TEST REPORT

|	
Applicant Name :	Shenzhen Xin Yuan Electronic Technology Co., Ltd.
Address :	401 4F Bldg.building B. No.5, 1st Rd Bantianshangxue Technology Park, Bantian St Longgang Dist., Shenzhen, Guangdong China
Report Number :	RA230403-16479E-RF-00
FCC ID:	2ASYE-T-HMI

Test Standard (s)

FCC PART 15.247

Sample Description

Product Type:	T-HMI
Model No.:	T-HMI
Multiple Model(s) No.:	N/A
Trade Mark:	LILYGO
Date Received:	2023/04/03
Report Date:	2023/05/09

Test Result:	Pass*

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

Prepared and Checked By: **Approved By:**
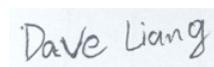
Dave Liang *Candy. Li*

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Dave Liang Candy Li
EMC Engineer EMC Engineer

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	RA230403-16479E-RF-00	Original Report	2023/05/09

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Frequency Range	BLE: 2402-2480MHz Wi-Fi: 2412-2472MHz
Maximum Conducted Output Power	BLE: 3.56dBm Wi-Fi:14.22dBm
Modulation Technique	BLE: GFSK Wi-Fi: DSSS, OFDM
Antenna Specification*	-4.32dBi (provided by the applicant)
Voltage Range	DC 5V from USB port
Sample serial number	2417-1 (Assigned by ATC)
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.

Each test item follows test standards and with no deviation.

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		5%
RF output power, conducted		0.71dB
Unwanted Emission, conducted		1.6dB
AC Line Conducted emission		2.72dB
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 429 7.01.

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

Wi-Fi

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442	/	/

Note: The channel 1, 7, 13 were tested for the 802.11b/g/n20 mode, channel 3, 7, 11 were tested for the 802.11n40 mode.

BLE

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

Note: EUT was tested with Channel 0, 19 and 39.

Equipment Modifications

No modification was made to the EUT tested.

EUT Exercise Software

"EspRFTestTool *" exercise software was used the test. And the software and power level was provided by applicant.

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	1Mbps	20	20	20
802.11g	6Mbps	20	20	20
802.11n20	MCS0	20	20	20
802.11n40	MCS0	20	20	20
BLE	1Mbps	9	8	6
	2Mbps	9	8	6

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

Duty cycle

Test Result: Compliant. Please refer to the plots as follow for Wi-Fi and Appendix BLE.

Mode	Frequency (MHz)	Ton (ms)	Ton+off (ms)	Duty Cycle (%)	1/T (kHz)
802.11b	2442	32.94	32.97	99.91	0.030
802.11g	2442	5.51	5.54	99.46	0.181
802.11n20	2442	5.08	5.11	99.41	0.197
802.11n40	2442	2.47	2.50	98.80	0.405

802.11b Mode
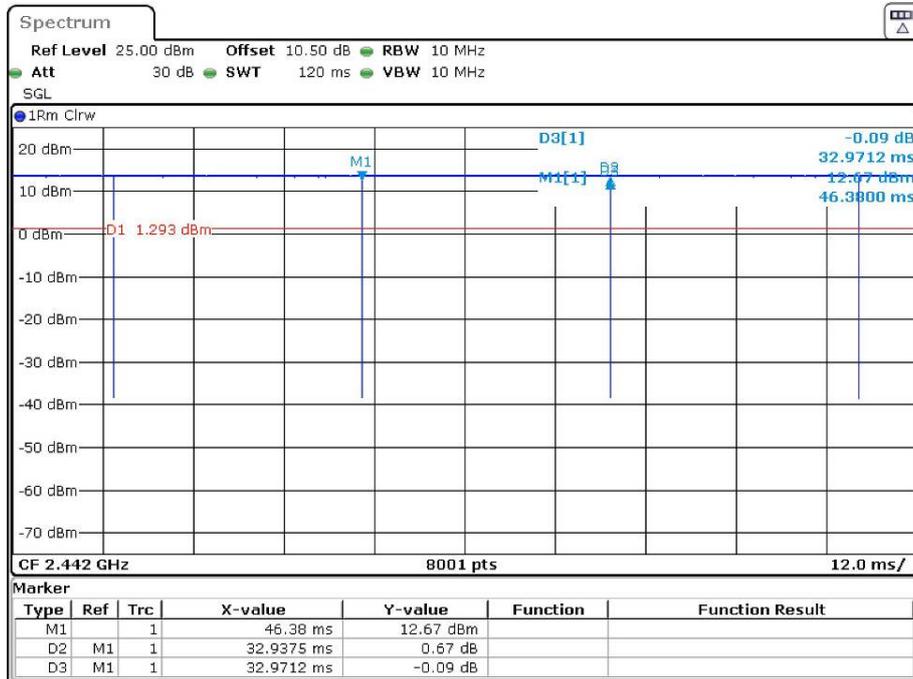
Date: 20.APR.2023 16:08:32

802.11g Mode
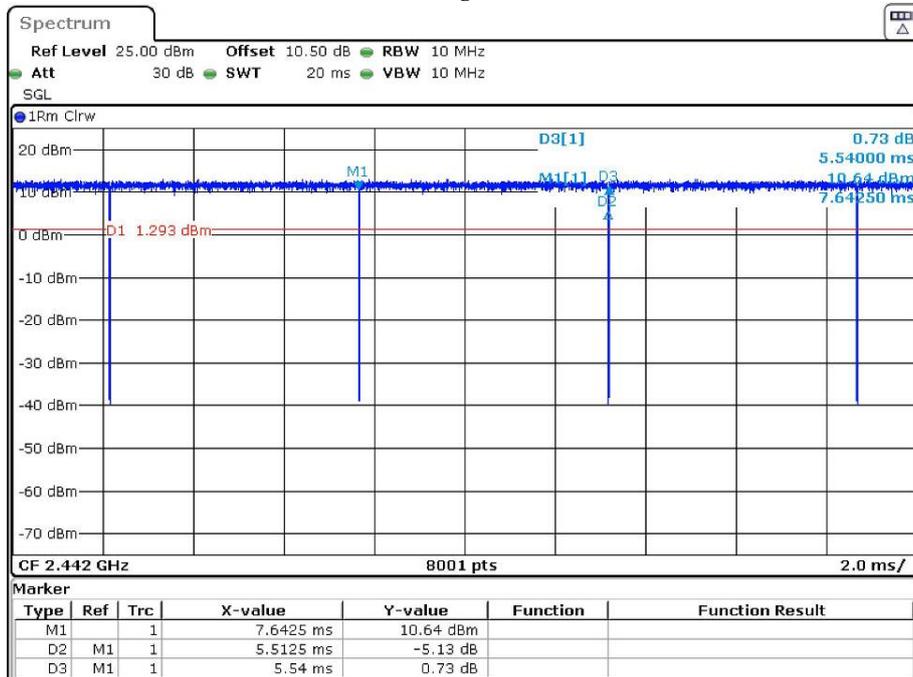
Date: 20.APR.2023 16:14:36

802.11n20

Spectrum					
Ref Level 25.00 dBm	Offset 10.50 dB	RBW 10 MHz			
● Att 30 dB	● SWT 20 ms	● VBW 10 MHz			

SGL

● 1Rm Clrw

M1[1] 9.32 dBm
1.49750 ms
D2[1] -15.69 dB

D1 -8.689 dBm

CF 2.442 GHz   8001 pts   2.0 ms/

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	1.4975 ms	9.32 dBm		
D2	M1	1	5.08 ms	-15.69 dB		
D3	M1	1	5.1075 ms	0.50 dB		
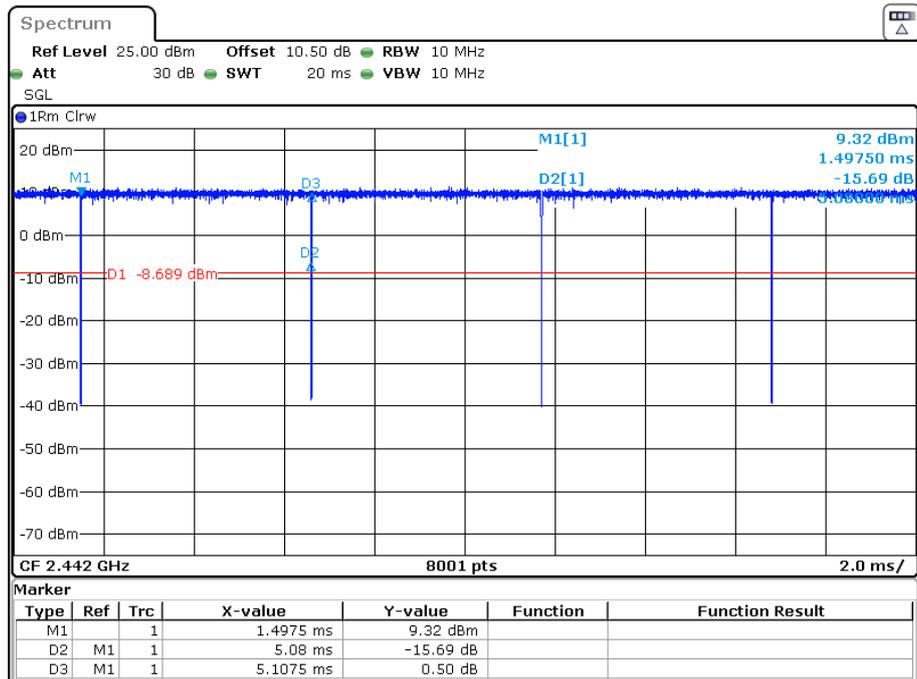
Date: 20.APR.2023 11:18:18

802.11n40

Spectrum					
Ref Level 25.00 dBm	Offset 10.50 dB	RBW 10 MHz			
● Att 30 dB	● SWT 20 ms	● VBW 10 MHz			

SGL

● 1Rm Clrw

M1[1] 5.09 dBm
1.11000 ms
D2[1] -3.77 dB
2.46750 ms

D1 -11.559 dBm

CF 2.442 GHz   8001 pts   2.0 ms/

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	1.11 ms	5.09 dBm		
D2	M1	1	2.4675 ms	-3.77 dB		
D3	M1	1	2.495 ms	0.53 dB		
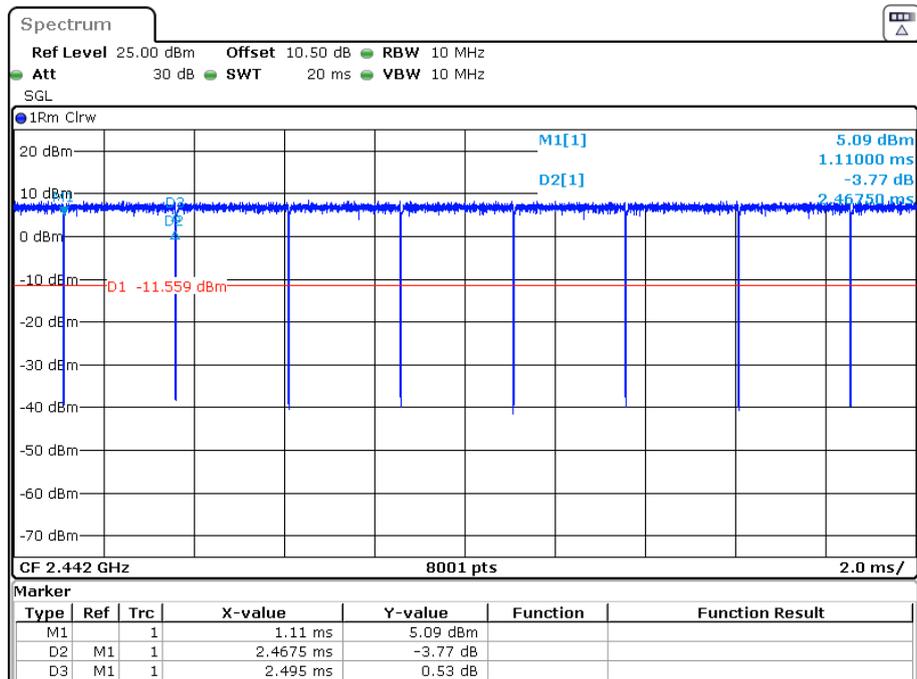
Date: 20.APR.2023 11:56:10

Support Equipment List and Details

Manufacturer	Description	Model	Serial Number
TECNO	Adapter	U180TSA	Unknown

External I/O Cable

Cable Description	Length (m)	From Port	To
Un-shielding Detachable USB Cable	0.5	EUT	Adapter

Block Diagram of Test Setup

For conducted emission

For Radiated Emissions:

AC Mains

Adapter

EUT ←→ 10cm

Receptacle

1.0 Meter

Non-Conductive Table
80/150 cm above Ground Plane
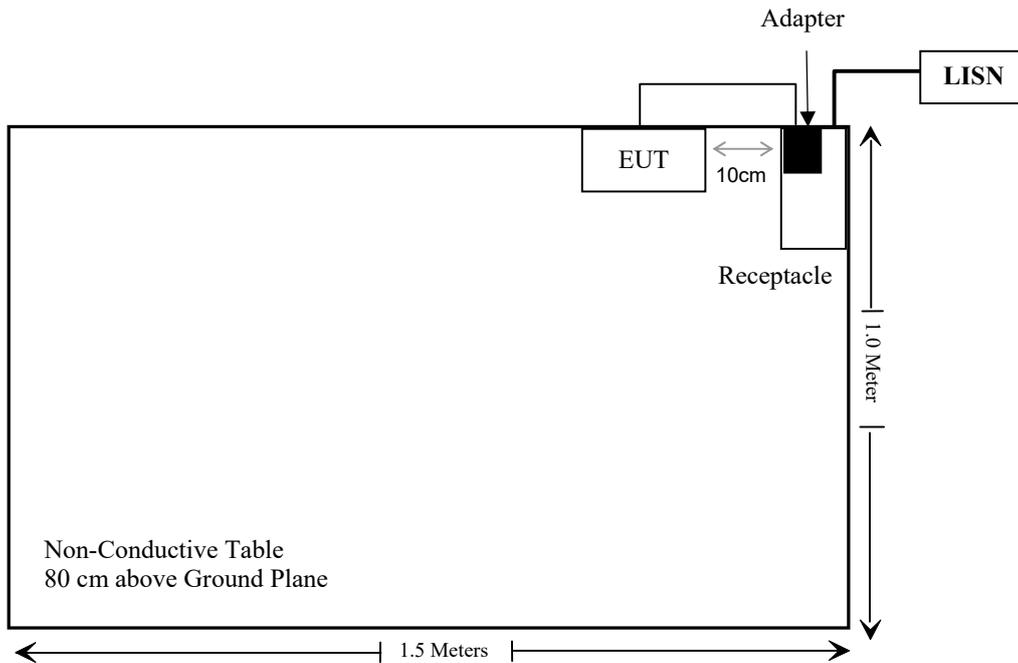
1.5 Meters
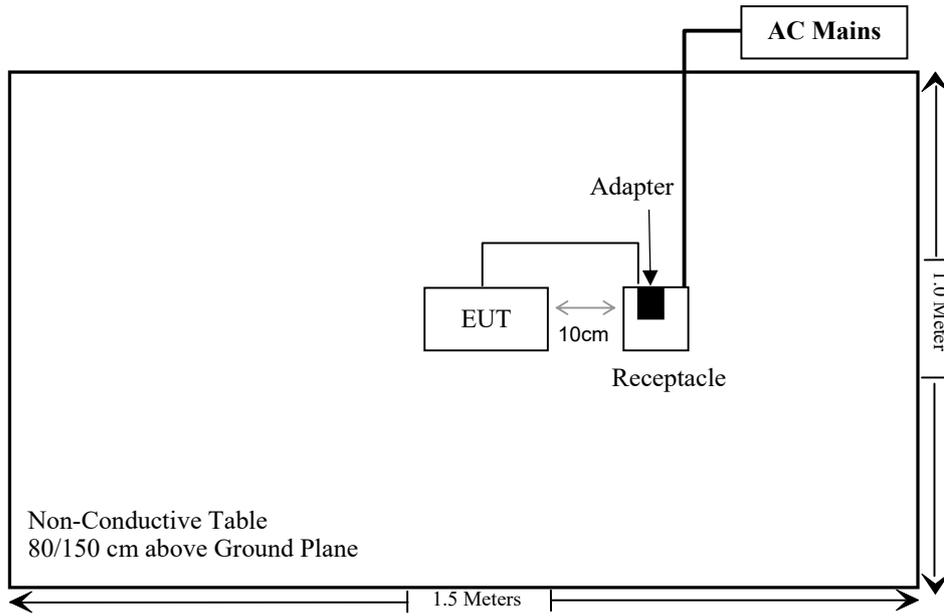
SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
FCC§15.247 (i), §1.1307 (b) (3) &§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.	ESH3-Z5	100305	2022/12/01	2023/11/30
Rohde & Schwarz	L.I.S.N.	ENV216	101314	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.17	N0350	2022/11/25	2023/11/24
Conducted Emission Test Software: e3 19821b (V9)					
Radiated emission 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-18405536-J0	15964001002	2022/11/08	2023/11/07
Schwarzbeck	Bilog Antenna	VULB9163	9163-323	2021/07/06	2024/07/05
Schwarzbeck	Horn Antenna	BBHA9120D	9120D-1067	2022/11/30	2025/11/29
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2022/12/26	2025/12/25
Radiated Emission Test Software: e3 19821b (V9)					
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

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
RF Conducted Test					
Rohde&Schwarz	Spectrum Analyzer	FSV-40	101948	2022/11/25	2023/11/24
SPECTRUM ANALYZER	Rohde & Schwarz	FSU26	200982	2022/07/04	2023/07/03
Tonscend	RF Control Unit	JS0806-2	19G8060182	2022/10/24	2023/10/23
Agilent	USB wideband power sensor	U2021XA	MY54250003	2022/06/27	2023/06/26
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§15.247 (i), §1.1307 (b) (3) &§2.1091 – RF EXPOSURE

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.

According to KDB 447498 D04 Interim General RF Exposure Guidance

MPE-Based Exemption:

General frequency and separation-distance dependent MPE-based effective radiated power(ERP) thresholds are in Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] to support an exemptionfrom further evaluation from 300 kHz through 100 GHz.

Table 1 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	$0.0128\ R^2 f$.
1,500-100,000	$19.2 R^2$.

Ris the minimum separation distance in meters
f = frequency in MHz

Result

Mode	Frequency (MHz)	Antenna Gain		Tune up conducted power	ERP		Evaluation Distance (m)	ERP Limit (W)
		(dBi)	(dBd)	(dBm)	(dBm)	(W)		
BLE	2402-2480	-4.32	-6.47	4.0	-2.47	0.00057	0.2	0.768
Wi-Fi	2412-2472	-4.32	-6.47	15.0	8.53	0.007	0.2	0.768

Note: Wi-Fi and BLE cannot transmit simultaneous,

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 one internal PCB antenna which was permanently attached and the maximum antenna gain is -4.32dBi, 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
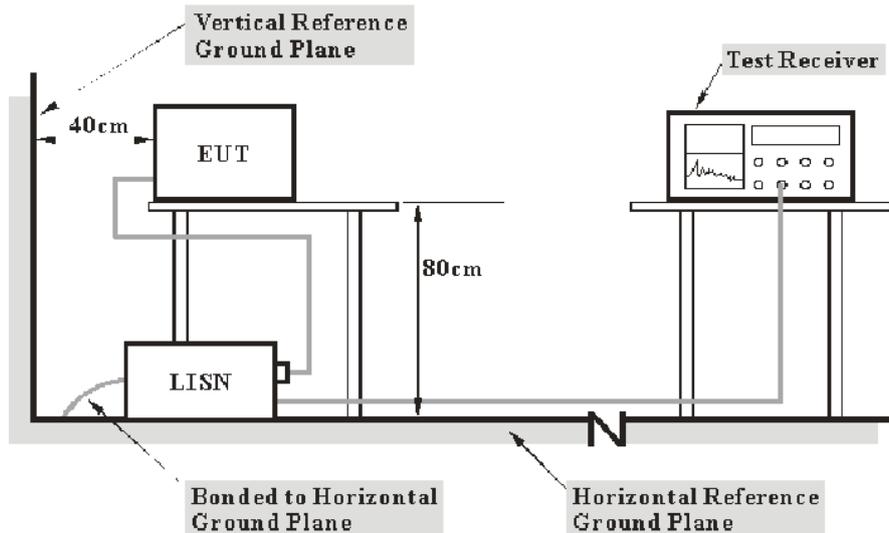
Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 30 cm from other units and other metal planes support units.

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.

Transd Factor & Margin Calculation

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

Transd 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:	55 %
ATM Pressure:	101.3 kPa

The testing was performed by Jerry Wu on 2023-04-23.

