ELECTROMAGNETIC EMISSIONS COMPLIANCE REPORT INTENTIONAL RADIATOR CERTIFICATION TO FCC PART 15 SUBPART C REQUIREMENT

OF

Zalpha Series - Autonomous Mobile Robot

Model No.: Zalpha-MG-S-01, Zalpha-MG-S-03, Zalpha-MG-S-05, Zalpha-MG-E-01, Zalpha-MG-E-03, Zalpha-MG-E-05, Zalpha-MG-L-01, Zalpha-MG-L-03, Zalpha-MG-L-05, Zalpha-TS-TS-01, Zalpha-TS-S-03, Zalpha-TS-S-05, Zalpha-TS-E-01, Zalpha-TS-E-03, Zalpha-TS-E-05, Zalpha-TS-L-01, Zalpha-TS-L-03, Zalpha-TS-L-05, Zalpha-TS-SB-01, Zalpha-TS-SB-03, Zalpha-TS-SB-05, Zalpha-TS-EB-01, Zalpha-TS-EB-03, Zalpha-TS-EB-05

FCC ID: 2AP2R-ZALPHA3-TS

Trademark: ZALPHA

Report No.: EA20100455F05001

Issue Date: September 18, 2021

Prepared for

DF Automation & Robotics Sdn Bhd

No 5, Jalan Impian Emas 18, Taman Impian Emas, Skudai, 81300, Johor, Malaysia.

Prepared by

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VERIFICATION OF COMPLIANCE

Applicant:	DF Automation & Robotics Sdn Bhd No 5, Jalan Impian Emas 18, Taman lmpian Emas, Skudai, 81300, Johor, Malaysia.
Manufacturer:	DF Automation & Robotics Sdn Bhd No 5, Jalan Impian Emas 18, Taman lmpian Emas, Skudai, 81300, Johor, Malaysia.
Product Description:	Zalpha Series - Autonomous Mobile Robot
Model Number:	Zalpha-MG-S-01, Zalpha-MG-S-03, Zalpha-MG-S-05, Zalpha-MG-E-01, Zalpha-MG-E-03, Zalpha-MG-E-05, Zalpha-MG-L-01, Zalpha-MG-L-03, Zalpha-MG-L-05, Zalpha-TS-S-01, Zalpha-TS-S-03, Zalpha-TS-S-05, Zalpha-TS-E-01, Zalpha-TS-E-03, Zalpha-TS-E-05, Zalpha-TS-L-01, Zalpha-TS-L-03, Zalpha-TS-L-05, Zalpha-TS-SB-01, Zalpha-TS-SB-03, Zalpha-TS-SB-05, Zalpha-TS-EB-01, Zalpha-TS-EB-03, Zalpha-TS-EB-05 (Note:1. Zalpha-Mg and Zalpha-TS: MG represent Magnetic Strip Guidance Navigation by using our magnetic sensor board (MSB), while TS represent Laser-based Natural Feature Navigation by using laser sensor to navigate. 2. S/E/L/SB/EB: They represent the body size configuration, S (Standard size), E (Extended size), L (Lowbed size), SB (Standard size with bottom sensor), EB (Extended size with bottom sensor)3) Number 01/03/05: They represent the payload. 01 = 100kg, 03 = 300kg, 05 = 500kg. We choose Zalpha-TS-EB-05 for all tests.)

We hereby certify that:

The above equipment was tested by Dong Guan Anci Electronic Technology Co., Ltd.The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in ANSI C63.10-2013 and the energy emitted by the sample EUT tested as described in this report is in compliance with conducted and radiated emission limits of FCC Rules Part 15.247(2020).

Date of Test : June 21, 2021 to September 02, 2021

Prepared by : Tomas Yang/Supervisor

Reviewer & Authorized Signer : Alan He/Manager

Modified Information

Version	Summary	Revision Date	Report No.
Ver.1.0	Original Report	/	EA20100455F05001

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1. General Information

1.1 Product Description

Characteristics	Description
Product Name	Zalpha Series - Autonomous Mobile Robot
Model number	Zalpha-TS-EB-05
Power Supply	DC 28.8V, 12.5A
Test Power Supply	AC 240V/60Hz for Adapter and Battery 25.6V
Adapter Information	Model: Zalpha-CH01 Input: AC 220-240V～50/60Hz 3A Output:DC 28.8V 12.5A
IEEE 802.11 WLAN Mode Supported	☒802.11b(20MHz channel bandwidth) ☒802.11g(20MHz channel bandwidth) ☒802.11n(20MHz channel bandwidth) ☒802.11n(40MHz channel bandwidth)
MIMO Mode	802.11n(HT20), 802.11n(HT40)
Modulation	DSSS with DBPSK/DQPSK/CCK for 802.11b; OFDM with BPSK/QPSK/16QAM/64QAM for 802.11g/n;
Operating Frequency Range	2412-2462MHz for 802.11b/g; 2412-2462MHz for 802.11n(HT20); 2422-2452MHz for 802.11n(HT40);
Number of Channels	11 channels for 802.11b/g; 11 channels for 802.11n(HT20); 7 channels for 802.11n(HT40);
Transmit Power Max	20.89dBm for 802.11b; 19.07dBm for 802.11g; 21.219dBm for 802.11n(HT20); 21.925 dBm for 802.11n(HT40);
Antenna Type	2TX2RX
Antenna Port	☒Ant1; ☒Ant2;
Smart system	☒SISO for 802.11b/g ☒MIMO for 802.11n
Antenna Gain	2dBi (for per antenna port Max) 5dBi for MIMO(Ant1+Ant2 Directional Gain)
Antenna Type	External antenna
Antenna Connector	IPEX ANT Connector

Note: *for more details, please refer to the User's manual of the EUT.*

2. System Test Configuration

2.1 EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner which intends to maximize its emission characteristics in a continuous normal application.

2.2 EUT Exercise

The Transmitter was operated in the normal operating mode. The TX frequency was fixed which was for the purpose of the measurements.

2.3 Test Procedure

2.3.1 Conducted Emissions

The EUT is a placed on as turn table which is 0.8 m above ground plane. According to the requirements in Section 13.1.4.1 of ANSI C63.10-2013 Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30 MHz using CISPR Quasi-Peak and average detector mode.

2.3.2 Radiated Emissions

The EUT is a placed on as turn table which is 0.8 m above ground plane. The turn table shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3m away from the receiving antenna which varied from 1m to 4m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. Emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 13.1.4.1 of ANSI C63.10-2013.

2.4 Configuration of Tested System

Fig. 2-1 Configuration of Tested System

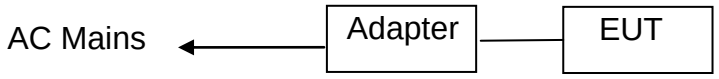


Table 2-1 Equipment Used in Tested System

Item	Equipment	Trademark	Model No.	FCC ID	Note
1.	Zalpha Series - Autonomous Mobile Robot	ZALPHA	Zalpha-TS-EB-05	2AP2R-ZALPHA3-TS	EUT
2.	Adapter	ZALPHA	Zalpha-CH01	N/A	***Support Equipment***

Note:

(1) Unless otherwise denoted as EUT in『Remark』column, device(s) used in tested system is a support equipment.

3. Description of Test Modes

The EUT has been tested under its typical operating condition.
The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner which intends to maximize its emission characteristics in a continuous normal application.

The Transmitter was operated in the normal operating mode. The TX frequency was fixed which was for the purpose of the measurements.

Test of channel included the lowest and middle and highest frequency to perform the test, then record on this report.

Those data rates (802.11b: 1 Mbps; 802.11g: 6 Mbps; 802.11n (HT20): MCS0; 802.11n (HT40): MCS0) were used for all test.

Pre-defined engineering program for regulatory testing used to control the EUT for staying in continuous transmitting mode is programmed. EUT is connected by com port, and transimit the control instruction via test software(artgui.exe).

Frequency and Channel list for 802.11 b/g/n (HT20):

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

Frequency and Channel list for 802.11 n (HT40):

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
3	2422	5	2432	8	2447
4	2427	6	2437	9	2452
		7	2442		

Test Frequency and Channel for 802.11 b/g/n (HT20):

Lowest Frequency		Middle Frequency		Highest Frequency	
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2412	6	2437	11	2462

Test Frequency and channel for 802.11 n (HT40):

Lowest Frequency		Middle Frequency		Highest Frequency	
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
3	2422	6	2437	9	2452

Operated Mode for Worst Duty cycle:

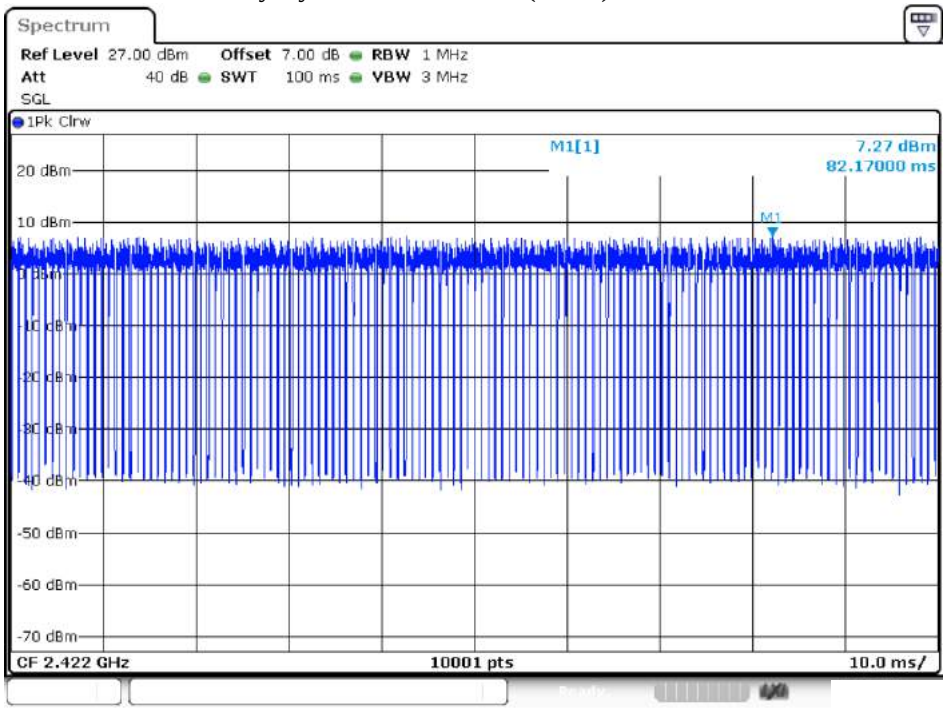
We tested antenna A and antenna B. The test results are similar, the worst test data for Antenna A:

Duty Cycle:

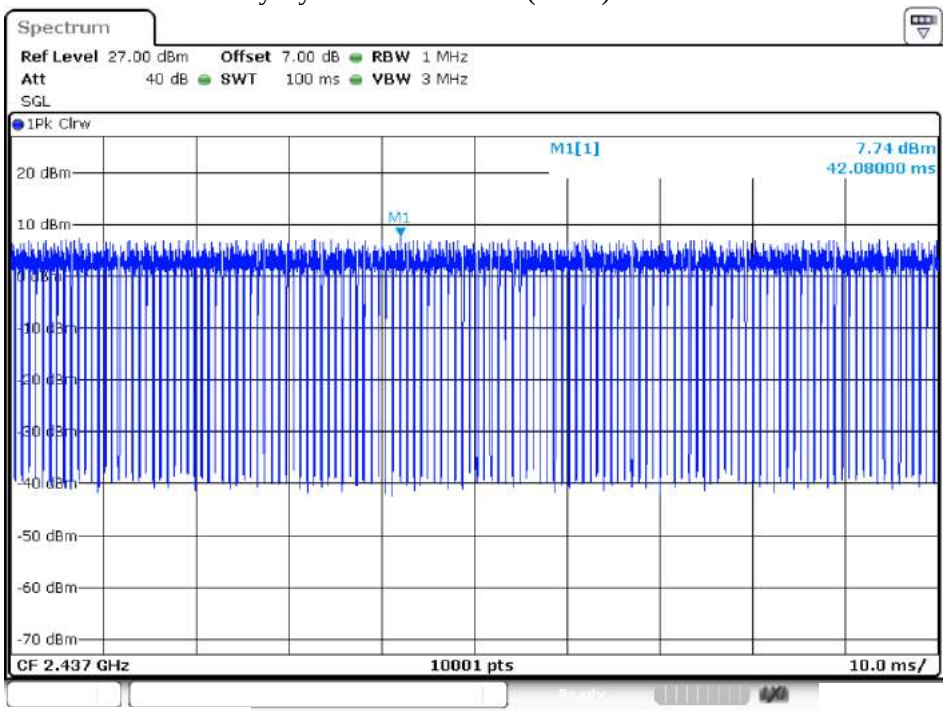
Mode	Frequency (MHz)	Duty Cycle (%)	Correction Factor (dB)
802.11b	2412	99.96	0
802.11b	2437	99.93	0
802.11b	2462	99.96	0
802.11g	2412	99.48	0.02
802.11g	2437	99.54	0.02
802.11g	2462	99.75	0.01
802.11n(HT20)	2412	99.74	0.01
802.11n(HT20)	2437	99.66	0.01
802.11n(HT20)	2462	99.71	0.01
802.11n(HT40)	2422	99.38	0.03
802.11n(HT40)	2437	99.22	0.03
802.11n(HT40)	2452	99.32	0.03

All the modulation modes were tested the data of the worst mode (TX 802.11n HT40) are recorded in the following pages:

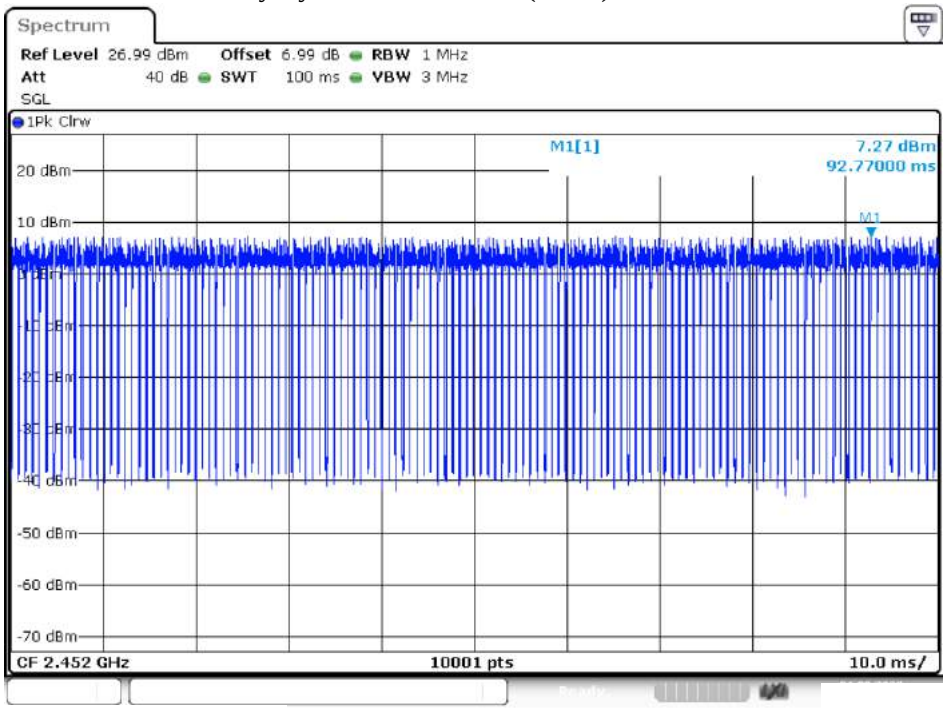
Duty Cycle NVNT 802.11n(HT40) 2422MHz



Duty Cycle NVNT 802.11n(HT40) 2437MHz



Duty Cycle NVNT 802.11n(HT40) 2452MHz



4. Summary of Test Results

FCC Rules	Description Of Test	Result
§15.247(a)(2)	6dB bandwidth	Pass
§15.247(b)(3)	Max Peak output Power test	Pass
§15.247(e)	Power density	Pass
§15.247(d)	Band edge test	Pass
§15.207	AC Power Conducted Emission	Pass
§15.247(d), §15.209	Radiated Emission	Pass
§15.247(d)	Antenna Port Emission	Pass
§15.247(b)&§15.203	Antenna Application	Pass

RELATED SUBMITTAL(S) / GRANT(S):

This submittal(s) (test report) is intended for FCC ID: 2AP2R-ZALPHA3-TS filing to comply with Section 15.247 of the FCC Part 15, Subpart C Rules.

5. Test Methodology

According to its specifications, the EUT must comply with the requirements of the following standards:
FCC 47 CFR Part 2, Subpart J
FCC 47 CFR Part 15, Subpart C
KDB 558074 D01 15.247 Meas Guidance v05r02
FCC KDB 662911 D01 Multiple Transmitter Output v02r01
FCC KDB 662911 D02 MIMO With Cross Polarized Antenna V01

6. Test Facility

Site Description

EMC Lab	:	Accredited by CNAS, 2017.06.26 The certificate is valid until 2022.10.28 The Laboratory has been assessed and proved to be in compliance with CNAS-CL01:2006 (identical to ISO/IEC 17025:2005) The Certificate Registration Number is L6214. Accredited by A2LA, 2018.03.15 The Certificate Number is 4422.01. .
Name of Firm	:	Dong Guan Anci Electronic Technology Co., Ltd. 1-2 Floor, Building A, No.11, Headquarters 2 Road, Songshan, Lake Hi-tech Industrial Development Zone, Dongguan City, Guangdong Pr., China.

7. TEST SYSTEM UNCERTAINTY

The following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty
Radio Frequency	±1x10^-5
Maximum Peak Output Power Test	±1.0dB
Conducted Emissions Test	±2.0dB
Radiated Emission Test	±2.0dB
Power Density	±2.0dB
Occupied Bandwidth Test	±1.0dB
Band Edge Test	±3dB
All emission, radiated	±3dB
Antenna Port Emission	±3dB
Temperature	±0.5℃
Humidity	±3%

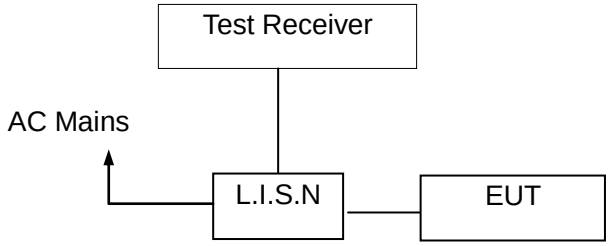
Measurement Uncertainty for a level of Confidence of 95%

8. Conducted Emissions Test

8.1 Measurement Procedure

1. The EUT was placed on a table which is 0.8m above ground plane.
2. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
3. Repeat above procedures until all frequency measured were complete.

8.2 Test SET-UP (Block Diagram of Configuration)



8.3 Measurement Equipment Used

Conducted Emission Test Site				
EQUIPMENT TYPE	**MFR**	**MODEL NUMBER**	**SERIAL NUMBER**	**Calibrated until**
L.I.S.N	SCHWARZBECK	NSLK 8127	8127-669	2022-05-22
10 db attenuator	JFW	50FP-010-H4	4360846-427-1	2022-05-22
RF Cable	N/A	N/A	2#	2022-05-22
EMI Test Receiver	ROHDE&SCHWARZ	ESCI	101358	2022-05-22
Shielded Room	chengyu	8m*4m*3m	N/A	2022-05-22
Test Software	Farad	EZ-EMC Ver:ANCI-8A1	N/A	N/A

8.4 Conducted Emission Limit

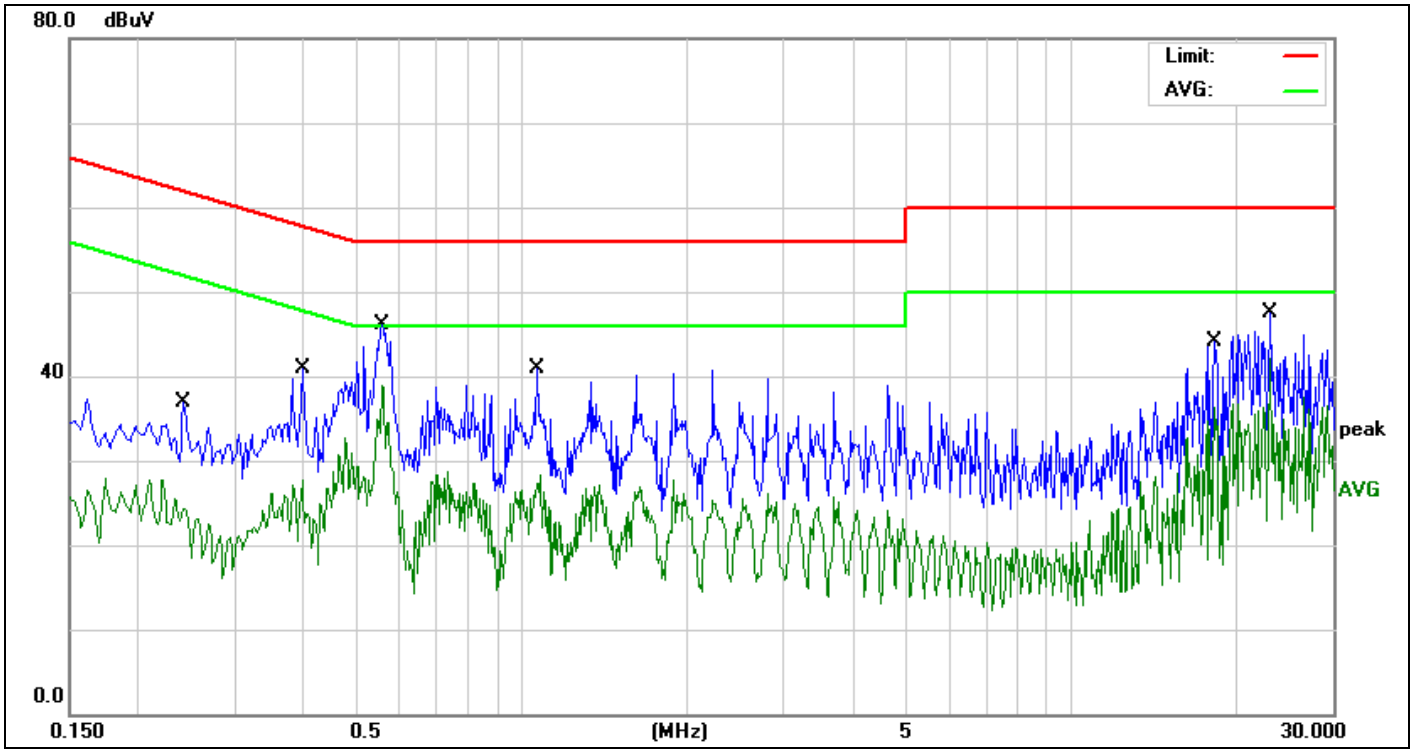
Conducted Emission

Frequency(MHz)	**Quasi-peak**	**Average**
0.15-0.5	66-56	56-46
0.5-5.0	56	46
5.0-30.0	60	50

Note: 1. The lower limit shall apply at the transition frequencies
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

8.5 Measurement Result

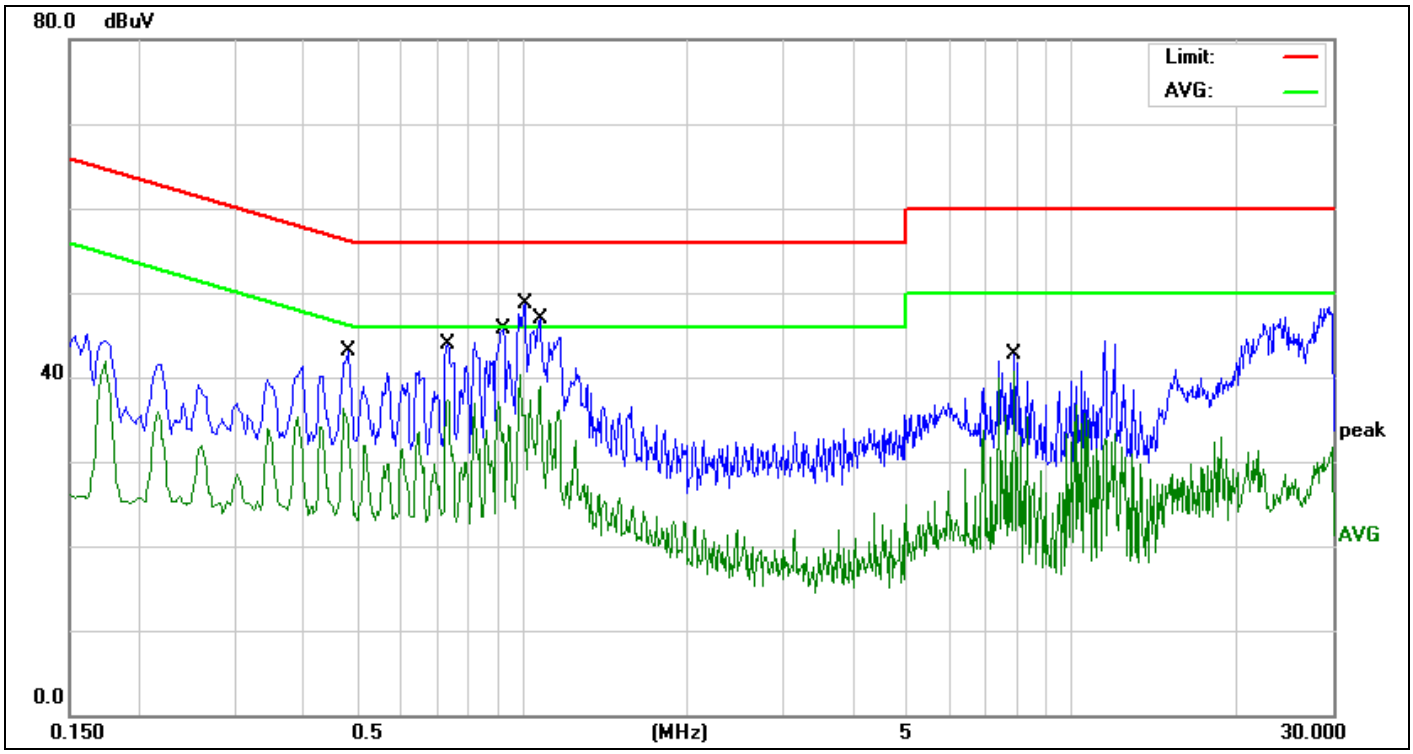
All the modulation modes were tested the data of the worst mode (TX 802.11n HT40 MIMO 2452MHz) are recorded in the following pages and the others modulation methods do not exceed the limits. Please refer to following pages.



