FCC PART 15.247

TEST REPORT

For

Vuzix Corporation

25 Hendrix Rd, West Henrietta, New York, United States 14586

FCC ID: 2AA9D-490

Report Type:	Product Type:
Original Report	M4000

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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	M4000
Tested Model	490
Frequency Range	BLE: 2402-2480MHz Wi-Fi: 2412-2462MHz/2422-2452MHz
Maximum Conducted Peak Output Power	BLE: 6.76Bm(LE 1M), 6.92dBm(LE 2M) Wi-Fi: 20.51dBm(802.11b), 23.81dBm(802.11g), 23.61dBm(802.11n-HT20), 22.82dBm(802.11n-HT40)
Modulation Technique	BLE: GFSK Wi-Fi: DSSS, OFDM
Antenna Specification	-4.1 dBi
Voltage Range	DC 3.7V from battery
Date of Test	2020-05-14 to 2020-07-30
Sample serial number	RSZ200511004-RF-S1 (Assigned by BACL, Shenzhen)
Received date	2020-05-11
Sample/EUT Status	Good condition

Objective

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

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

Related Submittal(s)/Grant(s)

FCC Part 15.247 DSS, Part 15.407 NII submissions with FCC ID: 2AA9D-490.

Test Methodology

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

And KDB 558074 D01 15.247 Meas Guidance v05r02.

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

Measurement Uncertainty

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

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

Test Facility

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

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

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

SYSTEM TEST CONFIGURATION

Description of Test Configuration

For 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 mode, EUT was tested with Channel 1, 6 and 11

For 802.11n-HT40 mode, 7 channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2422	6	2447
2	2427	7	2452
3	2432	/	/
4	2437	/	/
5	2442	/	/

EUT was tested with Channel 1, 4 and 7.

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.exe” 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	18	18	18
802.11g	6 Mbps	16.5	16.5	16.5
802.11n-HT20	MCS0	16.5	16.5	16.5
802.11n-HT40	MCS0	16	16	16
BLE	/	Default	Default	Default

Pre-scan with all the data rates, the above data rate is the worst case for Wi-Fi test.

Duty cycle

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

Support Equipment List and Details

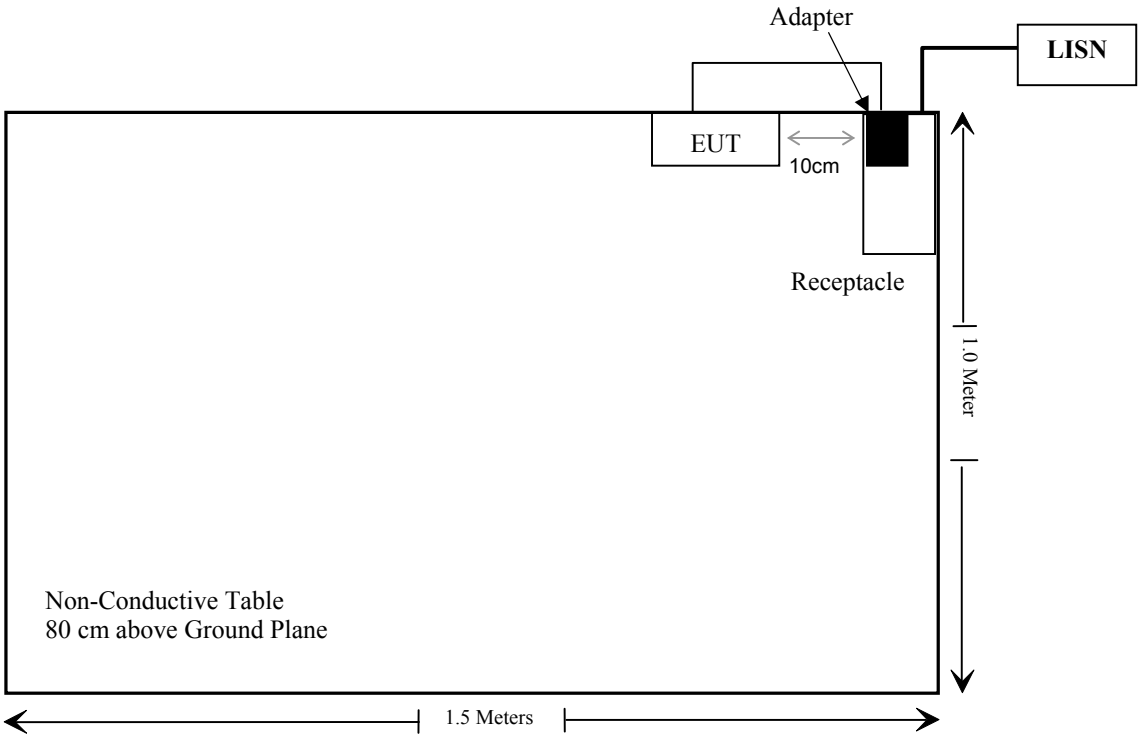
Manufacturer	Description	Model	Serial Number
Dongguan Aohai Power Technology Co.,Ltd.	Adapter	A8-501000	A1906034835

External I/O Cable

Cable Description	Length (m)	From Port	To
Un-shielding Detachable USB Cable	1.0	EUT	Adapter

Block Diagram of Test Setup

For conducted emission:



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (i), §1.1307 (b) (1)& §2.1093	RF Exposure	Compliance
§15.203	Antenna Requirement	Compliance
§15.207 (a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209, §15.247(d)	Spurious Emissions	Compliance
§15.247 (a)(2)	6 dB Emission Bandwidth	Compliance
§15.247(b)(3)	Maximum Conducted Output Power	Compliance
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliance
§15.247(e)	Power Spectral Density	Compliance

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Emissions Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	101120	2020/7/9	2021/7/8
Rohde & Schwarz	LISN	ENV216	101613	2020/1/22	2021/1/21
Rohde & Schwarz	Transient Limitor	ESH3Z2	DE25985	2019/11/29	2020/11/28
Unknow	CE Cable	CE Cable	UF A210B-1-0720-504504	2019/11/29	2020/11/28
Rohde & Schwarz	CE Test software	EMC 32	V8.53.0	NCR	NCR
Radiated Emission Test					
R&S	EMI Test Receiver	ESR3	102455	2020/7/9	2021/7/8
Sonoma instrument	Pre-amplifier	310 N	186238	2020/4/20	2021/4/20
Sunol Sciences	Broadband Antenna	JB1	A040904-1	2017/12/22	2020/12/21
Unknow	Cable 2	RF Cable 2	F-03-EM197	2019/11/29	2020/11/28
Unknow	Cable	Chamber Cable 1	F-03-EM236	2019/11/29	2020/11/28
Rohde & Schwarz	Auto test software	EMC 32	V9.10	NCR	NCR
Rohde & Schwarz	Spectrum Analyzer	FSV40-N	102259	2019/7/22	2020/7/21
COM-POWER	Pre-amplifier	PA-122	181919	2019/11/29	2020/11/28
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2019/11/29	2020/11/28
Sunol Sciences	Horn Antenna	DRH-118	A052604	2017/12/22	2020/12/21
Insulted Wire Inc.	RF Cable	SPS-2503-3150	02222010	2019/11/29	2020/11/28
Unknow	RF Cable	W1101-EQ1 OUT	F-19-EM005	2019/11/29	2020/11/28
SNSD	Band Reject filter	BSF2402-2480MN-0898-001	2.4G filter	2020/4/20	2021/4/20
Ducommun Technolagies	Horn antenna	ARH-4223-02	1007726-02 1304	2017/12/6	2020/12/5
RF Conducted Test					
Tonscend Corporation	RF control Unit	JS0806-2	19D8060154	2019/7/10	2020/7/9
Rohde & Schwarz	Signal and Spectrum Analyzer	FSV40	101473	2019/7/22	2020/7/21
Unknow	RF Cable	Unknow	2301 276	2019/11/29	2020/11/28

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

FCC§15.247 (i), §1.1307 (b) (1) &§2.1093 – RF EXPOSURE

Applicable Standard

According to FCC §2.1093 and §1.1307(b) (1), systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

According to KDB 447498 D01 General RF Exposure Guidance

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:
[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where
1. f(GHz) is the RF channel transmit frequency in GHz.
2. Power and distance are rounded to the nearest mW and mm before calculation.
3. The result is rounded to one decimal place for comparison.
4. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test Exclusion.

For worst case:

For BLE mode:

Frequency (MHz)	Maximum Tune-up power		Calculated Distance (mm)	Calculated Value	Threshold (1-g SAR)	SAR Test Exclusion
	(dBm)	(mW)				
2480	7	5	5	1.6	3.0	**Yes**

For WIFI mode:

Please refer to SAR test report: RSZ200511004-20B.

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 integral antenna arrangement for BLE and Wi-Fi. The antenna gain is -4.1dBi, fulfill the requirement of this section. Please refer to the EUT photos.

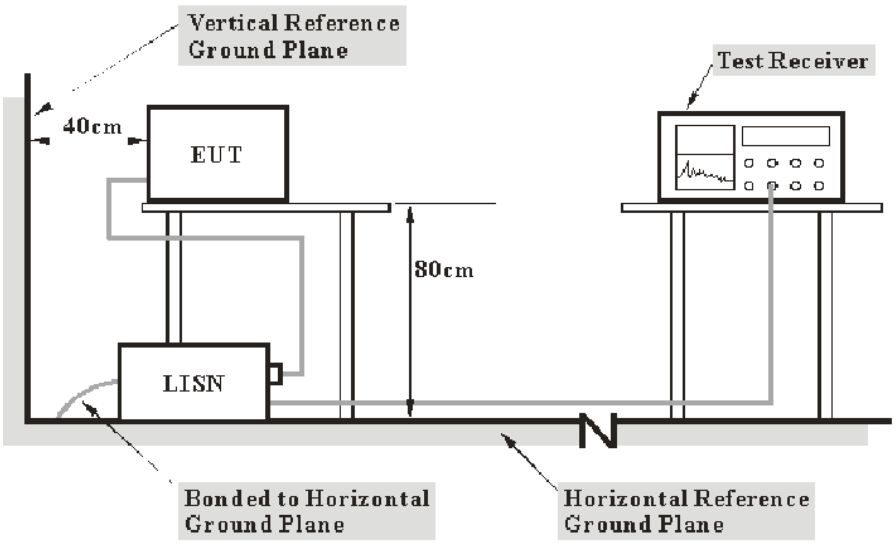
Result: Compliance.

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:

Correction Factor = LISN VDF + Cable Loss + 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:

Margin = Limit – Corrected Amplitude

Test Data

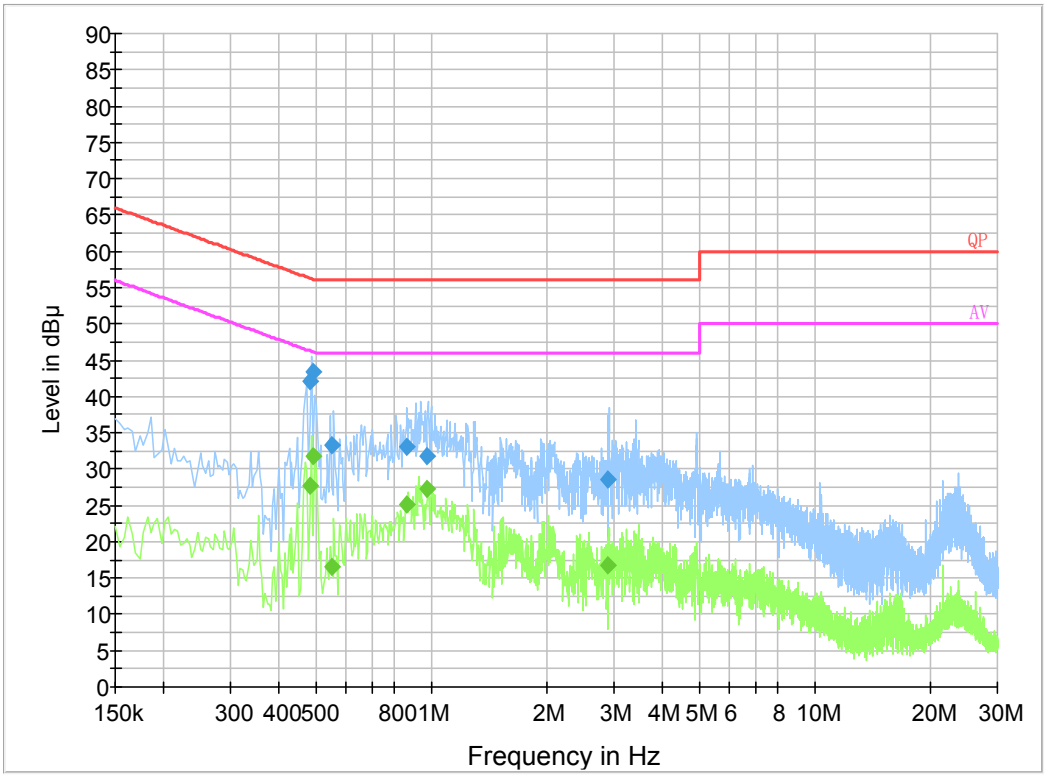
Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	65 %
ATM Pressure:	101.0 kPa

The testing was performed by Haiguo Li on 2020-07-29.

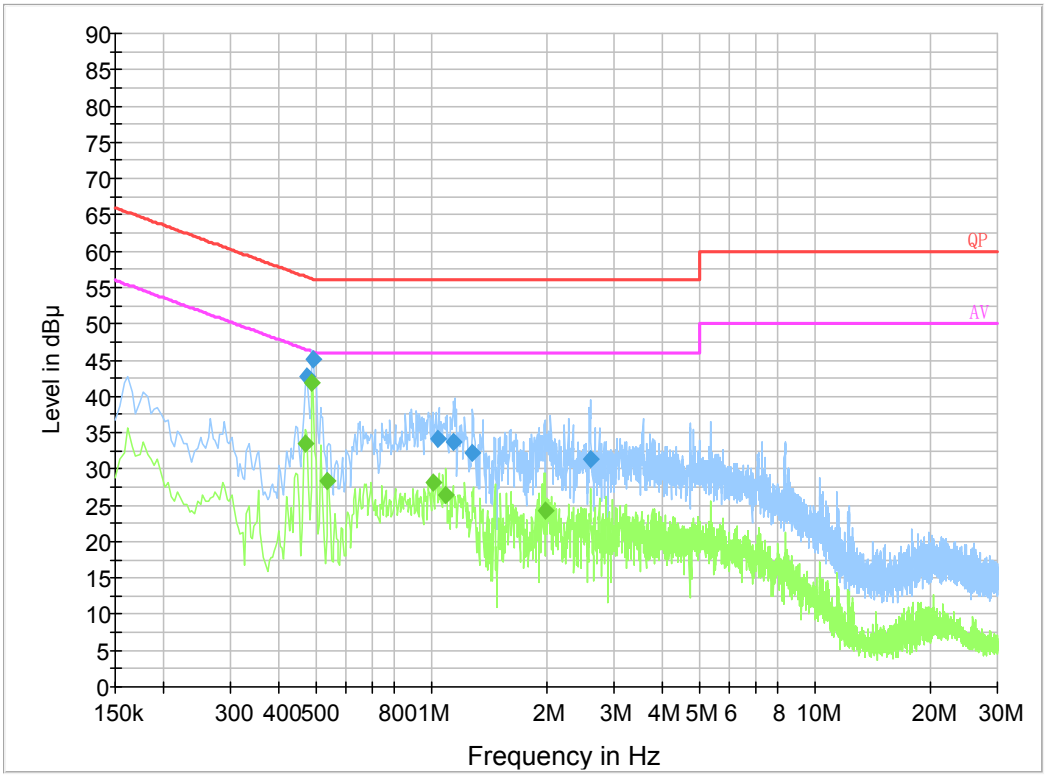
EUT operation mode: Transmitting (worst case at 802.11g mode, high channel)

AC 120V/60 Hz, Line



Frequency (MHz)	Corrected Amplitude (dBµV)	Correction Factor (dB)	Limit (dBµV)	Margin (dB)	Detector (PK/Ave./QP)
0.481110	42.0	19.8	56.3	14.3	QP
0.490650	43.4	19.8	56.2	12.8	QP
0.549630	33.2	19.8	56.0	22.8	QP
0.861010	33.1	19.8	56.0	22.9	QP
0.975270	31.9	19.9	56.0	24.1	QP
2.882290	28.7	19.9	56.0	27.3	QP
0.481110	27.8	19.8	46.3	18.5	Ave.
0.490650	31.9	19.8	46.2	14.3	Ave.
0.549630	16.6	19.8	46.0	29.4	Ave.
0.861010	25.2	19.8	46.0	20.8	Ave.
0.975270	27.2	19.9	46.0	18.8	Ave.
2.882290	16.7	19.9	46.0	29.3	Ave.

