

FCC PART 15.247

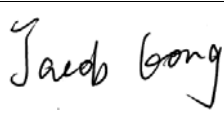
TEST REPORT

For

Thundercomm Technology Co., Ltd

Building 4, No. 99, Data Valley Middle Road, Xiantao District, Yubei District, Chongqing, China

FCC ID: FCC ID: 2AOHH-TURBOXC865

Report Type: Original Report	Product Type: Robotics RB5
Report Number: RSZ200701002-00A	
Report Date: 2021-08-04	
Jacob Kong 	
Reviewed By: RF Engineer	
Prepared By: Bay Area Compliance Laboratories Corp. (Shenzhen) 5F(B-West) , 6F, 7F, the 3rd Phase of Wan Li Industrial Building D, Shihua Rd, FuTian Free Trade Zone, Shenzhen, China Tel: +86-755-33320018 Fax: +86-755-33320008 www.baclcorp.com.cn	

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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	Robotics RB5
Tested Model	TurboX C865 Dev Kit
Frequency Range	BLE: 2402-2480MHz Wi-Fi: 2412-2462MHz/2422-2452MHz
Maximum Conducted Peak Power	BLE: 5.67Bm(LE 1M), 5.77dBm(LE 2M) Wi-Fi: 18.34dBm(802.11b), 20.02dBm(802.11g), 22.40dBm(802.11n-HT20), 21.20dBm(802.11n-HT40), 21.40dBm(802.11ax20), 19.20dBm(802.11ax40)
Modulation Technique	BLE: GFSK Wi-Fi: DSSS, OFDM
Antenna Specification*	PIFA Antenna: -3.0dBi(provided by the applicant)
Voltage Range	DC 12V from adapter
Date of Test	2021-04-09 to 2021-07-20
Sample number	RSZ200701002-RF-S1(Assigned by BACL, Shenzhen)
Received date	2020-07-01
Sample/EUT Status	Good condition
Adapter Information	Model:LYD1202500B Input :100-240V,0.68A,50/60Hz Output:12.0V,2.5A

Objective

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

Each test item follows test standards and with no deviation.

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℃
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 5F(B-West) , 6F, 7F, the 3rd Phase of Wan Li Industrial Building D, Shihua Rd, FuTian Free Trade Zone, Shenzhen, 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 802.11b, 802.11g and 802.11n-HT20 mode, 11 channels are provided to testing:

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

For 802.11b, 802.11g, 802.11n-HT20, 802.11ax20 mode, EUT was tested with Channel 1, 6 and 11.

For 802.11n-HT40, 802.11ax40 mode, EUT was tested with Channel 3, 6 and 9.

For LE 1M&LE 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, 19 and 39.

Equipment Modifications

No modification was made to the EUT tested.

EUT Exercise Software

“QRCT” *exercise software was used

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

Mode	Data rate	Power level*		
		Low channel	Middle channel	High channel
802.11b	1 Mbps	17	17	17
802.11g	6 Mbps	17	17	16
802.11n-HT20	MCS0	16	16	16
802.11n-HT40	MCS0	16	16	16
802.11ax20	MCS11	14	14	14
802.11ax40	MCS11	13	13	13
BLE	Default	Default	Default	Default

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

The device supports SISO in 802.11b and 802.11g mode, and SISO and MIMO in other modes, per pretest, the MIMO mode was the worst mode for 802.11n and ax modes. The device not support Beamforming mode.

Support Equipment List and Details

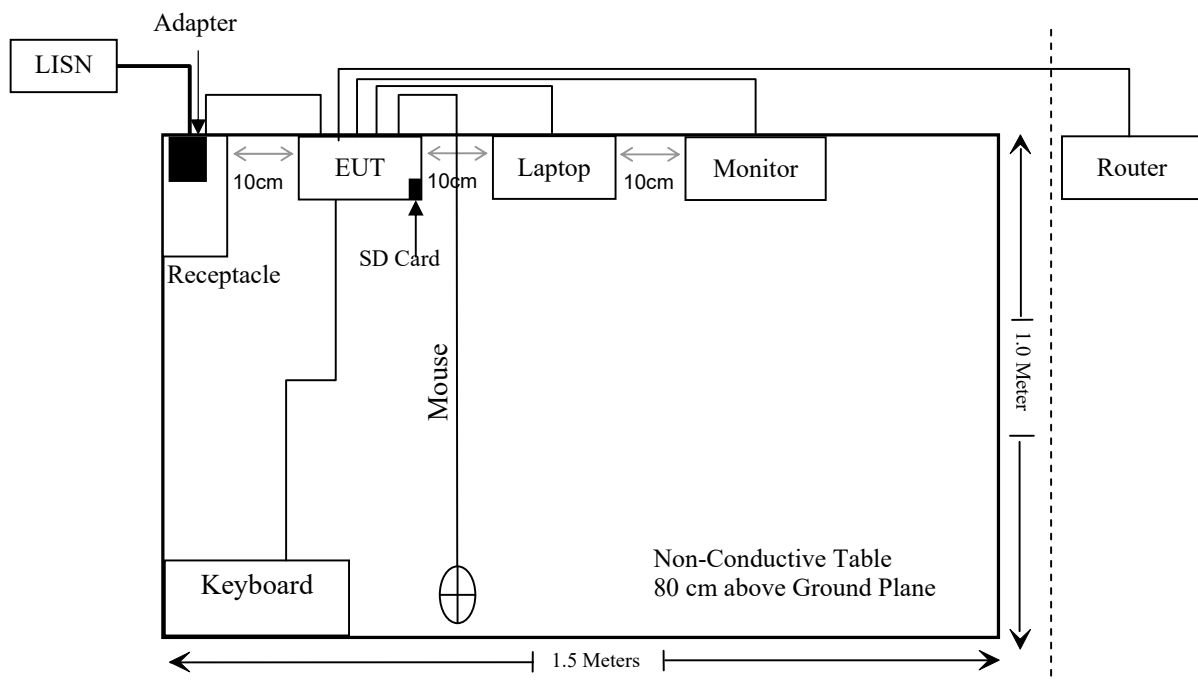
Manufacturer	Description	Model	Serial Number
DELL	Laptop	Latitude E6520	H067T A00
SAMSUNG	Monitor	S24E390HL	ZZFRH4ZN303357K
TCL	Monitor	L32F3301B	RD851P2
HIKVISION	Router	DS-3WR03-E	10021642429
maxin	Keyborad	KEY-663	1210001678
DELL	Mouse	M-U0026	DZL-M-U0026(B)
Sandisk	SD Card	SDSDUNG-128G-ZN61N	SD012463

External I/O Cable

Cable Description	Length (m)	From Port	To
Un-shielding Un-Detachable AC Cable	1.0	Receptacle	LISN
Un-shielding Un-Detachable DC Cable	1.2	Adapter	EUT
Un-Shielding Detachable USB to Type-C Cable	1.0	EUT	Laptop
Un-Shielding Detachable HDMI Cable	2.5	EUT	Monitor
Un-Shielding Detachable RJ45 Cable	10	EUT	Router
Un-shielding Un-Detachable USB Cable	1.2	EUT	Mouse
Un-shielding Un-Detachable USB Cable	1.2	EUT	Keyboard

Block Diagram of Test Setup

For conducted emission:



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (i), §2.1091	Maximum Permissible Exposure(MPE)	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	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 Emissions Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	101120	2020/08/04	2021/08/03
Rohde & Schwarz	LISN	ENV216	101613	2020/08/04	2021/08/03
Rohde & Schwarz	Transient Limiter	ESH3Z2	DE25985	2020/11/29	2021/11/28
Unknown	CE Cable	CE Cable	UF A210B-1-0720-504504	2020/11/29	2021/11/28
Rohde & Schwarz	CE Test software	EMC 32	V8.53.0	NCR	NCR
Radiated Emission Test					
R&S	EMI Test Receiver	ESR3	102455	2020/08/04	2021/08/03
Sonoma instrument	Pre-amplifier	310 N	186238	2020/08/04	2021/08/03
Sunol Sciences	Broadband Antenna	JB1	A040904-2	2020/12/22	2023/12/21
Unknown	Cable 2	RF Cable 2	F-03-EM197	2020/11/29	2021/11/28
Unknown	Cable	Chamber Cable 1	F-03-EM236	2020/11/29	2021/11/28
Rohde & Schwarz	Auto test software	EMC 32	V9.10	NCR	NCR
Rohde & Schwarz	Spectrum Analyzer	FSV40-N	102259	2020/08/04	2021/08/03
COM-POWER	Pre-amplifier	PA-122	181919	2020/11/29	2021/11/28
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2020/11/28	2021/11/27
Sunol Sciences	Horn Antenna	DRH-118	A052604	2017/12/22	2020/12/21
Insulated Wire Inc.	RF Cable	SPS-2503-3150	02222010	2020/11/29	2021/11/28
Unknown	RF Cable	W1101-EQ1 OUT	F-19-EM005	2020/11/29	2021/11/28
SNSD	Band Reject filter	BSF2402-2480MN-0898-001	2.4G filter	2020/04/20	2021/04/20
Ducommun Technologies	Horn antenna	ARH-4223-02	1007726-021304	2020/12/06	2023/12/05
RF Conducted Test					
Tonscend Corporation	RF control Unit	JS0806-2	19D8060154	2020/08/04	2021/08/03
Rohde & Schwarz	Signal and Spectrum Analyzer	FSV40	101473	2020/08/04	2021/08/03

* **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)

For simultaneously transmit system, the calculated power density should comply with:

$$\sum_i \frac{S_i}{S_{Limit,i}} \leq 1$$

Mode	Frequency (MHz)	Antenna Gain		Tune up conducted power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		(dBi)	(numeric)	(dBm)	(mW)			
Bluetooth	2402-2480	-3.0	0.50	2.0	1.58	20	0.00016	1
BLE	2402-2480	-3.0	0.50	6.0	3.98	20	0.0004	1
2.4G Wi-Fi	2412-2462	-3.0	0.50	23.0	199.53	20	0.0198	1
5G Wi-Fi	5150-5250	0	1.0	17.0	51.12	20	0.0102	1
	5250-5350	0	1.0	17.0	51.12	20	0.0102	1
	5470-5725	0	1.0	19.0	79.43	20	0.0158	1
	5725-5850	0	1.0	15.0	31.62	20	0.0063	1

Note: 1. the tune up conducted power was declared by the applicant
 2. the 2.4G Wi-Fi can transmit at the same time with the 5G Wi-Fi. The Bluetooth can't transmit at the same time with Wi-Fi.

Simultaneous transmitting consideration:

The ratio= $MPE_{2.4G}/limit + MPE_{5G}/limit = 0.0198 + 0.0158 = 0.0356 < 1.0$

So simultaneous exposure comply with the limit.

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 a PCB antenna arrangement which was permanently attached for BLE and two PCB antennas arrangement which was permanently attached for Wi-Fi, and all antenna gain is -3.0 dBi, fulfill the requirement of this section. Please refer to the EUT photos.

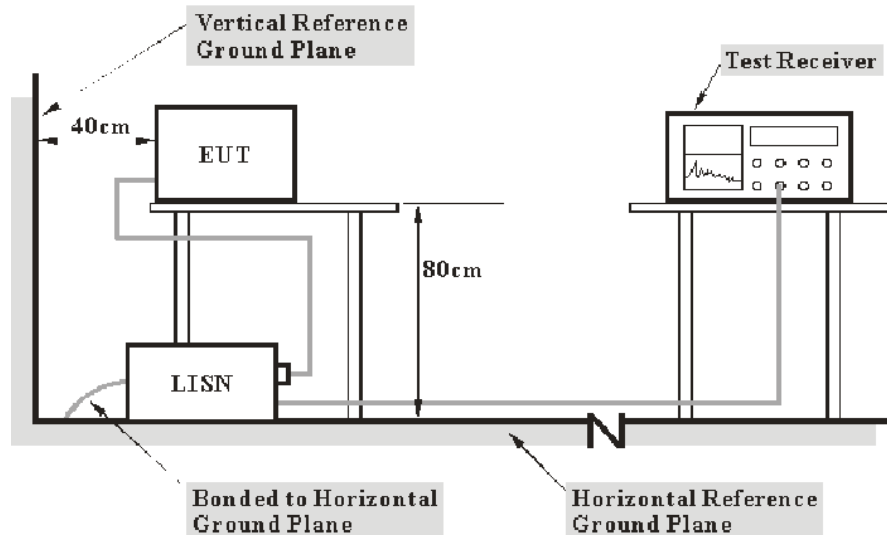
Result: Compliance.