Site:	**843**	**Phase:L1**	**Temperature(C):26(C)**
Limit:	**FCC PART 15C Conduction(QP)**		**Humidity(%):60%**
EUT:	**Zalpha Series - Autonomous Mobile Robot**	**Test Time:**	**2021-07-02**
M/N.:	**Zalpha-TS-EB-05**	**Power Rating:**	**AC 240V/60Hz**
Mode:	**WIFI TX2452**	**Test Engineer:**	**Sunshine**
Note:			

No.	Frequency (MHz)	Reading Level(dBuV)	Factor (dB)	Measure-ment(dBuV)	Limit (dBuV)	Over (dB)	Detector	Comment
1	0.9300	32.75	9.81	42.56	56.00	-13.44	QP	
2	0.9300	22.35	9.81	32.16	46.00	-13.84	AVG	
3	1.0180	35.57	9.82	45.39	56.00	-10.61	QP	
4	1.0180	24.45	9.82	34.27	46.00	-11.73	AVG	
5	1.0859	36.28	9.84	46.12	56.00	-9.88	QP	
6 *	1.0859	31.22	9.84	41.06	46.00	-4.94	AVG	
7	1.1820	34.20	9.87	44.07	56.00	-11.93	QP	
8	1.1820	22.10	9.87	31.97	46.00	-14.03	AVG	
9	7.8700	31.29	10.03	41.32	60.00	-18.68	QP	
10	7.8700	31.03	10.03	41.06	50.00	-8.94	AVG	
11	21.0020	34.25	10.15	44.40	60.00	-15.60	QP	
12	21.0020	24.17	10.15	34.32	50.00	-15.68	AVG	

*:Maximum data x:Over limit !:over margin



Site:	**843**	**Phase:N**	**Temperature(C):26(C)**
Limit:	**FCC PART 15C Conduction(QP)**		**Humidity(%):60%**
EUT:	**Zalpha Series - Autonomous Mobile Robot**	**Test Time:**	**2021-07-02**
M/N.:	**Zalpha-TS-EB-05**	**Power Rating:**	**AC 240V/60Hz**
Mode:	**WIFI TX2452**	**Test Engineer:**	**Sunshine**
Note:			

No.	Frequency (MHz)	Reading Level(dBuV)	Factor (dB)	Measure-ment(dBuV)	Limit (dBuV)	Over (dB)	Detector	Comment
1	0.4860	31.22	9.73	40.95	56.24	-15.29	QP	
2	0.4860	22.51	9.73	32.24	46.24	-14.00	AVG	
3	0.7340	32.17	9.77	41.94	56.00	-14.06	QP	
4 *	0.7340	27.22	9.77	36.99	46.00	-9.01	AVG	
5	0.9260	34.29	9.81	44.10	56.00	-11.90	QP	
6	0.9260	23.86	9.81	33.67	46.00	-12.33	AVG	
7	1.0140	36.97	9.82	46.79	56.00	-9.21	QP	
8	1.0140	25.94	9.82	35.76	46.00	-10.24	AVG	
9	1.0780	34.59	9.84	44.43	56.00	-11.57	QP	
10	1.0780	26.69	9.84	36.53	46.00	-9.47	AVG	
11	7.8700	31.04	10.03	41.07	60.00	-18.93	QP	
12	7.8700	30.26	10.03	40.29	50.00	-9.71	AVG	

*:Maximum data x:Over limit !:over margin

9. Radiated Emission Test

9.1 Measurement Procedure

1. Below 1000MHz, The EUT was placed on a turn table which is 0.8m above ground plane, And above 1000MHz, The EUT was placed on a styrofoam table which is 1.5m above ground plane.
2. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measured was complete.

When spectrum scanned from 30MHz to 1GHz setting resolution bandwidth 120KHz and video bandwidth 300KHz:

EMI Test Receiver	Setting
Attenuation	Auto
RBW	120KHz
VBW	300KHz
Detector	QP
Trace	Max hold

When spectrum scanned above 1GHz setting resolution bandwidth 1MHz, video bandwidth 3MHz:

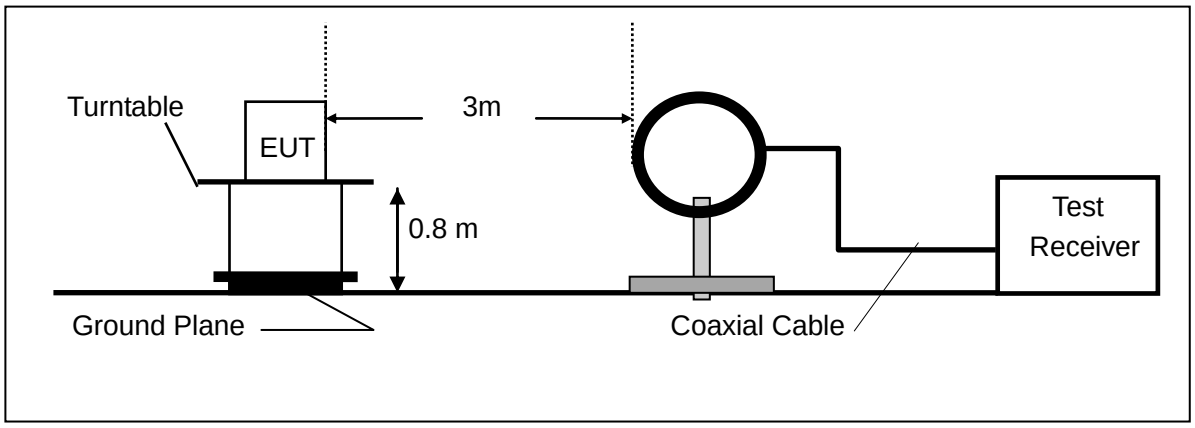
EMI Test Receiver	Setting
Attenuation	Auto
RBW	1MHz
VBW	3MHz
Detector	Peak
Trace	Max hold

When spectrum scanned above 1GHz setting resolution bandwidth 1MHz, video bandwidth 10Hz:

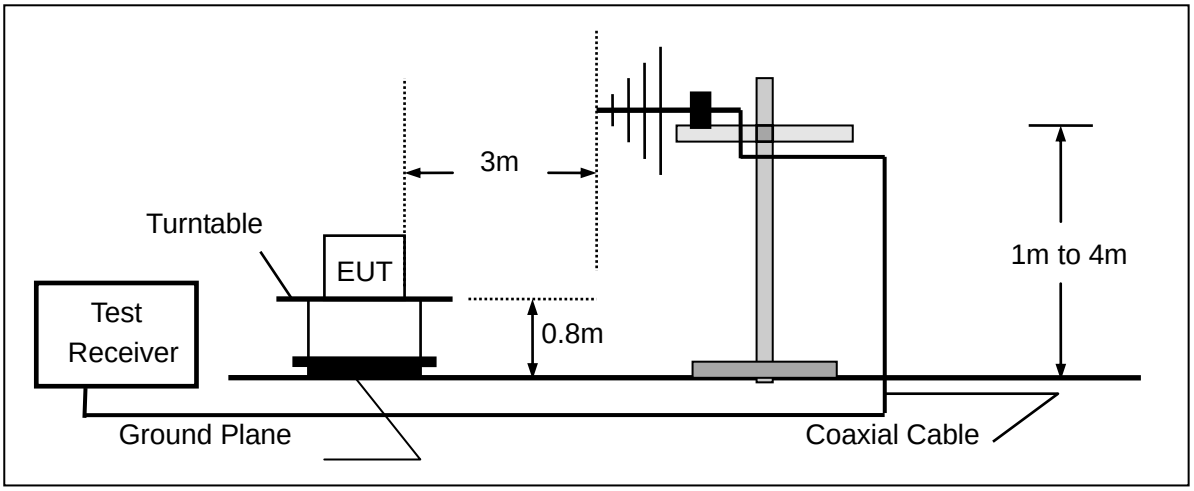
EMI Test Receiver	Setting
Attenuation	Auto
RBW	1MHz
VBW	10Hz
Detector	Peak
Trace	Max hold

9.2 Test SET-UP (Block Diagram of Configuration)

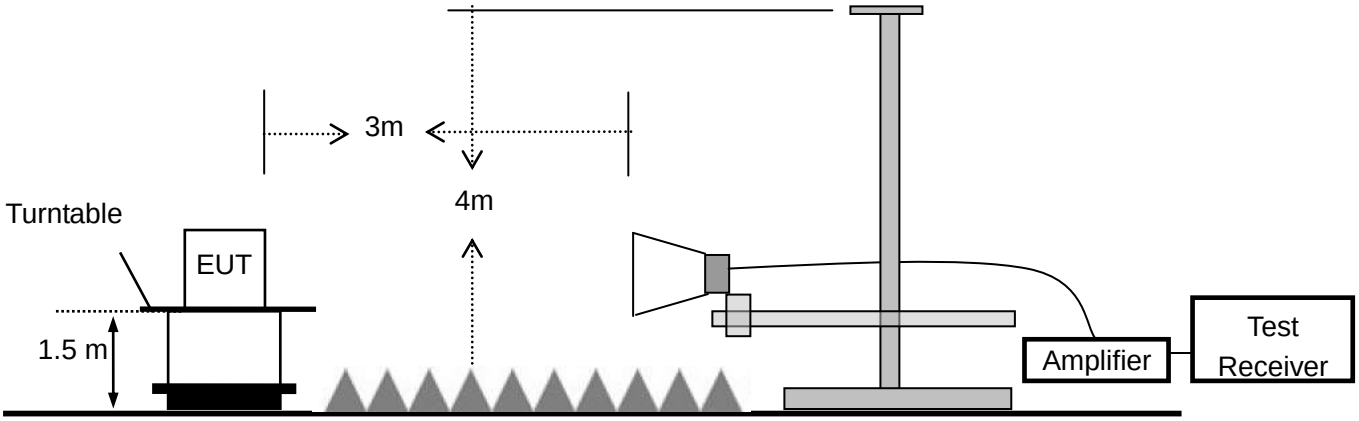
(A) Radiated Emission Test Set-Up, Frequency Below 30MHz



(B) Radiated Emission Test Set-Up, Frequency Below 1000MHz



(C) Radiated Emission Test Set-Up, Frequency above 1000MHz



9.3 Measurement Equipment Used

Item	Equipment	Manufacturer	Model No.	Serial No.	Calibrated until
1.	EMI Test Receiver	Rohde & Schwarz	ESPI	100502	2021-11-19
2.	Pre-Amplifier	HP	8447D	2727A06172	2022-05-22
3.	Bilog Antenna	Schwarzbeck	VULB9163	VULB9163-588	2022-05-22
4.	Loop Antenna	Schwarzbeck	FMZB 1516	1516-141	2021-11-19
5.	Spectrum Analyzer	Rohde & Schwarz	FSV40	US40240623	2021-11-19
6.	Low noise Amplifiers	A-INFO	LA1018N4009	J1013130524001	2022-05-22
7.	Horn antenna	A-INFO	LB-10180-SF	J2031090612123	2022-05-22
8.	Broadband RF Power Amplifier	AEROFLEX	AEROFLEX100KHz-40GHz	J1013130524001	2021-11-19
9.	DRG Horm Antenna	A.H.SYSTEMS	SAS-574	J2031090612123	2021-11-19
10.	RF Cable	Gigalink Microwave	ZT40-2.92J-2.92J-2m	N/A	2021-11-19
11.	RF Cable	Gigalink Microwave	ZT40-2.92J-2.92J-0.3m	N/A	2021-11-19
12.	RF Cable	N/A	N/A	6#	2022-05-22
13.	RF Cable	N/A	N/A	1-1#	2022-05-22
14.	RF Cable	N/A	N/A	1-2#	2022-05-22
15.	RF Cable	N/A	N/A	7#	2022-05-22
16.	3m Semi-anechoic Chamber	chengyu	9m*6m*6m	N/A	2022-05-22
17.	Test Software	Farad	EZ-EMC Ver:ANCI-3A1	N/A	N/A

9.4 Radiated Emission Limit

The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table15.209(a):

Frequencies (MHz)	Field Strength (micorvolts/meter)	Measurement Distance (meters)
0.009~0.490	2400/F(KHz)	300
0.490~1.705	24000/F(KHz)	30
1.705~30.0	30	30
30~88	100	3
88~216	150	3
216~960	200	3
Above 960	500	3

Restricted bands of operation

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])

Remark : 1. Emission level in dBuV/m=20 log (uV/m)

2. Measurement was performed at an antenna to the closed point of EUT distance of meters.

3. Only spurious frequency is permitted to locate within the Restricted Bands specified in provision of ξ 15.205, and the emissions located in restricted bands also comply with 15.209 limit.

9.5 Measurement Result

Below 30MHz:

All the modulation modes were tested the data of the test mode are recorded in the following pages.

Operation Mode:	TX Mode	Test Date :	2021-07-02
Frequency Range:	9KHz~30MHz	Temperature :	28℃
Test Result:	PASS	Humidity :	60 %
Measured Distance:	3m	Test By:	Andy

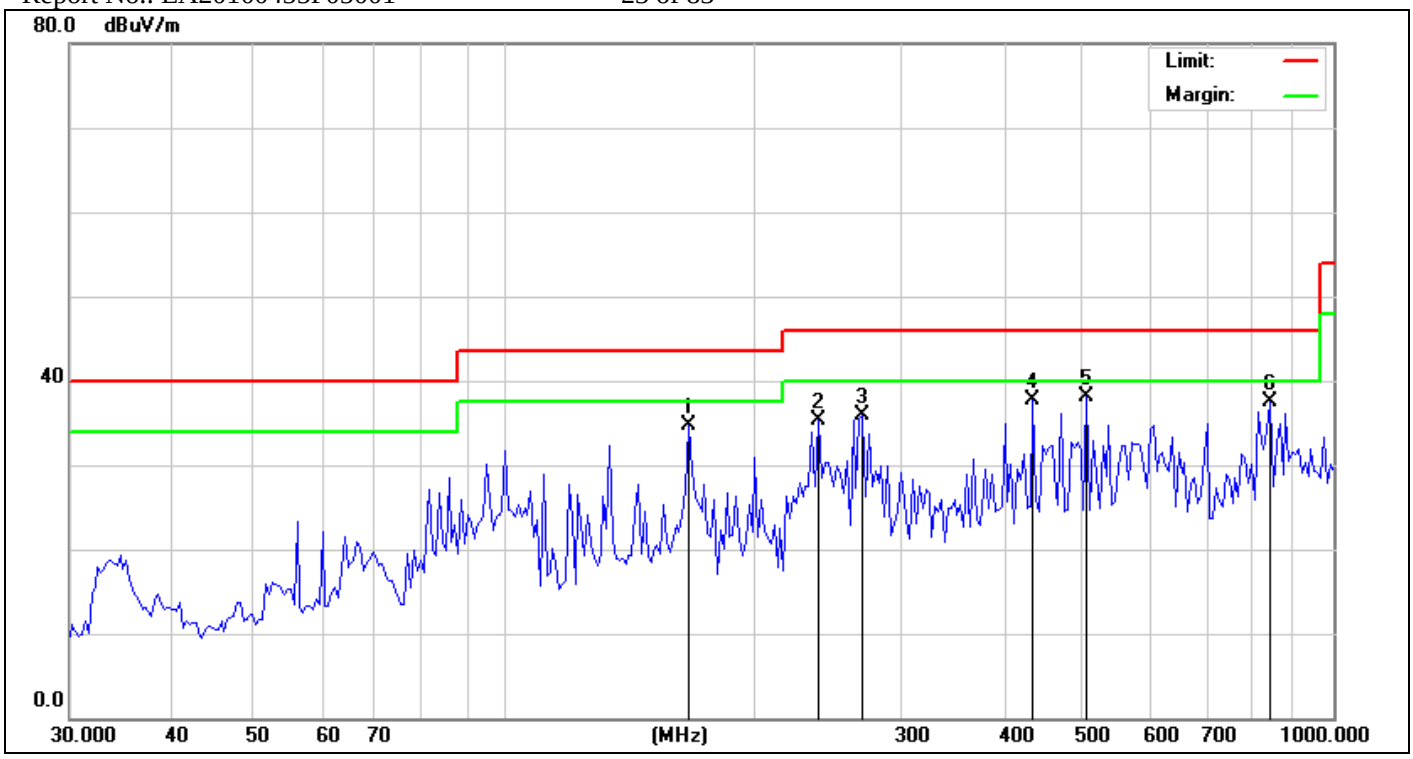
Freq. (MHz)	Ant.Pol. H/V	Emission Level (dBuV/m)	Limit 3m (dBuV/m)	Over (dB)
--	--	--	--	--

Note: the amplitude of spurious emission that is attenuated by more than 20dB below the permissible limit has no need to be reported.
Distance extrapolation factor =40log(Specific distance/ test distance)(dB);
Limit line=Specific limits(dBuV) + distance extrapolation factor.

Below 1000MHz:

All the modulation modes were tested the data of the worst mode (ANT1: 802.11b 2412MHz) are recorded in the following pages and the others modulation methods do not exceed the limits.

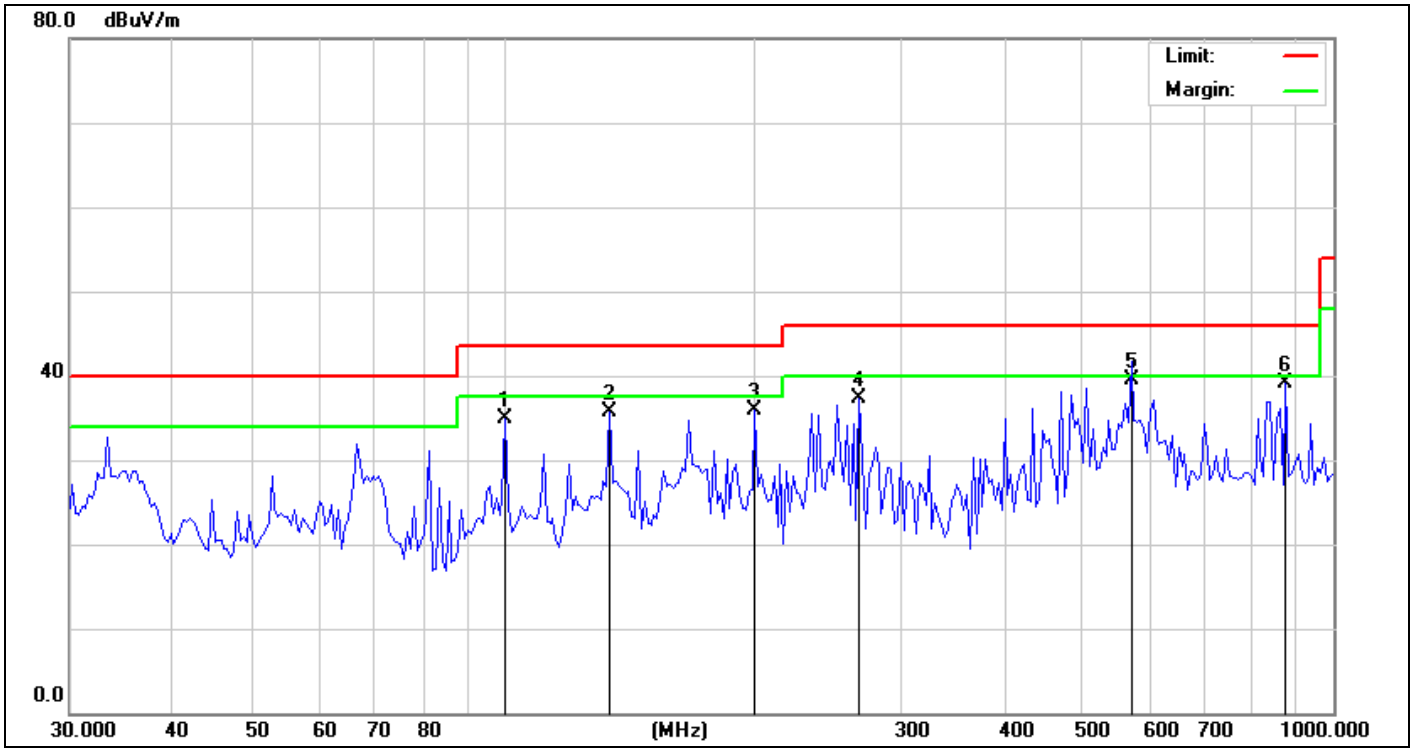
Please refer to the following test plots:



Site:	**LAB**	**Antenna::Horizontal**	**Temperature(C):26(C)**
Limit:	**FCC Part 15 C 3m Radiation**		**Humidity(%):60%**
EUT:	**Zalpha Series - Autonomous Mobile Robot**	**Test Time:**	**2021-07-02**
M/N.:	**Zalpha-TS-EB-05**	**Power Rating:**	**Battery 25.6V**
Mode:	**TX2412**	**Test Engineer:**	**Dyson**
Note:			

No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Det.	Remark
1	167.2366	52.60	-17.83	34.77	43.50	-8.73	QP	
2	239.5670	50.01	-14.76	35.25	46.00	-10.75	QP	
3	270.8493	49.57	-13.74	35.83	46.00	-10.17	QP	
4	434.8267	48.15	-10.44	37.71	46.00	-8.29	QP	
5 *	504.7062	47.06	-8.95	38.11	46.00	-7.89	QP	
6	839.1816	41.10	-3.57	37.53	46.00	-8.47	QP	

Note: 1. Result Level = Read Level+ Antenna Factor+ Cable Loss- Amp. Factor



Site:	**LAB**	**Antenna::Vertical**	**Temperature(C):26(C)**
Limit:	**FCC Part 15 C 3m Radiation**		**Humidity(%):60%**
EUT:	**Zalpha Series - Autonomous Mobile Robot**	**Test Time:**	**2021-07-02**
M/N.:	**Zalpha-TS-EB-05**	**Power Rating:**	**Battery 25.6V**
Mode:	**TX2412**	**Test Engineer:**	**Dyson**
Note:			

No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Det.	Remark
1	100.5806	52.15	-17.19	34.96	43.50	-8.54	QP	
2	134.3232	54.25	-18.64	35.61	43.50	-7.89	QP	
3	201.0398	52.15	-16.26	35.89	43.50	-7.61	QP	
4	268.4852	51.07	-13.83	37.24	46.00	-8.76	QP	
5 *	570.6100	46.58	-7.02	39.56	46.00	-6.44	QP	
6	876.7829	42.25	-3.08	39.17	46.00	-6.83	QP	

Note: 1. Result Level = Read Level+ Antenna Factor+ Cable Loss- Amp. Factor

Above 1000MHz:

Operation Mode: 802.11b Lowest Test Date : 2021-07-02
Test Voltage: AC 120V/60Hz Test by: Andy

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4824	V	95.88	77.07	-32.3	63.58	44.77	74	54	-10.42	-9.23
7236	V	99.69	81.32	-37.2	62.49	44.12	74	54	-11.51	-9.88
9648	V	103.36	83.83	-39.8	63.56	44.03	74	54	-10.44	-9.97
12060	V	103.64	84.09	-40.5	63.14	43.59	74	54	-10.86	-10.41
14472	V	105.75	84.82	-41.7	64.05	43.12	74	54	-9.95	-10.88
16884	V	102.49	83.88	-40	62.49	43.88	74	54	-11.51	-10.12
4824	H	93.73	74.57	-31.6	62.13	42.97	74	54	-11.87	-11.03
7236	H	98.17	78.11	-35.5	62.67	42.61	74	54	-11.33	-11.39
9648	H	99.85	80.77	-38.3	61.55	42.47	74	54	-12.45	-11.53
12060	H	100.94	80.59	-39	61.94	41.59	74	54	-12.06	-12.41
14472	H	102.85	83.67	-42	60.85	41.67	74	54	-13.15	-12.33
16884	H	100.24	79.63	-39.3	60.94	40.33	74	54	-13.06	-13.67

Operation Mode: 802.11b Middle Test Date : 2021-07-02
Test Voltage: AC 120V/60Hz Test by: Andy

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4874	V	96.32	75.89	-32.3	64.02	43.59	74	54	-9.98	-10.41
7311	V	101.31	80.84	-37.2	64.11	43.64	74	54	-9.89	-10.36
9688	V	103.39	83.01	-39.8	63.59	43.21	74	54	-10.41	-10.79
12185	V	103.83	82.68	-40.5	63.33	42.18	74	54	-10.67	-11.82
14622	V	103.69	83.16	-41	62.69	42.16	74	54	-11.31	-11.84
17059	V	104.58	83.25	-41.1	63.48	42.15	74	54	-10.52	-11.85
4874	H	93.74	72.17	-31.6	62.14	40.57	74	54	-11.86	-13.43
7311	H	96.59	75.61	-35.5	61.09	40.11	74	54	-12.91	-13.89
9688	H	101.72	77.89	-38.3	63.42	39.59	74	54	-10.58	-14.41
12185	H	99.34	78.87	-39	60.34	39.87	74	54	-13.66	-14.13
14622	H	102.59	81.12	-42	60.59	39.12	74	54	-13.41	-14.88
17059	H	101.37	79.66	-41.5	59.87	38.16	74	54	-14.13	-15.84

Operation Mode: 802.11b Highest

Test Voltage: AC 120V/60Hz

Test Date : 2021-07-02

Test by: Andy

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4924	V	95.96	76.46	-32.3	63.66	44.16	74	54	-10.34	-9.84
7386	V	100.35	80.84	-37.2	63.15	43.64	74	54	-10.85	-10.36
9848	V	103.85	82.95	-39.8	64.05	43.15	74	54	-9.95	-10.85
12310	V	104.61	83.76	-40.5	64.11	43.26	74	54	-9.89	-10.74
14772	V	104.94	83.55	-41	63.94	42.55	74	54	-10.06	-11.45
17234	V	104.22	83.26	-41.1	63.12	42.16	74	54	-10.88	-11.84
4924	H	91.71	73.77	-31.6	60.11	42.17	74	54	-13.89	-11.83
7386	H	97.38	77.19	-35.5	61.88	41.69	74	54	-12.12	-12.31
9848	H	99.43	78.64	-38.3	61.13	40.34	74	54	-12.87	-13.66
12310	H	99.32	79.22	-39	60.32	40.22	74	54	-13.68	-13.78
14772	H	101.58	83.19	-42	59.58	41.19	74	54	-14.42	-12.81
17234	H	100.29	82.39	-41.5	58.79	40.89	74	54	-15.21	-13.11

All emissions not reported were more than 20dB below the specified limit or in the noise floor.

Note: (1) All Readings are Peak Value and AV.
(2) Emission Level= Reading Level+Probe Factor +Cable Loss.
(3) Data of measurement within this frequency range shown " – " in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

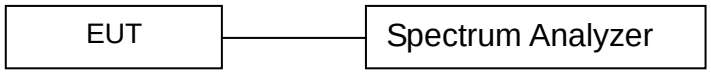
10. 6dB Bandwidth Test

10.1Measurement Procedure

The EUT was operating in IEEE 802.11b, 802.11g, 802.11n(HT20), 802.11n(HT40) mode or could be controlled its channel. Printed out the test result from the spectrum by hard copy function.