AC 120V/60 Hz, Neutral



Frequency (MHz)	Corrected Amplitude (dBµV)	Correction Factor (dB)	Limit (dBµV)	Margin (dB)	Detector (PK/Ave./QP)
0.474890	42.8	19.8	56.4	13.6	QP
0.490650	45.2	19.8	56.2	11.0	QP
1.046250	34.1	19.8	56.0	21.9	QP
1.148690	33.6	19.8	56.0	22.4	QP
1.278770	32.2	19.8	56.0	23.8	QP
2.594850	31.4	19.8	56.0	24.6	QP
0.470000	33.5	19.8	46.5	13.0	Ave.
0.490000	41.8	19.8	46.2	4.4	Ave.
0.538000	28.4	19.8	46.0	17.6	Ave.
1.010000	28.1	19.8	46.0	17.9	Ave.
1.094000	26.3	19.8	46.0	19.7	Ave.
1.978000	24.2	19.9	46.0	21.8	Ave.

Note:

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

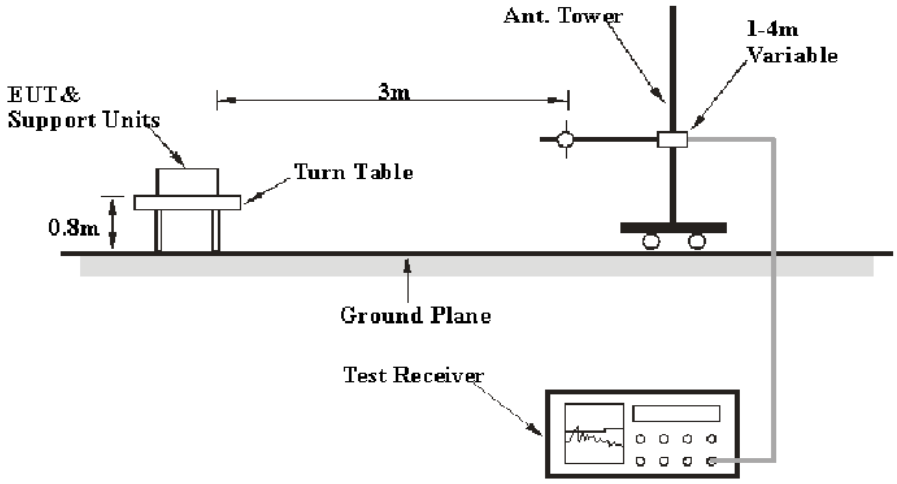
FCC §15.209, §15.205 & §15.247(d) - SPURIOUS EMISSIONS

Applicable Standard

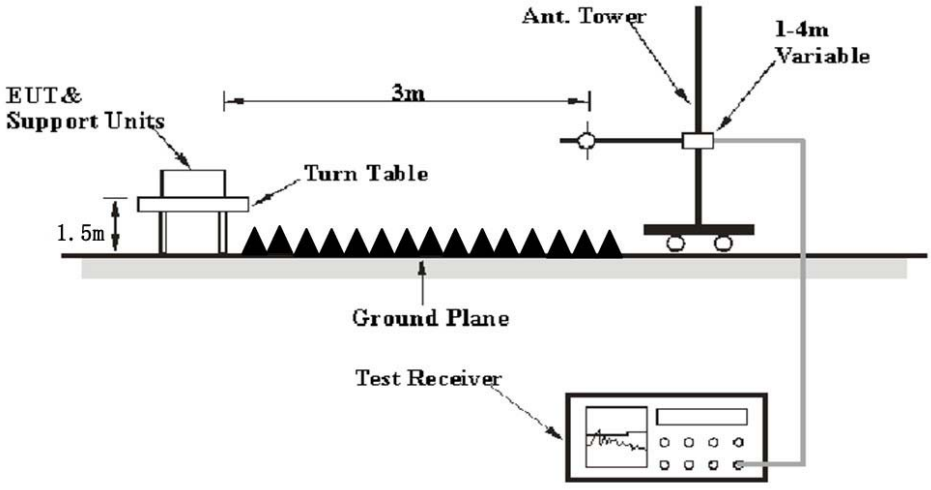
FCC §15.247 (d); §15.209; §15.205;

EUT Setup

Below 1 GHz:



Above 1GHz:



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

EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 25 GHz.

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

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

Note 1: when duty cycle is no less than 98%
Note 2: when duty cycle is less than 98%

Test Procedure

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

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

Corrected Amplitude & Margin Calculation

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

Corrected Amplitude = Meter Reading + Antenna Factor + Cable Loss - Amplifier Gain

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

Margin = Limit – Corrected Amplitude

Test Data

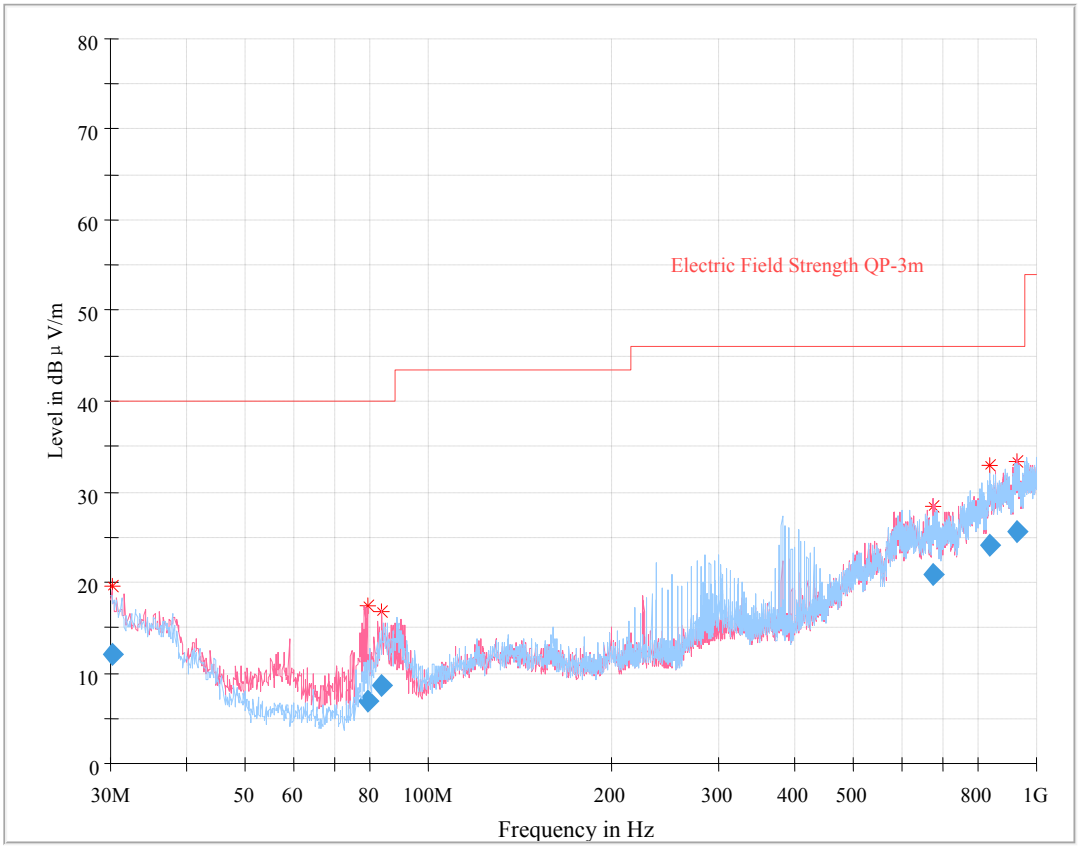
Environmental Conditions

Temperature:	25~26 ℃
Relative Humidity:	52~60 %
ATM Pressure:	101.0 kPa

The testing was performed by Charlie Cha on 2020-07-30 for below 1GHz and by Leven Gan on 2020-05-20 for above 1GHz.

EUT operation mode: Transmitting

30 MHz~1 GHz: *(worst case at 802.11g mode, high channel)*



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna height (cm)	Antenna Polarity	Turntable position (degree)	Correction Factor (dB/m)	Limit (dBµV/m)	Margin (dB)
30.281815	12.11	327.0	V	252.0	-7.8	40.00	27.89
79.545000	6.96	122.0	V	243.0	-20.0	40.00	33.04
83.971500	8.61	117.0	V	247.0	-19.6	40.00	31.39
677.122000	20.87	110.0	V	349.0	-1.4	46.00	25.13
838.300250	24.09	196.0	H	220.0	2.8	46.00	21.91
928.069250	25.61	360.0	V	132.0	4.7	46.00	20.39

1 GHz-25 GHz (Wi-Fi):

802.11b Mode:

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)									
2388.74	28.10	PK	333	1.9	H	31.87	59.97	74	14.03
2388.74	13.55	Ave.	333	1.9	H	31.87	45.42	54	8.58
2484.21	27.87	PK	3	1.4	H	32.13	60.00	74	14.00
2484.21	13.53	Ave.	3	1.4	H	32.13	45.66	54	8.34
4824.00	43.02	PK	146	2.3	H	6.28	49.30	74	24.70
4824.00	30.21	Ave.	146	2.3	H	6.28	36.49	54	17.51
Middle Channel (2437MHz)									
4874.00	43.71	PK	201	1.7	H	6.76	50.47	74	23.53
4874.00	30.82	Ave.	201	1.7	H	6.76	37.58	54	16.42
High Channel (2462 MHz)									
2389.47	27.97	PK	319	1.9	H	31.87	59.84	74	14.16
2389.47	13.68	Ave.	319	1.9	H	31.87	45.55	54	8.45
2483.95	28.69	PK	151	1.6	H	32.13	60.82	74	13.18
2483.95	14.12	Ave.	151	1.6	H	32.13	46.25	54	7.75
4924.00	43.53	PK	75	1.5	H	6.76	50.29	74	23.71
4924.00	29.67	Ave.	75	1.5	H	6.76	36.43	54	17.57

802.11g Mode:

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)									
2388.68	28.17	PK	0	1.5	H	31.87	60.04	74	13.96
2388.68	13.74	Ave.	0	1.5	H	31.87	45.61	54	8.39
2484.17	28.46	PK	106	1.3	H	32.13	60.59	74	13.41
2484.17	13.77	Ave.	106	1.3	H	32.13	45.90	54	8.10
4824.00	43.45	PK	357	2.2	H	6.28	49.73	74	24.27
4824.00	28.04	Ave.	357	2.2	H	6.28	34.32	54	19.68
Middle Channel (2437MHz)									
4874.00	43.59	PK	32	2.5	H	6.76	50.35	74	23.65
4874.00	28.56	Ave.	32	2.5	H	6.76	35.32	54	18.68
High Channel (2462 MHz)									
2387.68	27.73	PK	262	2.0	H	31.87	59.60	74	14.40
2387.68	13.62	Ave.	262	2.0	H	31.87	45.49	54	8.51
2484.55	27.81	PK	185	1.7	H	32.13	59.94	74	14.06
2484.55	13.60	Ave.	185	1.7	H	32.13	45.73	54	8.27
4924.00	43.45	PK	134	1.5	H	6.76	50.21	74	23.79
4924.00	28.77	Ave.	134	1.5	H	6.76	35.53	54	18.47

802.11n-HT20 Mode:

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)									
2388.98	28.11	PK	319	2.3	H	31.87	59.98	74	14.02
2388.98	13.74	Ave.	319	2.3	H	31.87	45.61	54	8.39
2484.62	28.24	PK	1	1.4	H	32.13	60.37	74	13.63
2484.62	13.78	Ave.	1	1.4	H	32.13	45.91	54	8.09
4824.00	43.85	PK	32	1.5	H	6.28	50.13	74	23.87
4824.00	29.06	Ave.	32	1.5	H	6.28	35.34	54	18.66
Middle Channel (2437MHz)									
4874.00	43.29	PK	266	1.5	H	6.76	50.05	74	23.95
4874.00	29.56	Ave.	266	1.5	H	6.76	36.32	54	17.68
High Channel (2462 MHz)									
2389.62	27.92	PK	311	1.8	H	31.87	59.79	74	14.21
2389.62	13.71	Ave.	311	1.8	H	31.87	45.58	54	8.42
2484.09	31.38	PK	12	2.4	H	32.13	63.51	74	10.49
2484.09	15.68	Ave.	12	2.4	H	32.13	47.81	54	6.19
4924.00	43.51	PK	176	2.0	H	6.76	50.27	74	23.73
4924.00	29.51	Ave.	176	2.0	H	6.76	36.27	54	17.73

802.11n-HT40 Mode:

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)									
2388.67	31.59	PK	49	1.7	H	31.87	63.46	74	10.54
2388.67	17.19	Ave.	49	1.7	H	31.87	49.06	54	4.94
2484.73	27.78	PK	224	1.5	V	32.13	59.91	74	14.09
2484.73	13.57	Ave.	224	1.5	V	32.13	45.70	54	8.30
4844.00	43.79	PK	182	2.2	H	6.28	50.07	74	23.93
4844.00	28.93	Ave.	182	2.2	H	6.28	35.21	54	18.79
Middle Channel (2437MHz)									
4874.00	43.24	PK	240	1.8	H	6.76	50.00	74	24.00
4874.00	29.07	Ave.	240	1.8	H	6.76	35.83	54	18.17
High Channel (2452 MHz)									
2388.47	28.21	PK	253	1.8	H	31.87	60.08	74	13.92
2388.47	13.72	Ave.	253	1.8	H	31.87	45.59	54	8.41
2483.89	32.31	PK	242	1.6	H	32.13	64.44	74	9.56
2483.89	17.32	Ave.	242	1.6	H	32.13	49.45	54	4.55
4904.00	42.29	PK	239	1.2	H	6.76	49.05	74	24.95
4904.00	29.27	Ave.	239	1.2	H	6.76	36.03	54	17.97

1 GHz-25 GHz (LE 1M):

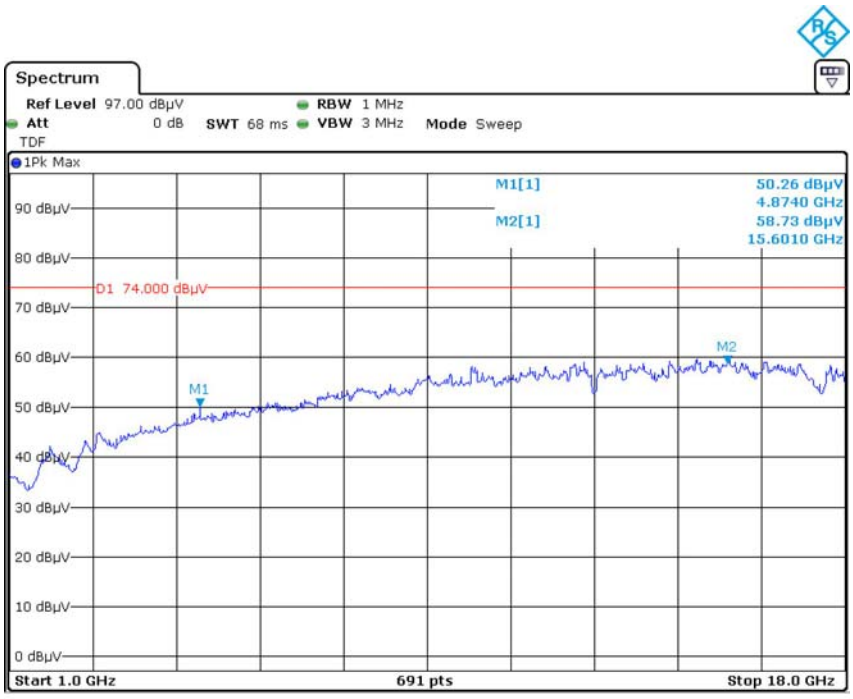
Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBµV/m)	Limit (dBµV/m)	Margin (dB)
	Reading (dBµV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2388.63	27.64	PK	86	1.2	H	31.87	59.51	74	14.49
2388.63	13.57	Ave.	86	1.2	H	31.87	45.44	54	8.56
2484.51	27.59	PK	116	2.5	H	32.13	59.72	74	14.28
2484.51	13.56	Ave.	116	2.5	H	32.13	45.69	54	8.31
4804.00	42.78	PK	151	2.3	H	6.28	49.06	74	24.94
4804.00	28.34	Ave.	151	2.3	H	6.28	34.62	54	19.38
Middle Channel (2440 MHz)									
4880.00	43.90	PK	260	1.8	H	6.21	50.11	74	23.89
4880.00	29.04	Ave.	260	1.8	H	6.21	35.25	54	18.75
High Channel (2480 MHz)									
2387.90	27.77	PK	177	2.4	H	31.87	59.64	74	14.36
2387.90	13.61	Ave.	177	2.4	H	31.87	45.48	54	8.52
2485.54	27.64	PK	121	1.6	H	32.13	59.77	74	14.23
2485.54	13.57	Ave.	121	1.6	H	32.13	45.70	54	8.30
4960.00	43.30	PK	10	1.6	H	6.80	50.10	74	23.90
4960.00	28.27	Ave.	10	1.6	H	6.80	35.07	54	18.93