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 Data

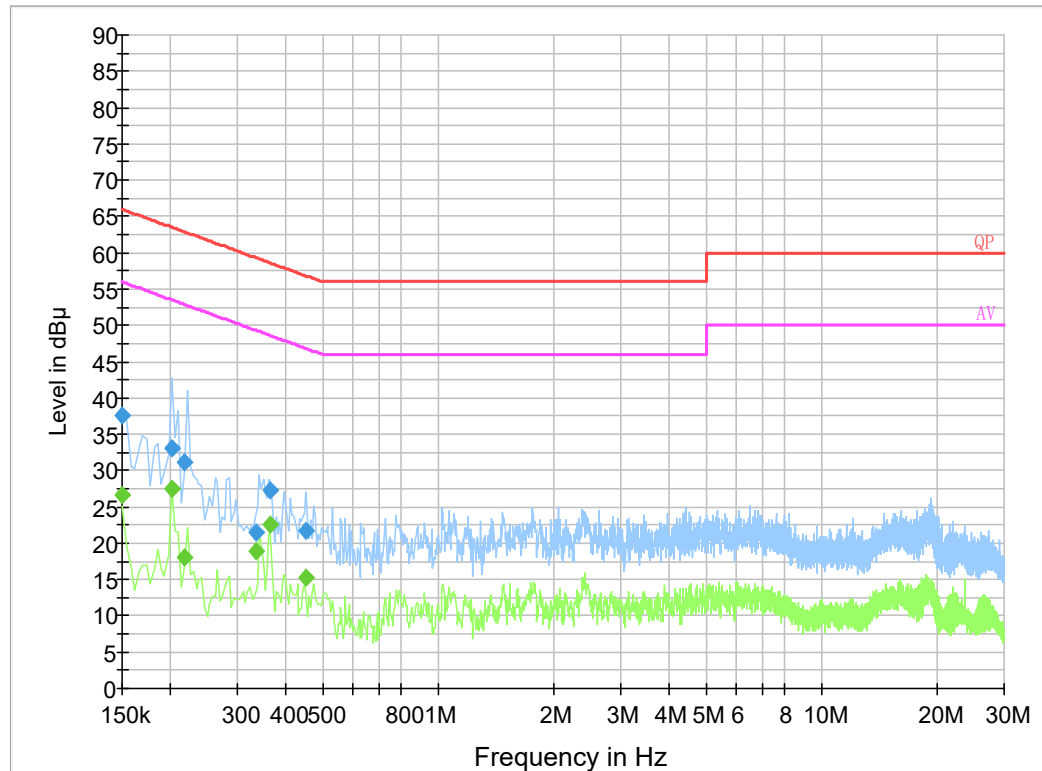
Environmental Conditions

Temperature:	26 °C
Relative Humidity:	67 %
ATM Pressure:	101.0 kPa

The testing was performed by Haiguo Li on 2021-07-20.

EUT operation mode: Transmitting (Worst case)

AC 120V/60 Hz, Line

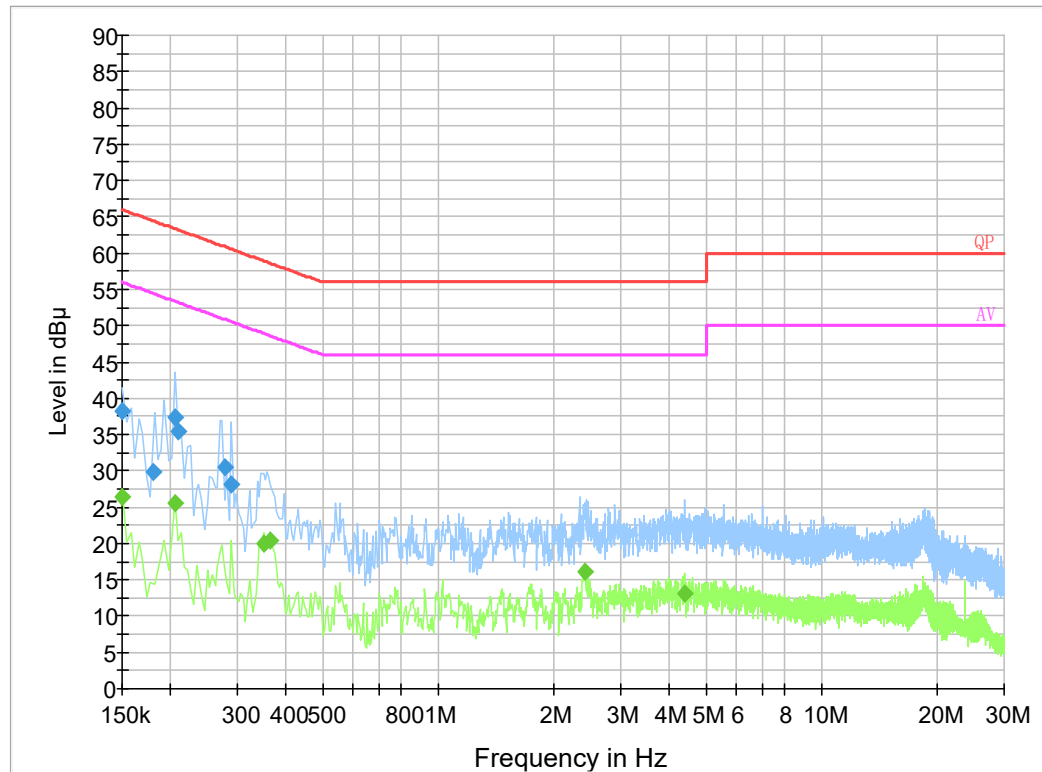


Final Result 1

Frequency (MHz)	QuasiPeak (dB μV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB μV)
0.150000	37.5	9.000	L1	19.8	28.5	66.0
0.201500	33.1	9.000	L1	19.8	30.4	63.5
0.217500	31.1	9.000	L1	19.8	31.8	62.9
0.336870	21.5	9.000	L1	19.8	37.8	59.3
0.364570	27.4	9.000	L1	19.9	31.2	58.6
0.451190	21.6	9.000	L1	19.8	35.3	56.9

Final Result 2

Frequency (MHz)	Average (dB μV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB μV)
0.150000	26.6	9.000	L1	19.8	29.4	56.0
0.201500	27.5	9.000	L1	19.8	26.0	53.5
0.217500	18.1	9.000	L1	19.8	34.8	52.9
0.336870	18.9	9.000	L1	19.8	30.4	49.3
0.364570	22.6	9.000	L1	19.9	26.0	48.6
0.451190	15.2	9.000	L1	19.8	31.7	46.9

AC 120V/60 Hz, Neutral:**Final Result 1**

Frequency (MHz)	QuasiPeak (dB μ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.150000	38.2	9.000	N	19.8	27.8	66.0
0.181500	29.8	9.000	N	19.8	34.6	64.4
0.205500	37.3	9.000	N	19.8	26.1	63.4
0.210500	35.5	9.000	N	19.8	27.7	63.2
0.277500	30.6	9.000	N	19.7	30.3	60.9
0.289500	28.2	9.000	N	19.7	32.3	60.5

Final Result 2

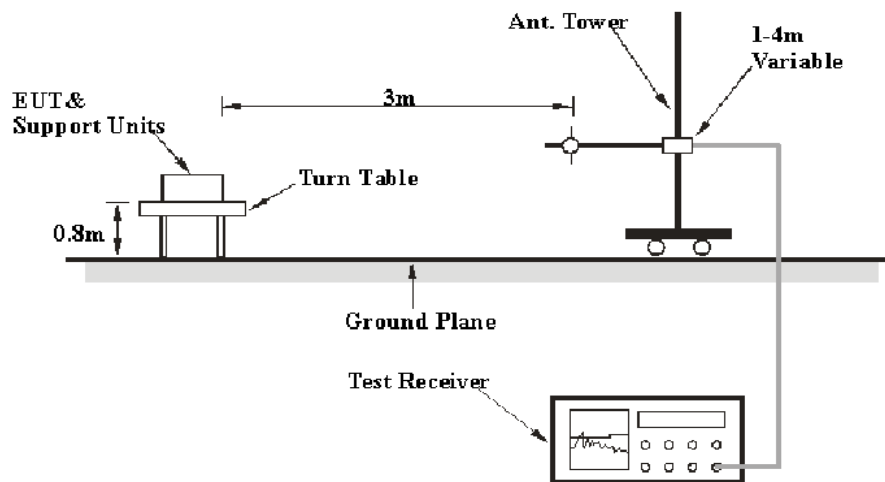
Frequency (MHz)	Average (dB μ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.150000	26.4	9.000	N	19.8	29.6	56.0
0.206000	25.5	9.000	N	19.8	27.9	53.4
0.350000	19.9	9.000	N	19.9	29.1	49.0
0.366000	20.4	9.000	N	19.9	28.2	48.6
2.414000	16.0	9.000	N	19.8	30.0	46.0
4.406000	13.2	9.000	N	19.9	32.8	46.0

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

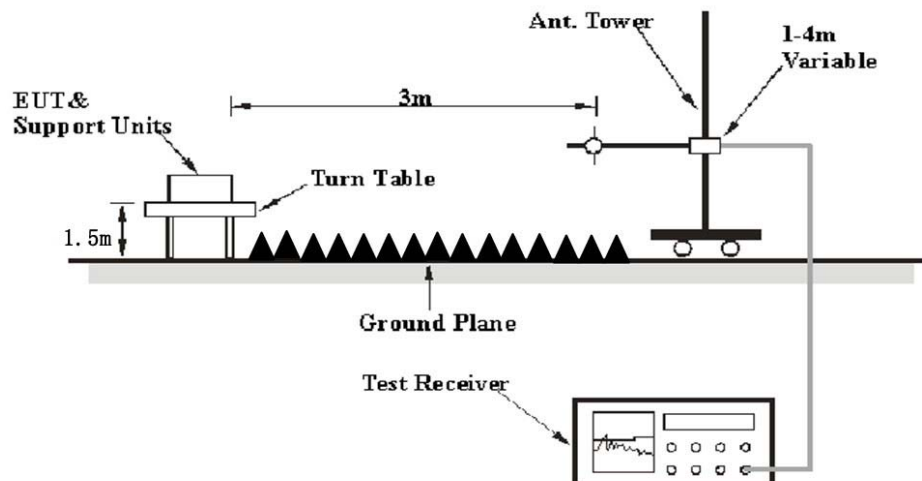
FCC §15.247 (d); §15.209; §15.205;