1. Set resolution bandwidth (RBW) = 100 kHz.
2. Set the video bandwidth (VBW) ≥ 3 x RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequency) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

10.2Test SET-UP (Block Diagram of Configuration)



10.3Measurement Equipment Used

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	CALIBRATED UNTIL
Spectrum Analyzer	Rohde & Schwarz	FSV40	US40240623	2021-11-19
Coaxial Cable	Gigalink Microwave	ZT40	19022092	2021-11-19
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	2021-11-19

Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

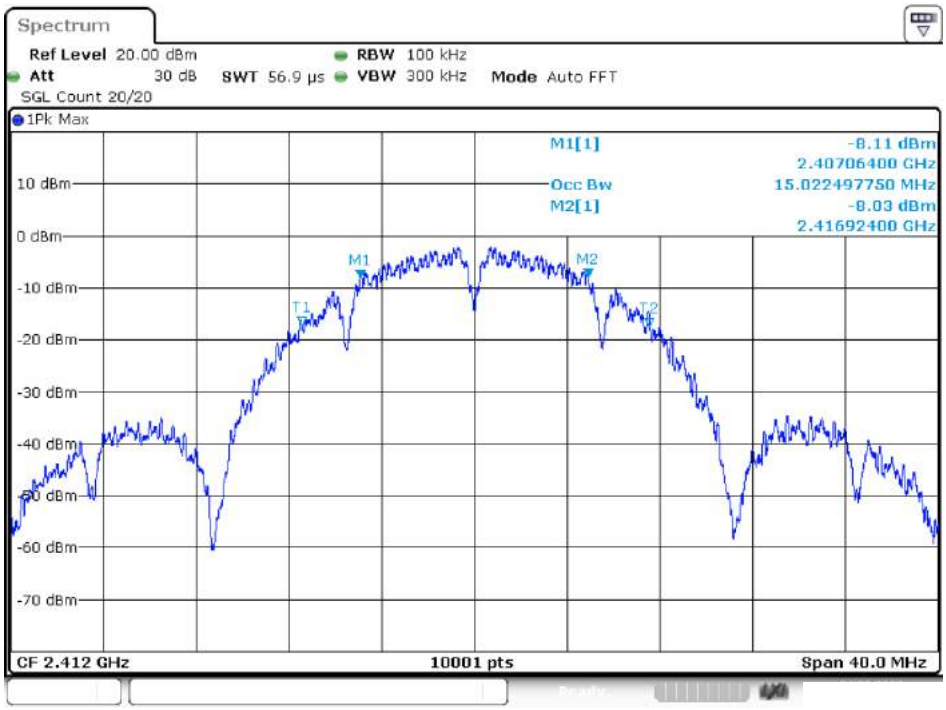
10.4Measurement Results

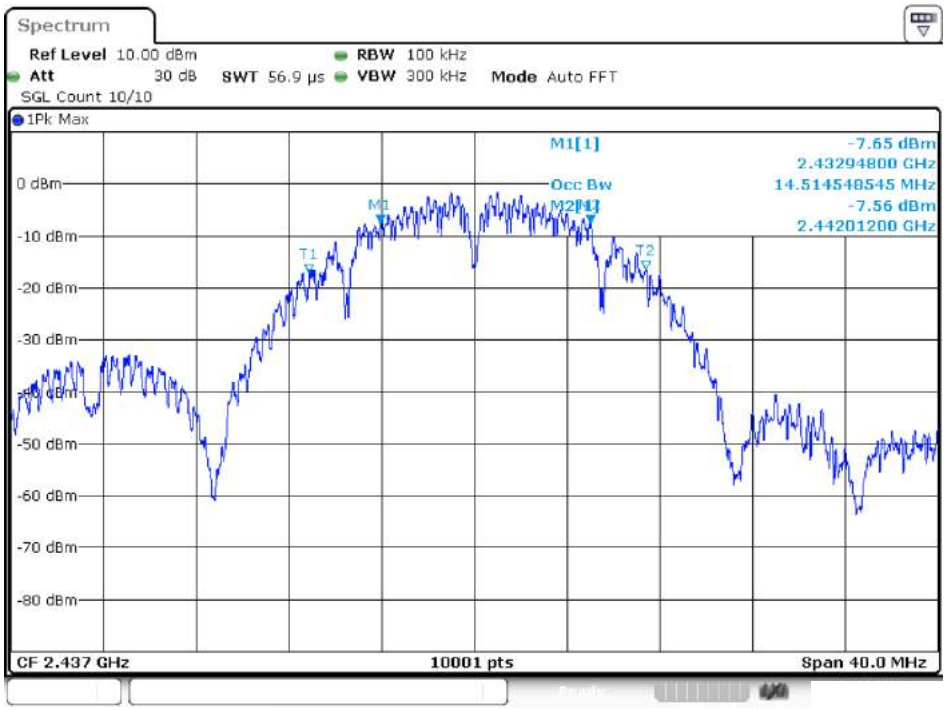
6 Bandwidth Test Data Chart:

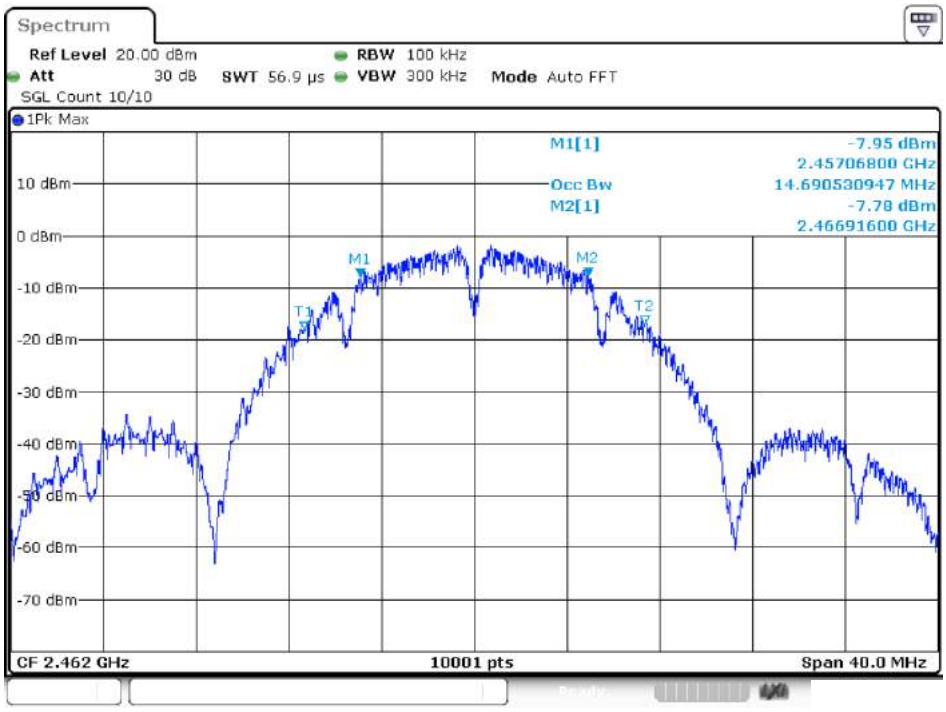
Refer to attached data chart.

Spectrum Detector:	PK	Test Date :	June 28, 2021
Test By:	Andy	Temperature :	28℃
Humidity :	60%		

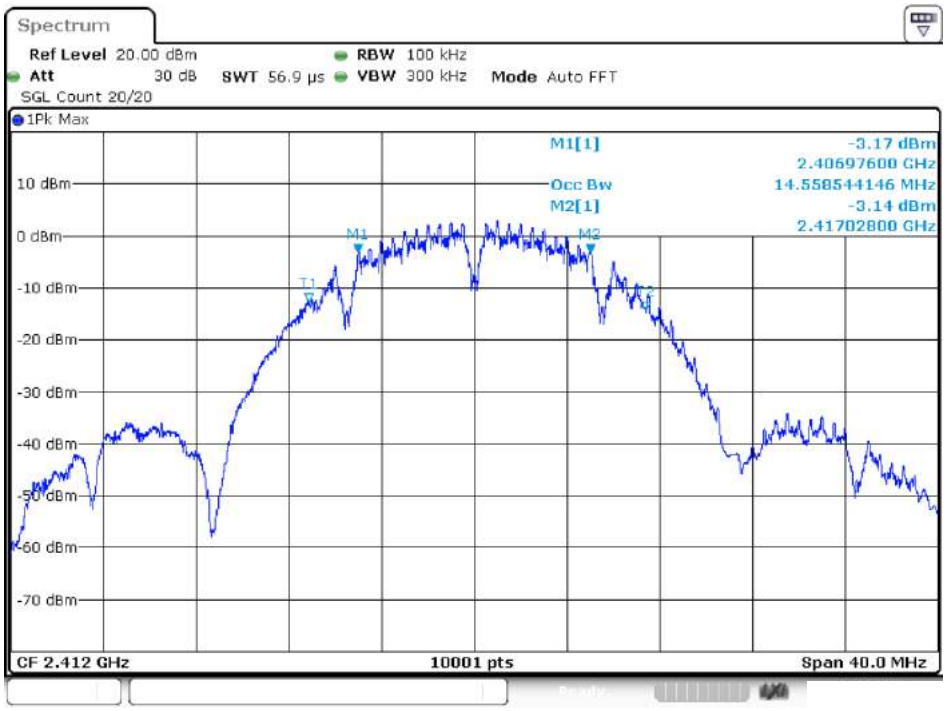
IEEE 802.11b SISO Ant1			
Channel frequency (MHz)	Measurement level (MHz)	Required Limit (KHz)	Result
2412	9.860	>500	Pass
2437	9.064	>500	
2462	9.848	>500	

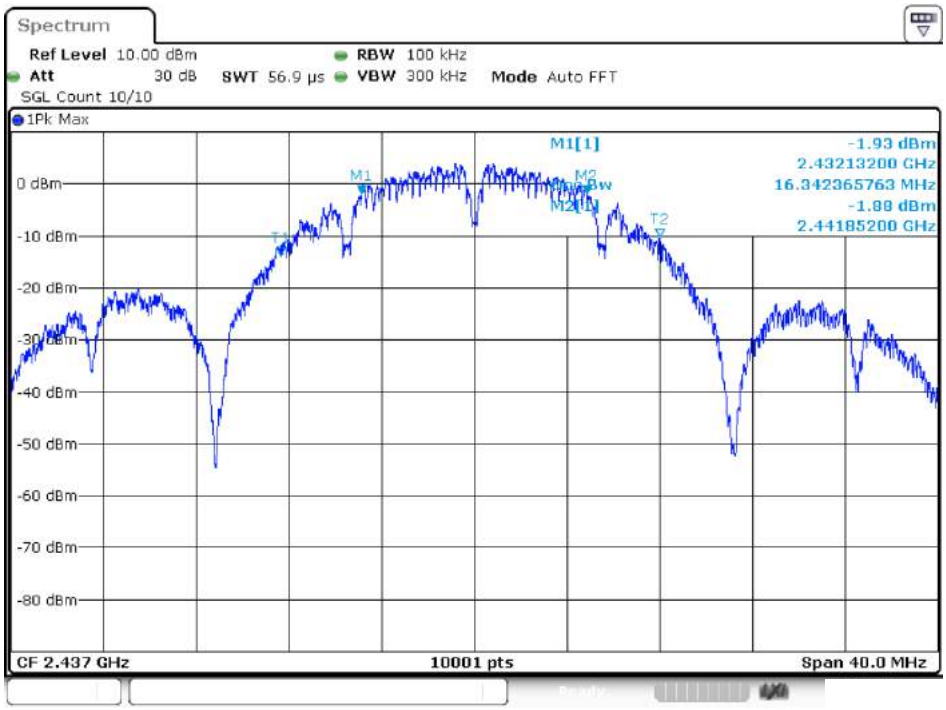


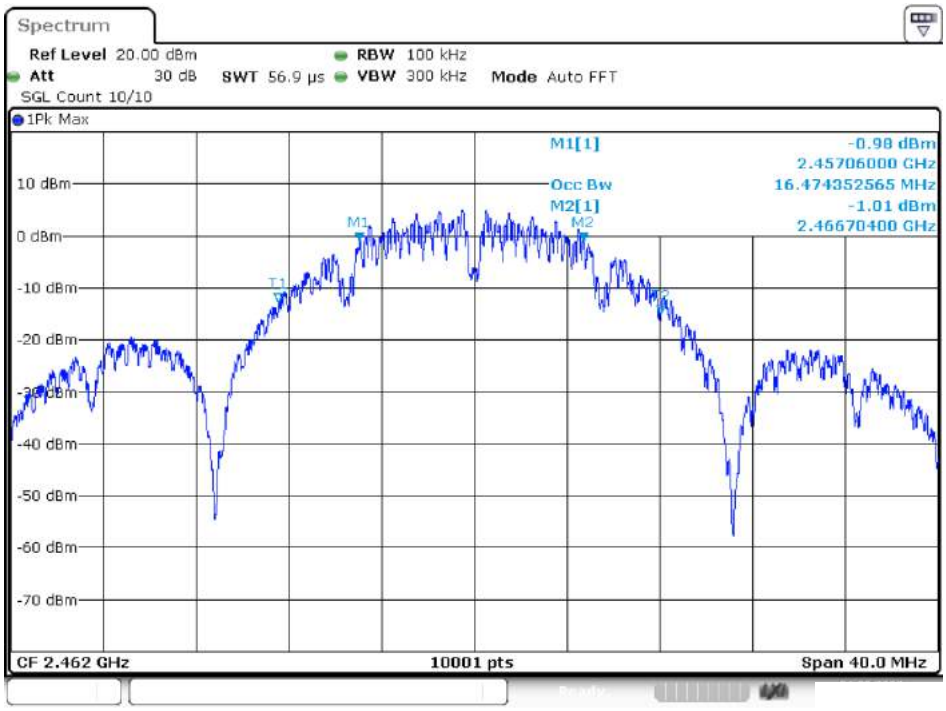

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -7.65 dBm 2.43294800 GHz
Occ Bw 14.514548545 MHz
M2[1] -7.56 dBm 2.44201200 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 40.0 MHz


Spectrum
Ref Level 20.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -7.95 dBm 2.45706800 GHz
Occ Bw 14.690530947 MHz
M2[1] -7.78 dBm 2.46691600 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
CF 2.462 GHz
10001 pts
Span 40.0 MHz

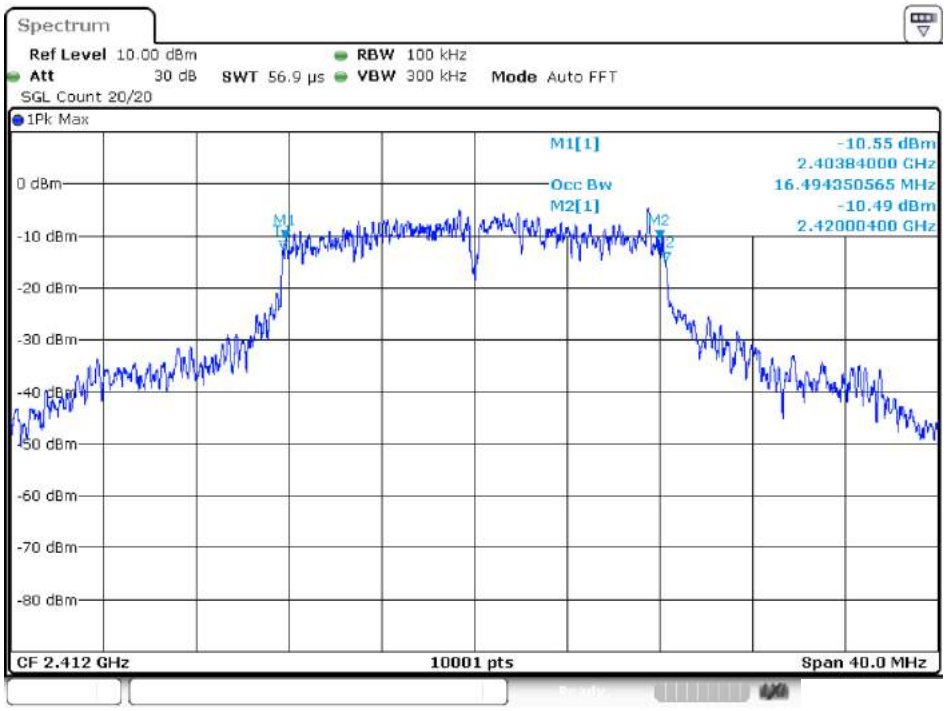
IEEE 802.11b SISO Ant2			
Channel frequency (MHz)	Measurement level (MHz)	Required Limit (KHz)	Result
2412	10.052	>500	Pass
2437	9.720	>500	
2462	9.644	>500	

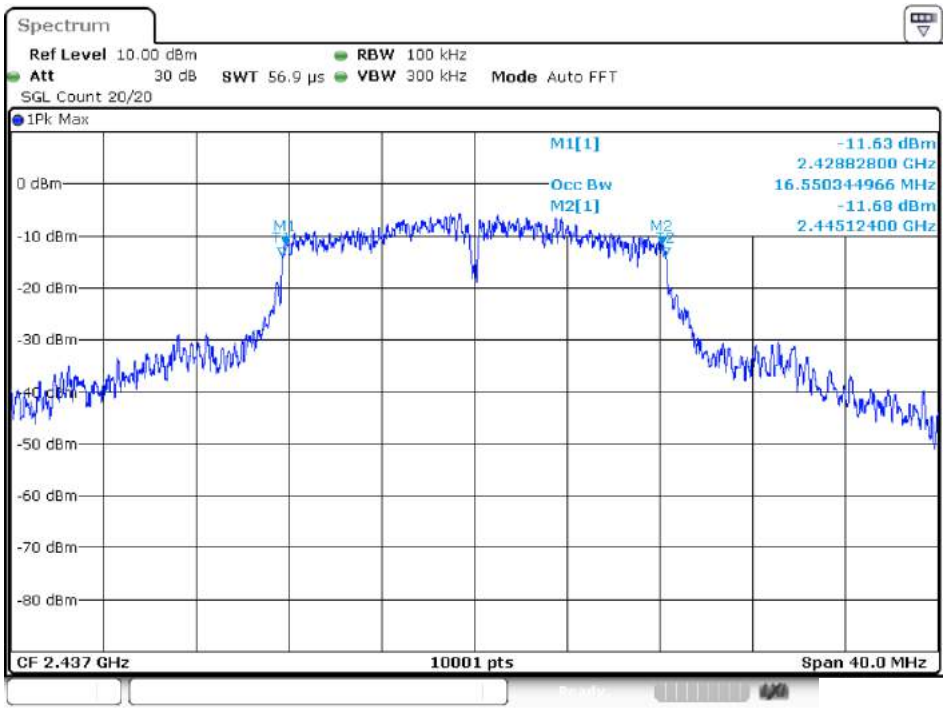


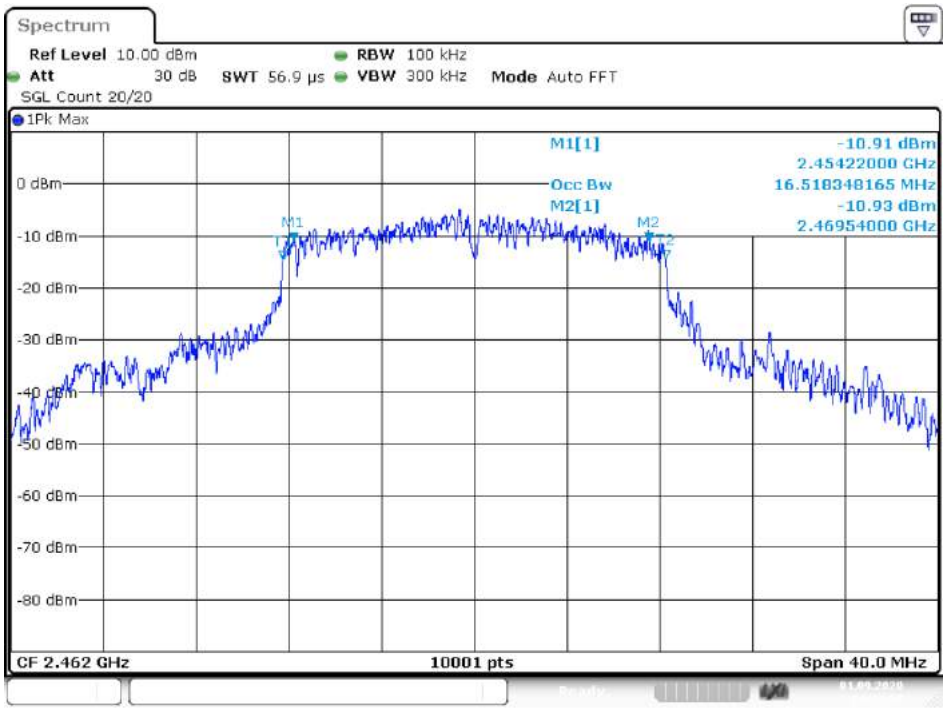

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1]
-1.93 dBm
2.43213200 GHz
16.342365763 MHz
-1.88 dBm
2.44185200 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 40.0 MHz


Spectrum
Ref Level 20.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1]
-0.98 dBm
2.45706000 GHz
16.474352565 MHz
-1.01 dBm
2.46670400 GHz
Occ Bw
M2[1]
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
CF 2.462 GHz
10001 pts
Span 40.0 MHz

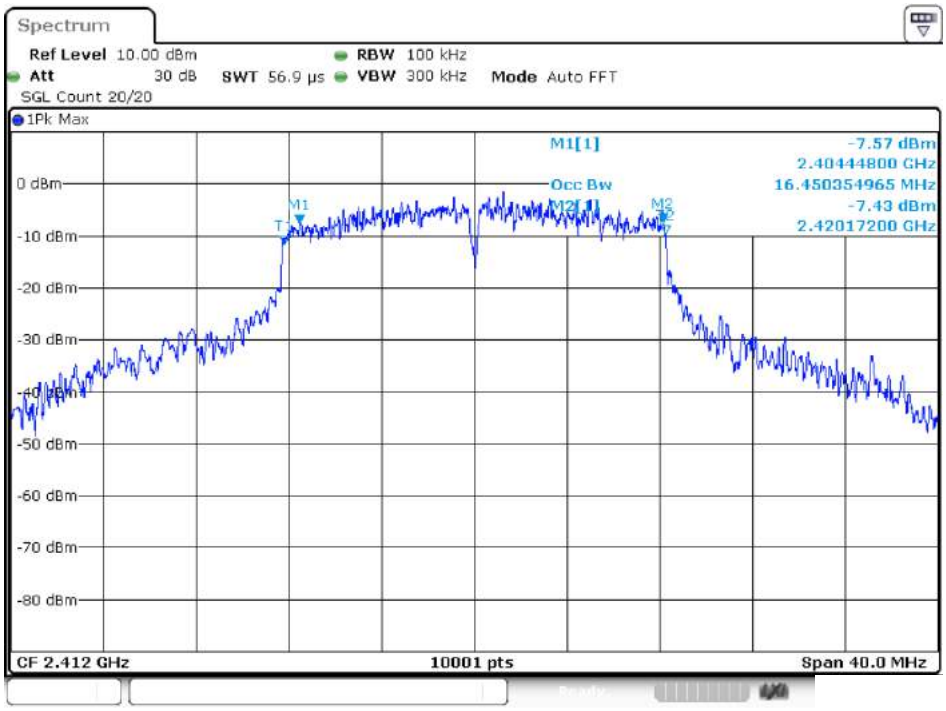
IEEE 802.11g SISO Ant1			
Channel frequency (MHz)	Measurement level (MHz)	Required Limit (KHz)	Result
2412	16.164	>500	Pass
2437	16.296	>500	
2462	15.32	>500	

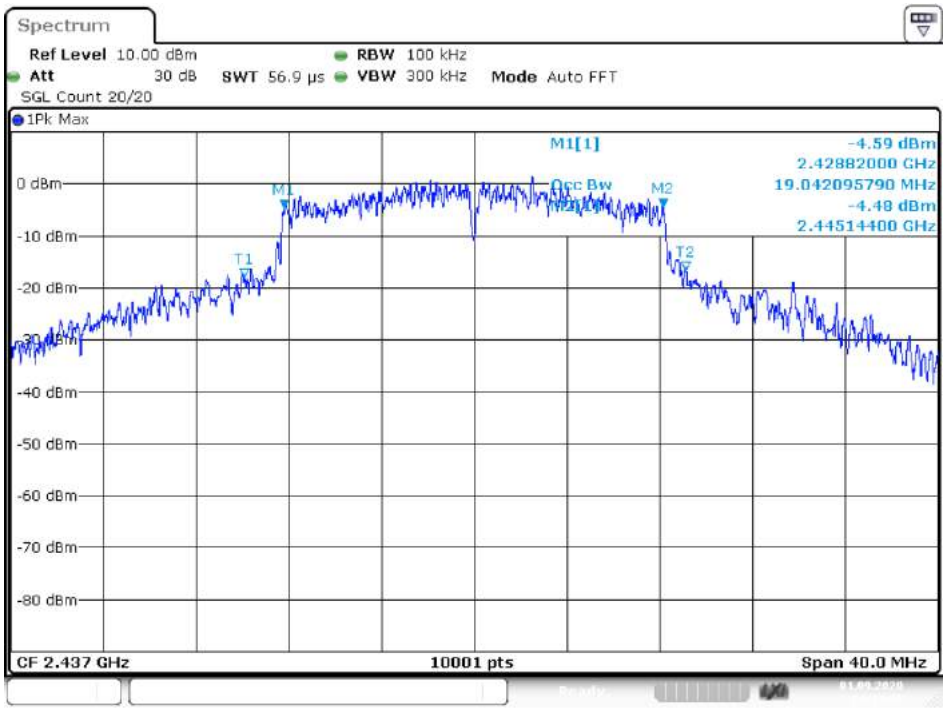


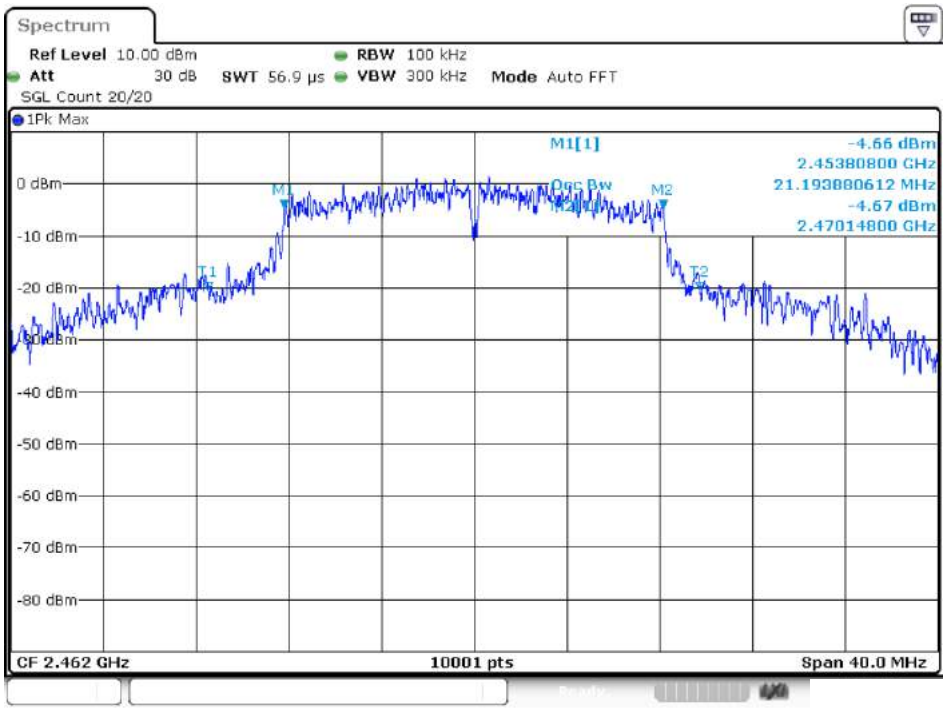

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1] -11.63 dBm
2.42882800 GHz
Occ Bw 16.550344966 MHz
M2[1] -11.68 dBm
2.44512400 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 40.0 MHz


Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1] -10.91 dBm
2.45422000 GHz
Occ Bw 16.518348165 MHz
M2[1] -10.93 dBm
2.46954000 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.462 GHz
10001 pts
Span 40.0 MHz

IEEE 802.11g SISO Ant2			
Channel frequency (MHz)	Measurement level (MHz)	Required Limit (KHz)	Result
2412	15.724	>500	Pass
2437	16.324	>500	
2462	16.340	>500	

