TEST REPORT

Applicant Name :	M5Stack Technology Co.,Ltd
Address :	5F, Tangwei Stock Commercial Building, Youli Road, Bao'an District, Shenzhen, Guangdong, China
Report Number :	RA230420-21001E-RF-00B
FCC ID:	2AN3WM5CORE2V11

Test Standard (s)

FCC Part 15.247

Sample Description

Product:	M5Core2 v1.1
Tested Model:	Core2 v1.1
Trade Mark:	M5STACK
Date Received:	2023-04-20
Date of Test:	2023-04-22 to 2023-06-07
Report Date:	2023-06-07

Test Result:	Pass*

* In the configuration tested, the EUT complied with the standards above.

Prepared and Checked By:

Bob Liao

EMC Engineer

Approved By:

Candy Li

EMC Engineer

Note: This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "★".

Shenzhen Accurate Technology Co., Ltd. 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.

TABLE OF CONTENTS

DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	RA230420-21001E-RF-00B	Original Report	2023-06-07

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	M5Core2 v1.1	
Tested Model	Core2 v1.1	
Hardware Version	v1.1	
Software Version	v1.1	
Frequency Range	BLE: 2402-2480MHz Wi-Fi: 2412-2462MHz	
Maximum Conducted Peak Output Power	BLE 1M: 0.4dBm	
Maximum Conducted Average Output Power	Wi-Fi	
	15.94dBm(802.11b)	12.24dBm(802.11n20)
	12.38dBm(802.11g)	11.87dBm(802.11n40)
Modulation Technique	BLE: GFSK Wi-Fi: DSSS, OFDM	
Antenna Specification*	Internal Antenna: 2.46dBi(provided by the applicant)	
Voltage Range	DC 5V from USB port or DC 3.7V from battery	
Sample serial number	RA230420-21001E-RF-S1(CE&RE) RA230420-21001E-RF-S2(RF Conducted Test) (Assigned by ATC, Shenzhen)	
Sample/EUT Status	Good condition	

Objective

This test report is 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.

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 Shenzhen Accurate Technology Co., Ltd. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		5%
RF Frequency		$0.082*10^{-7}$
RF output power, conducted		0.71dB
Unwanted Emission, conducted		1.6dB
AC Power Lines Conducted Emissions		2.74dB
Emissions, Radiated	30MHz - 1GHz	5.08dB
	1GHz - 18GHz	4.96dB
	18GHz - 26.5GHz	5.16dB
Temperature		1℃
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 Shenzhen Accurate Technology Co., Ltd. to collect test data is located on the Floor 1, KuMaKe Building, Dongzhou Community, Guangming Street, Guangming District, 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.: 708358, the FCC Designation No.: CN1189.

Accredited by American Association for Laboratory Accreditation (A2LA).The Certificate Number is 4297.01.

The lab has been recognized by Innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements, the CAB identifier: CN0016. The Registration Number is 30241.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

For 2.4GHz Wi-Fi mode, total 11channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2412	7	2442
2	2417	8	2447
3	2422	9	2452
4	2427	10	2457
5	2432	11	2462
6	2437	/	/

802.11b, 802.11g and 802.11n-HT20 mode was tested with Channel 1, 6 and 11.
802.11n-HT40 mode was tested with Channel 3, 6 and 9.

For BLE 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, 19 and 39.

Special Accessories

The DC cable with a ferrite cord.

Equipment Modifications

No modification was made to the EUT tested.

EUT Exercise Software

Software “EspRFTestTool”* was used during testing and power level as below, which provided by manufacturer.

Mode	Data Rate (Mbps)	Power Level*
802.11 b	1	8
802.11 g	6	8
802.11 n20	MCS0	8
802.11 n40	MCS0	8
BLE	1M	4

The worse-case data rates are determined to be as above for each mode based upon investigations by measuring the output power and PSD across all data rates, bandwidths and modulations.

Duty cycle

Test Result: Compliant. Please refer to the Appendix Wi-Fi and Appendix BLE.

Support Equipment List and Details

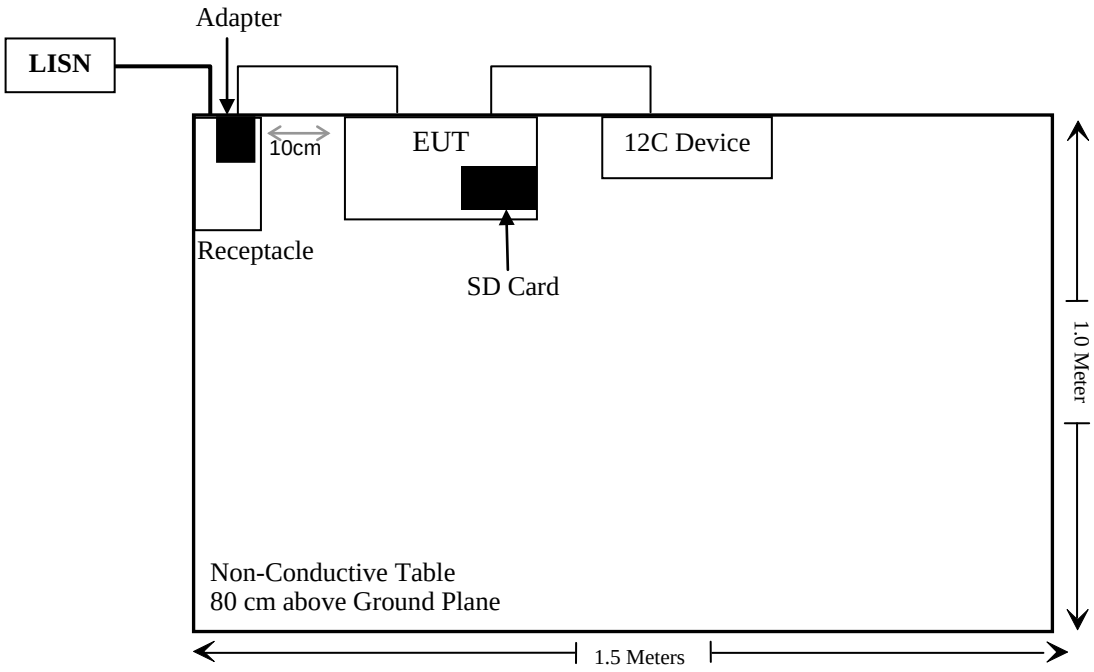
Manufacturer	Description	Model	Serial Number
MEIZU	Adapter	UP0830	162600278502
UNKNOW	SD Card	UNKNOW	UNKNOW
UNKNOW	12C Device	SHT30(QMP6988)	UNKNOW

External I/O Cable

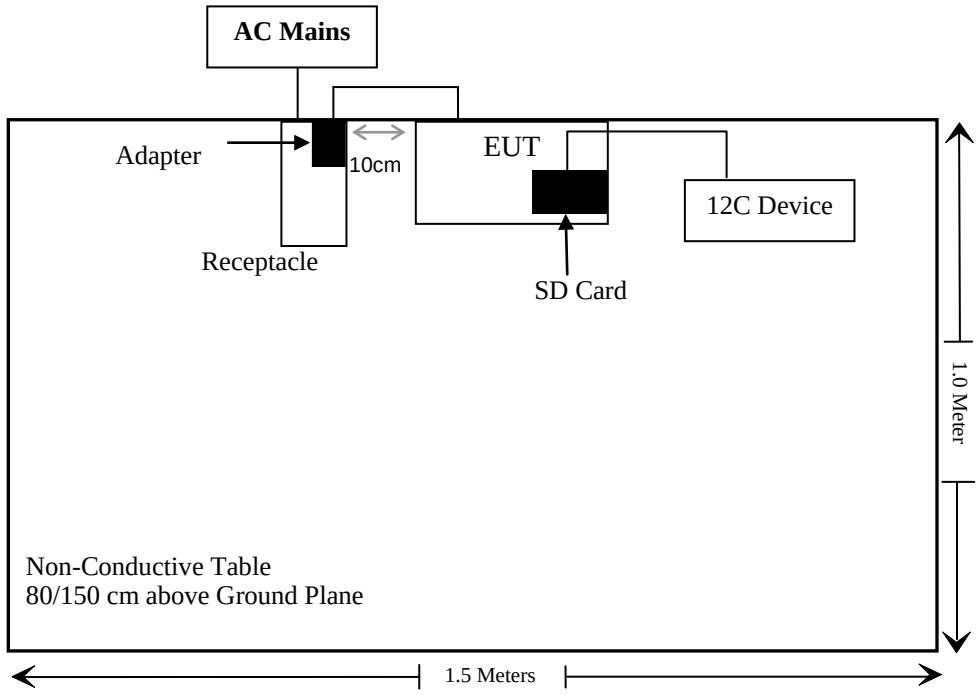
Cable Description	Length(m)	From/Port	To
Un-shielding Detachable DC Cable	0.4	Adapter	EUT
Un-shielding Un-Detachable Cable	0.2	12C Device	EUT

Block Diagram of Test Setup

For Conducted Emission



For Radiated Emission



Note: the support table edge was flush with the center of turntable

SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
FCC §1.1310 & §2.1091	RF Exposure	Compliant
§15.203	Antenna Requirement	Compliant
§15.207 (a)	AC Line Conducted Emissions	Compliant
§15.205, §15.209, §15.247(d)	Spurious Emissions	Compliant
§15.247 (a)(2)	6 dB Emission Bandwidth & Occupied Bandwidth	Compliant
§15.247(b)(3)	Maximum Conducted Output Power	Compliant
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliant
§15.247(e)	Power Spectral Density	Compliant

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Emission Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	100784	2022/11/25	2023/11/24
Rohde & Schwarz	L.I.S.N.	ENV216	101314	2022/11/25	2023/11/24
Anritsu Corp	50 Coaxial Switch	MP59B	6100237248	2022/12/07	2023/12/06
Unknown	RF Coaxial Cable	No.17	N0350	2022/11/25	2023/11/24
Conducted Emission Test Software: e3 191218 (V9)					
Radiated Emissions Test					
Rohde & Schwarz	Test Receiver	ESR	102725	2022/11/25	2023/11/24
Rohde & Schwarz	Spectrum Analyzer	FSV40	101949	2022/11/25	2023/11/24
SONOMA INSTRUMENT	Amplifier	310 N	186131	2022/11/08	2023/11/07
A.H. Systems, inc.	Preamplifier	PAM-0118P	135	2022/11/08	2023/11/07
Quinstar	Amplifier	QLW-184055 36-J0	15964001002	2022/11/08	2023/11/07
Schwarzbeck	Bilog Antenna	VULB9163	9163-194	2023/02/14	2026/02/13
Schwarzbeck	Horn Antenna	BBHA9120D	837	2023/02/22	2026/02/21
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2022/12/26	2025/12/25
Unknown	RF Coaxial Cable	No.10	N050	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.11	N1000	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.12	N040	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.13	N300	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.14	N800	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.15	N600	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.16	N650	2022/11/25	2023/11/24
Wainwright	High Pass Filter	WHKX3.6/18 G-10SS	5	2022/11/25	2023/11/24
Radiated Emission Test Software: e3 191218 (V9)					
RF Conducted Test					
Rohde & Schwarz	Spectrum Analyzer	FSV-40	101495	2022/11/25	2023/11/24
Agilent	Power Sensor	U2021XA	MY5425003	2023/02/25	2024/02/24
Rohde & Schwarz	Open Switch and Control Unit	OSP120 + OSP-B157	101244 + 100866	2022/11/25	2023/11/24
WEINSCHEL	10dB Attenuator	5324	AU 3842	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.31	RF-01	Each time	

*** Statement of Traceability:** Shenzhen Accurate Technology Co., Ltd. attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §1.1310 & §2.1091-RF EXPOSURE

Applicable Standard

According to KDB 447498 D04 Interim General RF Exposure Guidance v01, clause 2.1.4 –MPE-Based Exemption:

An alternative to the SAR-based exemption is provided in § 1.1307(b)(3)(i)(C), for a much wider frequency range, from 300 kHz to 100 GHz, applicable for separation distances greater or equal to $\lambda/2\pi$, where λ is the free-space operating wavelength in meters. The MPE-based test exemption condition is in terms of ERP, defined as the product of the maximum antenna gain and the delivered maximum time-averaged power. For this case, a RF source is an RF exempt device if its ERP (watts) is no more than a frequency-dependent value, as detailed tabular form in Appendix B. These limits have been derived based on the basic specifications on Maximum Permissible Exposure (MPE) considered for the FCC rules in § 1.1310(e)(1).