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%

Test Procedure

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

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 Data

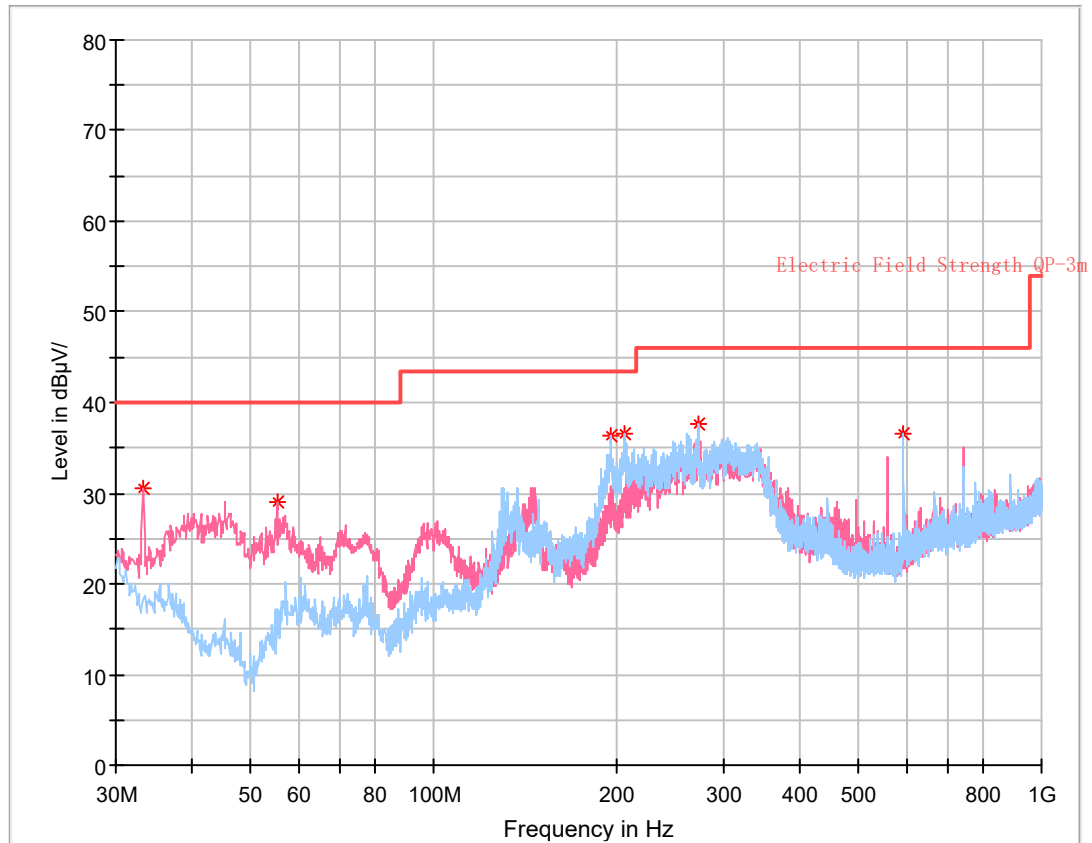
Environmental Conditions

Temperature:	26.8~29 °C
Relative Humidity:	50~51 %
ATM Pressure:	101~101.2 kPa

The testing was performed by Cloud Qiu on 2021-07-19 for below 1GHz and Alan He on 2021-04-08 and 2021-04-09 for above 1GHz.

EUT operation mode: Transmitting

30 MHz~1 GHz: (the worst case at 802.11n20 mode, 2412MHz+802.11ac20 mode 5785 MHz)



Critical_Freqs

Frequency (MHz)	MaxPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.273750	30.60	40.00	9.40	100.0	V	115.0	-6.1
55.220000	28.94	40.00	11.06	100.0	V	23.0	-16.6
195.627500	36.43	43.50	7.07	100.0	H	189.0	-11.6
205.448750	36.50	43.50	7.00	100.0	H	228.0	-11.1
272.378750	37.53	46.00	8.47	100.0	H	199.0	-11.0
594.055000	36.56	46.00	9.44	100.0	H	199.0	-4.5

1 GHz-25 GHz (Wi-Fi):**802.11b Mode (Antenna 1 is the worst case):**

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 (2412 MHz)									
2388.64	30.03	PK	184	1.5	H	31.87	61.90	74	12.10
2388.64	14.59	Ave.	184	1.5	H	31.87	46.46	54	7.54
2496.84	29.58	PK	234	2.1	H	32.13	61.71	74	12.29
2496.84	14.61	Ave.	234	2.1	H	32.13	46.74	54	7.26
4824.00	44.13	PK	46	2.0	H	6.28	50.41	74	23.59
4824.00	30.41	Ave.	46	2.0	H	6.28	36.69	54	17.31
Middle Channel (2437MHz)									
4874.00	43.84	PK	39	1.8	H	6.76	50.60	74	23.40
4874.00	29.34	Ave.	39	1.8	H	6.76	36.10	54	17.90
High Channel (2462 MHz)									
2389.54	29.49	PK	53	1.6	H	31.87	61.36	74	12.64
2389.54	14.55	Ave.	53	1.6	H	31.87	46.42	54	7.58
2496.84	29.09	PK	204	1.5	H	32.13	61.22	74	12.78
2496.84	14.62	Ave.	204	1.5	H	32.13	46.75	54	7.25
4924.00	44.69	PK	332	1.6	H	6.76	51.45	74	22.55
4924.00	29.31	Ave.	332	1.6	H	6.76	36.07	54	17.93

802.11g Mode(Antenna 1 is the worst case):

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 (2412 MHz)									
2388.94	29.16	PK	227	1.6	H	31.87	61.03	74	12.97
2388.94	15.14	Ave.	227	1.6	H	31.87	47.01	54	6.99
2496.84	29.37	PK	34	1.3	H	32.13	61.50	74	12.50
2496.84	14.47	Ave.	34	1.3	H	32.13	46.60	54	7.40
4824.00	43.81	PK	342	1.4	H	6.28	50.09	74	23.91
4824.00	29.18	Ave.	342	1.4	H	6.28	35.46	54	18.54
Middle Channel (2437MHz)									
4874.00	44.54	PK	153	1.2	H	6.76	51.30	74	22.70
4874.00	29.67	Ave.	153	1.2	H	6.76	36.43	54	17.57
High Channel (2462 MHz)									
2385.64	28.94	PK	254	1.1	H	31.87	60.81	74	13.19
2385.64	15.09	Ave.	254	1.1	H	31.87	46.96	54	7.04
2496.84	30.60	PK	24	2.1	H	32.13	62.73	74	11.27
2496.84	15.10	Ave.	24	2.1	H	32.13	47.23	54	6.77
4924.00	44.02	PK	143	2.5	H	6.76	50.78	74	23.22
4924.00	29.31	Ave.	143	2.5	H	6.76	36.07	54	17.93

802.11n-HT20 Mode (MIMO mode is the worst case):

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 (2412 MHz)									
2387.68	28.88	PK	110	1.6	H	31.87	60.75	74	13.25
2387.68	15.01	Ave.	110	1.6	H	31.87	46.88	54	7.12
2491.93	30.73	PK	196	1.8	H	32.13	62.86	74	11.14
2491.93	14.61	Ave.	196	1.8	H	32.13	46.74	54	7.26
4824.00	44.33	PK	30	1.8	H	6.28	50.61	74	23.39
4824.00	29.22	Ave.	30	1.8	H	6.28	35.50	54	18.50
Middle Channel (2437MHz)									
4874.00	44.53	PK	247	1.5	H	6.76	51.29	74	22.71
4874.00	29.47	Ave.	247	1.5	H	6.76	36.23	54	17.77
High Channel (2462 MHz)									
2383.56	28.96	PK	33	2.0	H	31.87	60.83	74	13.17
2383.56	14.42	Ave.	33	2.0	H	31.87	46.29	54	7.71
2491.93	28.89	PK	40	1.2	H	32.13	61.02	74	12.98
2491.93	14.73	Ave.	40	1.2	H	32.13	46.86	54	7.14
4924.00	44.58	PK	124	1.0	H	6.76	51.34	74	22.66
4924.00	29.49	Ave.	124	1.0	H	6.76	36.25	54	17.75

802.11n-HT40 Mode(MIMO mode is the worst case):

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 (2422 MHz)									
2379.15	29.58	PK	287	1.3	H	31.87	61.45	74	12.55
2379.15	16.26	Ave.	287	1.3	H	31.87	48.13	54	5.87
2496.91	29.61	PK	26	2.4	H	32.13	61.74	74	12.26
2496.91	14.89	Ave.	26	2.4	H	32.13	47.02	54	6.98
4844.00	43.82	PK	53	2.0	H	6.28	50.10	74	23.90
4844.00	29.61	Ave.	53	2.0	H	6.28	35.89	54	18.11
Middle Channel (2437MHz)									
4874.00	44.34	PK	359	1.7	H	6.76	51.10	74	22.90
4874.00	29.68	Ave.	359	1.7	H	6.76	36.44	54	17.56
High Channel (2452 MHz)									
2377.69	29.89	PK	72	2.2	H	31.87	61.76	74	12.24
2377.69	16.48	Ave.	72	2.2	H	31.87	48.35	54	5.65
2495.91	29.61	PK	109	1.1	H	32.13	61.74	74	12.26
2495.91	14.89	Ave.	109	1.1	H	32.13	47.02	54	6.98
4904.00	43.37	PK	2	1.8	H	6.76	50.13	74	23.87
4904.00	29.57	Ave.	2	1.8	H	6.76	36.33	54	17.67

802.11ax20 Mode(MIMO mode is the worst case):

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 (2412 MHz)									
2378.94	29.04	PK	75	1.7	H	31.87	60.91	74	13.09
2378.94	14.73	Ave.	75	1.7	H	31.87	46.60	54	7.40
2496.97	28.97	PK	217	1.7	H	32.13	61.10	74	12.90
2496.97	14.53	Ave.	217	1.7	H	32.13	46.66	54	7.34
4824.00	44.17	PK	186	2.3	H	6.28	50.45	74	23.55
4824.00	29.73	Ave.	186	2.3	H	6.28	36.01	54	17.99
Middle Channel (2437MHz)									
4874.00	44.58	PK	76	1.6	H	6.76	51.34	74	22.66
4874.00	29.91	Ave.	76	1.6	H	6.76	36.67	54	17.33
High Channel (2462 MHz)									
2389.54	28.73	PK	147	1.7	H	31.87	60.60	74	13.40
2389.54	14.54	Ave.	147	1.7	H	31.87	46.41	54	7.59
2496.97	28.84	PK	121	1.1	H	32.13	60.97	74	13.03
2496.97	14.70	Ave.	121	1.1	H	32.13	46.83	54	7.17
4924.00	43.11	PK	292	1.0	H	6.76	49.87	74	24.13
4924.00	29.67	Ave.	292	1.0	H	6.76	36.43	54	17.57

802.11ax40 Mode (MIMO mode is the worst case):

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 (2422 MHz)									
2381.57	29.05	PK	207	2.5	H	31.87	60.92	74	13.08
2381.57	14.71	Ave.	207	2.5	H	31.87	46.58	54	7.42
2489.97	29.31	PK	133	1.7	H	32.13	61.44	74	12.56
2489.97	14.46	Ave.	133	1.7	H	32.13	46.59	54	7.41
4844.00	44.14	PK	21	2.2	H	6.28	50.42	74	23.58
4844.00	29.03	Ave.	21	2.2	H	6.28	35.31	54	18.69
Middle Channel (2437MHz)									
4874.00	44.19	PK	261	1.3	H	6.76	50.95	74	23.05
4874.00	29.32	Ave.	261	1.3	H	6.76	36.08	54	17.92
High Channel (2452 MHz)									
2383.94	29.68	PK	104	1.6	H	31.87	61.55	74	12.45
2383.94	14.11	Ave.	104	1.6	H	31.87	45.98	54	8.02
2484.82	29.56	PK	146	2.5	H	32.13	61.69	74	12.31
2484.82	14.94	Ave.	146	2.5	H	32.13	47.07	54	6.93
4904.00	44.76	PK	185	2.3	H	6.76	51.52	74	22.48
4904.00	29.39	Ave.	185	2.3	H	6.76	36.15	54	17.85

Co-location Transmitting

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)				
802.11b mode 2462MHz+802.11a mode 5180MHz									
4924.00	44.32	PK	203	1.8	H	6.76	51.08	74	22.92
4924.00	29.08	Ave.	203	1.8	H	6.76	35.84	54	18.16
10360.00	43.12	PK	219	1.4	H	17.42	60.54	77.7	17.16