EUT operation mode: Transmitting (Worst case is 802.11b mode low channel)

AC 120V/60 Hz, Line
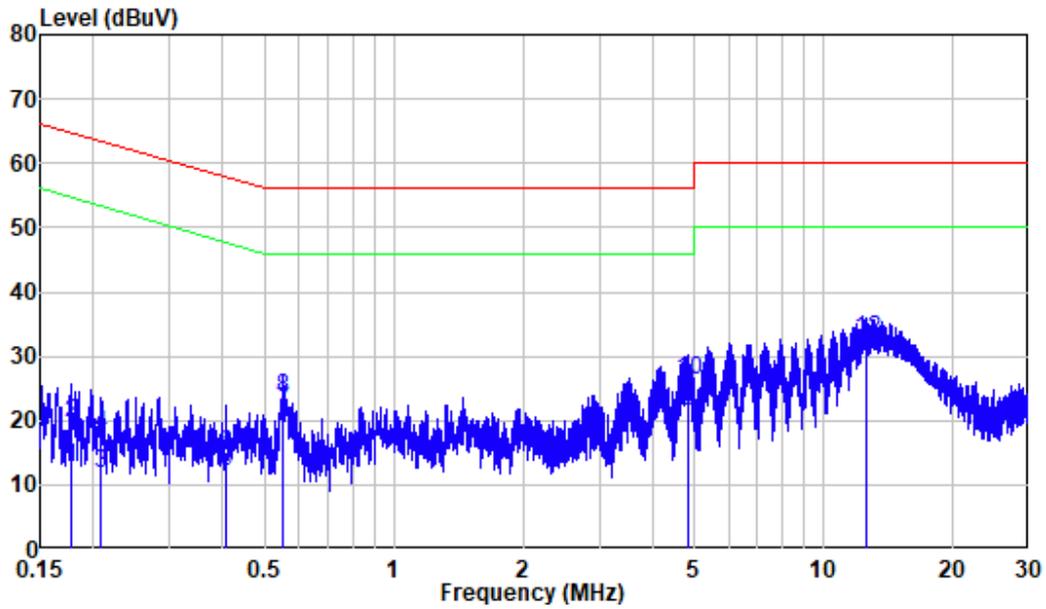

```
Site      : Shielding Room
Condition: Line
Job No.   : RA230403-16479E-RF
Mode      : 2.4G WIFI Transmitting
Power     : AC 120V 60Hz
```

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.177	9.98	2.60	12.58	54.61	-42.03	Average
2	0.177	9.98	9.75	19.73	64.61	-44.88	QP
3	0.209	9.99	1.85	11.84	53.26	-41.42	Average
4	0.209	9.99	7.93	17.92	63.26	-45.34	QP
5	0.407	10.04	2.07	12.11	47.70	-35.59	Average
6	0.407	10.04	4.62	14.66	57.70	-43.04	QP
7	0.553	10.10	11.43	21.53	46.00	-24.47	Average
8	0.553	10.10	13.45	23.55	56.00	-32.45	QP
9	4.816	10.78	10.61	21.39	46.00	-24.61	Average
10	4.816	10.78	15.60	26.38	56.00	-29.62	QP
11	12.549	13.51	16.30	29.81	50.00	-20.19	Average
12	12.549	13.51	19.08	32.59	60.00	-27.41	QP

AC 120V/60 Hz, Neutral
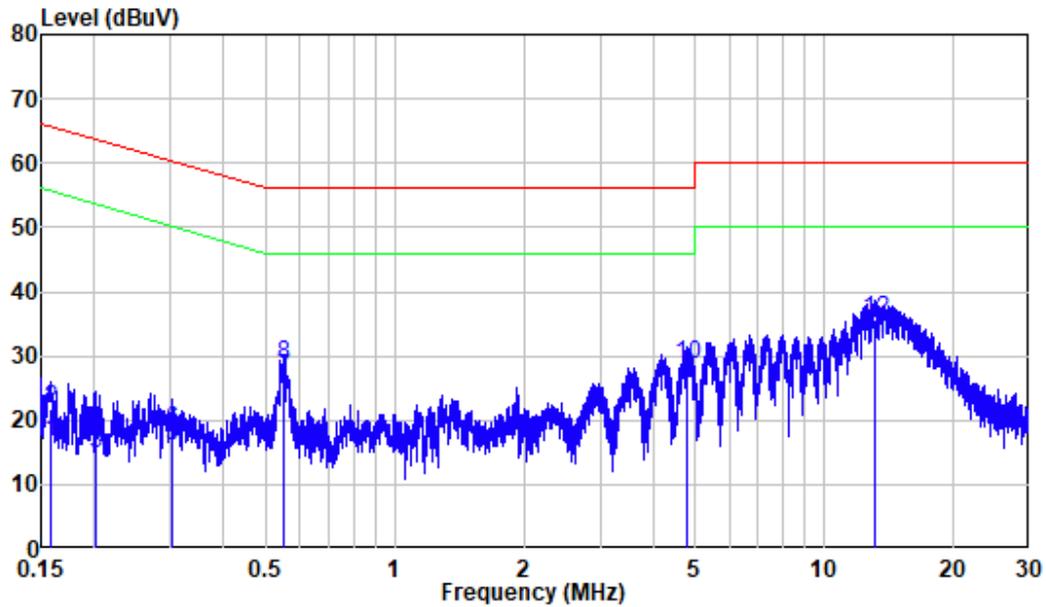

```
Site      : Shielding Room
Condition : Neutral
Job No.   : RA230403-16479E-RF
Mode      : 2.4G WIFI Transmitting
Power     : AC 120V 60Hz
```

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.158	10.18	6.29	16.47	55.55	-39.08	Average
2	0.158	10.18	11.69	21.87	65.55	-43.68	QP
3	0.200	10.19	4.54	14.73	53.60	-38.87	Average
4	0.200	10.19	8.25	18.44	63.60	-45.16	QP
5	0.303	10.27	5.80	16.07	50.17	-34.10	Average
6	0.303	10.27	8.13	18.40	60.17	-41.77	QP
7	0.552	10.22	16.20	26.42	46.00	-19.58	Average
8	0.552	10.22	18.43	28.65	56.00	-27.35	QP
9	4.784	10.61	15.13	25.74	46.00	-20.26	Average
10	4.784	10.61	18.14	28.75	56.00	-27.25	QP
11	13.083	13.69	18.94	32.63	50.00	-17.37	Average
12	13.083	13.69	22.02	35.71	60.00	-24.29	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:
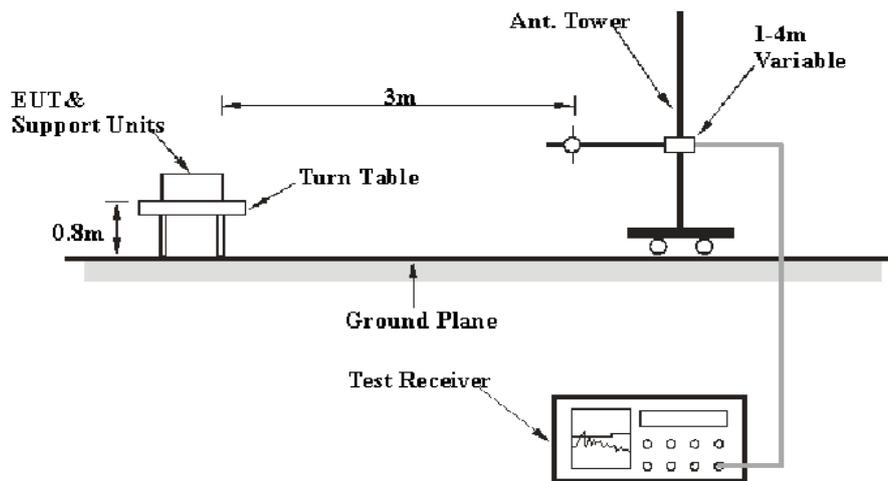
Above 1GHz:
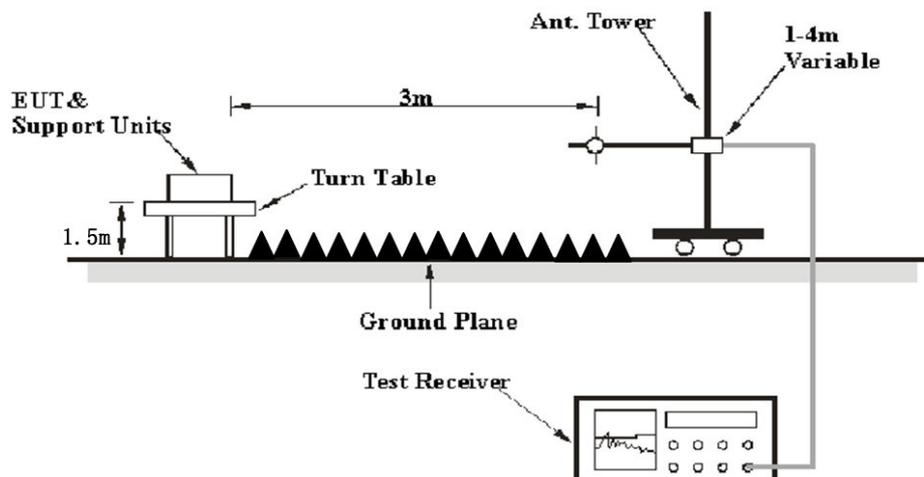
The radiated emission tests were performed in the 3 meters test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209, and FCC 15.247 limits.

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%

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:	24~25.5°C
Relative Humidity:	52~56 %
ATM Pressure:	101.1 kPa

The testing was performed by Jimi Zheng on 2023-04-23 for below 1GHz and Jason Liu on 2023-04-18 for above 1GHz

EUT operation mode: Transmitting

30MHz-1GHz: *(Worst case is 802.11b mode Middle channel)*

Note: When the test result of Peak was less than the limit of QP, just the peak value was recorded.

Horizontal:
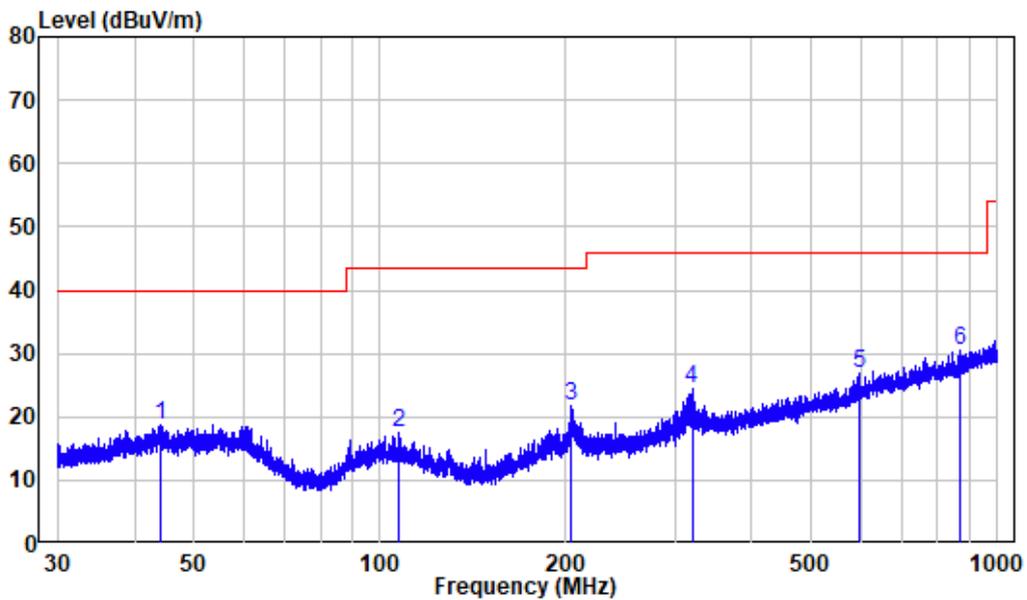

```
Site      : chamber
Condition: 3m HORIZONTAL
Job No.   : RA230403-16479E-RF
Test Mode: 2.4G WIFI Transmitting
```

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	44.178	-9.91	28.48	18.57	40.00	-21.43	Peak
2	107.510	-11.98	29.46	17.48	43.50	-26.02	Peak
3	203.791	-11.73	33.32	21.59	43.50	-21.91	Peak
4	320.077	-8.45	33.02	24.57	46.00	-21.43	Peak
5	595.916	-2.64	29.61	26.97	46.00	-19.03	Peak
6	868.369	0.89	29.51	30.40	46.00	-15.60	Peak

Vertical
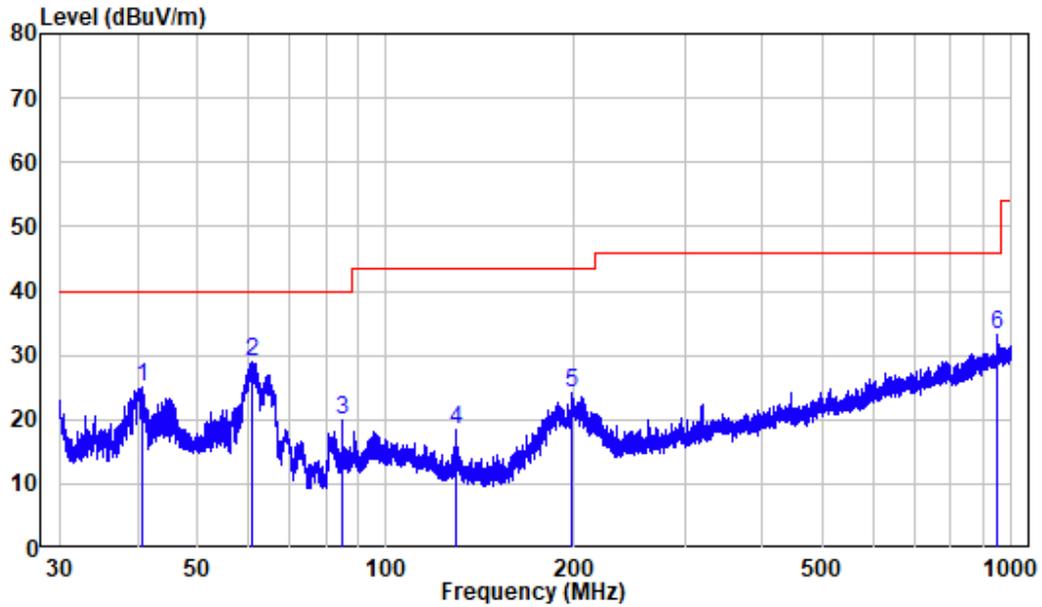
Site   : chamber
Condition: 3m VERTICAL
Job No.   : RA230403-16479E-RF
Test Mode: 2.4G WIFI Transmitting

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	40.791	-10.21	35.27	25.06	40.00	-14.94	Peak
2	61.132	-11.08	39.98	28.90	40.00	-11.10	Peak
3	84.851	-15.69	35.62	19.93	40.00	-20.07	Peak
4	129.695	-14.87	33.15	18.28	43.50	-25.22	Peak
5	198.588	-11.49	35.61	24.12	43.50	-19.38	Peak
6	947.930	1.98	31.31	33.29	46.00	-12.71	Peak

1-25 GHz:

BLE_1M:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
	Reading (dBµV)	PK/Ave		Height (m)	Polar (H/V)				
Low Channel 2402MHz									
2389.13	73.70	PK	93	2	H	-10.70	63.00	74	-11.00
2389.13	53.43	AV	93	2	H	-10.70	42.73	54	-11.27
2388.94	73.19	PK	124	1.5	V	-10.70	62.49	74	-11.51
2388.94	53.26	AV	124	1.5	V	-10.70	42.56	54	-11.44
2390	72.31	PK	22	1.9	H	-10.70	61.61	74	-12.39
2390	52.87	AV	22	1.9	H	-10.70	42.17	54	-11.83
2390	72.12	PK	168	2.1	V	-10.70	61.42	74	-12.58
2390	53.75	AV	168	2.1	V	-10.70	43.05	54	-10.95
4804	61.00	PK	186	2.1	H	-6.11	54.89	74	-19.11
4804	47.09	AV	186	2.1	H	-6.11	40.98	54	-13.02
4804	62.13	PK	10	2	V	-6.11	56.02	74	-17.98
4804	48.54	AV	10	2	V	-6.11	42.43	54	-11.57
Middle Channel 2440MHz									
4880	60.72	PK	187	1.6	H	-5.91	54.81	74	-19.19
4880	46.58	AV	187	1.6	H	-5.91	40.67	54	-13.33
4880	61.84	PK	360	1.7	V	-5.91	55.93	74	-18.07
4880	47.76	AV	360	1.7	V	-5.91	41.85	54	-12.15
High Channel 2480MHz									
2483.5	68.54	PK	93	2.2	H	-10.55	57.99	74	-16.01
2483.5	54.22	AV	93	2.2	H	-10.55	43.67	54	-10.33
2483.5	68.35	PK	232	1.6	V	-10.55	57.8	74	-16.20
2483.5	54.06	AV	232	1.6	V	-10.55	43.51	54	-10.49
2483.75	70.17	PK	214	1.8	H	-10.55	59.62	74	-14.38
2483.75	54.78	AV	214	1.8	H	-10.55	44.23	54	-9.77
2484.24	70.02	PK	5	2.4	V	-10.54	59.48	74	-14.52
2484.24	54.58	AV	5	2.4	V	-10.54	44.04	54	-9.96
4960	60.17	PK	170	1.7	H	-5.47	54.70	74	-19.30
4960	45.76	AV	170	1.7	H	-5.47	40.29	54	-13.71
4960	61.28	PK	169	1.7	V	-5.47	55.81	74	-18.19
4960	46.99	AV	169	1.7	V	-5.47	41.52	54	-12.48

BLE_2M:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave		Height (m)	Polar (H/V)				
Low Channel 2402MHz									
2385.24	67.71	PK	143	2	H	-10.71	57.00	74	-17.00
2385.24	54.02	AV	143	2	H	-10.71	43.31	54	-10.69
2387.45	67.56	PK	353	1.1	V	-10.71	56.85	74	-17.15
2387.45	53.89	AV	353	1.1	V	-10.71	43.18	54	-10.82
2390	65.89	PK	12	2.4	H	-10.70	55.19	74	-18.81
2390	53.58	AV	12	2.4	H	-10.70	42.88	54	-11.12
2390	65.77	PK	253	2	V	-10.70	55.07	74	-18.93
2390	53.46	AV	253	2	V	-10.70	42.76	54	-11.24
4804	61.10	PK	323	2	H	-6.11	54.99	74	-19.01
4804	46.71	AV	323	2	H	-6.11	40.60	54	-13.40
4804	62.29	PK	329	1.6	V	-6.11	56.18	74	-17.82
4804	47.58	AV	329	1.6	V	-6.11	41.47	54	-12.53
Middle Channel 2440MHz									
4880	60.75	PK	112	1.7	H	-5.91	54.84	74	-19.16
4880	46.42	AV	112	1.7	H	-5.91	40.51	54	-13.49
4880	61.81	PK	300	2.1	V	-5.91	55.9	74	-18.10
4880	47.33	AV	300	2.1	V	-5.91	41.42	54	-12.58
High Channel 2480MHz									
2483.5	66.47	PK	349	2.4	H	-10.55	55.92	74	-18.08
2483.5	54.14	AV	349	2.4	H	-10.55	43.59	54	-10.41
2483.5	66.36	PK	101	1.4	V	-10.55	55.81	74	-18.19
2483.5	54.03	AV	101	1.4	V	-10.55	43.48	54	-10.52
2485.54	68.36	PK	8	2.4	H	-10.53	57.83	74	-16.17
2485.54	54.63	AV	8	2.4	H	-10.53	44.1	54	-9.90
2484.37	68.24	PK	92	1.7	V	-10.54	57.7	74	-16.30
2484.37	53.51	AV	92	1.7	V	-10.54	42.97	54	-11.03
4960	59.96	PK	176	2.1	H	-5.47	54.49	74	-19.51
4960	45.82	AV	176	2.1	H	-5.47	40.35	54	-13.65
4960	61.17	PK	119	1.1	V	-5.47	55.70	74	-18.30
4960	46.66	AV	119	1.1	V	-5.47	41.19	54	-12.81

Wi-Fi:

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave		Height (m)	Polar (H/V)				
802.11b									
Low Channel 2412MHz									
2388.75	68.55	PK	136	1.8	H	-10.70	57.85	74	-16.15
2388.75	53.43	AV	136	1.8	H	-10.70	42.73	54	-11.27
2387.68	68.20	PK	94	1.3	V	-10.71	57.49	74	-16.51
2387.68	53.29	AV	94	1.3	V	-10.71	42.58	54	-11.42
2390	65.93	PK	91	1.5	H	-10.70	55.23	74	-18.77
2390	52.72	AV	91	1.5	H	-10.70	42.02	54	-11.98
2390	65.80	PK	247	1.9	V	-10.70	55.10	74	-18.90
2390	52.61	AV	247	1.9	V	-10.70	41.91	54	-12.09
4824	61.32	PK	76	1.4	H	-6.10	55.22	74	-18.78
4824	52.51	AV	76	1.4	H	-6.10	46.41	54	-7.59
4824	62.96	PK	40	1.8	V	-6.10	56.86	74	-17.14
4824	55.27	AV	40	1.8	V	-6.10	49.17	54	-4.83
Middle Channel 2442MHz									
4884	61.82	PK	153	1.3	H	-5.89	55.93	74	-18.07
4884	53.31	AV	153	1.3	H	-5.89	47.42	54	-6.58
4884	63.63	PK	42	2	V	-5.89	57.74	74	-16.26
4884	56.10	AV	42	2	V	-5.89	50.21	54	-3.79
High Channel 2472MHz									
2483.5	66.49	PK	336	1.7	H	-10.55	55.94	74	-18.06
2483.5	56.23	AV	336	1.7	H	-10.55	45.68	54	-8.32
2483.5	66.35	PK	262	1.7	V	-10.55	55.8	74	-18.20
2483.5	56.08	AV	262	1.7	V	-10.55	45.53	54	-8.47
2485.97	70.09	PK	3	1.9	H	-10.53	59.56	74	-14.44
2485.97	61.04	AV	3	1.9	H	-10.53	50.51	54	-3.49
2486.86	69.84	PK	221	2.3	V	-10.52	59.32	74	-14.68
2486.86	60.65	AV	221	2.3	V	-10.52	50.13	54	-3.87
4944	62.28	PK	58	1.2	H	-5.57	56.71	74	-17.29
4944	55.66	AV	58	1.2	H	-5.57	50.09	54	-3.91
4944	64.17	PK	221	1.8	V	-5.57	58.60	74	-15.40
4944	57.51	AV	221	1.8	V	-5.57	51.94	54	-2.06

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
	Reading (dBµV)	PK/Ave		Height (m)	Polar (H/V)				
802.11g									
Low Channel 2412MHz									
2388.39	68.42	PK	257	1.5	H	-10.71	57.71	74	-16.29
2388.39	53.50	AV	257	1.5	H	-10.71	42.79	54	-11.21
2389.12	68.26	PK	265	2.5	V	-10.70	57.56	74	-16.44
2389.12	53.38	AV	265	2.5	V	-10.70	42.68	54	-11.32
2390	66.10	PK	98	1.4	H	-10.70	55.40	74	-18.60
2390	52.93	AV	98	1.4	H	-10.70	42.23	54	-11.77
2390	65.97	PK	297	1	V	-10.70	55.27	74	-18.73
2390	52.82	AV	297	1	V	-10.70	42.12	54	-11.88
4824	60.48	PK	281	2.4	H	-6.10	54.38	74	-19.62
4824	46.66	AV	281	2.4	H	-6.10	40.56	54	-13.44
4824	62.22	PK	223	2.1	V	-6.10	56.12	74	-17.88
4824	47.85	AV	223	2.1	V	-6.10	41.75	54	-12.25
Middle Channel 2442MHz									
4884	60.81	PK	242	2.3	H	-5.89	54.92	74	-19.08
4884	47.09	AV	242	2.3	H	-5.89	41.2	54	-12.80
4884	62.52	PK	166	1.8	V	-5.89	56.63	74	-17.37
4884	48.20	AV	166	1.8	V	-5.89	42.31	54	-11.69
High Channel 2472MHz									
2483.5	79.54	PK	136	1.1	H	-10.55	68.99	74	-5.01
2483.5	60.63	AV	136	1.1	H	-10.55	50.08	54	-3.92
2483.5	79.29	PK	280	2.3	V	-10.55	68.74	74	-5.26
2483.5	60.47	AV	280	2.3	V	-10.55	49.92	54	-4.08
2483.96	81.02	PK	273	1.8	H	-10.55	70.47	74	-3.53
2483.96	61.35	AV	273	1.8	H	-10.55	50.8	54	-3.20
2484.27	80.50	PK	274	2.3	V	-10.54	69.96	74	-4.04
2484.27	61.07	AV	274	2.3	V	-10.54	50.53	54	-3.47
4944	60.96	PK	2	1.7	H	-5.57	55.39	74	-18.61
4944	47.28	AV	2	1.7	H	-5.57	41.71	54	-12.29
4944	62.72	PK	110	2	V	-5.57	57.15	74	-16.85
4944	48.41	AV	110	2	V	-5.57	42.84	54	-11.16