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)									
2388.39	27.82	PK	139	1.4	H	31.87	59.69	74	14.31
2388.39	13.66	Ave.	139	1.4	H	31.87	45.53	54	8.47
2484.52	27.74	PK	123	1.8	H	32.13	59.87	74	14.13
2484.52	13.62	Ave.	123	1.8	H	32.13	45.75	54	8.25
4804.00	42.78	PK	151	2.3	H	6.28	49.06	74	24.94
4804.00	28.34	Ave.	151	2.3	H	6.28	34.62	54	19.38
Middle Channel (2440 MHz)									
4880.00	42.87	PK	229	1.1	H	6.76	49.63	74	24.37
4880.00	27.92	Ave.	229	1.1	H	6.76	34.68	54	19.32
High Channel (2480 MHz)									
2389.64	27.81	PK	227	1.9	H	31.87	59.68	74	14.32
2389.64	13.69	Ave.	227	1.9	H	31.87	45.56	54	8.44
2484.55	27.72	PK	143	2.2	H	32.13	59.85	74	14.15
2484.55	13.67	Ave.	143	2.2	H	32.13	45.80	54	8.20
4960.00	43.01	PK	74	1.0	H	6.80	49.81	74	24.19
4960.00	28.12	Ave.	74	1.0	H	6.80	34.92	54	19.08

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 Wi-Fi middle channel in 802.11b mode
Horizontal



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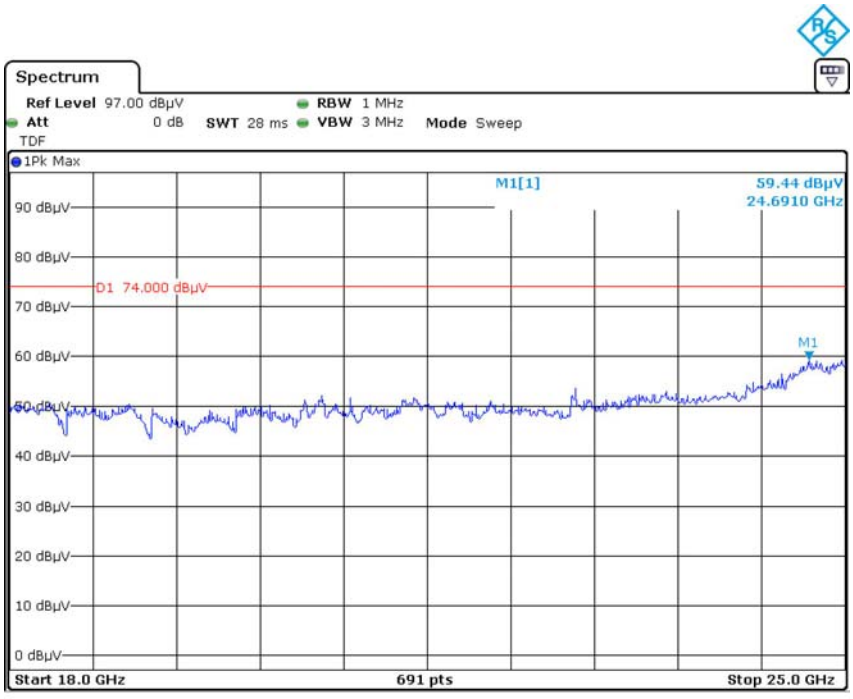
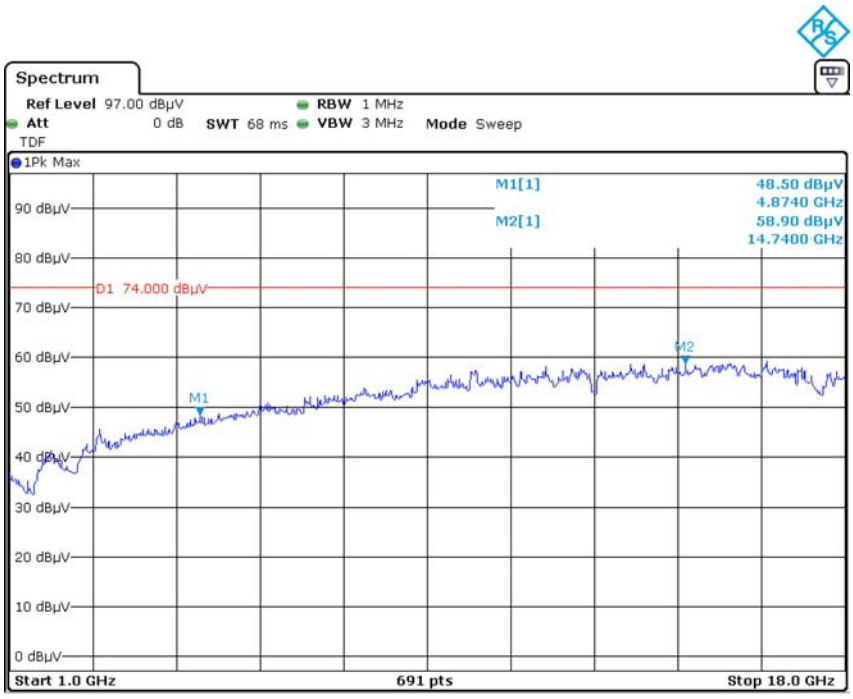


Date: 20.MAY.2020 20:24:35

Vertical



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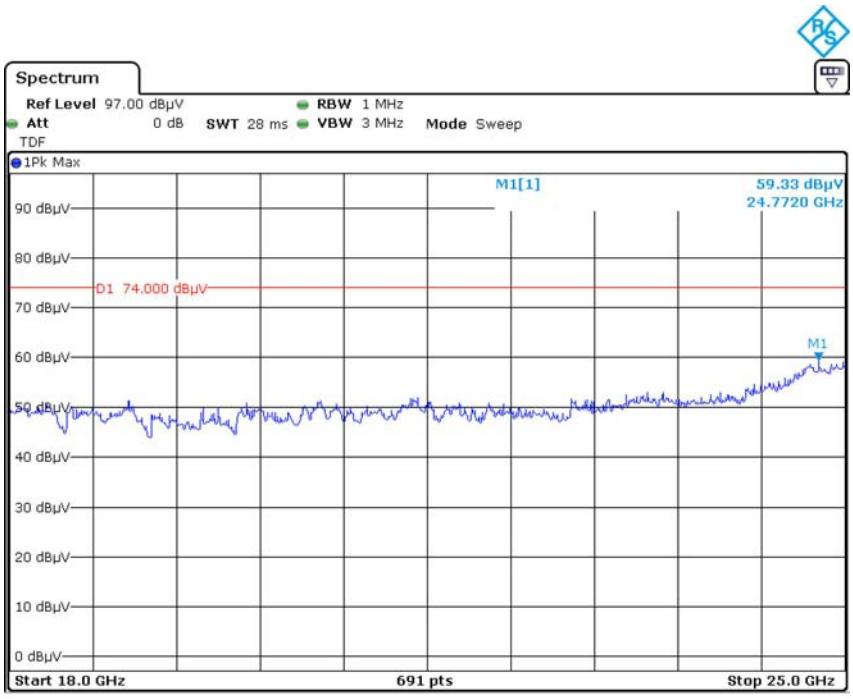

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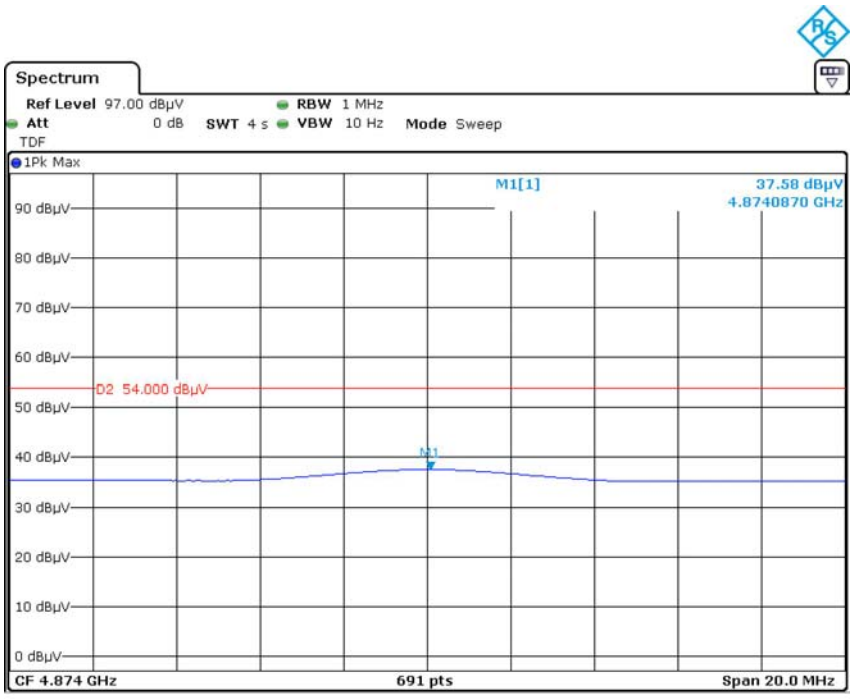
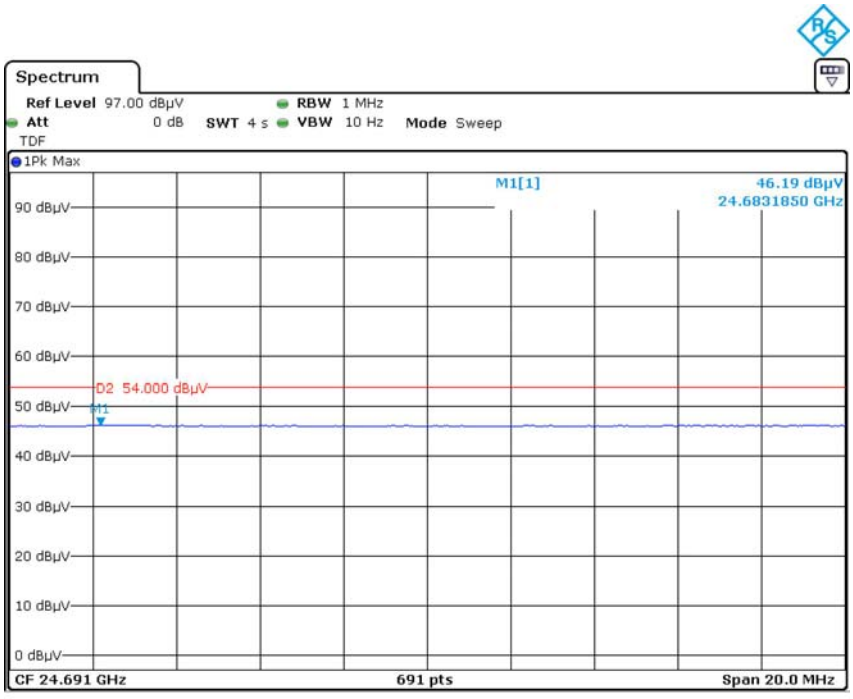
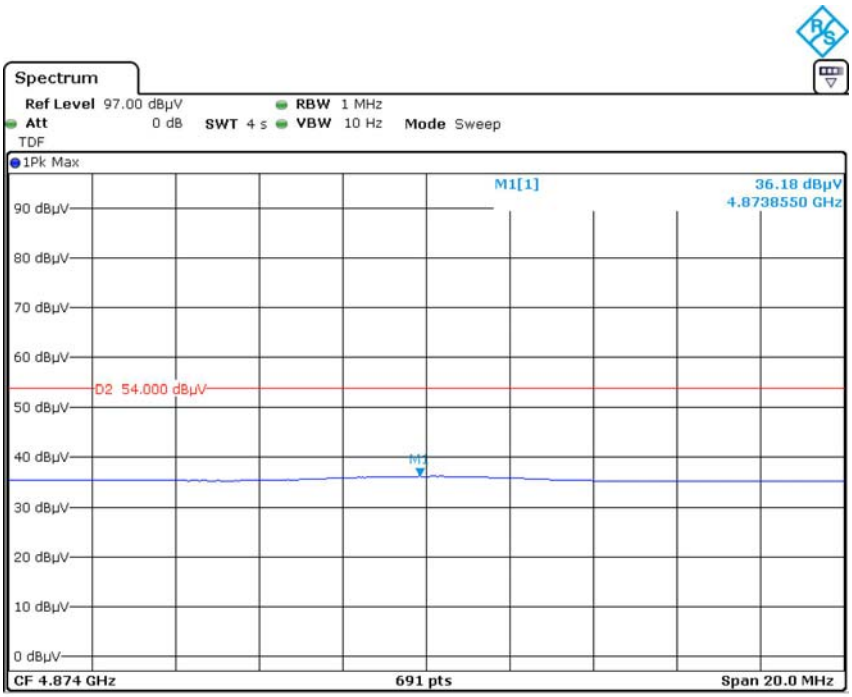
Pre-scan for Average
Horizontal





Vertical



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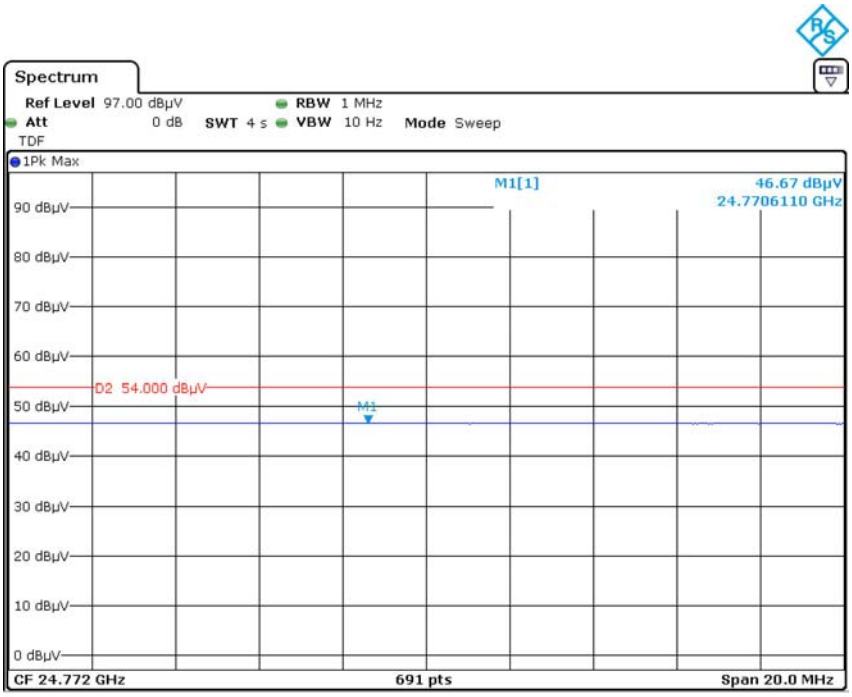


Date: 20.MAY.2020 20:37:42

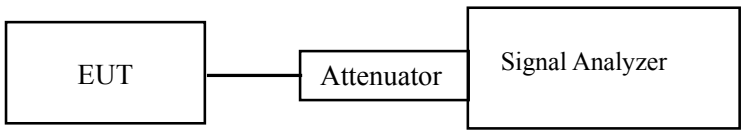
FCC §15.247(a) (2) – 6 dB EMISSION BANDWIDTH

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:	22 ℃
Relative Humidity:	50 %
ATM Pressure:	101.0 kPa

The testing was performed by Cary Guan from 2020-05-14 to 2020-05-20.

