FCC Part 15.247

TEST REPORT

For

MAD CATZ GLOBAL LIMITED

Office H on 22nd Floor, Kings Wing Plaza 2, No.1 on Kwan Street, Sha Tin, N.T., HK.

FCC ID: 2ASFYMR04DHINBL0000

Report Type:	**Product Type:**
Original Report	Hybrid Optical Gaming mouse

Report Producer : Kaylee Chiang

Report Number : RXZ190226003-00C

Report Date : 2019-06-19

Reviewed By: Jerry Chang

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Revision History

Revision	No.	Report Number	Issue Date	Description	Author/ Revised by
1.0	RXZ190226003	RXZ190226003-00C	2019-06-19	Original Report	Kaylee Chiang

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1 General Information

1.1 Product Description for Equipment under Test (EUT)

Applicant	MAD CATZ GLOBAL LIMITED
	Office H on 22nd Floor, Kings Wing Plaza 2, No.1 on Kwan Street, Sha Tin, N.T., HK.
Manufacturer	Dexin Electronics Co.,Ltd.
	No.2, Jianye 2 Road, Shitanpu Village. Tangxia Town, Dongguan Guangdong Province,P.R. China
Brand(Trade) Name	MAD CATZ
Product (Equipment)	Hybrid Optical Gaming mouse
Main Model Name	MAD CATZ R.A.T. AIR
Frequency Range	2406, 2430, 2445, 2460, 2478 MHz
Transmit Power	0.82 dBm
Modulation Technique	GFSK
Number of Channels	5 Channels
Antenna Specification	PCB Antenna / 1.974 dBi
Power Operation (Voltage Range)	☐ AC 120V/60Hz ☐ Adapter I/P ☐ By AC Power Cord ☐ PoE
	☒ DC Type ☐ Battery ☐ DC Power Supply ☒ External from USB Cable: 5Vdc ☐ External DC Adapter
	☐ Host System
Received Date	Feb 27, 2019
Date of Test	Mar 07, 2019 ~ June 19, 2019

**All measurement and test data in this report was gathered from production sample serial number: 190226003 (Assigned by BACL, Taiwan).*

1.2 Objective

This report is prepared on behalf of *MAD CATZ GLOBAL LIMITED* in accordance with Part 2, Subpart J, Part 15, Subparts A and C of the Federal Communication Commission's rules.

The objective is to determine compliance with FCC Part 15.247 rules for Output Power, Antenna Requirements, 6 dB Bandwidth, Power Spectral Density, 100 kHz Bandwidth of Band Edges Measurement, Conducted and Radiated Spurious Emissions.

1.3 Related Submittal(s)/Grant(s)

N/A.

1.4 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.

1.5 Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (Taiwan) to collect test data is located on

☒70, Lane 169, Sec. 2, Datong Road, Xizhi Dist., New Taipei City 22183, Taiwan, R.O.C.

☐68-3, Lane 169, Sec. 2, Datong Road, Xizhi Dist., New Taipei City 22183, Taiwan, R.O.C.

Bay Area Compliance Laboratories Corp. (Taiwan) Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 3180) and the FCC designation No.TW3180 under the Mutual Recognition Agreement (MRA) in FCC Test. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.10.

The Federal Communications Commission has the reports on file and is listed under FCC Registration No.: 974454. The test site has been approved by the FCC for public use and is listed in the FCC Public Access Link (PAL) database.

2 System Test Configuration

2.1 Description of Test Configuration

The system was configured for testing in engineering mode, the maximum power output configured by default setting and switched the channels by keys.

There are totally 5 channels.

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2406	4	2430
2	2478	5	2445
3	2460	--	--

There were tested with channel 1, 2 and 5.

2.2 Equipment Modifications

No modification was made to the EUT.

2.3 EUT Exercise Software

There was no software to used.

2.4 Support Equipment List and Details

Description	Manufacturer	Model Number	BSMI	FCC ID	S/N
NB	DELL	E6410	N/A	PD98260NGU	10912240367
FIX	N/A	N/A	N/A	N/A	N/A

2.5 External Cable List and Details

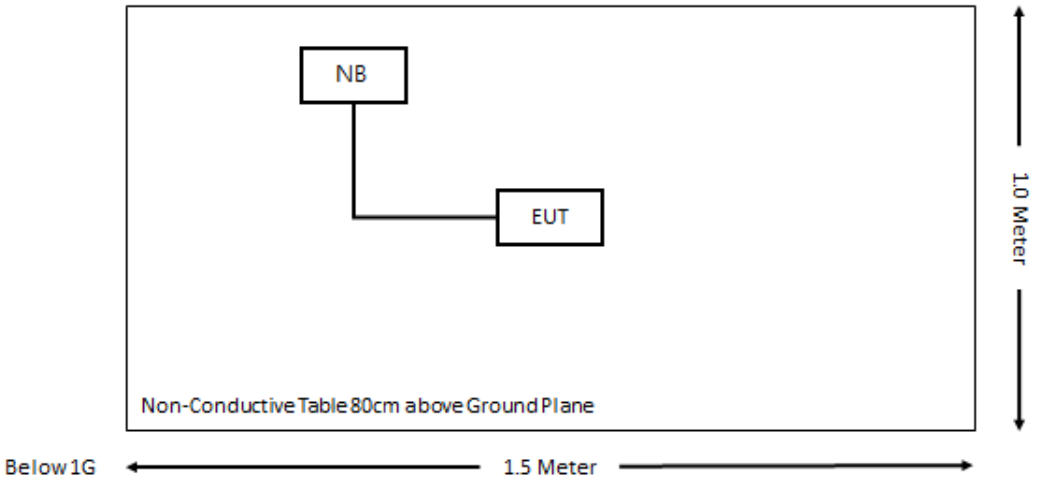
Cable Description	Length (m)	From	To
Micro USB Cable	1.5	NB	Base
Micro USB Cable	1.5	NB	FIX

2.6 Block Diagram of Test Setup

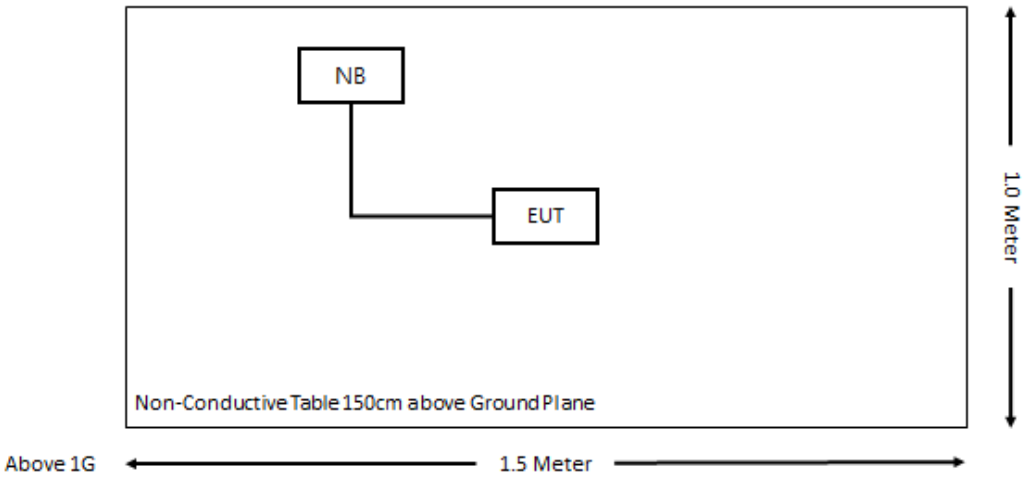
See test photographs attached in setup photos for the actual connections between EUT and support equipment.

Radiation:

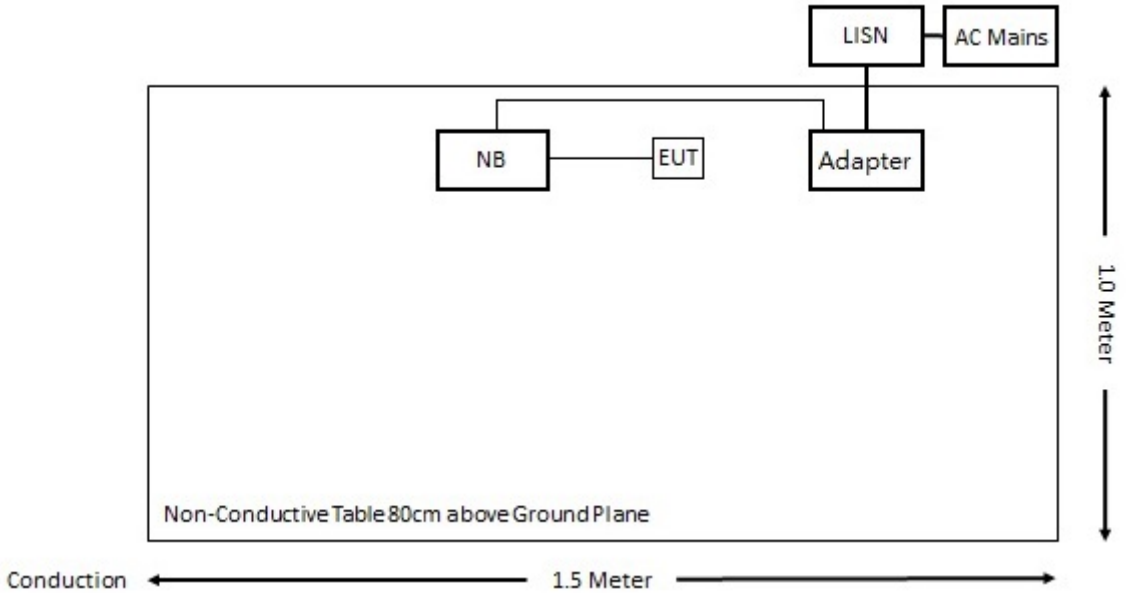
Below 1GHz:



Above 1GHz:



Conduction:



2.7 Duty Cycle

According to KDB 558074 D01 15.247 Meas Guidance v05 section 6.0:

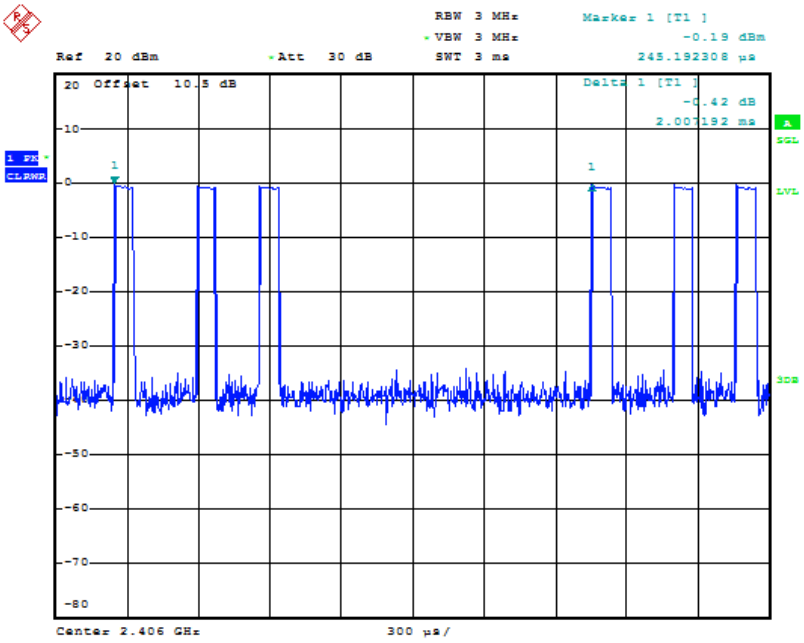
All measurements are to be performed with the EUT transmitting at 100% duty cycle at its maximum power control level; however, if 100% duty cycle cannot be achieved, measurements of duty cycle, x, and maximumpower transmission duration, T, are required for each tested mode of operation.

On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
0.247	2.007	0.12	9.21

Note: Duty Cycle Correction Factor = 10*log(1/duty cycle)

Please refer to the following plots.

Duty Period



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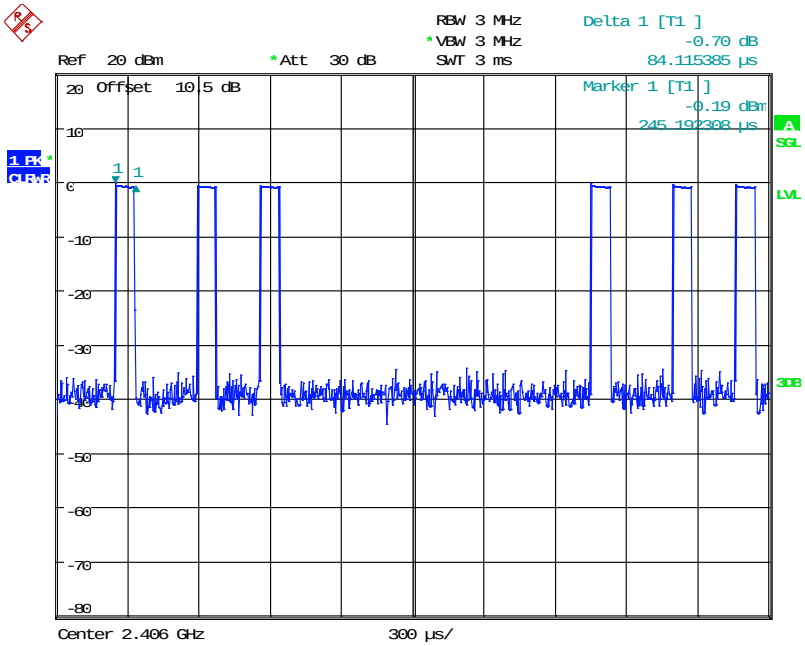
Tx on 1



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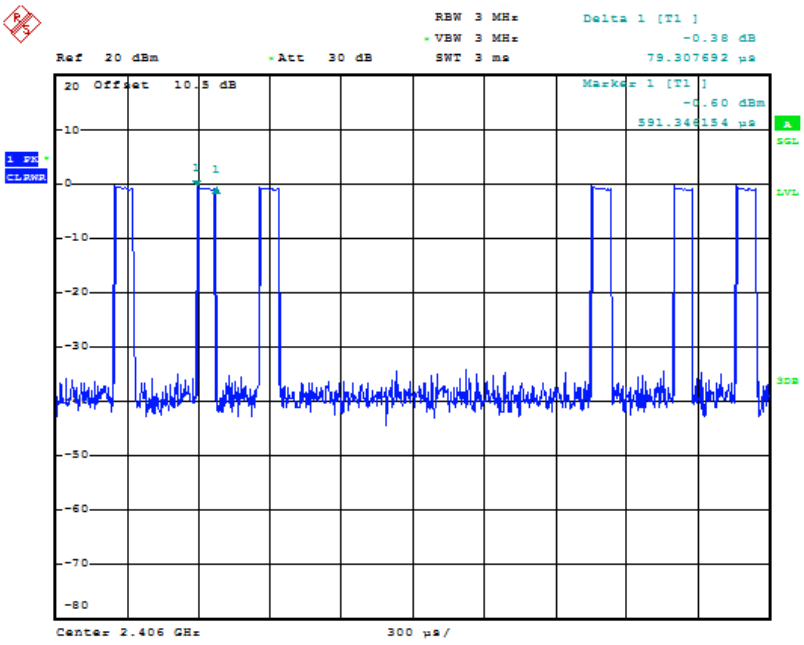

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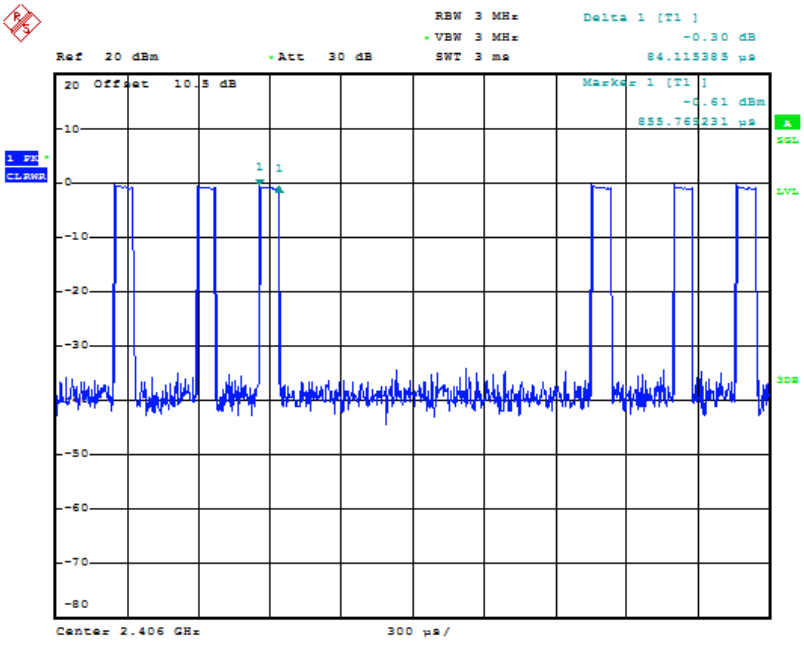
Tx on 3



Date: 9.APR.2019 19:50:30

3 Summary of Test Results

FCC Rules	Description of Test	Results
§15.247(i), §2.1093	RF Exposure	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 Peak Output Power	Compliance
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliance
§15.247(e)	Power Spectral Density	Compliance

4 Test Equipment List and Details

Description	Manufacturer	Model	Serial Number	Calibration Date	Calibration Due Date
AC Line Conduction Room (CON-A)					
LISN	Rohde & Schwarz	ENV216	101612	2019/02/21	2020/02/20
EMI Test Receiver	Rohde & Schwarz	ESR7	101419	2018/10/23	2019/10/22
Pulse Limiter	Rohde & Schwarz	ESH3Z2	TXZEM104	2018/08/03	2019/08/02
RF Cable	EMEC	EM-CB5D	001	2018/07/02	2019/07/01
Software	AUDIX	E3	V9.150826k	N.C.R	N.C.R
Radiated Room (966-A)					
Bilog Antenna with 6 dB Attenuator	SUNOL SCIENCES & MINI-CIRCUITS	JB6/UNAT-6+	A050115/15542_01	2018/12/11	2019/12/10
Horn Antenna	EMCO	3115	9311-4158	2018/04/20	2019/04/19
Horn Antenna	ETS-Lindgren	3116	62638	2018/08/29	2019/08/28
Preamplifier	Sonoma	310N	130602	2018/07/04	2019/07/03
Preamplifier	EM Electronics Corp.	EM01G18G	060657	2018/12/07	2019/12/06
Microware Preamplifier	EM Electronics Corporation	EM18G40G	060656	2019/01/11	2020/01/10
EMI Test Receiver	Rohde & Schwarz	ESR7	101419	2018/10/23	2019/10/22
Spectrum Analyzer	Rohde & Schwarz	FSV40	101435	2019/02/13	2020/02/12
Micro flex Cable	UTIFLEX	FSCM 64639 / (2M)	93D0127	2018/07/31	2019/07/30
Micro flex Cable	UTIFLEX	UFA210A-1-3149-300300	MFR64639 226389-001	2018/11/16	2019/11/15
Micro flex Cable	ROSNOL	K1K50-UP0264-K1K50-450CM	160309-1	2019/03/04	2020/03/03
Micro flex Cable	ROSNOL	K1K50-UP0264-K1K50-80CM	160309-2	2019/01/16	2020/01/15
Turn Table	Champro	TT-2000	060772-T	N.C.R	N.C.R
Antenna Tower	Champro	AM-BS-4500-B	060772-A	N.C.R	N.C.R
Controller	Champro	EM1000	60772	N.C.R	N.C.R
Software	Farad	EZ_EMC	BACL-03A1	N.C.R	N.C.R