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave		Height (m)	Polar (H/V)				
802.11n20									
Low Channel 2412MHz									
2387.45	68.99	PK	319	2.1	H	-10.71	58.28	74	-15.72
2387.45	53.64	AV	319	2.1	H	-10.71	42.93	54	-11.07
2389.36	68.81	PK	172	2.2	V	-10.70	58.11	74	-15.89
2389.36	53.50	AV	172	2.2	V	-10.70	42.80	54	-11.20
2390	66.19	PK	169	1.5	H	-10.70	55.49	74	-18.51
2390	53.02	AV	169	1.5	H	-10.70	42.32	54	-11.68
2390	66.06	PK	211	1.2	V	-10.70	55.36	74	-18.64
2390	52.90	AV	211	1.2	V	-10.70	42.20	54	-11.80
4824	60.91	PK	172	1.4	H	-6.10	54.81	74	-19.19
4824	47.19	AV	172	1.4	H	-6.10	41.09	54	-12.91
4824	62.62	PK	37	1.8	V	-6.10	56.52	74	-17.48
4824	48.33	AV	37	1.8	V	-6.10	42.23	54	-11.77
Middle Channel 2442MHz									
4884	61.31	PK	304	1.3	H	-5.89	55.42	74	-18.58
4884	47.66	AV	304	1.3	H	-5.89	41.77	54	-12.23
4884	62.90	PK	230	1.4	V	-5.89	57.01	74	-16.99
4884	48.79	AV	230	1.4	V	-5.89	42.9	54	-11.10
High Channel 2472MHz									
2483.5	80.14	PK	283	2.3	H	-10.55	69.59	74	-4.41
2483.5	60.77	AV	283	2.3	H	-10.55	50.22	54	-3.78
2483.5	79.95	PK	59	2	V	-10.55	69.4	74	-4.60
2483.5	60.63	AV	59	2	V	-10.55	50.08	54	-3.92
2483.87	81.59	PK	158	1.2	H	-10.55	71.04	74	-2.96
2483.87	61.76	AV	158	1.2	H	-10.55	51.21	54	-2.79
2484.19	81.11	PK	326	2.2	V	-10.54	70.57	74	-3.43
2484.19	61.20	AV	326	2.2	V	-10.54	50.66	54	-3.34
4944	61.52	PK	227	2.4	H	-5.57	55.95	74	-18.05
4944	47.77	AV	227	2.4	H	-5.57	42.20	54	-11.80
4944	63.10	PK	50	1.7	V	-5.57	57.53	74	-16.47
4944	48.96	AV	50	1.7	V	-5.57	43.39	54	-10.61

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave		Height (m)	Polar (H/V)				
802.11n40									
Low Channel 2422MHz									
2384.25	68.62	PK	94	1.8	H	-10.71	57.91	74	-16.09
2384.25	54.00	AV	94	1.8	H	-10.71	43.29	54	-10.71
2387.44	68.44	PK	284	2	V	-10.71	57.73	74	-16.27
2387.44	53.87	AV	284	2	V	-10.71	43.16	54	-10.84
2390	66.42	PK	246	1.2	H	-10.70	55.72	74	-18.28
2390	53.47	AV	246	1.2	H	-10.70	42.77	54	-11.23
2390	66.30	PK	268	1.2	V	-10.70	55.60	74	-18.40
2390	53.35	AV	268	1.2	V	-10.70	42.65	54	-11.35
4844	60.71	PK	248	1.2	H	-6.09	54.62	74	-19.38
4844	45.56	AV	248	1.2	H	-6.09	39.47	54	-14.53
4844	61.98	PK	177	1.2	V	-6.09	55.89	74	-18.11
4844	46.77	AV	177	1.2	V	-6.09	40.68	54	-13.32
Middle Channel 2442MHz									
4884	61.01	PK	344	1.6	H	-5.89	55.12	74	-18.88
4884	45.80	AV	344	1.6	H	-5.89	39.91	54	-14.09
4884	62.22	PK	143	2.1	V	-5.89	56.33	74	-17.67
4884	46.73	AV	143	2.1	V	-5.89	40.84	54	-13.16
High Channel 2462MHz									
2483.5	67.62	PK	194	1.6	H	-10.55	57.07	74	-16.93
2483.5	53.74	AV	194	1.6	H	-10.55	43.19	54	-10.81
2483.5	67.47	PK	341	1.9	V	-10.55	56.92	74	-17.08
2483.5	53.61	AV	341	1.9	V	-10.55	43.06	54	-10.94
2484.39	69.78	PK	52	1.1	H	-10.54	59.24	74	-14.76
2484.39	54.47	AV	52	1.1	H	-10.54	43.93	54	-10.07
2483.97	69.54	PK	120	2	V	-10.55	58.99	74	-15.01
2483.97	54.36	AV	120	2	V	-10.55	43.81	54	-10.19
4924	61.25	PK	302	1.8	H	-5.67	55.58	74	-18.42
4924	45.96	AV	302	1.8	H	-5.67	40.29	54	-13.71
4924	62.47	PK	246	1.9	V	-5.67	56.80	74	-17.20
4924	47.14	AV	246	1.9	V	-5.67	41.47	54	-12.53

Note:
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
Corrected Amplitude = Corrected Factor + Reading
Margin = Corrected. Amplitude - Limit
The other spurious emission which is in the noise floor level was not recorded.

1-18 GHz:

Pre-scan for 802.11b mode, High Channel
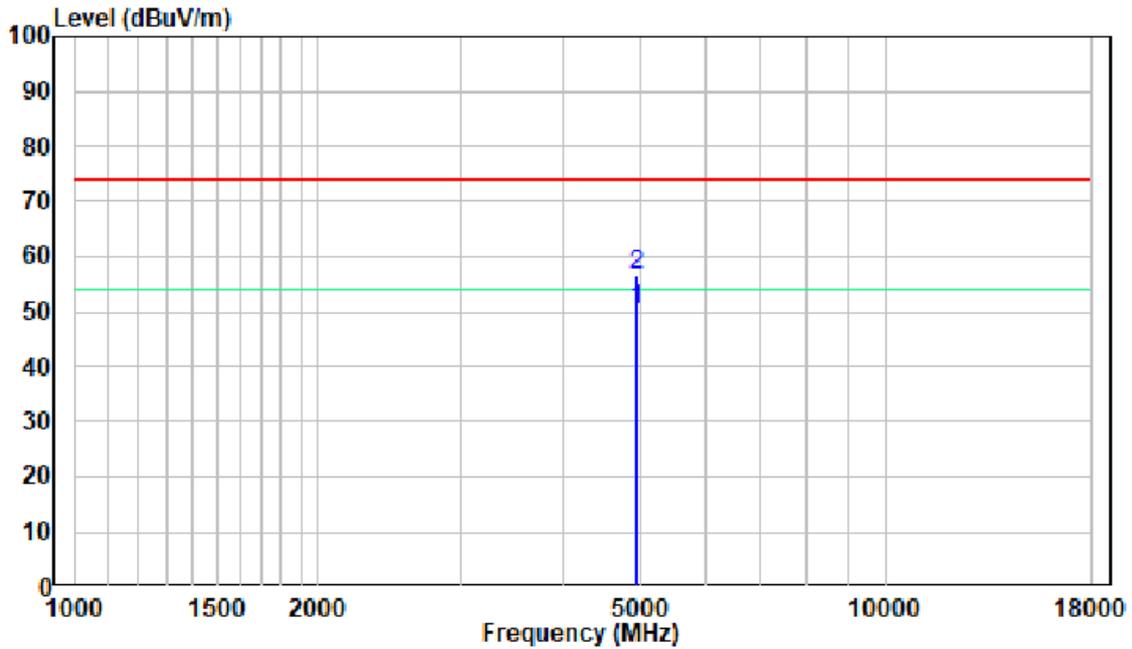
Horizontal
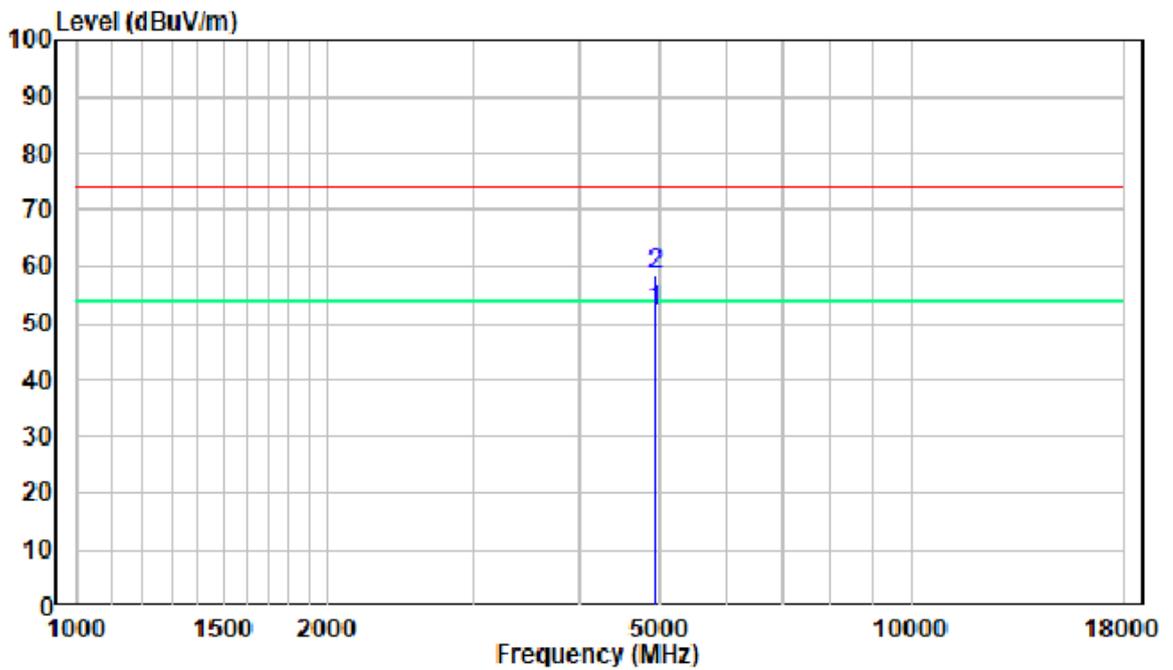
Vertical

18 -25GHz:

Pre-scan for 802.11b mode, High Channel

Horizontal
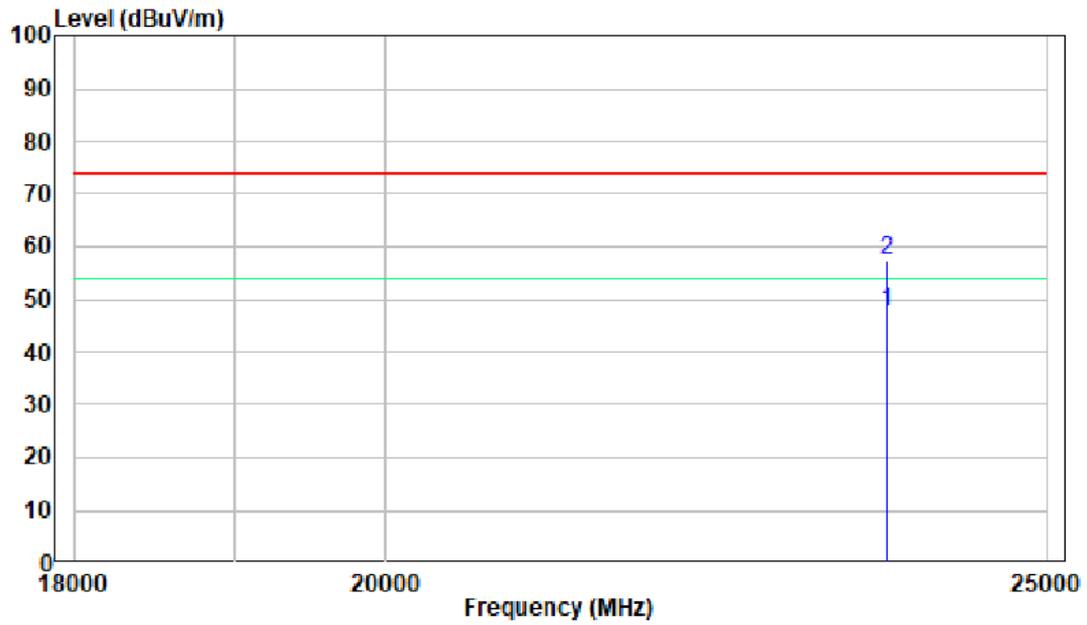
Vertical
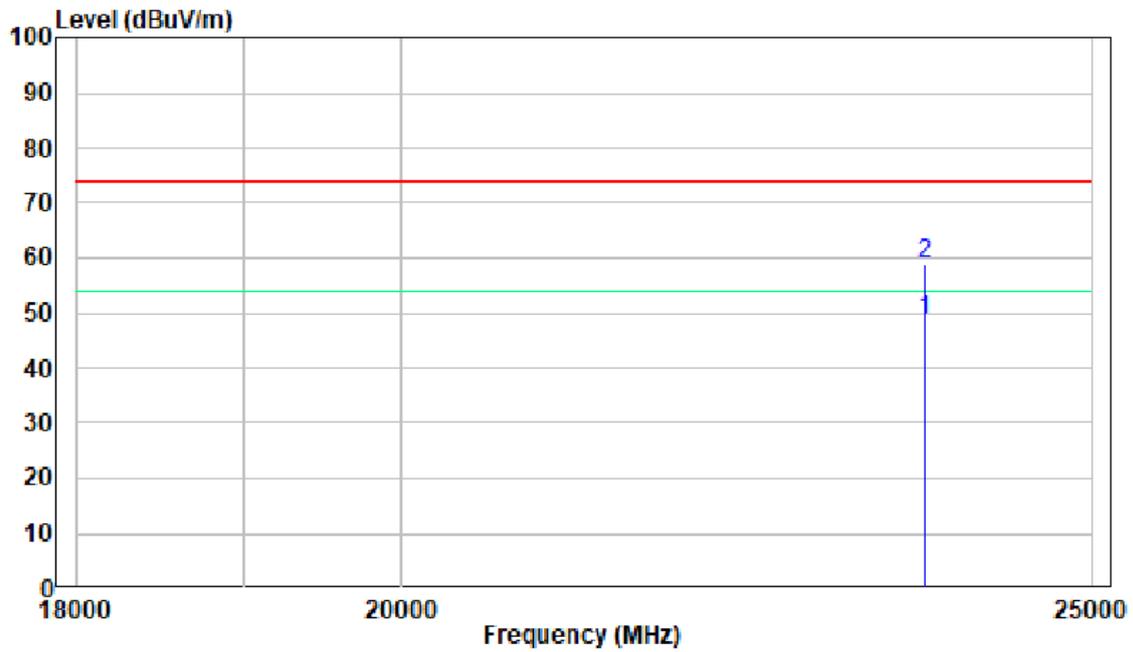
FCC §15.247(a) (2) – 6 dB EMISSION BANDWIDTH & OCCUPIED BANDWIDTH

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

Test Method: ANSI C63.10-2013 Clause 11.8.1 & Clause 6.9.3

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.
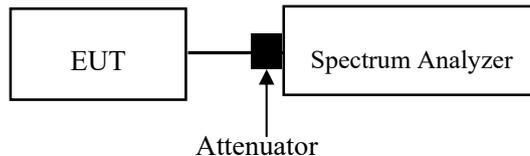
Test Data

Environmental Conditions

Temperature:	25.8 ℃
Relative Humidity:	54-58%
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang from 2023-04-14 to 2023-05-09.

EUT operation mode: Transmitting

Test Result: Compliant. The test data of BLE please refer to the Appendix and the test data of 2.4G Wi-Fi please see the plots as follow:

Channel	Frequency (MHz)	6 dB Emission Bandwidth (MHz)	99% Emission Bandwidth (MHz)	Limit (kHz)
802.11b mode				
Low	2412	9.57	13.11	≥500
Middle	2442	9.60	13.11	≥500
High	2472	9.60	13.11	≥500
802.11g mode				
Low	2412	16.41	17.10	≥500
Middle	2442	16.41	17.14	≥500
High	2472	16.41	17.14	≥500
802.11n-HT20 mode				
Low	2412	17.64	18.06	≥500
Middle	2442	17.67	18.06	≥500
High	2472	17.64	18.06	≥500
802.11n-HT40 mode				
Low	2422	31.44	34.05	≥500
Middle	2442	32.70	34.13	≥500
High	2462	32.70	34.13	≥500

6dB Bandwidth:
802.11b Mode:

Low Channel

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.40756 GHz	-1.20 dBm		
D2	M1	1	9.57 MHz	-0.31 dB		
M3		1	2.41161 GHz	4.85 dBm		
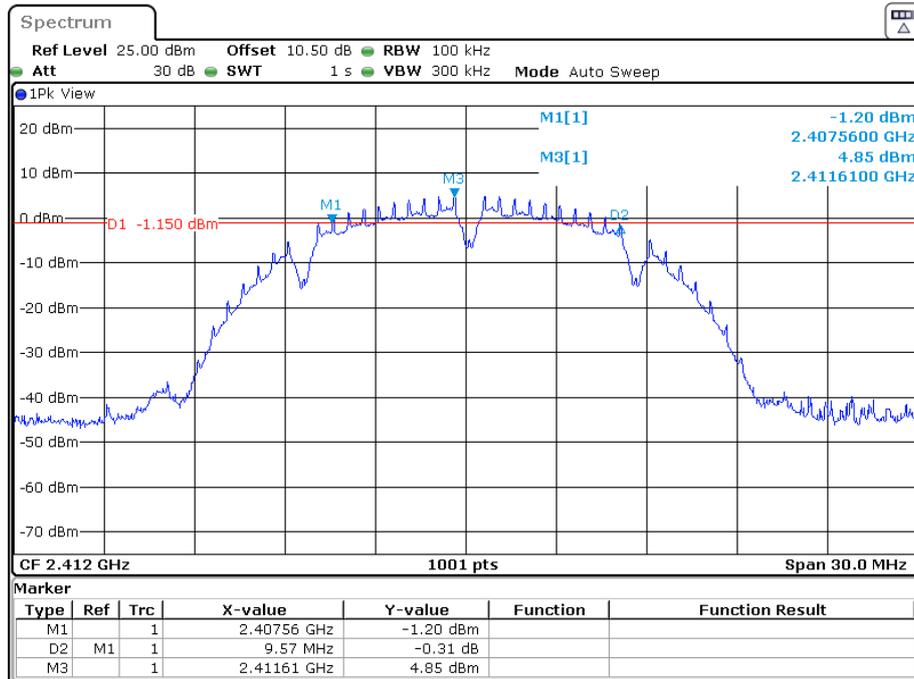
Date: 20.APR.2023 10:51:39

Middle Channel

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.43708 GHz	-1.33 dBm		
D2	M1	1	9.6 MHz	-1.09 dB		
M3		1	2.442599 GHz	5.03 dBm		
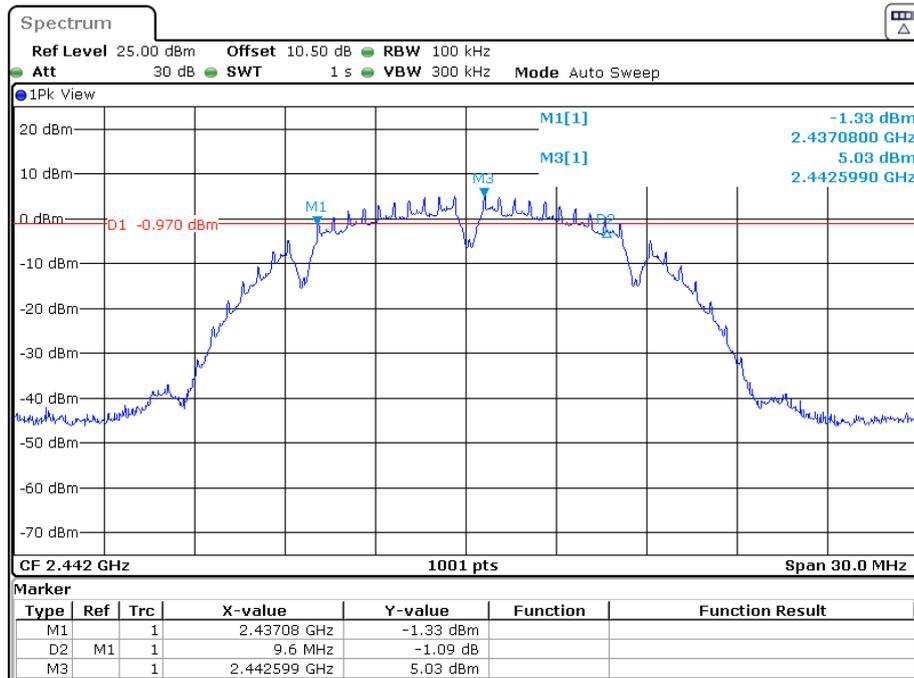
Date: 20.APR.2023 10:55:36