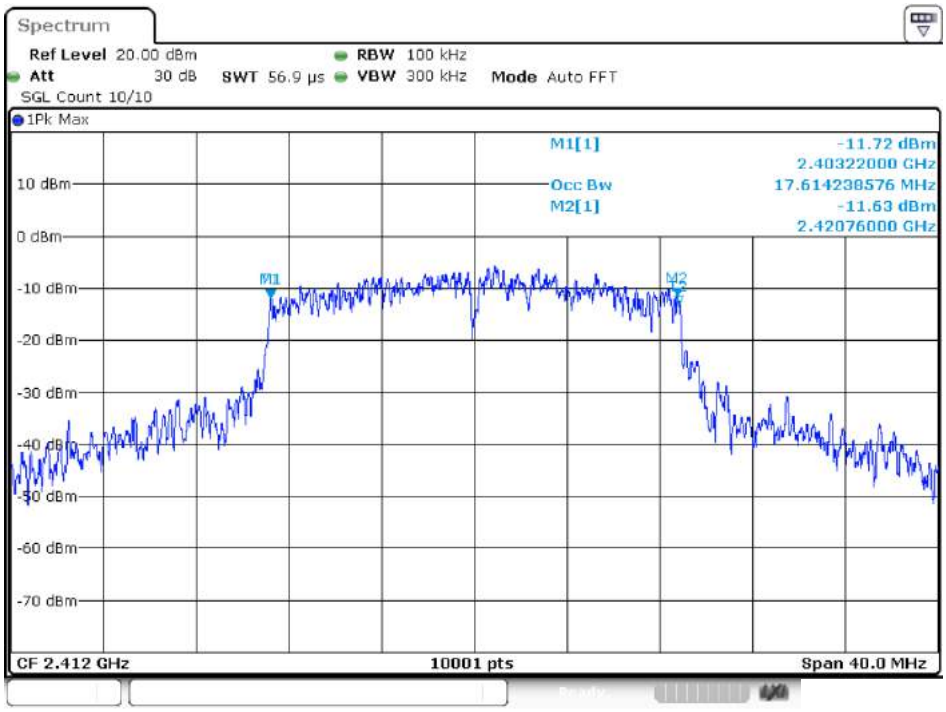


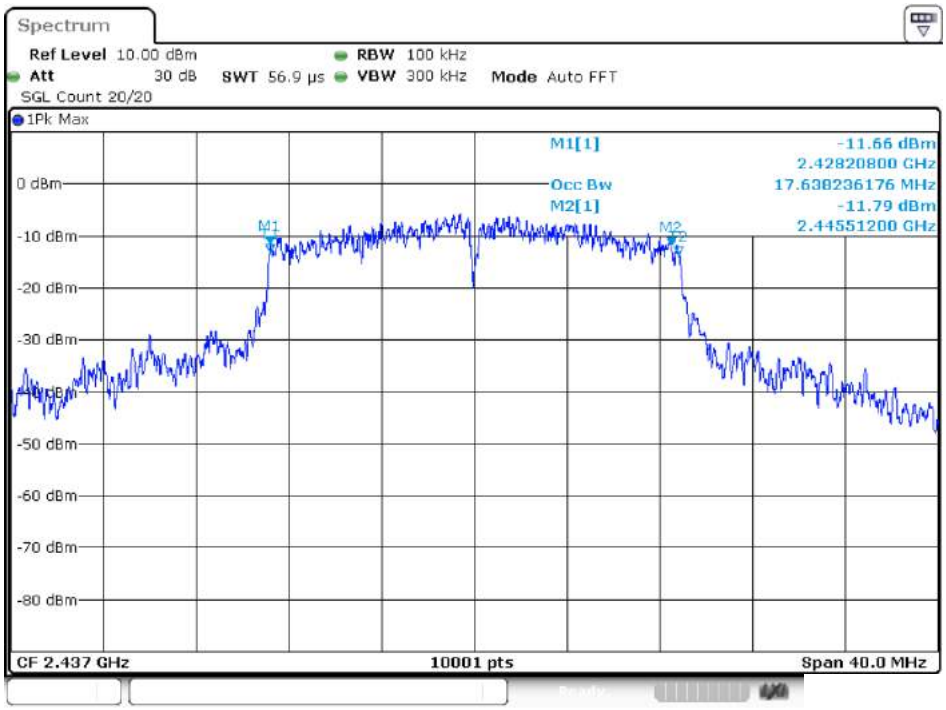

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1]
-4.59 dBm
2.42882000 GHz
19.042095790 MHz
-4.48 dBm
2.44514400 GHz
Occ Bw
M1
M2
T1
T2
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 40.0 MHz

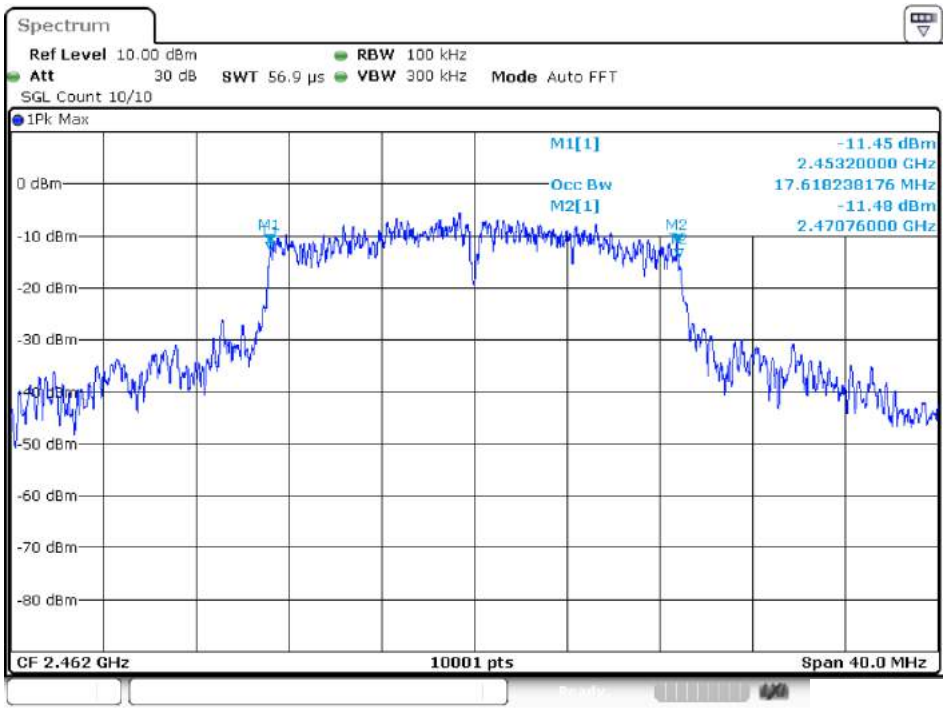

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1]
-4.66 dBm
2.45380800 GHz
21.193880612 MHz
-4.67 dBm
2.47014800 GHz
Occ Bw
M1
M2
T1
T2
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.462 GHz
10001 pts
Span 40.0 MHz

IEEE 802.11n(HT20) MIMO				
Channel frequency (MHz)	Measurement level (MHz)		Required Limit (KHz)	Result
	Ant1	Ant2		
2412	17.540	17.552	>500	Pass
2437	17.304	17.560	>500	
2462	17.560	17.252	>500	

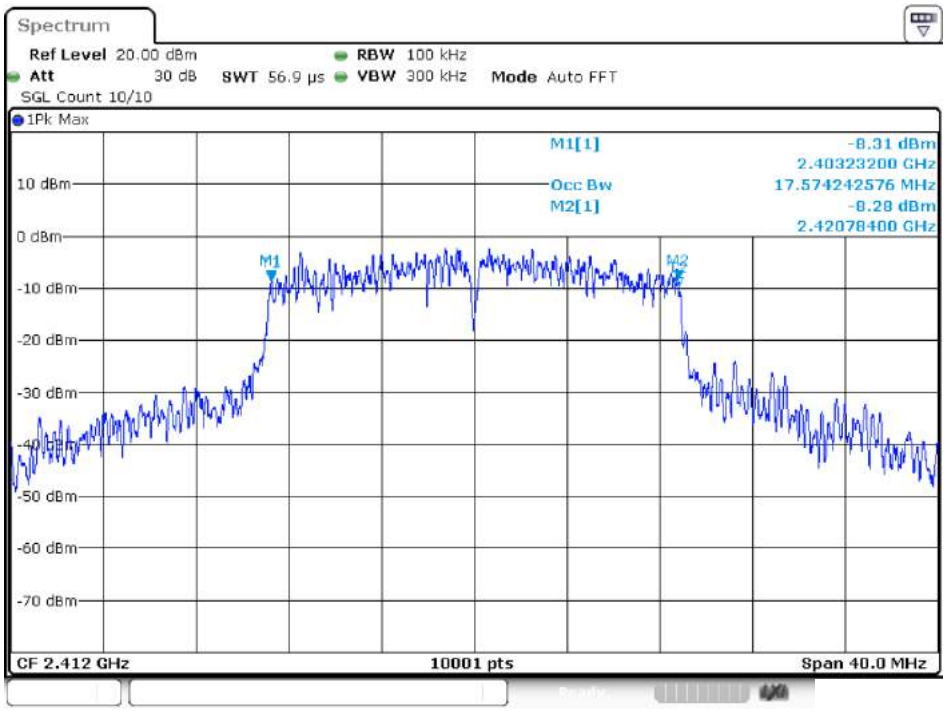
Ant1

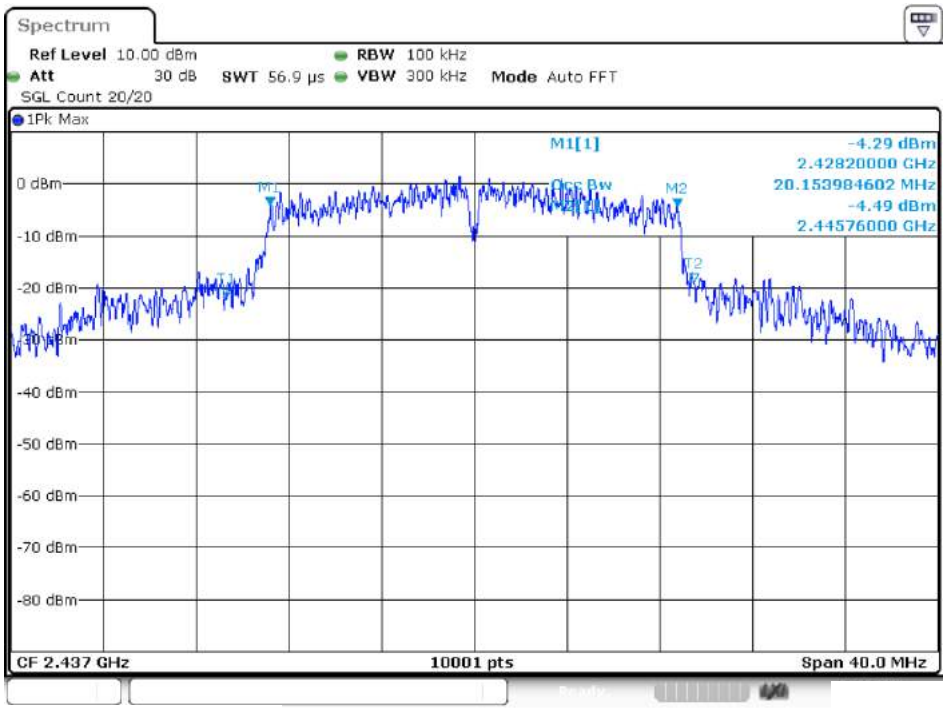


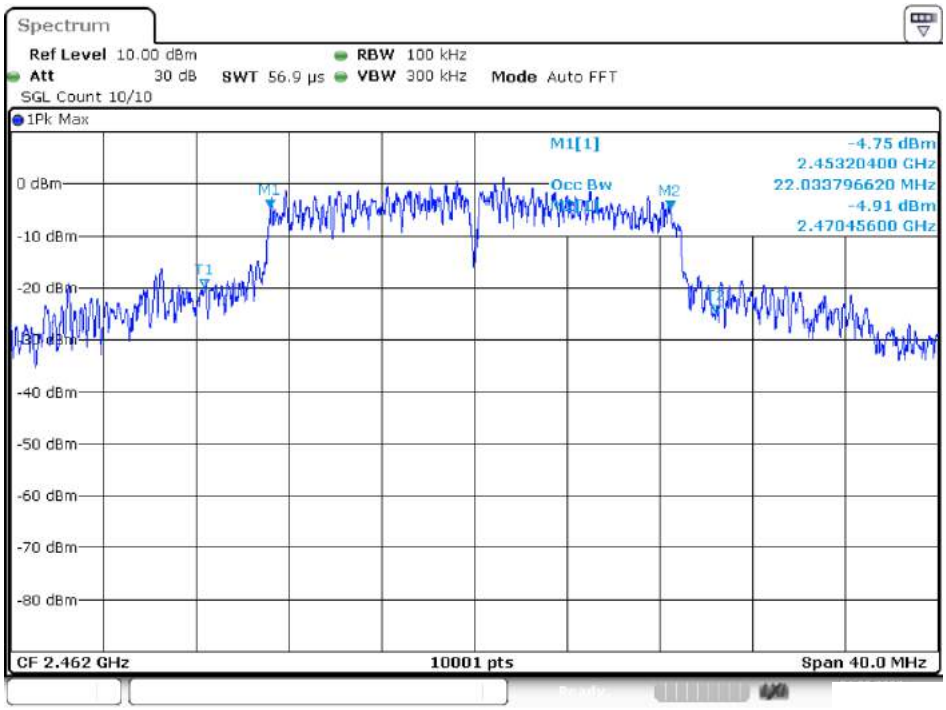

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1] -11.66 dBm
2.42820800 GHz
Occ Bw 17.638236176 MHz
M2[1] -11.79 dBm
2.44551200 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 40.0 MHz


Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -11.45 dBm
2.45320000 GHz
Occ Bw 17.618238176 MHz
M2[1] -11.48 dBm
2.47076000 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.462 GHz
10001 pts
Span 40.0 MHz

Ant2

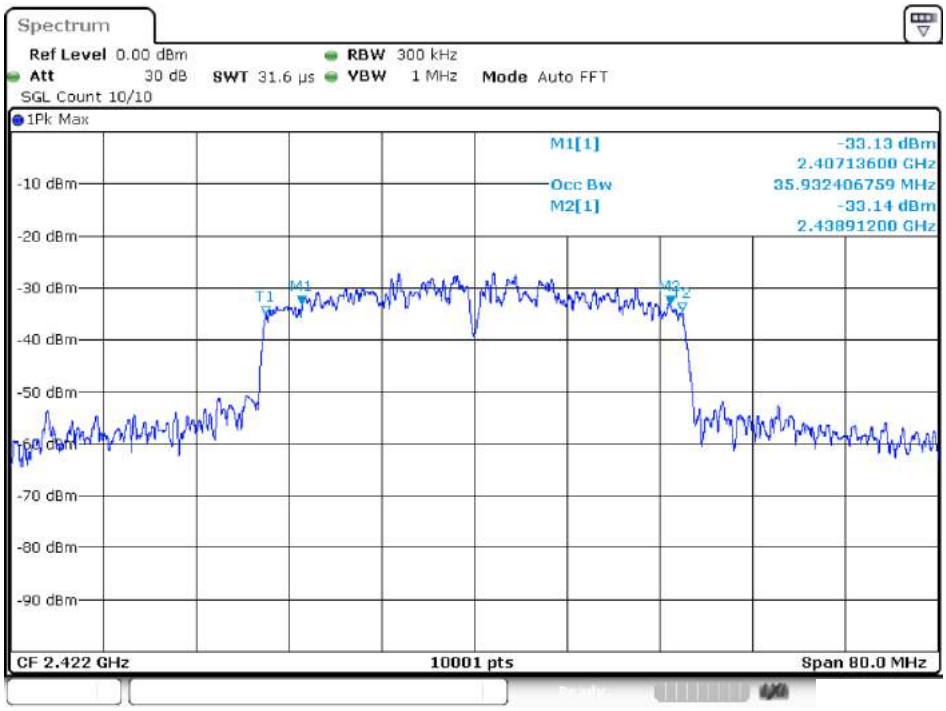

Spectrum
Ref Level 20.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -8.31 dBm
2.40323200 GHz
Occ Bw 17.574242576 MHz
M2[1] -8.28 dBm
2.42078400 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-50 dBm
-60 dBm
-70 dBm
M1
M2
CF 2.412 GHz
10001 pts
Span 40.0 MHz

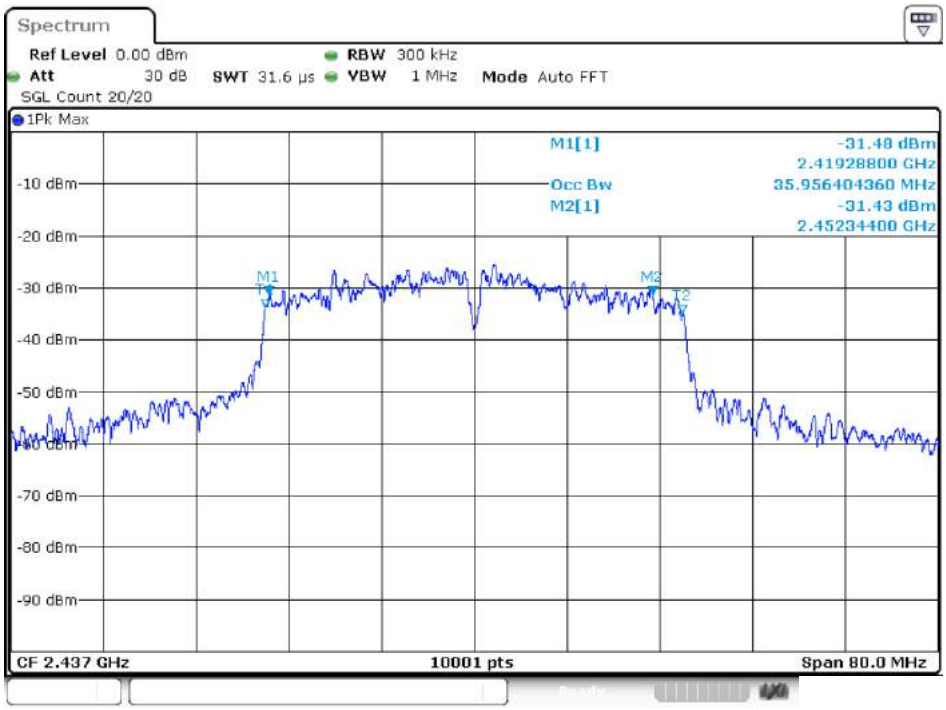

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1] -4.29 dBm
2.42820000 GHz
Occ Bw 20.153984602 MHz
M2[1] -4.49 dBm
2.44576000 GHz
0 dBm
-10 dBm
-20 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
M2
CF 2.437 GHz
10001 pts
Span 40.0 MHz

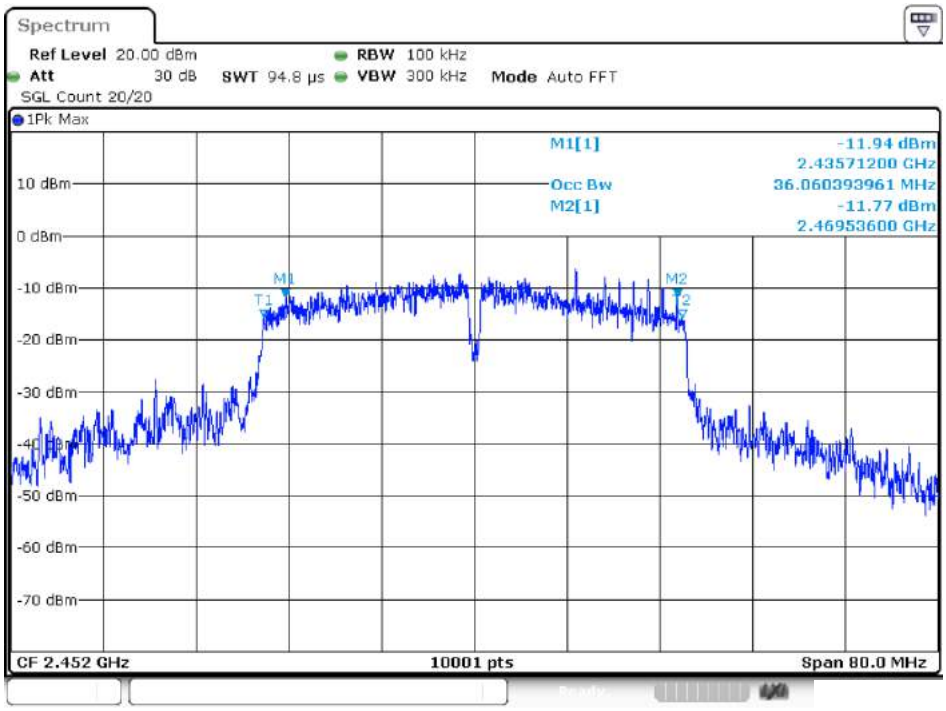

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 56.9 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1]
-4.75 dBm
2.45320400 GHz
22.033796620 MHz
-4.91 dBm
2.47045600 GHz
Occ Bw
M1
M2
T1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.462 GHz
10001 pts
Span 40.0 MHz

IEEE 802.11n (HT40) MIMO				
Channel frequency (MHz)	Measurement level (MHz)		Required Limit (KHz)	Result
	Ant1	Ant2		
2422	31.776	31.648	>500	Pass
2437	33.056	30.752	>500	
2452	33.824	35.640	>500	

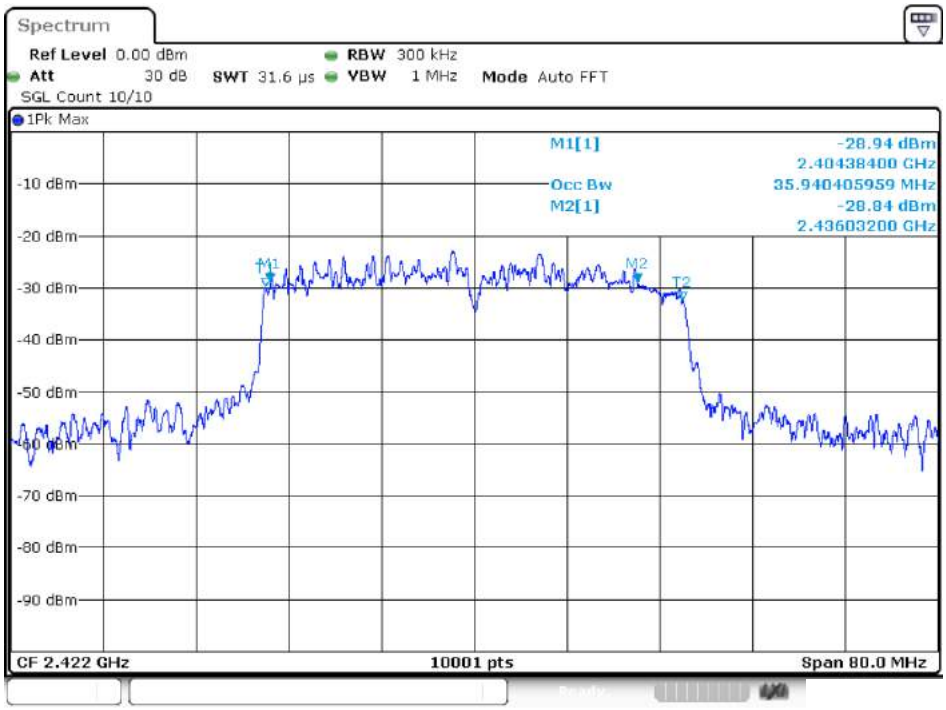
Ant1

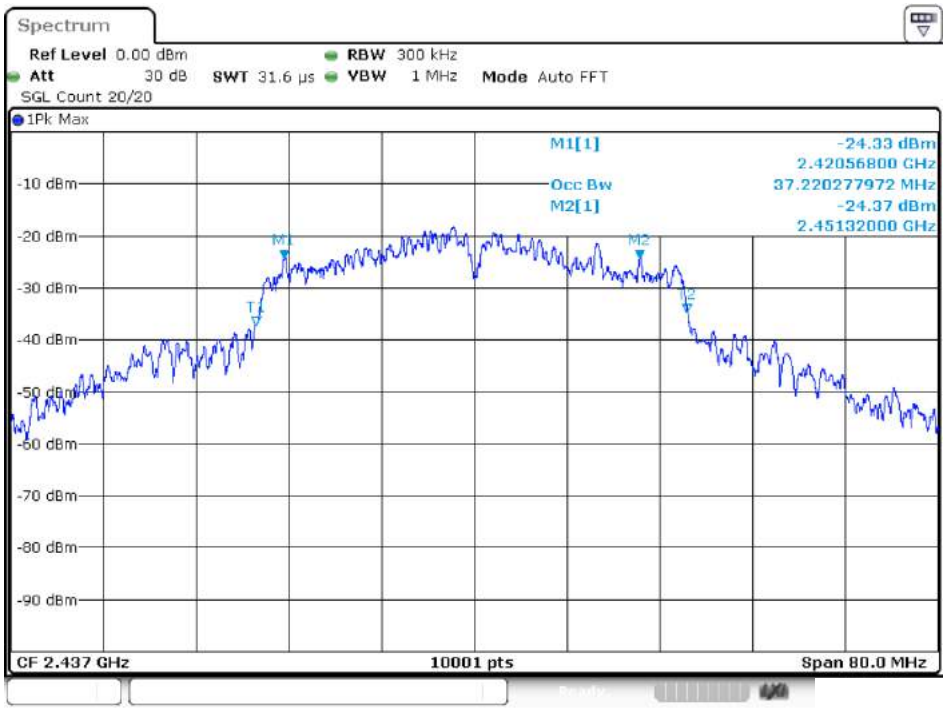


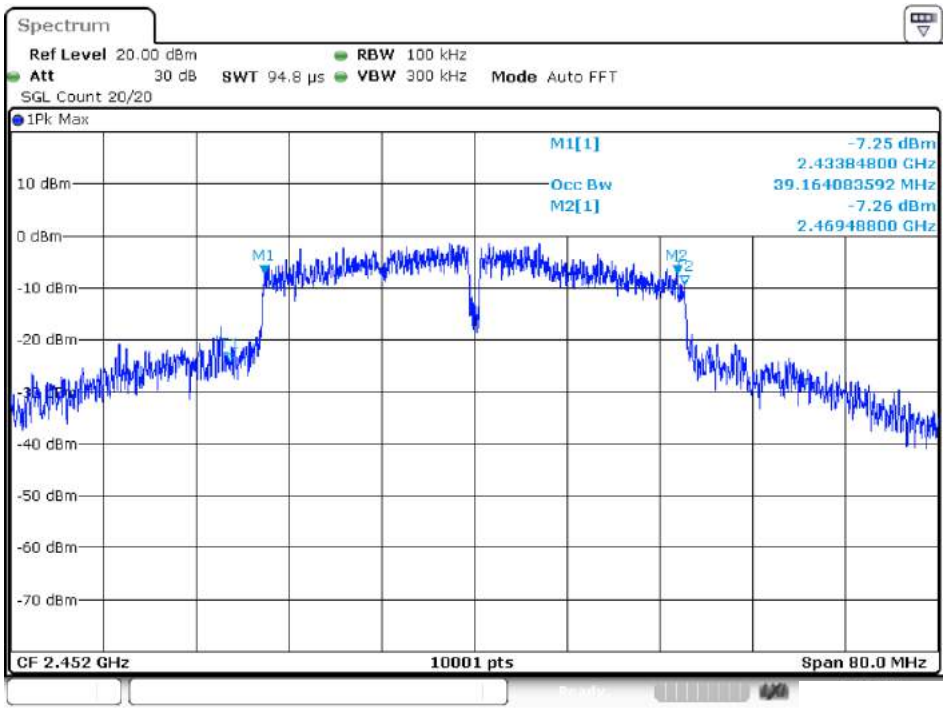

Spectrum
Ref Level 0.00 dBm
RBW 300 kHz
Att 30 dB
SWT 31.6 µs
VBW 1 MHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1]
-31.48 dBm
2.41928800 GHz
Occ Bw
35.956404360 MHz
M2[1]
-31.43 dBm
2.45234400 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-70 dBm
-80 dBm
-90 dBm
CF 2.437 GHz
10001 pts
Span 80.0 MHz


Spectrum
Ref Level 20.00 dBm
RBW 100 kHz
Att 30 dB
SWT 94.8 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1]
-11.94 dBm
2.43571200 GHz
Occ Bw
36.060393961 MHz
M2[1]
-11.77 dBm
2.46953600 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-50 dBm
-60 dBm
-70 dBm
CF 2.452 GHz
10001 pts
Span 80.0 MHz

Ant2


Spectrum
Ref Level 0.00 dBm
RBW 300 kHz
Att 30 dB
SWT 31.6 µs
VBW 1 MHz
Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -28.94 dBm
2.40438400 GHz
Occ Bw 35.940405959 MHz
M2[1] -28.84 dBm
2.43603200 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
CF 2.422 GHz
10001 pts
Span 80.0 MHz


Spectrum
Ref Level 0.00 dBm
RBW 300 kHz
Att 30 dB
SWT 31.6 µs
VBW 1 MHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1] -24.33 dBm
2.42056800 GHz
Occ Bw 37.220277972 MHz
M2[1] -24.37 dBm
2.45132000 GHz
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
CF 2.437 GHz
10001 pts
Span 80.0 MHz


Spectrum
Ref Level 20.00 dBm
RBW 100 kHz
Att 30 dB
SWT 94.8 µs
VBW 300 kHz
Mode Auto FFT
SGL Count 20/20
1Pk Max
M1[1] -7.25 dBm
2.43384800 GHz
Occ Bw 39.164083592 MHz
M2[1] -7.26 dBm
2.46948800 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
M1
M2
CF 2.452 GHz
10001 pts
Span 80.0 MHz

11. Maximum Peak Output Power Test

11.1 Measurement Procedure

(1) According to FCC Part15.247(b)(3)

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall utilize a fast-responding diode detector.