Description	Manufacturer	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Room					
Spectrum Analyzer	Rohde & Schwarz	FSU26	200268	2018/05/04	2019/05/03
Cable	WOKEN	SFL402	S02-160323-07	2019/02/11	2020/02/10
Power Sensor	KEYSIGHT	U2021XA	MY54080018	2019/03/06	2020/03/05
Attenuator	MINI-CIRCUITS	BW-S10W5+	N/A	2019/03/07	2020/03/06

***Statement of Traceability:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to the SI System of Units via the R.O.C. Center for Measurement Standards of the Electronics Testing Center, Taiwan (ETC) or to another internationally recognized National Metrology Institute (NMI), and were compliant with the current Taiwan Accreditation Foundation (TAF) requirements*

5 FCC §15.247(i) & 2.1093 - RF Exposure

5.1 Applicable Standard

According to FCC §15.247(i)

Systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

According to KDB 447498 D01 General RF Exposure Guidance, the 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances
≤ 50 mm are determined by:

[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] • [$\sqrt{}$f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

1. f(GHz) is the RF channel transmit frequency in GHz.
2. Power and distance are rounded to the nearest mW and mm before calculation.
3. The result is rounded to one decimal place for comparison.
4. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test Exclusion.

5.2 RF Exposure Evaluation Result

FCC

Worse case:

SAR evaluation:

Frequency	Tunp-up Power		Evaluation Distrance	Calculated Value	Threshold	SAR Test Exclusion
(MHz)	(dBm)	(mW)	(mm)		(1-g SAR)	
2406	1	1.259	5	0.4	3	Yes

Result: SAR test is exempted.

6 FCC §15.203 – Antenna Requirements

6.1 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.

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 does not exceed 6dBi.

6.2 Antenna Information

Manufacturer	Type	Antenna Gain	Result
DEXIN Corporation	PCB Antenna	1.974 dBi	Compliance

The EUT has one integral antenna arrangement, which was permanently attached; fulfill the requirement of this section.

7 FCC §15.207(a) – AC Line Conducted Emissions

7.1 Applicable Standard

According to §15.207

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 Note 1	56 to 46 Note 2
0.5-5	56	46
5-30	60	50

Note 1: Decreases with the logarithm of the frequency.

Note 2: A linear average detector is required

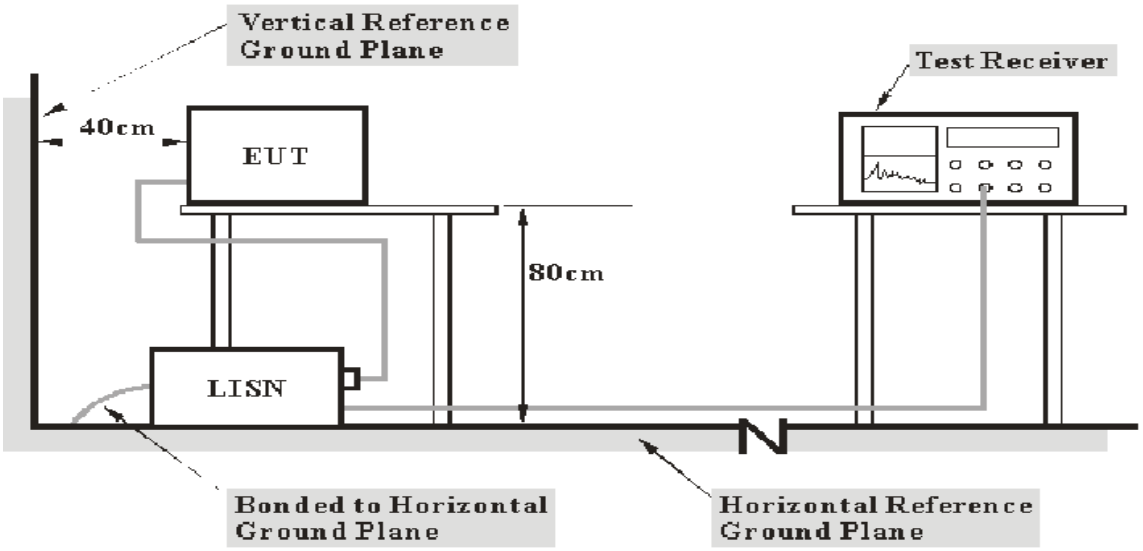
7.2 Measurement Uncertainty

Input quantities to be considered for conducted disturbance measurements maybe receiver reading, attenuation of the connection between LISN/ISN and receiver, LISN/ISN voltage division factor, LISN/ISN VDF frequency interpolation and receiver related input quantities, etc.

Based on CISPR 16-4-2:2011, the expended combined standard uncertainty of conducted disturbance test at Bay Area Compliance Laboratories Corp. (Taiwan) is shown as below. And the uncertainty will not be taken into consideration for the test data recorded in the report

Port	Expanded Measurement uncertainty
AC Mains	2.71 dB (k=2, 95% level of confidence)

7.3 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.

7.4 EMI Test Receiver Setup

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

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

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

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

7.6 Corrected Factor & Margin Calculation

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

Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

The "Over Limit" column of the following data tables indicates the degree of compliance with the applicable limit. For example, an over limit of -7 dB means the emission is 7 dB below the limit. The equation for Over Limit calculation is as follows:

Over Limit = Level – Limit Line

7.7 Environmental Conditions

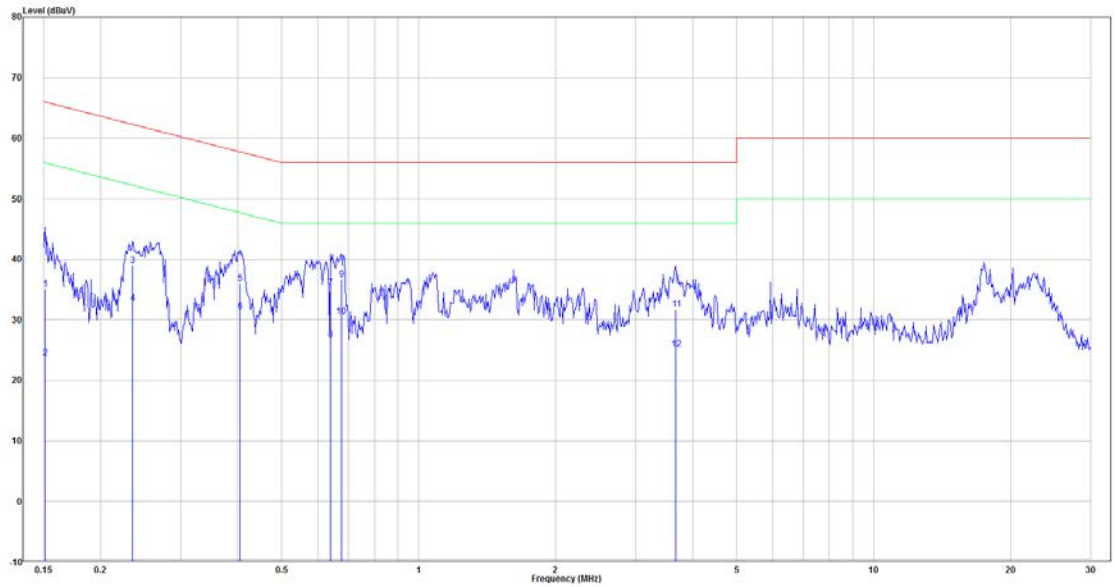
Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

The testing was performed by Tom Hsu on 2019-06-19.