High Channel
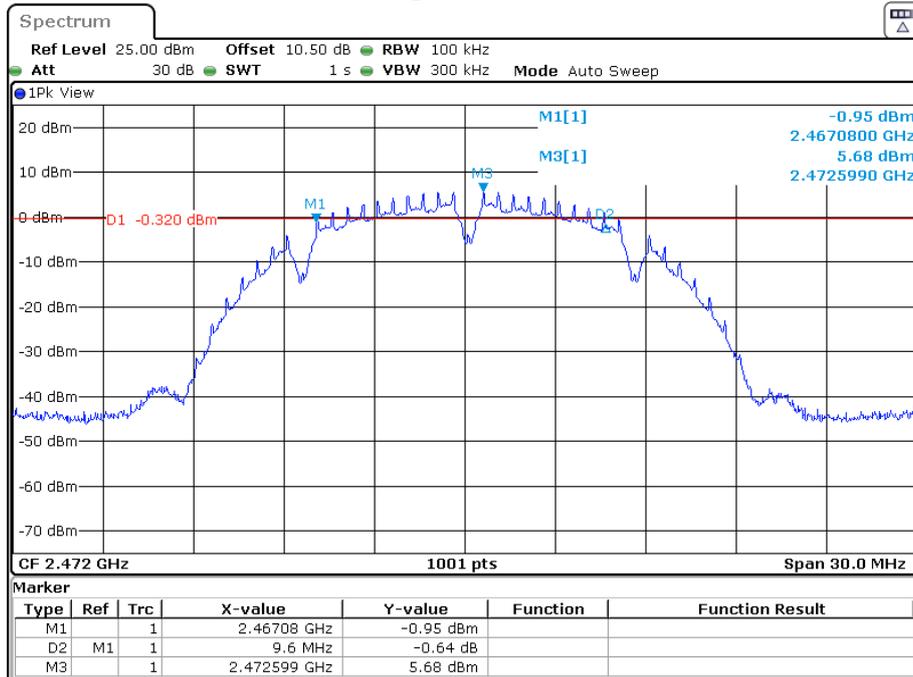
Date: 20.APR.2023 11:00:46

802.11g Mode:

Low Channel
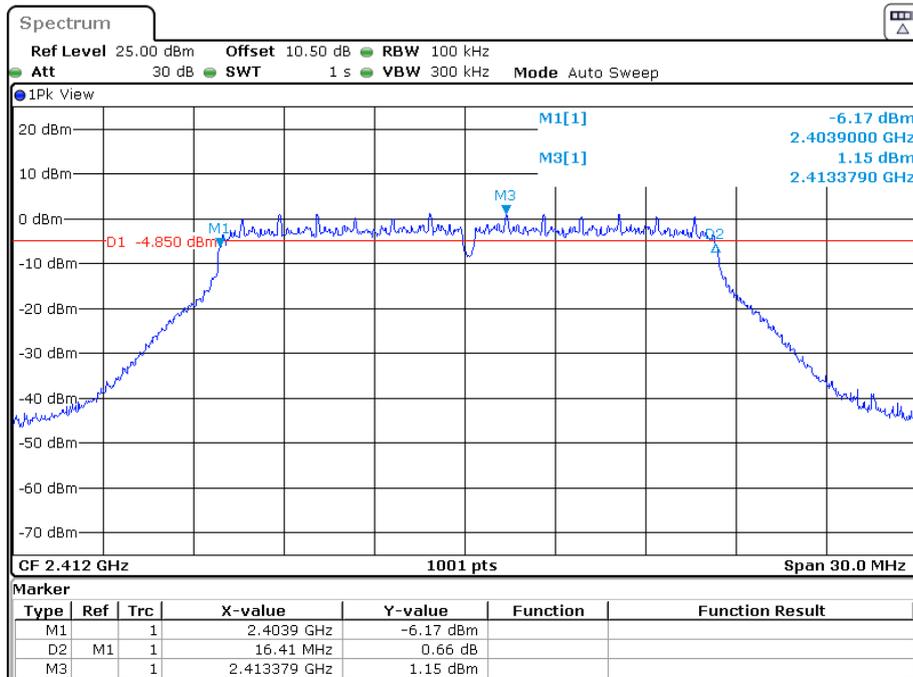
Date: 20.APR.2023 11:04:45

Middle Channel


```
Spectrum
  Ref Level 25.00 dBm    Offset 10.50 dB ● RBW  100 kHz
● Att        30 dB ● SWT       1 s ● VBW  300 kHz   Mode Auto Sweep
● 1Pk View
                                          M1[1]              -5.67 dBm
  20 dBm                                                  2.4339000 GHz
                                          M3[1]               1.44 dBm
  10 dBm                                                  2.4358560 GHz
   0 dBm                    M3
  D1 -4.560 dBm    M1                                D2
 -10 dBm                                              △
 -20 dBm
 -30 dBm
 -40 dBm
 -50 dBm
 -60 dBm
 -70 dBm
  CF 2.442 GHz                    1001 pts              Span 30.0 MHz
```

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4339 GHz	-5.67 dBm		
D2	M1	1	16.41 MHz	0.20 dB		
M3		1	2.435856 GHz	1.44 dBm		

Date: 20.APR.2023 11:08:22

High Channel


```
Spectrum
  Ref Level 25.00 dBm    Offset 10.50 dB ● RBW  100 kHz
● Att        30 dB ● SWT       1 s ● VBW  300 kHz   Mode Auto Sweep
● 1Pk View
                                          M1[1]              -5.02 dBm
  20 dBm                                                  2.4639000 GHz
                                          M3[1]               2.06 dBm
  10 dBm                                                  2.4658560 GHz
   0 dBm                    M3
  D1 -3.940 dBm    M1                                D2
 -10 dBm                                              △
 -20 dBm
 -30 dBm
 -40 dBm
 -50 dBm
 -60 dBm
 -70 dBm
  CF 2.472 GHz                    1001 pts              Span 30.0 MHz
```

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4639 GHz	-5.02 dBm		
D2	M1	1	16.41 MHz	0.14 dB		
M3		1	2.465856 GHz	2.06 dBm		

Date: 20.APR.2023 11:12:20

802.11n-20 Mode:

Low Channel
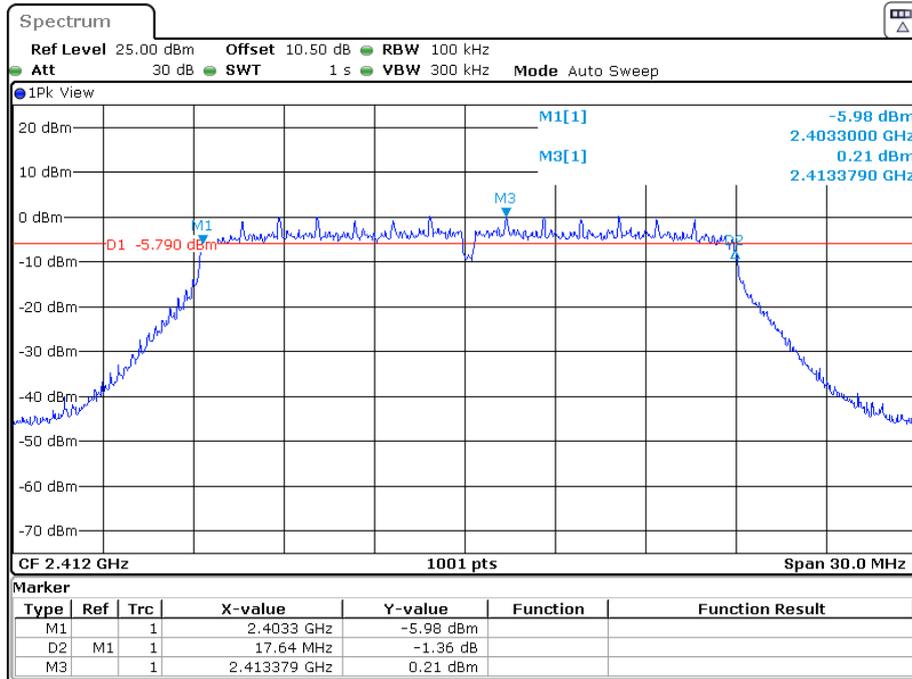
Date: 20.APR.2023 11:16:02

Middle Channel
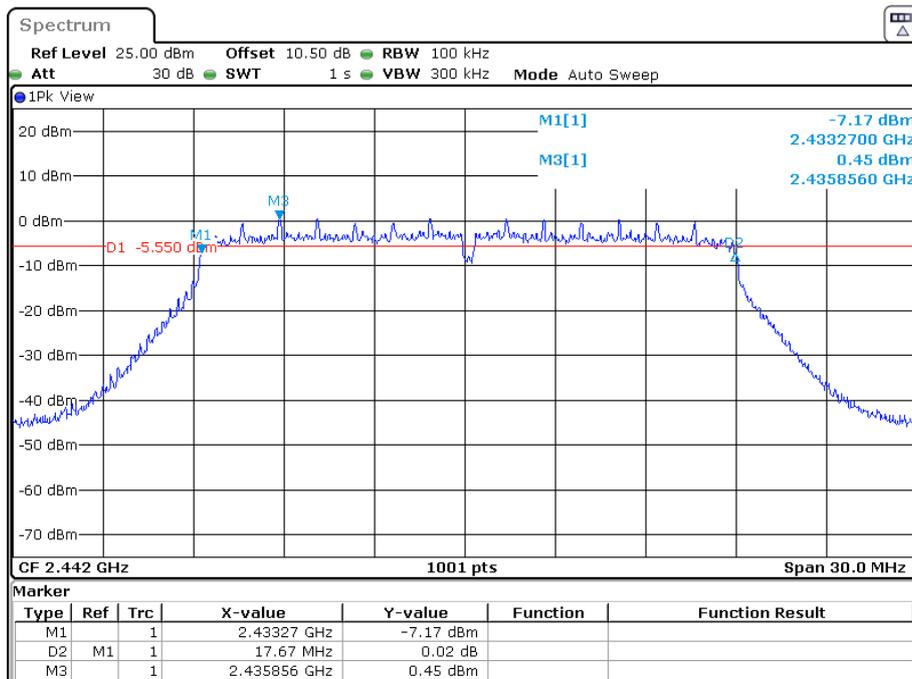
Date: 20.APR.2023 11:20:03

High Channel
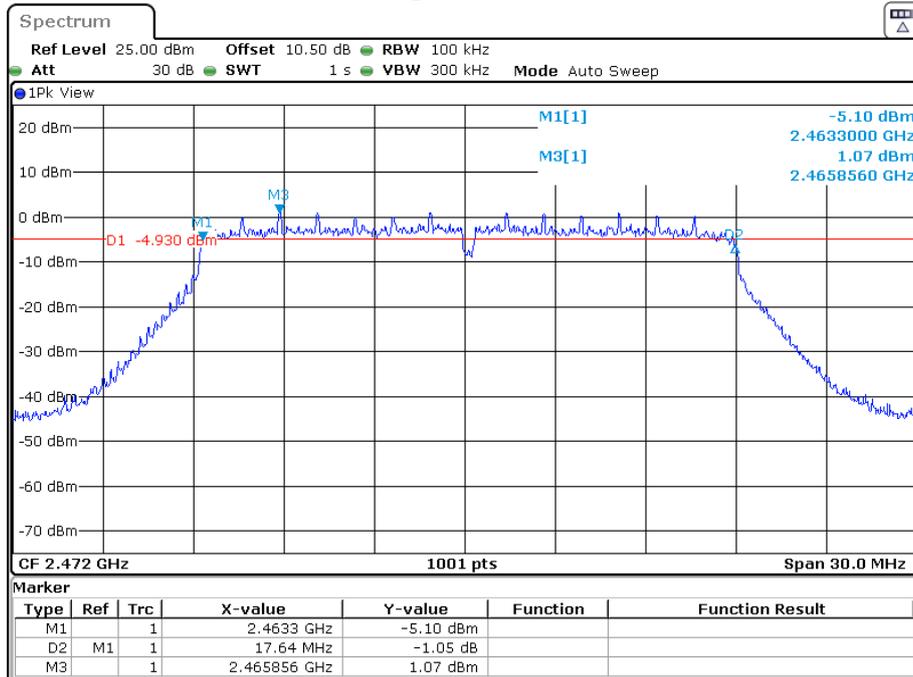
Date: 20.APR.2023 11:23:02

802.11n-40Mode:

Low Channel
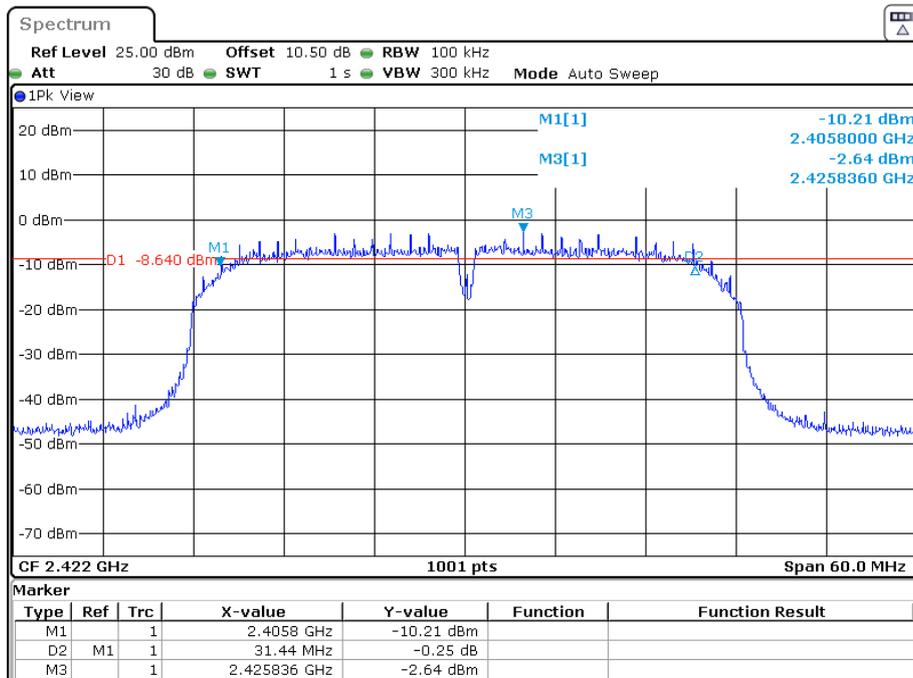
Date: 20.APR.2023 11:26:22

Middle Channel
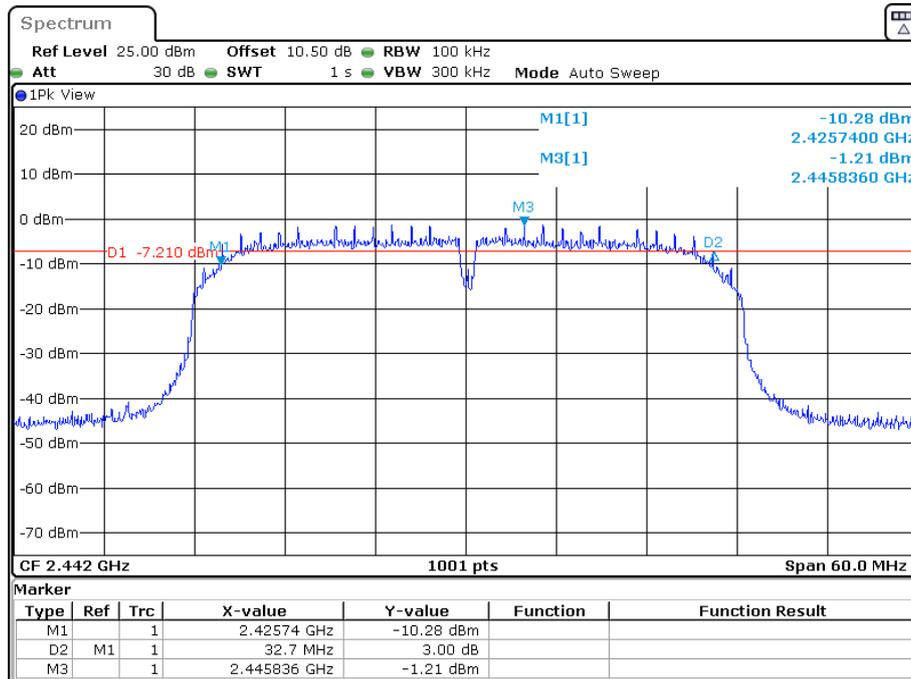
Date: 20.APR.2023 12:02:48

## High Channel
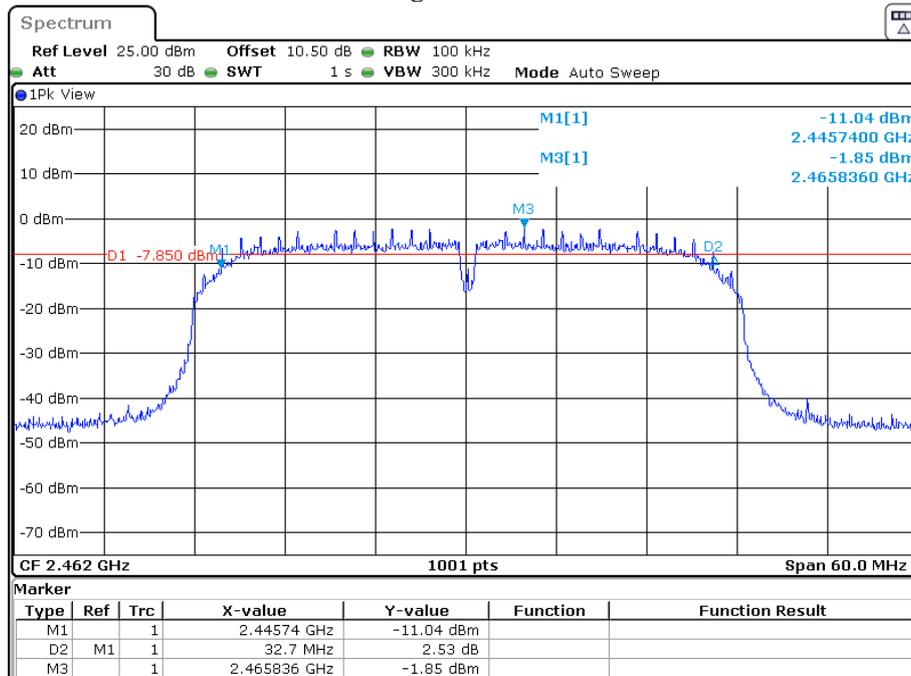
Date: 20.APR.2023 11:33:21

99%Emission Bandwidth:
802.11b Mode:
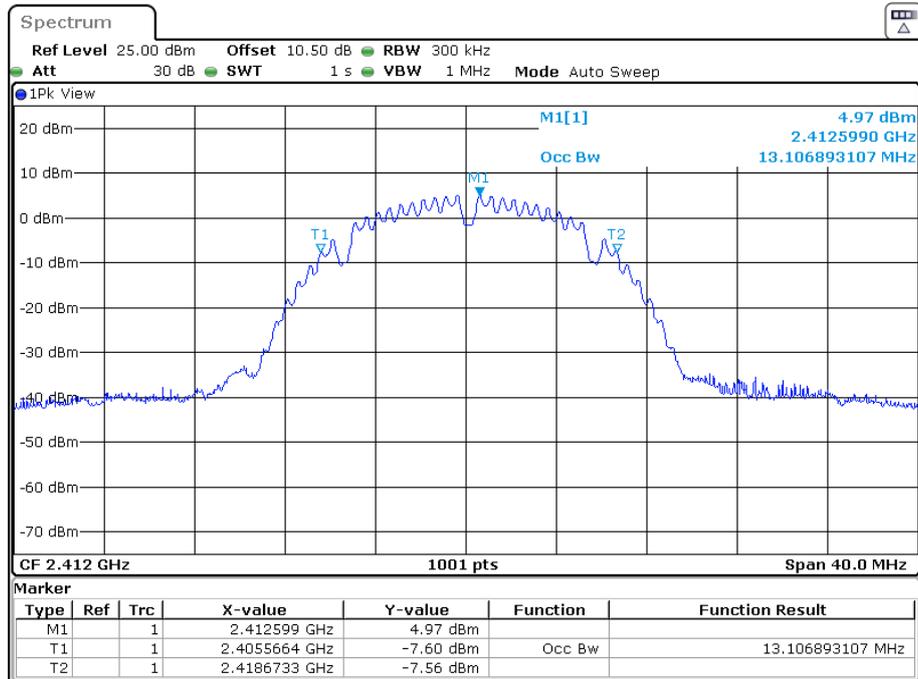
Low Channel

Date: 20.APR.2023 10:51:01

Middle Channel
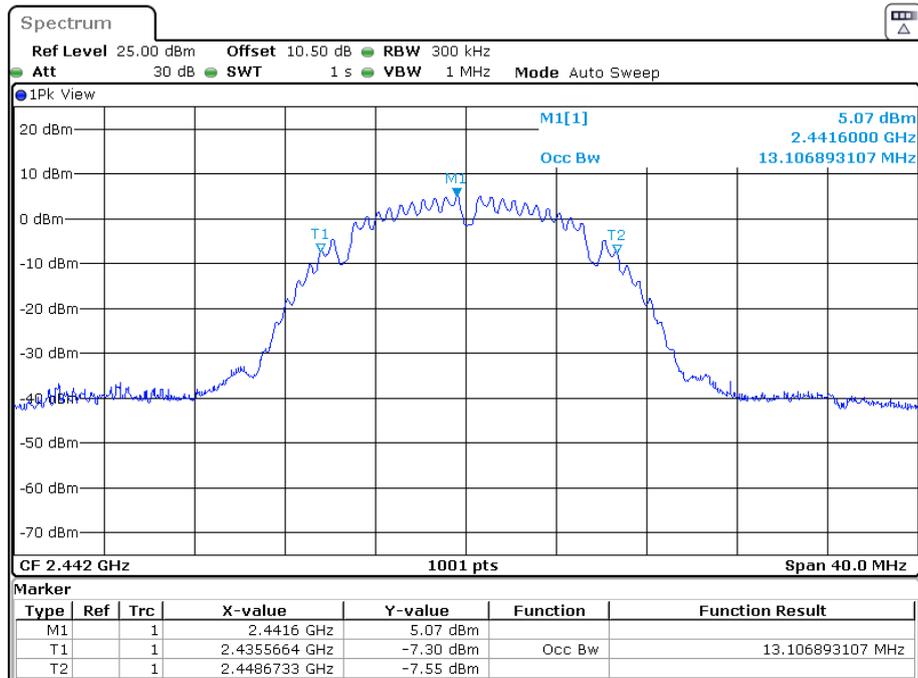
Date: 20.APR.2023 10:55:02