The testing follows FCC public Notice DA 00-705 Measurement Guidelines.

The RF output of EUT was connected to the power meter by RF cable and attnuator. The path loss was compensated to the results for each measurement.

Set to the maximum output power setting and enable the EUT transmit continuously.

Measure the conducted output power with cable loss and record the results in the test report.

Measure and record the results in the report.

(2) According to FCC Part 15.247(b)(4):

Conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Note: If antenna Gain exceeds 6 dBi, then Output power Limit=30-(Gain - 6)

11.2 Test SET-UP (Block Diagram of Configuration)

11.3 Measurement Equipment Used

EQUIPMENT TYPE	Manufacturer	Model No.	Serial Number	Calibrated until.
USB RF Power sensor	RadiPower	RPR3006W	17I00015SNO88	2021-11-19
RF Test Software	MAIWEI	MTS 8310	N/A	N/A

11.4 Peak Power output limit

The maximum peak conducted output power of the intentional radiator for systems using digital modulation in the 2400 - 2483.5 MHz bands shall not exceed: 1 Watt (30dBm).

11.5Measurement Results

Spectrum Detector:	PK	Test Date :	June 28, 2021
Test By:	Andy	Temperature :	28℃
Test Result:	PASS	Humidity :	60%

Operation Mode	Channel Number	Channel Frequency (MHz)	Measurement Level (dBm)			Limit (dBm)	Verdict
			Ant1	Ant2	Sum		
802.11b	1	2412	20.89	20.46	--	30	PASS
	6	2437	18.79	18.20	--	30	PASS
	11	2462	18.84	18.52	--	30	PASS
802.11g	1	2412	17.61	17.24	--	30	PASS
	6	2437	16.81	18.96	--	30	PASS
	11	2462	16.83	19.07	--	30	PASS
802.11n (HT20)	1	2412	16.59	15.96	19.297	30	PASS
	6	2437	17.07	19.11	21.219	30	PASS
	11	2462	16.76	18.34	20.632	30	PASS
802.11n (HT40)	3	2422	17.22	16.92	20.083	30	PASS
	6	2437	17.32	20.07	21.919	30	PASS
	9	2452	17.22	20.13	21.925	30	PASS

Note:
1. For MIMO System of 802.11n(HT20) and 802.11n(HT40), total power is calculated by combining the output power of each antenna according to KDB662911.
2. Antenna 1 Gain: 2dBi, Antenna 2 Gain: 2dBi. For antennas with gains of 6dBi or less, maximum allowed Transmitter output watt(+30dBm)
3. In MIMO, Ant1+Ant2 Directional Gain=G_{ANT}+10Log(N)dBi=2+10log(2)=5dBi.

12. Band Edge Test

12.1 Measurement Procedure

For Conducted Test

1. The testing follows FCC KDB Publication No. 558074 DTS D01 Meas. Guidance v04.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Set RBW = 100 kHz, VBW=300 kHz, Peak Detector. Unwanted Emissions measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz when maximum peak conducted output power procedure is used. Measure and record the results in the test report.
5. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

For Radiated emission Test

1. The testing follows FCC KDB Publication No. 558074 DTS D01 Meas. Guidance v04.
2. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level.
3. The EUT was placed on a turntable with 0.8 meter above ground.
4. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level.
6. For measurement below 1GHz, If the emission level of the EUT measured by the peak detector is 3 dB lower than the applicable limit, the peak emission level will be reported. Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.
7. Repeat above procedures until all frequency measured were complete.

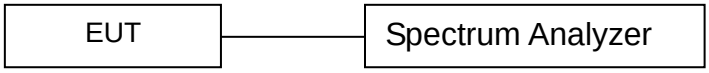
When spectrum scanned above 1GHz setting resolution bandwidth 1MHz, video bandwidth 3MHz.

EMI Test Receiver	Setting
Attenuation	Auto
RBW	1MHz
VBW	3MHz
Detector	Peak
Trace	Max hold

When spectrum scanned above 1GHz setting resolution bandwidth 1MHz, video bandwidth 10Hz.

EMI Test Receiver	Setting
Attenuation	Auto
RBW	1MHz
VBW	10Hz
Detector	Peak
Trace	Max hold

12.2 Test SET-UP (Block Diagram of Configuration)



12.3 Measurement Equipment Used

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	CALIBRATED UNTIL
Spectrum Analyzer	Rohde & Schwarz	FSV40	US40240623	2021-11-19
Coaxial Cable	Gigalink Microwave	ZT40	19022092	2021-11-19
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	2021-11-19

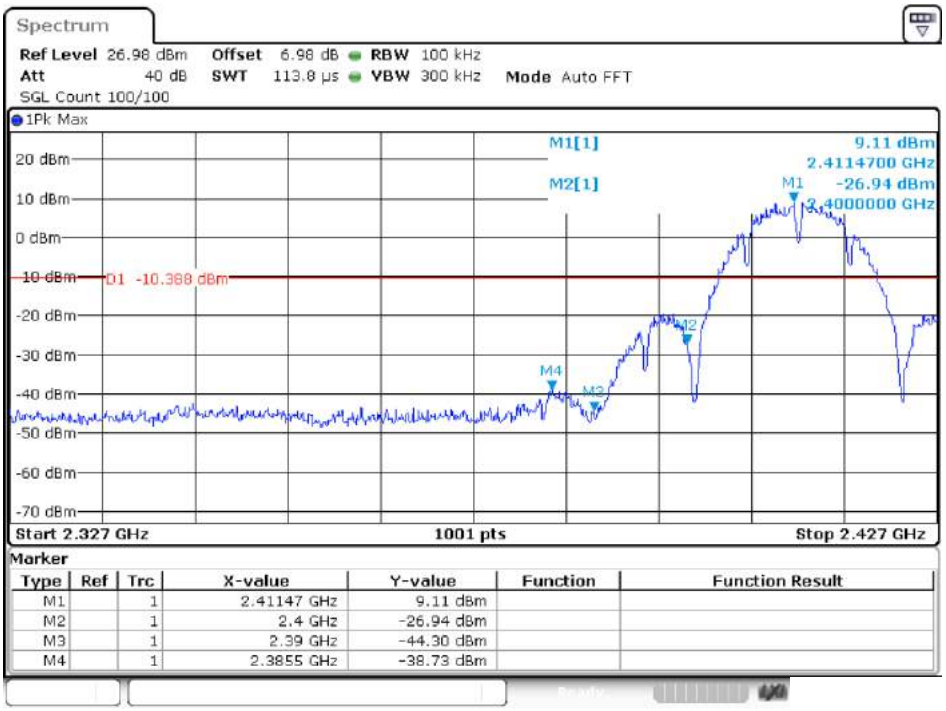
Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

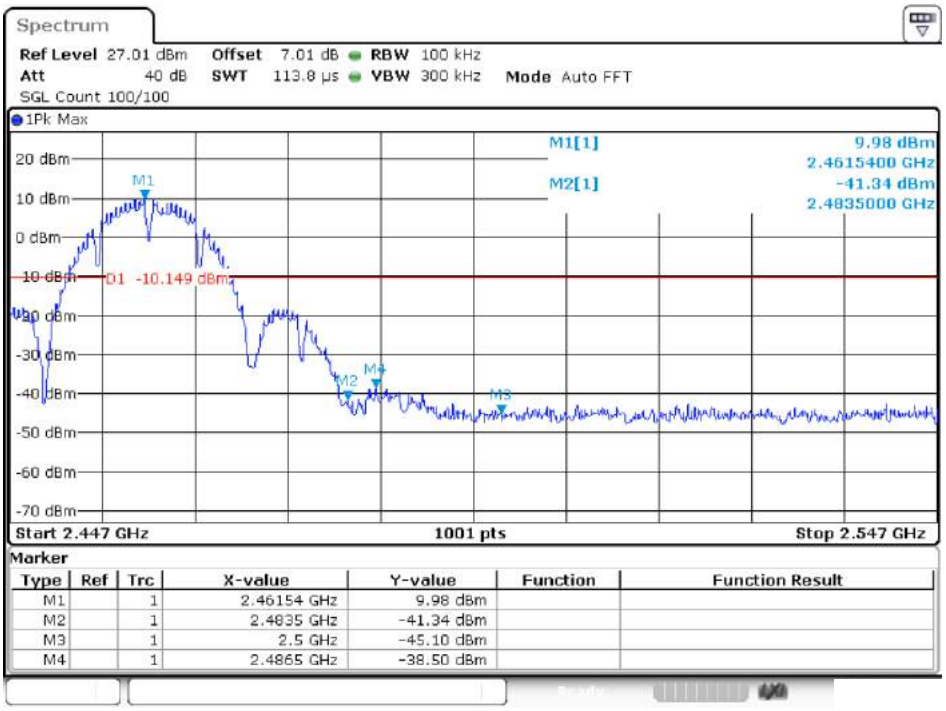
12.4 Measurement Results

1. Conducted Test

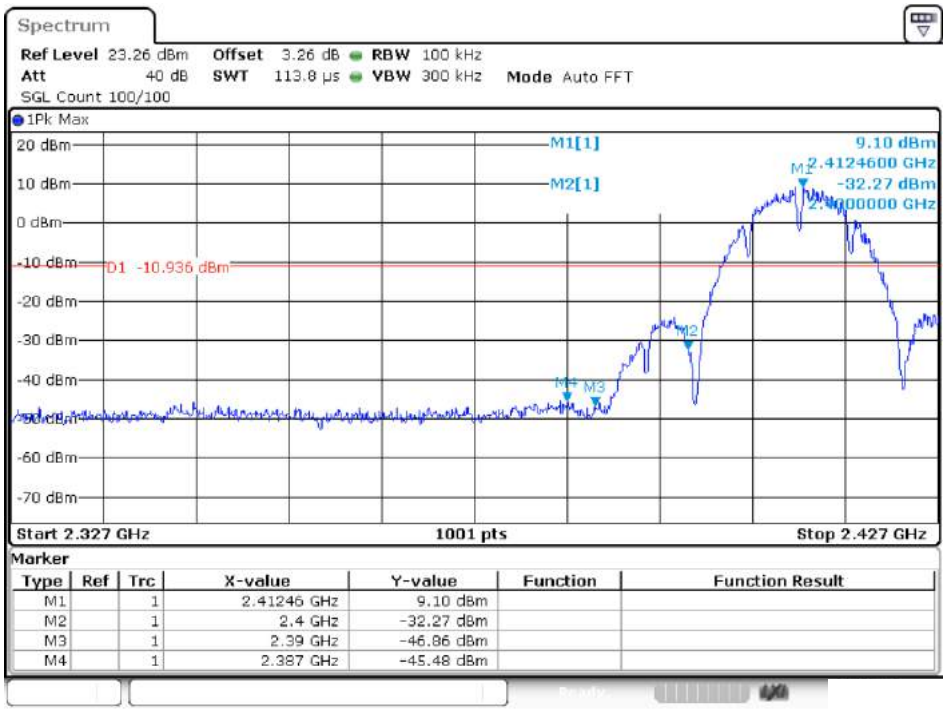
Please refer to the following pages.

Test Mode: IEEE 802.11b SISO Ant1



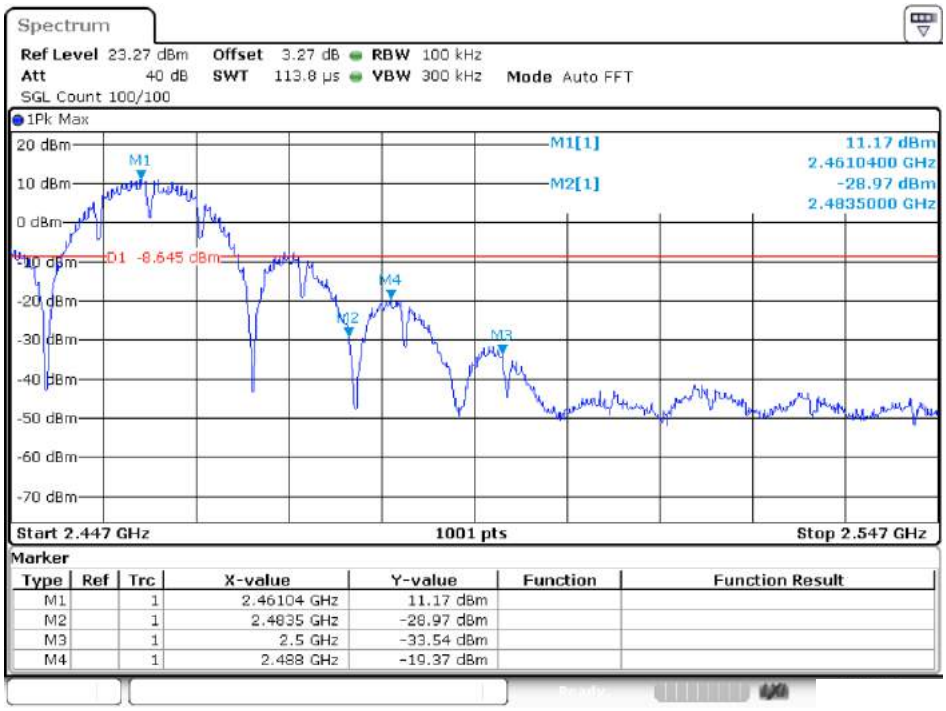


Test Mode: IEEE 802.11b SISO Ant2



Marker

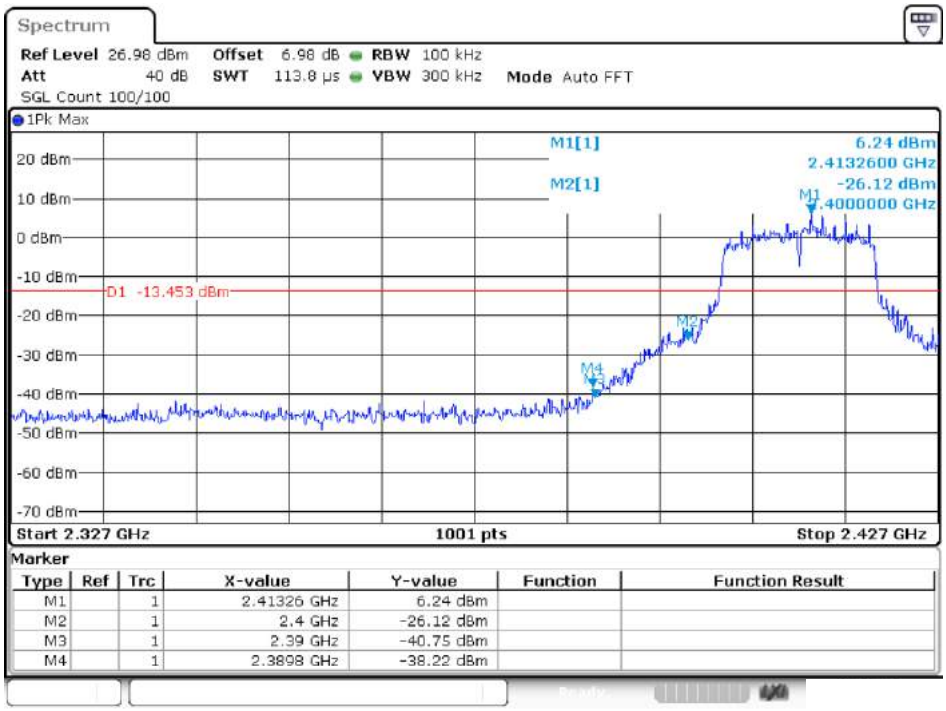
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.41246 GHz	9.10 dBm		
M2		1	2.4 GHz	-32.27 dBm		
M3		1	2.39 GHz	-46.86 dBm		
M4		1	2.387 GHz	-45.48 dBm		

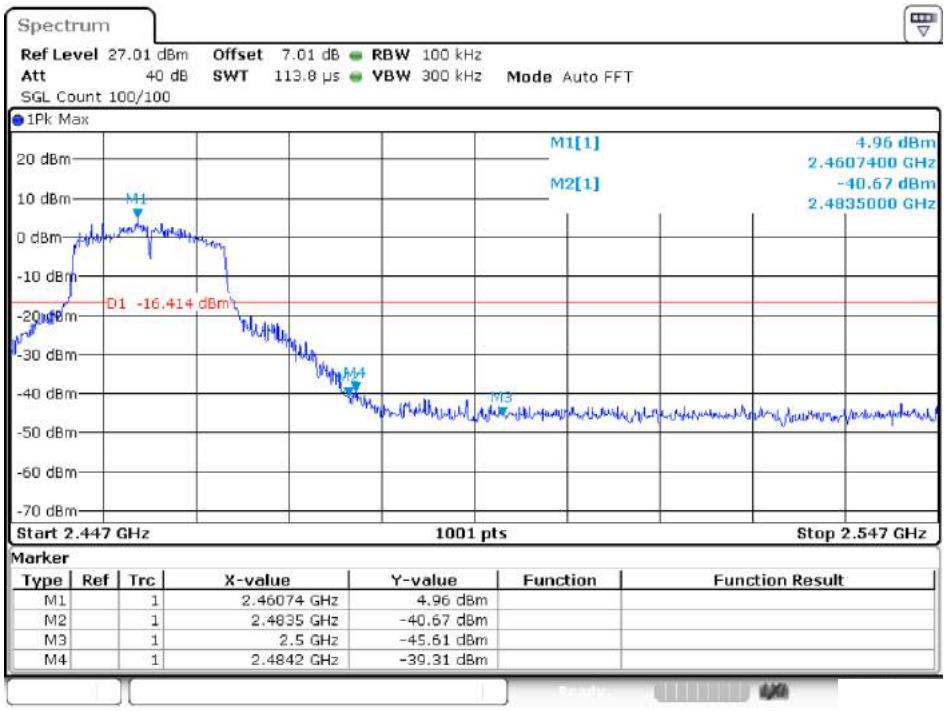


Marker

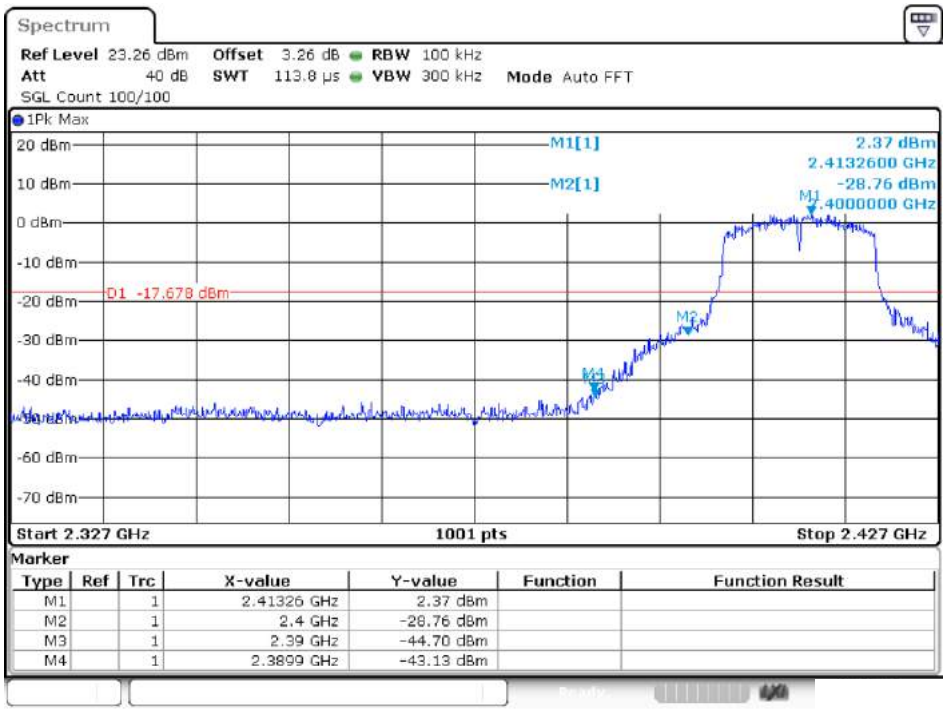
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.46104 GHz	11.17 dBm		
M2		1	2.4835 GHz	-28.97 dBm		
M3		1	2.5 GHz	-33.54 dBm		
M4		1	2.488 GHz	-19.37 dBm		