7.8 Test Results

Test Mode: Transmitting

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.151	15.61	19.45	35.06	65.96	-30.90	QP
2	0.151	4.18	19.45	23.63	55.96	-32.33	Average
3	0.235	19.53	19.46	38.99	62.27	-23.28	QP
4	0.235	13.28	19.46	32.75	52.27	-19.53	Average
5	0.404	16.62	19.47	36.09	57.76	-21.67	QP
6	0.404	11.86	19.47	31.33	47.76	-16.43	Average
7	0.640	15.79	19.48	35.28	56.00	-20.72	QP
8	0.640	7.26	19.48	26.74	46.00	-19.26	Average
9	0.676	17.23	19.48	36.71	56.00	-19.29	QP
10	0.676	11.07	19.48	30.55	46.00	-15.45	Average
11	3.680	12.15	19.58	31.73	56.00	-24.27	QP
12	3.680	5.57	19.58	25.15	46.00	-20.85	Average

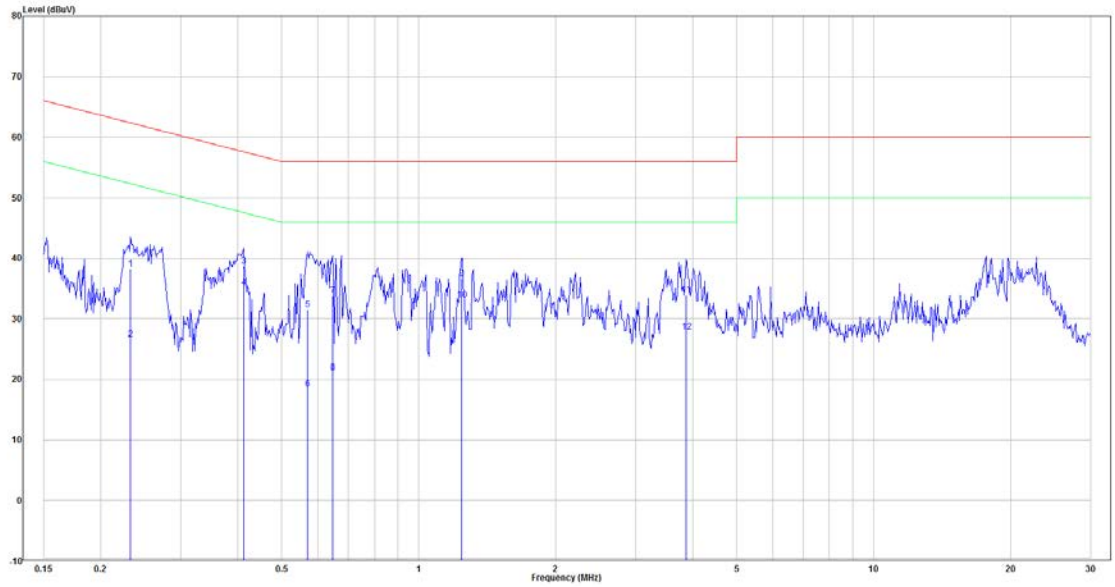
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.233	18.84	19.46	38.30	62.36	-24.05	QP
2	0.233	7.16	19.46	26.62	52.36	-25.73	Average
3	0.413	19.26	19.46	38.72	57.60	-18.87	QP
4	0.413	15.69	19.46	35.15	47.60	-12.44	Average
5	0.570	11.98	19.47	31.45	56.00	-24.55	QP
6	0.570	-1.02	19.47	18.45	46.00	-27.55	Average
7	0.646	14.41	19.47	33.88	56.00	-22.12	QP
8	0.646	1.66	19.47	21.14	46.00	-24.86	Average
9	1.241	17.14	19.50	36.64	56.00	-19.36	QP
10	1.241	13.56	19.50	33.05	46.00	-12.95	Average
11	3.868	14.44	19.57	34.02	56.00	-21.98	QP
12	3.868	8.30	19.57	27.88	46.00	-18.12	Average

Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

8 FCC §15.209, §15.205 , §15.247(d) – Spurious Emissions

8.1 Applicable Standard

As per FCC §15.35(d): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1MHz.

As Per FCC §15.205(a) except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 – 0.110 0.495 – 0.505 2.1735 – 2.1905 4.125 – 4.128 4.17725 – 4.17775 4.20725 – 4.20775 6.215 – 6.218 6.26775 – 6.26825 6.31175 – 6.31225 8.291 – 8.294 8.362 – 8.366 8.37625 – 8.38675 8.41425 – 8.41475 12.29 – 12.293 12.51975 – 12.52025 12.57675 – 12.57725 13.36 – 13.41	16.42 – 16.423 16.69475 – 16.69525 25.5 – 25.67 37.5 – 38.25 73 – 74.6 74.8 – 75.2 108 – 121.94 123 – 138 149.9 – 150.05 156.52475 – 156.52525 156.7 – 156.9 162.0125 –167.17 167.72 – 173.2 240 – 285 322 – 335.4 399.9 – 410 608 – 614	960 – 1240 1300 – 1427 1435 – 1626.5 1645.5 – 1646.5 1660 – 1710 1718.8 – 1722.2 2200 – 2300 2310 – 2390 2483.5 – 2500 2690 – 2900 3260 – 3267 3.332 – 3.339 3 3458 – 3 358 3.600 – 4.400	4. 5 – 5. 15 5. 35 – 5. 46 7.25 – 7.75 8.025 – 8.5 9.0 – 9.2 9.3 – 9.5 10.6 – 12.7 13.25 – 13.4 14.47 – 14.5 15.35 – 16.2 17.7 – 21.4 22.01 – 23.12 23.6 – 24.0 31.2 – 31.8 36.43 – 36.5 Above 38.6

As per FCC §15.209(a): Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (micro volts/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

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As per FCC §15.247 (d) 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).

8.2 Measurement Uncertainty

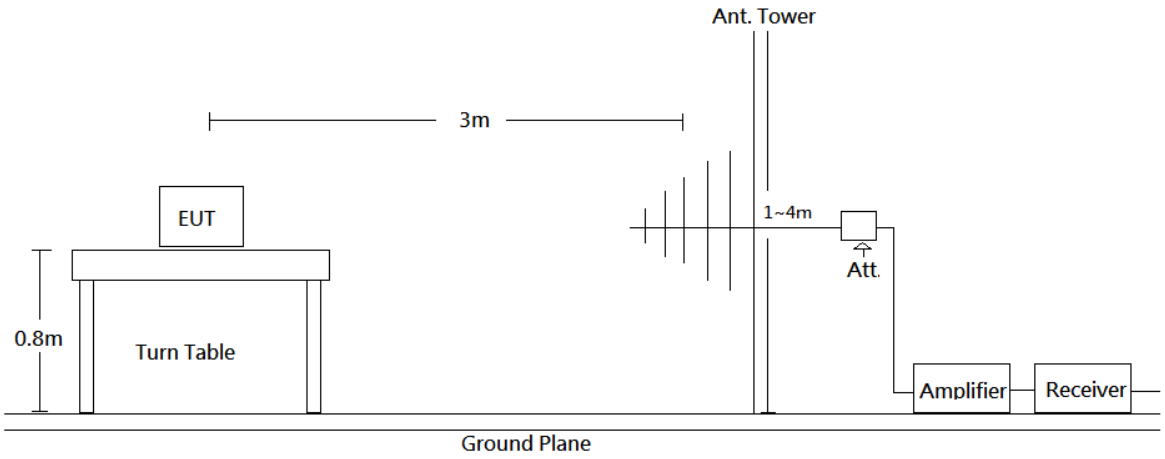
All measurements involve certain levels of uncertainties, especially in field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Based on CISPR 16-4-2:2011, the expended combined standard uncertainty of radiation emissions at Bay Area Compliance Laboratories Corp. (Taiwan) is shown in below table. And the uncertainty will not be taken into consideration for the test data recorded in the report.

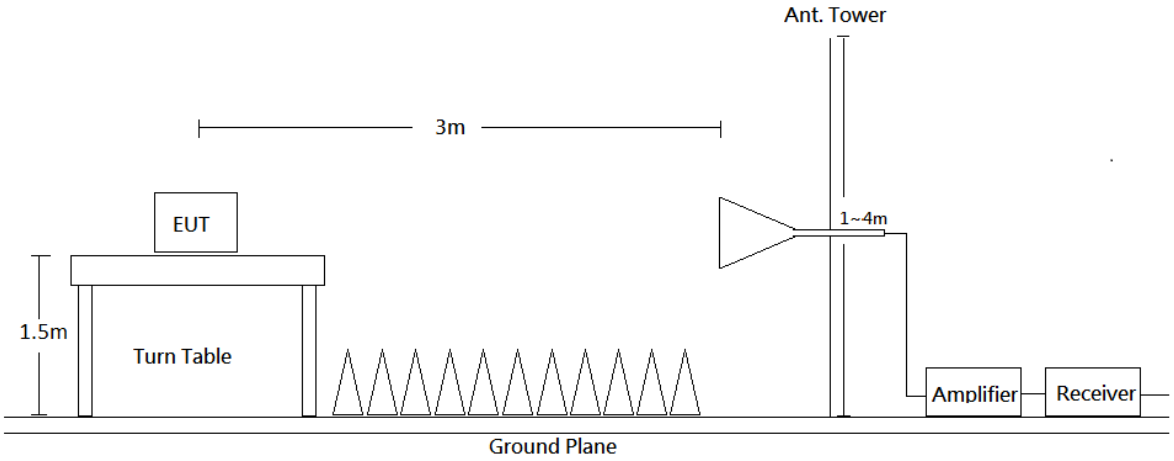
Frequency	Measurement uncertainty
30 MHz~200 MHz	3.75 dB (k=2, 95% level of confidence)
200 MHz~1 GHz	4.21 dB (k=2, 95% level of confidence)
1 GHz~6 GHz	4.83 dB (k=2, 95% level of confidence)
6 GHz~18 GHz	5.18 dB (k=2, 95% level of confidence)
18 GHz~26 GHz	4.55 dB (k=2, 95% level of confidence)
26 GHz~40 GHz	4.67 dB (k=2, 95% level of confidence)

8.3 EUT Setup

Below 1 GHz:



Above 1 GHz:



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

8.4 EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 26.5 GHz. During the radiated emission test, the EMI test receiver was set with the following configurations measurement method 6.3 in ANSI C63.10.

Frequency Range	RBW	VBW	Detector	Duty cycle	Measurement method
30-1000 MHz	120 kHz	/	QP		QP
Above 1 GHz	1 MHz	3 MHz	PK		PK
	1 MHz	3 MHz	RMS	>98%	Ave
	1 MHz	1/T	PK	<98%	Ave

8.5 Test Procedure

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

All data was recorded in the Quasi-peak detector mode from 30 MHz to 1 GHz and PK and average detector modes for frequencies above 1 GHz.

8.6 Corrected Factor & Margin Calculation

The Correct Factor 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:

Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

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:

Margin = Result – Limit

8.7 Test Results Summary

According to the data in the following table, the EUT complied with the FCC §15.209 Limit.