Table to § 1.1307(b)(3)(i)(C) - Single RF Sources Subject to Routine Environmental Evaluation

RF Source frequency (MHz)	Threshold ERP (watts)
0.3-1.34	1,920 R^2.
1.34-30	3,450 R^2/f^2.
30-300	3.83 R^2.
300-1,500	0.0128 R^2f.
1,500-100,000	19.2R^2.

f = frequency in MHz;
R = minimum separation distance from the body of a nearby person (appropriate units, e.g., m);

Test Result:

For worst case:

Mode	Frequency Range (MHz)	Tune-up Output Power		Antenna Gain		ERP		Evaluation Distance (cm)	ERP Limit (mW)
		(dBm)	(mW)	(dBi)	(dBd)	(dBm)	(mW)		
BDR/EDR	2402-2480	9	7.94	2.46	0.31	9.31	8.53	20	768
BLE	2402-2480	0.5	1.12	2.46	0.31	0.81	1.21	20	768
2.4G WIFI	2412-2462	16	39.81	2.46	0.31	16.31	42.76	20	768

Note 1: The tune-up power was declared by the applicant.
Note 2: 0dBd=2.15dBi.
Note 3: the BT and Wi-Fi cannot transmit at same time.

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

Result: Compliant.

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.
c. 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 one internal antenna arrangement, which was permanently attached and the antenna gain is 2.46dBi, fulfill the requirement of this section. Please refer to the EUT photos.

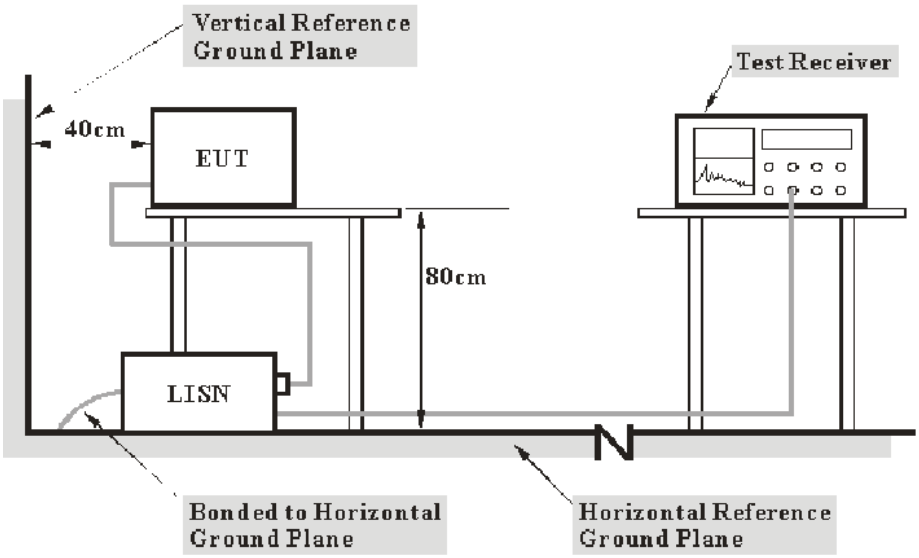
Result: Compliant.

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.

Factor & Margin Calculation

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

Factor = LISN VDF + Cable Loss

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 calculation is as follows:

Over Limit = Level – Limit
Level = Read Level + Factor

Test Data

Environmental Conditions

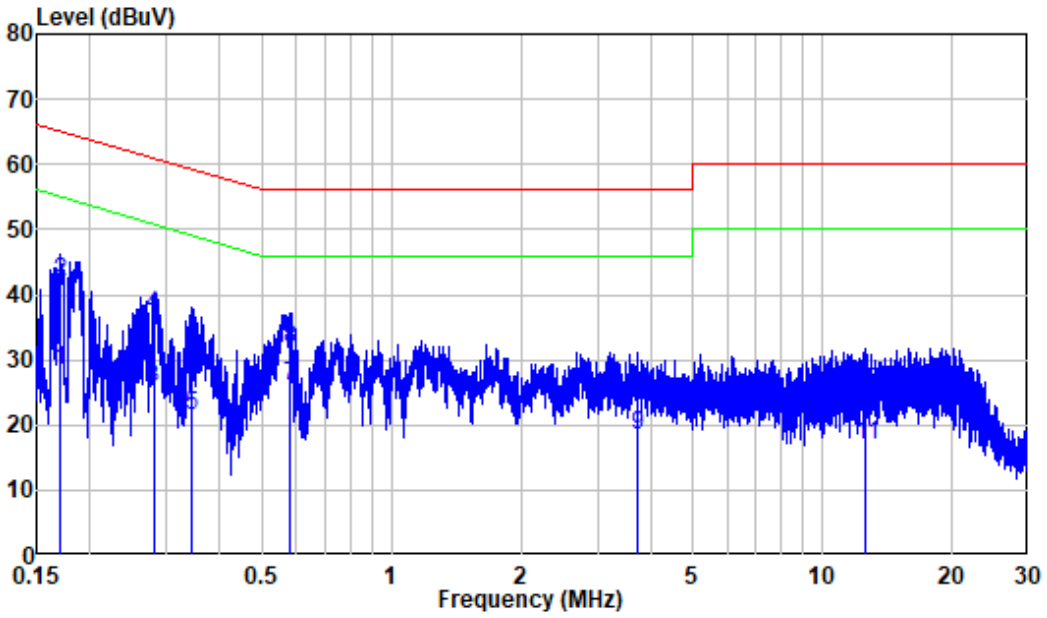
Temperature:	23 ℃
Relative Humidity:	53 %
ATM Pressure:	101.0 kPa

The testing was performed by Jerry Wu on 2023-05-31.

EUT operation mode: Transmitting

BLE: (worst case Low channel)

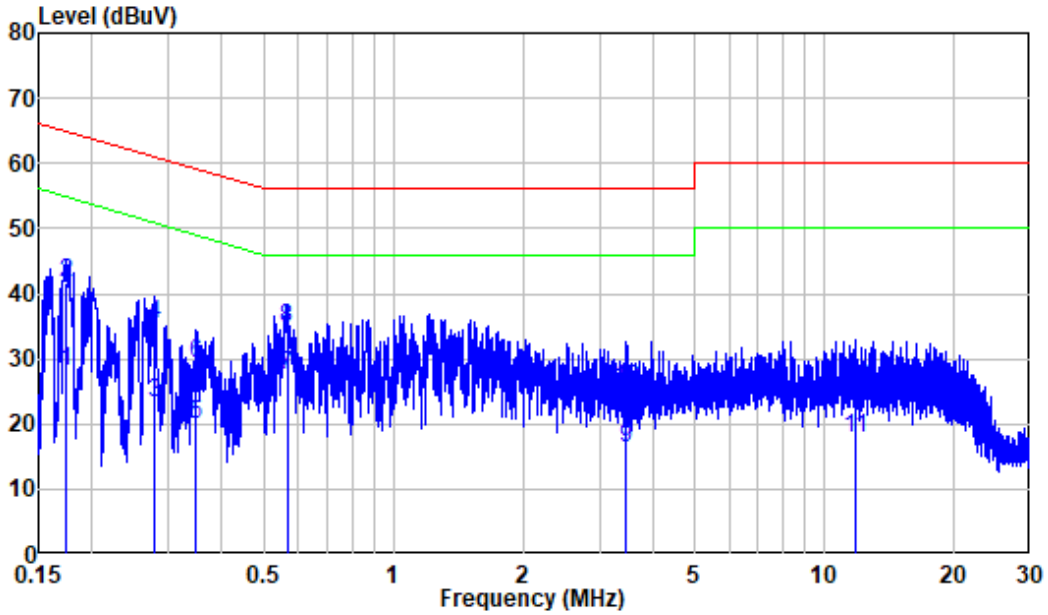
AC 120V/60 Hz, Line



Site : Shielding Room
Condition: Line
Job No. : RA230420-21001E-RF
Mode : Full load+BLE Transmission
Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.171	10.33	18.06	28.39	54.92	-26.53	Average
2	0.171	10.33	31.53	41.86	64.92	-23.06	QP
3	0.280	10.38	15.15	25.53	50.81	-25.28	Average
4	0.280	10.38	26.49	36.87	60.81	-23.94	QP
5	0.343	10.45	10.95	21.40	49.13	-27.73	Average
6	0.343	10.45	19.49	29.94	59.13	-29.19	QP
7	0.583	10.62	15.22	25.84	46.00	-20.16	Average
8	0.583	10.62	21.03	31.65	56.00	-24.35	QP
9	3.725	10.53	7.94	18.47	46.00	-27.53	Average
10	3.725	10.53	14.24	24.77	56.00	-31.23	QP
11	12.582	10.37	6.67	17.04	50.00	-32.96	Average
12	12.582	10.37	14.61	24.98	60.00	-35.02	QP

AC 120V/60 Hz, Neutral

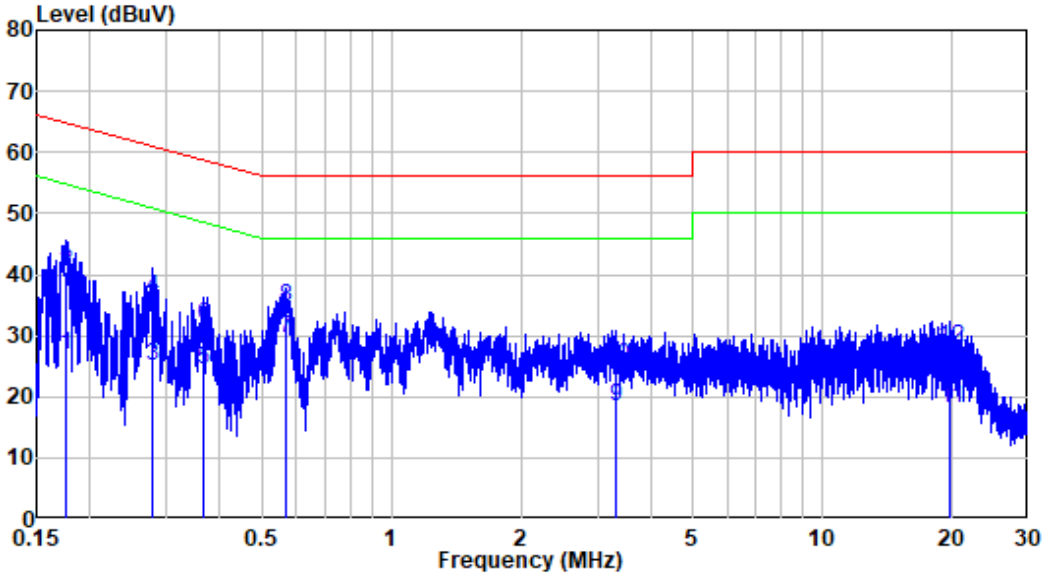


Site : Shielding Room
Condition: Neutral
Job No. : RA230420-21001E-RF
Mode : Full load+BLE Transmission
Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.174	10.28	17.79	28.07	54.78	-26.71	Average
2	0.174	10.28	31.44	41.72	64.78	-23.06	QP
3	0.278	10.35	12.93	23.28	50.86	-27.58	Average
4	0.278	10.35	24.99	35.34	60.86	-25.52	QP
5	0.349	10.39	9.39	19.78	48.99	-29.21	Average
6	0.349	10.39	18.76	29.15	58.99	-29.84	QP
7	0.566	10.47	17.00	27.47	46.00	-18.53	Average
8	0.566	10.47	24.21	34.68	56.00	-21.32	QP
9	3.454	10.53	5.87	16.40	46.00	-29.60	Average
10	3.454	10.53	14.72	25.25	56.00	-30.75	QP
11	11.776	10.50	7.45	17.95	50.00	-32.05	Average
12	11.776	10.50	14.95	25.45	60.00	-34.55	QP

2.4G WIFI: (worst case 802.11b, Low channel)

