8	19.8	63.2	17.4	QP
0.987090	35.8	19.9	56.0	20.2	QP
1.046250	37.1	19.9	56.0	18.9	QP
0.150000	41.8	19.8	56.0	14.2	Ave.
0.165500	36.8	19.9	55.2	18.4	Ave.
0.193500	37.4	19.8	53.9	16.5	Ave.
0.209500	37.3	19.8	53.2	15.9	Ave.
0.987090	29.2	19.9	46.0	16.8	Ave.
1.046250	31.6	19.9	46.0	14.4	Ave.

AC 120 V/60 Hz, Neutral

Frequency (MHz)	Corrected Amplitude (dBμV)	Correction Factor (dB)	Limit (dBμV)	Margin (dB)	Detector (PK/Ave./QP)
0.154500	56.0	19.8	65.8	9.8	QP
0.169500	52.0	19.8	65.0	13.0	QP
0.190501	49.7	19.8	64.0	14.3	QP
0.225500	45.7	19.8	62.6	16.9	QP
1.046250	37.9	19.8	56.0	18.1	QP
9.458090	38.8	19.9	60.0	21.2	QP
0.150000	41.8	19.8	56.0	14.2	Ave.
0.178000	39.7	19.8	54.6	14.9	Ave.
0.206000	38.6	19.8	53.4	14.8	Ave.
0.222000	40.2	19.8	52.7	12.5	Ave.
0.994000	29.8	19.8	46.0	16.2	Ave.
1.050000	31.5	19.8	46.0	14.5	Ave.

BLE 2M Mode: (Middle channel was worst case)**AC 120 V/60 Hz, Line**

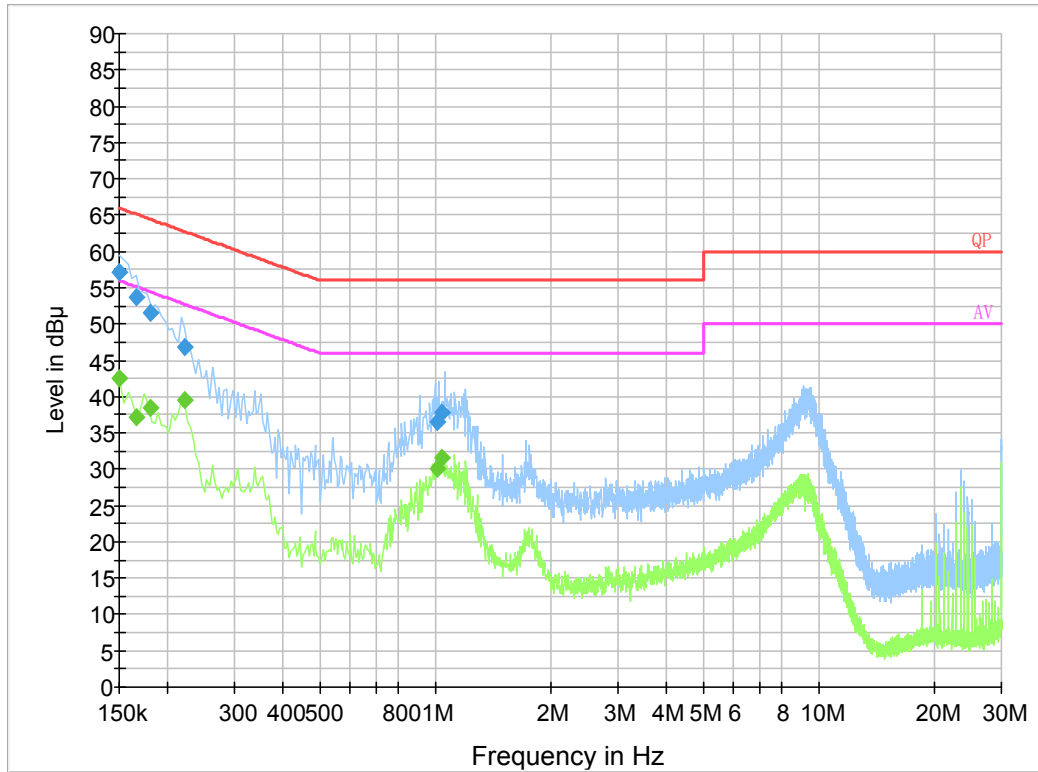
Frequency (MHz)	Corrected Amplitude (dBμV)	Correction Factor (dB)	Limit (dBμV)	Margin (dB)	Detector (PK/Ave./QP)
0.150000	56.6	19.8	66.0	9.4	QP
0.165500	52.8	19.9	65.2	12.4	QP
0.190501	49.4	19.8	64.0	14.6	QP
0.221500	48.1	19.8	62.8	14.7	QP
0.999030	37.8	19.9	56.0	18.2	QP
1.026370	37.1	19.9	56.0	18.9	QP
0.150000	41.8	19.8	56.0	14.2	Ave.
0.165500	35.7	19.9	55.2	19.5	Ave.
0.190501	35.8	19.8	54.0	18.2	Ave.
0.221500	42.6	19.8	52.8	10.2	Ave.
0.999030	31.1	19.9	46.0	14.9	Ave.
1.026370	30.9	19.9	46.0	15.1	Ave.

AC 120 V/60 Hz, Neutral

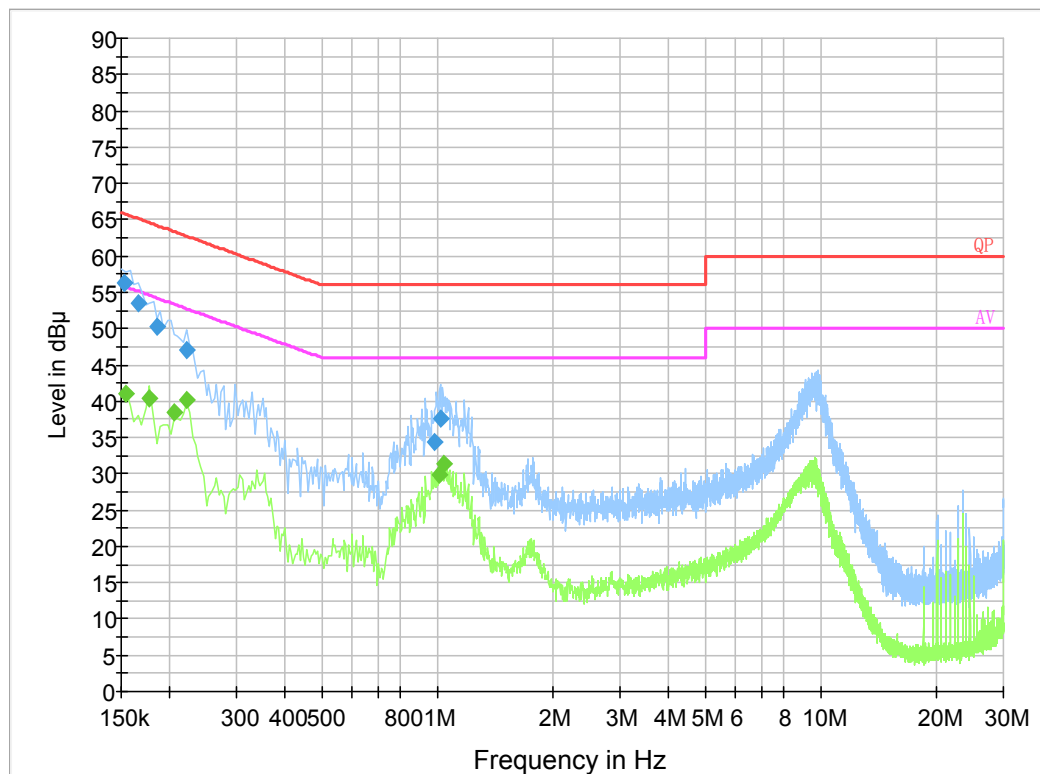
Frequency (MHz)	Corrected Amplitude (dBμV)	Correction Factor (dB)	Limit (dBμV)	Margin (dB)	Detector (PK/Ave./QP)
0.150000	56.7	19.8	66.0	9.3	QP
0.169500	51.2	19.8	65.0	13.8	QP
0.185500	49.7	19.8	64.2	14.5	QP
0.221500	48.2	19.8	62.8	14.6	QP
0.998970	37.1	19.8	56.0	18.9	QP
1.062250	37.2	19.8	56.0	18.8	QP
0.150000	41.9	19.8	56.0	14.1	Ave.
0.206000	40.1	19.8	53.4	13.3	Ave.
0.222000	42.4	19.8	52.7	10.3	Ave.
0.230000	38.1	19.8	52.4	14.3	Ave.
0.998000	31.6	19.8	46.0	14.4	Ave.
1.050000	31.4	19.8	46.0	14.6	Ave.

ZigBee Mode: (Middle channel was worst case)

AC 120 V/60 Hz, Line:



Frequency (MHz)	Corrected Amplitude (dBμV)	Correction Factor (dB)	Limit (dBμV)	Margin (dB)	Detector (PK/Ave./QP)
0.150000	57.0	19.8	66.0	9.0	QP
0.165500	53.6	19.9	65.2	11.6	QP
0.181500	51.5	19.9	64.4	12.9	QP
0.222500	46.8	19.8	62.7	15.9	QP
1.014970	36.5	19.9	56.0	19.5	QP
1.046070	37.7	19.9	56.0	18.3	QP
0.150000	42.5	19.8	56.0	13.5	Ave.
0.165500	37.2	19.9	55.2	18.0	Ave.
0.181500	38.4	19.9	54.4	16.0	Ave.
0.222500	39.6	19.8	52.7	13.1	Ave.
1.014970	30.2	19.9	46.0	15.8	Ave.
1.046070	31.5	19.9	46.0	14.5	Ave.