8.8 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

The Radiation Spurious Emissions testing was performed by Tom Hsu on 2019-03-29 ~ 2019-04-09.

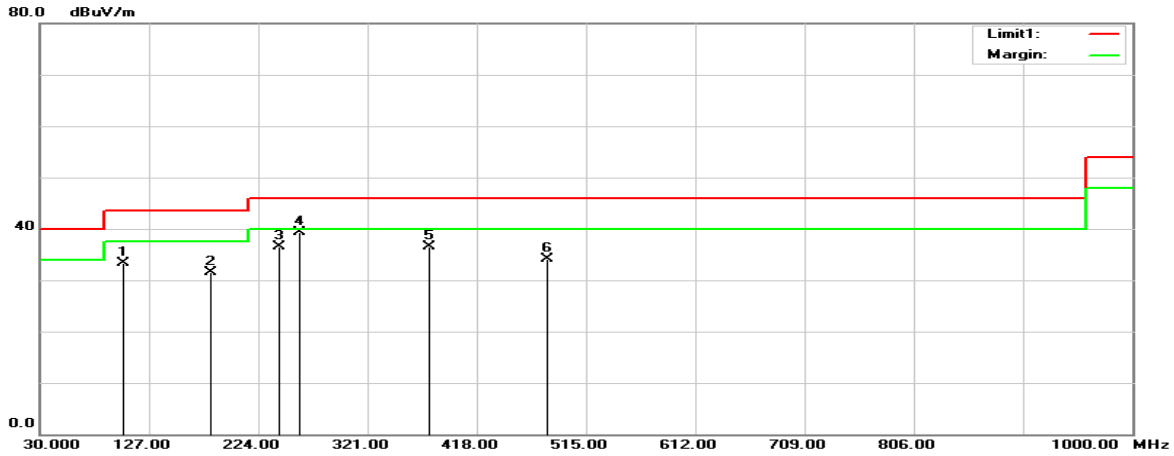
The Conducted Spurious Emissions testing was performed by Tom Hsu on 2019-04-09.

8.9 Test Results

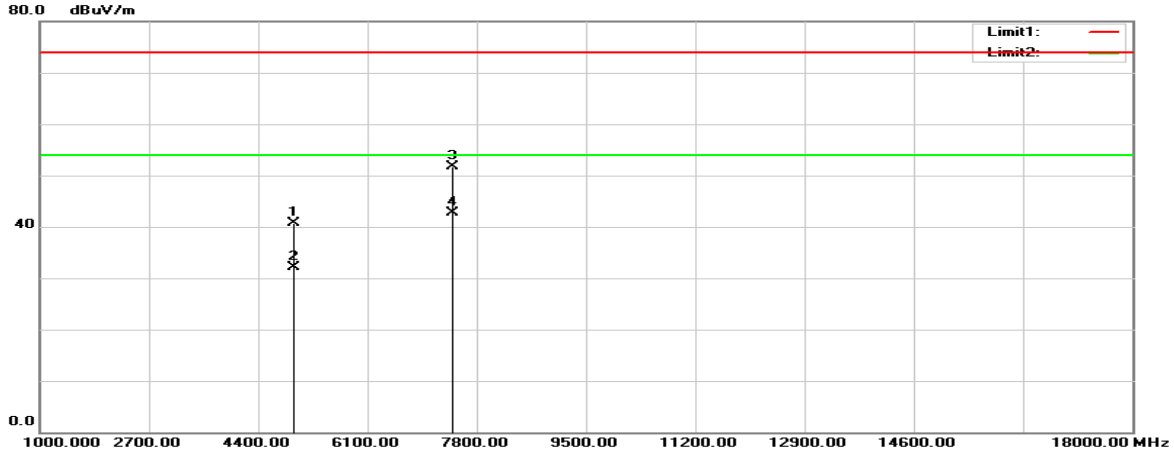
Test Mode: Transmitting (Pre-scan with three orthogonal axis, and worse case as X axis.)

Horizontal (*worst case is high channel*)

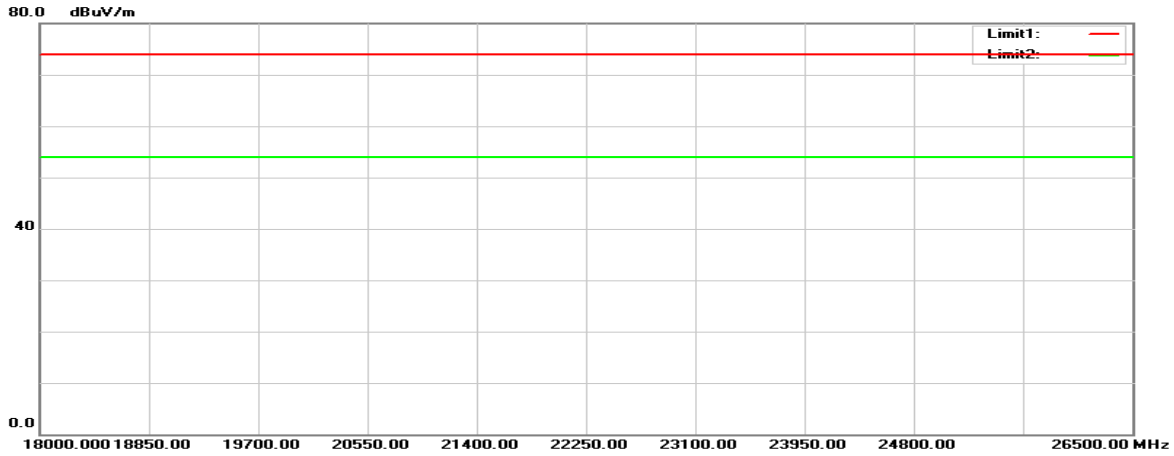
30MHz-1GHz:



1GHz-18GHz:

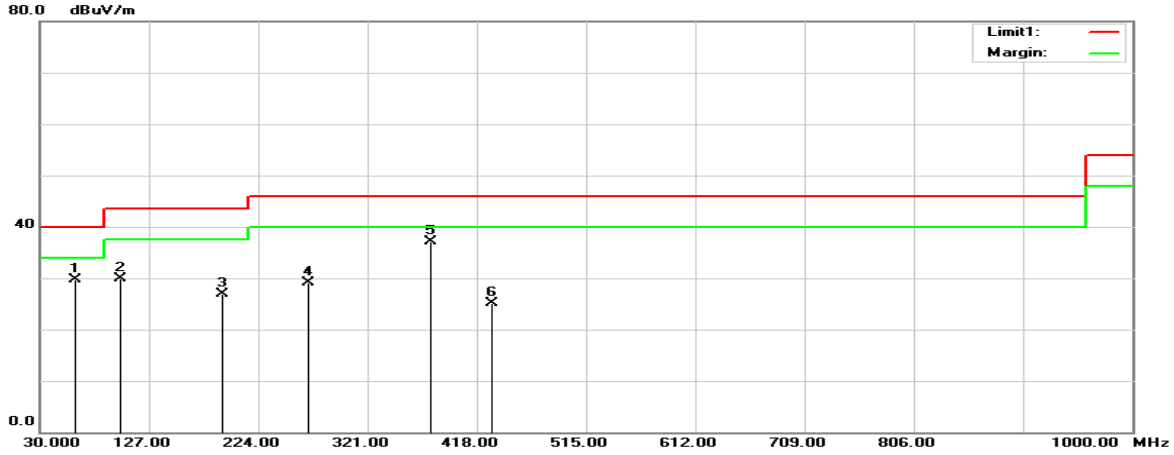


18GHz-26.5GHz:

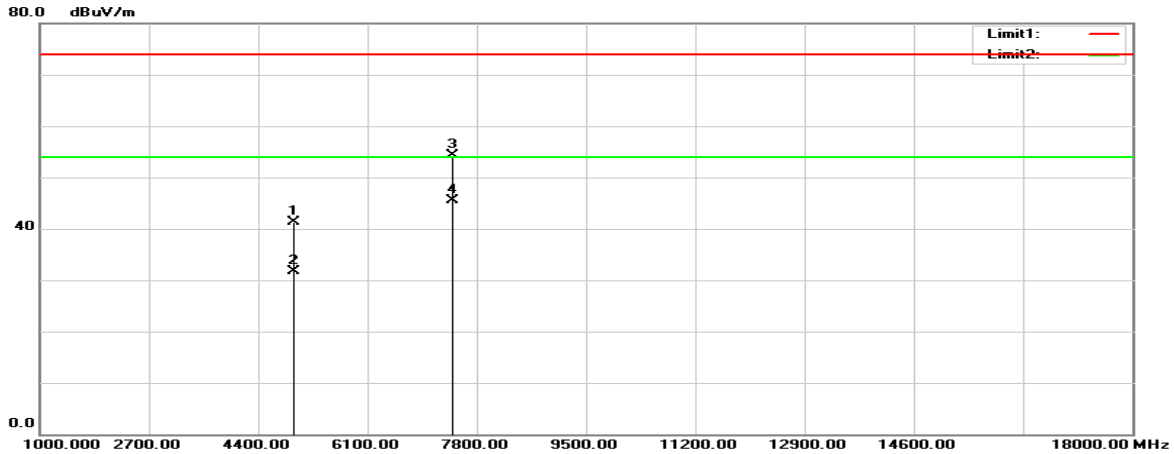


Vertical (*worst case is high channel*)