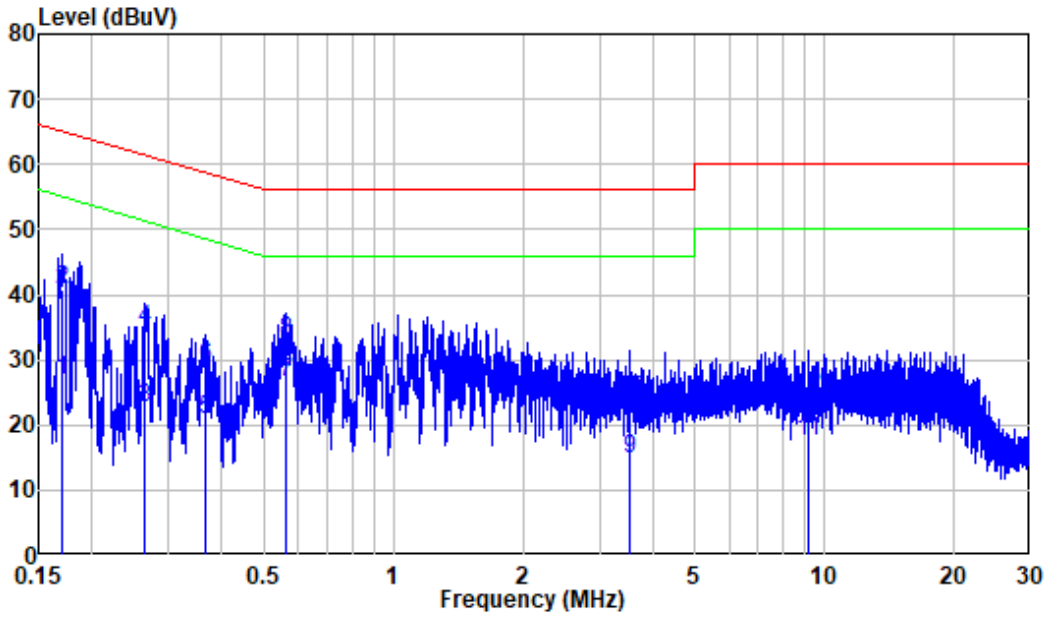
AC 120V/60 Hz, Line



Site : Shielding Room
Condition: Line
Job No. : RA230420-21001E-RF
Mode : Full load+2.4G WIFI Transmission
Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.176	10.32	16.65	26.97	54.65	-27.68	Average
2	0.176	10.32	30.27	40.59	64.65	-24.06	QP
3	0.279	10.38	14.79	25.17	50.85	-25.68	Average
4	0.279	10.38	25.82	36.20	60.85	-24.65	QP
5	0.365	10.46	14.13	24.59	48.62	-24.03	Average
6	0.365	10.46	21.10	31.56	58.62	-27.06	QP
7	0.567	10.61	19.08	29.69	46.00	-16.31	Average
8	0.567	10.61	24.25	34.86	56.00	-21.14	QP
9	3.300	10.50	7.95	18.45	46.00	-27.55	Average
10	3.300	10.50	14.54	25.04	56.00	-30.96	QP
11	19.818	10.32	7.74	18.06	50.00	-31.94	Average
12	19.818	10.32	17.89	28.21	60.00	-31.79	QP

AC 120V/60 Hz, Neutral



Site : Shielding Room
Condition: Neutral
Job No. : RA230420-21001E-RF
Mode : Full load+2.4G WIFI Transmission
Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.170	10.28	16.51	26.79	54.95	-28.16	Average
2	0.170	10.28	30.59	40.87	64.95	-24.08	QP
3	0.264	10.34	12.30	22.64	51.30	-28.66	Average
4	0.264	10.34	24.44	34.78	61.30	-26.52	QP
5	0.366	10.40	10.39	20.79	48.60	-27.81	Average
6	0.366	10.40	18.51	28.91	58.60	-29.69	QP
7	0.562	10.47	15.98	26.45	46.00	-19.55	Average
8	0.562	10.47	22.55	33.02	56.00	-22.98	QP
9	3.518	10.54	4.31	14.85	46.00	-31.15	Average
10	3.518	10.54	13.36	23.90	56.00	-32.10	QP
11	9.125	10.66	6.71	17.37	50.00	-32.63	Average
12	9.125	10.66	13.91	24.57	60.00	-35.43	QP

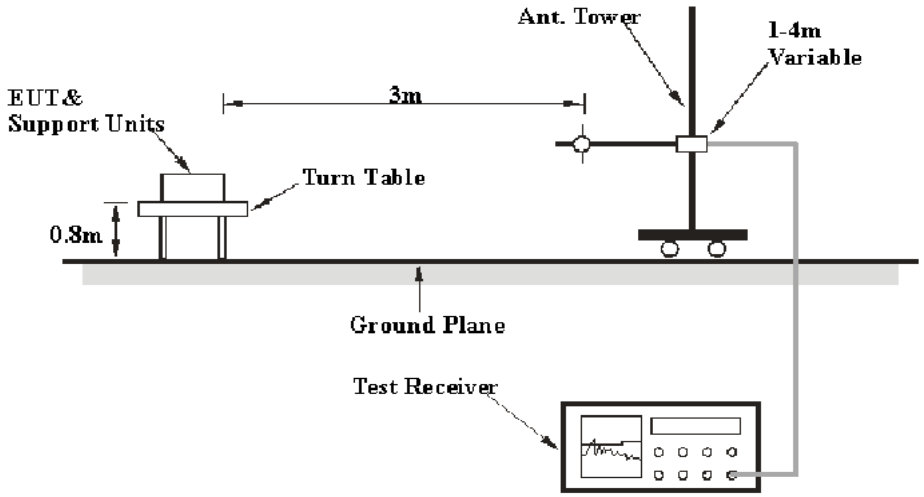
FCC §15.209, §15.205 & §15.247(d) - SPURIOUS EMISSIONS

Applicable Standard

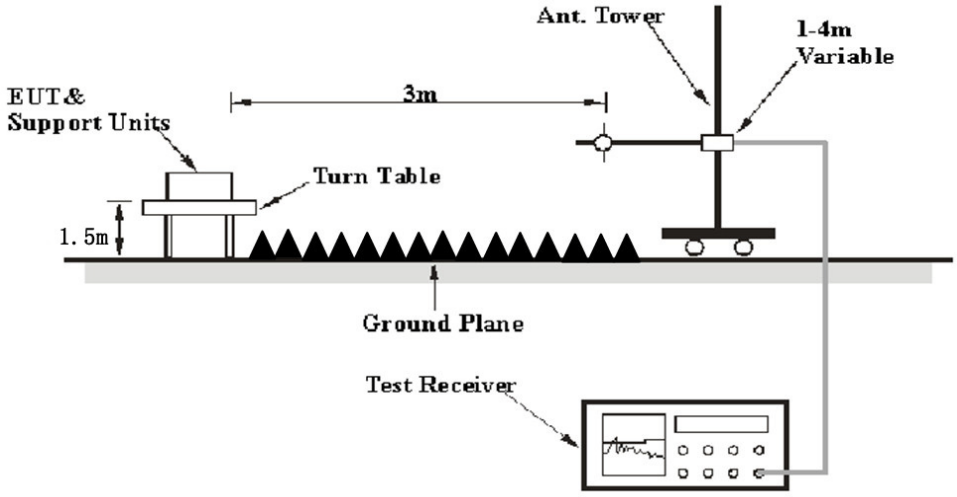
FCC §15.247 (d); §15.209; §15.205;

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

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%

If the maximized peak measured value complies with the limit, then it is unnecessary to perform QP/Avera ge measurement.

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.

Factor & Margin Calculation

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

Factor = Antenna Factor + Cable Loss - Amplifier Gain

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

Over Limit/Margin = Level / Corrected Amplitude – Limit
Level / Corrected Amplitude = Read Level + Factor

Test Data

Environmental Conditions

Temperature:	23-24 ℃
Relative Humidity:	56-57 %
ATM Pressure:	101.0 kPa

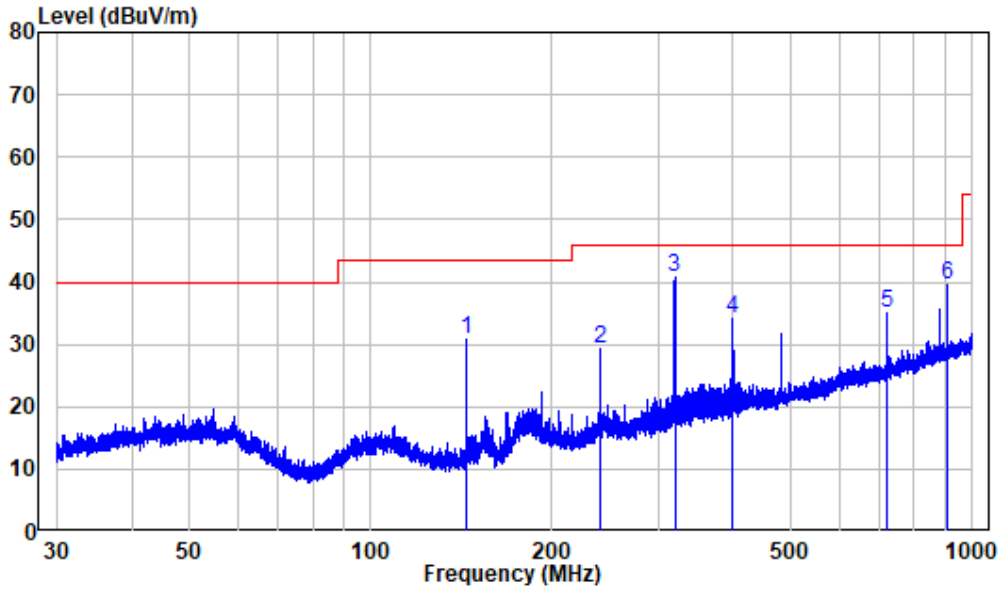
The Below 1G testing was performed by Jason Liu on 2023-05-31.
The Above 1G testing was performed by Jimi Zheng on 2023-04-22.

EUT operation mode: Transmitting (Pre-scan in the X, Y and Z axes of orientation, the worst case X-axis of orientation was recorded)

30MHz-1GHz:

BLE (worst case, high channel)

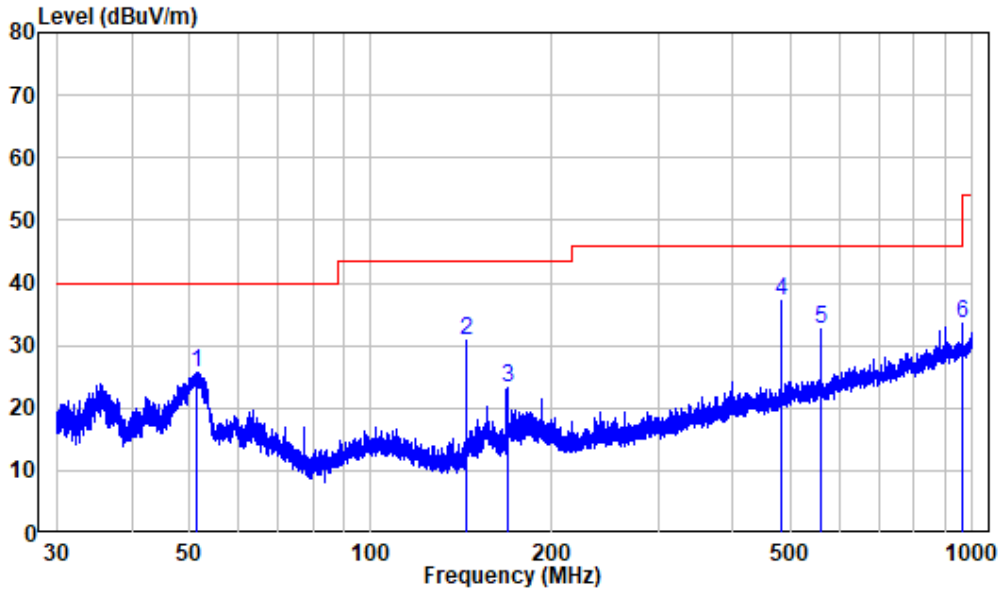
Horizontal



Site : chamber
Condition: 3m HORIZONTAL
Job No. : RA230420-21001E-RF
Test Mode: Full load+BLE Transmission

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	144.335	-15.50	46.25	30.75	43.50	-12.75	Peak
2	239.987	-10.83	40.05	29.22	46.00	-16.78	Peak
3	320.077	-8.56	49.20	40.64	46.00	-5.36	Peak
4	400.081	-6.33	40.51	34.18	46.00	-11.82	Peak
5	720.146	-1.34	36.44	35.10	46.00	-10.90	Peak
6	908.073	1.98	37.60	39.58	46.00	-6.42	Peak