AC 120 V/60 Hz, Neutral:

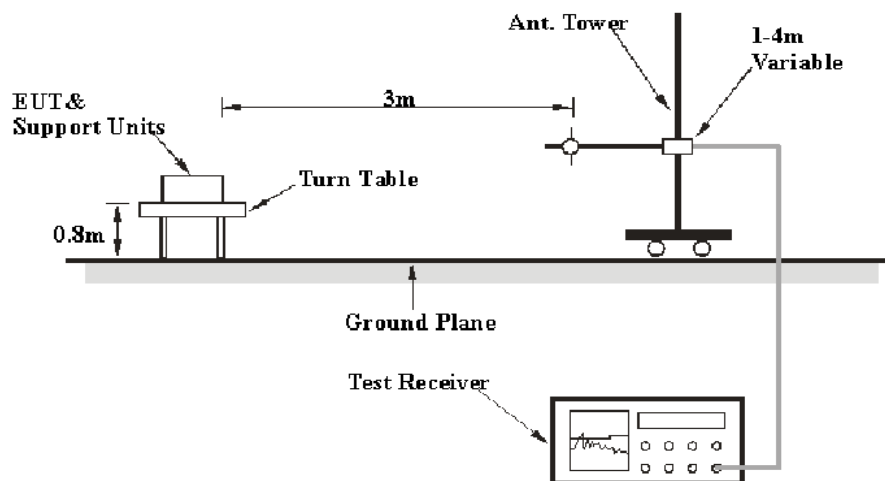
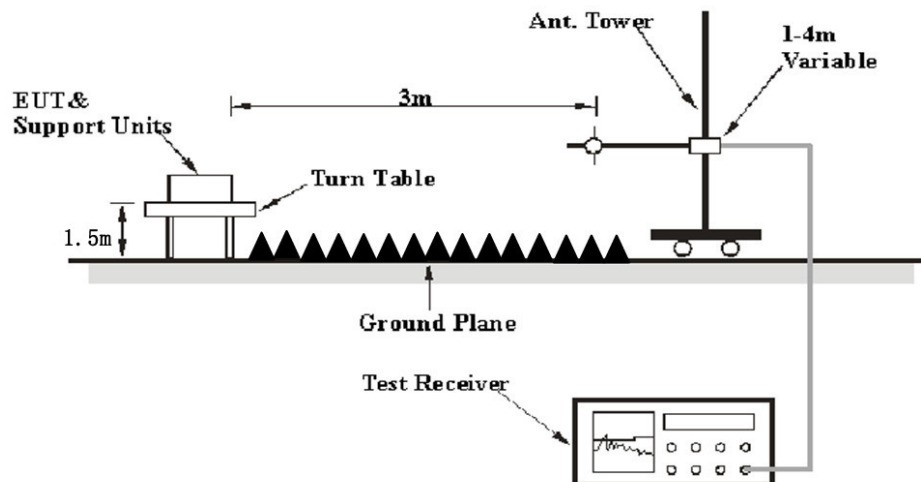
Frequency (MHz)	Corrected Amplitude (dBμV)	Correction Factor (dB)	Limit (dBμV)	Margin (dB)	Detector (PK/Ave./QP)
0.153500	56.3	19.8	65.8	9.5	QP
0.165500	53.5	19.8	65.2	11.7	QP
0.185500	50.2	19.8	64.2	14.0	QP
0.221500	47.0	19.8	62.8	15.8	QP
0.983030	34.5	19.8	56.0	21.5	QP
1.022730	37.5	19.8	56.0	18.5	QP
0.154000	40.9	19.8	55.8	14.9	Ave.
0.178000	40.4	19.8	54.6	14.2	Ave.
0.206000	38.5	19.8	53.4	14.9	Ave.
0.222000	40.1	19.8	52.7	12.6	Ave.
1.010000	29.8	19.8	46.0	16.2	Ave.
1.046000	31.5	19.8	46.0	14.5	Ave.

Note:

- 1) Correction Factor = LISN VDF (Voltage Division Factor) + Cable Loss + Transient Limiter Attenuation
- 2) Corrected Amplitude = Reading + Correction Factor
- 3) Margin = Limit – Corrected Amplitude

FCC §15.209, §15.205 & §15.247(d) - SPURIOUS EMISSIONS**Applicable Standard**

FCC §15.247 (d); §15.209; §15.205;

EUT Setup**Below 1 GHz:****Above 1GHz:**

The radiated emission tests were performed in the 3 meters test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209, and FCC 15.247 limits.

EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 25 GHz.

During the radiated emission test, the EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1MHz	3 MHz	/	PK
	1MHz	10 Hz ^{Note 1}	/	Average
	1MHz	> 1/T ^{Note 2}	/	Average

Note 1: when duty cycle is no less than 98%

Note 2: when duty cycle is less than 98%

Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

Data was recorded in Quasi-peak detection mode for frequency range of 30 MHz-1 GHz, peak and Average detection modes for frequencies above 1 GHz.

Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

$$\text{Corrected Amplitude} = \text{Meter Reading} + \text{Antenna Factor} + \text{Cable Loss} - \text{Amplifier Gain}$$

The “**Margin**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

$$\text{Margin} = \text{Limit} - \text{Corrected Amplitude}$$

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.209 and 15.247.

Test Data

Environmental Conditions

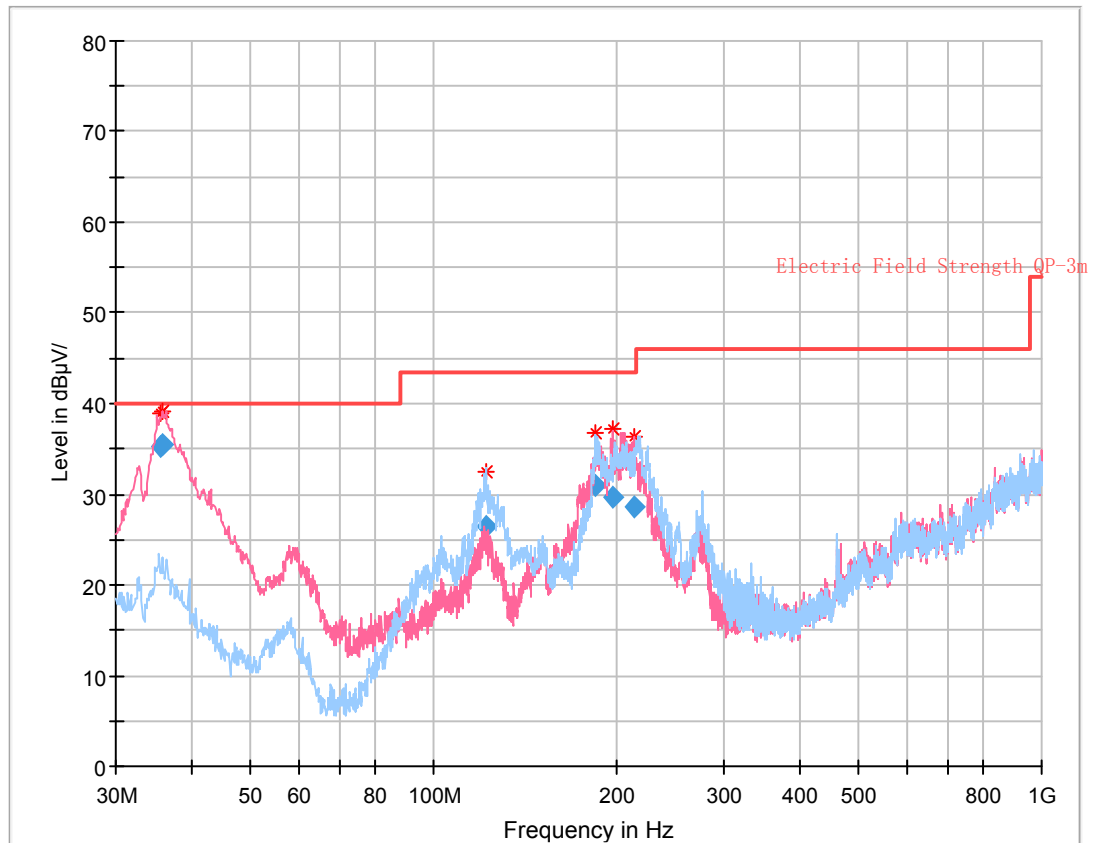
Temperature:	23~25 °C
Relative Humidity:	52~56 %
ATM Pressure:	101.0 kPa

The testing was performed by Zero Yan, Charlie Cha & Leo Huang from 2020-02-02 to 2020-03-30.

EUT operation mode: Transmitting

BLE 1M Mode: (Middle channel was worst case)

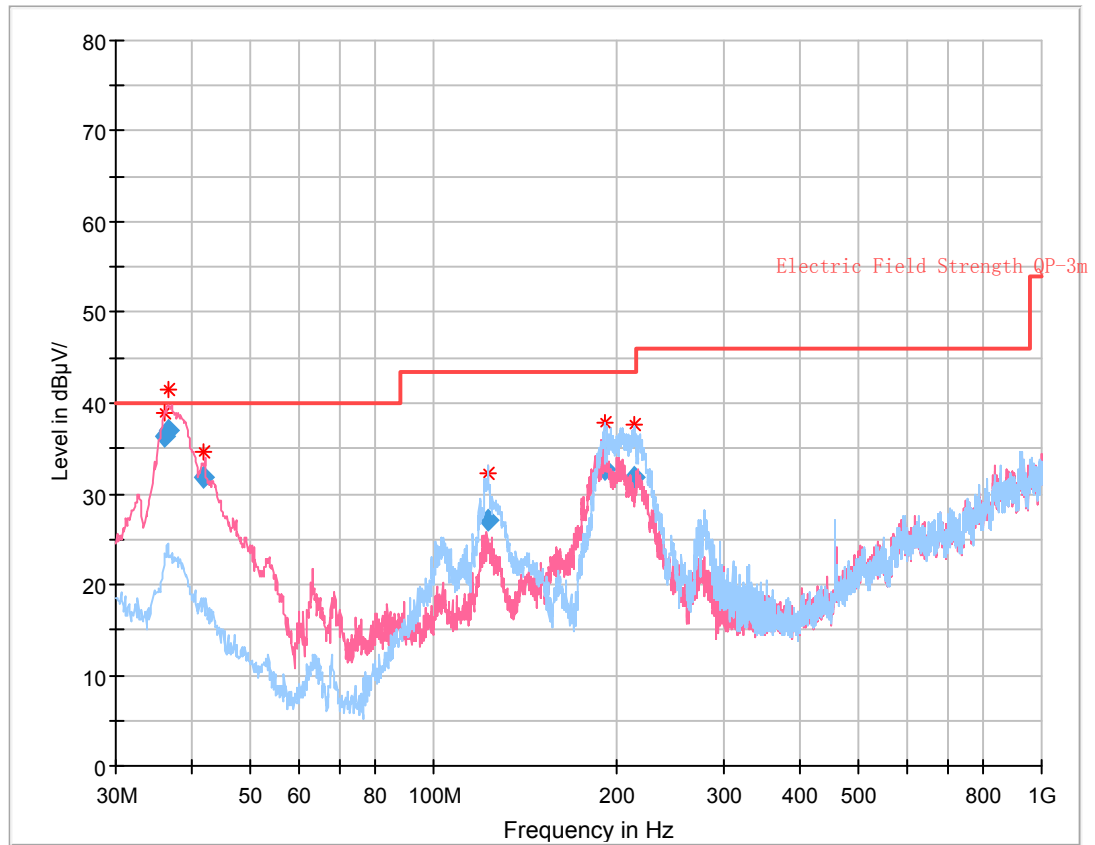
30 MHz~1 GHz:



Frequency (MHz)	Corrected Amplitude (dBμV/m)	Antenna height (cm)	Antenna Polarity	Turntable position (degree)	Correction Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
35.559875	35.34	102.0	V	234.0	-10.9	40.00	4.66
35.854875	35.45	115.0	V	334.0	-11.1	40.00	4.55
122.035500	26.46	294.0	H	281.0	-14.1	43.50	17.04
184.630500	30.93	121.0	H	300.0	-15.2	43.50	12.57
196.934625	29.75	103.0	V	90.0	-14.2	43.50	13.75
213.036750	28.53	111.0	V	95.0	-13.9	43.50	14.97

1 GHz-25 GHz:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2361.81	28.62	PK	102	2.0	H	31.87	60.49	74	13.51
2361.81	13.56	Ave.	102	2.0	H	31.87	45.43	54	8.57
2486.77	28.51	PK	88	2.5	H	32.13	60.64	74	13.36
2486.77	13.49	Ave.	88	2.5	H	32.13	45.62	54	8.38
4804.00	43.81	PK	134	1.5	H	5.40	49.21	74	24.79
4804.00	28.76	Ave.	134	1.5	H	5.40	34.16	54	19.84
4804.00	42.83	PK	41	1.3	V	6.28	49.11	74	24.89
4804.00	28.52	Ave.	41	1.3	V	6.28	34.80	54	19.20
Middle Channel (2442 MHz)									
4884.00	43.96	PK	324	1.9	H	6.43	50.39	74	23.61
4884.00	28.82	Ave.	324	1.9	H	6.43	35.25	54	18.75
4884.00	42.87	PK	76	1.1	V	6.76	49.63	74	24.37
4884.00	29.39	Ave.	76	1.1	V	6.76	36.15	54	17.85
High Channel (2480 MHz)									
2331.82	28.55	PK	131	1.1	H	31.64	60.19	74	13.81
2331.82	13.46	Ave.	131	1.1	H	31.64	45.10	54	8.90
2495.68	28.86	PK	50	1.5	H	32.13	60.99	74	13.01
2495.68	13.65	Ave.	50	1.5	H	32.13	45.78	54	8.22
4960.00	44.28	PK	50	1.6	H	6.95	51.23	74	22.77
4960.00	29.13	Ave.	50	1.6	H	6.95	36.08	54	17.92
4960.00	42.89	PK	275	1.8	V	6.80	49.69	74	24.31
4960.00	29.46	Ave.	275	1.8	V	6.80	36.26	54	17.74

BLE 2M Mode: (Middle channel was worst case)**30 MHz~1 GHz:**

Frequency (MHz)	Corrected Amplitude (dBμV/m)	Antenna height (cm)	Antenna Polarity	Turntable position (degree)	Correction Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
36.145625	36.41	101.0	V	58.0	-11.3	40.00	3.59
36.604750	37.09	110.0	V	157.0	-11.6	40.00	2.91
41.797250	31.74	102.0	V	124.0	-15.1	40.00	8.26
123.273500	27.00	292.0	H	90.0	-14.1	43.50	16.50
190.658750	32.64	110.0	H	96.0	-15.1	43.50	10.86
213.858375	31.78	101.0	H	275.0	-13.9	43.50	11.72

1 GHz-25 GHz:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2389.43	27.92	PK	341	2.1	H	31.87	59.79	74	14.21
2389.43	14.56	Ave.	341	2.1	H	31.87	46.43	54	7.57
2483.57	27.83	PK	94	1.8	H	32.13	59.96	74	14.04
2483.57	14.48	Ave.	94	1.8	H	32.13	46.61	54	7.39
4804.00	43.68	PK	134	2.0	H	6.28	49.96	74	24.04
4804.00	29.69	Ave.	134	2.0	H	6.28	35.97	54	18.03
4804.00	42.69	PK	23	2.3	V	6.28	48.97	74	25.03
4804.00	29.39	Ave.	23	2.3	V	6.28	35.67	54	18.33
Middle Channel (2442 MHz)									
4884.00	43.03	PK	159	1.6	H	6.76	49.79	74	24.21
4884.00	29.36	Ave.	159	1.6	H	6.76	36.12	54	17.88
4884.00	42.69	PK	273	1.4	V	6.76	49.45	74	24.55
4884.00	29.42	Ave.	273	1.4	V	6.76	36.18	54	17.82
High Channel (2480 MHz)									
2488.76	27.54	PK	25	1.2	H	32.13	59.67	74	14.33
2488.76	14.37	Ave.	25	1.2	H	32.13	46.50	54	7.50
2487.97	28.40	PK	7	1.4	H	32.13	60.53	74	13.47
2487.97	14.65	Ave.	7	1.4	H	32.13	46.78	54	7.22
4960.00	43.40	PK	234	1.3	H	6.80	50.20	74	23.80
4960.00	29.66	Ave.	234	1.3	H	6.80	36.46	54	17.54
4960.00	43.06	PK	125	2.3	V	6.80	49.86	74	24.14
4960.00	29.47	Ave.	125	2.3	V	6.80	36.27	54	17.73

Note:

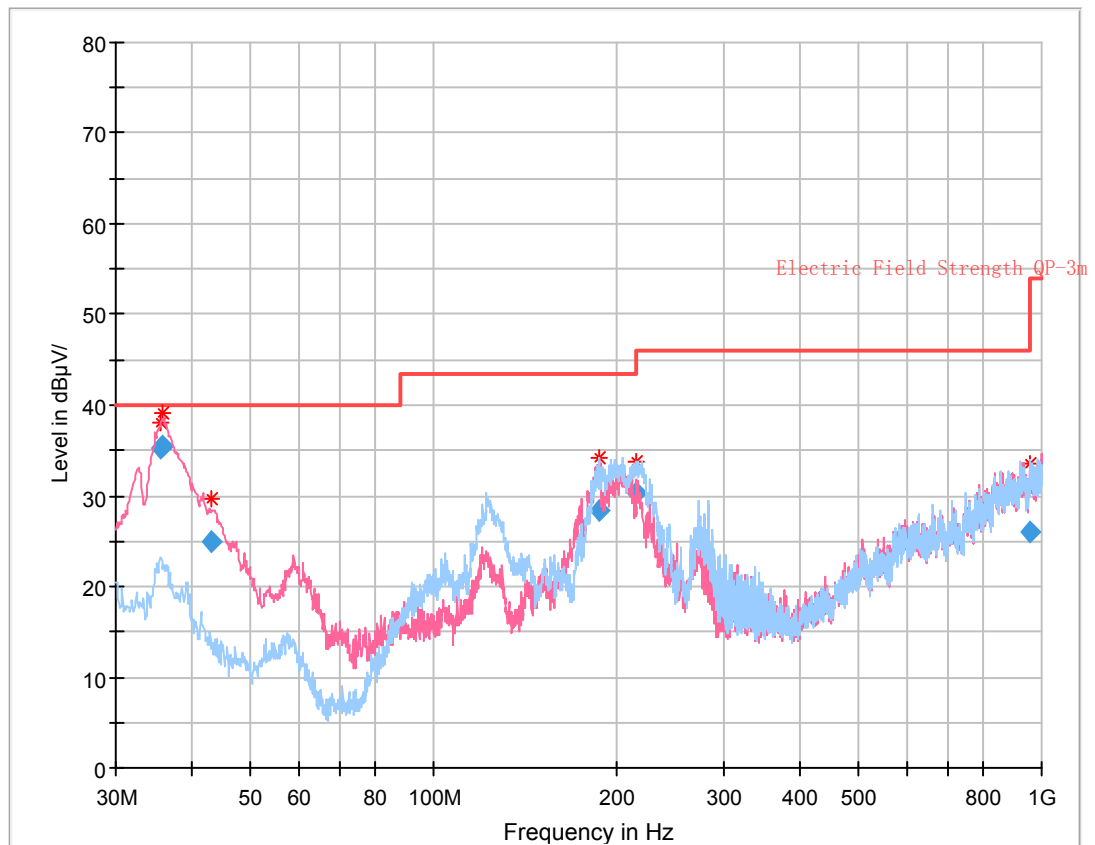
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor

Corrected Amplitude = Corrected Factor + Reading

Margin = Limit - Corrected. Amplitude

The other spurious emission which is 20dB to the limit was not recorded.

And for the pre-scan is performed with the 2400-2483.5MHz band filter.