EUT operation mode: Transmitting

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

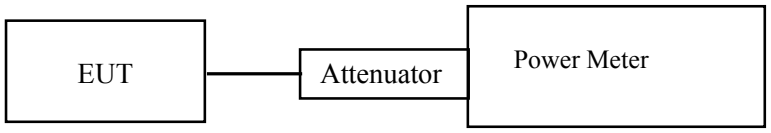
FCC §15.247(b) (3) - MAXIMUM CONDUCTED OUTPUT POWER

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:	22 ℃
Relative Humidity:	50 %
ATM Pressure:	101.0 kPa

The testing was performed by Cary Guan from 2020-05-14 to 2020-05-20.

EUT operation mode: Transmitting

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

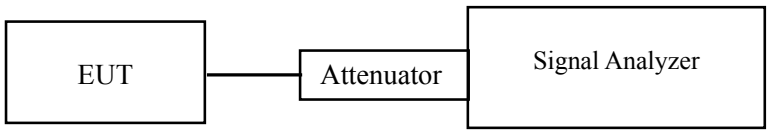
FCC §15.247(d) – 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE

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:	22 ℃
Relative Humidity:	50 %
ATM Pressure:	101.0 kPa

The testing was performed by Cary Guan from 2020-05-14 to 2020-05-20.

EUT operation mode: Transmitting

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

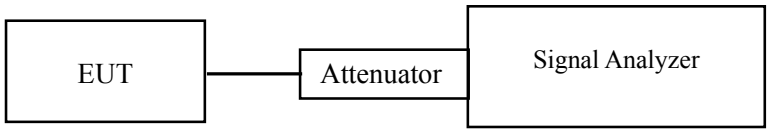
FCC §15.247(e) - POWER SPECTRAL DENSITY

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: 3kHz≤ RBW≤100 kHz.
3. Set the VBW ≥ 3×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:	22 ℃
Relative Humidity:	50 %
ATM Pressure:	101.0 kPa

The testing was performed by Cary Guan from 2020-05-14 to 2020-05-20.

EUT operation mode: Transmitting

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

APPENDIX Wi-Fi

Appendix A: DTS Bandwidth

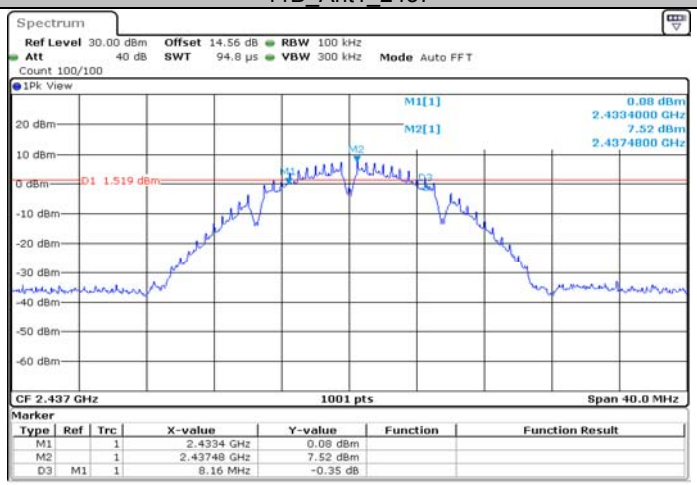
Test Result

TestMode	Antenna	Channel	DTS BW [MHz]	Limit[MHz]	Verdict
11B	Ant1	2412	9.120	0.5	PASS
		2437	8.160	0.5	PASS
		2462	9.120	0.5	PASS
11G	Ant1	2412	16.000	0.5	PASS
		2437	15.560	0.5	PASS
		2462	15.800	0.5	PASS
11N20SISO	Ant1	2412	16.120	0.5	PASS
		2437	15.400	0.5	PASS
		2462	15.760	0.5	PASS
11N40SISO	Ant1	2422	35.280	0.5	PASS
		2437	34.000	0.5	PASS
		2452	35.280	0.5	PASS

Test Graphs

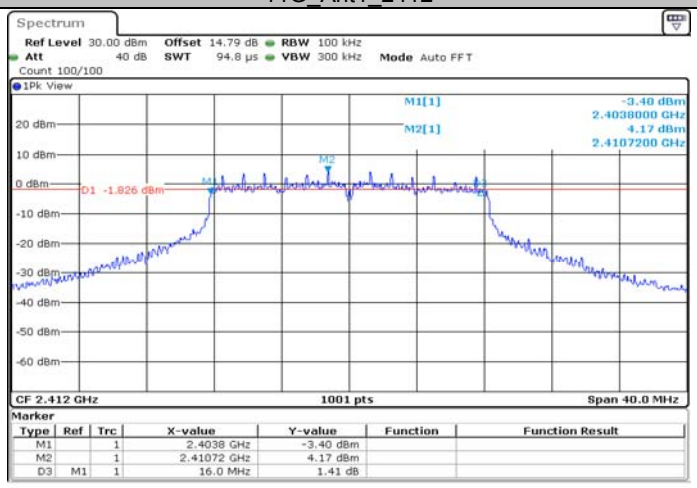
11B_Ant1_2412

11B_Ant1_2437

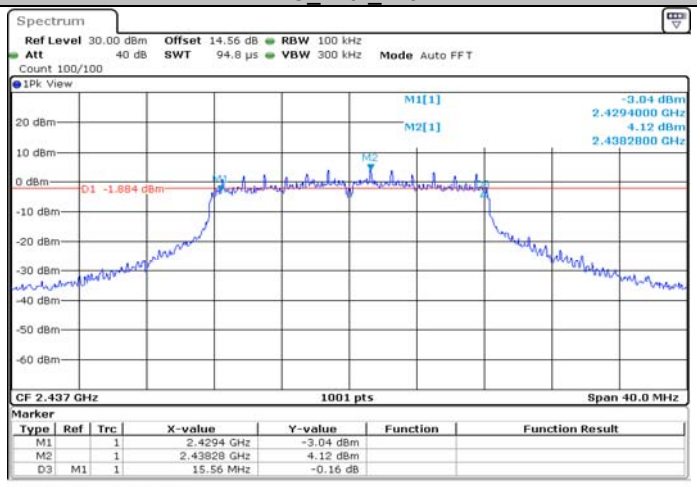


11B_Ant1_2462

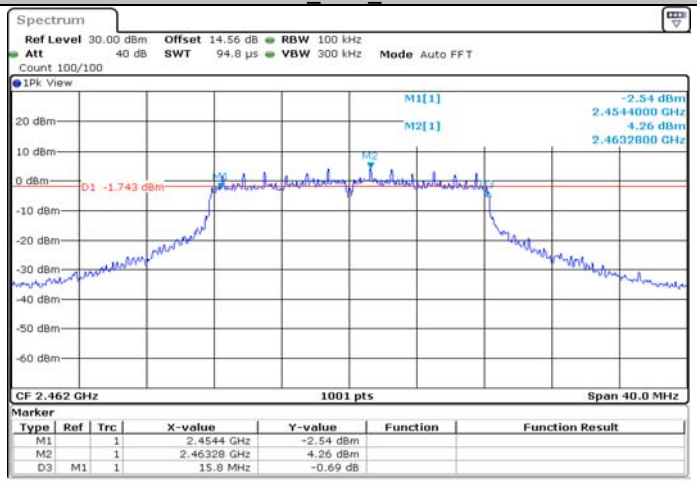
11G_Ant1_2412



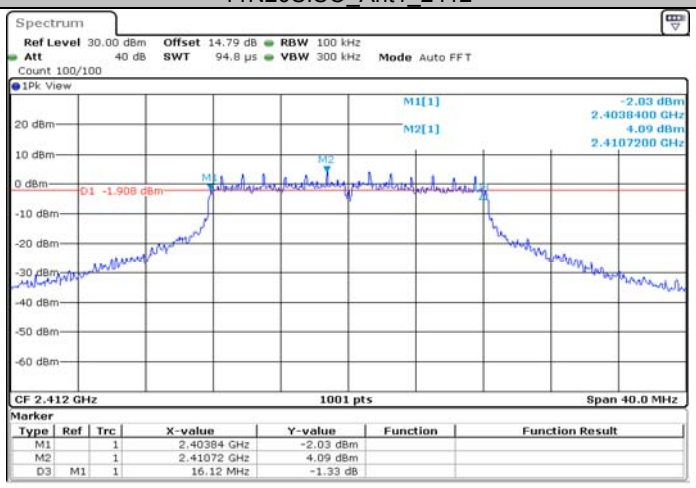
11G_Ant1_2437



11G_Ant1_2462



11N20SISO_Ant1_2412



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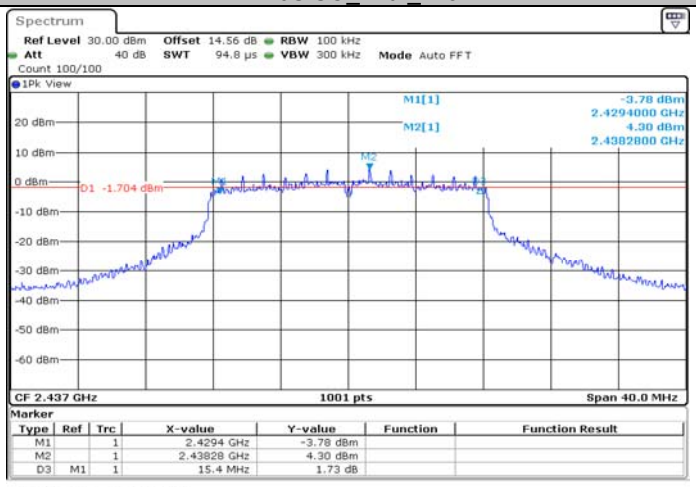
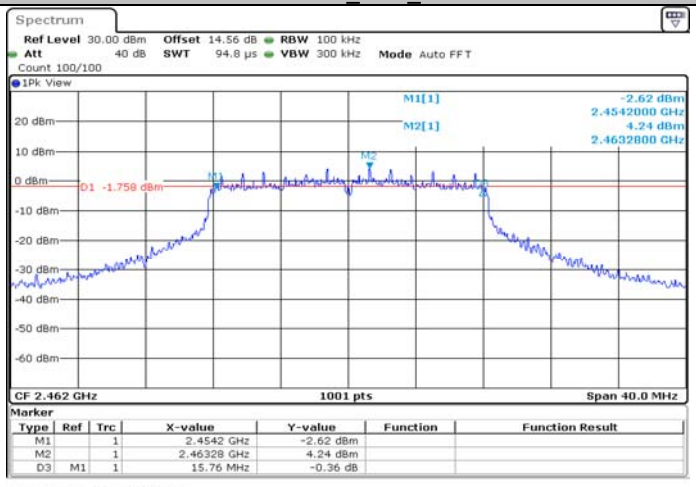
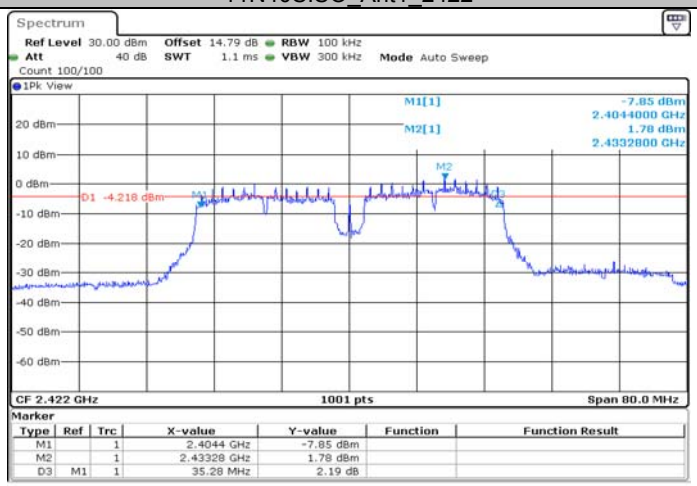


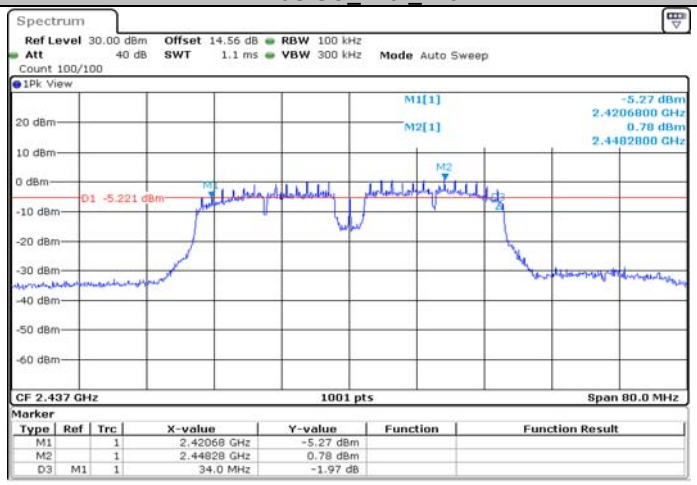
11N20SISO_Ant1_2462



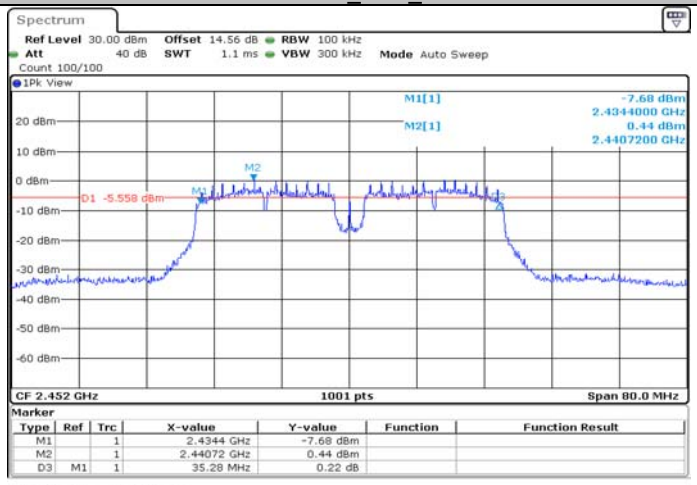
11N40SISO_Ant1_2422



11N40SISO_Ant1_2437



11N40SISO_Ant1_2452



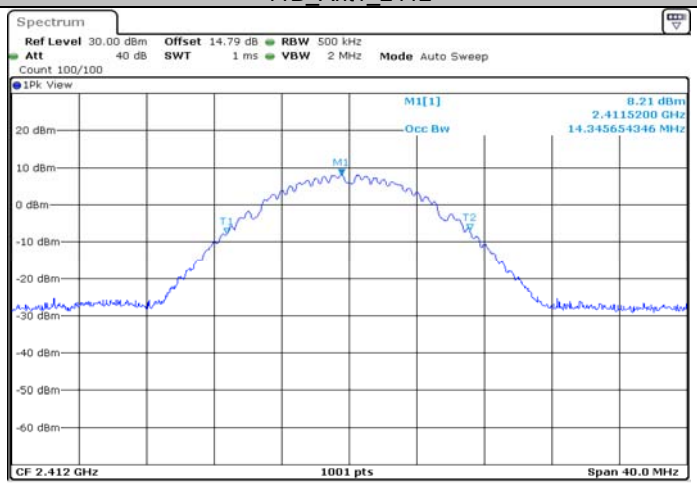
Appendix B: Occupied Channel Bandwidth

Test Result

TestMode	Antenna	Channel	OCB [MHz]	Limit[MHz]	Verdict
11B	Ant1	2412	14.346	---	PASS
		2437	14.026	---	PASS
		2462	14.186	---	PASS
11G	Ant1	2412	17.582	---	PASS
		2437	17.223	---	PASS
		2462	17.263	---	PASS
11N20SISO	Ant1	2412	17.622	---	PASS
		2437	17.263	---	PASS
		2462	17.263	---	PASS
11N40SISO	Ant1	2422	36.763	---	PASS
		2437	36.284	---	PASS
		2452	36.444	---	PASS