High Channel

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.47164 GHz	5.75 dBm		
T1		1	2.4655664 GHz	-6.63 dBm	Occ Bw	13.106893107 MHz
T2		1	2.4786733 GHz	-6.83 dBm		

Date: 20.APR.2023 11:00:12

802.11g Mode:

Low Channel

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.417994 GHz	4.08 dBm		
T1		1	2.4035285 GHz	-5.28 dBm	Occ Bw	17.102897103 MHz
T2		1	2.4206314 GHz	-4.61 dBm		
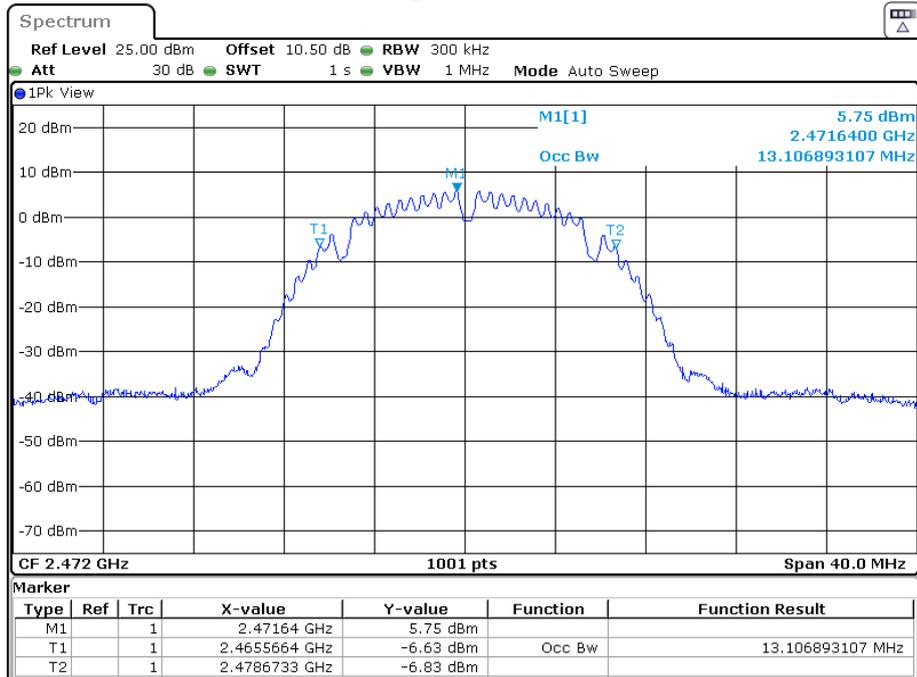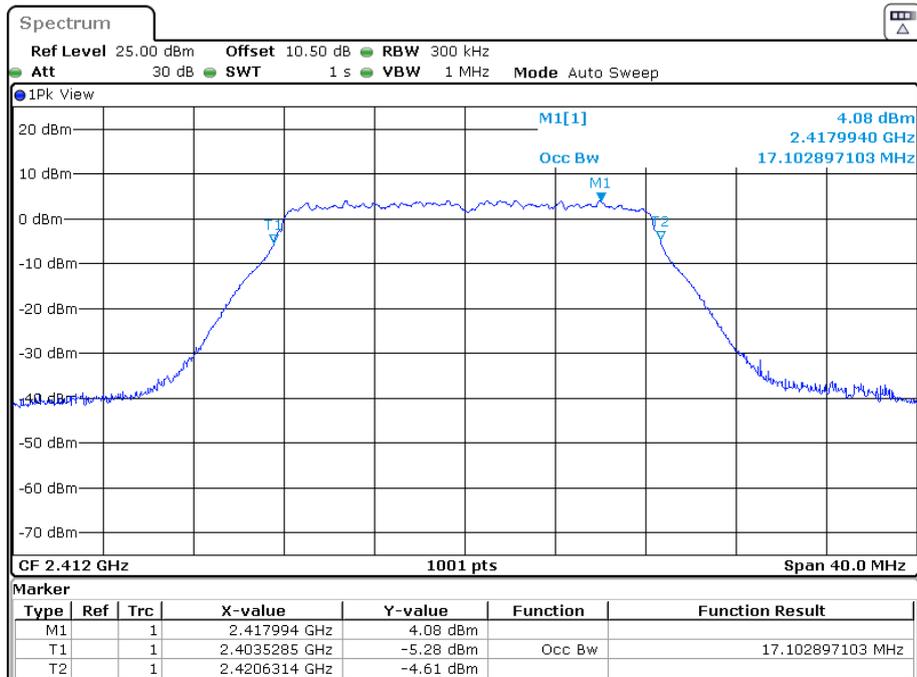
Date: 20.APR.2023 11:04:07

Middle Channel

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.436725 GHz	4.38 dBm		
T1		1	2.4334885 GHz	-5.57 dBm	Occ Bw	17.142857143 MHz
T2		1	2.4506314 GHz	-4.61 dBm		
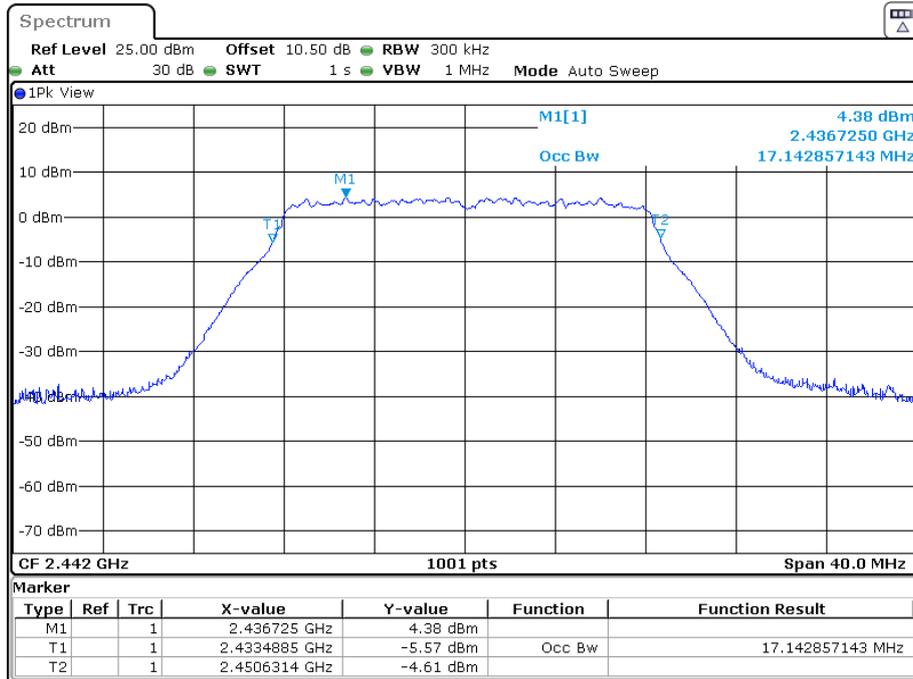
Date: 20.APR.2023 11:07:48

High Channel

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.466725 GHz	4.97 dBm		
T1		1	2.4634885 GHz	-4.96 dBm	Occ Bw	17.142857143 MHz
T2		1	2.4806314 GHz	-4.06 dBm		
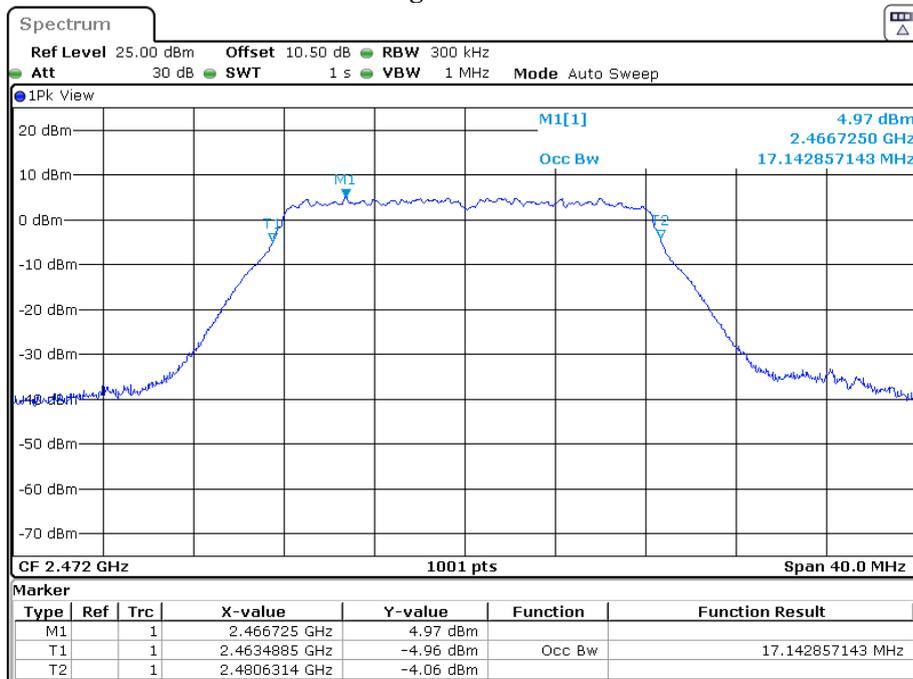
Date: 20.APR.2023 11:11:45

802.11n-20 Mode:

Low Channel

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.410482 GHz	2.80 dBm		
T1		1	2.4030889 GHz	-5.28 dBm	Occ Bw	18.061938062 MHz
T2		1	2.4211508 GHz	-4.66 dBm		
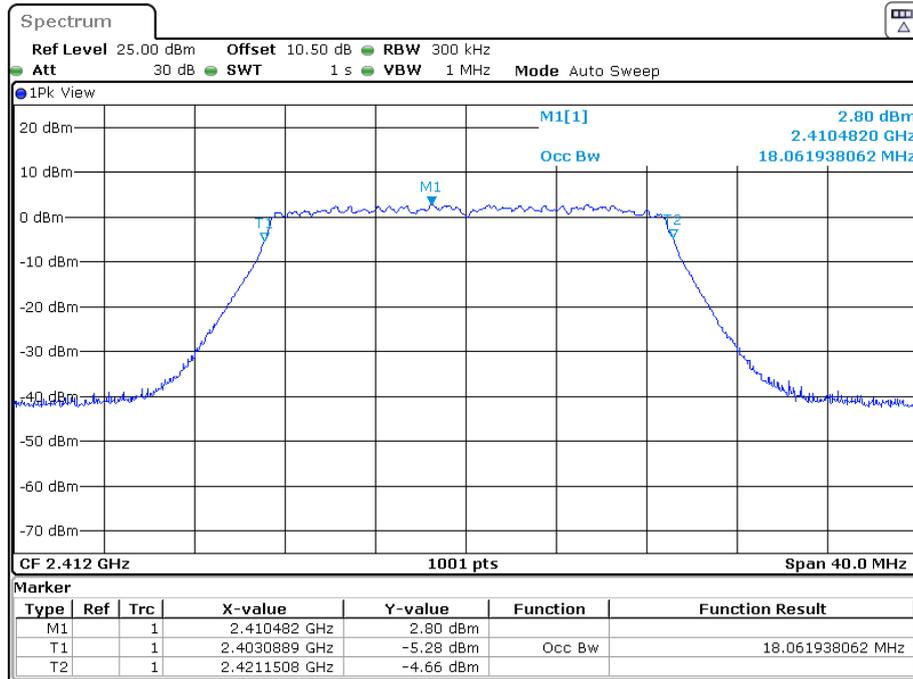
Date: 20.APR.2023 11:15:35

Middle Channel

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.440482 GHz	3.12 dBm		
T1		1	2.4330889 GHz	-4.76 dBm	Occ Bw	18.061938062 MHz
T2		1	2.4511508 GHz	-4.55 dBm		
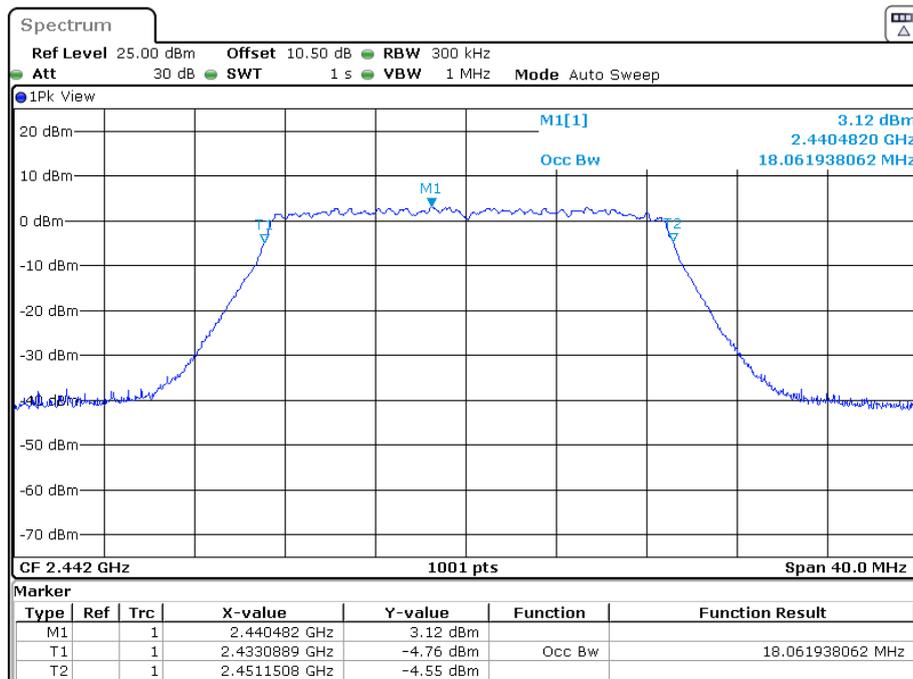
Date: 20.APR.2023 11:19:28

High Channel

Spectrum

Ref Level 25.00 dBm	Offset 10.50 dB ● RBW 300 kHz	
● Att 30 dB ● SWT 1 s ● VBW 1 MHz	Mode Auto Sweep	

● 1Pk View

M1[1]   3.68 dBm
2.4704820 GHz
Occ Bw   18.061938062 MHz

CF 2.472 GHz   1001 pts   Span 40.0 MHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.470482 GHz	3.68 dBm		
T1		1	2.4630889 GHz	-4.23 dBm	Occ Bw	18.061938062 MHz
T2		1	2.4811508 GHz	-3.88 dBm		
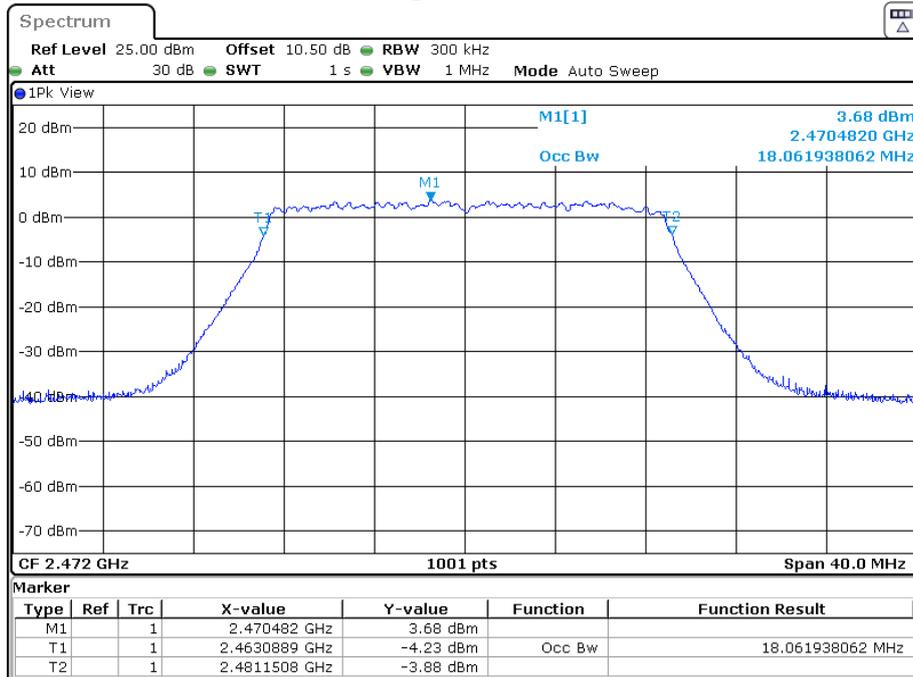
Date: 20.APR.2023 11:22:28

802.11n-40 Mode:

Low Channel

Spectrum

Ref Level 25.00 dBm	Offset 10.50 dB ● RBW 500 kHz	
● Att 30 dB ● SWT 1 s ● VBW 2 MHz	Mode Auto Sweep	

● 1Pk View

M1[1]   2.49 dBm
2.4255160 GHz
Occ Bw   34.045954046 MHz

CF 2.422 GHz   1001 pts   Span 80.0 MHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.425516 GHz	2.49 dBm		
T1		1	2.4051369 GHz	-6.27 dBm	Occ Bw	34.045954046 MHz
T2		1	2.4391828 GHz	-6.49 dBm		
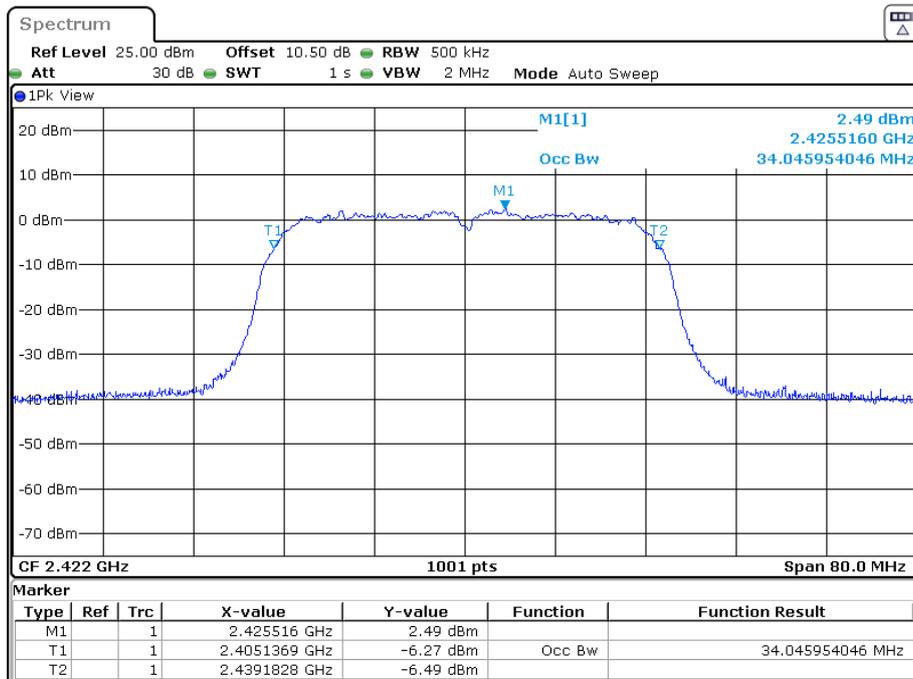
Date: 20.APR.2023 11:25:57

Middle Channel

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.445516 GHz	4.17 dBm		
T1		1	2.4250569 GHz	-4.71 dBm	Occ Bw	34.125874126 MHz
T2		1	2.4591828 GHz	-4.85 dBm		
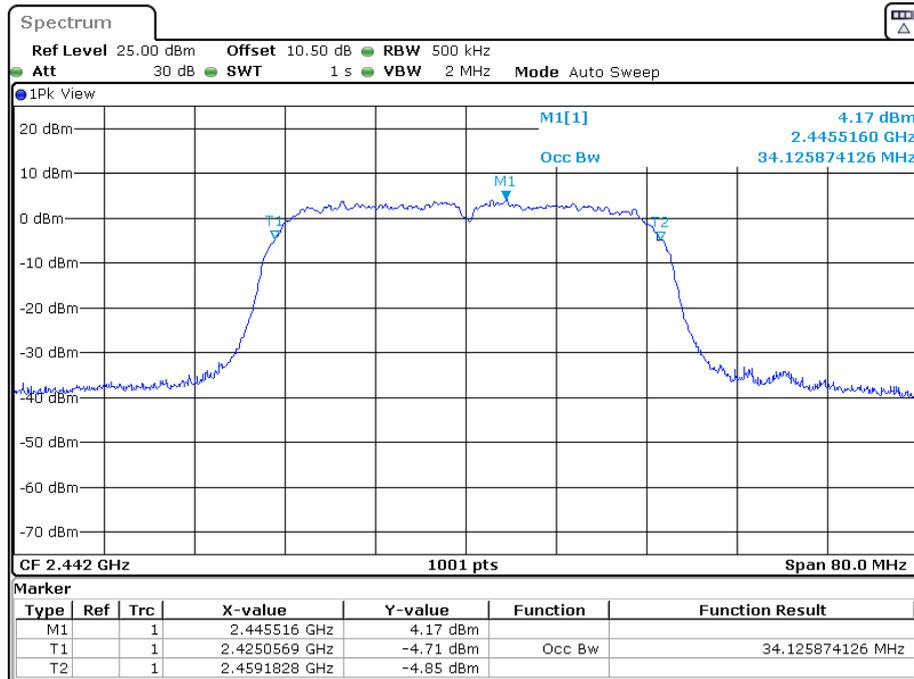
Date: 20.APR.2023 12:02:15

High Channel

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.465516 GHz	3.29 dBm		
T1		1	2.4451369 GHz	-5.67 dBm	Occ Bw	34.125874126 MHz
T2		1	2.4792627 GHz	-5.55 dBm		
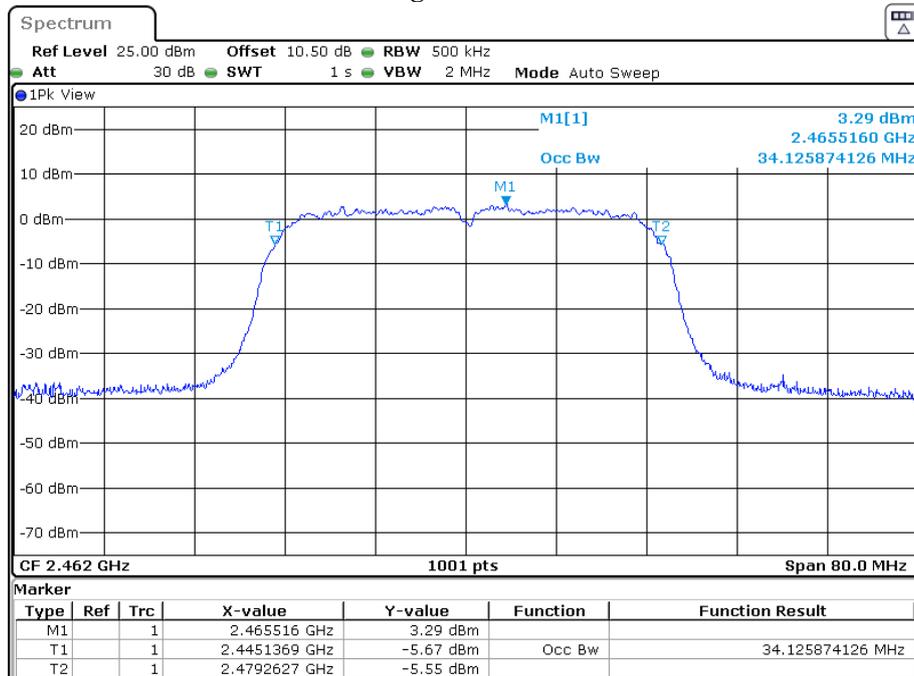
Date: 20.APR.2023 11:32:46

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

Test Method:

For BLE: ANSI C63.10-2013 Clause 11.9.1.1
For Wi-Fi: ANSI C63.10-2013 Clause 11.9.2.3.2

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:
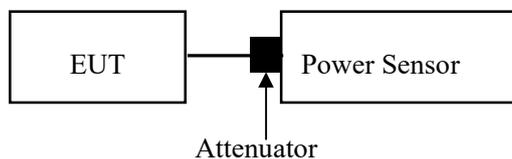
For BLE mode:
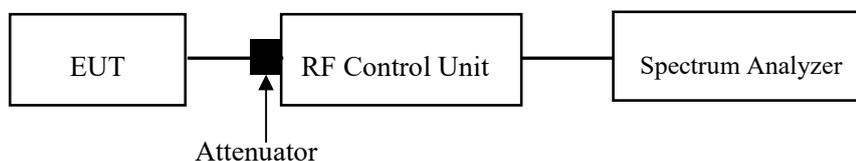
Test Data

Environmental Conditions

Temperature:	25.8 °C
Relative Humidity:	54-58%
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang from 2023-04-14 to 2023-05-09.