1 GHz-25 GHz (LE 1M):

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)									
2381.67	28.52	PK	191	1.0	H	31.87	60.39	74	13.61
2381.67	16.24	Ave.	191	1.0	H	31.87	48.11	54	5.89
2489.74	28.87	PK	264	1.2	H	32.13	61.00	74	13.00
2489.74	15.96	Ave.	264	1.2	H	32.13	48.09	54	5.91
4804.00	44.18	PK	42	1.4	H	6.28	50.46	74	23.54
4804.00	30.82	Ave.	42	1.4	H	6.28	37.10	54	16.90
Middle Channel (2440 MHz)									
4880.00	43.84	PK	159	2.4	H	6.76	50.60	74	23.40
4880.00	30.78	Ave.	159	2.4	H	6.76	37.54	54	16.46
High Channel (2480 MHz)									
2382.81	28.31	PK	125	2.3	H	31.87	60.18	74	13.82
2382.81	16.11	Ave.	125	2.3	H	31.87	47.98	54	6.02
2495.11	28.73	PK	28	1.3	H	32.13	60.86	74	13.14
2495.11	16.27	Ave.	28	1.3	H	32.13	48.40	54	5.60
4960.00	43.85	PK	209	2.5	H	6.80	50.65	74	23.35
4960.00	30.24	Ave.	209	2.5	H	6.80	37.04	54	16.96

1 GHz-25 GHz (LE 2M):

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)									
2384.94	28.49	PK	320	2.0	H	31.87	60.36	74	13.64
2384.94	16.21	Ave.	320	2.0	H	31.87	48.08	54	5.92
2485.68	28.32	PK	126	1.3	H	32.13	60.45	74	13.55
2485.68	16.19	Ave.	126	1.3	H	32.13	48.32	54	5.68
4804.00	44.27	PK	49	2.3	H	6.28	50.55	74	23.45
4804.00	30.71	Ave.	49	2.3	H	6.28	36.99	54	17.01
Middle Channel (2440 MHz)									
4880.00	44.12	PK	15	1.8	H	6.76	50.88	74	23.12
4880.00	30.38	Ave.	15	1.8	H	6.76	37.14	54	16.86
High Channel (2480 MHz)									
2389.61	28.49	PK	49	2.5	H	31.87	60.36	74	13.64
2389.61	16.21	Ave.	49	2.5	H	31.87	48.08	54	5.92
2487.71	28.32	PK	46	2.4	H	32.13	60.45	74	13.55
2487.71	16.19	Ave.	46	2.4	H	32.13	48.32	54	5.68
4960.00	43.81	PK	179	2.0	H	6.80	50.61	74	23.39
4960.00	30.17	Ave.	179	2.0	H	6.80	36.97	54	17.03

Note:

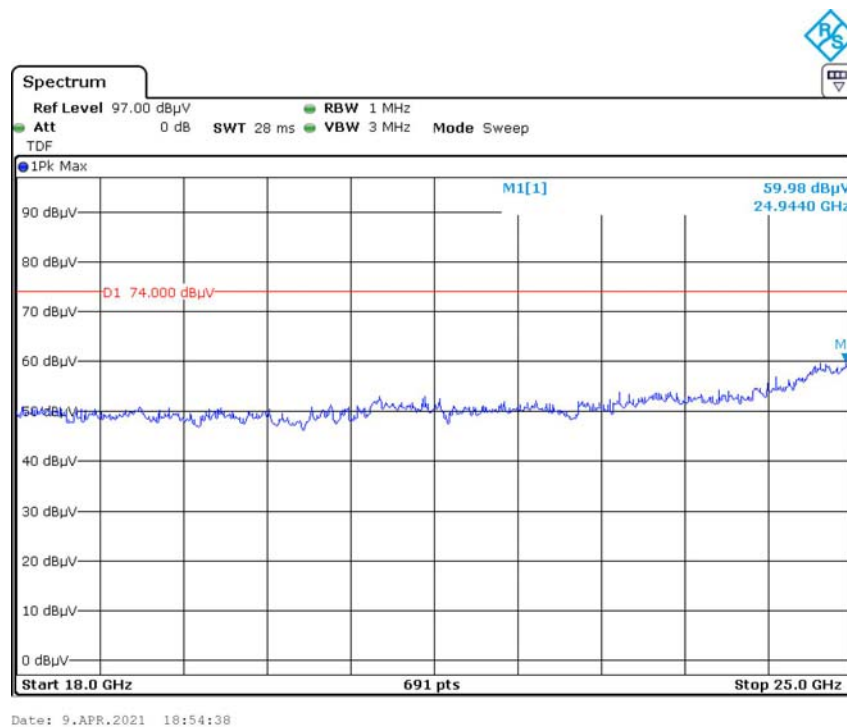
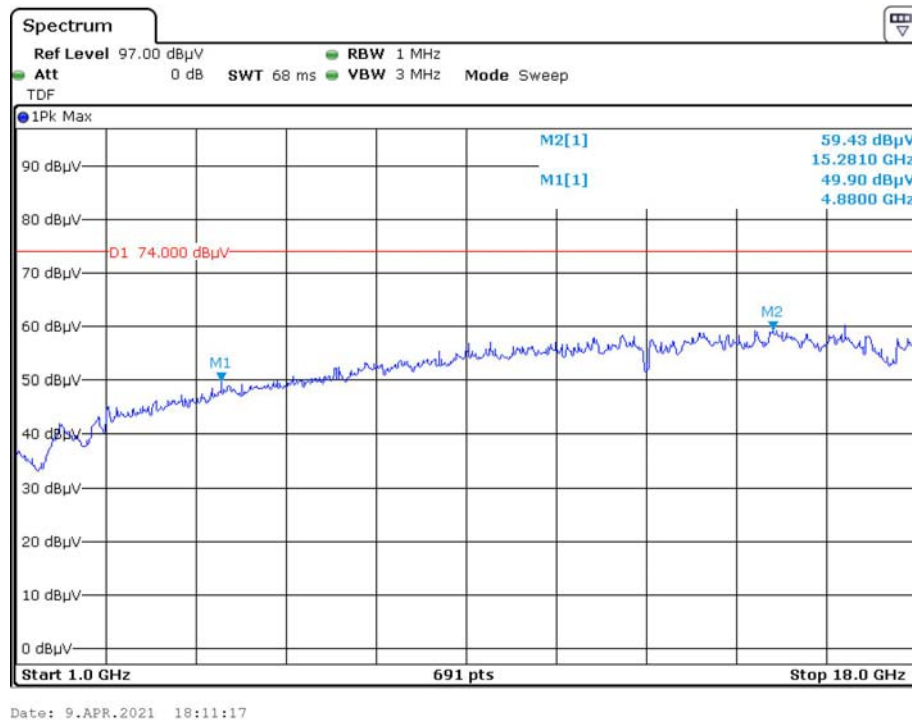
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor

Corrected Amplitude = Corrected Factor + Reading

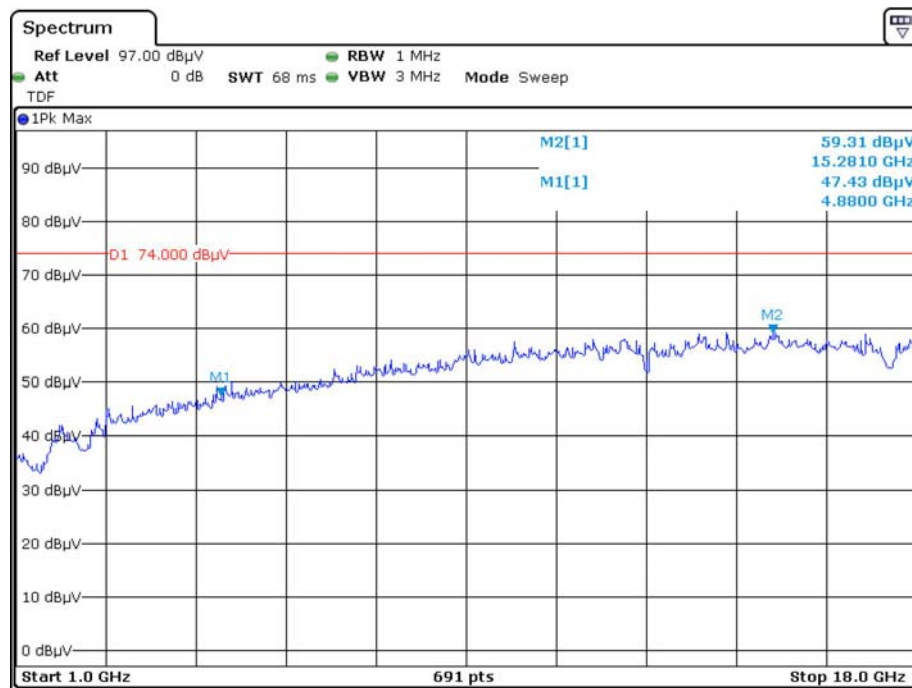
Margin = Limit - Corrected. Amplitude

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

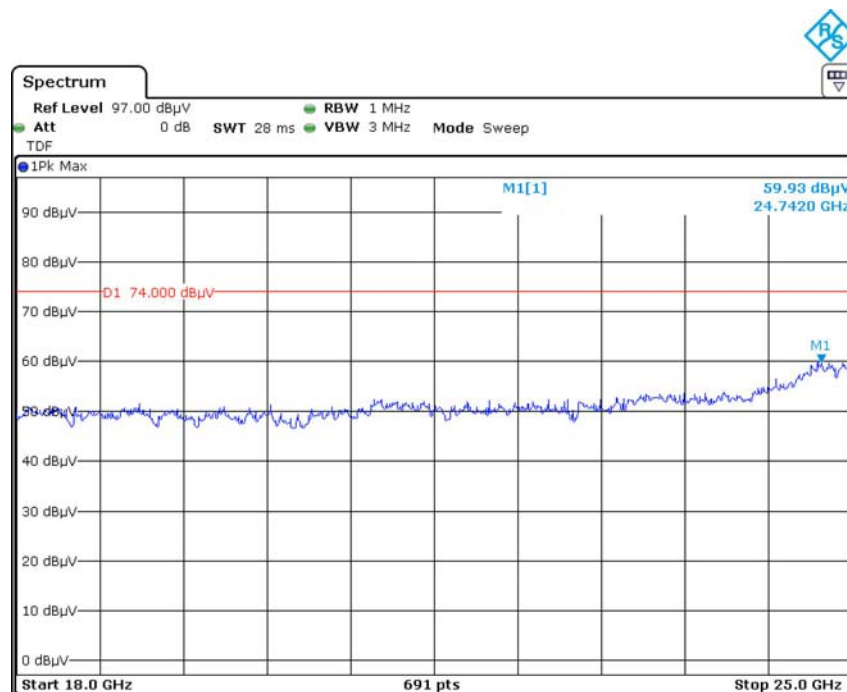
**Pre-scan with BLE 1M Mode, Middle channel
Horizontal**