ZigBee Mode:**30 MHz~1 GHz: (Middle channel was worst case)**

Frequency (MHz)	Corrected Amplitude (dBμV/m)	Antenna height (cm)	Antenna Polarity	Turntable position (degree)	Correction Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
35.631750	35.24	109.0	V	294.0	-10.9	40.00	4.76
35.851125	35.44	103.0	V	282.0	-11.1	40.00	4.56
43.212125	25.02	105.0	V	24.0	-16.0	40.00	14.98
187.267125	28.48	203.0	V	351.0	-15.2	43.50	15.02
215.868750	30.28	129.0	H	47.0	-13.9	43.50	13.22
959.749750	25.93	366.0	H	306.0	5.3	46.00	20.07

1 GHz-25 GHz:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2405 MHz)									
2329.26	28.52	PK	192	1.0	H	31.64	60.16	74	13.84
2329.26	13.65	Ave.	192	1.0	H	31.64	45.29	54	8.71
2486.77	28.83	PK	207	1.7	H	32.13	60.96	74	13.04
2486.77	13.92	Ave.	207	1.7	H	32.13	46.05	54	7.95
4810.00	43.88	PK	203	2.4	H	5.40	49.28	74	24.72
4810.00	28.61	Ave.	203	2.4	H	5.40	34.01	54	19.99
Middle Channel (2445 MHz)									
4890.00	44.15	PK	65	1.0	H	6.43	50.58	74	23.42
4890.00	28.74	Ave.	65	1.0	H	6.43	35.17	54	18.83
High Channel (2480 MHz)									
2324.31	28.16	PK	106	1.5	H	31.64	59.80	74	14.20
2324.31	13.78	Ave.	106	1.5	H	31.64	45.42	54	8.58
2494.59	28.39	PK	42	1.4	H	32.13	60.52	74	13.48
2494.59	14.03	Ave.	42	1.4	H	32.13	46.16	54	7.84
4960.00	44.13	PK	66	2.3	H	6.95	51.08	74	22.92
4960.00	28.72	Ave.	66	2.3	H	6.95	35.67	54	18.33

Note:

Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor

Corrected Amplitude = Corrected Factor + Reading

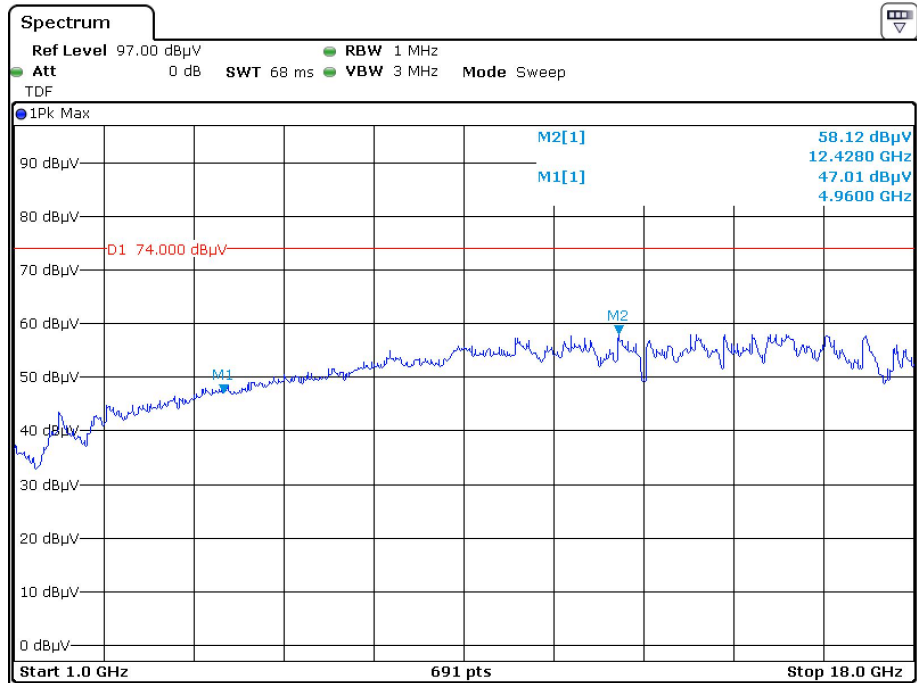
Margin = Limit - Corrected. Amplitude

The other spurious emission which is 20dB to the limit was not recorded.

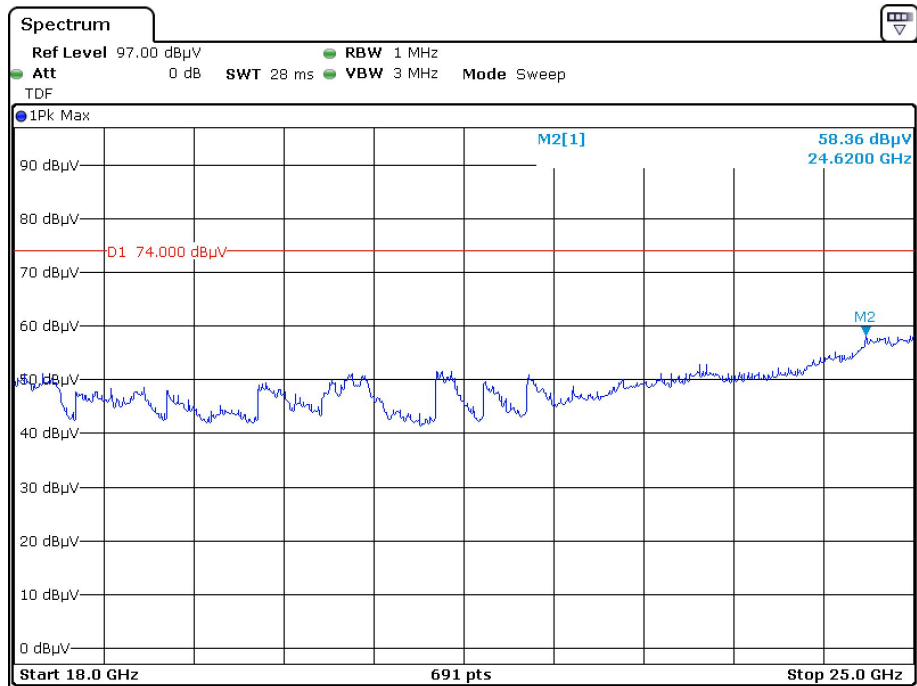
And for the pre-scan is performed with the 2400-2483.5MHz band filter.

Zigbee:

Pre-scan with High channel Horizontal

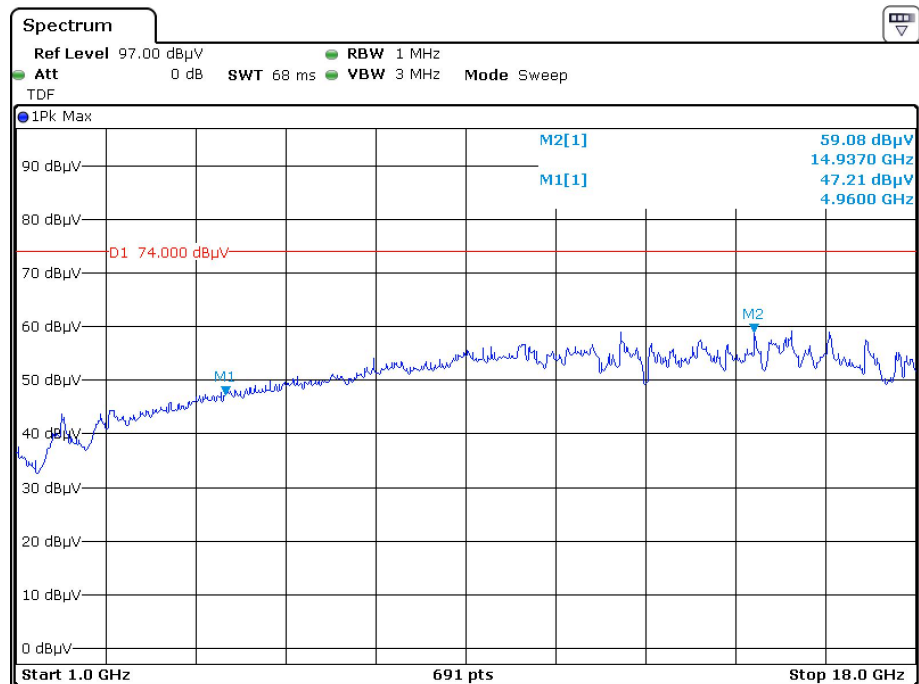


Date: 2.FEB.2020 17:02:40

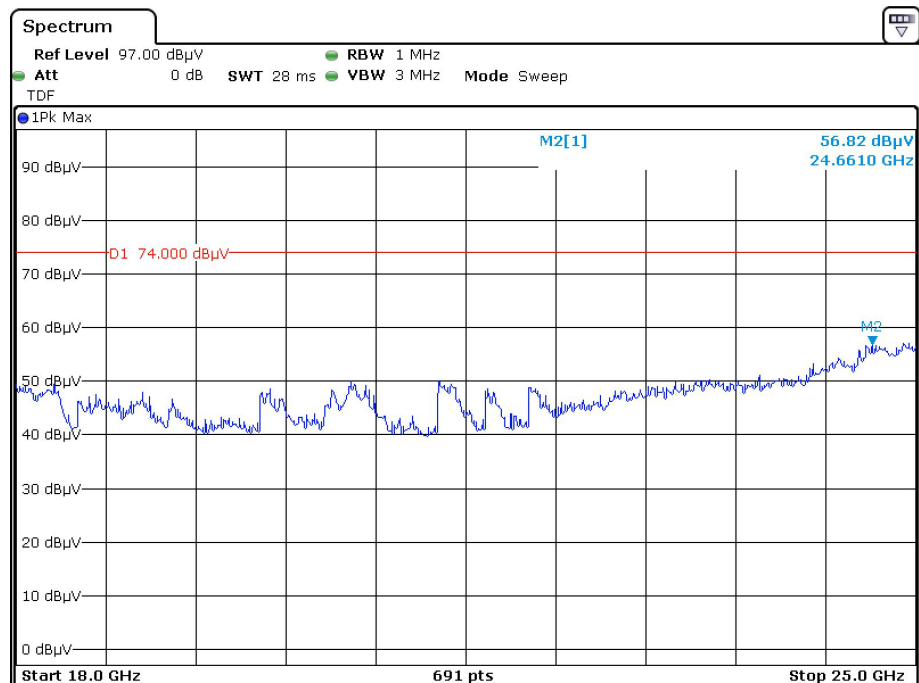


Date: 2.FEB.2020 17:51:17

Vertical

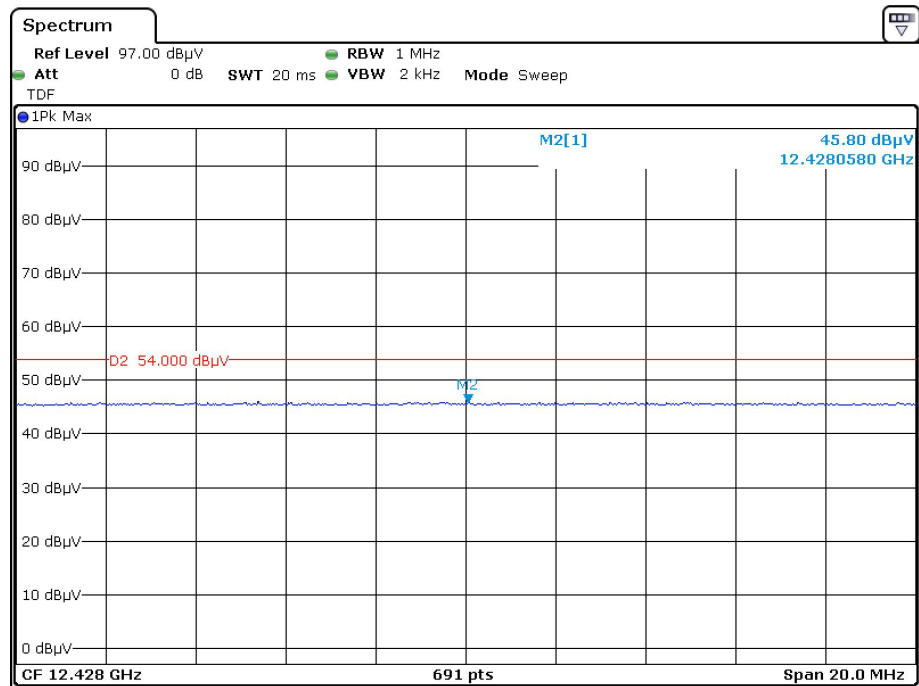


Date: 2.FEB.2020 17:14:22

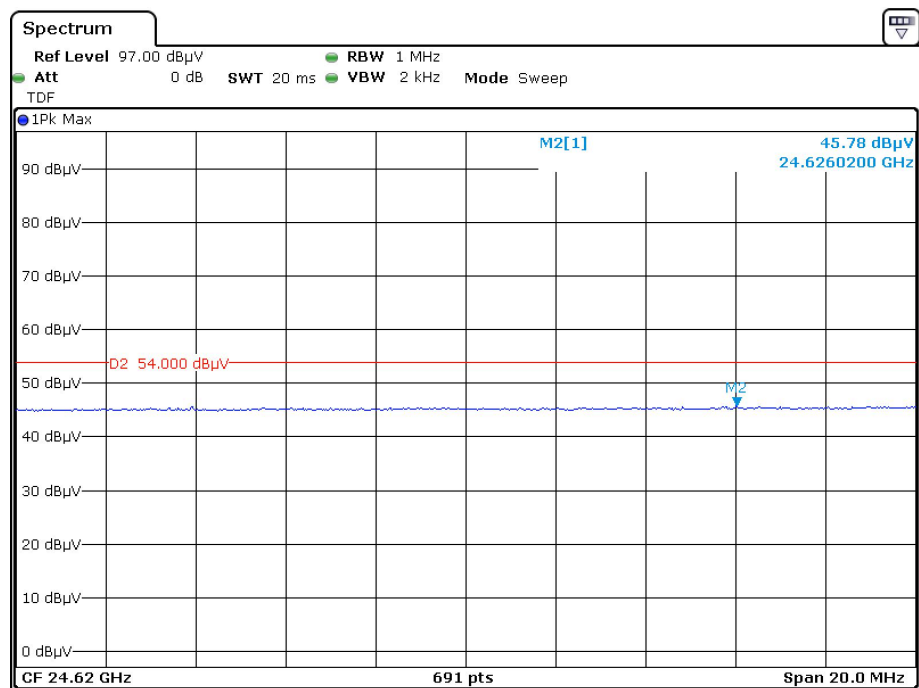


Date: 2.FEB.2020 18:06:41

Pre-scan for Average Horizontal

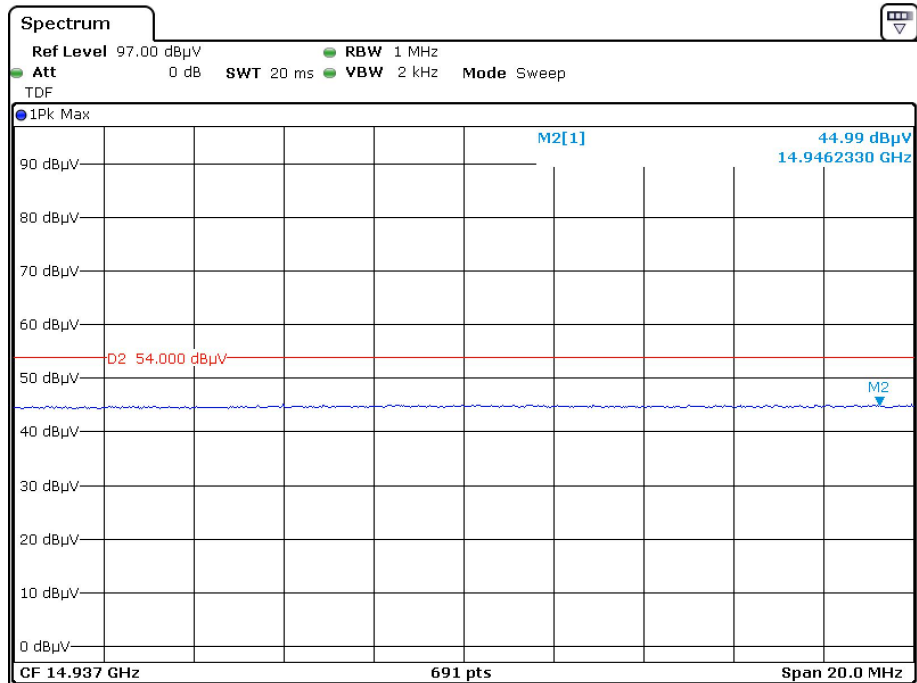


Date: 5.MAR.2020 17:05:48

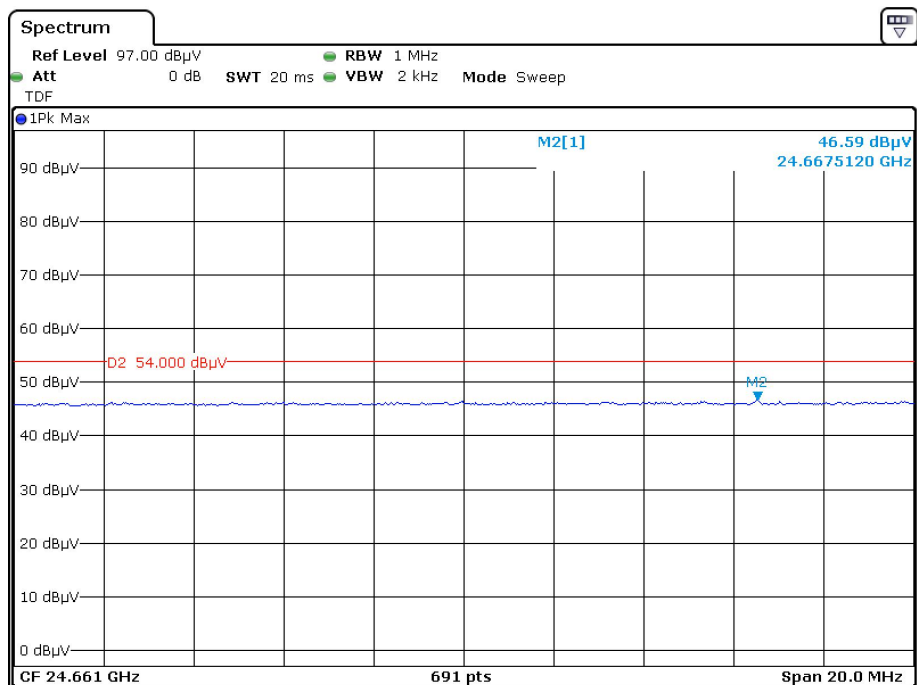


Date: 5.MAR.2020 18:02:29

Vertical



Date: 5.MAR.2020 17:19:19



Date: 5.MAR.2020 18:11:59

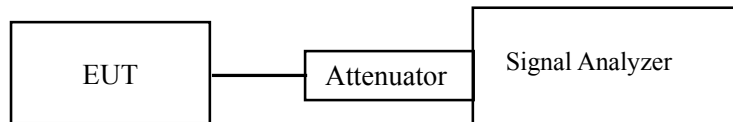
FCC §15.247(a) (2) – 6 dB EMISSION BANDWIDTH

Applicable Standard

Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 6 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.



Test Data

Environmental Conditions

Temperature:	23~25 °C
Relative Humidity:	50~51 %
ATM Pressure:	101.0 kPa

The testing was performed by Jimmy Xiao from 2020-02-19 to 2020-03-28.

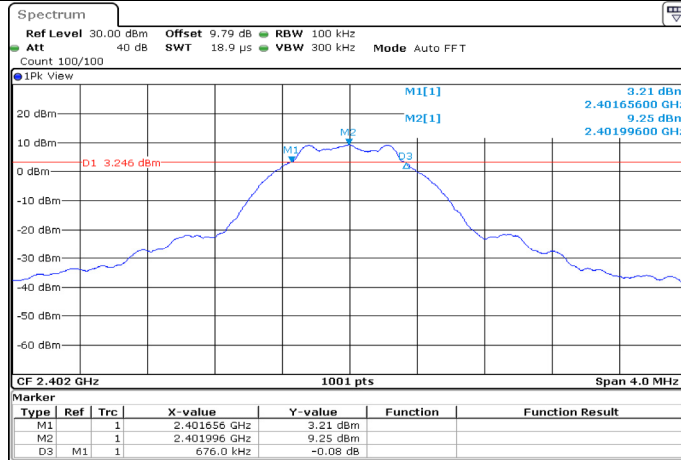
EUT operation mode: Transmitting

Test Result: Pass.

Please refer to the following table and plots.