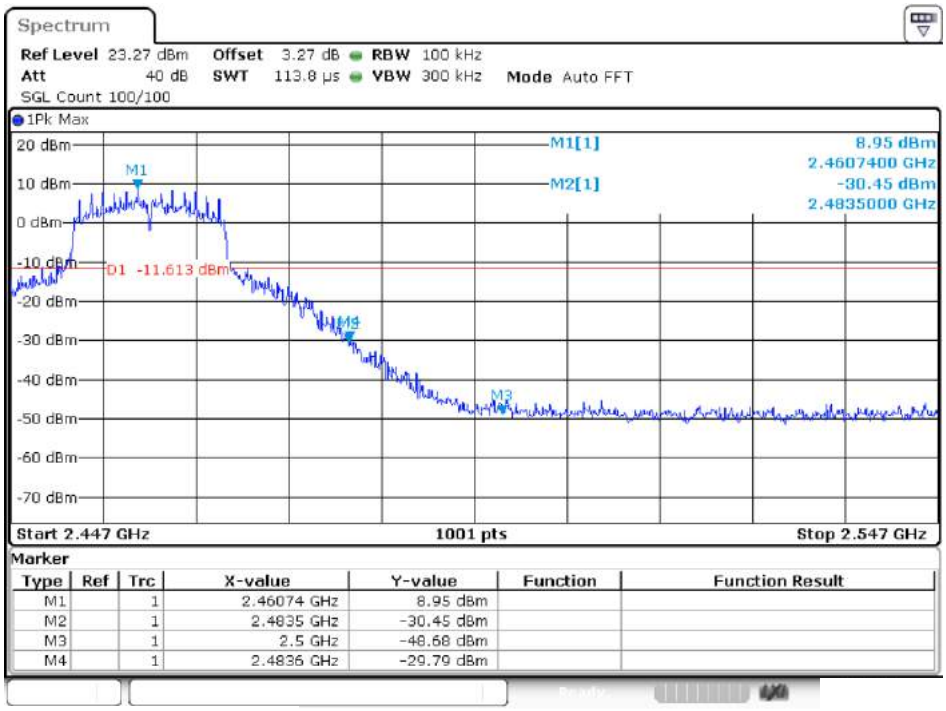
Test Mode: IEEE 802.11g SISO Ant1



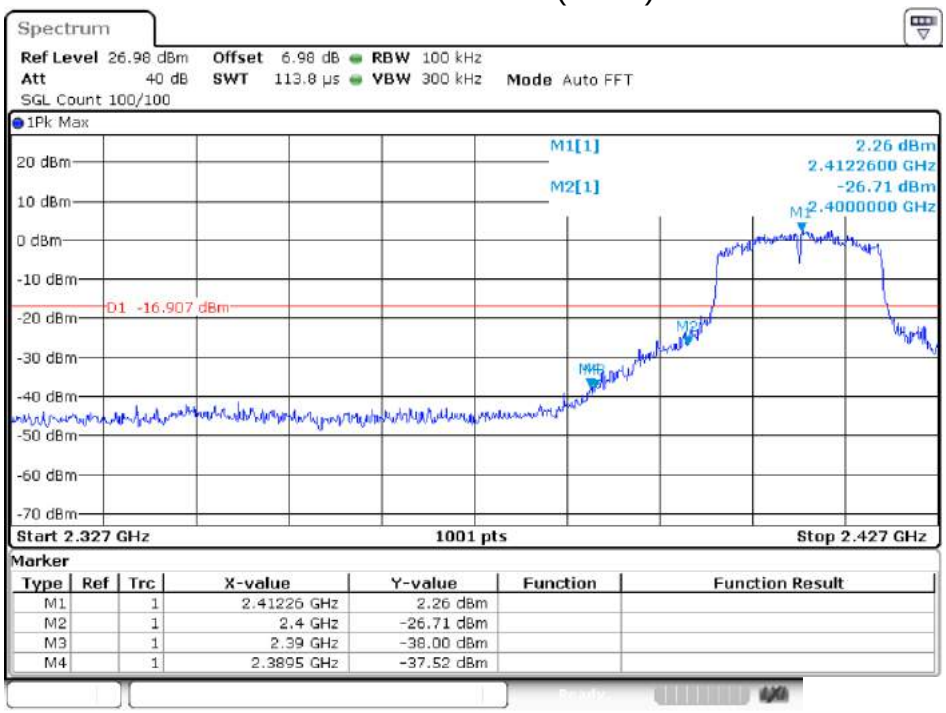


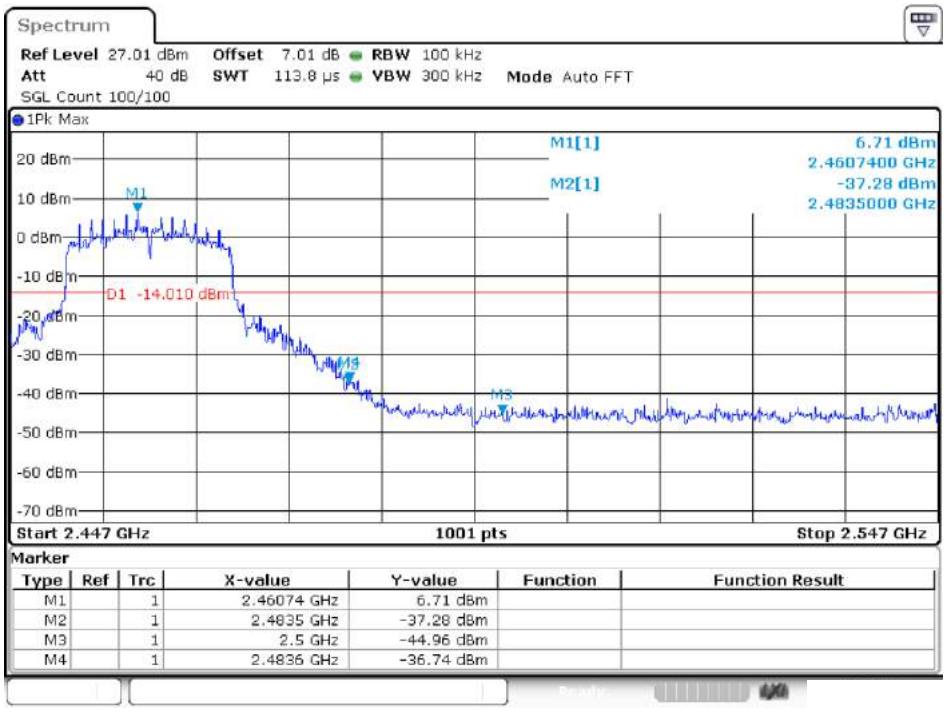
Test Mode: IEEE 802.11g SISO Ant2



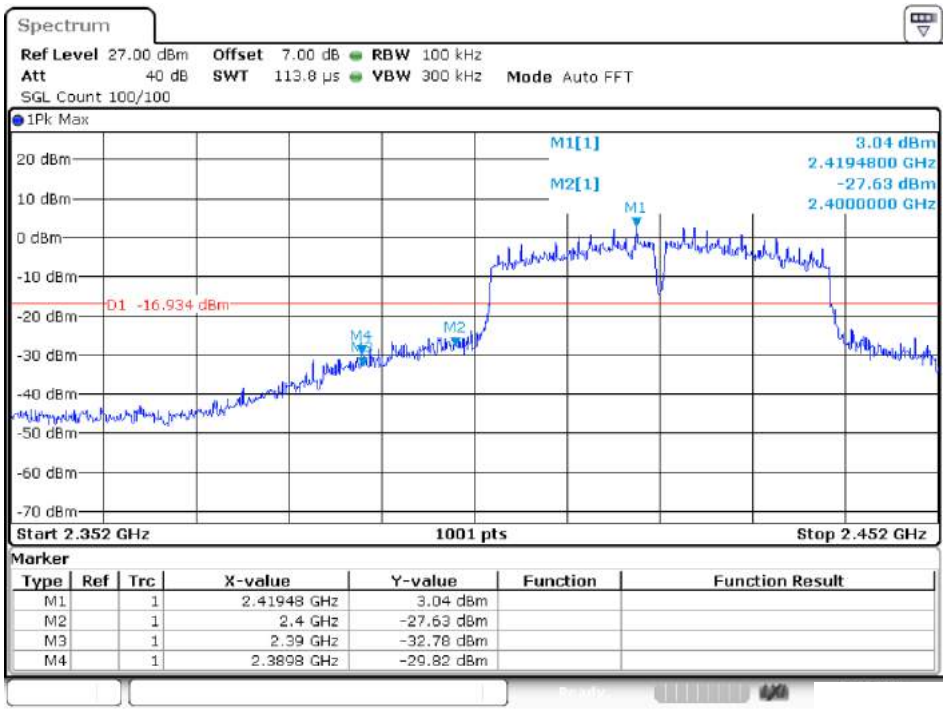


Test Mode: IEEE 802.11n(HT20) MIMO



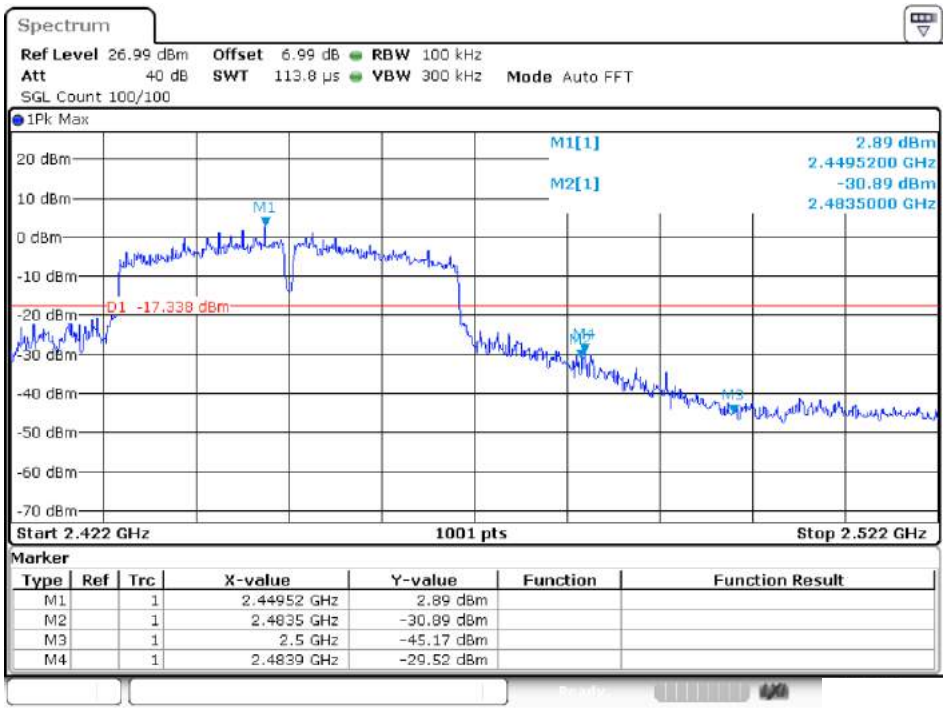


Test Mode: IEEE 802.11n(HT40) MIMO



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.41948 GHz	3.04 dBm		
M2		1	2.4 GHz	-27.63 dBm		
M3		1	2.39 GHz	-32.78 dBm		
M4		1	2.3898 GHz	-29.82 dBm		



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.44952 GHz	2.89 dBm		
M2		1	2.4835 GHz	-30.89 dBm		
M3		1	2.5 GHz	-45.17 dBm		
M4		1	2.4839 GHz	-29.52 dBm		

2. Radiated emission Test

Spectrum Detector:	PK/AV	Test Date :	2021-07-02
Test By:	Andy	Temperature :	28 ℃
Humidity :	65 %		

IEEE 802.11b SISO Ant1										
Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
<2400	H	86.65	68.41	-26.3	60.35	42.11	74	54	-13.65	-11.89
<2400	V	85.65	65.59	-26.1	59.55	39.49	74	54	-14.45	-14.51
>2483.5	H	88.09	67.52	-26.3	61.79	41.22	74	54	-12.21	-12.78
>2483.5	V	86.46	65.18	-26.1	60.36	39.08	74	54	-13.64	-14.92

IEEE 802.11b SISO Ant2										
Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
<2400	H	89.84	69.84	-26.3	63.54	43.54	74	54	-10.46	-10.46
<2400	V	88.21	68.29	-26.1	62.11	42.19	74	54	-11.89	-11.81
>2483.5	H	88.35	68.99	-26.3	62.05	42.69	74	54	-11.95	-11.31
>2483.5	V	86.79	65.99	-26.1	60.69	39.89	74	54	-13.31	-14.11

IEEE 802.11g SISO Ant1										
Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
<2400	H	90.45	70.55	-26.3	64.15	44.25	74	54	-9.85	-9.75
<2400	V	86.79	66.79	-26.1	60.69	40.69	74	54	-13.31	-13.31
>2483.5	H	87.89	67.78	-26.3	61.59	41.48	74	54	-12.41	-12.52
>2483.5	V	86.43	68.89	-26.1	60.33	42.79	74	54	-13.67	-11.21

IEEE 802.11g SISO Ant2										
Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
<2400	H	90.88	68.79	-26.3	64.58	42.49	74	54	-9.42	-11.51
<2400	V	88.21	65.97	-26.1	62.11	39.87	74	54	-11.89	-14.13
>2483.5	H	86.89	67.88	-26.3	60.59	41.58	74	54	-13.41	-12.42
>2483.5	V	85.97	66.74	-26.1	59.87	40.64	74	54	-14.13	-13.36

IEEE 802.11n(HT20)MIMO										
Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
<2400	H	89.27	70.32	-26.3	62.97	44.02	74	54	-11.03	-9.98
<2400	V	86.21	68.25	-26.1	60.11	42.15	74	54	-13.89	-11.85
>2483.5	H	88.76	68.64	-26.3	62.46	42.34	74	54	-11.54	-11.66
>2483.5	V	87.46	67.74	-26.1	61.36	41.64	74	54	-12.64	-12.36

IEEE 802.11n(HT40)MIMO										
Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
<2400	H	89.99	69.84	-26.3	63.69	43.54	74	54	-10.31	-10.46
<2400	V	86.26	68.21	-26.1	60.16	42.11	74	54	-13.84	-11.89
>2483.5	H	87.25	66.99	-26.3	60.95	40.69	74	54	-13.05	-13.31
>2483.5	V	85.98	66.35	-26.1	59.88	40.25	74	54	-14.12	-13.75

13. Maxiumum Power Spectral Density

13.1 Test Equipment

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	CALIBRATED UNTIL
Spectrum Analyzer	Rohde & Schwarz	FSV40	US40240623	2021-11-19
Coaxial Cable	Gigalink Microwave	ZT40	19022092	2021-11-19
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	2021-11-19

Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

13.2 Measuring Instruments and Setting

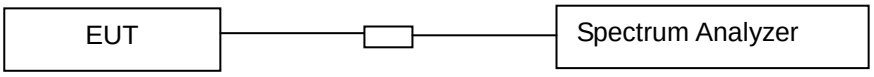
The following table is the setting of spectrum analyzer.

Spectrum analyzer	Setting
Attenuation	Auto
Span Frequency	Set the span to 1.5 times the DTS bandwidth.
RBW	3KHz
VBW	10KHz
Detector	Peak
Trace	Max hold
Sweep Time	Automatic

13.3 Test Procedures

a. The transmitter output (antenna port) was connected to the spectrum analyzer.
b. Set analyzer center frequency to DTS channel center frequency.
c. Set the analyzer span to a minimum of 1.5 times the DTS bandwidth.
d. Set the RBW=3KHz. Set the VBW=10KHz
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.

13.4 Block Diagram of Test Setup



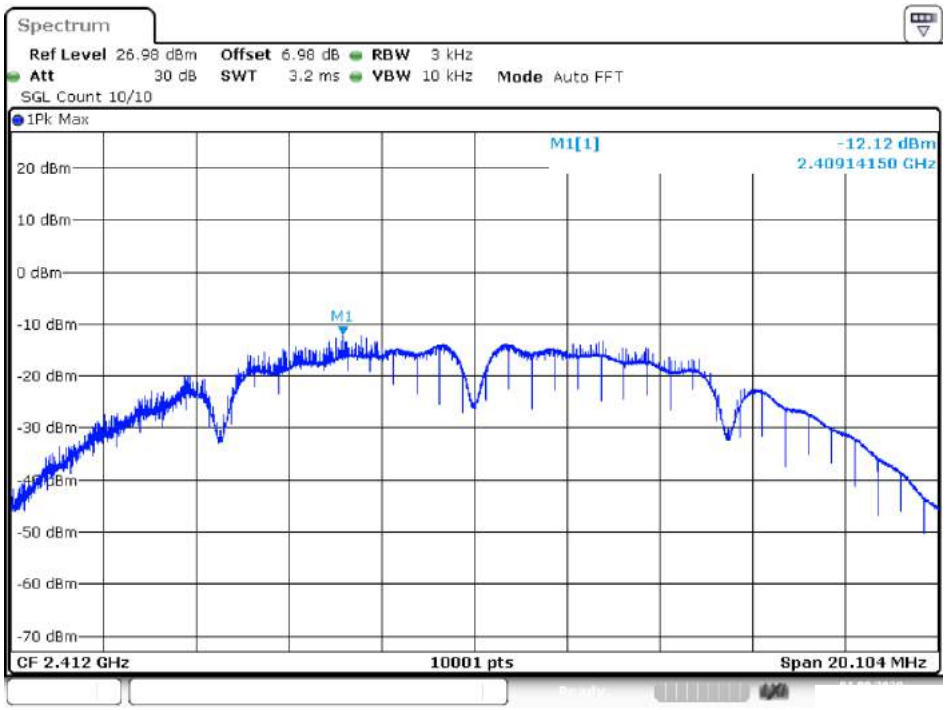
13.5Limit

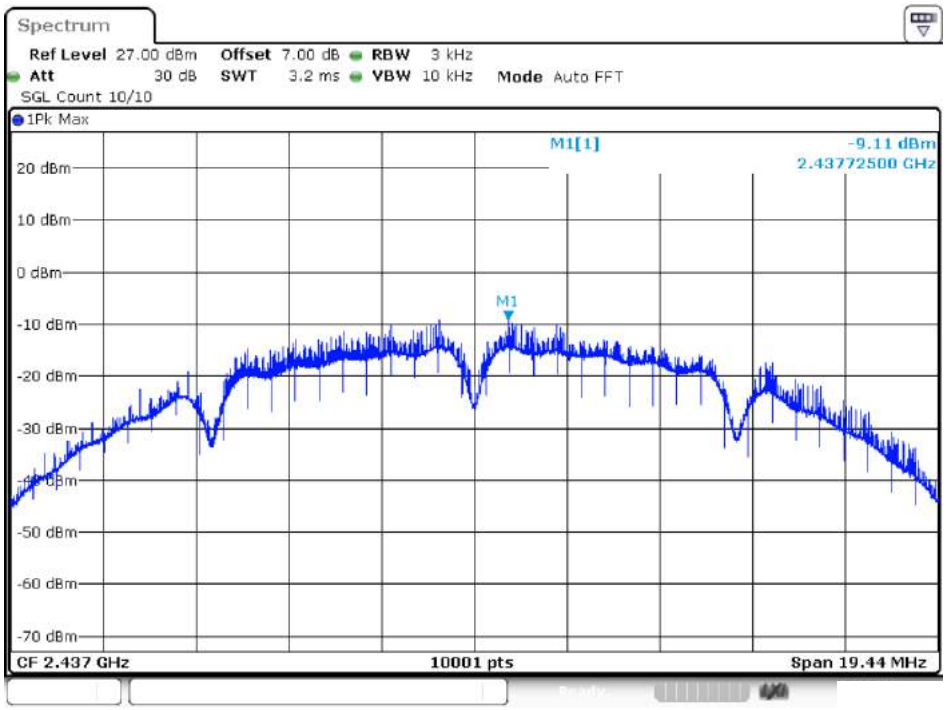
The transmitted power density averaged over any 1 second interval shall not be greater +8dBm in any 3 kHz bandwidth.

13.6Test Result

Spectrum Detector:	PK	Test Date :	June 28, 2021
Test By:	Andy	Temperature :	28℃
Humidity :	60%		

IEEE 802.11b SISO Ant1			
Channel frequency (MHz)	Power Density (dBm/3kHz)	Power Density Limit (dBm/3kHz)	Result
2412	-12.12	8	Pass
2437	-9.11		
2462	-9.03		





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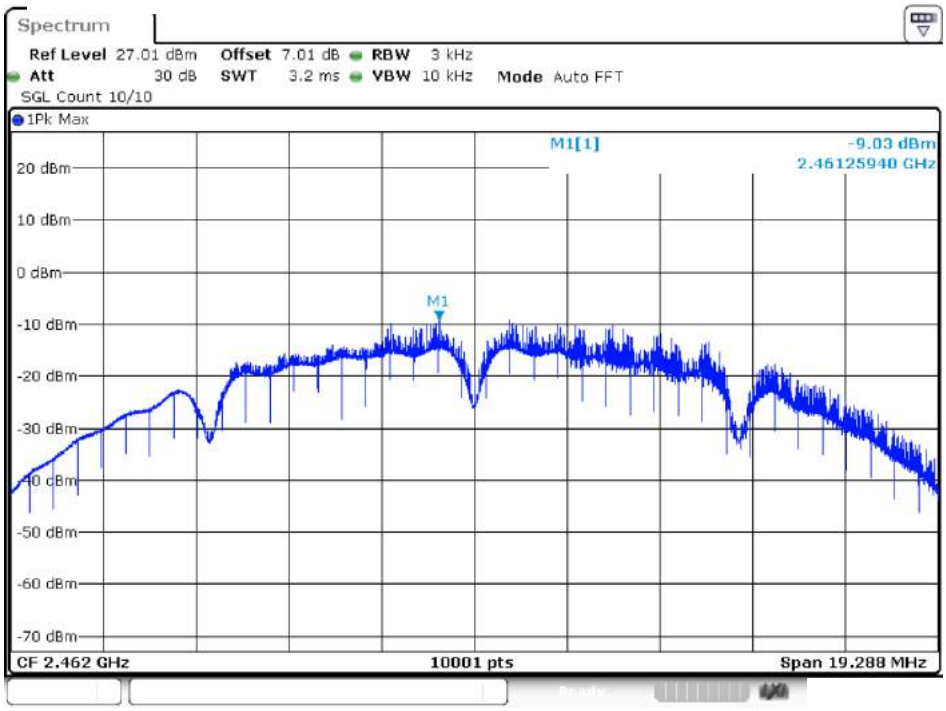
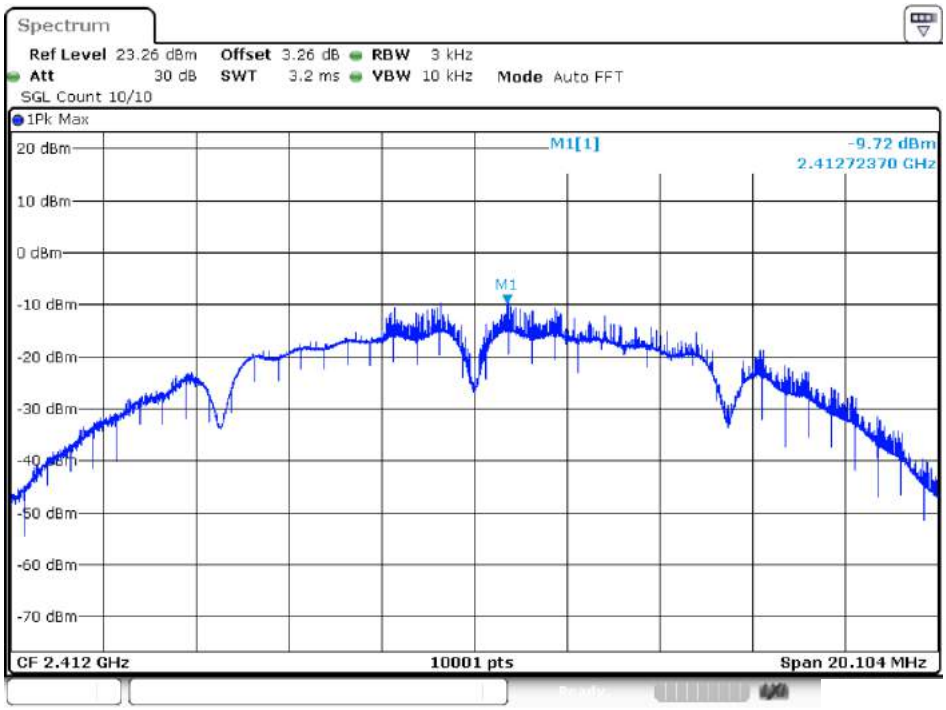
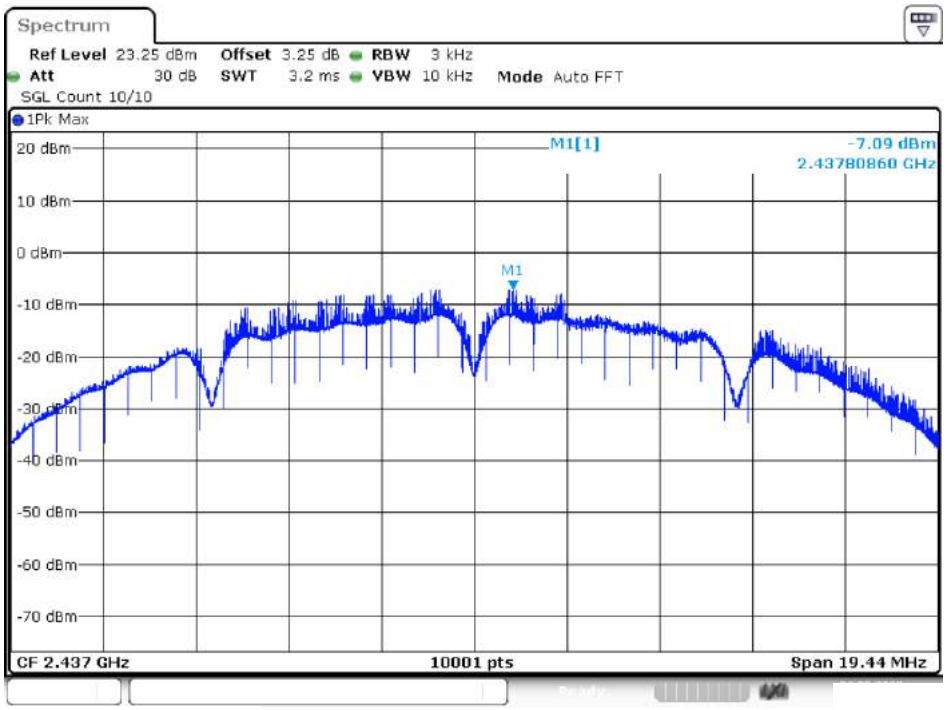
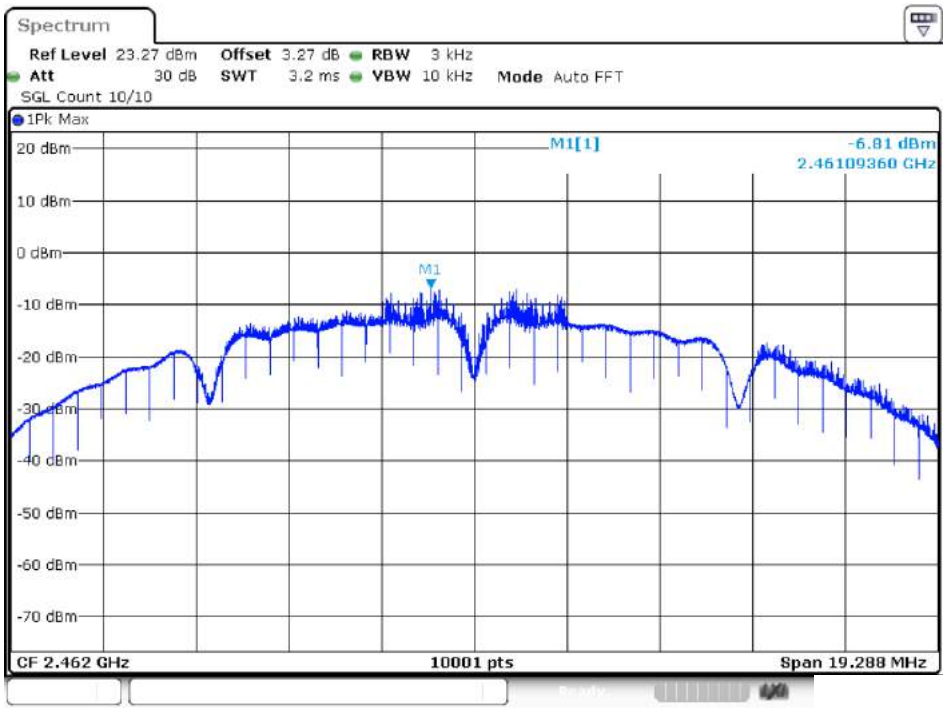


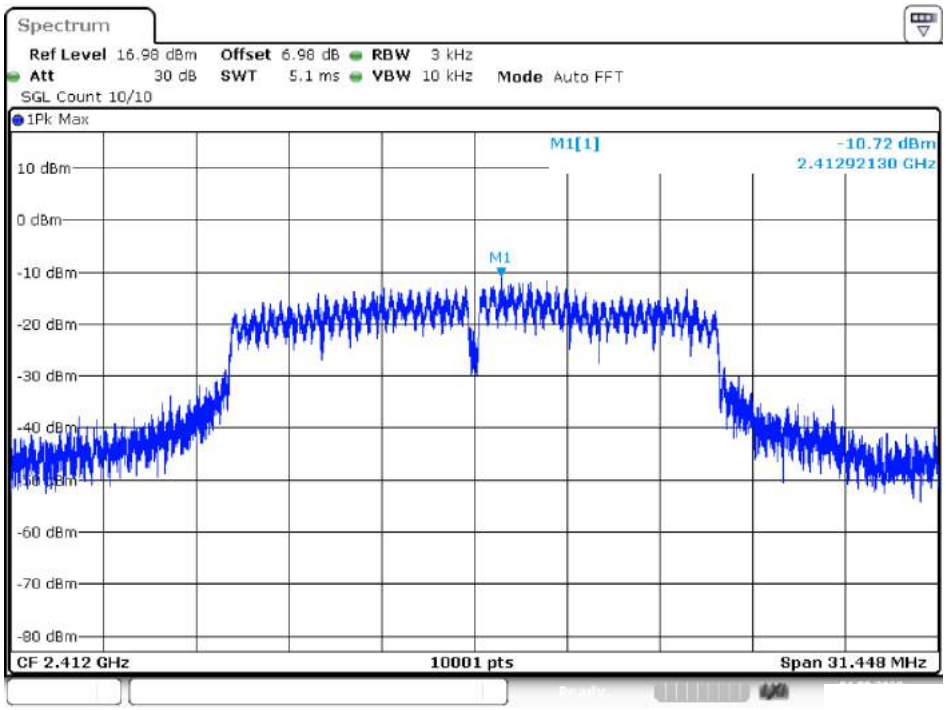
IEEE 802.11b SISO Ant2			
Channel frequency (MHz)	Power Density (dBm/3kHz)	Power Density Limit (dBm/3kHz)	Result
2412	-9.72	8	Pass
2437	-7.09		
2462	-6.81		

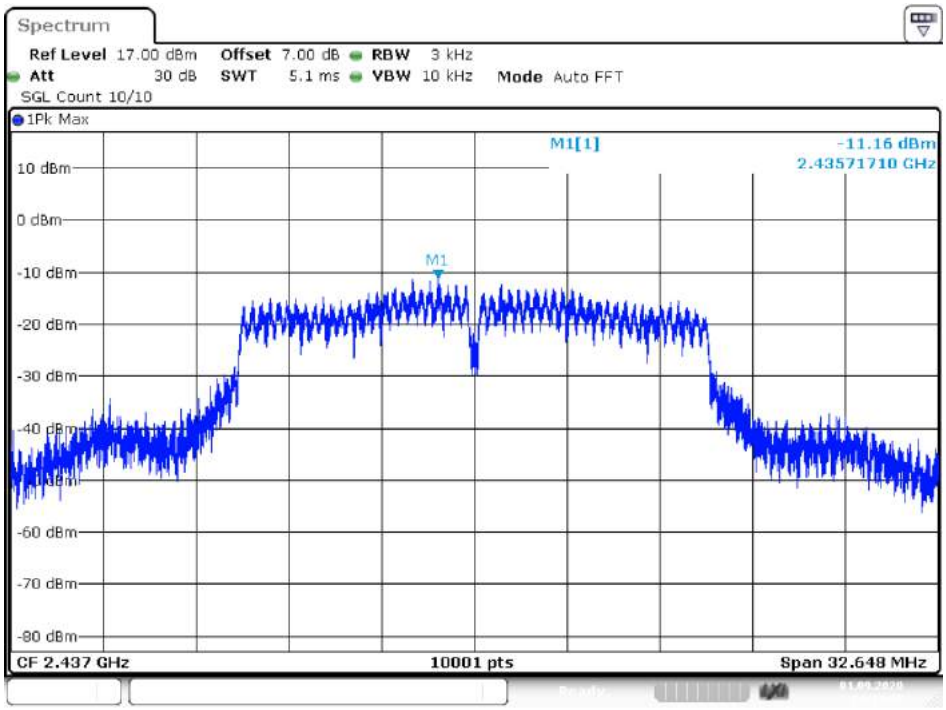


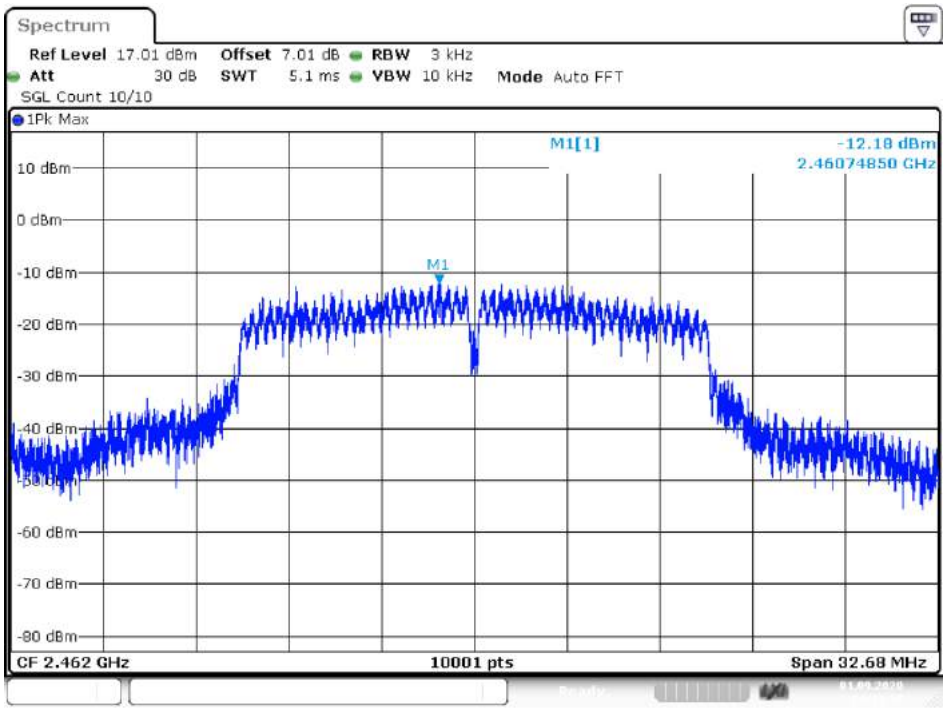

Spectrum
Ref Level 23.25 dBm Offset 3.25 dB RBW 3 kHz
Att 30 dB SWT 3.2 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -7.09 dBm
2.43780860 GHz
M1
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
CF 2.437 GHz
10001 pts
Span 19.44 MHz