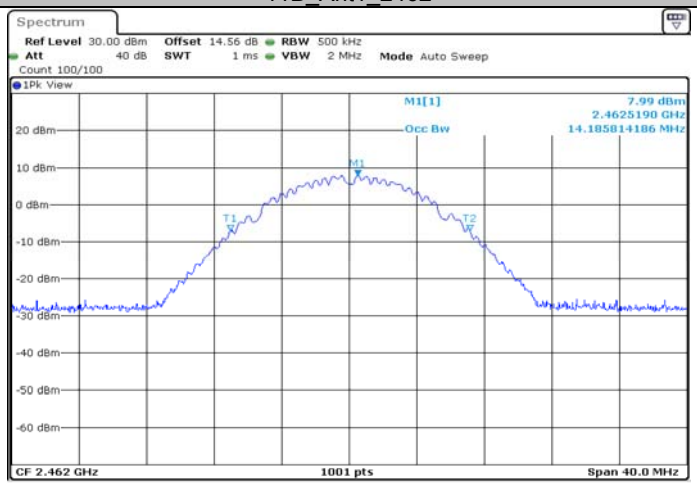
Test Graphs

11B_Ant1_2412

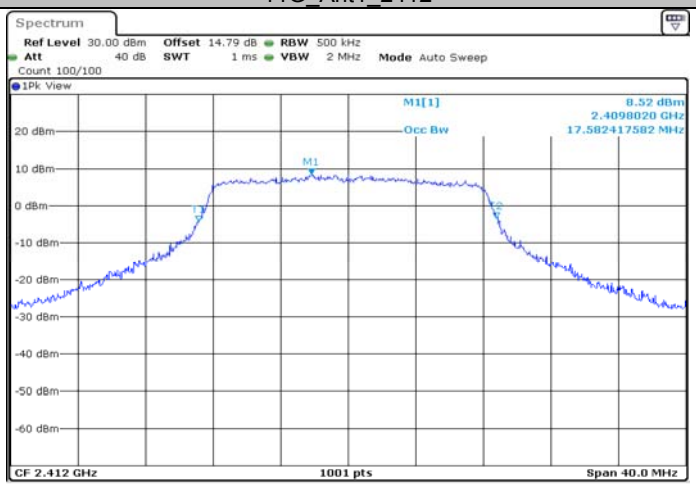


11B_Ant1_2437

11B_Ant1_2462

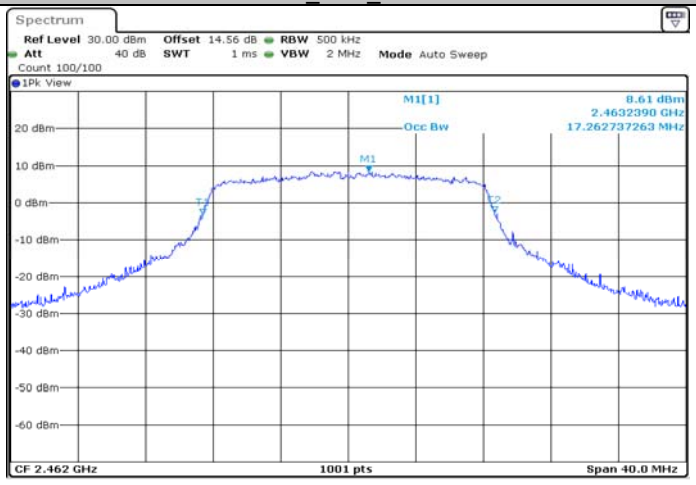


11G_Ant1_2412



11G_Ant1_2437

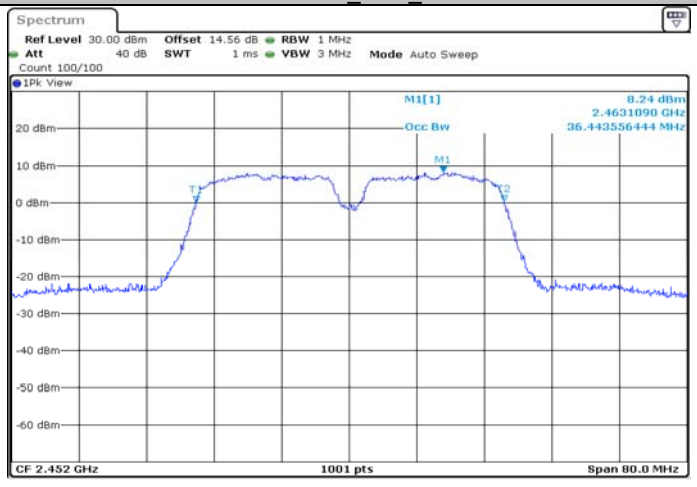
11G_Ant1_2462



11N20SISO_Ant1_2412

11N20SISO_Ant1_2437

11N20SISO_Ant1_2462

11N40SISO_Ant1_2422
11N40SISO_Ant1_2437
11N40SISO_Ant1_2452


Appendix C-1: Maximum conducted output power (Peak)

Test Result

TestMode	Antenna	Channel	Result[dBm]	Limit[dBm]	Verdict
11B	Ant1	2412	20.32	<=30	PASS
		2437	20.51	<=30	PASS
		2462	20.37	<=30	PASS
11G	Ant1	2412	23.12	<=30	PASS
		2437	23.44	<=30	PASS
		2462	23.81	<=30	PASS
11N20SISO	Ant1	2412	23.42	<=30	PASS
		2437	23.61	<=30	PASS
		2462	23.55	<=30	PASS
11N40SISO	Ant1	2422	22.82	<=30	PASS
		2437	22.63	<=30	PASS
		2452	22.56	<=30	PASS

Appendix C-2: Maximum conducted output power (Average)

Test Result

TestMode	Antenna	Channel	Result[dBm]	Limit[dBm]	Verdict
11B	Ant1	2412	17.64	<=30	PASS
		2437	17.89	<=30	PASS
		2462	17.65	<=30	PASS
11G	Ant1	2412	17.39	<=30	PASS
		2437	17.46	<=30	PASS
		2462	17.88	<=30	PASS
11N20SISO	Ant1	2412	17.34	<=30	PASS
		2437	17.67	<=30	PASS
		2462	17.51	<=30	PASS
11N40SISO	Ant1	2422	16.50	<=30	PASS
		2437	16.29	<=30	PASS
		2452	16.08	<=30	PASS

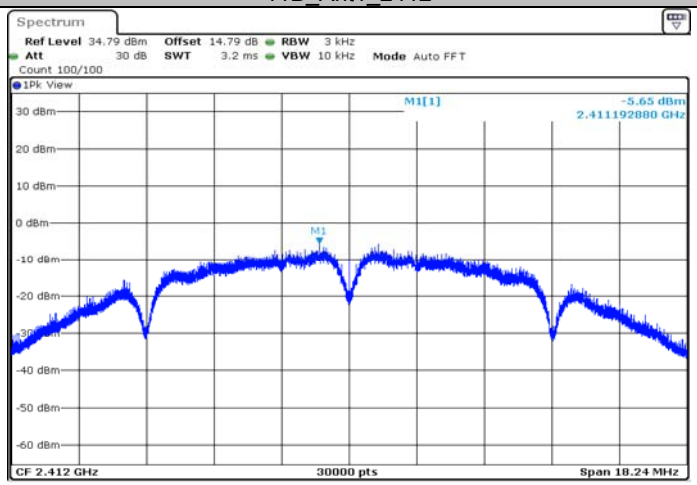
Appendix D: Maximum power spectral density

Test Result

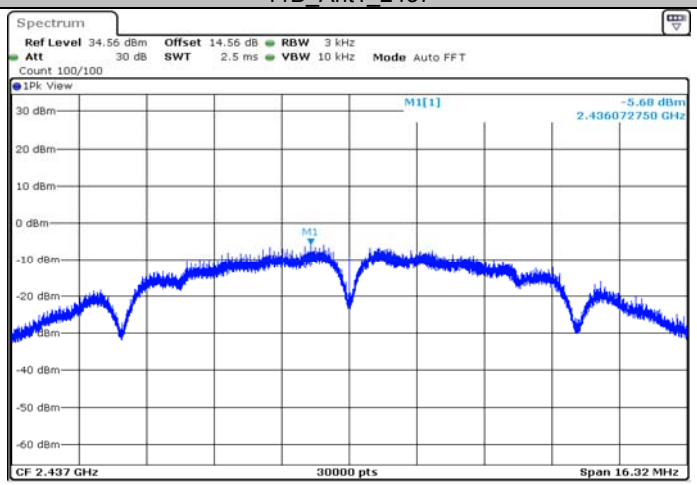
TestMode	Antenna	Channel	Result[dBm/3kHz]	Limit[dBm/3kHz]	Verdict
11B	Ant1	2412	-5.65	<=8	PASS
		2437	-5.68	<=8	PASS
		2462	-5.69	<=8	PASS
11G	Ant1	2412	-7.56	<=8	PASS
		2437	-5.90	<=8	PASS
		2462	-7.37	<=8	PASS
11N20SISO	Ant1	2412	-7.53	<=8	PASS
		2437	-6.02	<=8	PASS
		2462	-7.70	<=8	PASS
11N40SISO	Ant1	2422	-8.84	<=8	PASS
		2437	-7.31	<=8	PASS
		2452	-8.73	<=8	PASS