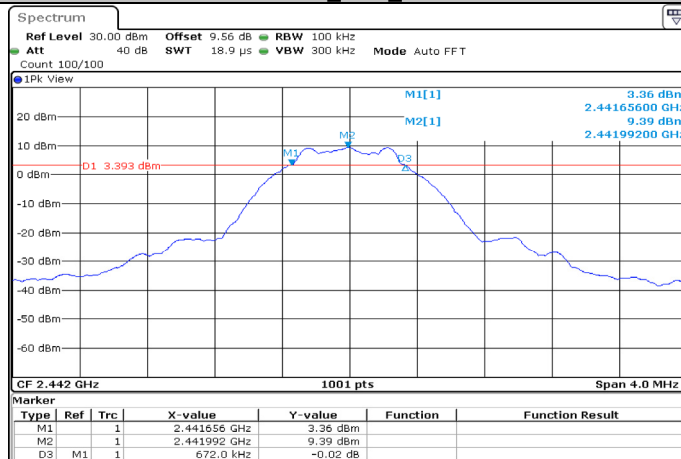
Test Mode	Antenna	Channel	DTS BW [MHz]	Limit [MHz]	Verdict
BLE 1M	Ant1	2402	0.676	0.5	PASS
		2442	0.672	0.5	PASS
		2480	0.668	0.5	PASS
BLE 2M	Ant1	2402	1.120	0.5	PASS
		2442	1.120	0.5	PASS
		2480	1.120	0.5	PASS
Zigbee	Ant1	2405	1.84	0.5	PASS
		2445	1.86	0.5	PASS
		2480	1.68	0.5	PASS

BLE 1M_Ant1_2402



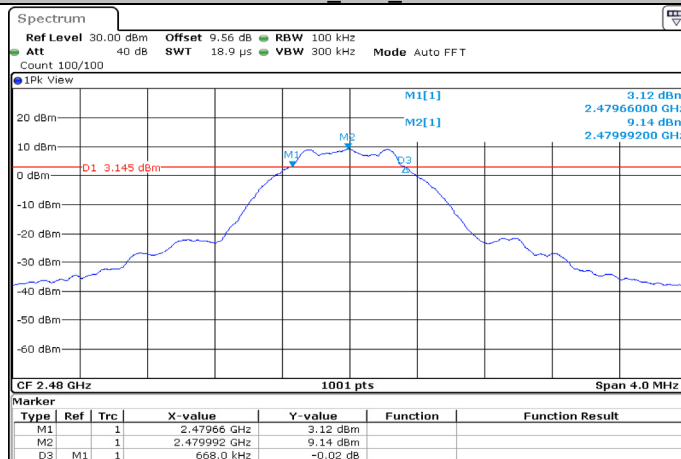
Date: 19.FEB.2020 17:18:29

BLE 1M_Ant1_2442



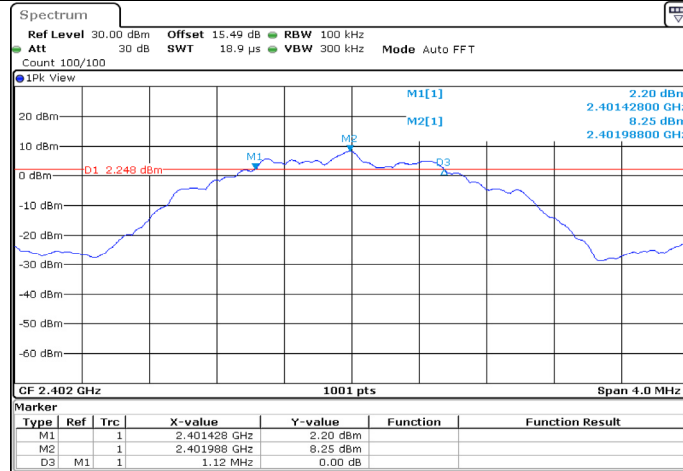
Date: 19.FEB.2020 17:24:01

BLE 1M_Ant1_2480



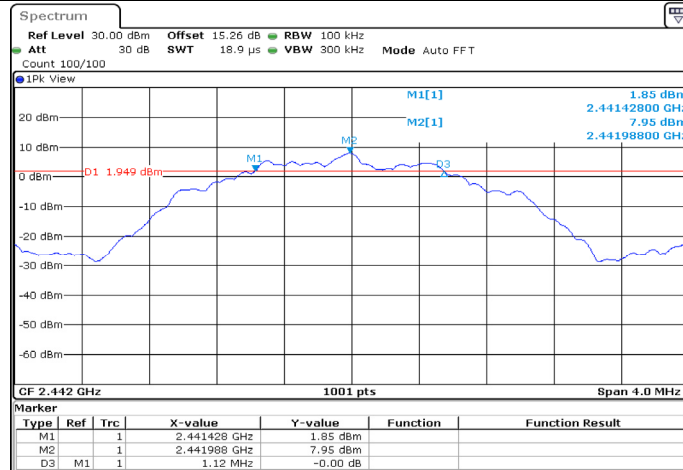
Date: 19.FEB.2020 17:26:09

BLE 2M_Ant1_2402



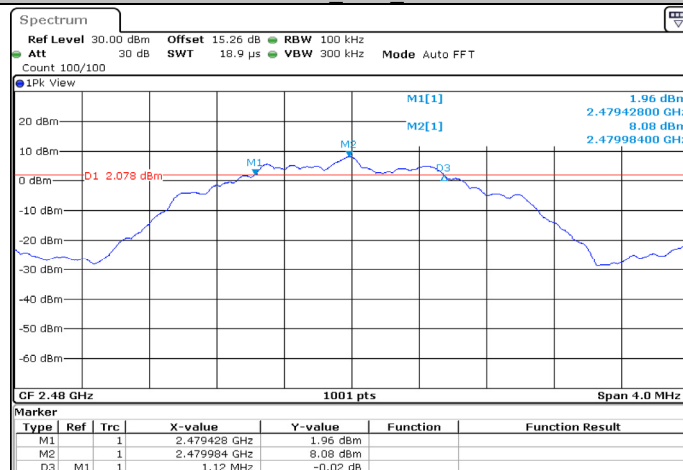
Date: 28.MAR.2020 17:37:10

BLE 2M_Ant1_2442



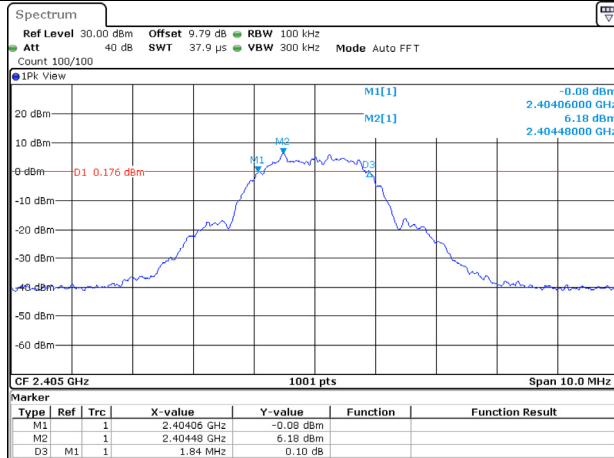
Date: 28.MAR.2020 17:40:22

BLE 2M_Ant1_2480



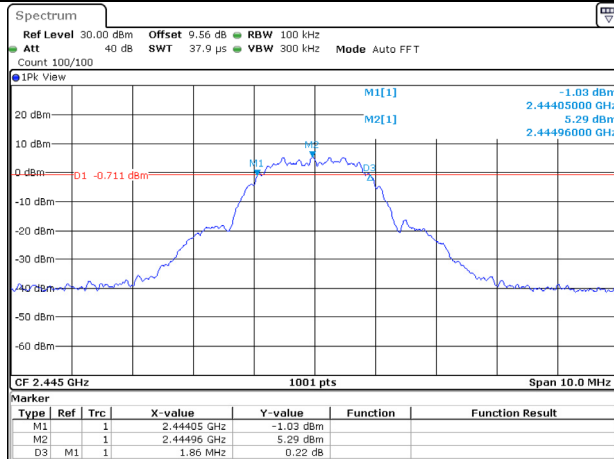
Date: 28.MAR.2020 17:42:27

Zigbee_Ant1_2405



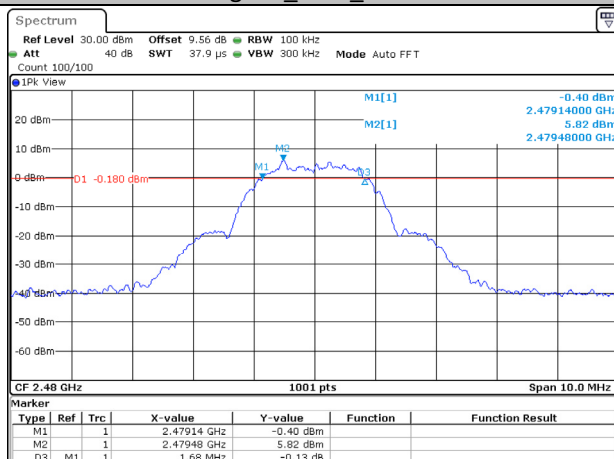
Date: 20.FEB.2020 09:31:36

Zigbee_Ant1_2445



Date: 20.FEB.2020 09:37:39

Zigbee_Ant1_2480



Date: 20.FEB.2020 09:39:49

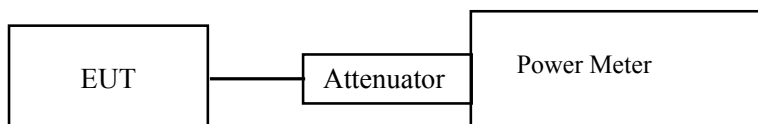
FCC §15.247(b) (3) - MAXIMUM CONDUCTED OUTPUT POWER

Applicable Standard

According to FCC §15.247(b) (3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

Test Procedure

1. Place the EUT on a bench and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.



Test Data

Environmental Conditions

Temperature:	23 °C
Relative Humidity:	51 %
ATM Pressure:	101.0 kPa

The testing was performed by Jimmy Xiao on 2020-02-20.