Spectrum
Ref Level 23.27 dBm Offset 3.27 dB RBW 3 kHz
Att 30 dB SWT 3.2 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -6.81 dBm
2.46109360 GHz
M1
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
CF 2.462 GHz
10001 pts
Span 19.288 MHz

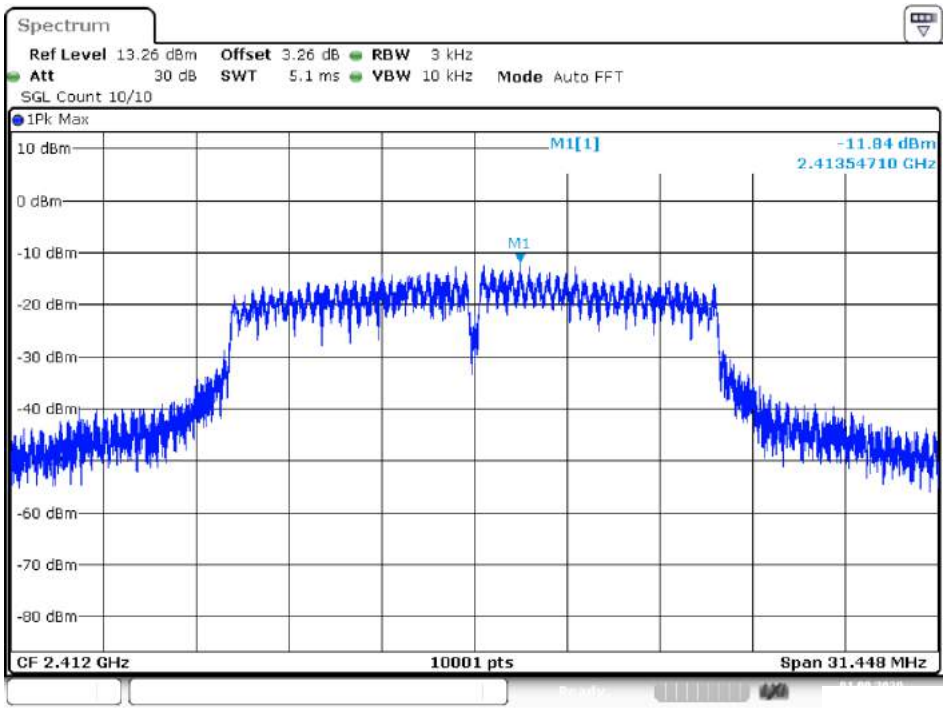
IEEE 802.11g(SISO) Ant 1			
Channel frequency (MHz)	Power Density (dBm/3kHz)	Power Density Limit (dBm/3kHz)	Result
2412	-10.72	8	Pass
2437	-11.16		
2462	-12.18		

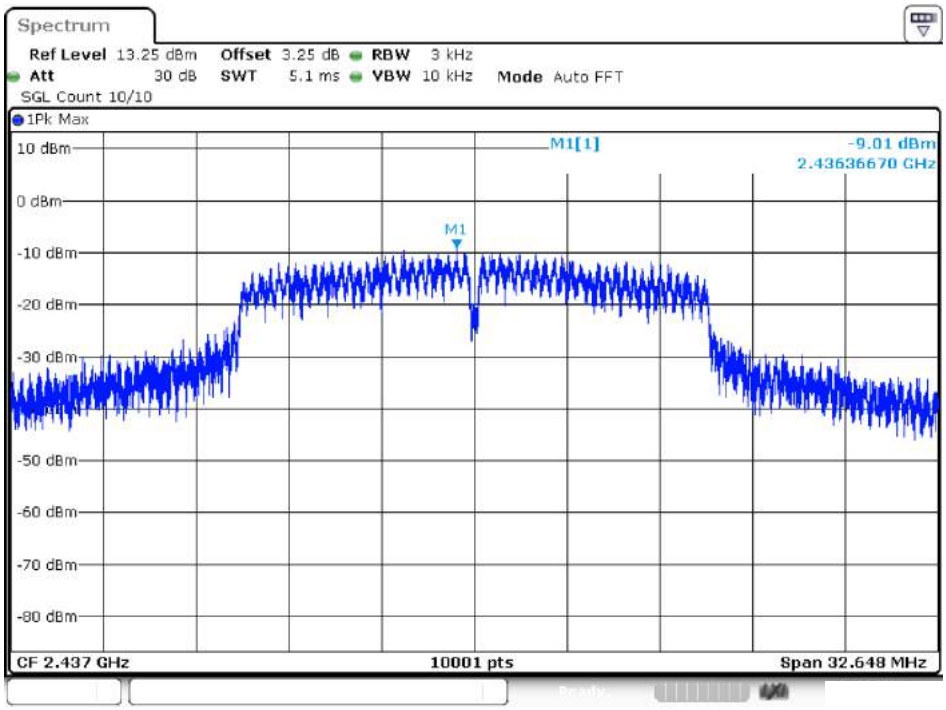


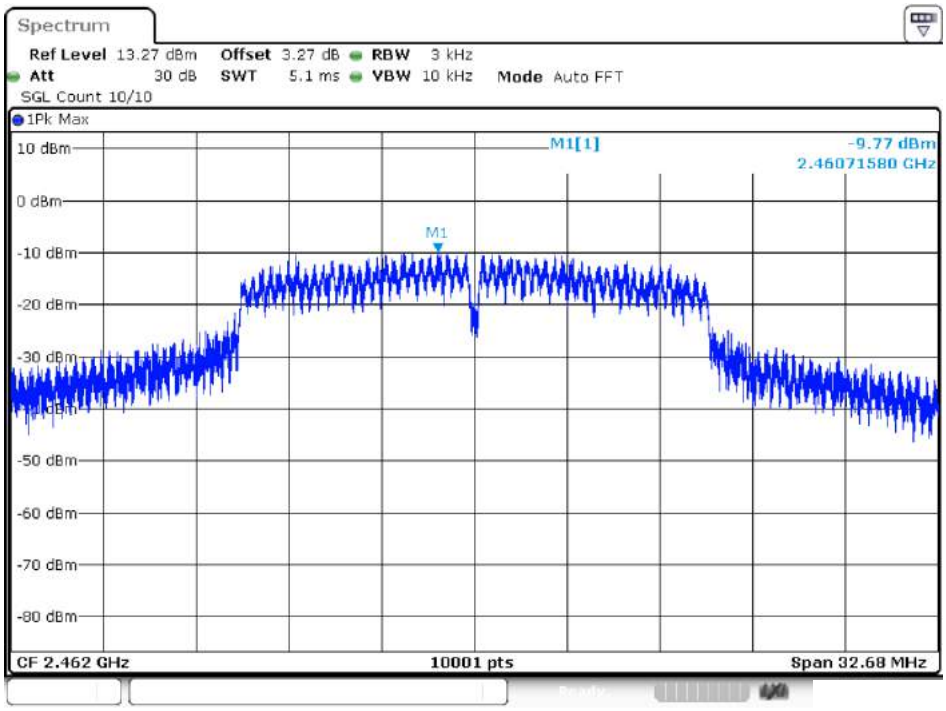

Spectrum
Ref Level 17.00 dBm Offset 7.00 dB RBW 3 kHz
Att 30 dB SWT 5.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -11.16 dBm
2.43571710 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 32.648 MHz


Spectrum
Ref Level 17.01 dBm Offset 7.01 dB RBW 3 kHz
Att 30 dB SWT 5.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -12.18 dBm
2.46074850 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.462 GHz
10001 pts
Span 32.68 MHz

IEEE 802.11g(SISO) Ant2			
Channel frequency (MHz)	Power Density (dBm/3kHz)	Power Density Limit (dBm/3kHz)	Result
2412	-11.84	8	Pass
2437	-9.01		
2462	-9.77		

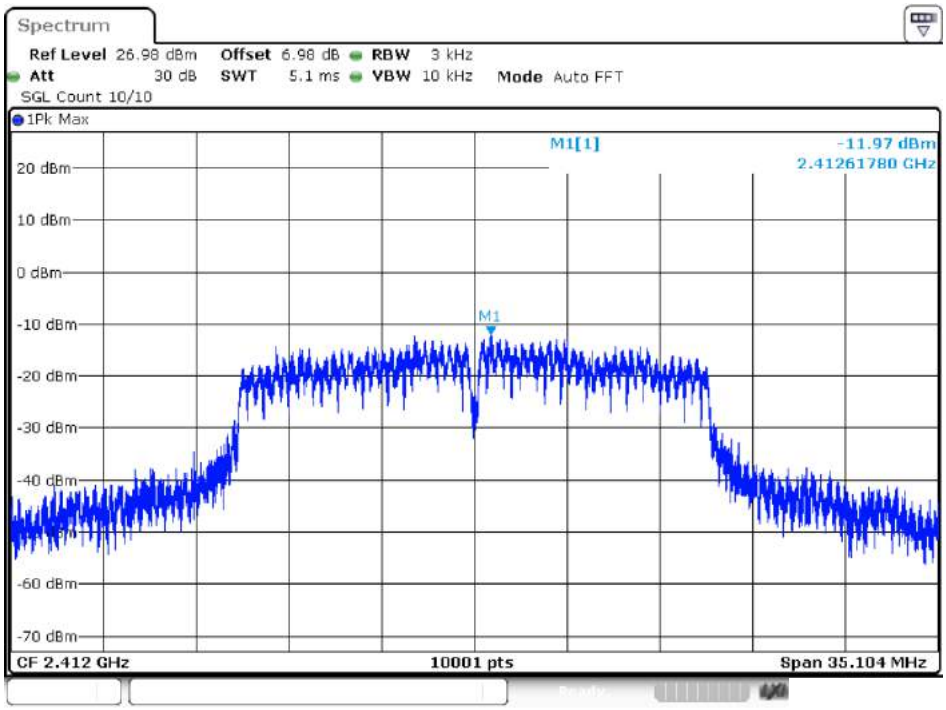


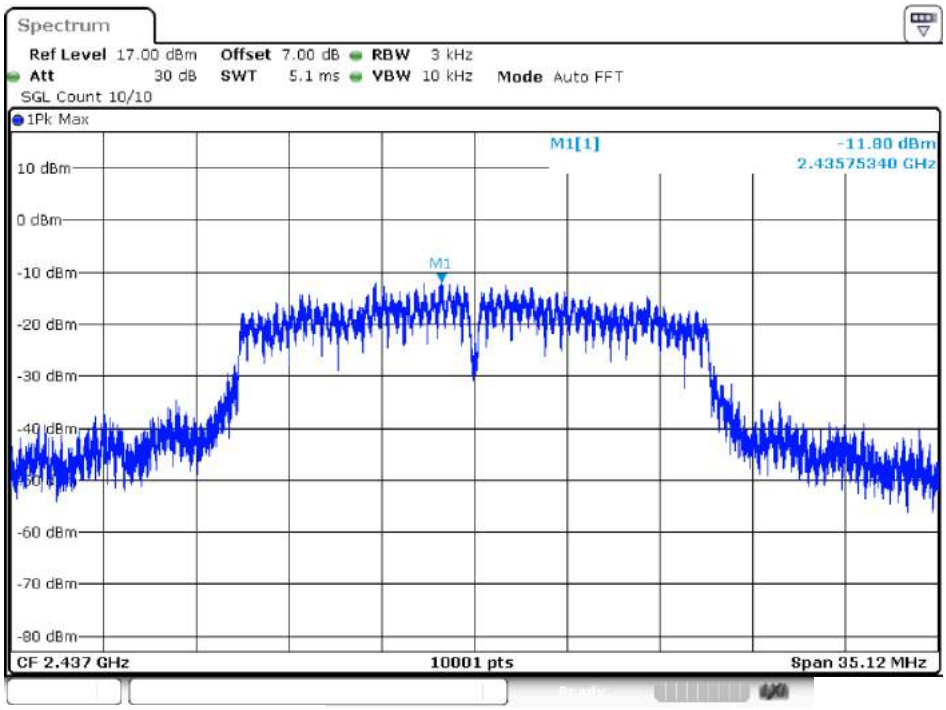

Spectrum
Ref Level 13.25 dBm Offset 3.25 dB RBW 3 kHz
Att 30 dB SWT 5.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -9.01 dBm
2.43636670 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 32.648 MHz

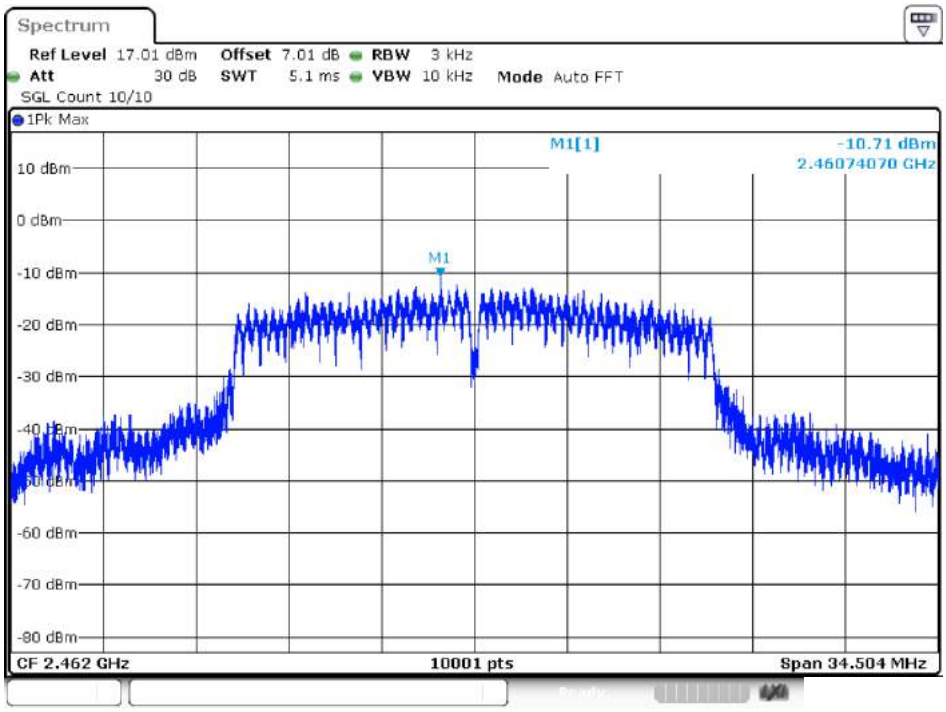

Spectrum
Ref Level 13.27 dBm Offset 3.27 dB RBW 3 kHz
Att 30 dB SWT 5.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -9.77 dBm
2.46071580 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.462 GHz
10001 pts
Span 32.68 MHz

IEEE 802.11n(HT20) MIMO(Antenna Gain=5dBi)					
Channel frequency (MHz)	Power Density (dBm/3kHz)			Power Density Limit (dBm/3kHz)	Result
	Ant1	Ant2	Total		
2412	-11.97	-12.75	-9.33	8	Pass
2437	-11.80	-8.85	-7.07		
2462	-10.71	-7.70	-5.94		
Remark: In MIMO, Ant1+Ant2 Directional Gain=G_{ant}+10Log(N)dBi=2+10Log(2)=5dBi. Directional Gain was according to KDB662911.					

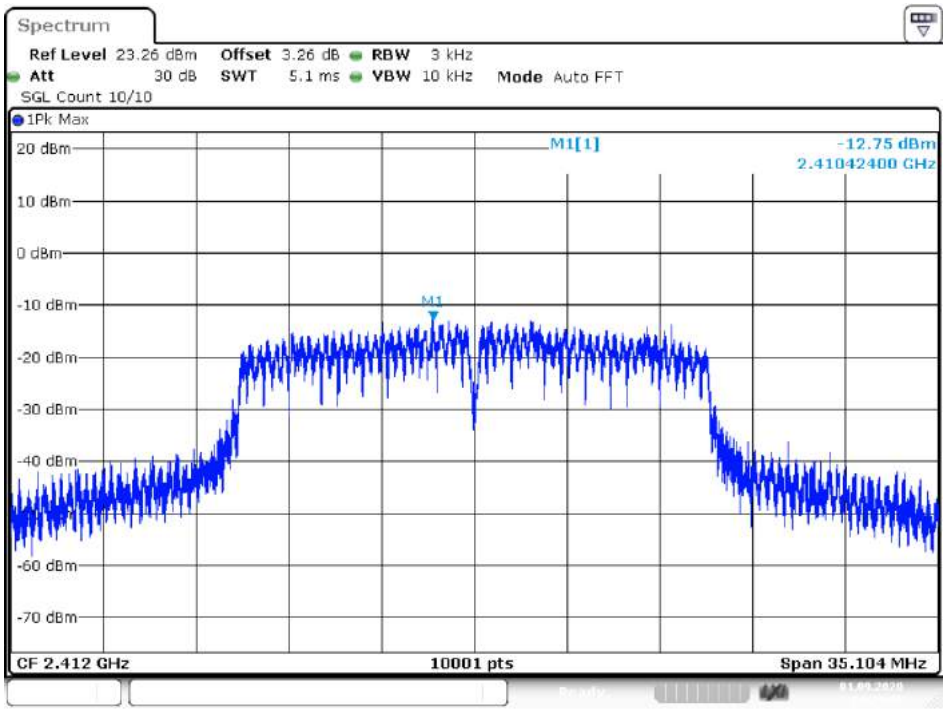
Ant1

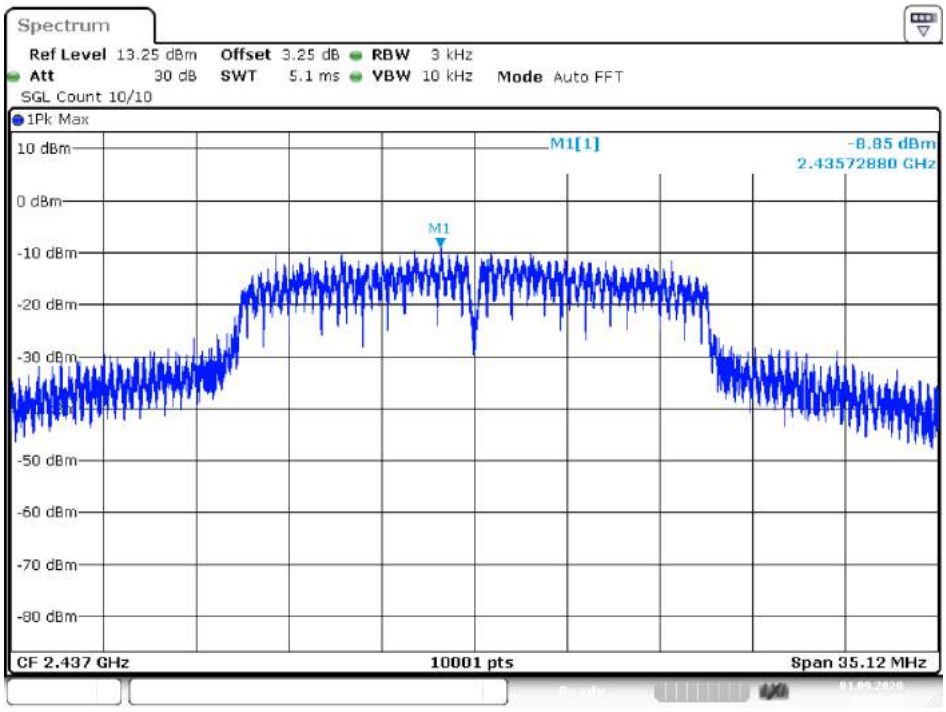


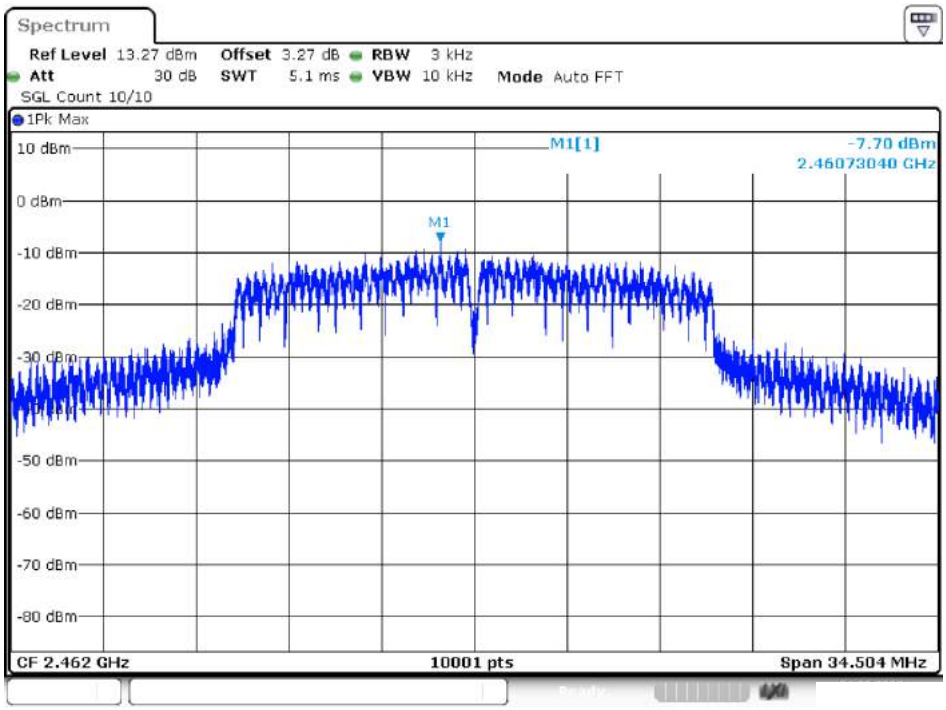

Spectrum
Ref Level 17.00 dBm Offset 7.00 dB RBW 3 kHz
Att 30 dB SWT 5.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -11.80 dBm
2.43575340 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 35.12 MHz


Spectrum
Ref Level 17.01 dBm Offset 7.01 dB RBW 3 kHz
Att 30 dB SWT 5.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -10.71 dBm
2.46074070 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.462 GHz
10001 pts
Span 34.504 MHz

Ant2


Spectrum
Ref Level 23.26 dBm Offset 3.26 dB RBW 3 kHz
Att 30 dB SWT 5.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -12.75 dBm
2.41042400 GHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-60 dBm
-70 dBm
M1
CF 2.412 GHz
10001 pts
Span 35.104 MHz

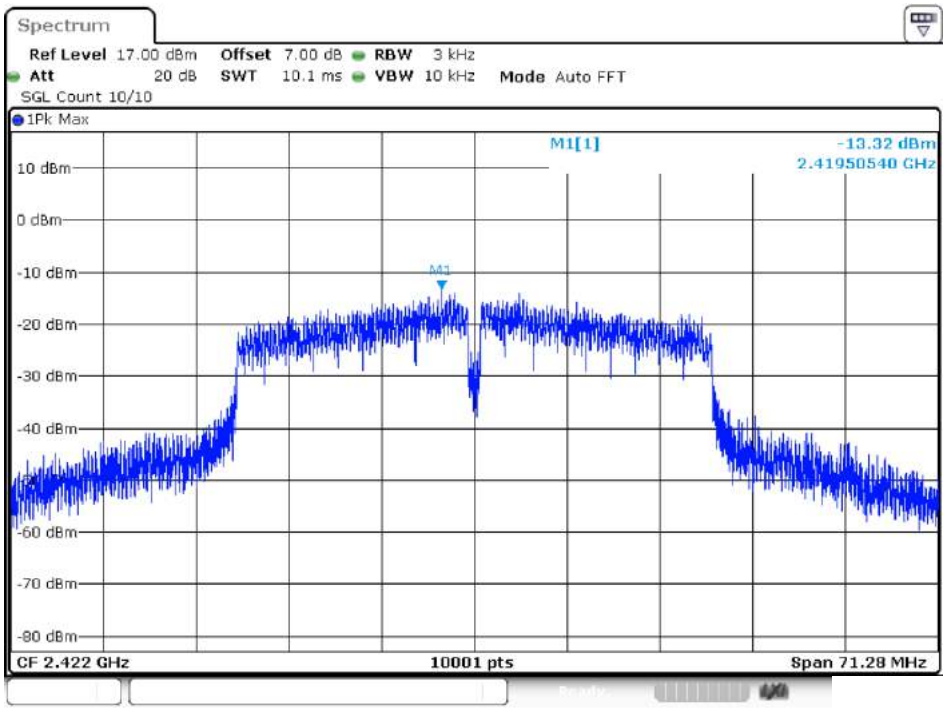

Spectrum
Ref Level 13.25 dBm Offset 3.25 dB RBW 3 kHz
Att 30 dB SWT 5.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -8.85 dBm
2.43572880 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
CF 2.437 GHz
10001 pts
Span 35.12 MHz

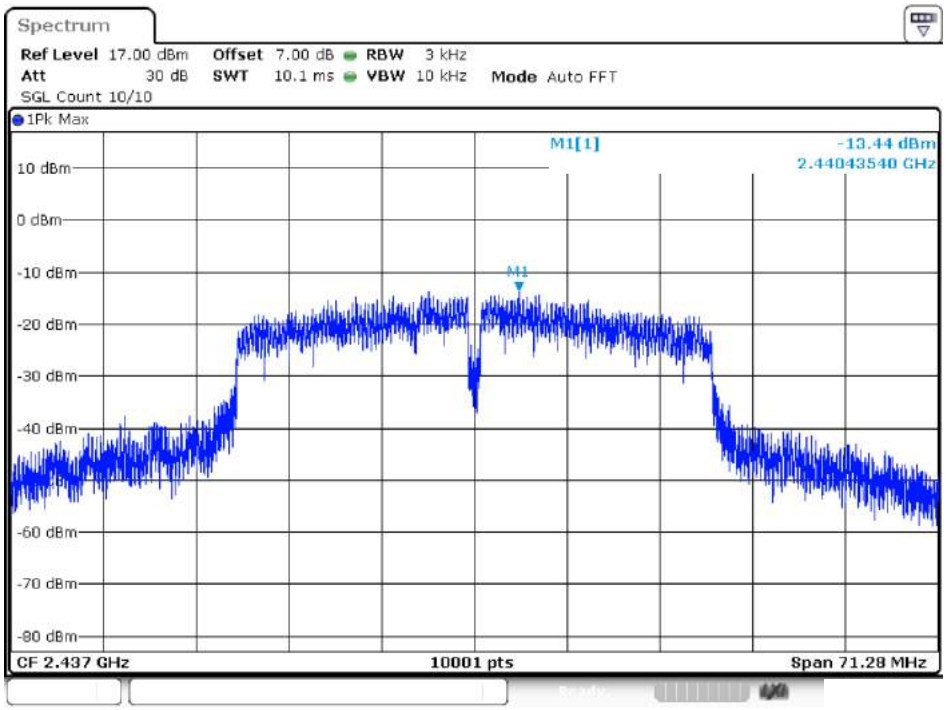


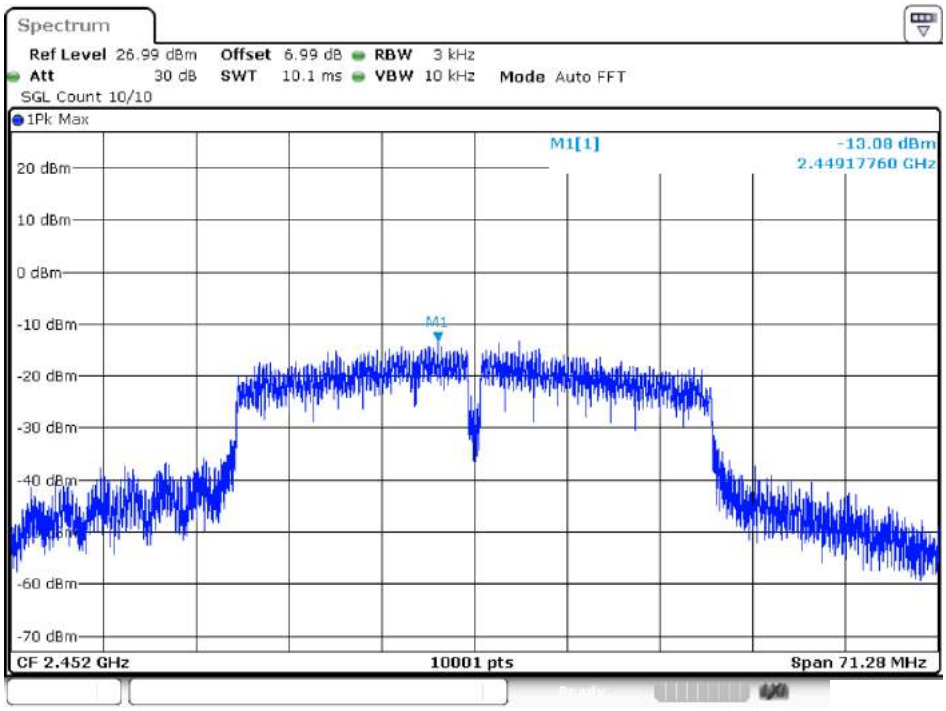
Date: 1.SEP.2020 04:26:57

IEEE 802.11n(HT40) MIMO(Antenna Gain=5dBi)					
Channel frequency (MHz)	Power Density (dBm/3kHz)			Power Density Limit (dBm/3kHz)	Result
	Ant 1	Ant 2	Total		
2422	-13.32	-13.95	-10.61	8	Pass
2437	-13.44	-9.99	-8.37		
2452	-13.08	-11.03	-8.93		
Remark: In MIMO, Ant1+Ant2 Directional Gain=G_{ant}+10Log(N)dBi=5+10Log(2)=5dBi. Directional Gain was according to KDB662911.					