Vertical

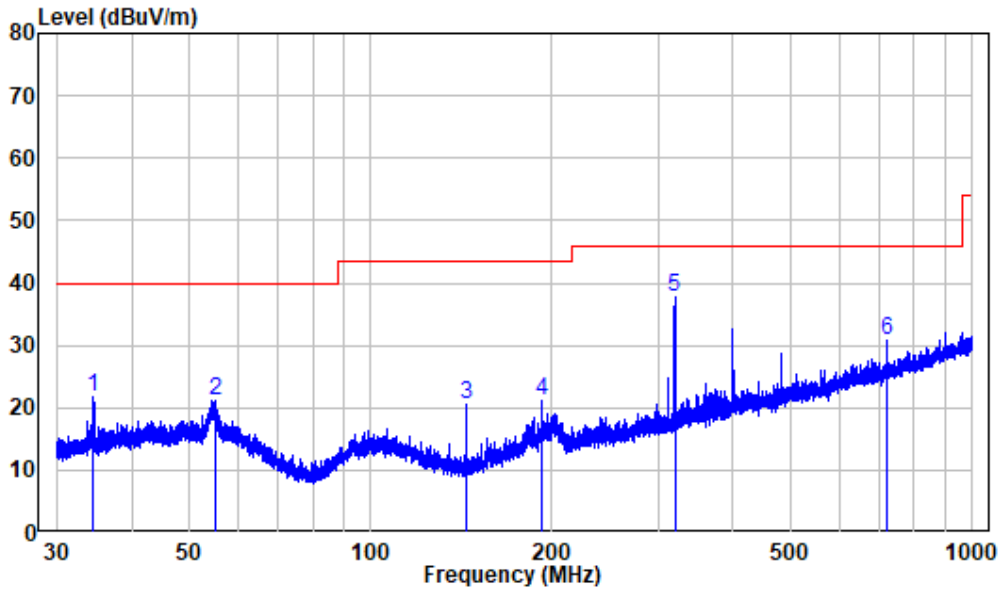


Site : chamber
Condition: 3m VERTICAL
Job No. : RA230420-21001E-RF
Test Mode: Full load+BLE Transmission

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	51.458	-9.99	35.63	25.64	40.00	-14.36	Peak
2	144.208	-15.50	46.30	30.80	43.50	-12.70	Peak
3	168.340	-13.68	37.06	23.38	43.50	-20.12	Peak
4	480.107	-4.78	41.97	37.19	46.00	-8.81	Peak
5	560.202	-3.64	36.11	32.47	46.00	-13.53	Peak
6	960.056	2.59	31.04	33.63	54.00	-20.37	Peak

2.4G WIFI (worst case 802.11g, high channel)

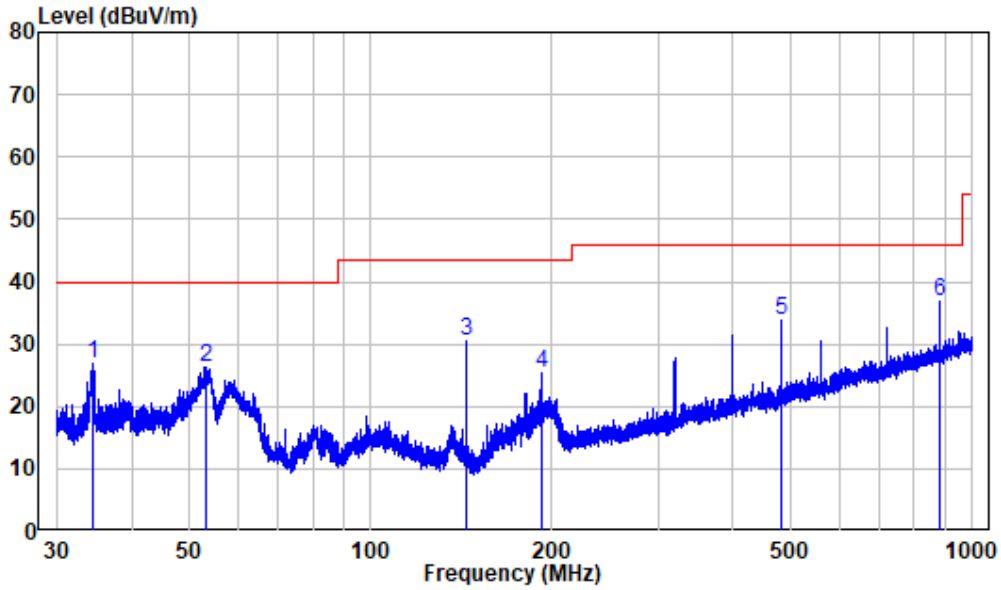
Horizontal



Site : chamber
Condition: 3m HORIZONTAL
Job No. : RA230420-21001E-RF
Test Mode: Full load+2.4GWIFI Transmission

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	34.502	-11.72	33.50	21.78	40.00	-18.22	Peak
2	55.076	-10.34	31.37	21.03	40.00	-18.97	Peak
3	144.208	-15.50	36.06	20.56	43.50	-22.94	Peak
4	192.250	-11.29	32.55	21.26	43.50	-22.24	Peak
5	320.077	-8.56	46.33	37.77	46.00	-8.23	Peak
6	720.146	-1.34	32.20	30.86	46.00	-15.14	Peak

Vertical



Site : chamber
Condition: 3m VERTICAL
Job No. : RA230420-21001E-RF
Test Mode: Full load+2.4GWIFI Transmission

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	34.457	-11.74	38.73	26.99	40.00	-13.01	Peak
2	53.295	-10.27	36.53	26.26	40.00	-13.74	Peak
3	144.272	-15.50	46.07	30.57	43.50	-12.93	Peak
4	192.419	-11.30	36.75	25.45	43.50	-18.05	Peak
5	480.107	-4.78	38.74	33.96	46.00	-12.04	Peak
6	880.249	1.52	35.33	36.85	46.00	-9.15	Peak

1-25 GHz:

BLE:

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
	Reading (dBuV)	PK/Ave		Height (m)	Polar (H/V)				
Low Channel									
2310	48.05	PK	353	1.8	H	-10.36	37.69	74	-36.31
2310	47.96	PK	77	1.5	V	-10.36	37.60	74	-36.40
2390	52.96	PK	299	1.8	H	-10.71	42.25	74	-31.75
2390	53.7	PK	113	1.2	V	-10.71	42.99	74	-31.01
4804	49.56	PK	106	1.3	H	-6.11	43.45	74	-30.55
4804	49.4	PK	129	1.6	V	-6.11	43.29	74	-30.71
Middle Channel									
4880	48.67	PK	53	1.5	H	-5.9	42.77	74	-31.23
4880	48.84	PK	256	2.0	V	-5.9	42.94	74	-31.06
High Channel									
2483.5	54.06	PK	322	1.2	H	-10.55	43.51	74	-30.49
2483.5	51.12	PK	206	1.8	V	-10.55	40.57	74	-33.43
2500	50.43	PK	122	1.0	H	-10.42	40.01	74	-33.99
2500	52.82	PK	154	2.2	V	-10.42	42.40	74	-31.60
4960	48.65	PK	37	1.6	H	-5.47	43.18	74	-30.82
4960	50.38	PK	1	2.0	V	-5.47	44.91	74	-29.09

Wi-Fi:

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
	Reading (dBuV)	PK/Ave		Height (m)	Polar (H/V)				
802.11B, Low Channel									
2310	56.03	PK	136	2.1	H	-10.36	45.67	74	-28.33
2310	55.42	PK	264	1.6	V	-10.36	45.06	74	-28.94
2390	57	PK	49	2.1	H	-10.71	46.29	74	-27.71
2390	57.26	PK	11	1.0	V	-10.71	46.55	74	-27.45
4824	51.46	PK	130	1.2	H	-6.11	45.35	74	-28.65
4824	51.26	PK	267	1.9	V	-6.11	45.15	74	-28.85
802.11B, Middle Channel									
4874	52.92	PK	282	1.2	H	-5.94	46.98	74	-27.02
4874	52.43	PK	109	1.3	V	-5.94	46.49	74	-27.51
802.11B, High Channel									
2483.5	56.79	PK	226	2.1	H	-10.55	46.24	74	-27.76
2483.5	56.97	PK	217	1.7	V	-10.55	46.42	74	-27.58
2500	57.52	PK	33	1.6	H	-10.42	47.10	74	-26.90
2500	58.58	PK	281	1.5	V	-10.42	48.16	74	-25.84
4924	52.62	PK	266	2.0	H	-5.67	46.95	74	-27.05
4924	51.05	PK	223	1.1	V	-5.67	45.38	74	-28.62

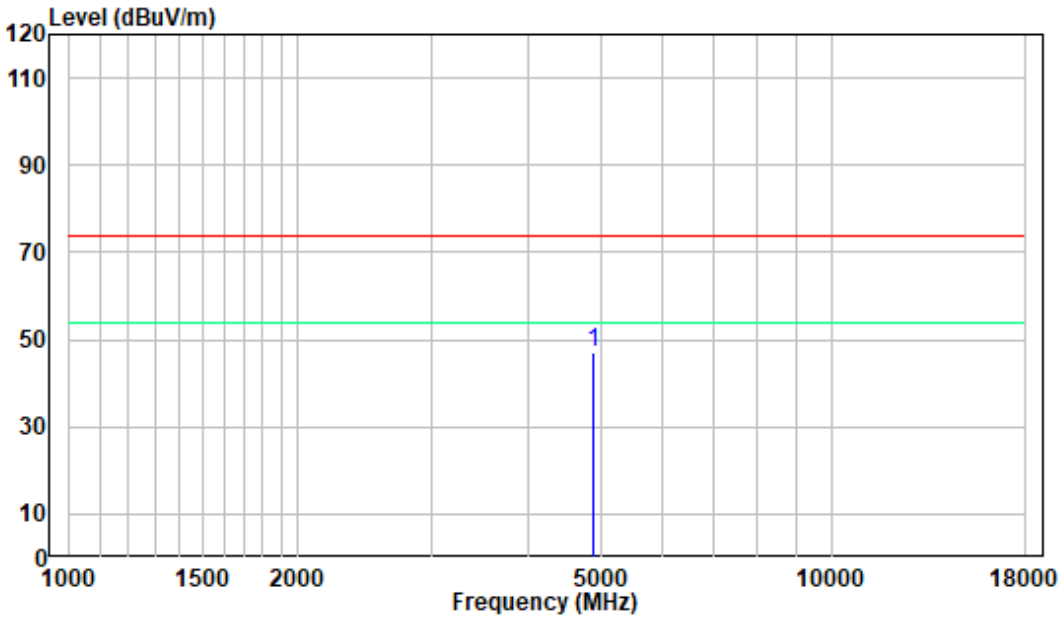
Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
	Reading (dBuV)	PK/Ave		Height (m)	Polar (H/V)				
802.11G, Low Channel									
2310	55.33	PK	297	1.1	H	-10.36	44.97	74	-29.03
2310	56.24	PK	272	1.2	V	-10.36	45.88	74	-28.12
2390	57.27	PK	258	1.6	H	-10.71	46.56	74	-27.44
2390	56.74	PK	274	1.5	V	-10.71	46.03	74	-27.97
4824	48.5	PK	57	2.0	H	-6.11	42.39	74	-31.61
4824	48.77	PK	26	1.9	V	-6.11	42.66	74	-31.34
802.11G, Middle Channel									
4874	49.93	PK	342	1.2	H	-5.94	43.99	74	-30.01
4874	48.77	PK	182	2.1	V	-5.94	42.83	74	-31.17
802.11G, High Channel									
2483.5	58.63	PK	15	1.6	H	-10.55	48.08	74	-25.92
2483.5	57.51	PK	64	1.6	V	-10.55	46.96	74	-27.04
2500	57.38	PK	95	1.2	H	-10.42	46.96	74	-27.04
2500	57.03	PK	95	1.2	V	-10.42	46.61	74	-27.39
4924	49.13	PK	62	1.9	H	-5.67	43.46	74	-30.54
4924	49.45	PK	55	1.0	V	-5.67	43.78	74	-30.22
802.11N20, Low Channel									
2310	56.09	PK	91	1.9	H	-10.36	45.73	74	-28.27
2310	56.36	PK	134	2.1	V	-10.36	46.00	74	-28.00
2390	58.44	PK	247	1.7	H	-10.71	47.73	74	-26.27
2390	56.72	PK	44	1.7	V	-10.71	46.01	74	-27.99
4824	49.52	PK	283	2.1	H	-6.11	43.41	74	-30.59
4824	48.99	PK	337	1.5	V	-6.11	42.88	74	-31.12
802.11N20, Middle Channel									
4874	49.29	PK	69	1.7	H	-5.94	43.35	74	-30.65
4874	49.06	PK	116	1.9	V	-5.94	43.12	74	-30.88
802.11N20, High Channel									
2483.5	66.42	PK	122	1.9	H	-10.55	55.87	74	-18.13
2483.5	47.02	AV	113	1.8	H	-10.55	36.47	54	-17.53
2483.5	58.25	PK	277	2.1	V	-10.55	47.70	74	-26.30
2500	63.3	PK	127	1.5	H	-10.42	52.88	74	-21.12
2500	57.06	PK	127	1.5	V	-10.42	46.64	74	-27.36
4924	50.71	PK	328	1.4	H	-5.67	45.04	74	-28.96
4924	50.41	PK	139	2.1	V	-5.67	44.74	74	-29.26
802.11N40, Low Channel									
2310	55.51	PK	277	1.9	H	-10.36	45.15	74	-28.85
2310	56.22	PK	81	1.4	V	-10.36	45.86	74	-28.14
2390	58.19	PK	81	1.4	H	-10.71	47.48	74	-26.52
2390	57.1	PK	71	2.2	V	-10.71	46.39	74	-27.61
4844	48.43	PK	170	1.4	H	-6.09	42.34	74	-31.66
4844	48.84	PK	72	1.0	V	-6.09	42.75	74	-31.25