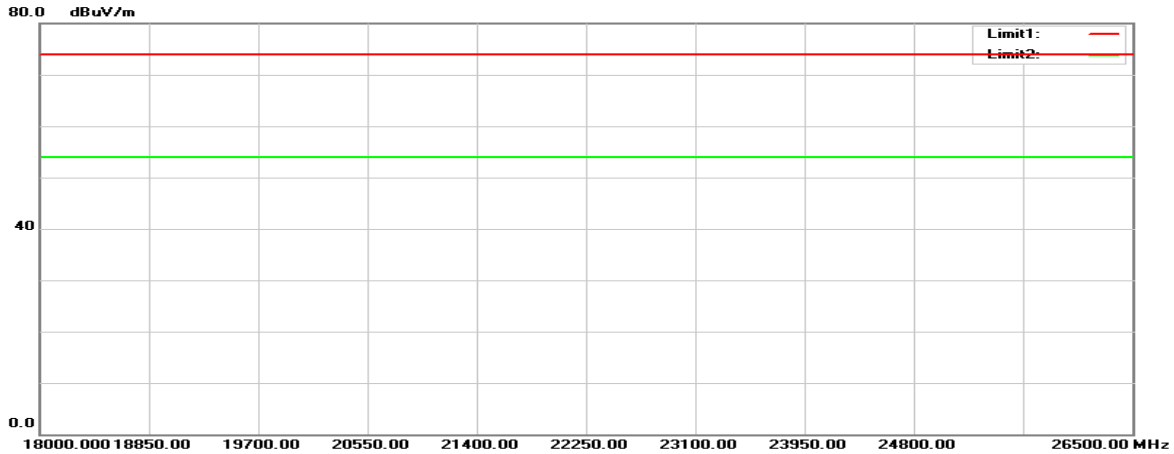
30MHz-1GHz:



1GHz-18GHz:



18GHz-26.5GHz:



Below 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
104.6900	45.31	-12.10	33.21	43.50	-10.29	100	39	QP
181.3200	42.92	-11.47	31.45	43.50	-12.05	100	66	QP
242.4300	46.79	-10.35	36.44	46.00	-9.56	100	79	QP
260.8600	48.74	-9.48	39.26	46.00	-6.74	100	70	QP
375.3200	42.90	-6.48	36.42	46.00	-9.58	100	92	QP
480.0800	38.88	-4.75	34.13	46.00	-11.87	100	358	QP

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
62.0100	46.63	-16.86	29.77	40.00	-10.23	100	20	QP
101.7800	43.15	-13.30	29.85	43.50	-13.65	100	75	QP
191.9900	37.99	-11.18	26.81	43.50	-16.69	100	84	QP
268.6200	38.53	-9.33	29.20	46.00	-16.80	100	337	QP
377.2600	44.19	-7.17	37.02	46.00	-8.98	100	359	QP
431.5800	31.35	-6.30	25.05	46.00	-20.95	100	95	QP

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Above 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
Low channel								
2390.000	59.22	-3.83	55.39	74.00	-18.61	300	172	peak
2390.000	39.81	-3.83	35.98	54.00	-18.02	300	172	AVG
2406.000	93.81	-3.78	90.03	N/A	N/A	283	180	peak
2406.000	89.40	-3.78	85.62	N/A	N/A	283	180	AVG
4812.000	43.38	1.65	45.03	74.00	-28.97	100	131	peak
4812.000	38.15	1.65	39.80	54.00	-14.20	100	131	AVG
Middle channel								
2445.000	93.11	-3.75	89.36	N/A	N/A	279	185	peak
2445.000	88.87	-3.75	85.12	N/A	N/A	279	185	AVG
4890.000	42.95	2.13	45.08	74.00	-28.92	100	131	peak
4890.000	38.51	2.13	40.64	54.00	-13.36	100	131	AVG
High channel								
2478.000	91.30	-3.55	87.75	N/A	N/A	278	185	peak
2478.000	87.20	-3.55	83.65	N/A	N/A	278	185	AVG
2483.500	64.30	-3.52	60.78	74.00	-13.22	300	189	peak
2483.500	39.99	-3.52	36.47	54.00	-17.53	300	189	AVG
4956.000	38.37	2.24	40.61	74.00	-33.39	100	75	peak
4956.000	29.88	2.24	32.12	54.00	-21.88	100	75	AVG
7434.000	42.67	8.96	51.63	74.00	-22.37	316	323	peak
7434.000	33.72	8.96	42.68	54.00	-11.32	316	323	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Vertical

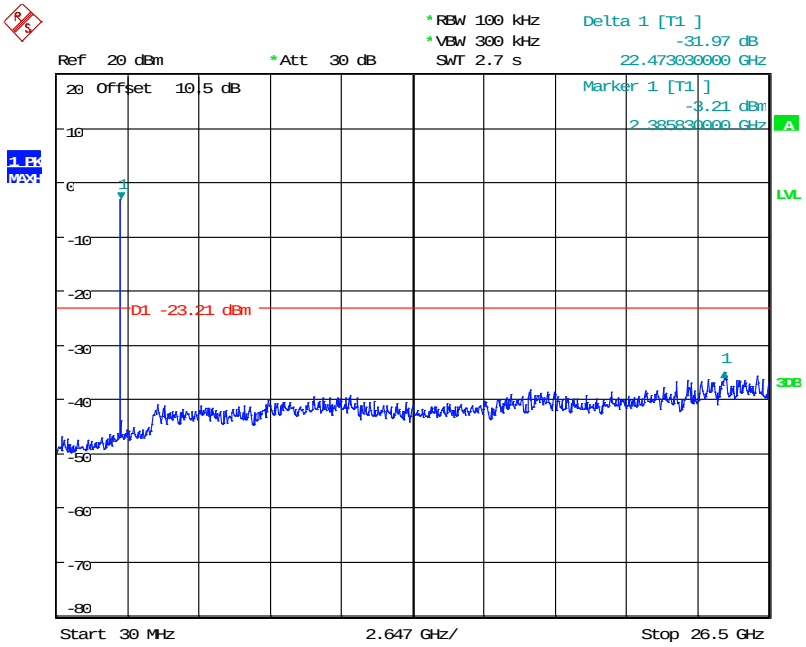
Frequency (MHz)	Reading (dBμV)	Correct Factor(dB/m)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
Low channel								
2390.000	57.27	-3.83	53.44	74.00	-20.56	300	219	peak
2390.000	39.70	-3.83	35.87	54.00	-18.13	300	219	AVG
2406.000	90.90	-3.78	87.12	N/A	N/A	363	246	peak
2406.000	86.67	-3.78	82.89	N/A	N/A	363	246	AVG
4812.000	43.00	1.65	44.65	74.00	-29.35	100	223	peak
4812.000	37.27	1.65	38.92	54.00	-15.08	100	223	AVG
7218.000	42.98	7.97	50.95	74.00	-23.05	107	237	peak
7218.000	36.55	7.97	44.52	54.00	-9.48	107	237	AVG
Middle channel								
2445.000	89.75	-3.75	86.00	N/A	N/A	310	256	peak
2445.000	85.88	-3.75	82.13	N/A	N/A	310	256	AVG
4890.000	42.88	2.13	45.01	74.00	-28.99	100	139	peak
4890.000	38.05	2.13	40.18	54.00	-13.82	100	139	AVG
7335.000	42.31	8.78	51.09	74.00	-22.91	100	225	peak
7335.000	35.78	8.78	44.56	54.00	-9.44	100	225	AVG
High channel								
2478.000	88.34	-3.55	84.79	N/A	N/A	342	261	peak
2478.000	84.18	-3.55	80.63	N/A	N/A	342	261	AVG
2483.500	61.81	-3.52	58.29	74.00	-15.71	300	263	peak
2483.500	39.95	-3.52	36.43	54.00	-17.57	300	263	AVG
4956.000	39.06	2.24	41.30	74.00	-32.70	100	326	peak
4956.000	29.50	2.24	31.74	54.00	-22.26	100	326	AVG
7434.000	45.43	8.96	54.39	74.00	-19.61	279	85	peak
7434.000	36.50	8.96	45.46	54.00	-8.54	279	85	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Conducted Spurious Emissions:

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Low	2406	31.97	≥ 20	PASS
Mid	2445	31.85	≥ 20	PASS
High	2478	31.10	≥ 20	PASS

Low Channel



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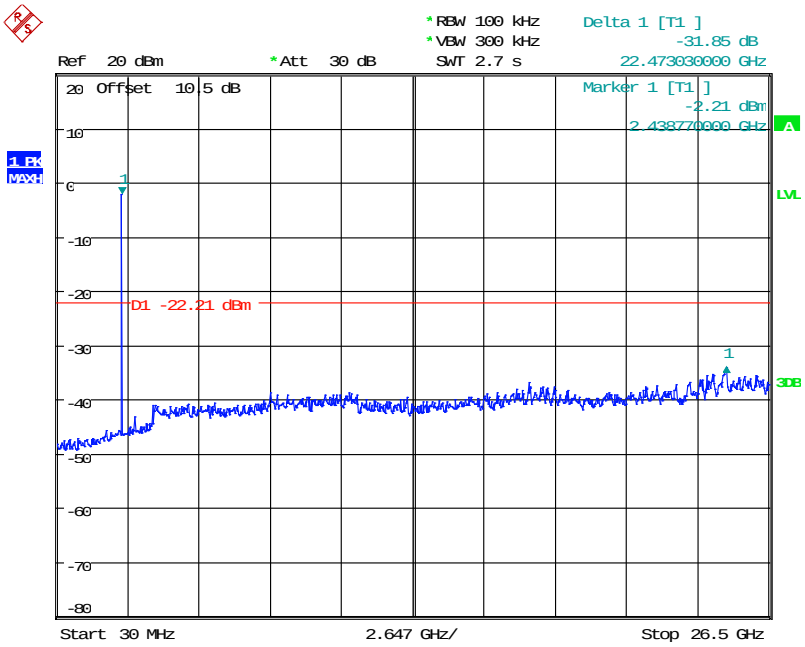
Middle Channel