Vertical

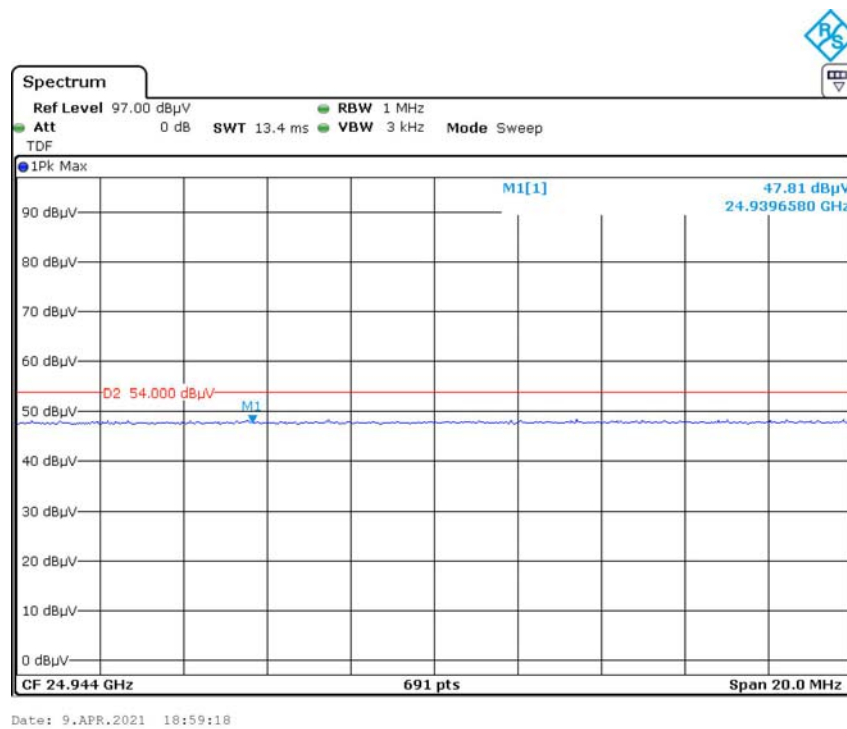
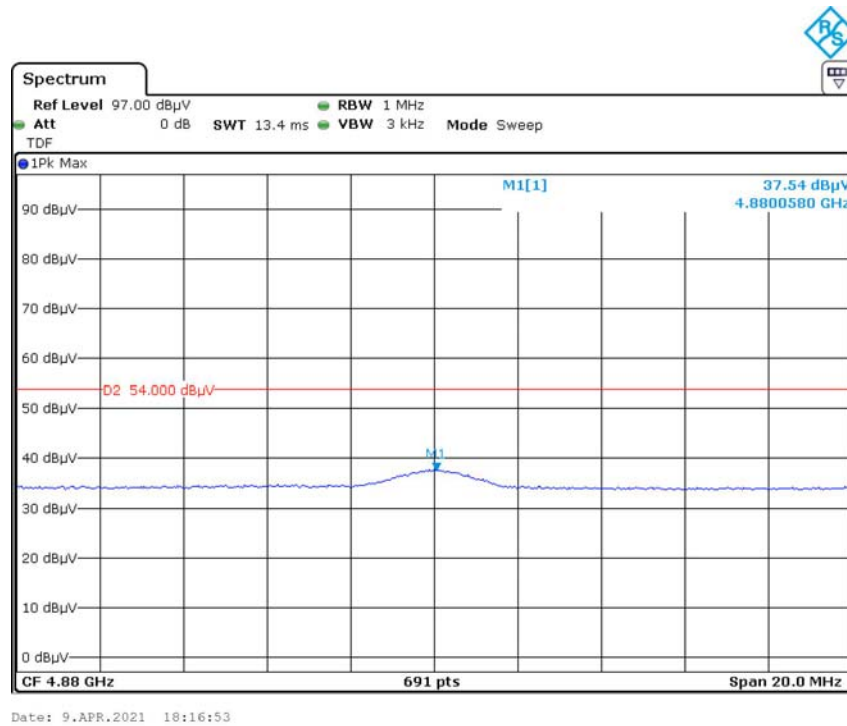


Date: 9.APR.2021 18:21:51

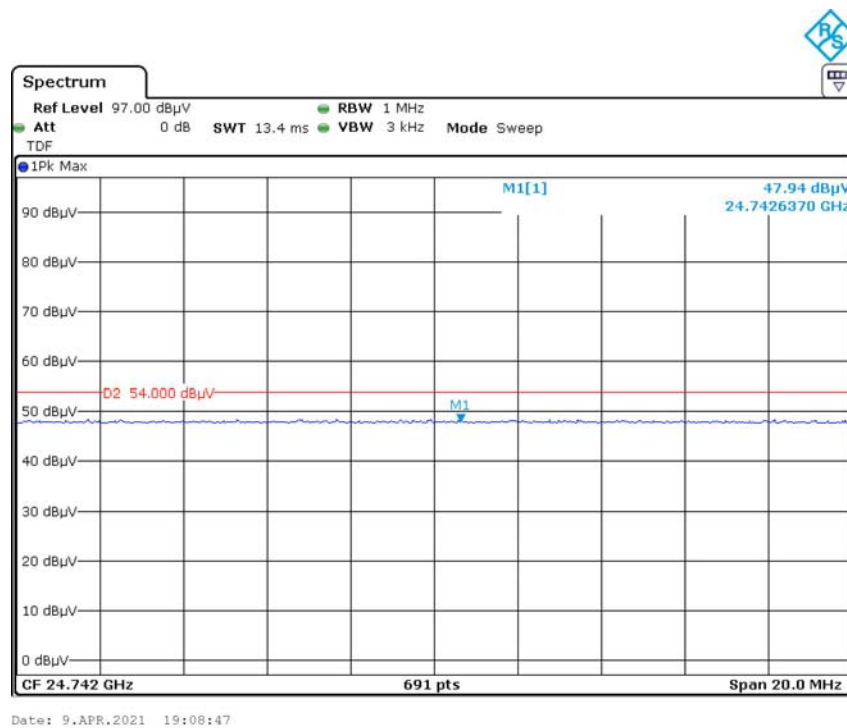
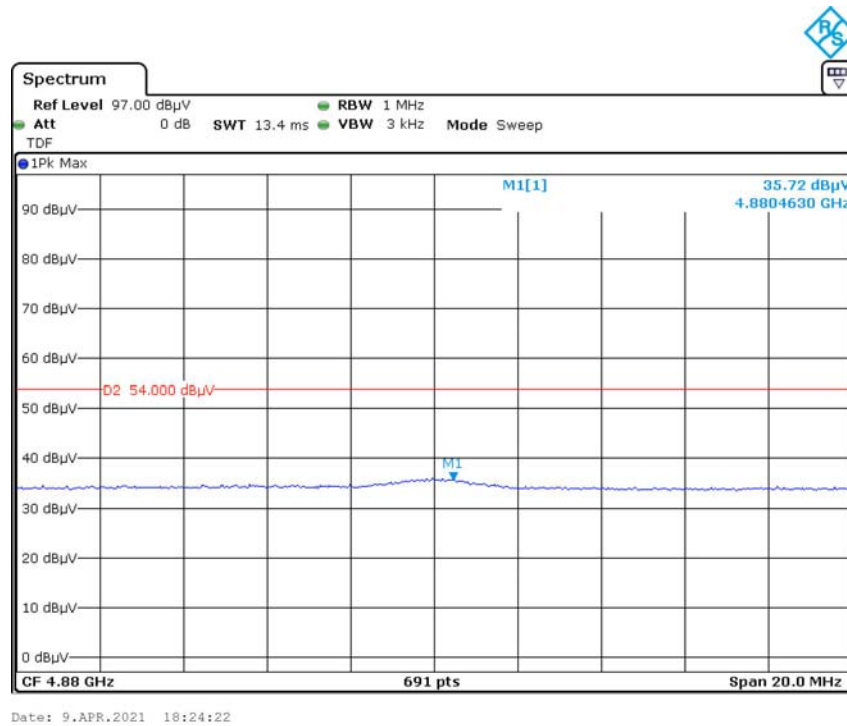


Date: 9.APR.2021 19:03:56

Average Horizontal



Vertical



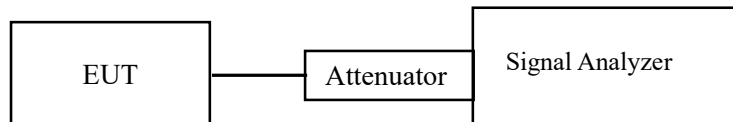
FCC §15.247(a) (2) – 6 dB EMISSION BANDWIDTH

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:	25 °C
Relative Humidity:	55%
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13 and 2021-07-15.

EUT operation mode: Transmitting

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

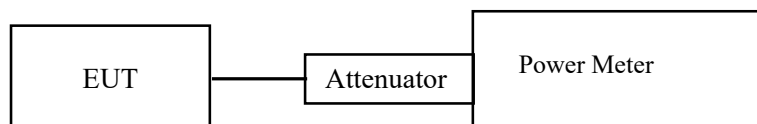
FCC §15.247(b) (3) - MAXIMUM CONDUCTED OUTPUT POWER

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

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:	25 °C
Relative Humidity:	55%
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13 and 2021-07-15.

EUT operation mode: Transmitting

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

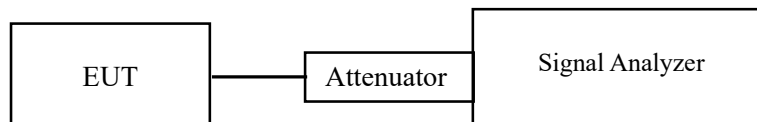
FCC §15.247(d) – 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE

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

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:	25 °C
Relative Humidity:	55%
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13 and 2021-07-15.

EUT operation mode: Transmitting

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

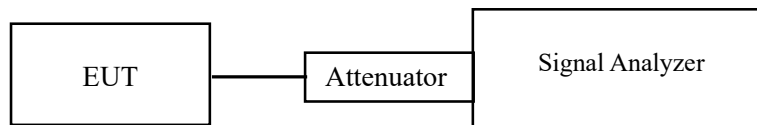
FCC §15.247(e) - POWER SPECTRAL DENSITY

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

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:	25 °C
Relative Humidity:	55%
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13 and 2021-07-15.

EUT operation mode: Transmitting

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

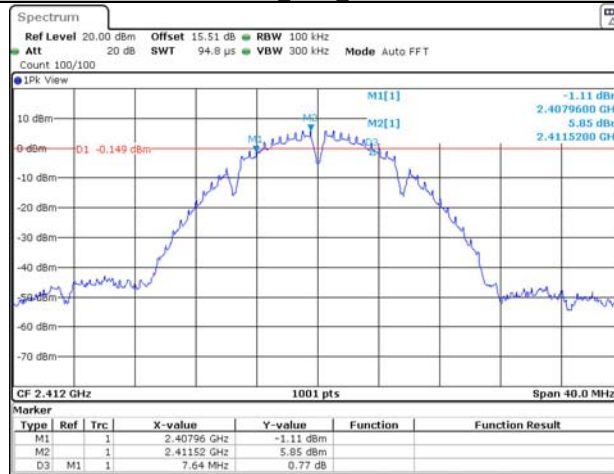
APPENDIX Wi-Fi

Appendix A: DTS Bandwidth Test Result

Test Mode	Antenna	Channel	DTS BW [MHz]	Limit[MHz]	Verdict
11B	Ant1	2412	7.640	0.5	PASS
	Ant0	2412	7.640	0.5	PASS
	Ant1	2437	7.640	0.5	PASS
	Ant0	2437	7.640	0.5	PASS
	Ant1	2462	7.640	0.5	PASS
	Ant0	2462	8.640	0.5	PASS
11G	Ant1	2412	16.360	0.5	PASS
	Ant0	2412	16.120	0.5	PASS
	Ant1	2437	16.400	0.5	PASS
	Ant0	2437	16.160	0.5	PASS
	Ant1	2462	16.400	0.5	PASS
	Ant0	2462	16.120	0.5	PASS
11N20MIMO	Ant1	2412	17.640	0.5	PASS
	Ant0	2412	17.000	0.5	PASS
	Ant1	2437	17.240	0.5	PASS
	Ant0	2437	17.240	0.5	PASS
	Ant1	2462	17.640	0.5	PASS
	Ant0	2462	17.400	0.5	PASS
11N40MIMO	Ant1	2422	35.440	0.5	PASS
	Ant0	2422	35.600	0.5	PASS
	Ant1	2437	36.080	0.5	PASS
	Ant0	2437	35.920	0.5	PASS
	Ant1	2452	36.400	0.5	PASS
	Ant0	2452	35.920	0.5	PASS
11AX20MIMO	Ant1	2412	19.200	0.5	PASS
	Ant0	2412	19.200	0.5	PASS
	Ant1	2437	19.200	0.5	PASS
	Ant0	2437	19.200	0.5	PASS
	Ant1	2462	19.160	0.5	PASS
	Ant0	2462	19.240	0.5	PASS
11AX40MIMO	Ant1	2422	38.240	0.5	PASS
	Ant0	2422	38.320	0.5	PASS
	Ant1	2437	38.400	0.5	PASS
	Ant0	2437	38.320	0.5	PASS
	Ant1	2452	38.480	0.5	PASS
	Ant0	2452	38.480	0.5	PASS