EUT operation mode: Transmitting

Test Result: Compliant. The test data of BLE please refer to the Appendix and the test data of 2.4G Wi-Fi please see the plots as follow:

Channel	Frequency (MHz)	Max Conducted Average Output Power (dBm)	Limit (dBm)
802.11b mode			
Low	2412	13.45	30
Middle	2442	13.52	30
High	2472	14.22	30
802.11g mode			
Low	2412	12.78	30
Middle	2442	13.00	30
High	2472	13.61	30
802.11n HT20 mode			
Low	2412	11.74	30
Middle	2442	11.99	30
High	2472	12.58	30
802.11n HT40 mode			
Low	2422	11.13	30
Middle	2442	12.86	30
High	2462	11.91	30

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

Test Method: ANSI C63.10-2013 Clause 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.
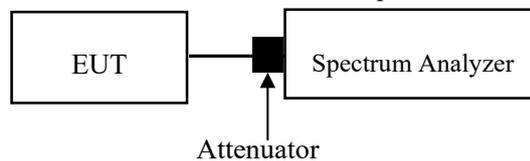
Test Data

Environmental Conditions

Temperature:	25.8 ℃
Relative Humidity:	52%
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang from 2023-04-14 to 2023-05-09.

EUT operation mode: Transmitting

Test Result: Compliant.

Conducted Band Edge Result:

The test data of BLE please refer to the Appendix and the test data of 2.4G Wi-Fi please see the plots as follow:

Wi-Fi

802.11b mode Left Side

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.41162 GHz	4.80 dBm		
M2		1	2.39991 GHz	-45.65 dBm		
M3		1	2.4 GHz	-43.16 dBm		

Date: 20.APR.2023 10:52:47

802.11b mode Right Side

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.471603 GHz	5.66 dBm		
M2		1	2.48715 GHz	-41.73 dBm		
M3		1	2.4835 GHz	-44.76 dBm		

Date: 20.APR.2023 11:01:46

802.11g mode Left Side

Spectrum

Ref Level 25.00 dBm   Offset 10.50 dB ● RBW 100 kHz
● Att   30 dB ● SWT   1 s ● VBW 300 kHz   Mode Auto Sweep
● 1Pk View

						M1[1]			0.90 dBm
									2.410810 GHz
						M2[1]			-38.56 dBm
									2.399910 GHz

20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm D1 -29.100 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm

M1
M3

Start 2.31 GHz   1001 pts   Stop 2.445 GHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.41081 GHz	0.90 dBm		
M2		1	2.39991 GHz	-38.56 dBm		
M3		1	2.4 GHz	-38.02 dBm		

Date: 20.APR.2023 11:05:42

802.11g mode Right Side

Spectrum

Ref Level 25.00 dBm   Offset 10.50 dB ● RBW 100 kHz
● Att   30 dB ● SWT   1 s ● VBW 300 kHz   Mode Auto Sweep
● 1Pk View

						M1[1]			2.00 dBm
									2.4658590 GHz
						M2[1]			-33.32 dBm
									2.4836000 GHz

20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm D1 -28.000 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm

M1
M3

Start 2.45 GHz   1001 pts   Stop 2.5 GHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.465859 GHz	2.00 dBm		
M2		1	2.4836 GHz	-33.32 dBm		
M3		1	2.4835 GHz	-31.93 dBm		

Date: 20.APR.2023 11:13:20

802.11n-20 mode Left Side

Spectrum					
Ref Level 25.00 dBm	Offset 10.50 dB	RBW 100 kHz			
Att 30 dB	SWT 1 s	VBW 300 kHz	Mode Auto Sweep		

1Pk View

M1[1]   0.07 dBm
              2.413370 GHz
M2[1]   -39.04 dBm
              2.399910 GHz

D1 -29.930 dBm

Start 2.31 GHz   1001 pts   Stop 2.445 GHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.41337 GHz	0.07 dBm		
M2		1	2.39991 GHz	-39.04 dBm		
M3		1	2.4 GHz	-38.14 dBm		

Date: 20.APR.2023 11:16:57

802.11n-20 mode Right Side

Spectrum					
Ref Level 25.00 dBm	Offset 10.50 dB	RBW 100 kHz			
Att 30 dB	SWT 1 s	VBW 300 kHz	Mode Auto Sweep		

1Pk View

M1[1]   1.07 dBm
              2.4734020 GHz
M2[1]   -33.50 dBm
              2.4837500 GHz

D1 -28.930 dBm

Start 2.45 GHz   1001 pts   Stop 2.5 GHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.473402 GHz	1.07 dBm		
M2		1	2.48375 GHz	-33.50 dBm		
M3		1	2.4835 GHz	-32.73 dBm		

Date: 20.APR.2023 11:24:03

802.11n-40 mode Left Side

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.42592 GHz	-2.71 dBm		
M2		1	2.39964 GHz	-43.28 dBm		
M3		1	2.4 GHz	-44.00 dBm		

Date: 20.APR.2023 11:27:07

802.11n-40 mode Right Side

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.465839 GHz	-1.81 dBm		
M2		1	2.48467 GHz	-41.53 dBm		
M3		1	2.4835 GHz	-42.83 dBm		

Date: 20.APR.2023 11:34:21

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

Test Method:

For BLE: ANSI C63.10-2013 Clause 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.

For Wi-Fi: ANSI C63.10-2013 Clause 11.10.3.

Method AVGPSD-1:

Method AVGPSD-1 uses trace averaging with EUT transmitting at full power throughout each sweep.

The following procedure may be used when the maximum (average) conducted output power was used to determine compliance to the fundamental output power limit. This is the baseline method for determining the maximum (average) conducted PSD level. If the instrument has a power averaging (rms) detector, then it must be used; otherwise, use the sample detector. The EUT must be configured to transmit continuously (D ≥ 98%), or else sweep triggering/signal gating must be implemented to ensure that measurements are made only when the EUT is transmitting at its maximum power control level (no transmitter OFF time to be considered):
a) Set instrument center frequency to DTS channel center frequency.
b) Set span to at least 1.5 times the OBW.
c) Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
d) Set VBW ≥ [3 × RBW].
e) Detector = power averaging (rms) or sample detector (when rms not available).
f) Ensure that the number of measurement points in the sweep ≥ [2 × span / RBW].
g) Sweep time = auto couple.
h) Employ trace averaging (rms) mode over a minimum of 100 traces.
i) Use the peak marker function to determine the maximum amplitude level.
j) If the measured value exceeds requirement, 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).
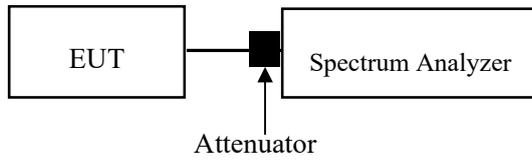
```
┌──────────┐         ┌──────────────────┐
│   EUT    │────────■│ Spectrum Analyzer│
└──────────┘    ↑    └──────────────────┘
            Attenuator
```

Test Data

Environmental Conditions

Temperature:	25.8 ℃
Relative Humidity:	54-58%
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang from 2023-04-14 to 2023-05-09.

EUT operation mode: Transmitting

Test Result: Compliant. The test data of BLE please refer to the Appendix and the test data of 2.4G Wi-Fi please see the plots as follow:

Channel	Frequency (MHz)	PSD (dBm/10kHz)	Limit (dBm/3kHz)
802.11b mode			
Low	2412	-13.15	≤8
Middle	2442	-12.52	≤8
High	2472	-12.54	≤8
802.11g mode			
Low	2412	-15.87	≤8
Middle	2442	-15.87	≤8
High	2472	-15.02	≤8
802.11n-HT20 mode			
Low	2412	-17.04	≤8
Middle	2442	-16.60	≤8
High	2472	-16.43	≤8
802.11n-HT40 mode			
Low	2422	-18.78	≤8
Middle	2442	-17.15	≤8
High	2462	-18.79	≤8

802.11 b mode：

Power Spectral Density, Low Channel
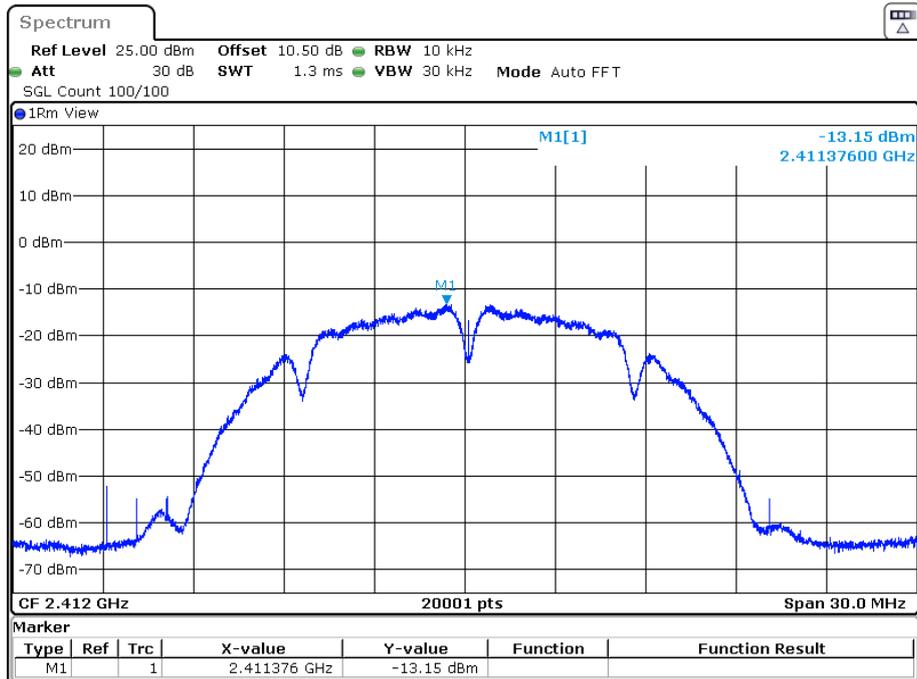
Date: 20.APR.2023 10:51:56

Power Spectral Density, Middle Channel
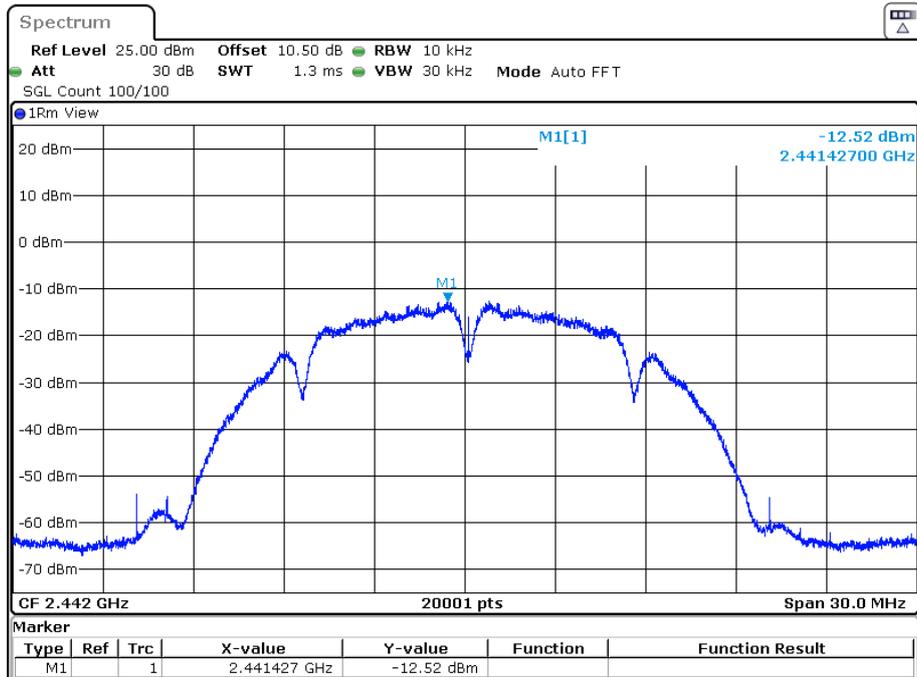
Date: 20.APR.2023 10:56:02

Power Spectral Density, High Channel

Spectrum							
Ref Level 25.00 dBm	**Offset** 10.50 dB	● **RBW** 10 kHz					
● **Att** 30 dB	**SWT** 1.3 ms	● **VBW** 30 kHz	**Mode** Auto FFT				
SGL Count 100/100							

● 1Rm View

M1[1]   -12.54 dBm
2.47123500 GHz

M1

CF 2.472 GHz   20001 pts   Span 30.0 MHz

Marker						
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.471235 GHz	-12.54 dBm		
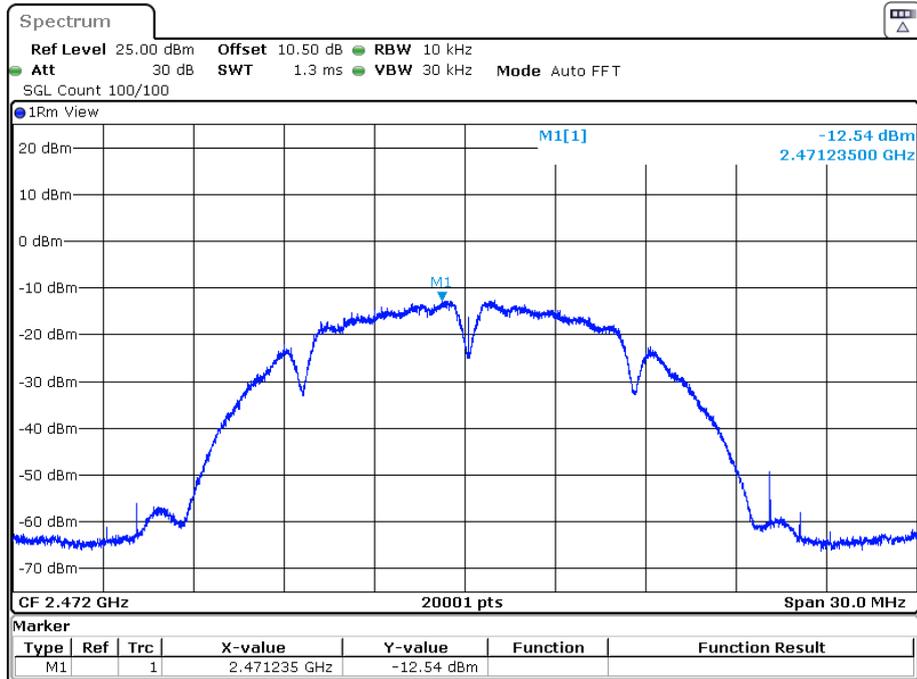
Date: 20.APR.2023 11:01:12

802.11 g mode：

Power Spectral Density, Low Channel
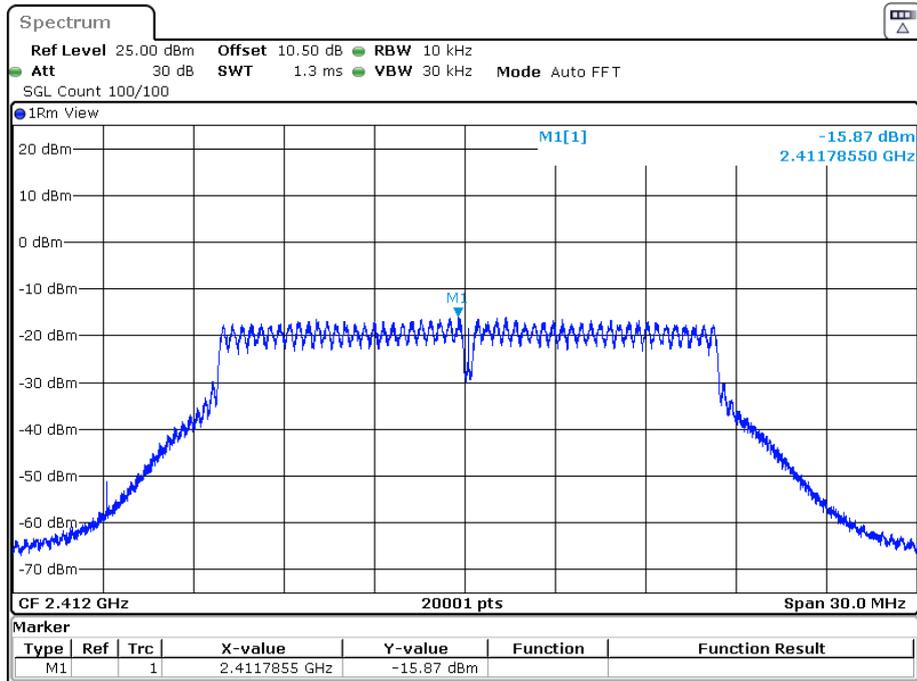
Date: 20.APR.2023 11:05:03

Power Spectral Density, Middle Channel
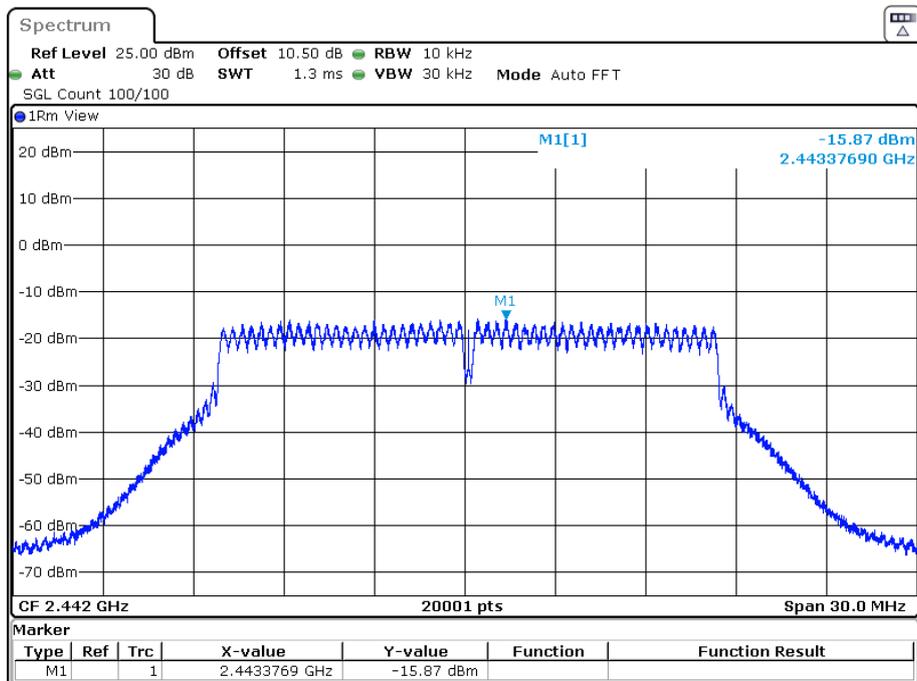
Date: 20.APR.2023 11:08:48

Power Spectral Density, High Channel
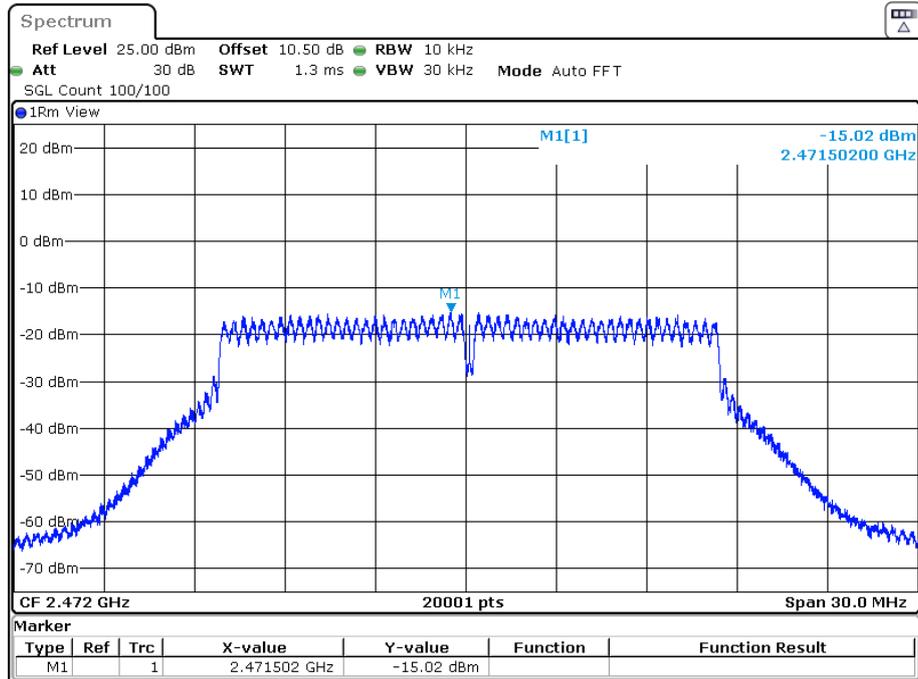
Date: 20.APR.2023 11:12:46