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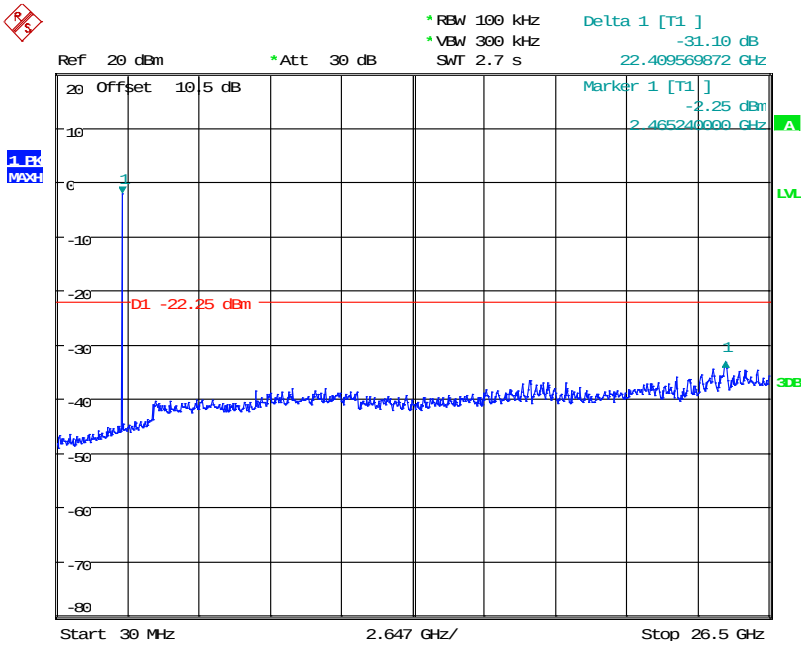
High Channel



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9 FCC §15.247(a)(2) – 6 dB Emission Bandwidth

9.1 Applicable Standard

According to FCC §15.247(a)(2).

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.

9.2 Test Procedure

The steps for the first option are as follows:

a) Set RBW = 100 kHz.

b) Set the VBW ≥ [3 × RBW].

c) Detector = peak.

d) Trace mode = max hold.

e) Sweep = auto couple.

f) Allow the trace to stabilize.

g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

9.3 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

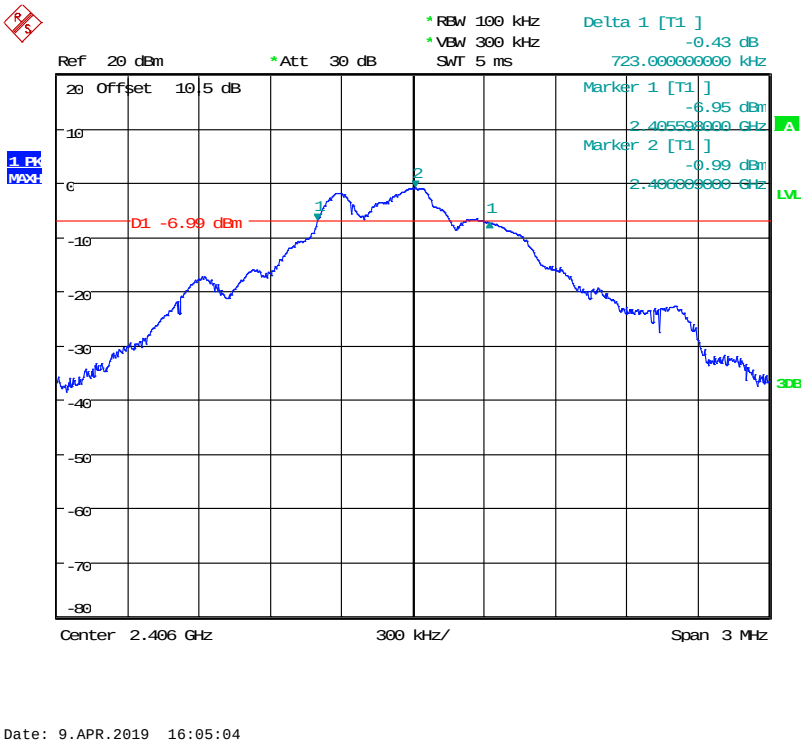
The testing was performed by Tom Hsu on 2019-04-09.

9.4 Test Results

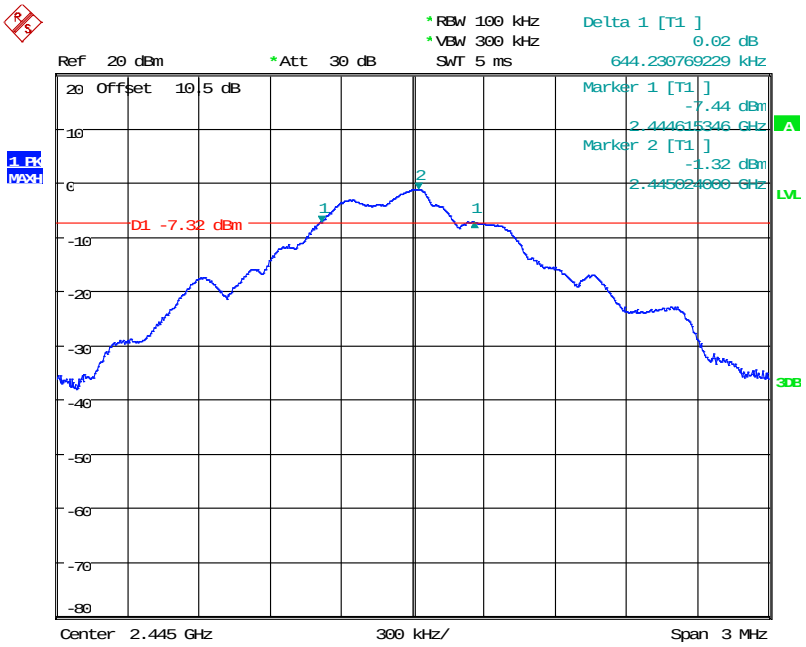
Channel	Frequency (MHz)	6 dB Emission Bandwidth (kHz)	Limit (kHz)	Result
Low	2406	723	> 500	Compliance
Middle	2445	644	> 500	Compliance
High	2478	674	> 500	Compliance

Please refer to the following plots

Low Channel



Middle Channel



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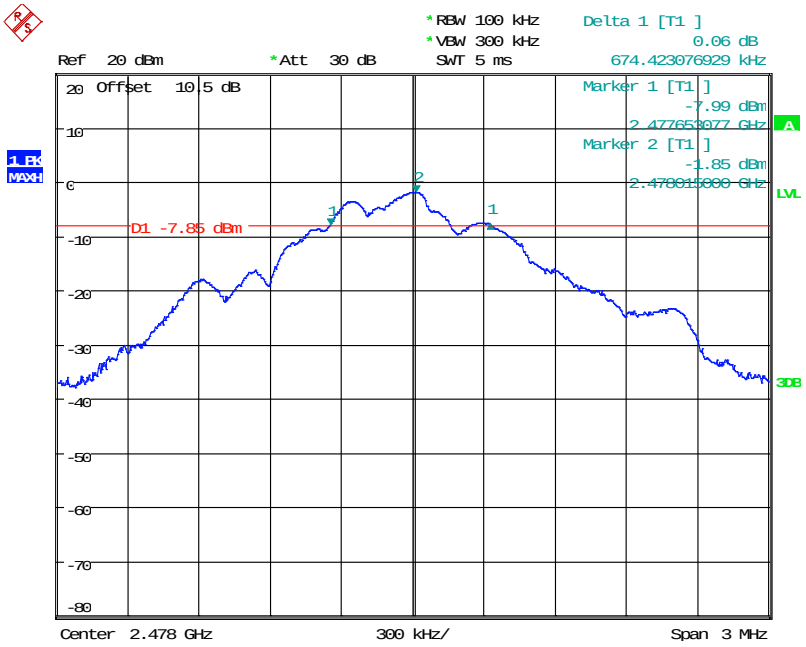
High Channel



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10 FCC §15.247(b)(3) – Maximum Output Power

10.1 Applicable Standard

According to FCC §15.247(b) (3).

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.

10.2 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 measuring equipment.

10.3 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

The testing was performed by Tom Hsu on 2019-04-09.

10.4 Test Results

Channel	Frequency	Maximum peak Conducted Output Power		Limit	Result
	(MHz)	(dBm)	(W)	(W)	
Low	2406	0.82	0.0012	1	PASS
Middle	2445	0.38	0.0011	1	PASS
High	2478	-0.06	0.0010	1	PASS

11 FCC§15.247(d) – 100 kHz Bandwidth of Frequency Band Edge

11.1 Applicable Standard

According to FCC §15.247(d).

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)).

11.2 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.