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
	Reading (dBuV)	PK/Ave		Height (m)	Polar (H/V)				
802.11N40, Middle Channel									
4874	48	PK	60	1.1	H	-5.94	42.06	74	-31.94
4874	48.8	PK	224	1.8	V	-5.94	42.86	74	-31.14
802.11N40, High Channel									
2483.5	59.74	PK	322	2.1	H	-10.55	49.19	74	-24.81
2483.5	57.63	PK	170	2.0	V	-10.55	47.08	74	-26.92
2500	58.56	PK	165	1.0	H	-10.42	48.14	74	-25.86
2500	56.63	PK	100	1.5	V	-10.42	46.21	74	-27.79
4904	49.62	PK	143	1.5	H	-5.77	43.85	74	-30.15
4904	48.76	PK	355	1.3	V	-5.77	42.99	74	-31.01

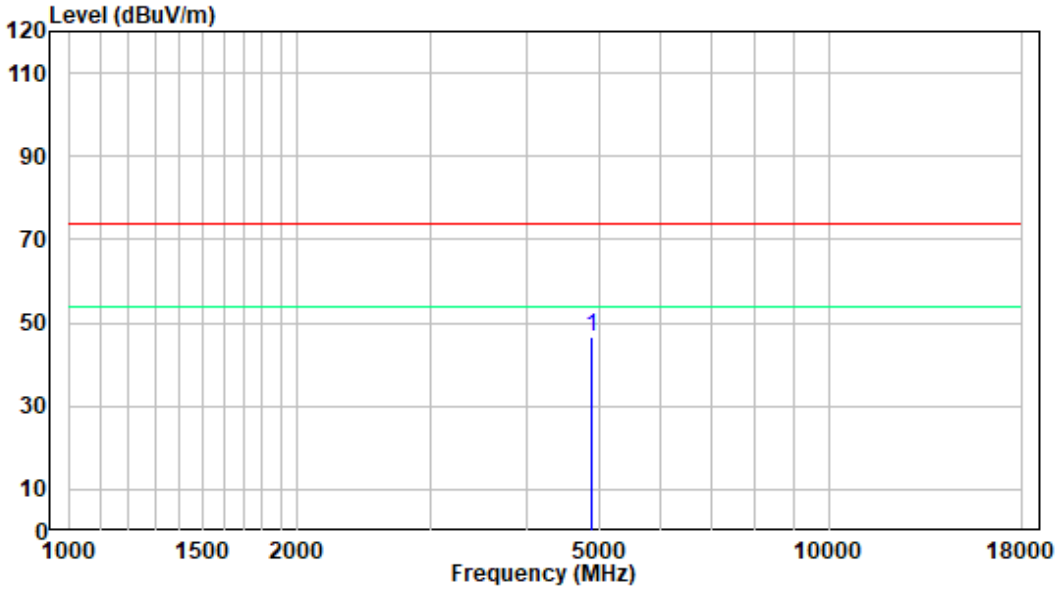
Note:
Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
Absolute Level (Corrected Amplitude) = Factor + Reading
Margin = Absolute Level (Corrected Amplitude) – Limit
The other spurious emission which is in the noise floor level was not recorded.
For above 1GHz, the test result of peak was 20dB below to the limit of peak, which can be compliant to the average limit, so just peak value was recorded.

1-18 GHz: (Pre-scan plots)

802.11 b Middle Channel (Worst case)
Horizontal

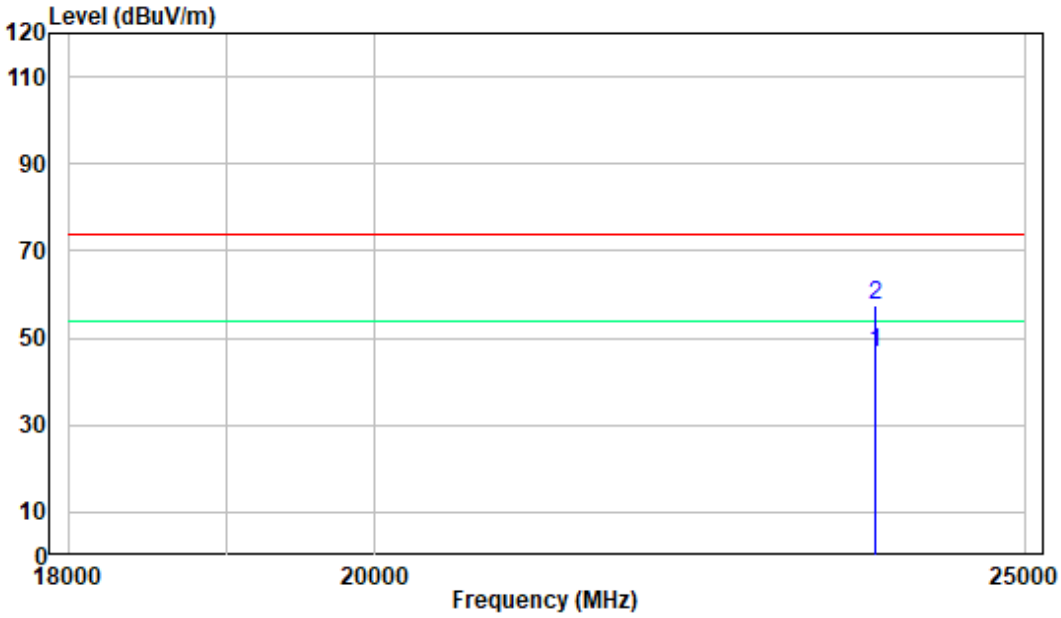


Vertical

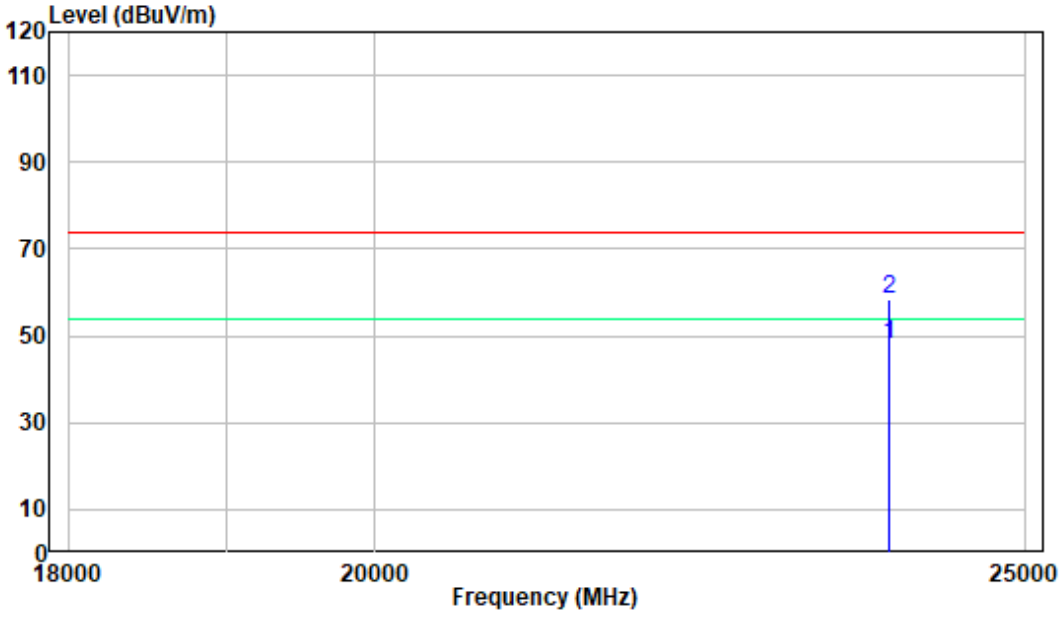


18 -25GHz: (Pre-scan plots)

802.11 b Middle Channel (Worst case)
Horizontal



Vertical



FCC §15.247(a) (2)-6 dB EMISSION BANDWIDTH & OCCUPIED BANDWIDTH

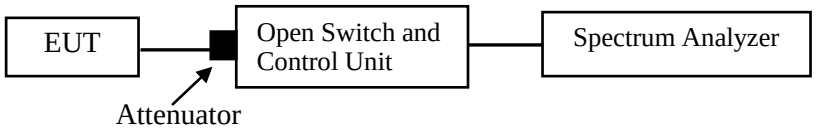
Applicable Standard

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

According to ANSI C63.10-2013, section 11.8 and section 6.9

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:	24℃
Relative Humidity:	53%
ATM Pressure:	101.0 kPa

The testing was performed by Matt Liang on 2023-04-25.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix Wi-Fi and Appendix BLE.

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

Applicable Standard

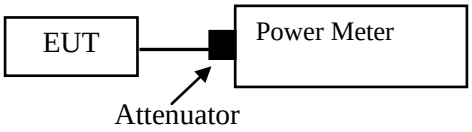
According to FCC §15.247(b) (3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted 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

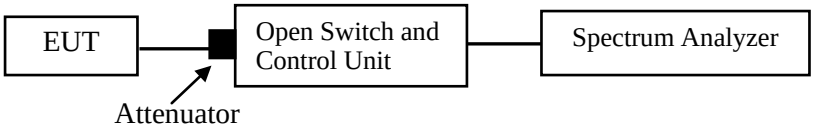
According to ANSI C63.10-2013, section 11.9.1.1 for BLE mode
According to ANSI C63.10-2013, section 11.9.2.3.2 for Wi-Fi mode

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.

For Wi-Fi mode:



For BLE mode:



Test Data

Environmental Conditions

Temperature:	24℃
Relative Humidity:	53%
ATM Pressure:	101.0 kPa

The testing was performed by Matt Liang on2023-04-25.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix Wi-Fi and Appendix BLE.

FCC §15.247(d)-100 kHz BANDWIDTH OF FREQUENCY BAND EDGE

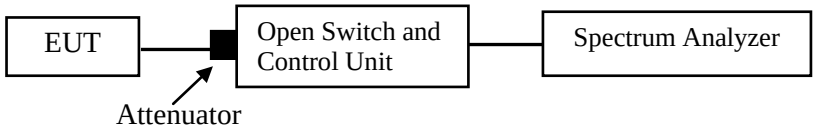
Applicable Standard

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

According to ANSI C63.10-2013, section 11.11

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:	24℃
Relative Humidity:	53%
ATM Pressure:	101.0 kPa

The testing was performed by Matt Liang on2023-04-25.

EUT operation mode: Transmitting

Test Result: Compliant.

Conducted Band Edge Result:

Please refer to the Appendix Wi-Fi and Appendix BLE.

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

According to ANSI C63.10-2013, section 11.10.2

Method PKPSD (peak PSD)

The following procedure shall be used if maximum peak conducted output power was used to determine compliance, and it is optional if the maximum conducted (average) output power was used to determine compliance:

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.