EUT operation mode: Transmitting

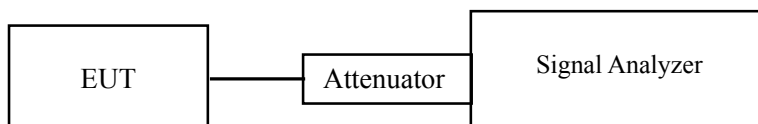
Test Mode	Antenna	Channel	Result [dBm]	Limit [dBm]	Verdict
BLE 1M	Ant1	2402	9.97	<=30	PASS
		2442	10.41	<=30	PASS
		2480	10.52	<=30	PASS
BLE 2M	Ant1	2402	9.20	<=30	PASS
		2442	9.15	<=30	PASS
		2480	9.34	<=30	PASS
Zigbee	Ant1	2405	9.63	<=30	PASS
		2445	10.02	<=30	PASS
		2480	10.14	<=30	PASS

FCC §15.247(d) – 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE**Applicable Standard**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW to 100 kHz and VBW of spectrum analyzer to 300 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.

**Test Data****Environmental Conditions**

Temperature:	23~25 °C
Relative Humidity:	50~51 %
ATM Pressure:	101.0 kPa

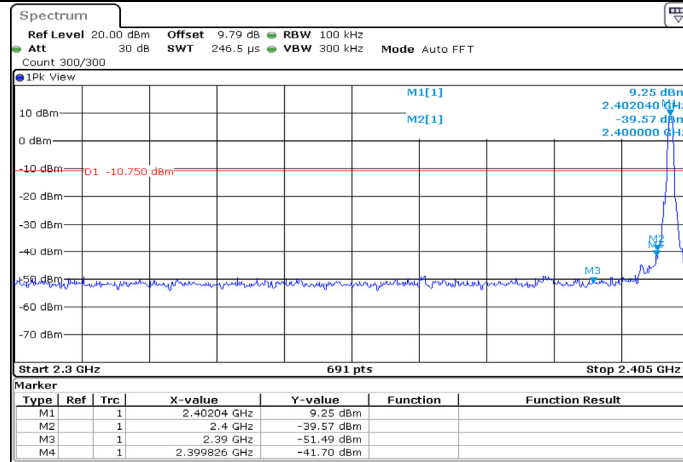
The testing was performed by Jimmy Xiao from 2020-02-19 to 2020-03-28.

EUT operation mode: Transmitting

Test Result: Compliance

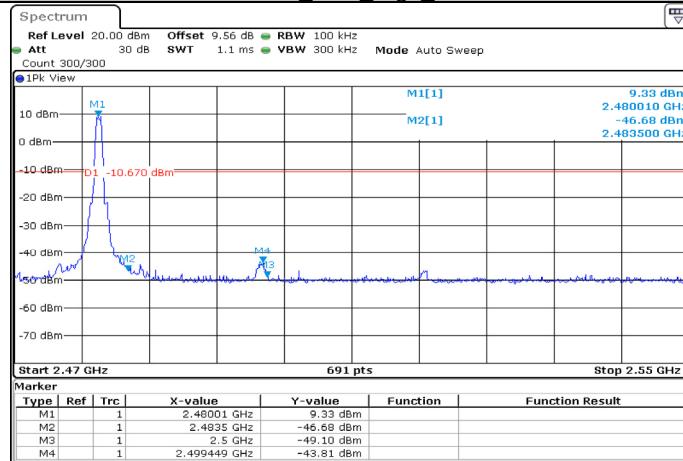
Please refer to the following plots.

BLE 1M Ant1 Low 2402



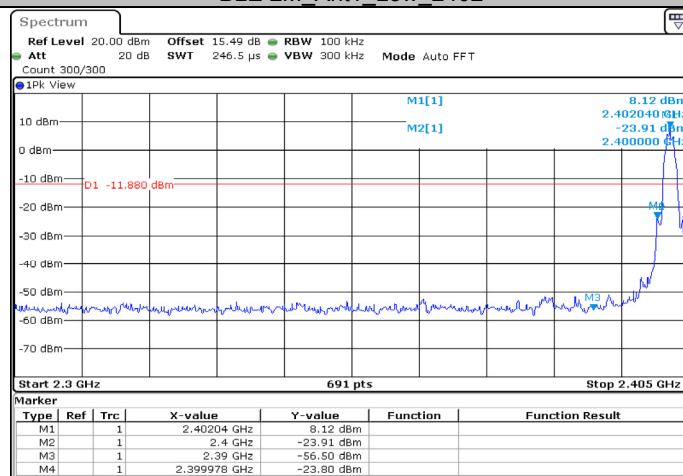
Date: 19.FEB.2020 17:18:55

BLE 1M Ant1 High 2480

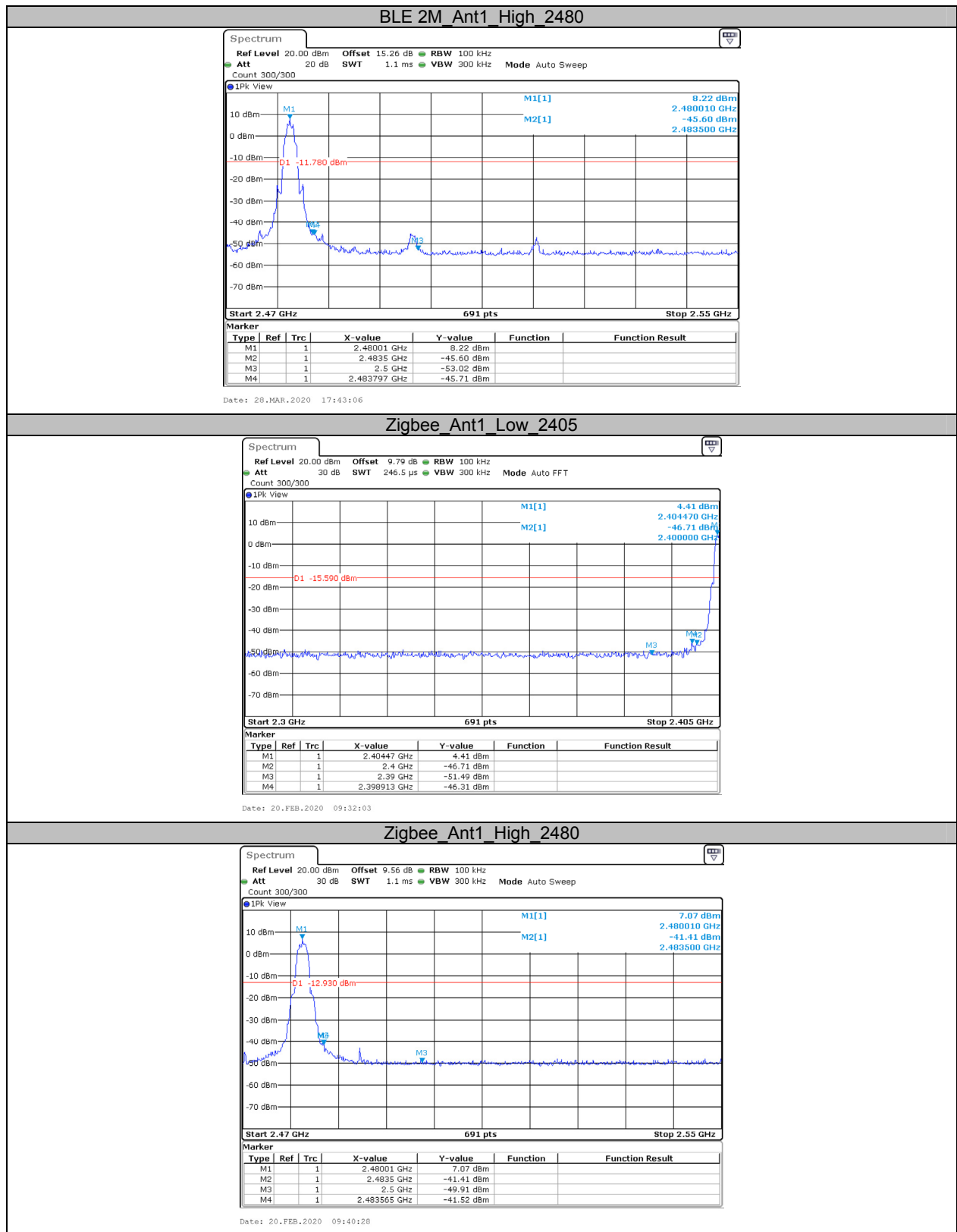


Date: 19.FEB.2020 17:26:36

BLE 2M Ant1 Low 2402



Date: 28.MAR.2020 17:37:43



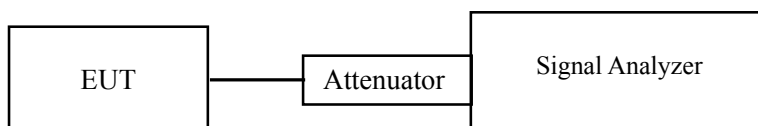
FCC §15.247(e) - POWER SPECTRAL DENSITY

Applicable Standard

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

Test Procedure

1. Use this procedure when the maximum peak conducted output power in the fundamental emission is used to demonstrate compliance.
2. Set the RBW to: $3\text{kHz} \leq \text{RBW} \leq 100\text{ kHz}$.
3. Set the VBW $\geq 3 \times \text{RBW}$.
4. Set the span to 1.5 times the DTS bandwidth.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.