11.3 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

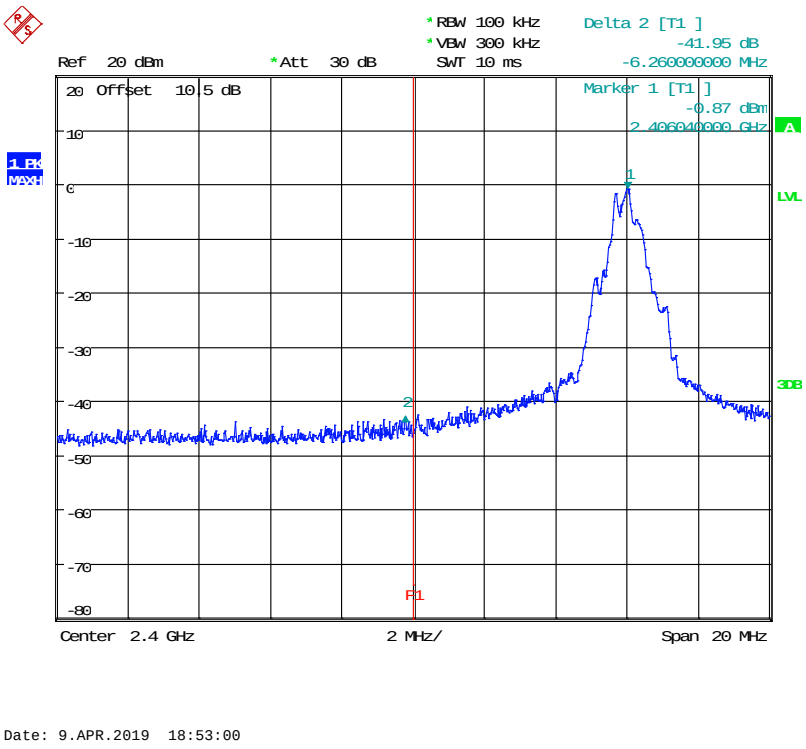
The testing was performed by Tom Hsu on 2019-04-09.

11.4 Test Results

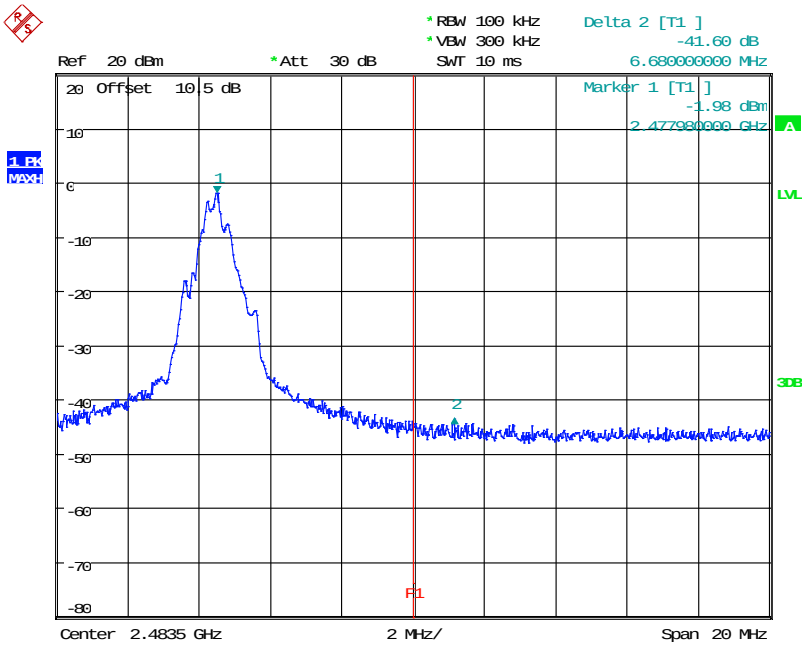
Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Low	2406	41.95	≥ 20	PASS
High	2478	41.60	≥ 20	PASS

Please refer to the following plots

Band Edge, Left Side



Band Edge, Right Side



12 FCC §15.247(e) – Power Spectral Density

12.1 Applicable Standard

According to FCC §15.247(e).

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.

12.2 Test Procedure

According to ANSI C63.10-2013

a) Set analyzer center frequency to DTS channel center frequency.

b) Set the span to 1.5 times the DTS bandwidth.

c) Set the RBW to 3 kHz ≤ RBW ≤ 100 kHz.

d) Set the VBW ≥ [3 × RBW].

e) Detector = peak.

f) Sweep time = auto couple.

g) Trace mode = max hold.

h) Allow trace to fully stabilize.

i) Use the peak marker function to determine the maximum amplitude level within the RBW.

j) If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat

12.3 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

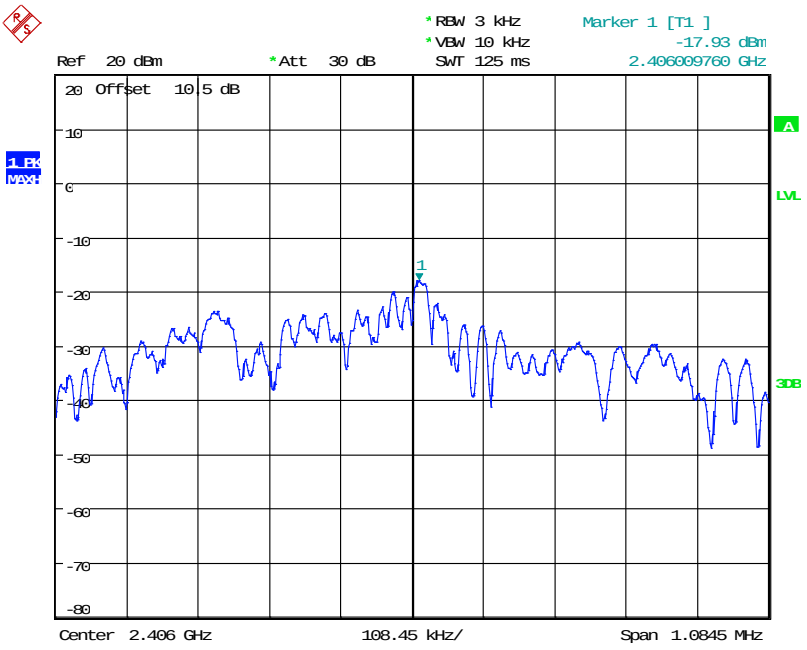
The testing was performed by Tom Hsu on 2019-04-09.

12.4 Test Results

Channel	Frequency (MHz)	Power Spectral Density (dBm/3 kHz)	Limit (dBm/3 kHz)	Result
Low	2406	-17.93	8	Compliance
Middle	2445	-17.63	8	Compliance
High	2478	-18.16	8	Compliance

Please refer to the following plots

Low Channel



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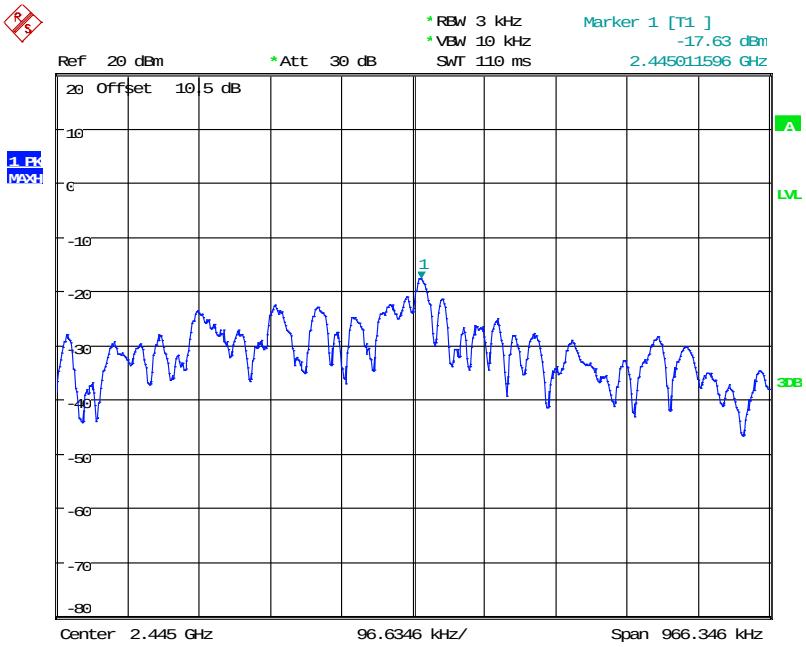
Middle Channel



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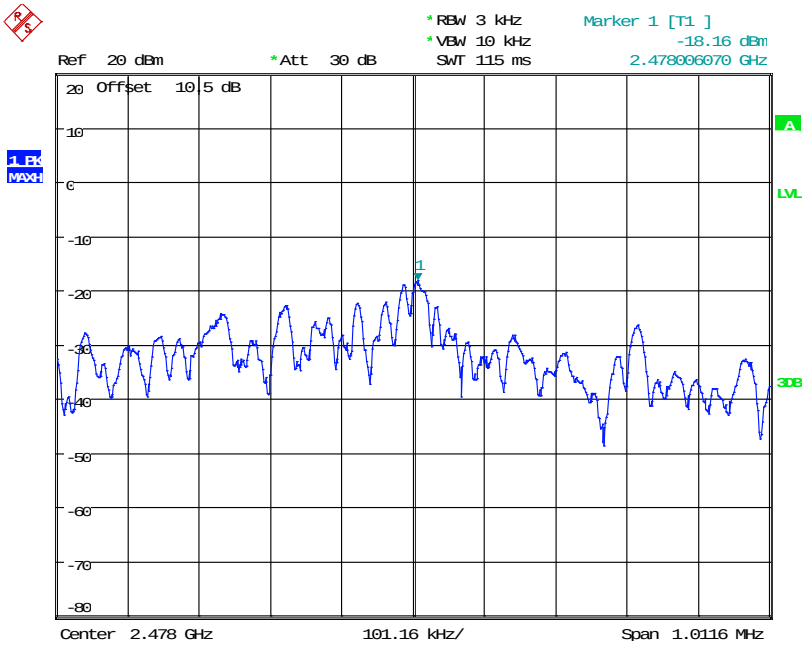
High Channel



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