802.11n-20 mode：

Power Spectral Density, Low Channel

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.412693 GHz	-17.04 dBm		
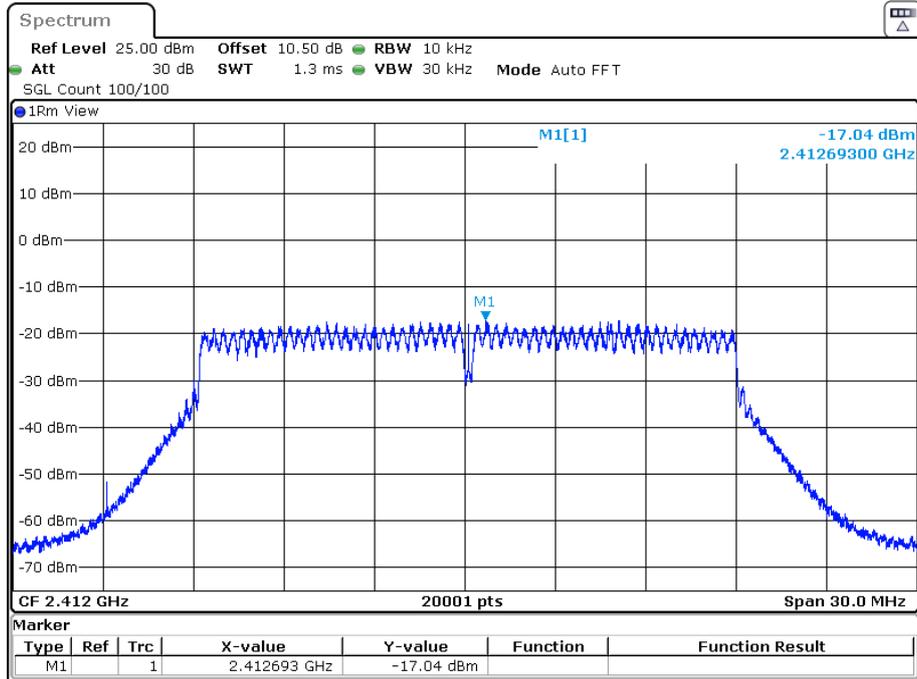
Date: 20.APR.2023 11:16:20

Power Spectral Density, Middle Channel

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.441484 GHz	-16.60 dBm		
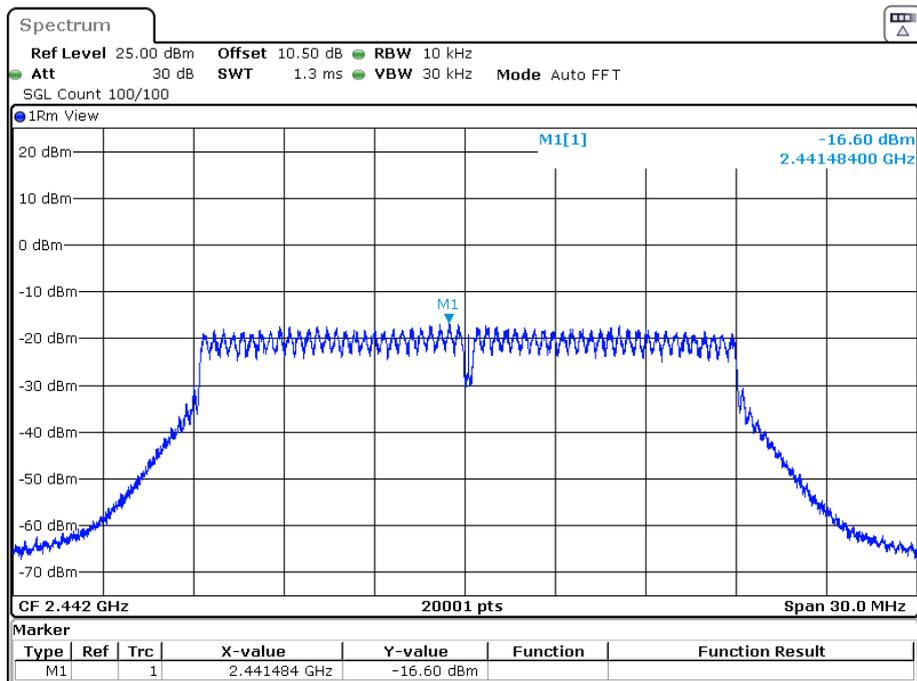
Date: 20.APR.2023 11:20:29

Power Spectral Density, High Channel
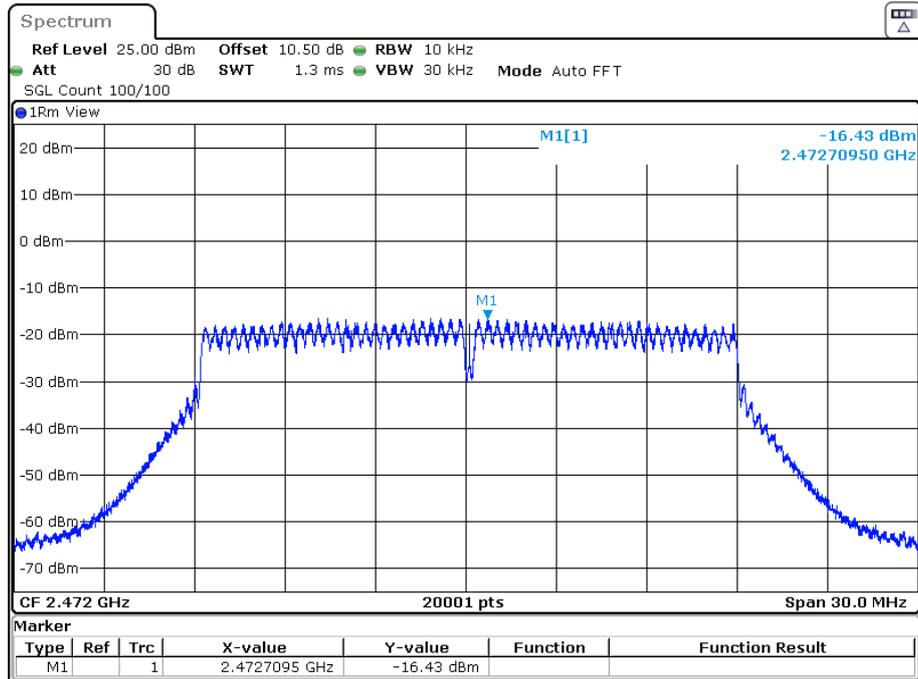
Date: 20.APR.2023   11:23:29

802.11n-40 mode：

## Power Spectral Density, Low Channel
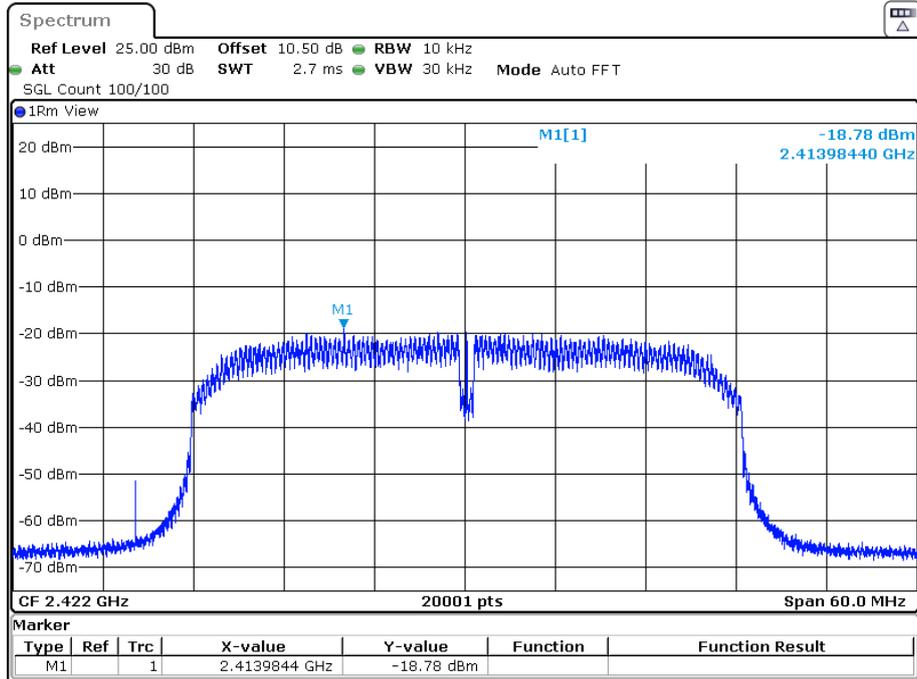
Date: 20.APR.2023 11:26:41

Power Spectral Density, Middle Channel
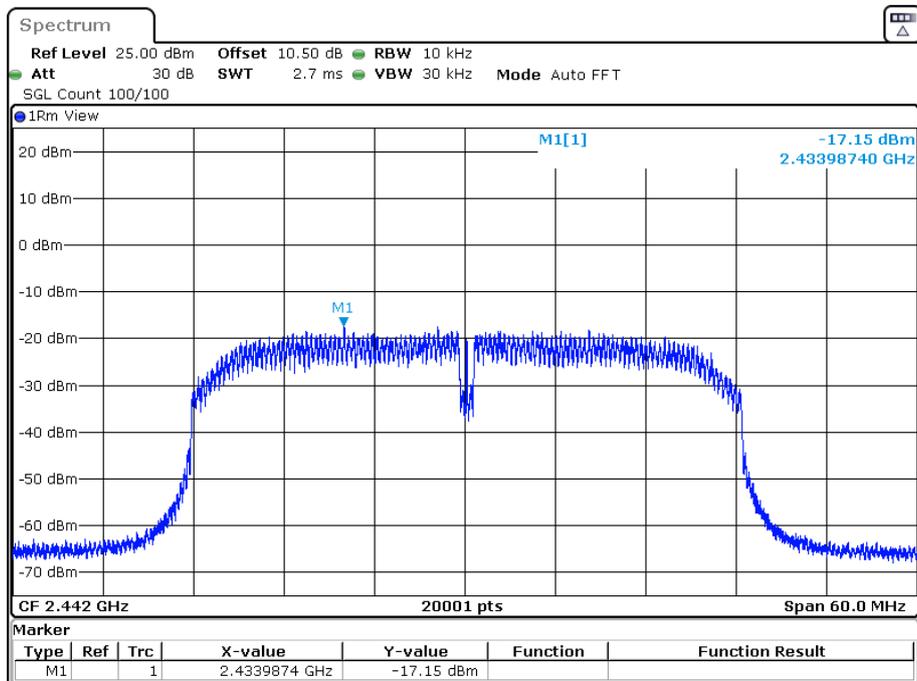
Date: 20.APR.2023 12:03:15

Power Spectral Density, High Channel
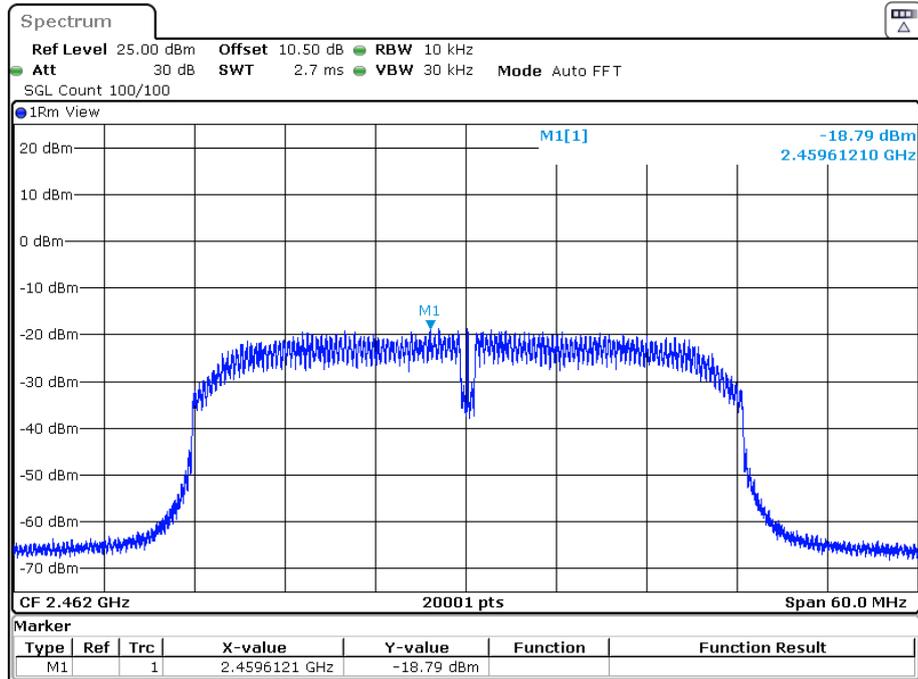
Date: 20.APR.2023 11:33:47

APPENDIX

Appendix A: DTS Bandwidth
Test Result

Test Mode	Antenna	Frequency[MHz]	DTS BW [MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	0.63	0.5	PASS
		2440	0.62	0.5	PASS
		2480	0.62	0.5	PASS
BLE_2M	Ant1	2402	1.09	0.5	PASS
		2440	1.09	0.5	PASS
		2480	1.09	0.5	PASS

Test Graphs

BLE_1M_Ant1_2402

Date: 9.MAY.2023 18:09:34

BLE_1M_Ant1_2440

Date: 9.MAY.2023 18:11:36

BLE_1M_Ant1_2480

Date: 9.MAY.2023 18:12:29

BLE_2M_Ant1_2402

Date: 9.MAY.2023 18:13:48

BLE_2M_Ant1_2440

Date: 9.MAY.2023 18:16:21

BLE_2M_Ant1_2480

Date: 9.MAY.2023 18:17:23
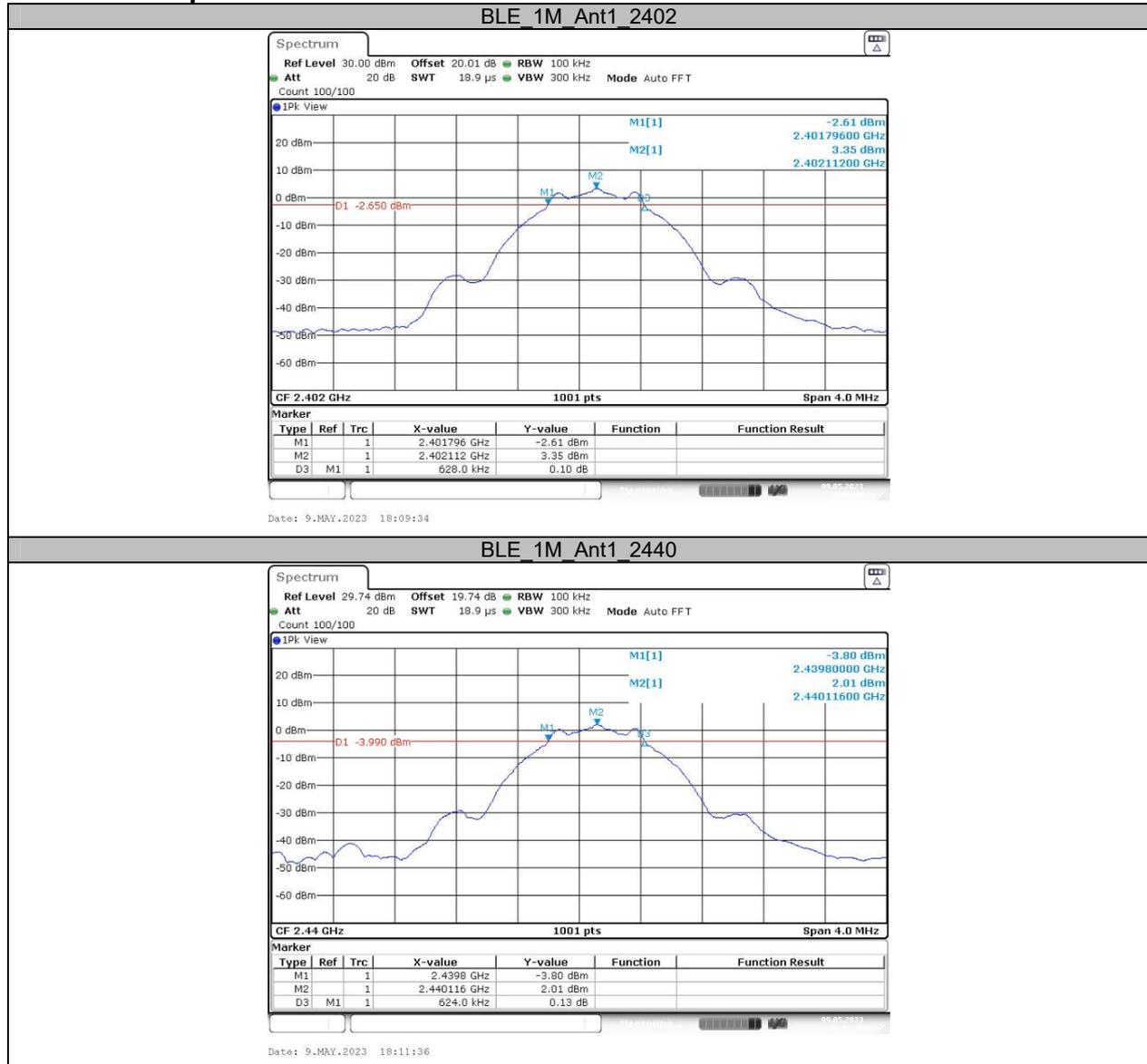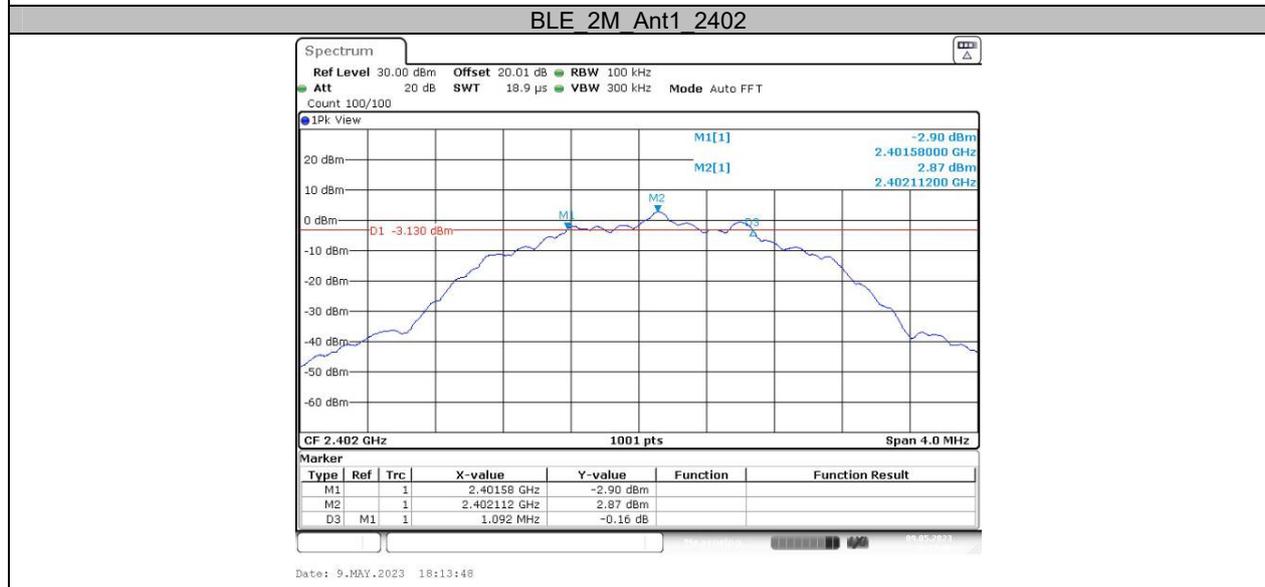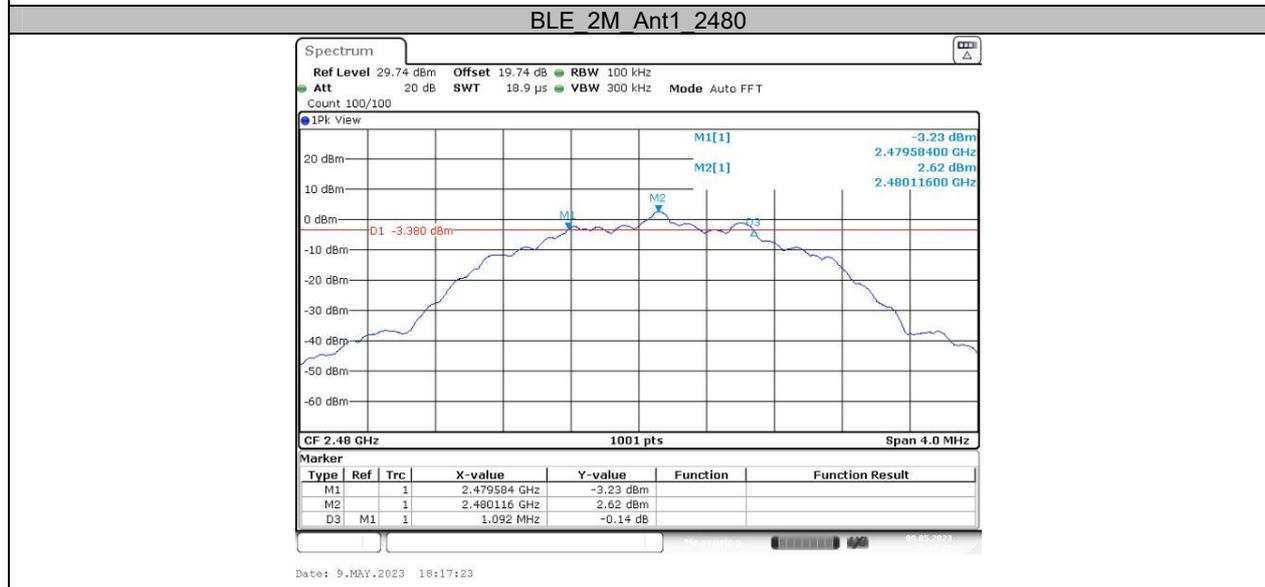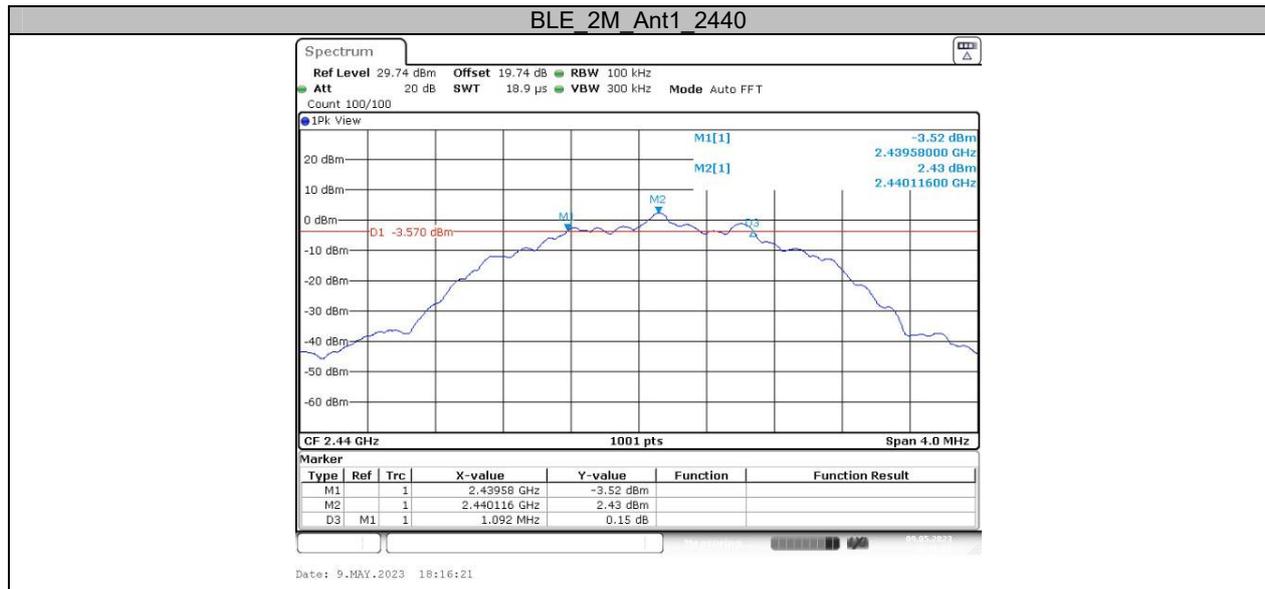
Appendix B: Occupied Channel Bandwidth
Test Result