According to ANSI C63.10-2013, section 11.10.3

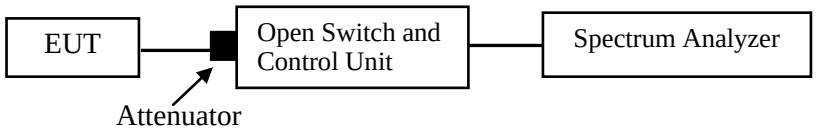
Method AVGPSD-1: (for duty cycle ≥ 98%)

1. Use this procedure when the maximum conducted average output power in the fundamental emission is used to demonstrate compliance and with continuous transmission (or at least 98% duty cycle).
2. Set the RBW to: 3kHz≤ RBW≤100 kHz.
3. Set the VBW ≥ 3×RBW.
4. Set the span to at least 1.5 times the OBW.
5. Detector = power averaging (rms) or sample detector (when rms not available).
6. Sweep time = auto couple.
7. Ensure that the number of measurement points in the sweep ≥ [2 · span / RBW].
8. Employ trace averaging (rms) mode over a minimum of 100 traces.
9. Use the peak marker function to determine the maximum amplitude level.
10. If measured value exceeds requirement specified by regulatory agency, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

According to ANSI C63.10-2013, section 11.10.5

Method AVGPSD-2: (for duty cycle < 98% and constant duty cycle)

1. Use this procedure when the maximum conducted average output power in the fundamental emission is used to demonstrate compliance and the continuous transmission (or at least 98% duty cycle) cannot be achieved but exhibit a constant duty cycle during the measurement duration.
2. Measure the duty cycle (D) of the transmitter output signal as described in C63.10-2013 Clause 11.6.
3. Set the RBW to: 3kHz≤ RBW≤100 kHz.
4. Set the VBW ≥ 3×RBW.
5. Set the span to at least 1.5 times the OBW.
6. Detector = power averaging (rms) or sample detector (when rms not available).
7. Sweep time = auto couple.
8. Ensure that the number of measurement points in the sweep ≥ [2 *span / RBW].
9. Do not use sweep triggering; allow sweep to “free run.”
10. Employ trace averaging (rms) mode over a minimum of 100 traces.
11. Use the peak marker function to determine the maximum amplitude level.
12. Add [10 log (1 / D)], where D is the duty cycle measured in step 2), to the measured PSD to compute the average PSD during the actual transmission time.
13. If measured value exceeds requirement specified by regulatory agency, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).



Test Data

Environmental Conditions

Temperature:	23-24℃
Relative Humidity:	50-53%
ATM Pressure:	101.0 kPa

The testing was performed by Matt Liang on 2023-05-25 and 2023-06-07.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix Wi-Fi and Appendix BLE.

APPENDIX Wi-Fi

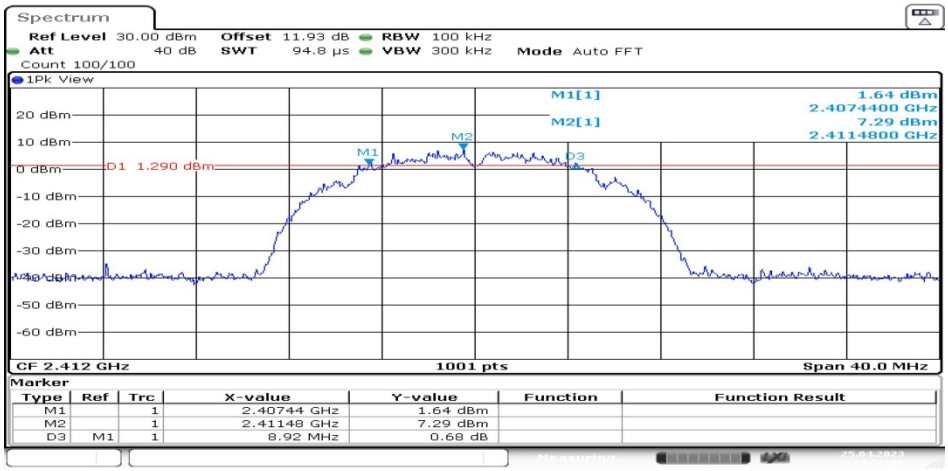
Appendix A: 6dB Emission Bandwidth

Test Result

Test Mode	Antenna	Channel [MHz]	DTS BW [MHz]	Limit[MHz]	Verdict
11B	Ant1	2412	8.92	0.5	PASS
		2437	9.68	0.5	PASS
		2462	9.12	0.5	PASS
11G	Ant1	2412	16.40	0.5	PASS
		2437	16.40	0.5	PASS
		2462	16.44	0.5	PASS
11N20SISO	Ant1	2412	17.56	0.5	PASS
		2437	17.56	0.5	PASS
		2462	17.56	0.5	PASS
11N40SISO	Ant1	2422	34.16	0.5	PASS
		2437	34.24	0.5	PASS
		2452	34.16	0.5	PASS

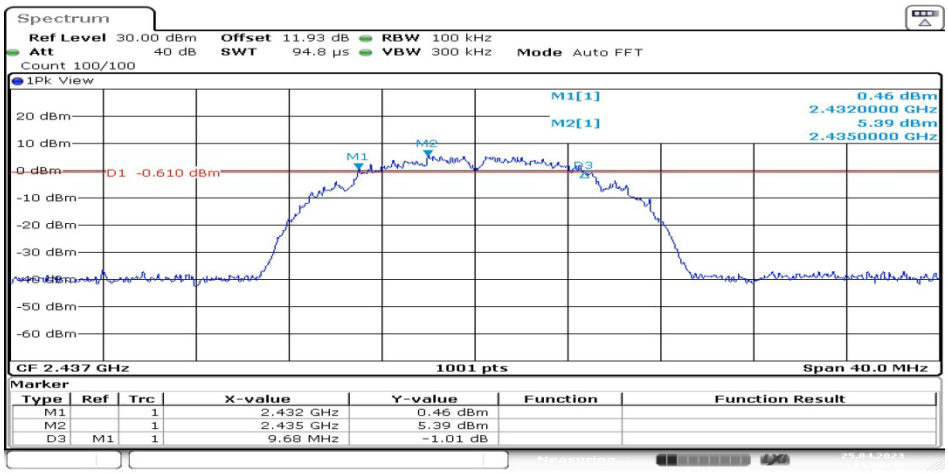
Test Graphs

11B-Ant1-2412



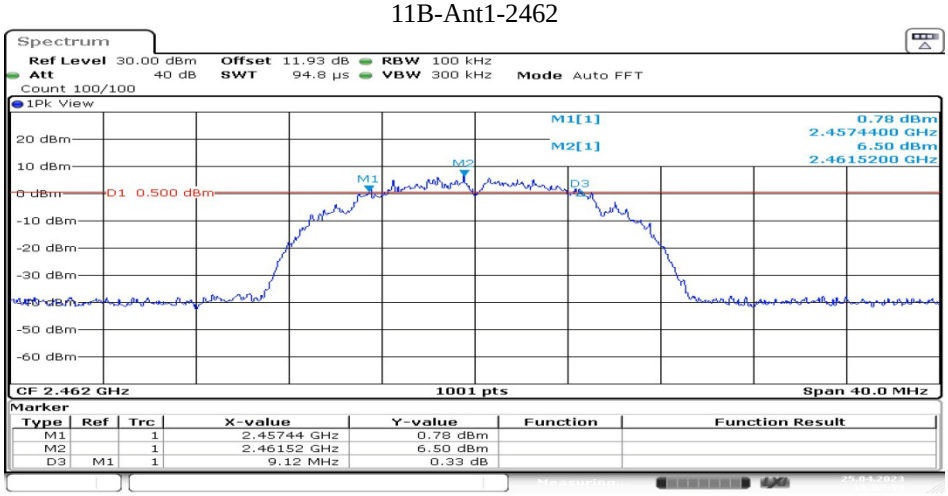
Date: 25.APR.2023 14:56:00

11B-Ant1-2437



Date: 25.APR.2023 15:00:58

11B-Ant1-2462



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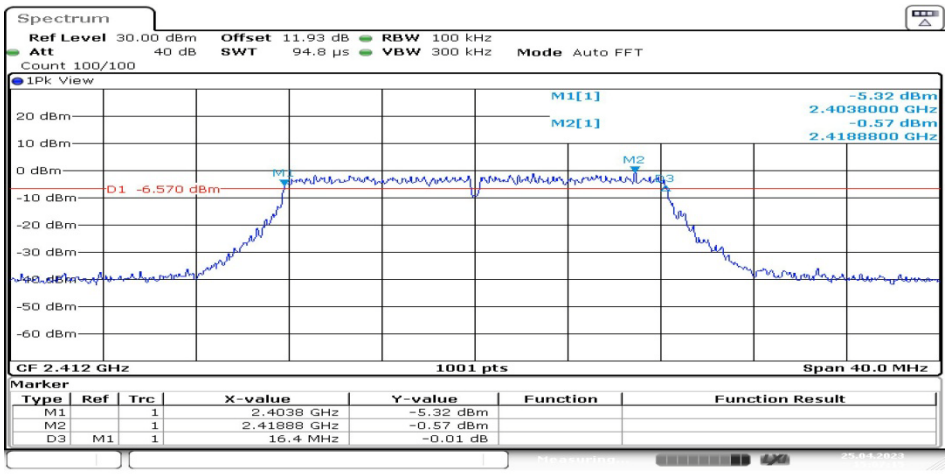
11G-Ant1-2412



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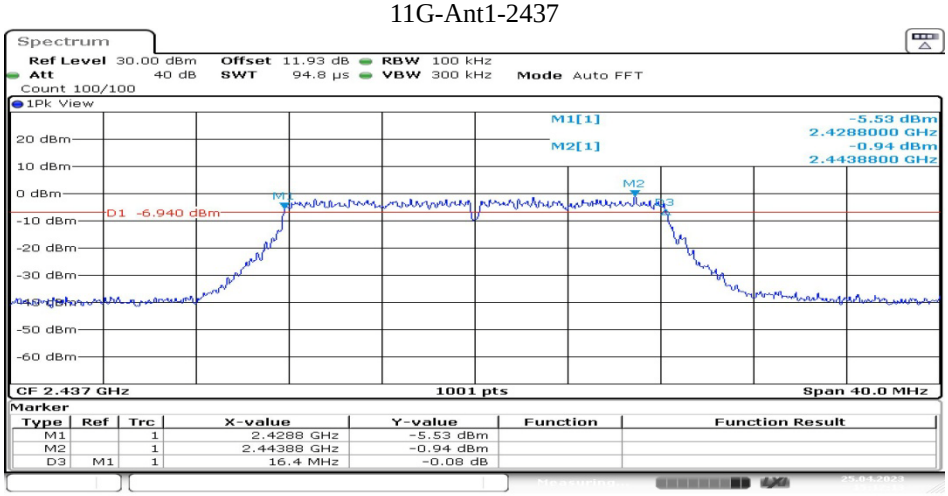
11G-Ant1-2437



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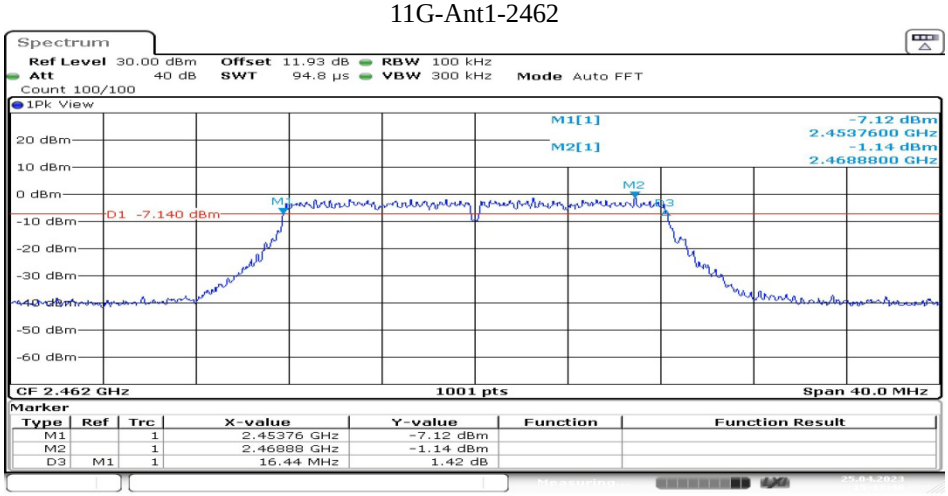
11G-Ant1-2462



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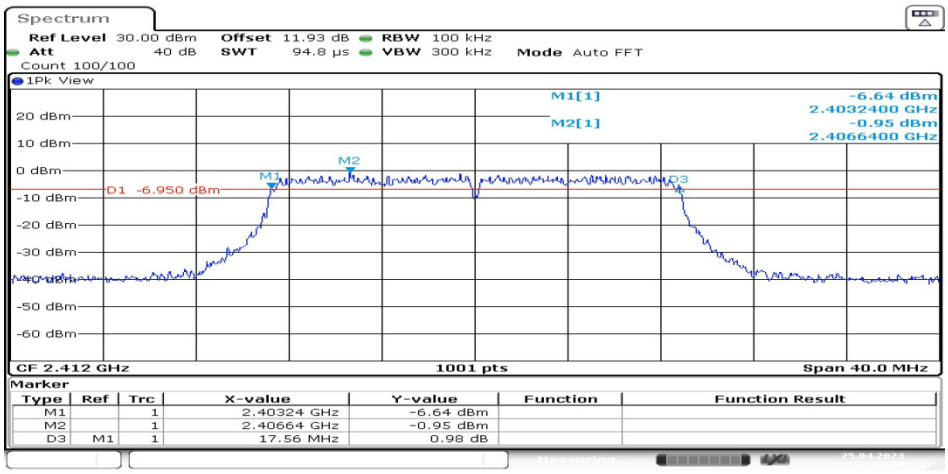
11N20SISO-Ant1-2412