Test Data

Environmental Conditions

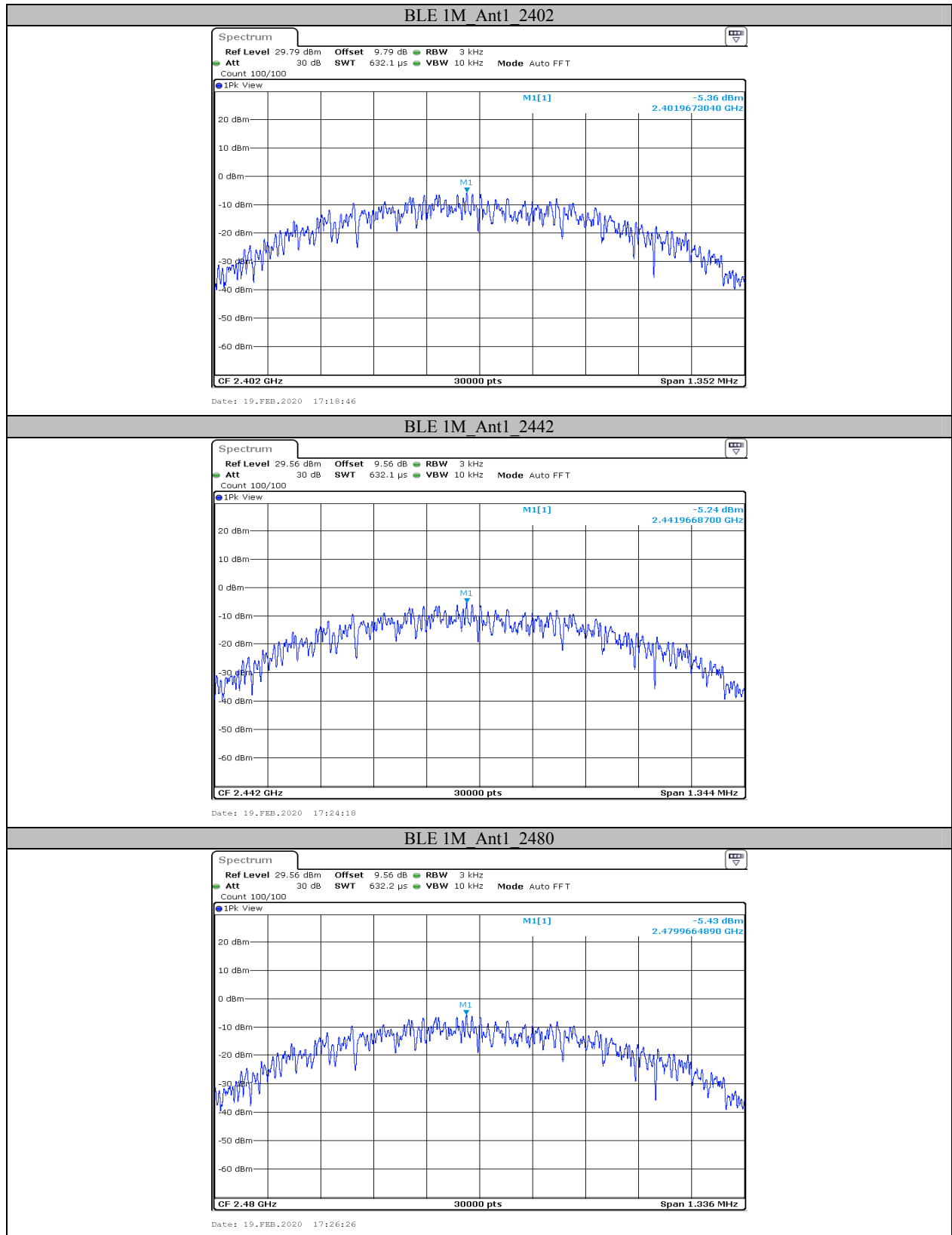
Temperature:	23~25 °C
Relative Humidity:	50~51 %
ATM Pressure:	101.0 kPa

The testing was performed by Jimmy Xiao from 2020-02-19 to 2020-03-28.

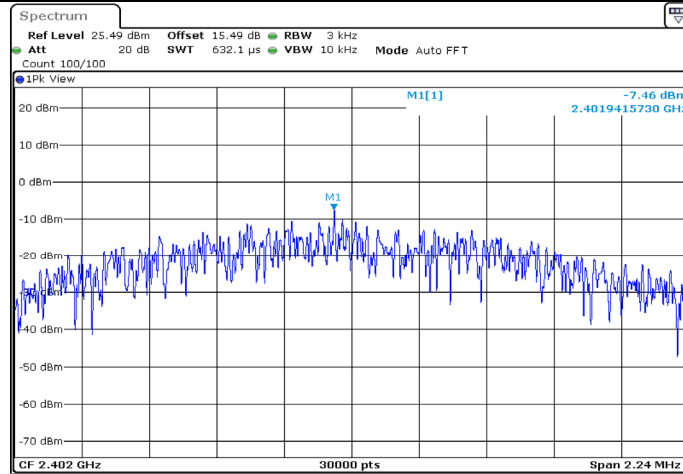
EUT operation mode: Transmitting

Test Result: Pass

Test Mode	Antenna	Channel	Result [dBm/3kHz]	Limit [dBm/3kHz]	Verdict
BLE 1M	Ant1	2402	-5.36	<=8	PASS
		2442	-5.24	<=8	PASS
		2480	-5.43	<=8	PASS
BLE 2M	Ant1	2402	-7.46	<=8	PASS
		2442	-7.76	<=8	PASS
		2480	-7.54	<=8	PASS
Zigbee	Ant1	2405	-2.99	<=8	PASS
		2445	-3.64	<=8	PASS
		2480	-3.64	<=8	PASS

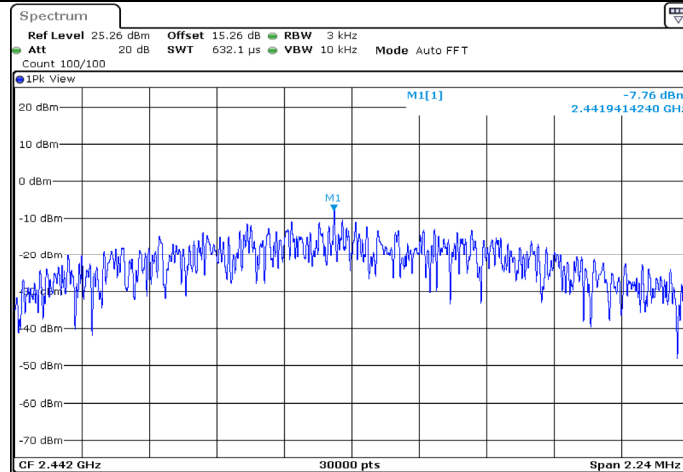


BLE 2M_Ant1_2402



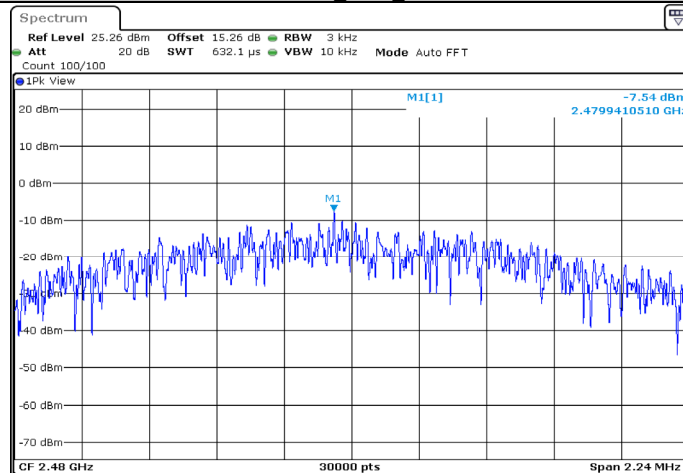
Date: 28.MAR.2020 17:37:34

BLE 2M_Ant1_2442



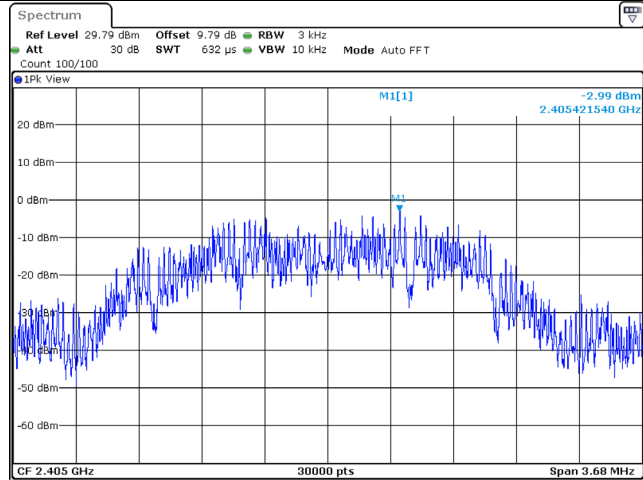
Date: 28.MAR.2020 17:40:52

BLE 2M_Ant1_2480

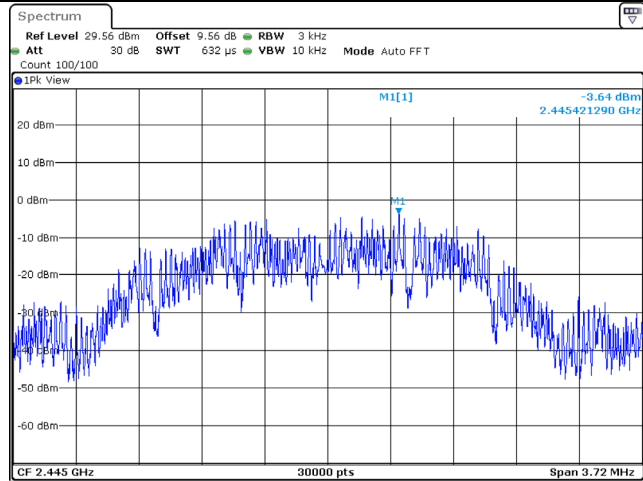


Date: 28.MAR.2020 17:42:57

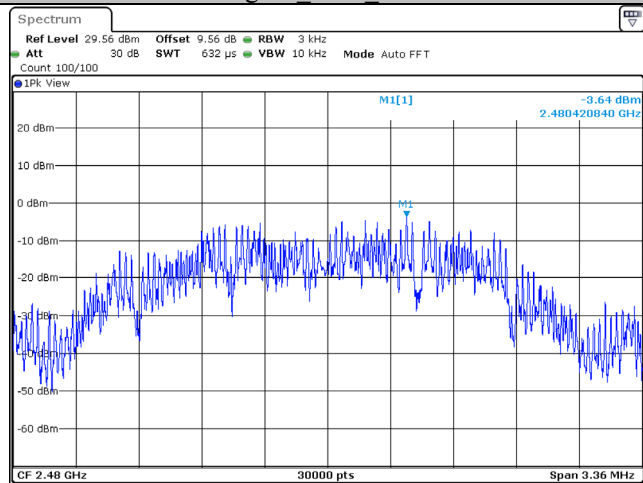
Zigbee Ant1 2405



Zigbee Ant1 2445



Zigbee Ant1 2480



***** END OF REPORT *****