Test Mode	Antenna	Frequency[MHz]	OCB [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	1.023	2401.604	2402.627	---	---
		2440	1.023	2439.604	2440.627	---	---
		2480	1.023	2479.608	2480.631	---	---
BLE_2M	Ant1	2402	2.022	2401.113	2403.135	---	---
		2440	2.018	2439.117	2441.135	---	---
		2480	2.022	2479.117	2481.139	---	---

Test Graphs

BLE_1M_Ant1_2402

Date: 9.MAY.2023 18:09:46

BLE_1M_Ant1_2440

Date: 9.MAY.2023 18:11:48

BLE_1M_Ant1_2480

Date: 9.MAY.2023 18:12:41

BLE_2M_Ant1_2402

Date: 9.MAY.2023 18:14:00

BLE_2M_Ant1_2440

Date: 9.MAY.2023 18:16:32

BLE_2M_Ant1_2480

Date: 9.MAY.2023 18:17:35
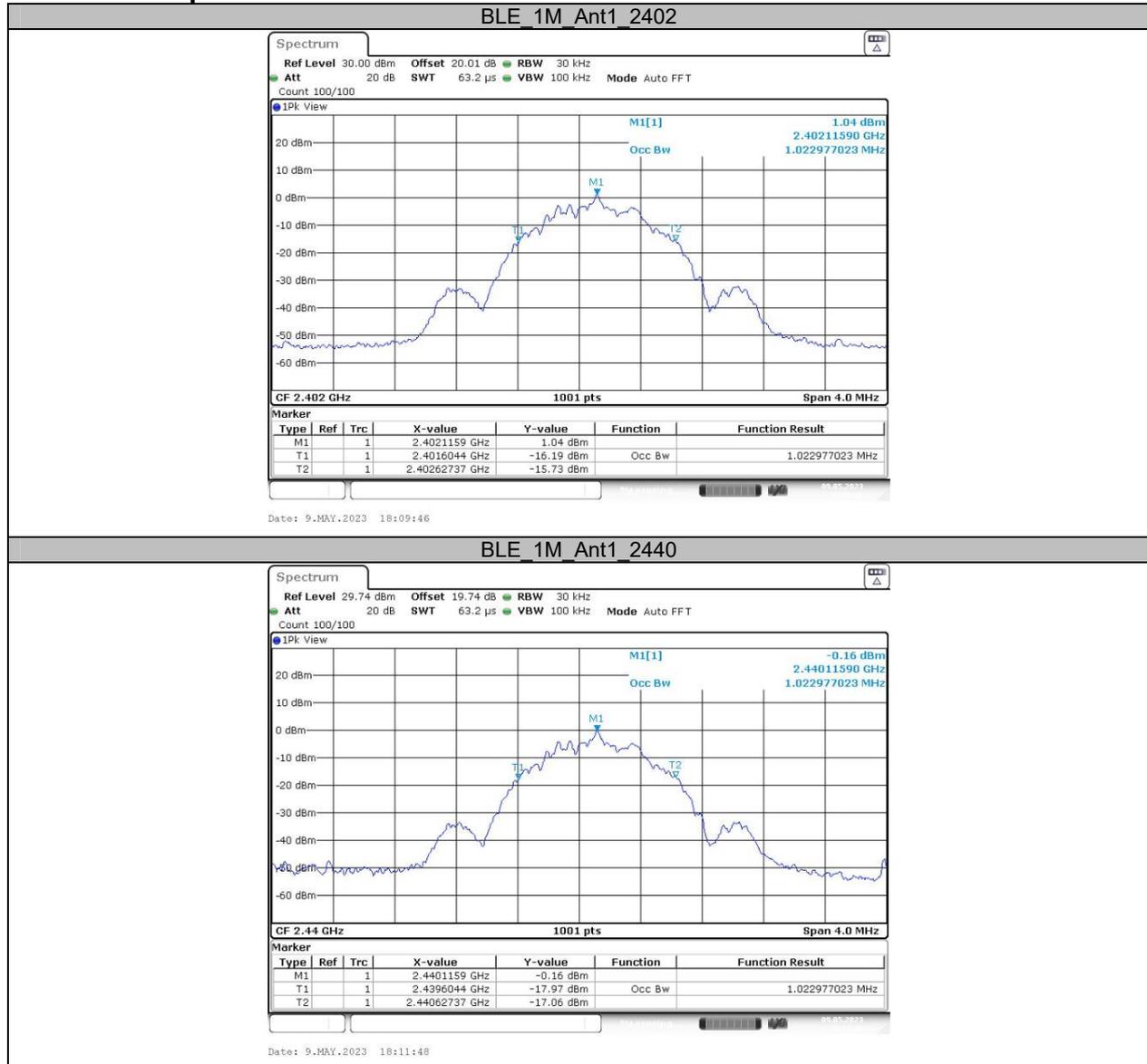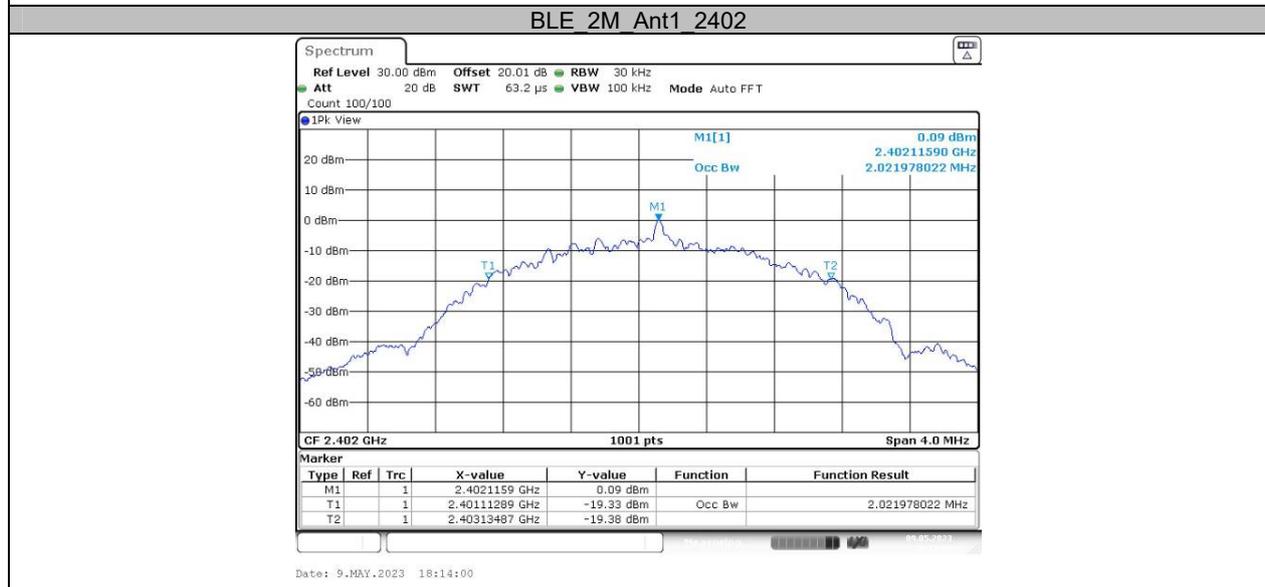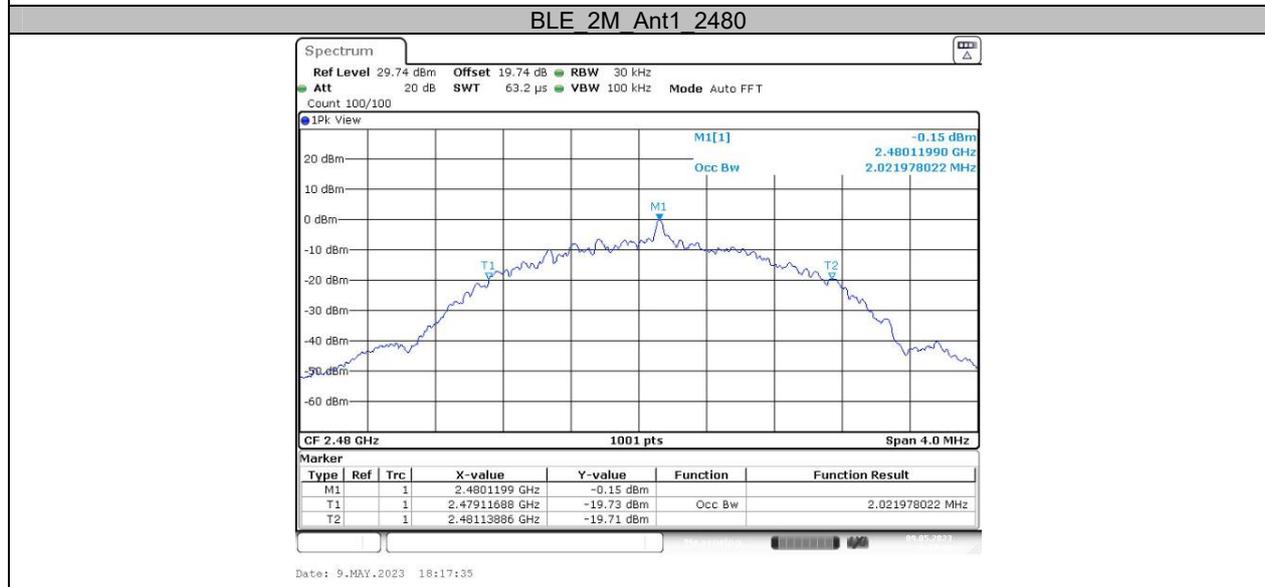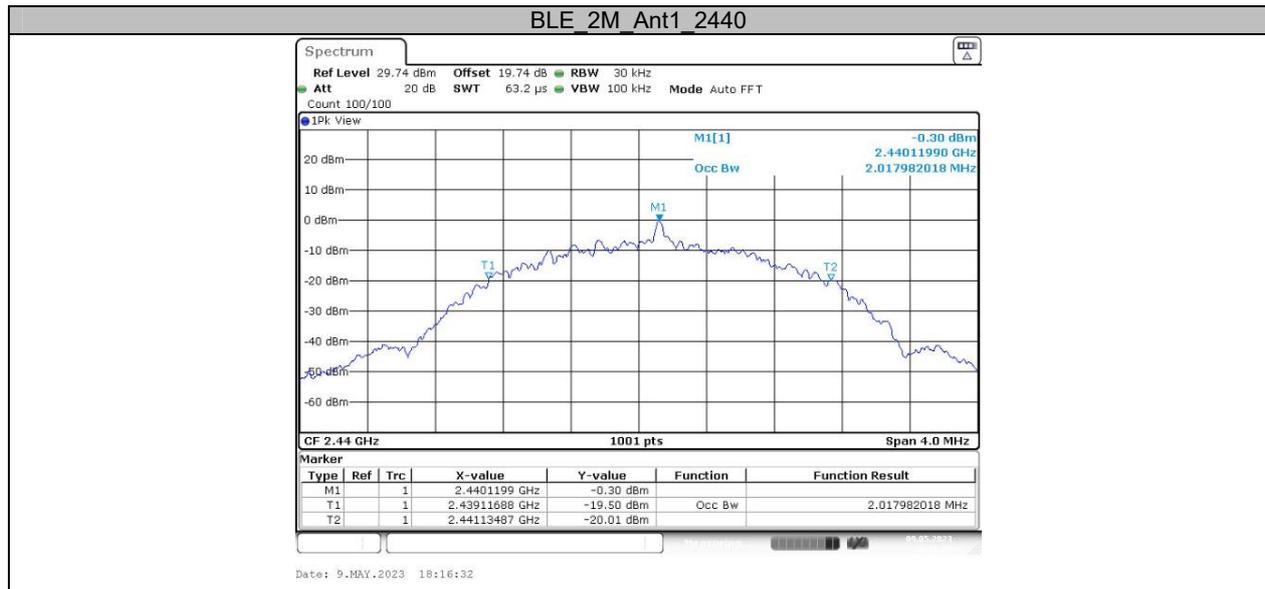
Appendix C: Maximum conducted output power
Test Result Peak

Test Mode	Antenna	Frequency[MHz]	Conducted Peak Powert[dBm]	Conducted Limit[dBm]	Verdict
BLE_1M	Ant1	2402	3.56	≤30	PASS
		2440	2.52	≤30	PASS
		2480	2.40	≤30	PASS
BLE_2M	Ant1	2402	2.93	≤30	PASS
		2440	2.52	≤30	PASS
		2480	2.73	≤30	PASS

Test Graphs Peak

BLE_1M_Ant1_2402

Date: 9.MAY.2023 18:09:53

BLE_1M_Ant1_2440

Date: 9.MAY.2023 18:10:54

BLE_1M_Ant1_2480

Spectrum

Ref Level 29.74 dBm   Offset 19.74 dB ● RBW   3 MHz
● Att   20 dB   SWT   1.3 µs ● VBW 10 MHz   Mode Auto FFT
Count 100/100

● 1Pk View

M1[1]   2.40 dBm
                         2.47965630 GHz

20 dBm

10 dBm

                    M1
0 dBm

-10 dBm

-20 dBm

-30 dBm

-40 dBm

-50 dBm

-60 dBm

CF 2.48 GHz   1001 pts   Span 8.0 MHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4796563 GHz	2.40 dBm		

Date: 9.MAY.2023 18:12:48

BLE_2M_Ant1_2402

Spectrum

Ref Level 30.00 dBm   Offset 20.01 dB ● RBW   3 MHz
● Att   20 dB   SWT   1.3 µs ● VBW 10 MHz   Mode Auto FFT
Count 100/100

● 1Pk View

M1[1]   2.93 dBm
                         2.40159240 GHz

20 dBm

10 dBm

                    M1
0 dBm

-10 dBm

-20 dBm

-30 dBm

-40 dBm

-50 dBm

-60 dBm

CF 2.402 GHz   1001 pts   Span 8.0 MHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4015924 GHz	2.93 dBm		

Date: 9.MAY.2023 18:15:29

BLE_2M_Ant1_2440

Spectrum

Ref Level 29.74 dBm   Offset 19.74 dB ● RBW   3 MHz
● Att   20 dB   SWT   1.3 μs ● VBW 10 MHz   Mode Auto FFT
Count 100/100

● 1Pk View

M1[1]   2.52 dBm
                                         2.44039960 GHz

M1

CF 2.44 GHz   1001 pts   Span 8.0 MHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4403996 GHz	2.52 dBm		

Date: 9.MAY.2023 18:16:40

BLE_2M_Ant1_2480

Spectrum

Ref Level 29.74 dBm   Offset 19.74 dB ● RBW   3 MHz
● Att   20 dB   SWT   1.3 μs ● VBW 10 MHz   Mode Auto FFT
Count 100/100

● 1Pk View

M1[1]   2.73 dBm
                                         2.48039960 GHz

M1

CF 2.48 GHz   1001 pts   Span 8.0 MHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4803996 GHz	2.73 dBm		

Date: 9.MAY.2023 18:17:42

Appendix D: Maximum power spectral density
Test Result

Test Mode	Antenna	Frequency[MHz]	Result[dBm/3kHz]	Limit[dBm/3kHz]	Verdict
BLE_1M	Ant1	2402	-11.62	≤8.00	PASS
		2440	-12.27	≤8.00	PASS
		2480	-11.36	≤8.00	PASS
BLE_2M	Ant1	2402	-14.26	≤8.00	PASS
		2440	-14.41	≤8.00	PASS
		2480	-14.14	≤8.00	PASS

Test Graphs

BLE_1M_Ant1_2402

Date: 9.MAY.2023 18:10:00

BLE_1M_Ant1_2440

Date: 9.MAY.2023 18:11:55

BLE_1M_Ant1_2480

Date: 9.MAY.2023 18:12:55

BLE_2M_Ant1_2402

Date: 9.MAY.2023 18:15:36

BLE_2M_Ant1_2440

Spectrum

Ref Level 29.74 dBm   Offset 19.74 dB   RBW   3 kHz
Att   20 dB   SWT   632.1 µs   VBW   10 kHz   Mode Auto FFT
Count 100/100

1Pk View

M1[1]   −14.41 dBm
                                                              2.44011110 GHz

M1

CF 2.44 GHz   1001 pts   Span 2.18 MHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4401111 GHz	−14.41 dBm		

Date: 9.MAY.2023 18:16:46

BLE_2M_Ant1_2480

Spectrum

Ref Level 29.74 dBm   Offset 19.74 dB   RBW   3 kHz
Att   20 dB   SWT   632.1 µs   VBW   10 kHz   Mode Auto FFT
Count 100/100

1Pk View

M1[1]   −14.14 dBm
                                                              2.48011540 GHz

M1

CF 2.48 GHz   1001 pts   Span 2.18 MHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4801154 GHz	−14.14 dBm		

Date: 9.MAY.2023 18:17:49

Appendix E: Band edge measurements
Test Graphs

BLE_1M_Ant1_Low_2402

Date: 9.MAY.2023 18:10:10

BLE_1M_Ant1_High_2480

Date: 9.MAY.2023 18:13:05

BLE_2M_Ant1_Low_2402

Spectrum

Ref Level 30.00 dBm   Offset 20.01 dB ● RBW 100 kHz
● Att   20 dB   SWT   75.8 µs ● VBW 300 kHz   Mode Auto FFT
Count 300/300

● 1Pk View

M1[1]   2.14 dBm
                                2.4020950 GHz
M2[1]   -47.32 dBm
                                2.4000000 GHz

D1 -17.860 dBm

Start 2.35 GHz   691 pts   Stop 2.405 GHz

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.402095 GHz	2.14 dBm		
M2		1	2.4 GHz	-47.32 dBm		
M3		1	2.39 GHz	-49.28 dBm		
M4		1	2.3786159 GHz	-46.92 dBm		

Date: 9.MAY.2023 18:14:24

BLE_2M_Ant1_High_2480

Spectrum

Ref Level 29.74 dBm   Offset 19.74 dB ● RBW 100 kHz
● Att   20 dB   SWT   94.8 µs ● VBW 300 kHz   Mode Auto FFT
Count 300/300

● 1Pk View

M1[1]   2.61 dBm
                                2.480130 GHz
M2[1]   -50.22 dBm
                                2.483500 GHz

D1 -17.390 dBm

Start 2.47 GHz   691 pts   Stop 2.55 GHz

Marker

| Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.48013 GHz	2.61 dBm		
M2		1	2.4835 GHz	-50.22 dBm		
M3		1	2.5 GHz	-49.61 dBm		
M4		1	2.503855 GHz	-46.50 dBm		

Date: 9.MAY.2023 18:17:58

Appendix F: Duty Cycle
Test Result

Test Mode	Antenna	Frequency[MHz]	ON Time [ms]	Period [ms]	Duty Cycle [%]	Duty Cycle Factor[dB]
BLE_1M	Ant1	2440	2.10	2.51	83.67	0.77
BLE_2M	Ant1	2440	1.06	1.87	56.68	2.47

Test Graphs

BLE_1M_Ant1_2440

Date: 9.MAY.2023 18:11:26

BLE_2M_Ant1_2440

Date: 9.MAY.2023 18:16:10

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