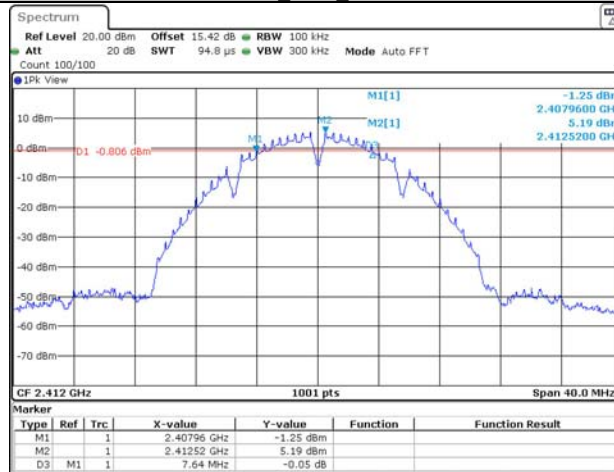
Test Graphs

11B Ant1 2412



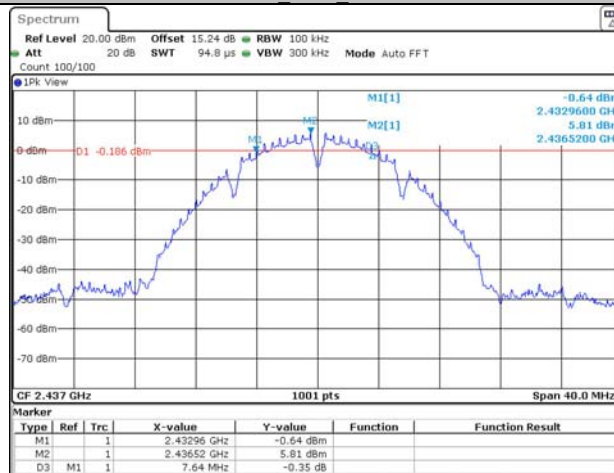
Date: 15.JUL.2021 11:17:19

11B Ant0 2412



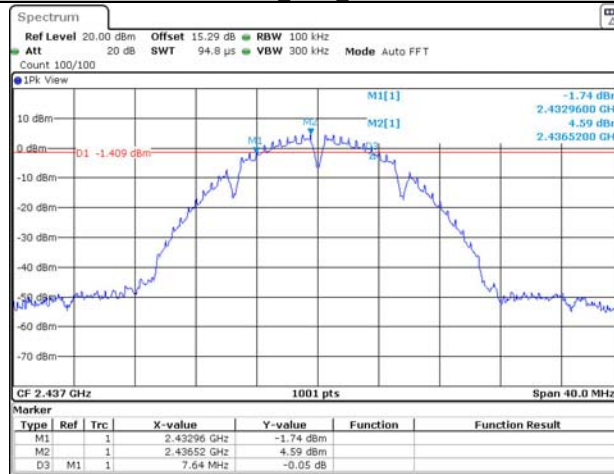
Date: 15.JUL.2021 11:34:03

11B Ant1 2437

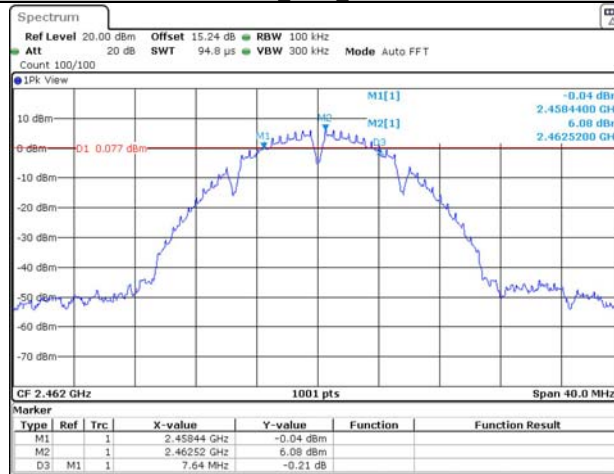


Date: 15.JUL.2021 11:19:36

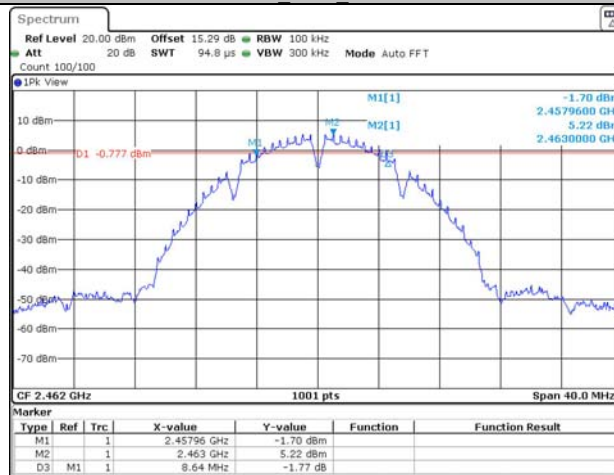
11B_Ant0_2437



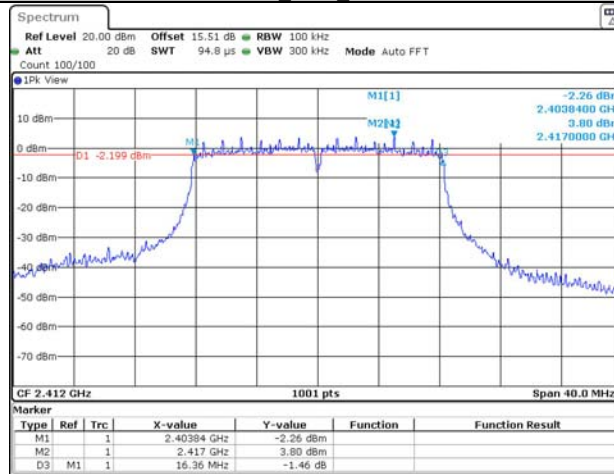
11B_Ant1_2462



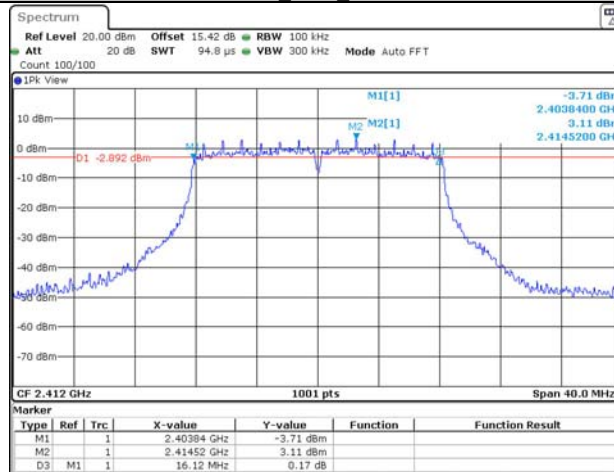
11B_Ant0_2462



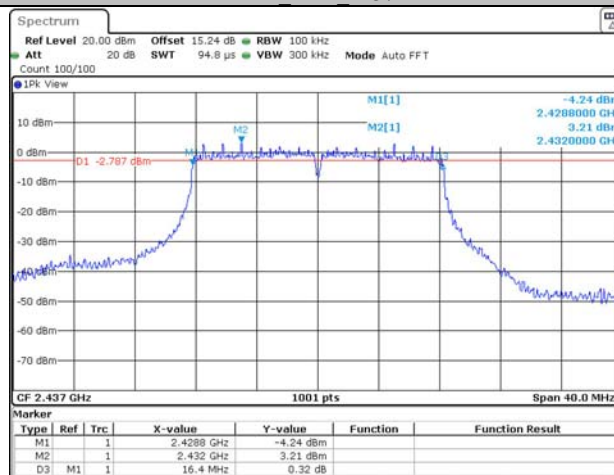
11G_Ant1_2412



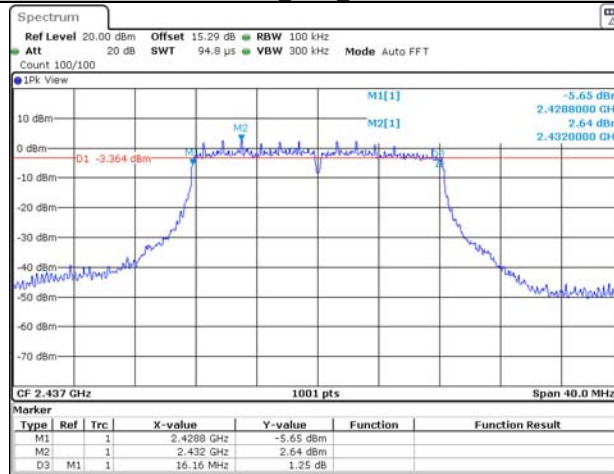
11G_Ant0_2412



11G_Ant1_2437

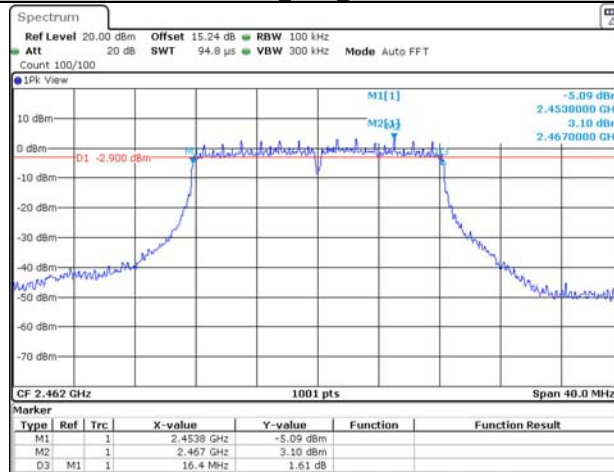


11G_Ant0_2437



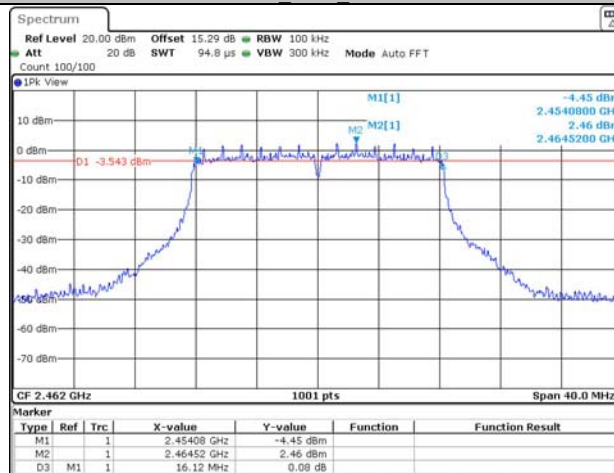
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11G_Ant1_2462



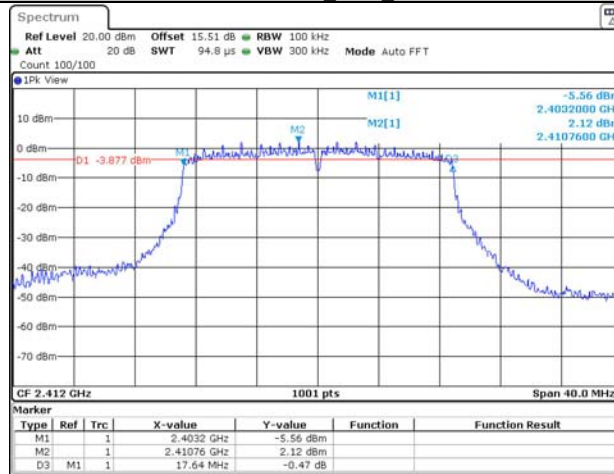
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11G_Ant0_2462