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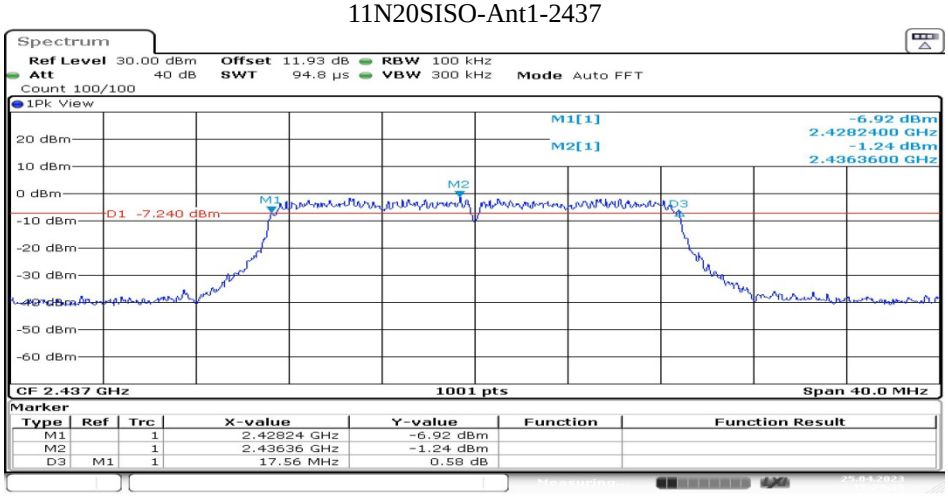
11N20SISO-Ant1-2437



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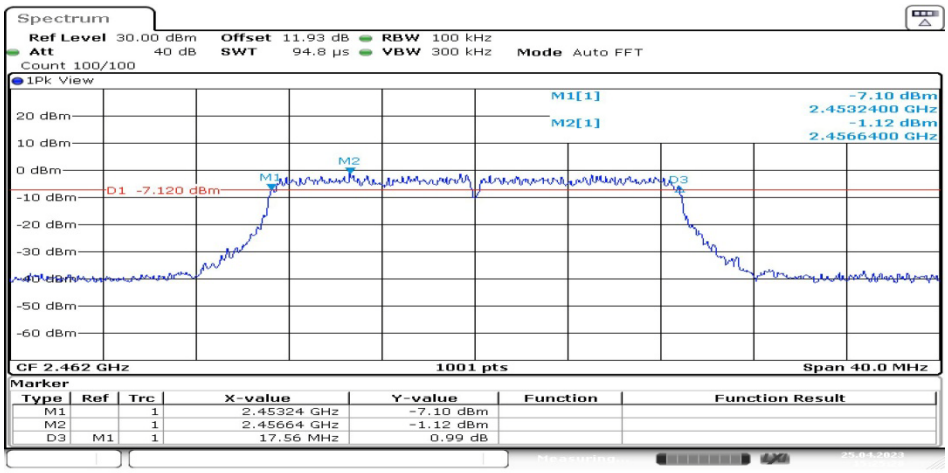
11N20SISO-Ant1-2462



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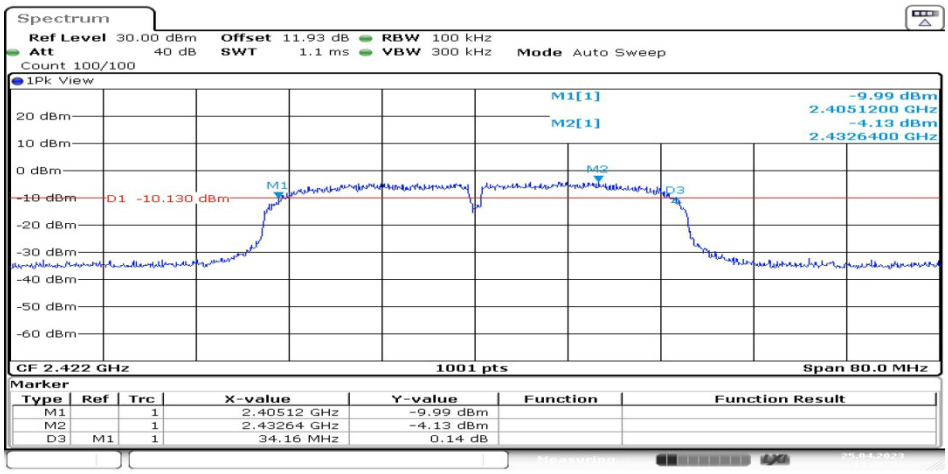
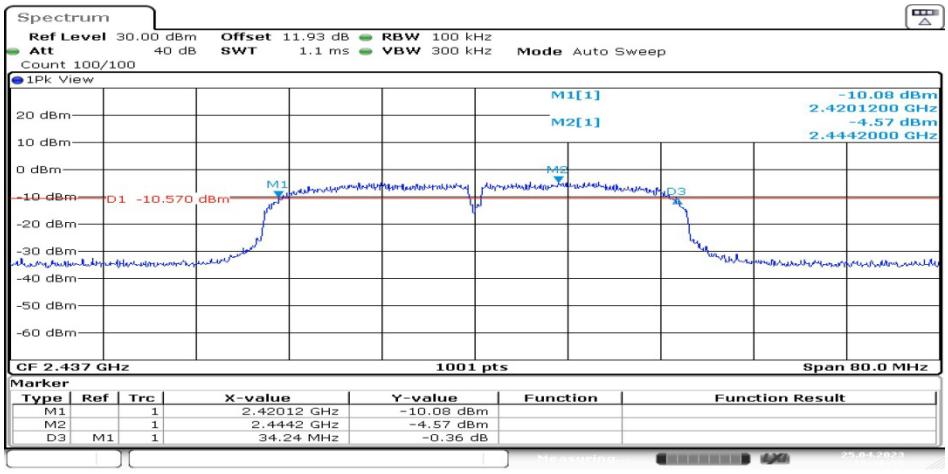
11N40SISO-Ant1-2422



Date: 25.APR.2023 15:46:03

11N40SISO-Ant1-2437



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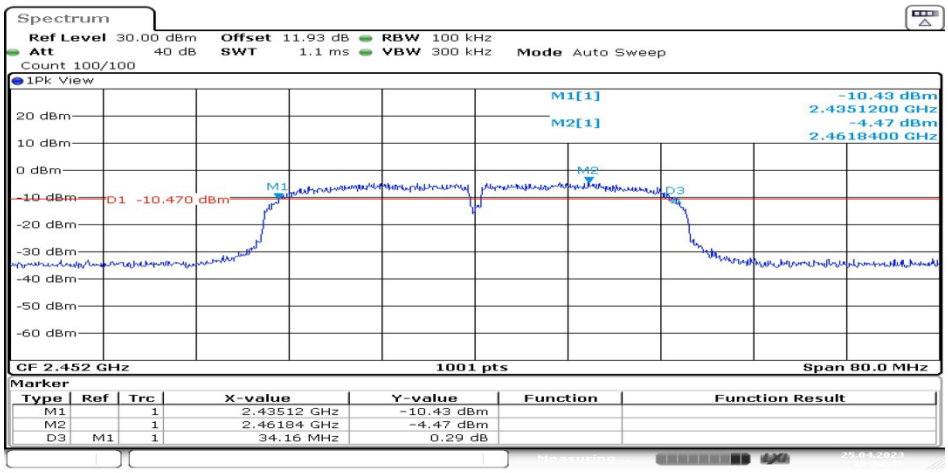
11N40SISO-Ant1-2452



Date: 25.APR.2023 15:38:46

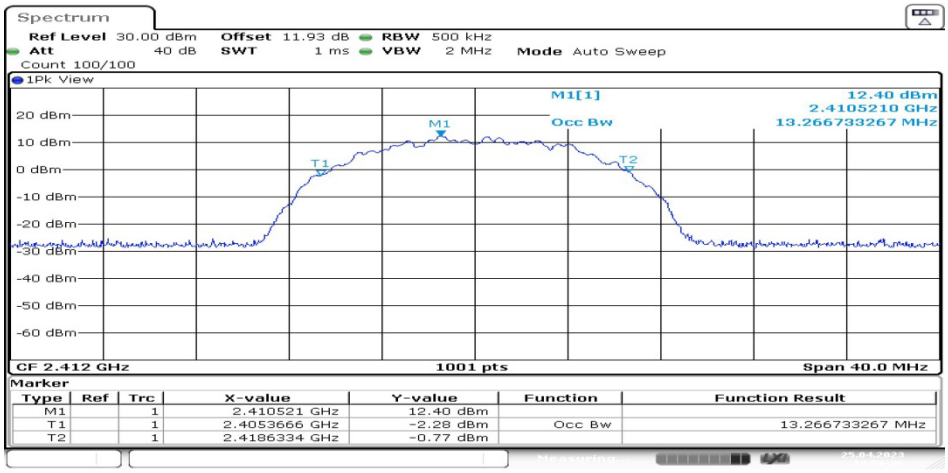
Appendix B: Occupied Channel Bandwidth

Test Result

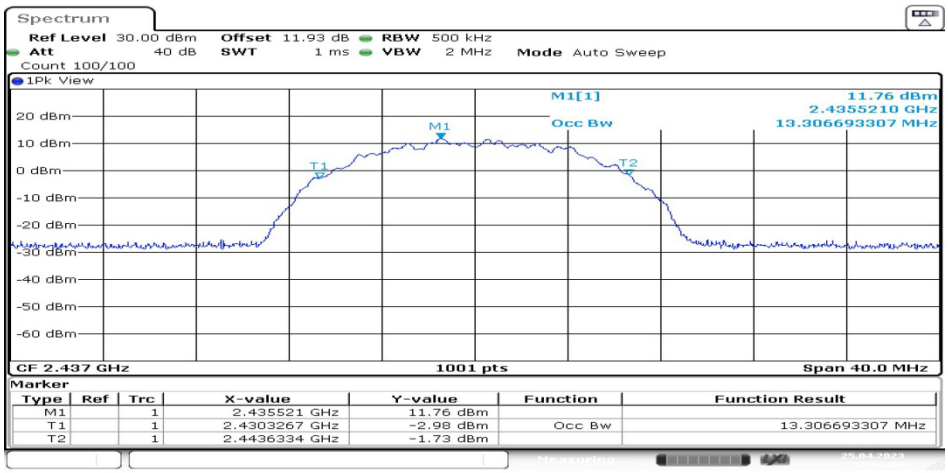
Test Mode	Antenna	Channel	OCB [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
11B	Ant1	2412	13.267	2405.3666	2418.6334	---	PASS
		2437	13.307	2430.3267	2443.6334	---	PASS
		2462	13.307	2455.3267	2468.6334	---	PASS
11G	Ant1	2412	16.983	2403.6084	2420.5914	---	PASS
		2437	16.983	2428.6084	2445.5914	---	PASS
		2462	16.983	2453.6084	2470.5914	---	PASS
11N20SISO	Ant1	2412	17.622	2403.2088	2420.8312	---	PASS
		2437	17.622	2428.2088	2445.8312	---	PASS
		2462	17.622	2453.2088	2470.8312	---	PASS
11N40SISO	Ant1	2422	35.245	2404.4975	2439.7423	---	PASS
		2437	35.245	2419.4975	2454.7423	---	PASS
		2452	35.325	2434.4176	2469.7423	---	PASS