Test Graphs

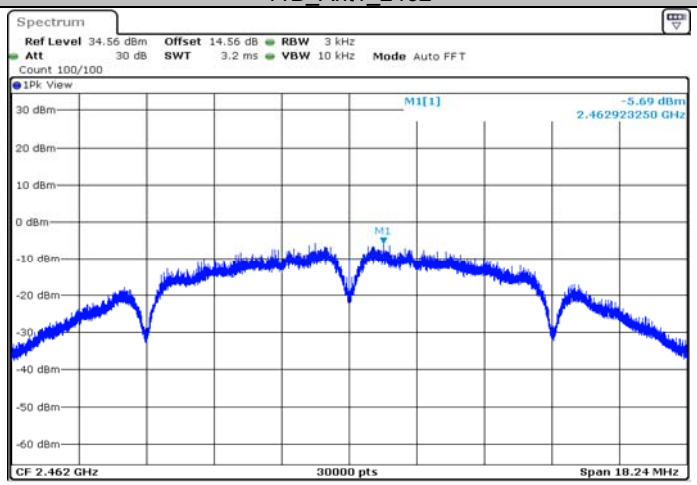
11B_Ant1_2412



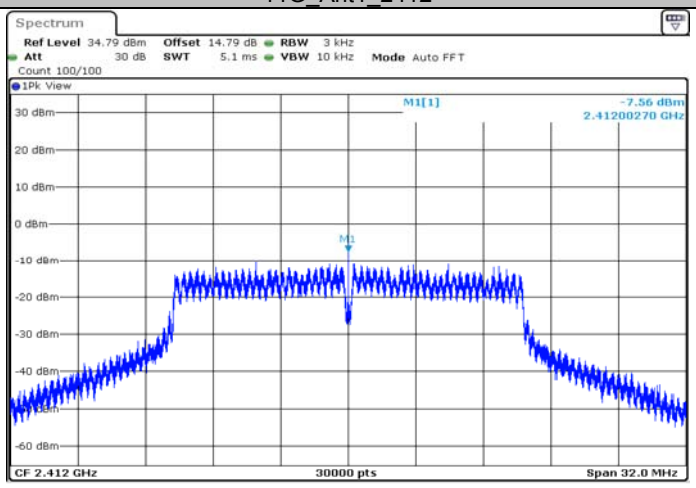
11B_Ant1_2437



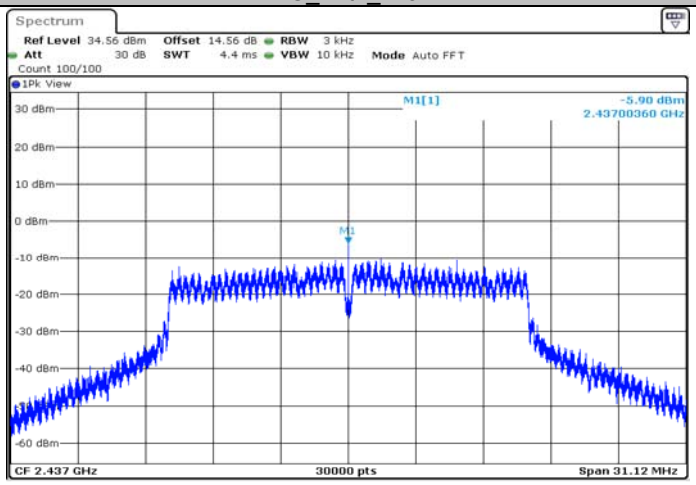
11B_Ant1_2462



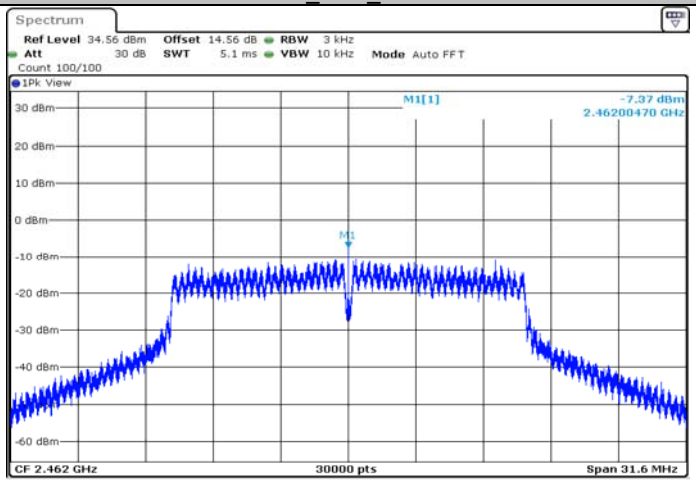
11G_Ant1_2412



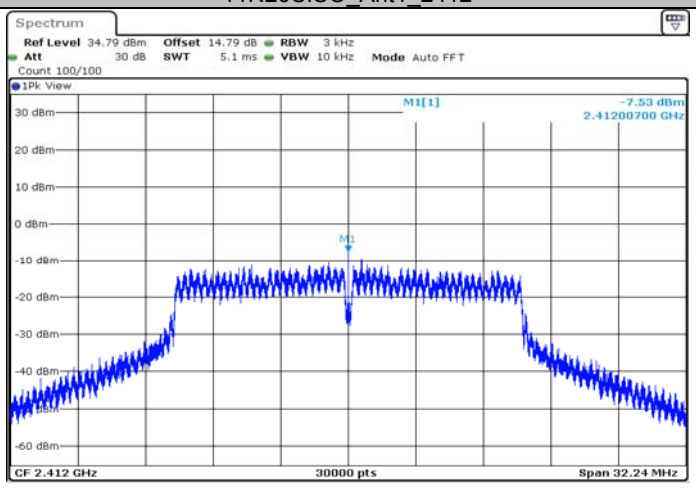
11G_Ant1_2437



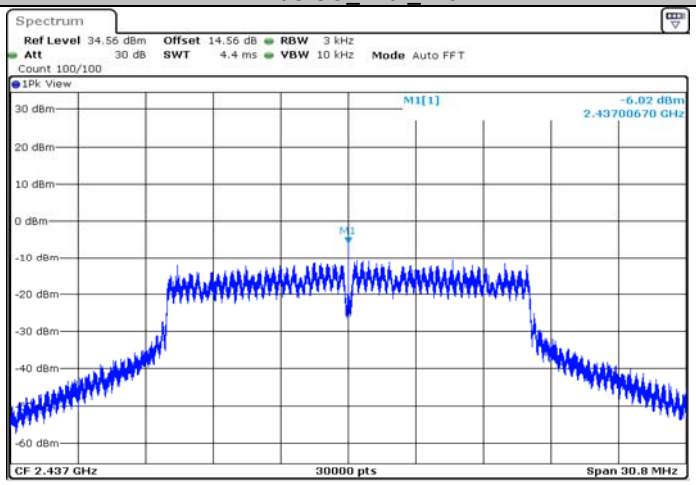
11G_Ant1_2462



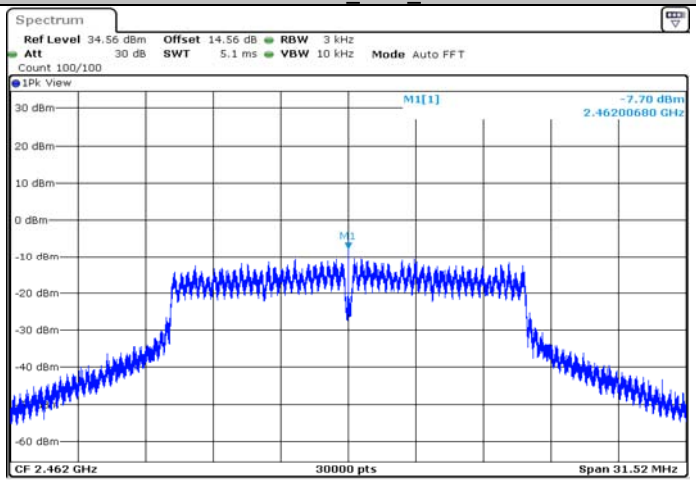
11N20SISO_Ant1_2412



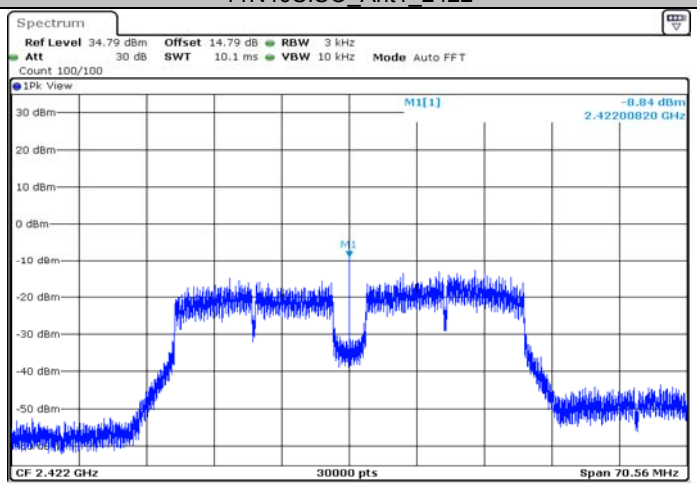
11N20SISO_Ant1_2437



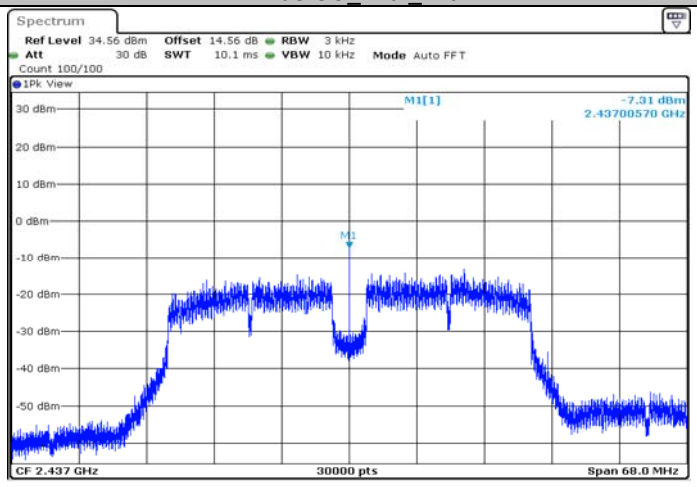
11N20SISO_Ant1_2462



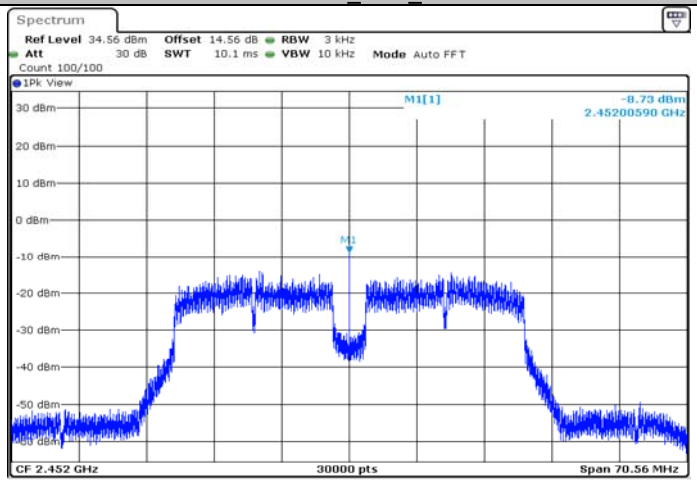
11N40SISO_Ant1_2422



11N40SISO_Ant1_2437



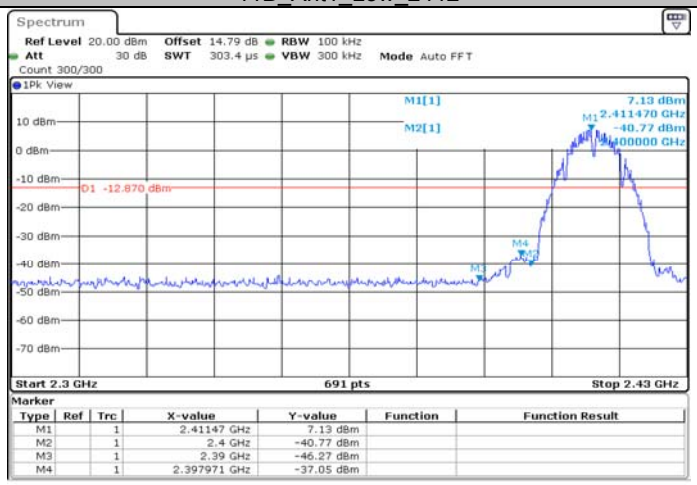
11N40SISO_Ant1_2452



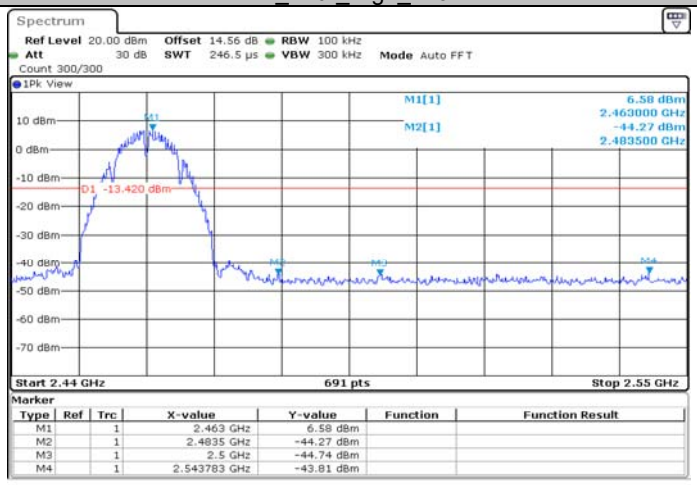
Appendix E:Band edge measurements

Test Graphs

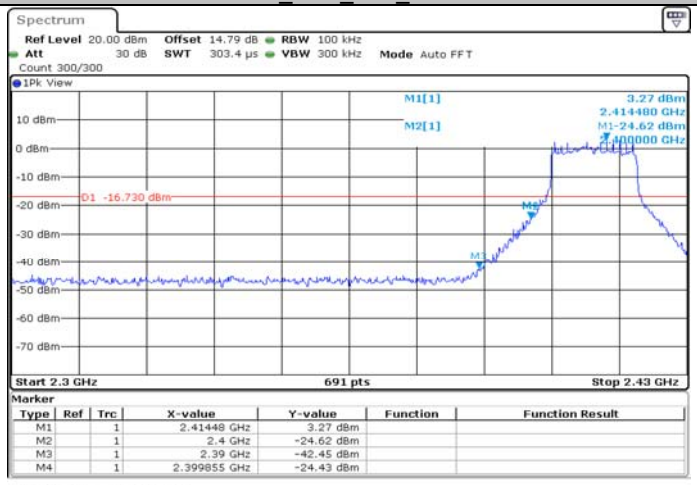
11B_Ant1_Low_2412



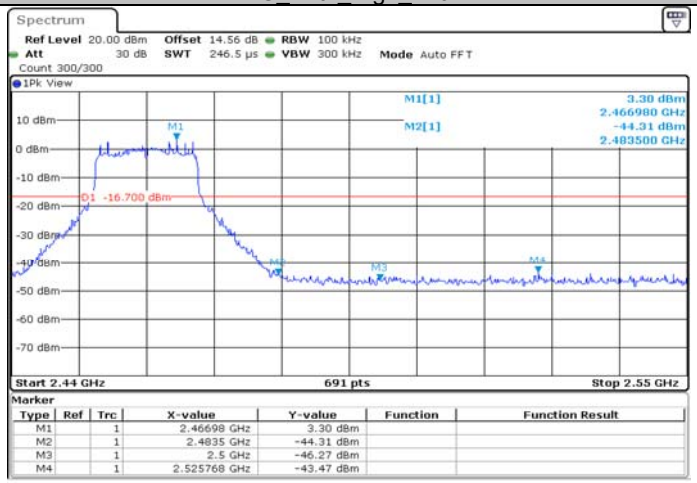
11B_Ant1_High_2462



11G_Ant1_Low_2412



11G_Ant1_High_2462

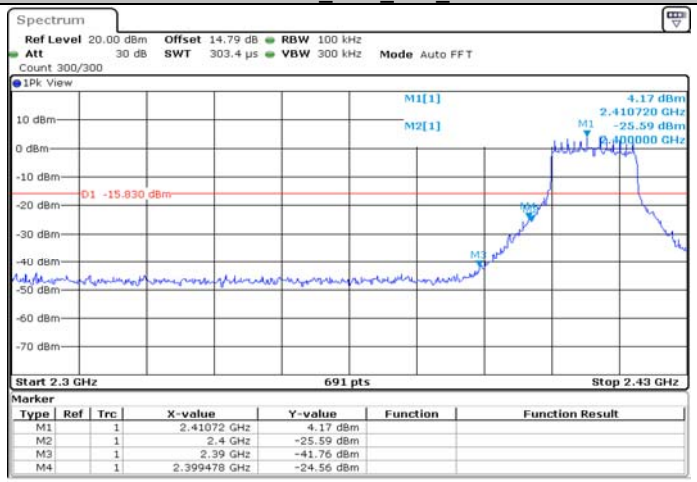


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.46698 GHz	3.30 dBm		
M2		1	2.4835 GHz	-44.31 dBm		
M3		1	2.5 GHz	-46.27 dBm		
M4		1	2.525768 GHz	-43.47 dBm		

Date: 14.MAY.2020 10:26:13

11N20SISO_Ant1_Low_2412

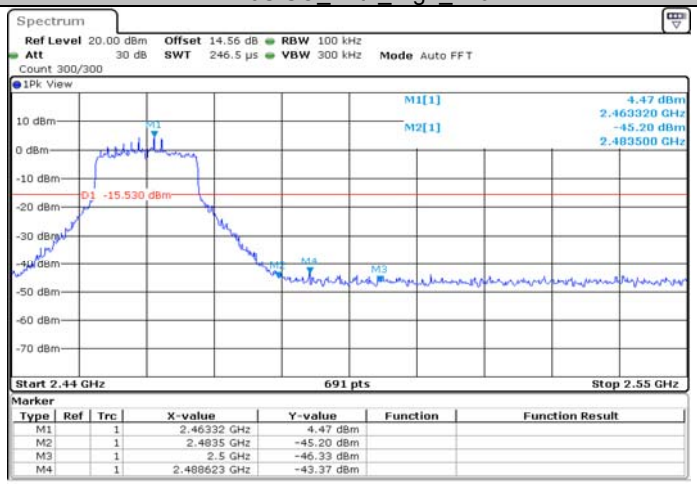


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.41072 GHz	4.17 dBm		
M2		1	2.4 GHz	-25.59 dBm		
M3		1	2.39 GHz	-41.76 dBm		
M4		1	2.399478 GHz	-24.56 dBm		

Date: 14.MAY.2020 10:28:23

11N20SISO_Ant1_High_2462

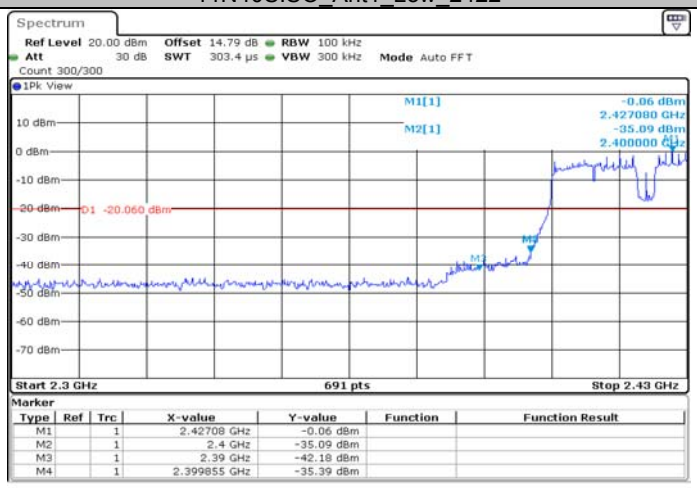


Marker

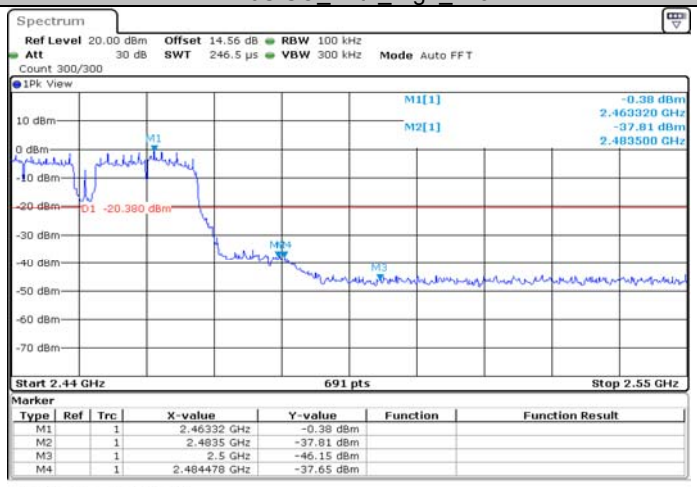
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.46332 GHz	4.47 dBm		
M2		1	2.4835 GHz	-45.20 dBm		
M3		1	2.5 GHz	-46.33 dBm		
M4		1	2.488623 GHz	-43.37 dBm		

Date: 14.MAY.2020 10:31:44

11N40SISO_Ant1_Low_2422



11N40SISO_Ant1_High_2452



Appendix F: Duty Cycle

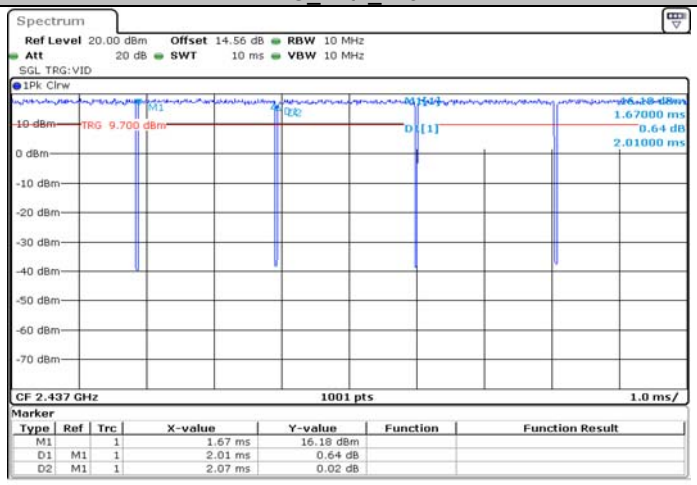
Test Result

TestMode	Antenna	Channel	TransmissionDuration [ms]	Transmission Period [ms]	Duty Cycle [%]
11B	Ant1	2437	12.15	12.33	98.58
11G	Ant1	2437	2.01	2.07	97.10
11N20SISO	Ant1	2437	2.01	2.06	97.57
11N40SISO	Ant1	2437	2.01	2.08	96.63