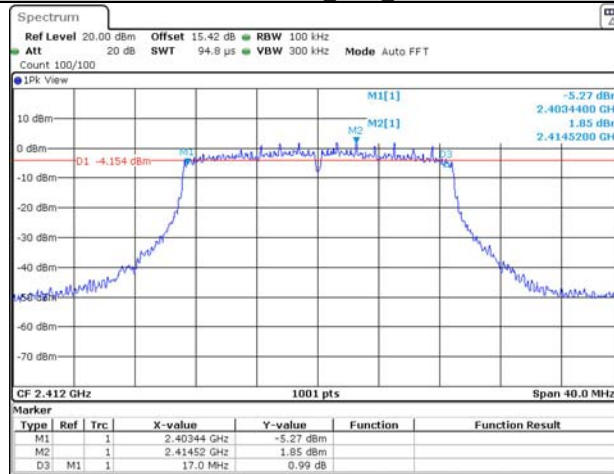


Date: 15.JUL.2021 11:42:32

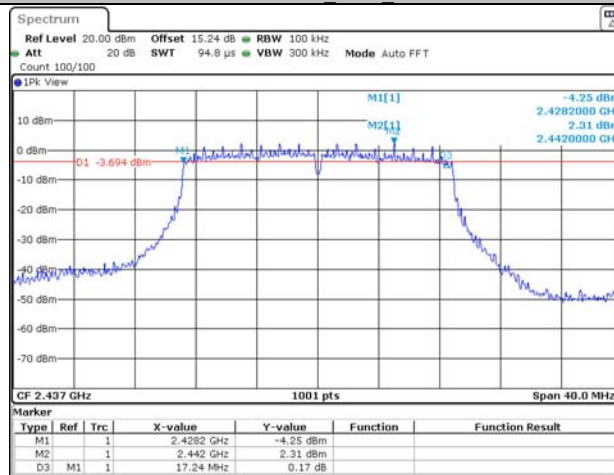
11N20MIMO Ant1 2412



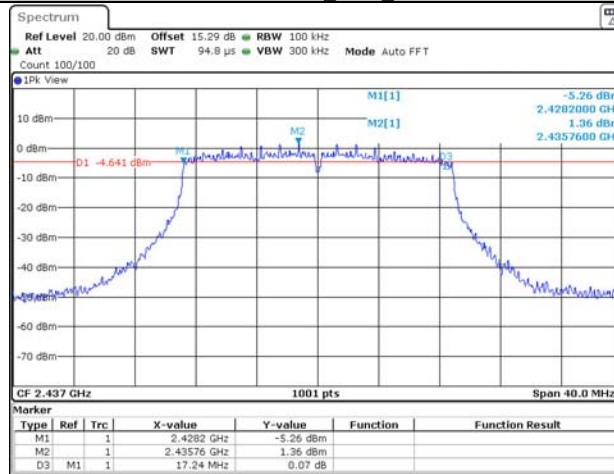
11N20MIMO Ant0 2412



11N20MIMO Ant1 2437

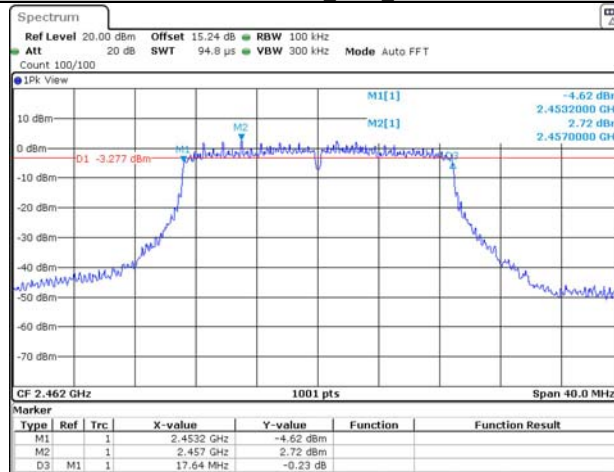


11N20MIMO Ant0 2437



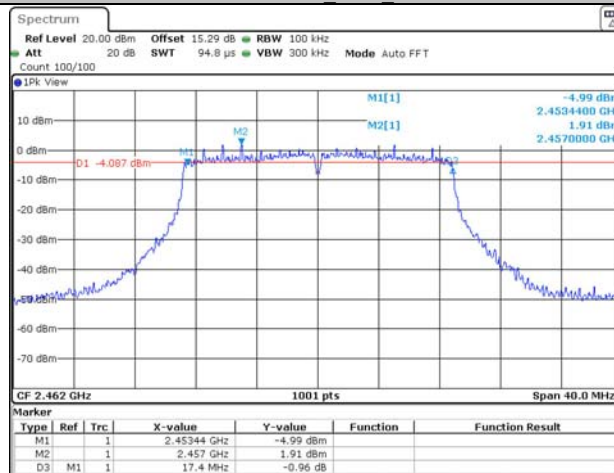
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11N20MIMO Ant1 2462



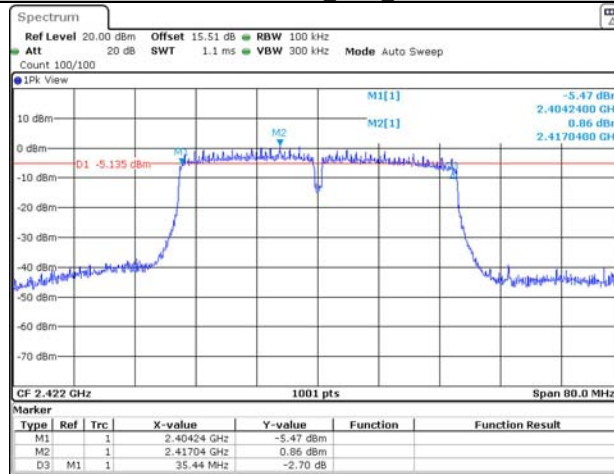
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11N20MIMO Ant0 2462



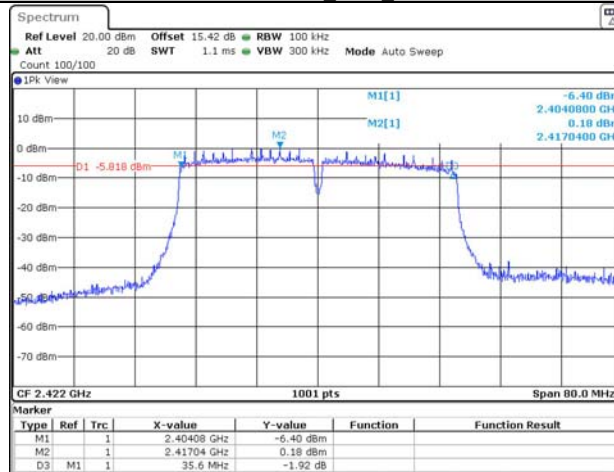
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11N40MIMO Ant1 2422



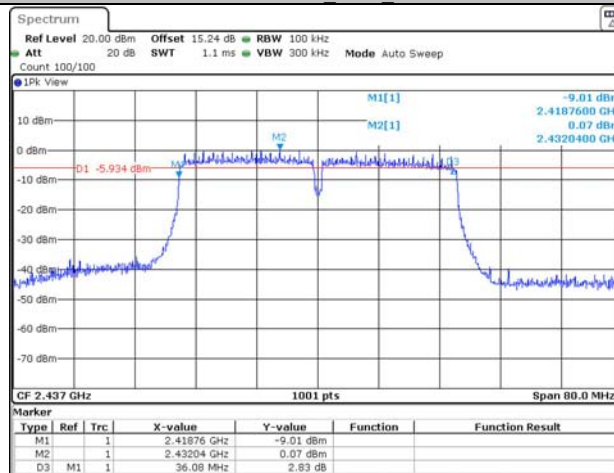
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11N40MIMO Ant0 2422



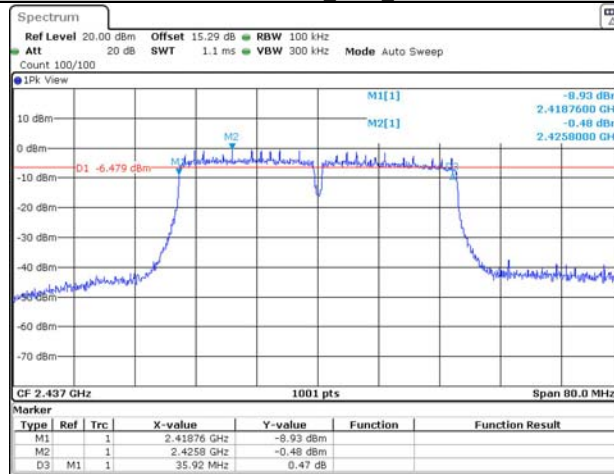
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11N40MIMO Ant1 2437



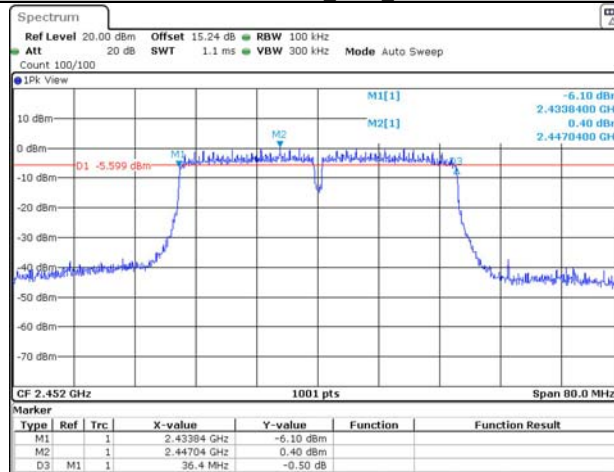
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11N40MIMO Ant0 2437



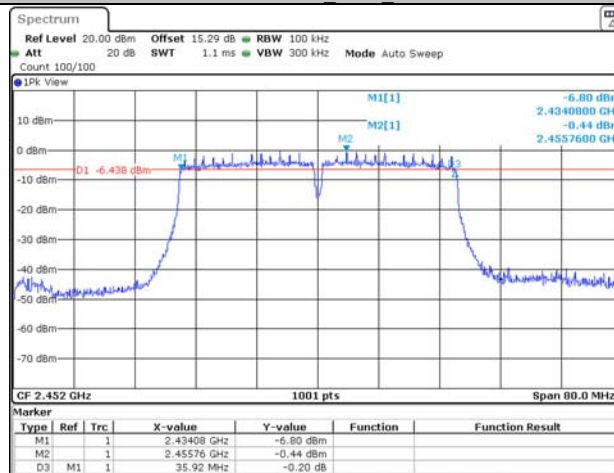
Date: 15.JUL.2021 13:15:26

11N40MIMO Ant1 2452



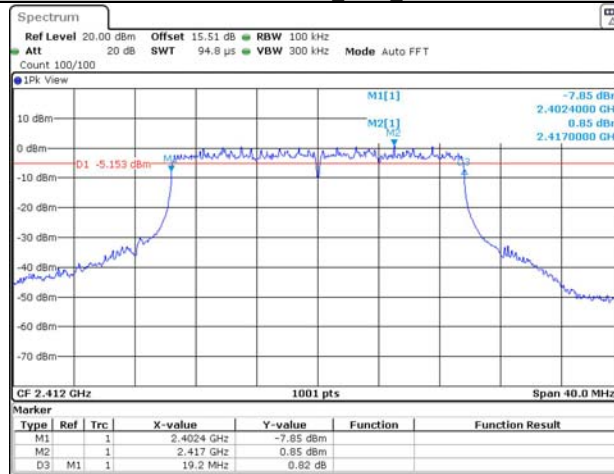
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11N40MIMO Ant0 2452