Test Graphs

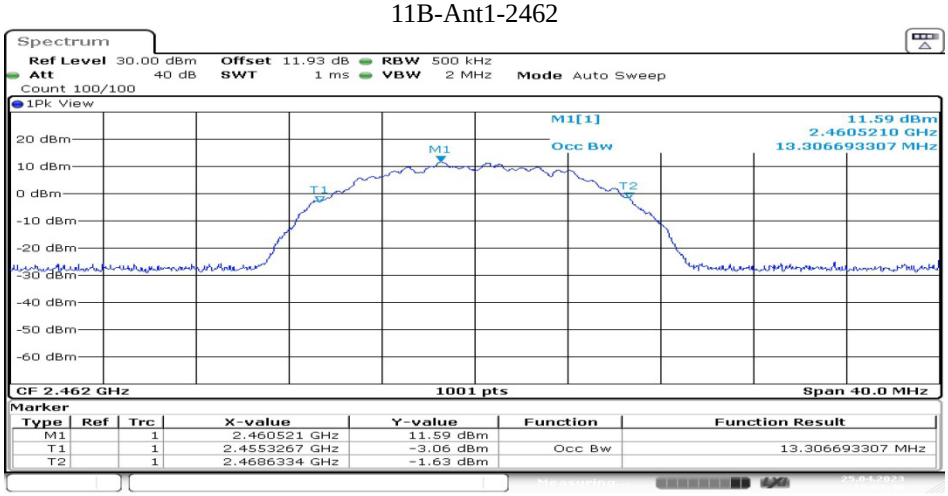
11B-Ant1-2412



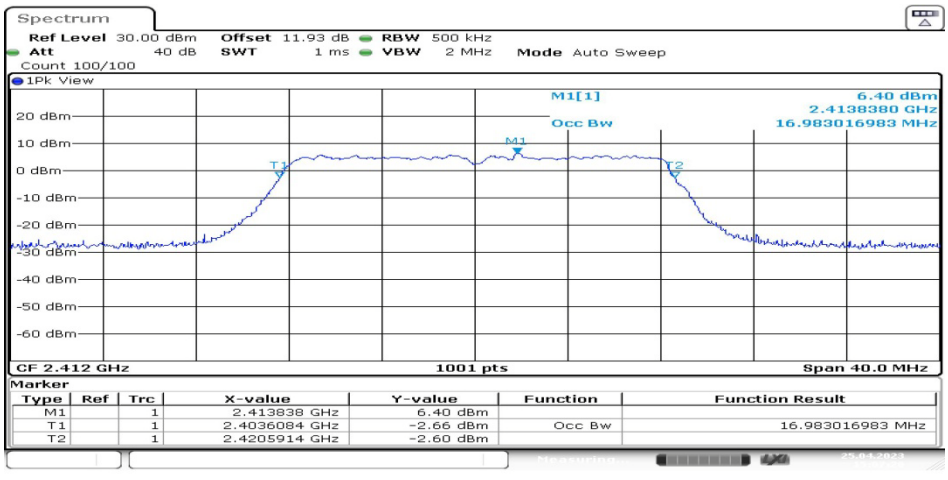
11B-Ant1-2437



11B-Ant1-2462



11G-Ant1-2412



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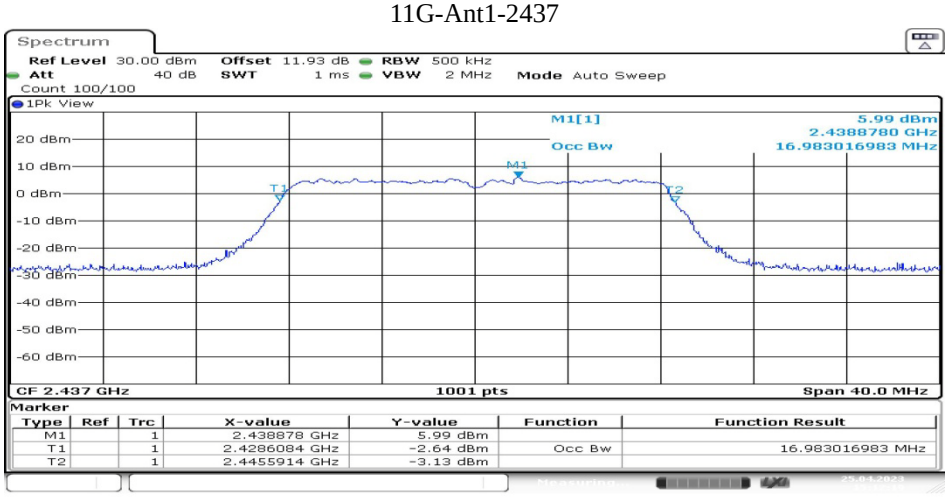

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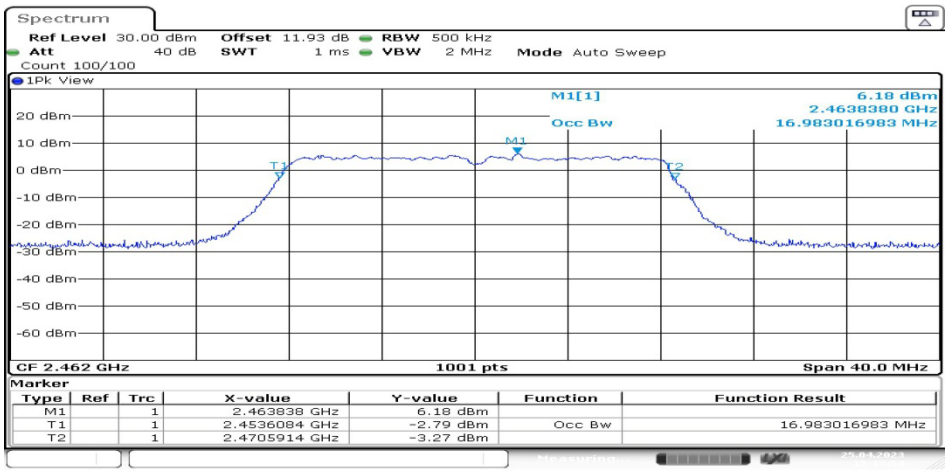

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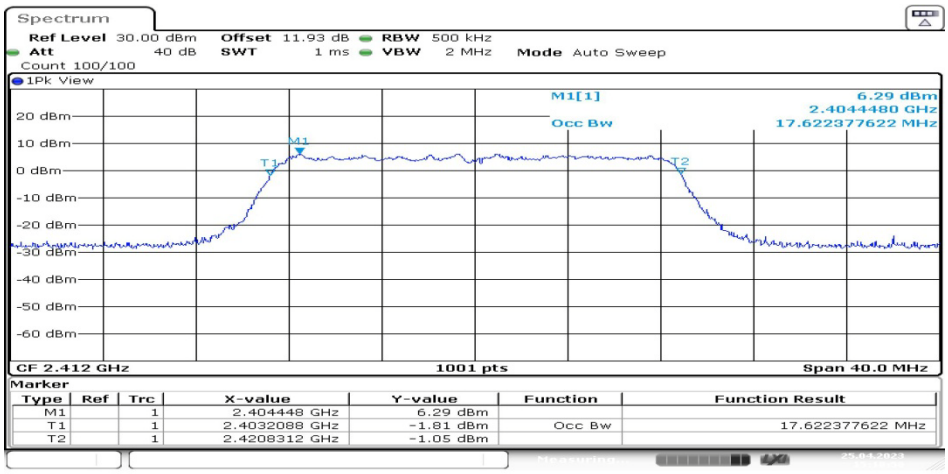

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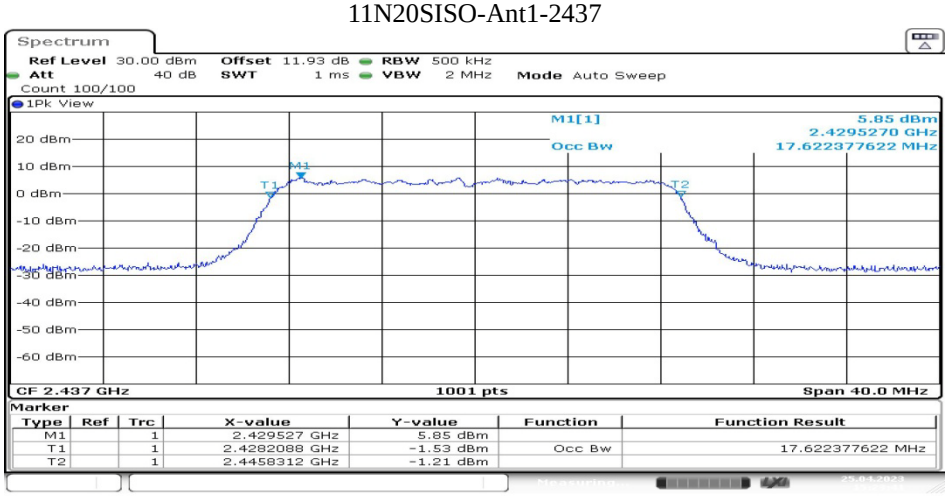

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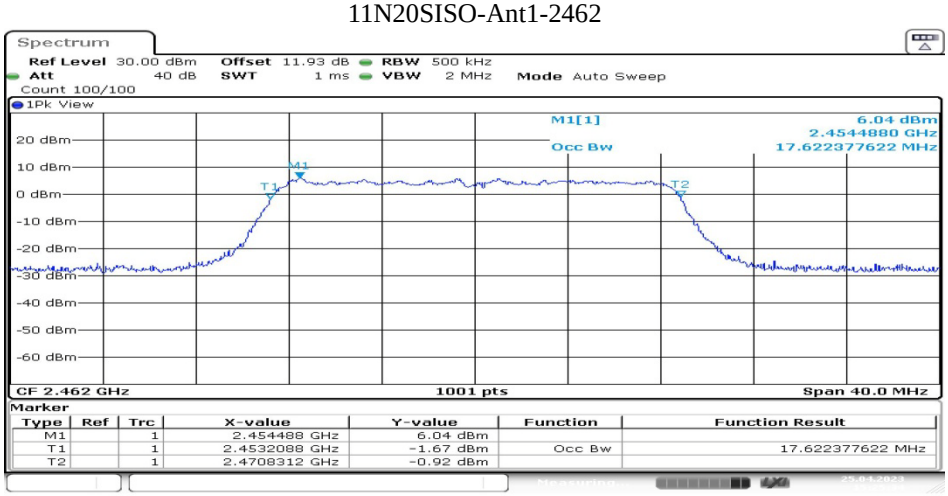

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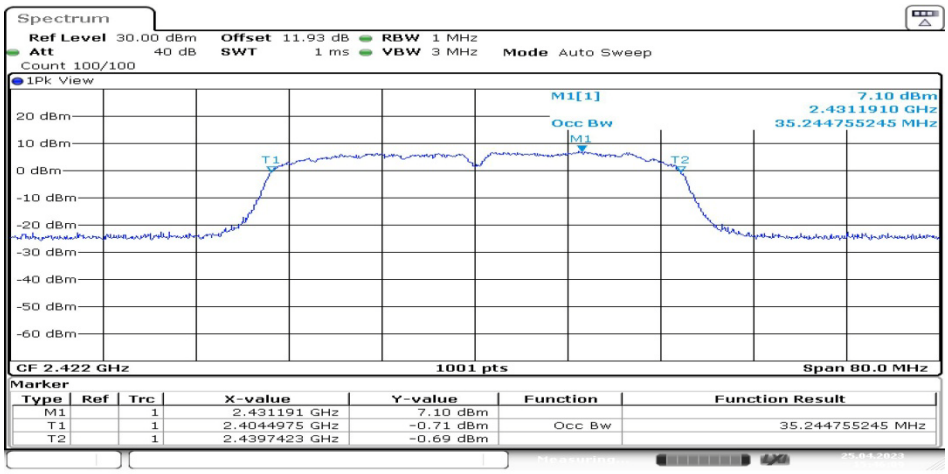

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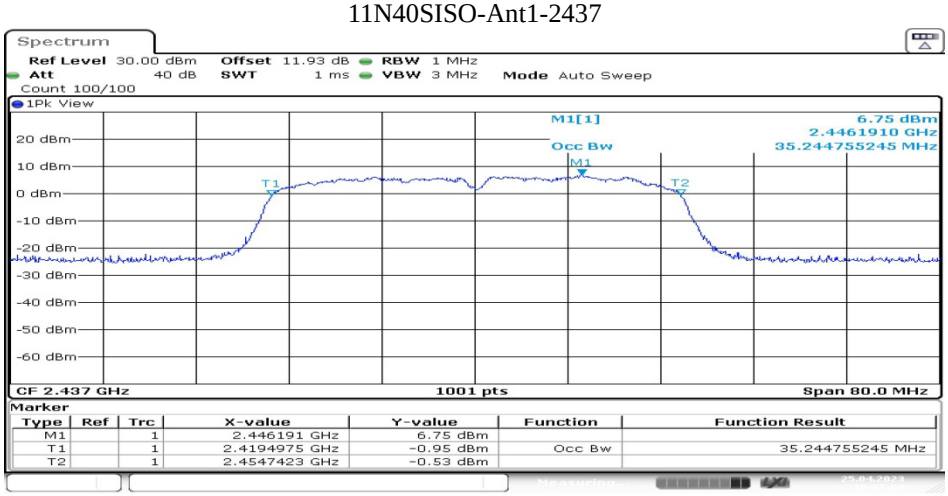

11N40SISO-Ant1-2452