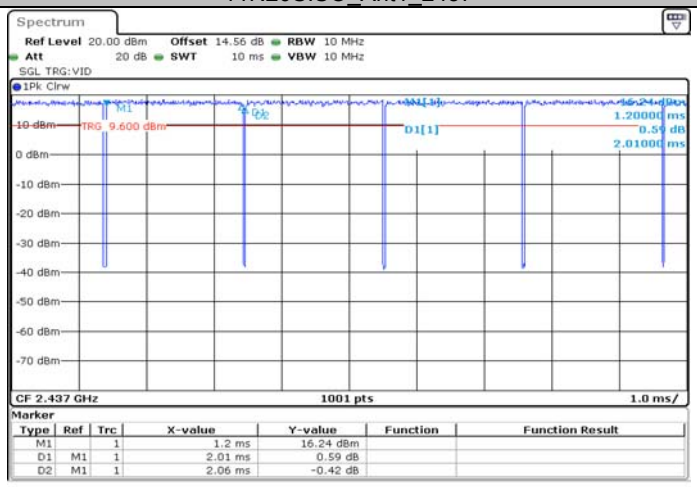
Test Graphs

11B_Ant1_2437

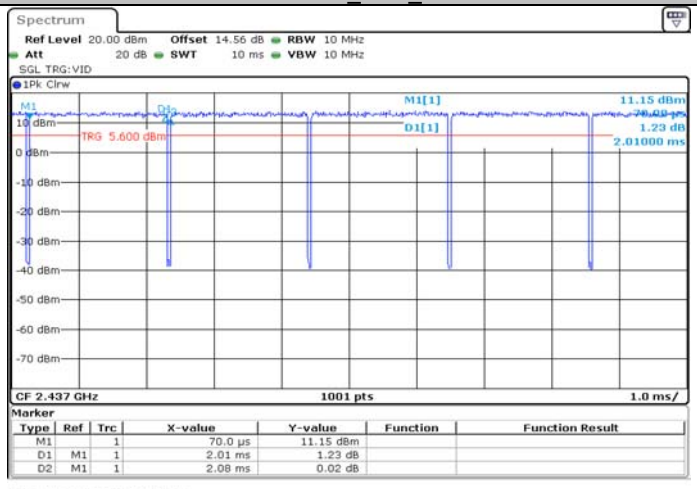
11G_Ant1_2437



11N20SISO_Ant1_2437



11N40SISO_Ant1_2437



APPENDIX BLE

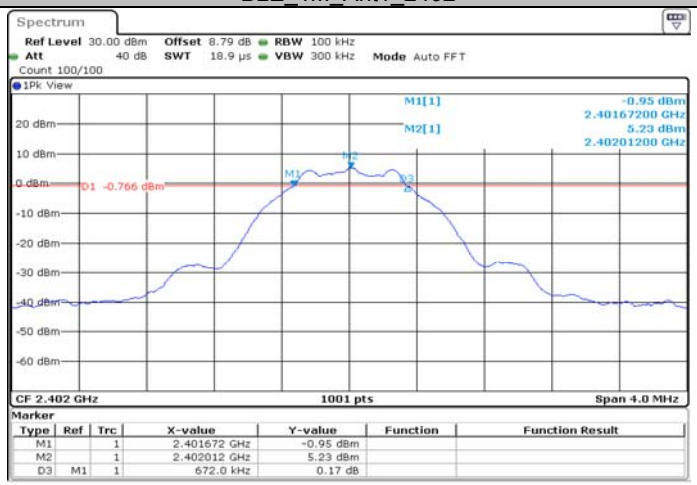
Appendix A: DTS Bandwidth

Test Result

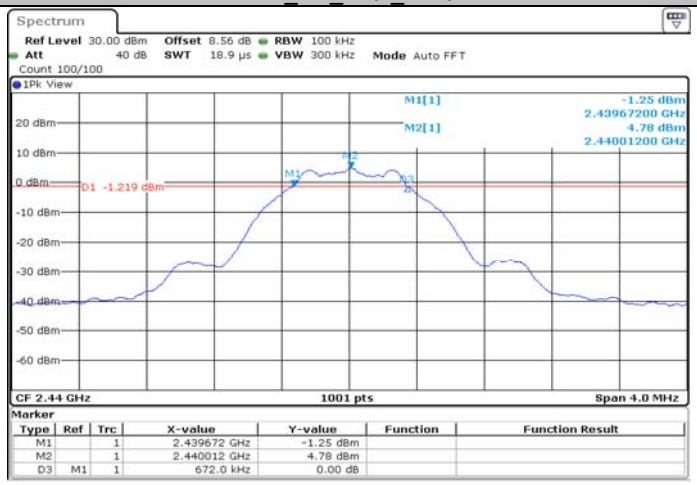
TestMode	Antenna	Channel	DTS BW [MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	0.672	0.5	PASS
		2440	0.672	0.5	PASS
		2480	0.668	0.5	PASS
BLE_2M	Ant1	2402	1.140	0.5	PASS
		2440	1.144	0.5	PASS
		2480	1.140	0.5	PASS

Test Graphs

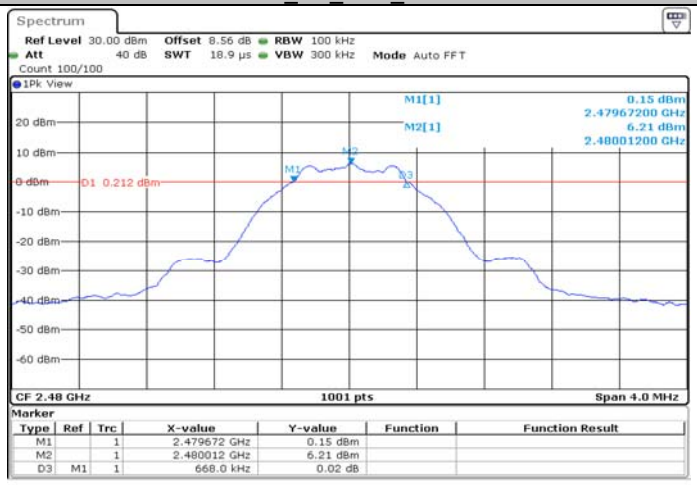
BLE_1M_Ant1_2402



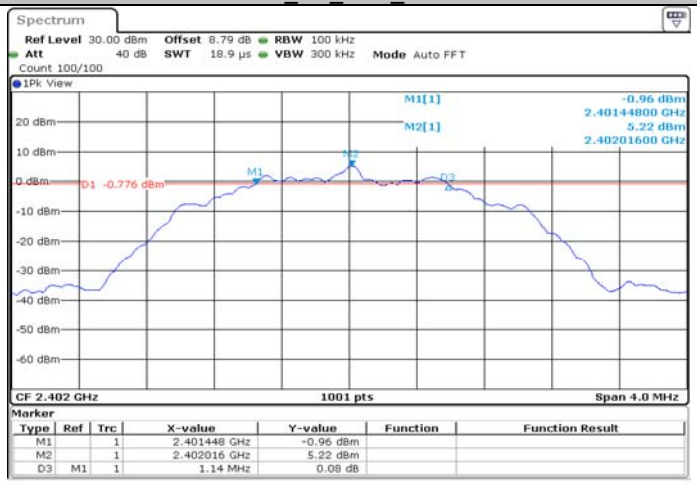
BLE_1M_Ant1_2440



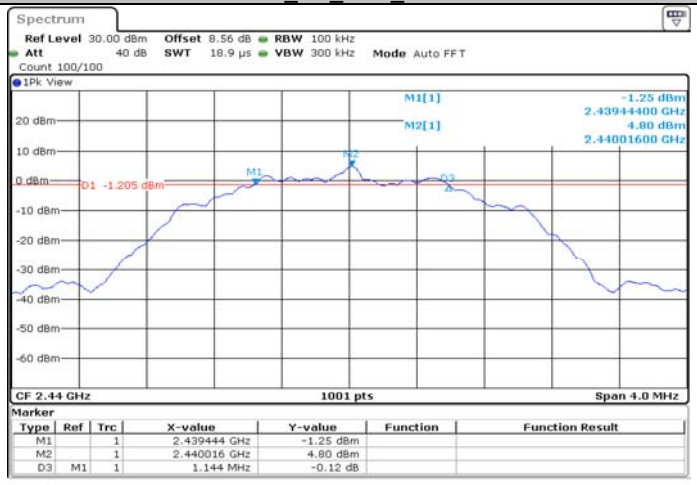
BLE_1M_Ant1_2480



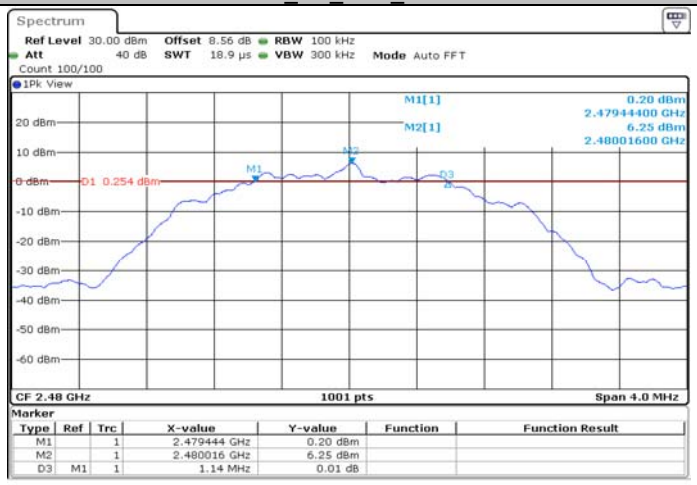
BLE_2M_Ant1_2402



BLE_2M_Ant1_2440



BLE_2M_Ant1_2480



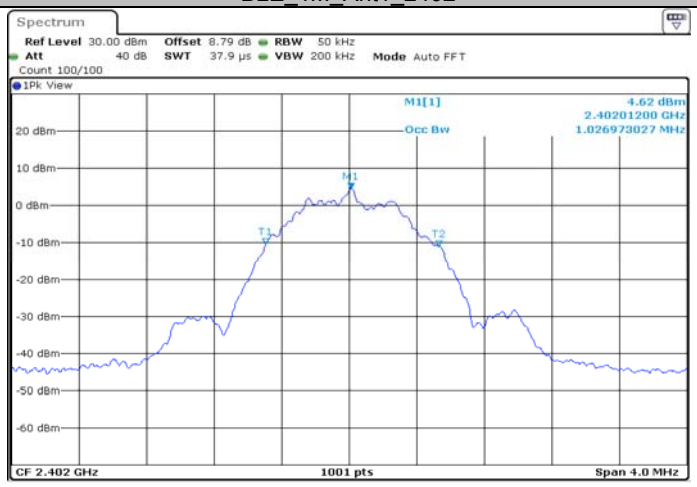
Appendix B: Occupied Channel Bandwidth

Test Result

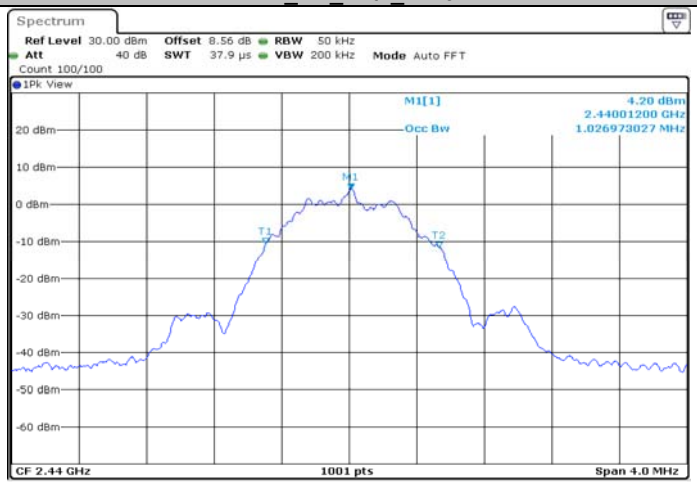
TestMode	Antenna	Channel	OCB [MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	1.027	---	PASS
		2440	1.027	---	PASS
		2480	1.031	---	PASS
BLE_2M	Ant1	2402	2.046	---	PASS
		2440	2.042	---	PASS
		2480	2.042	---	PASS

Test Graphs

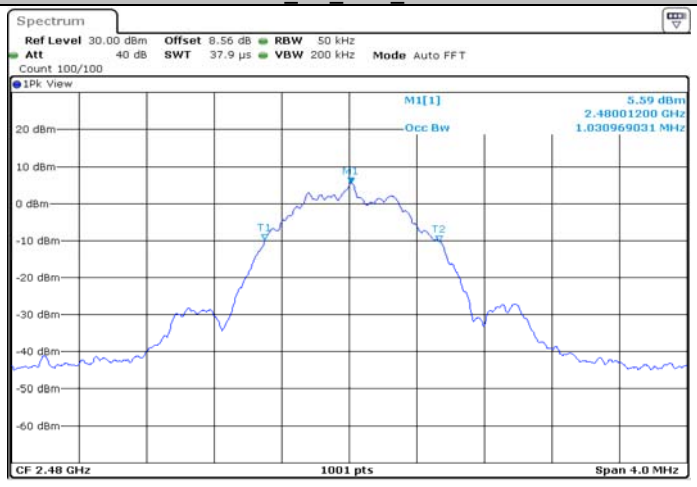
BLE_1M_Ant1_2402

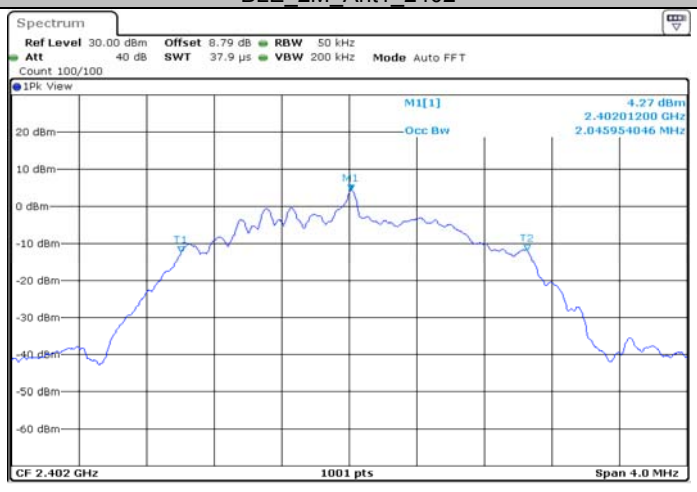
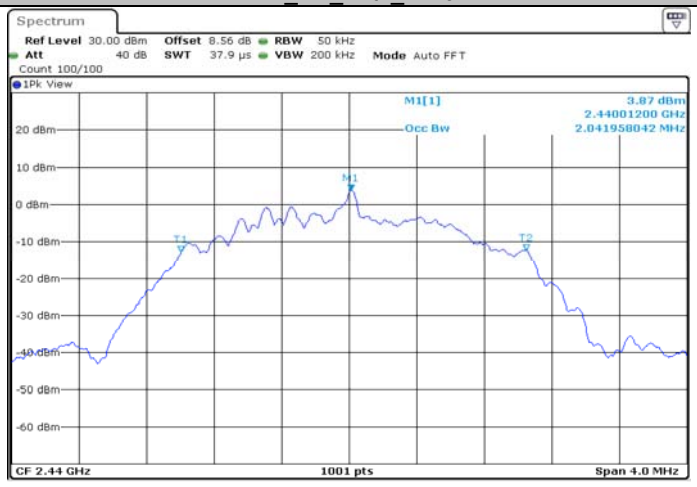