Date: 15.JUL.2021 13:18:03

11AX20MIMO Ant1 2412



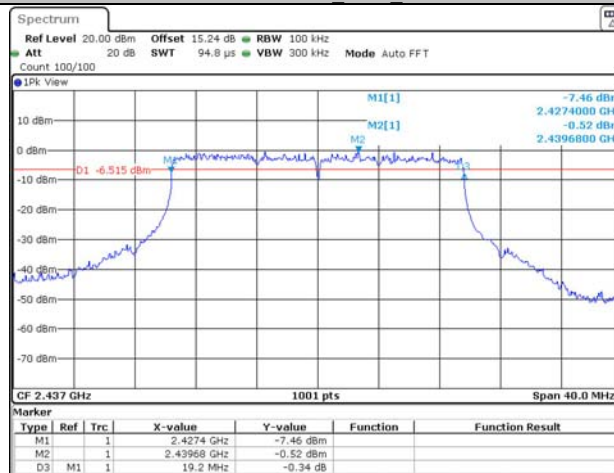
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11AX20MIMO Ant0 2412



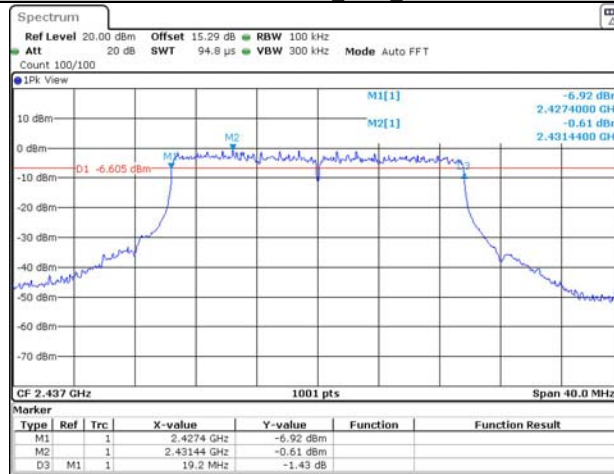
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11AX20MIMO Ant1 2437



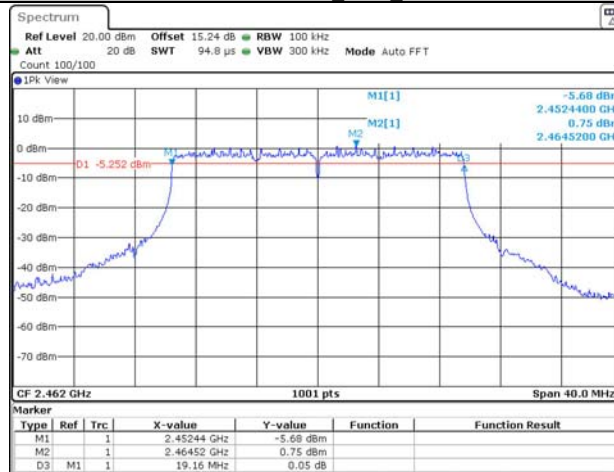
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11AX20MIMO Ant0 2437



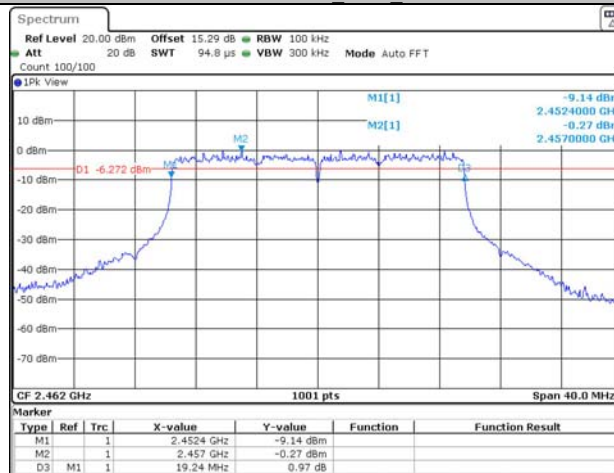
Date: 15.JUL.2021 13:26:36

11AX20MIMO Ant1 2462



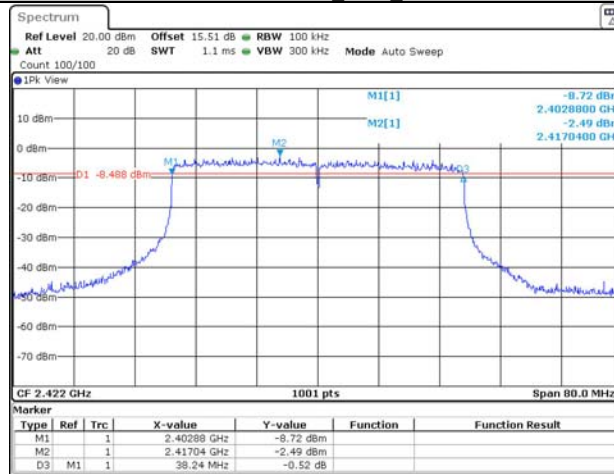
Date: 15.JUL.2021 13:28:37

11AX20MIMO Ant0 2462



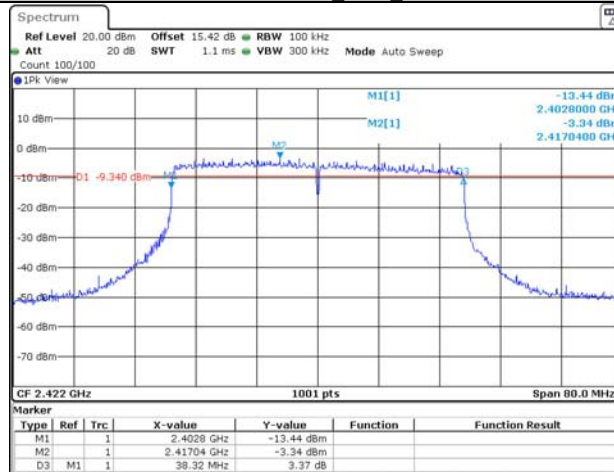
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11AX40MIMO Ant1 2422



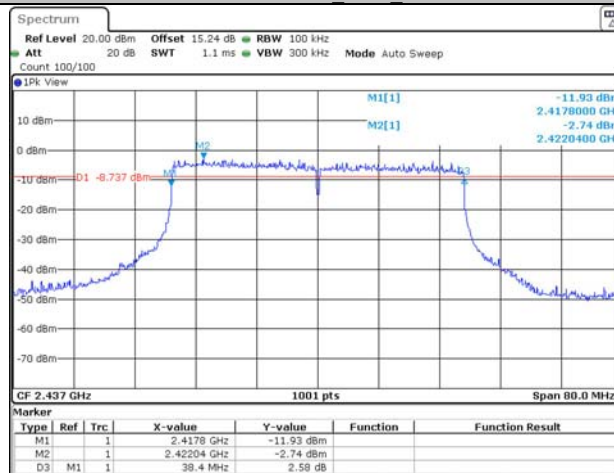
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11AX40MIMO Ant0 2422



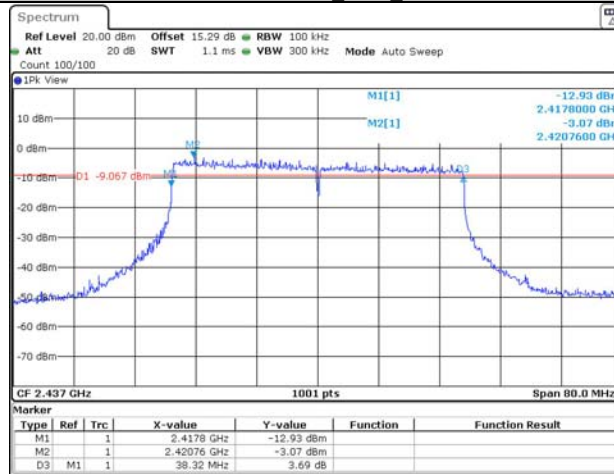
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11AX40MIMO Ant1 2437

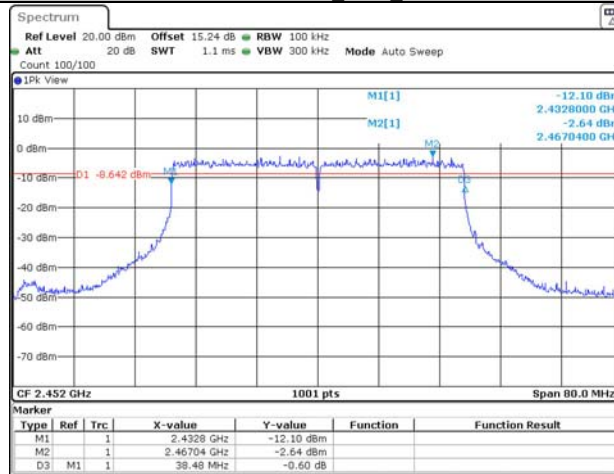


Date: 15.JUL.2021 13:57:33

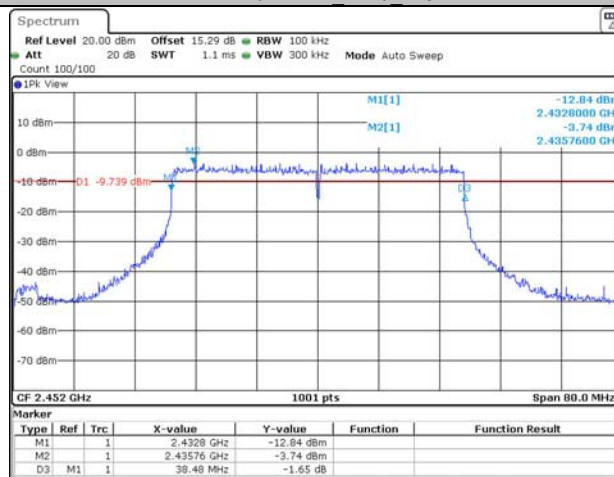
11AX40MIMO Ant0 2437



11AX40MIMO Ant1 2452



11AX40MIMO Ant0 2452



Appendix B: Occupied Channel Bandwidth Test Result

Test Mode	Antenna	Channel	OCB [MHz]	Limit[MHz]	Verdict
11B	Ant1	2412	12.827	---	PASS
	Ant0	2412	12.907	---	PASS
	Ant1	2437	13.027	---	PASS
	Ant0	2437	13.067	---	PASS
	Ant1	2462	12.987	---	PASS
	Ant0	2462	12.947	---	PASS
11G	Ant1	2412	16.464	---	PASS
	Ant0	2412	16.543	---	PASS
	Ant1	2437	16.543	---	PASS
	Ant0	2437	16.583	---	PASS
	Ant1	2462	16.464	---	PASS
	Ant0	2462	16.543	---	PASS
11N20MIMO	Ant1	2412	17.542	---	PASS
	Ant0	2412	17.622	---	PASS
	Ant1	2437	17.622	---	PASS
	Ant0	2437	17.742	---	PASS
	Ant1	2462	17.622	---	PASS
	Ant0	2462	17.702	---	PASS
11N40MIMO	Ant1	2422	35.884	---	PASS
	Ant0	2422	35.964	---	PASS
	Ant1	2437	36.124	---	PASS
	Ant0	2437	36.204	---	PASS
	Ant1	2452	36.044	---	PASS
	Ant0	2452	36.124	---	PASS
11AX20MIMO	Ant1	2412	19.221	---	PASS
	Ant0	2412	19.181	---	PASS
	Ant1	2437	19.221	---	PASS
	Ant0	2437	19.301	---	PASS
	Ant1	2462	19.301	---	PASS
	Ant0	2462	19.301	---	PASS
11AX40MIMO	Ant1	2422	38.282	---	PASS
	Ant0	2422	38.282	---	PASS
	Ant1	2437	38.362	---	PASS
	Ant0	2437	38.521	---	PASS
	Ant1	2452	38.442	---	PASS
	Ant0	2452	38.442	---	PASS

Test Graphs