BLE_1M_Ant1_2440



BLE_1M_Ant1_2480



BLE_2M_Ant1_2402

BLE_2M_Ant1_2440

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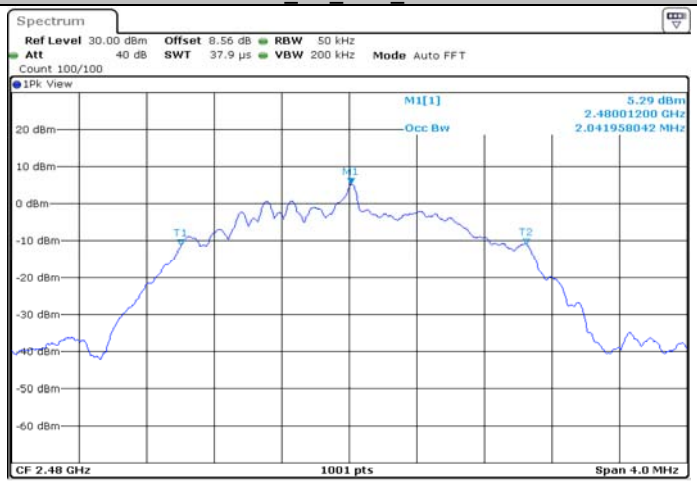


Appendix C: Maximum conducted Peakoutput power

Test Result

TestMode	Antenna	Channel	Result[dBm]	Limit[dBm]	Verdict
BLE_1M	Ant1	2402	5.47	<=30	PASS
		2440	5.57	<=30	PASS
		2480	6.76	<=30	PASS
BLE_2M	Ant1	2402	5.57	<=30	PASS
		2440	5.76	<=30	PASS
		2480	6.92	<=30	PASS

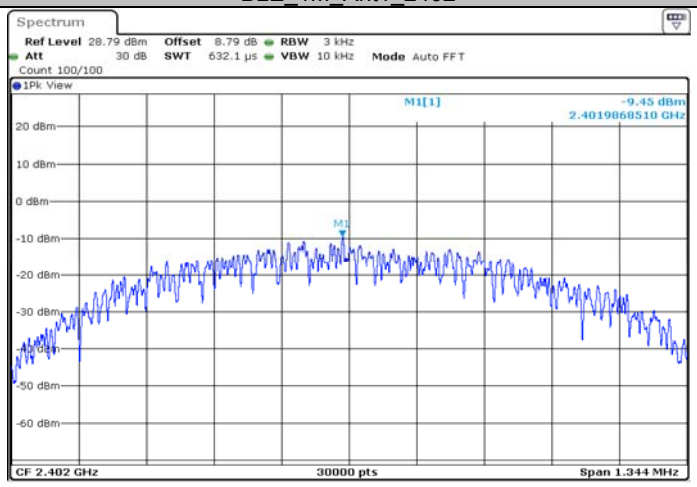
Appendix D: Maximum power spectral density

Test Result

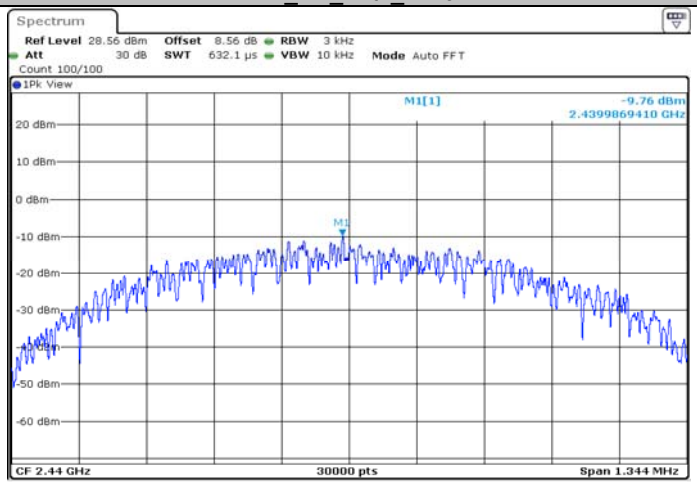
TestMode	Antenna	Channel	Result[dBm/3kHz]	Limit[dBm/3kHz]	Verdict
BLE_1M	Ant1	2402	-9.45	<=8	PASS
		2440	-9.76	<=8	PASS
		2480	-8.43	<=8	PASS
BLE_2M	Ant1	2402	-13.08	<=8	PASS
		2440	-13.30	<=8	PASS
		2480	-11.95	<=8	PASS

Test Graphs

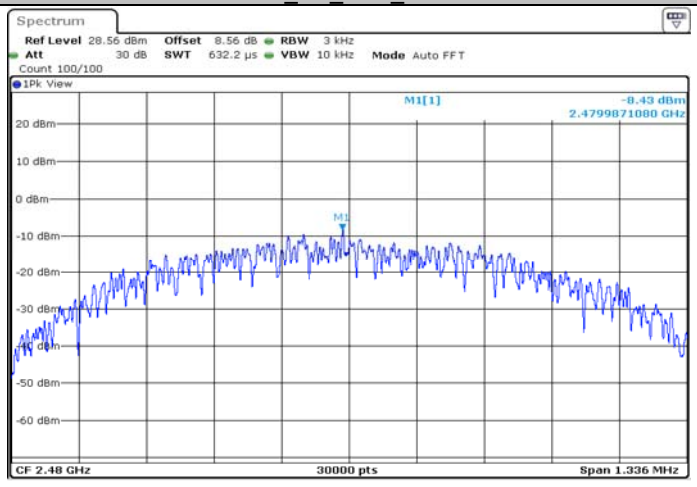
BLE_1M_Ant1_2402



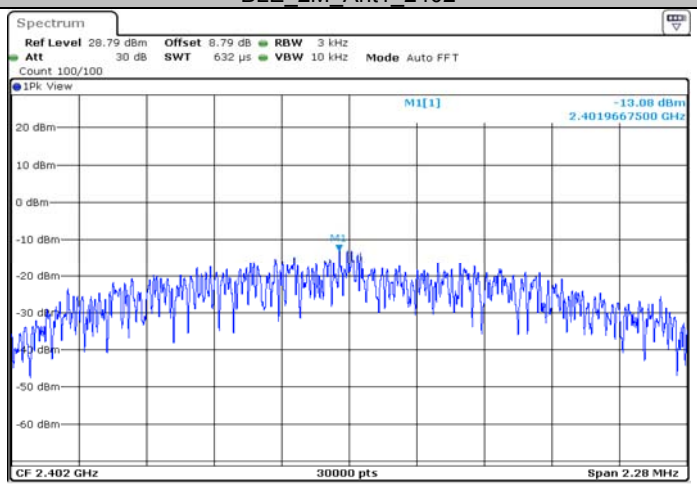
BLE_1M_Ant1_2440



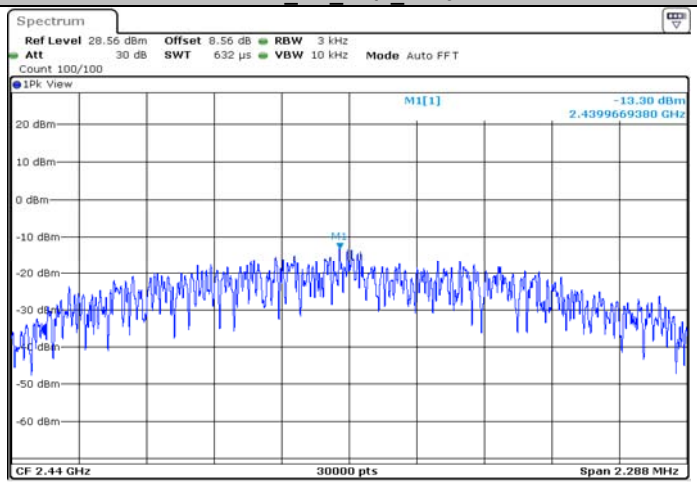
BLE_1M_Ant1_2480



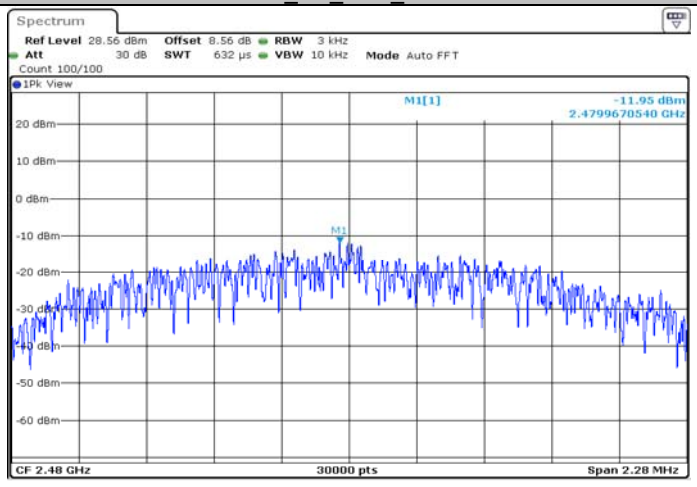
BLE_2M_Ant1_2402



BLE_2M_Ant1_2440



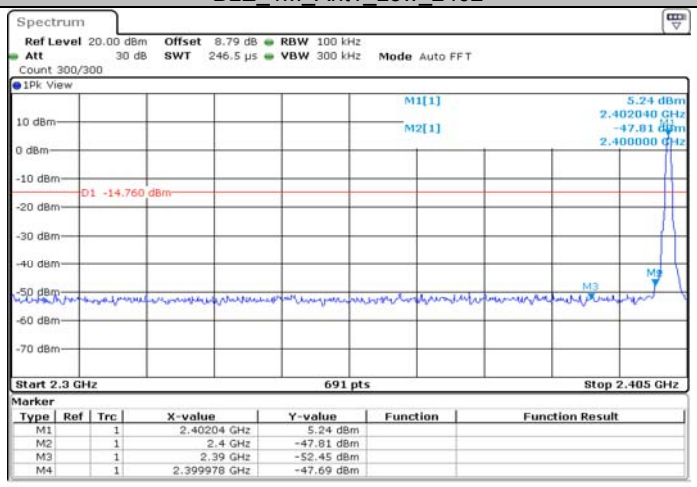
BLE_2M_Ant1_2480



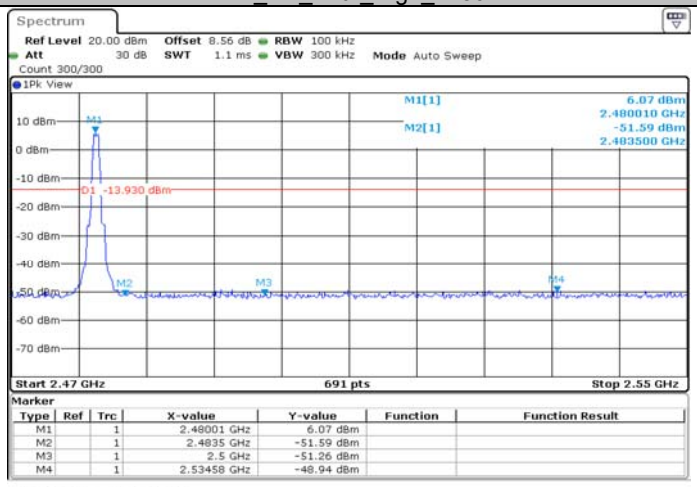
Appendix E: Band edge measurements

Test Graphs

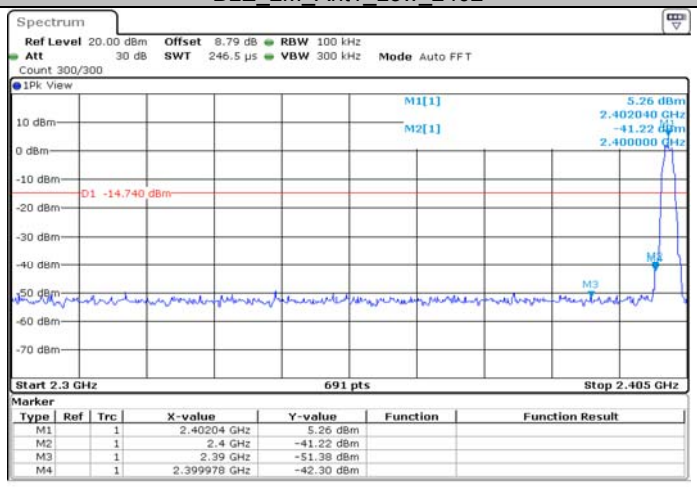
BLE_1M_Ant1_Low_2402



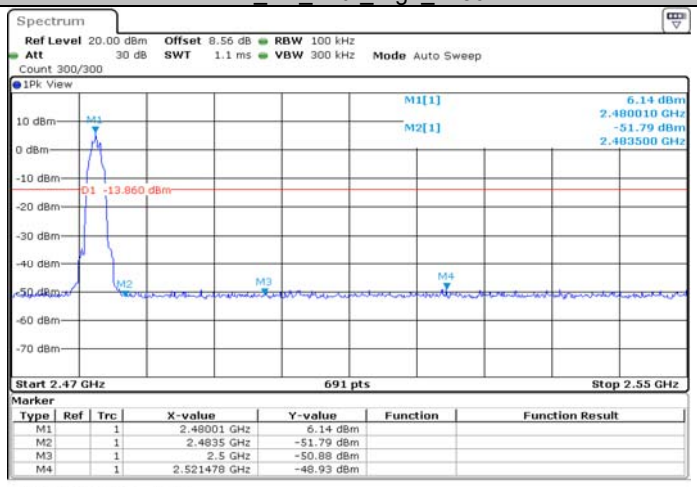
BLE_1M_Ant1_High_2480



BLE_2M_Ant1_Low_2402



BLE_2M_Ant1_High_2480



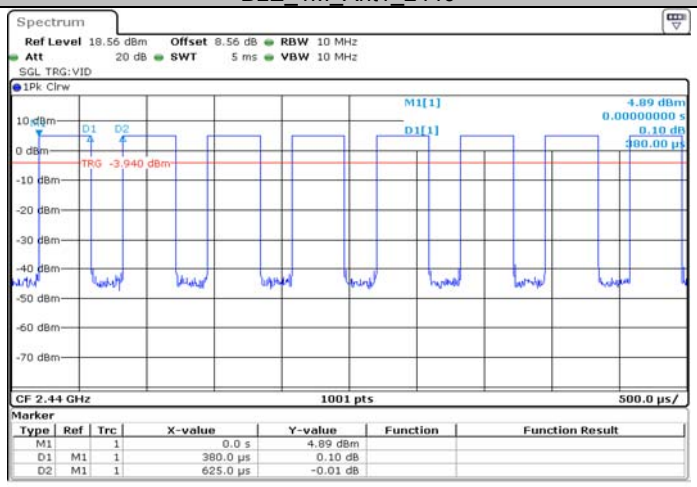
Appendix F: Duty Cycle

Test Result

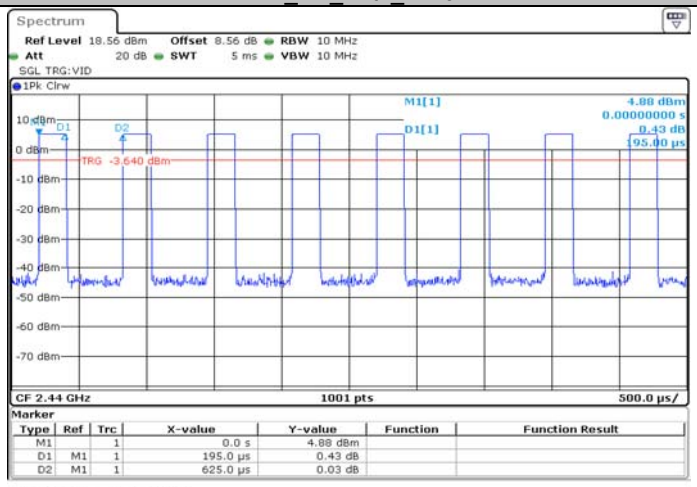
TestMode	Antenna	Channel	TransmissionDuration [ms]	Transmission Period [ms]	Duty Cycle [%]
BLE_1M	Ant1	2440	0.38	0.63	60.80
BLE_2M	Ant1	2440	0.20	0.63	31.20

Test Graphs

BLE_1M_Ant1_2440



BLE_2M_Ant1_2440



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