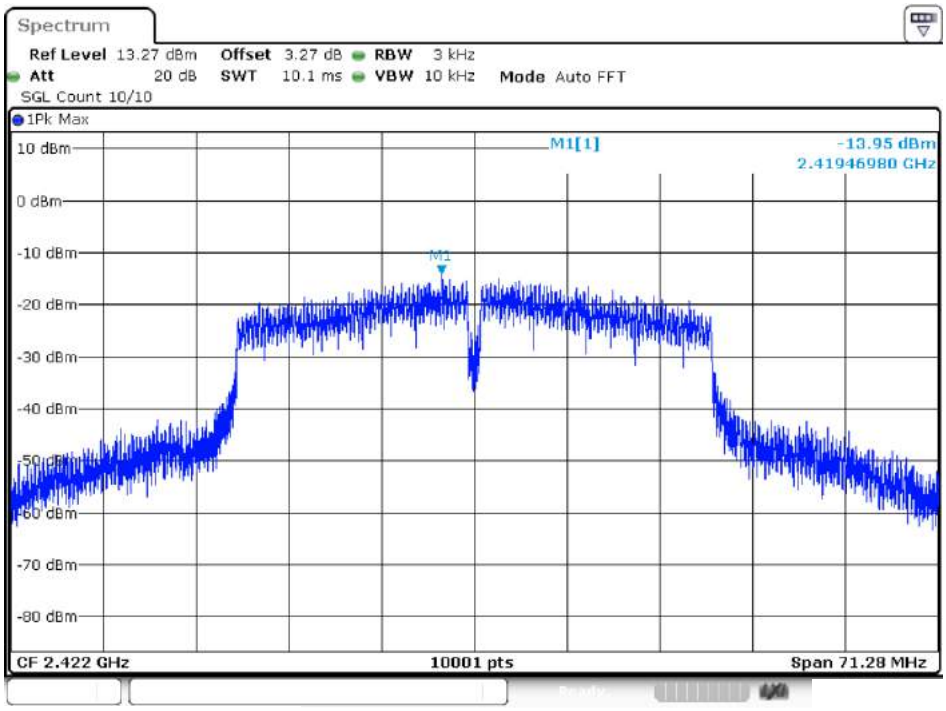
Ant1

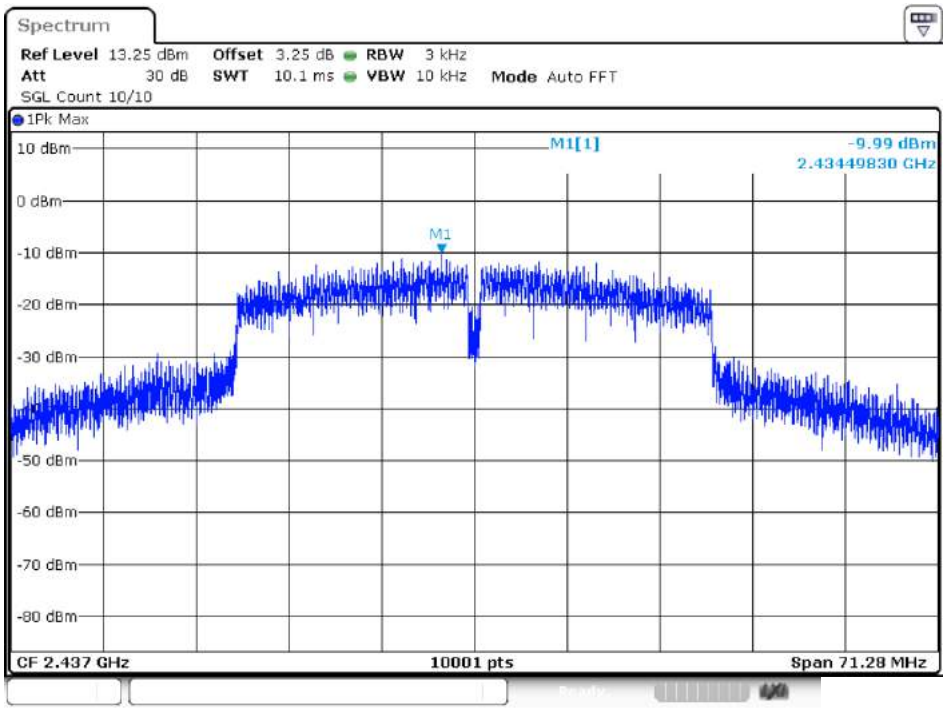


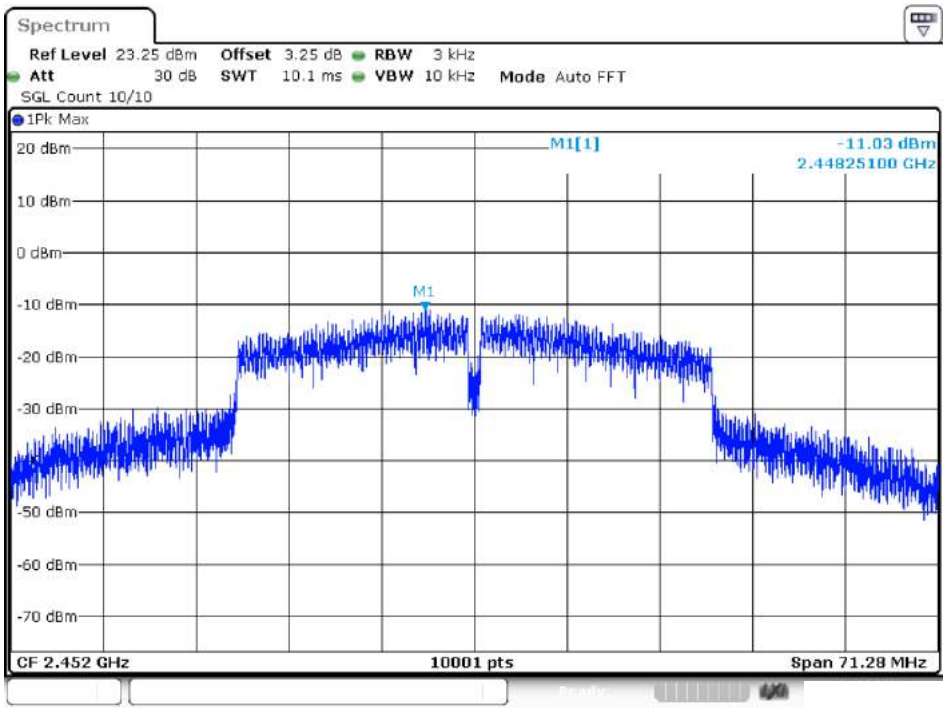

Spectrum
Ref Level 17.00 dBm Offset 7.00 dB RBW 3 kHz
Att 30 dB SWT 10.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -13.44 dBm
2.44043540 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.437 GHz
10001 pts
Span 71.28 MHz


Spectrum
Ref Level 26.99 dBm Offset 6.99 dB RBW 3 kHz
Att 30 dB SWT 10.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -13.08 dBm
2.44917760 GHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-60 dBm
-70 dBm
CF 2.452 GHz
10001 pts
Span 71.28 MHz

Ant2


Spectrum
Ref Level 13.27 dBm Offset 3.27 dB RBW 3 kHz
Att 20 dB SWT 10.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -13.95 dBm
2.41946980 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
CF 2.422 GHz
10001 pts
Span 71.28 MHz


Spectrum
Ref Level 13.25 dBm Offset 3.25 dB RBW 3 kHz
Att 30 dB SWT 10.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -9.99 dBm
2.43449830 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
CF 2.437 GHz
10001 pts
Span 71.28 MHz


Spectrum
Ref Level 23.25 dBm Offset 3.25 dB RBW 3 kHz
Att 30 dB SWT 10.1 ms VBW 10 kHz Mode Auto FFT
SGL Count 10/10
1Pk Max
M1[1] -11.03 dBm
2.44825100 GHz
M1
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-50 dBm
-60 dBm
-70 dBm
CF 2.452 GHz
10001 pts
Span 71.28 MHz

14. Antenna Port Emission

14.1 Test Equipment

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	CALIBRATED UNTIL
Spectrum Analyzer	Rohde & Schwarz	FSV40	US40240623	2021-11-19
Coaxial Cable	Gigalink Microwave	ZT40	19022092	2021-11-19
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	2021-11-19

Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

14.2 Measuring Instruments and Setting

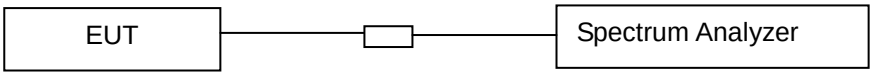
The following table is the setting of spectrum analyzer.

Spectrum analyzer	Setting
Attenuation	Auto
RBW	100kHz
VBW	300kHz
Detector	Peak
Trace	Max hold

14.3 Test Procedures

The conducted spurious emissions were measured conducted using a spectrum analyzer at low, Middle, and high channels, the limit was determined by attenuation 20dB of the RF peak power output.

14.4 Block Diagram of Test setup

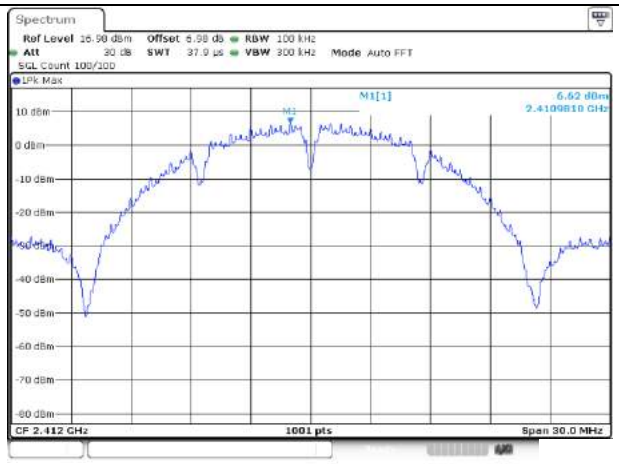
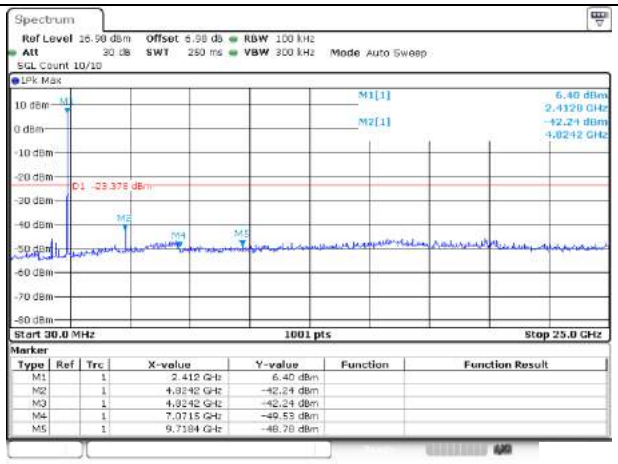


14.5 Test Result

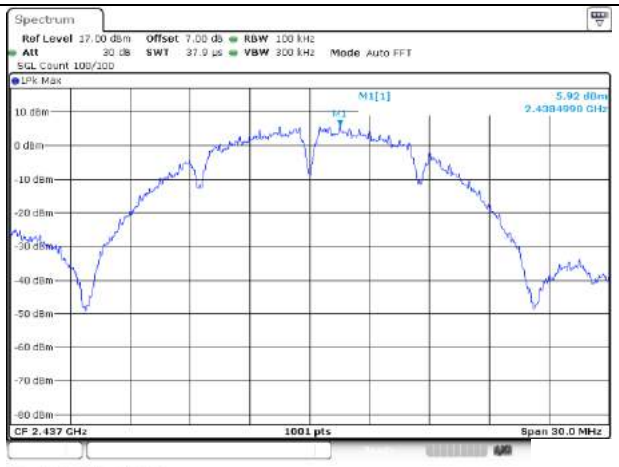
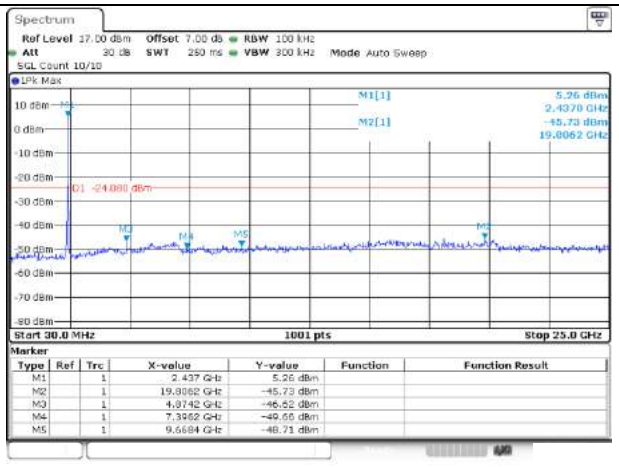
PASS.

Please refer to the following pages.

Tx. Spurious 802.11b 2412MHz Ant1 Emission

Reference	Emission
	

Tx. Spurious 802.11b 2437MHz Ant1 Emission

Reference	Emission
	

Tx. Spurious 802.11b 2462MHz Ant1 Emission

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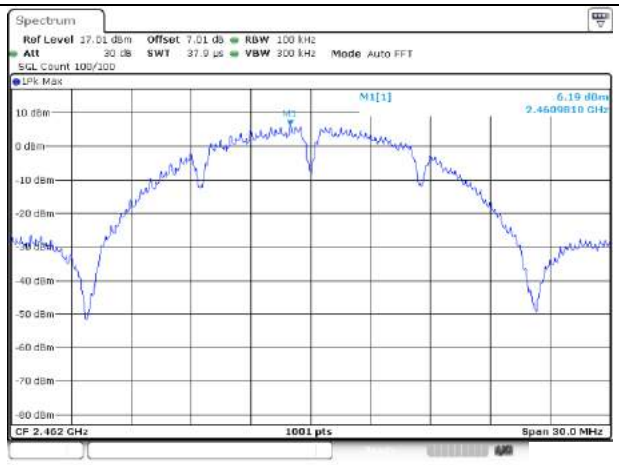
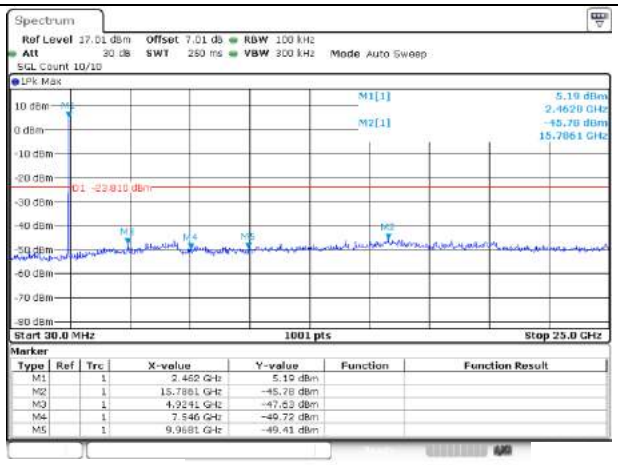
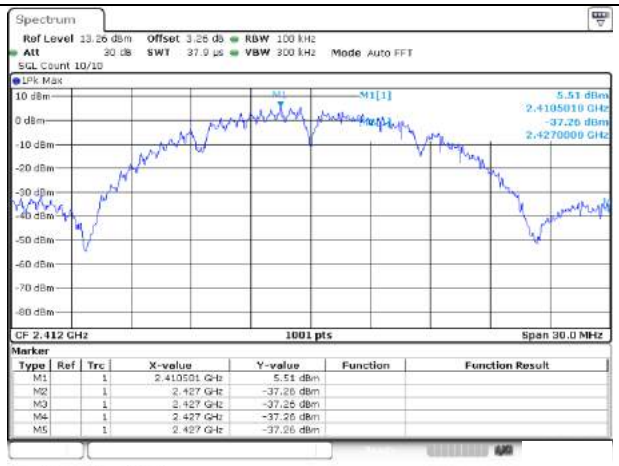
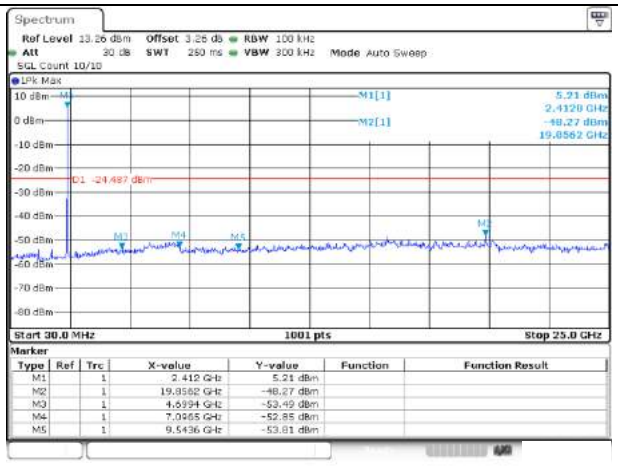
	

Tx. Spurious 802.11b 2412MHz Ant2 Emission

Reference	Emission
	

Tx. Spurious 802.11b 2437MHz Ant2 Emission

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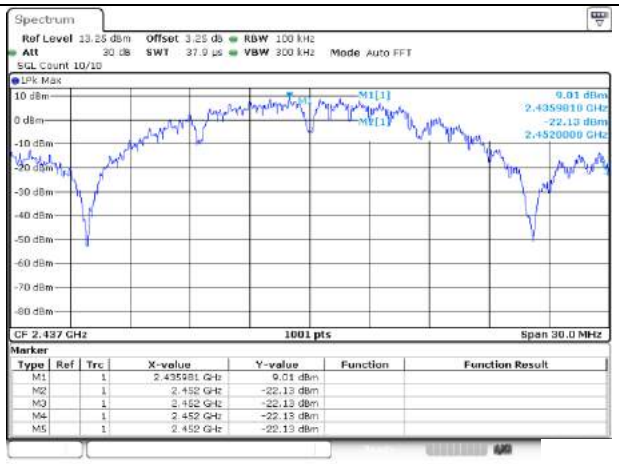	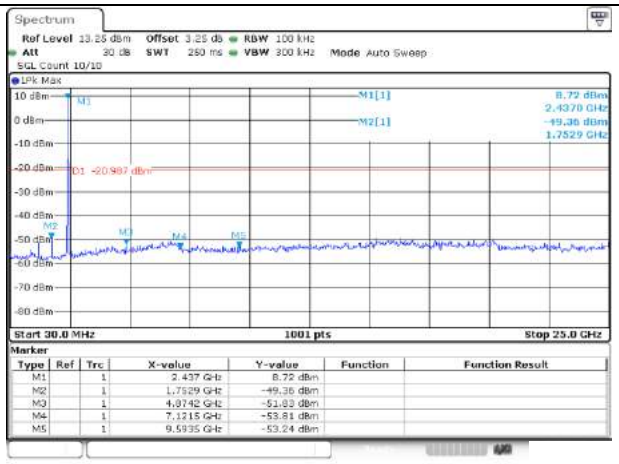

Tx. Spurious 802.11b 2462MHz Ant2 Emission

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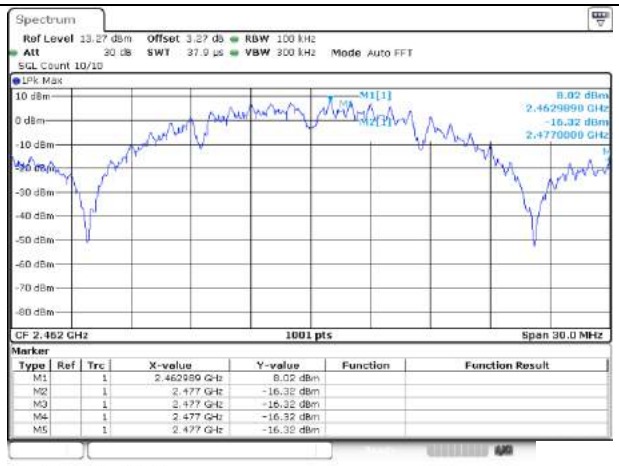	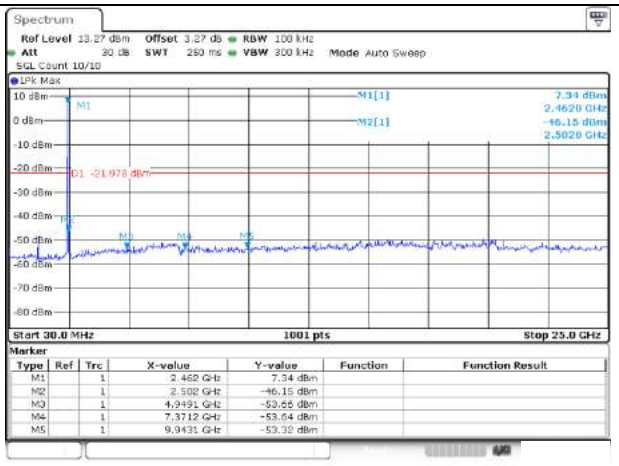

Tx. Spurious 802.11g 2412MHz Ant1 Emission

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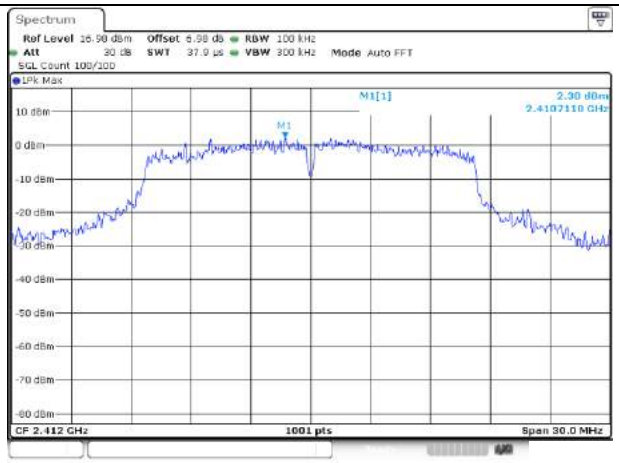	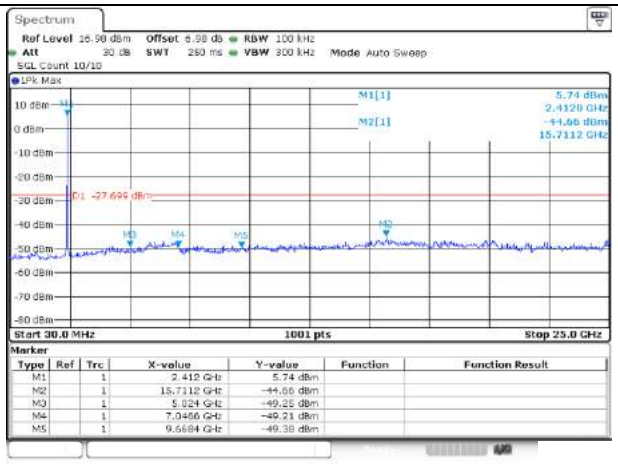

Tx. Spurious 802.11g 2437MHz Ant1 Emission

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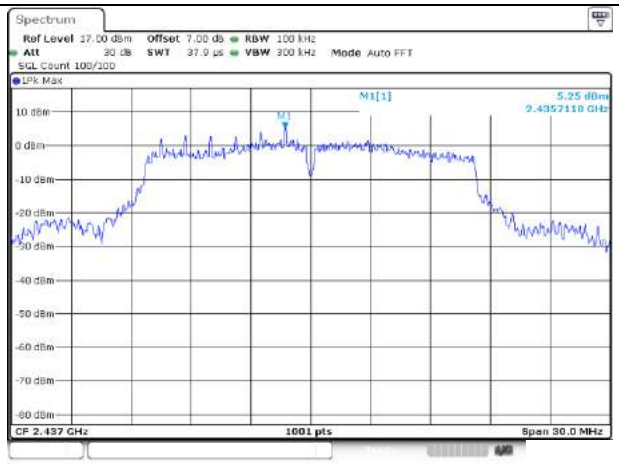	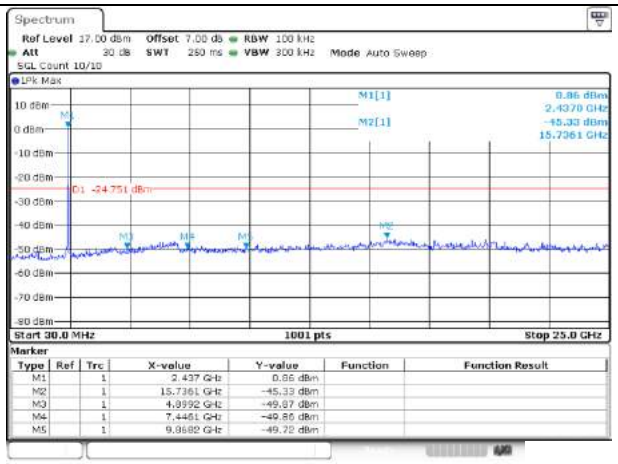

Tx. Spurious 802.11g 2462MHz Ant1 Emission

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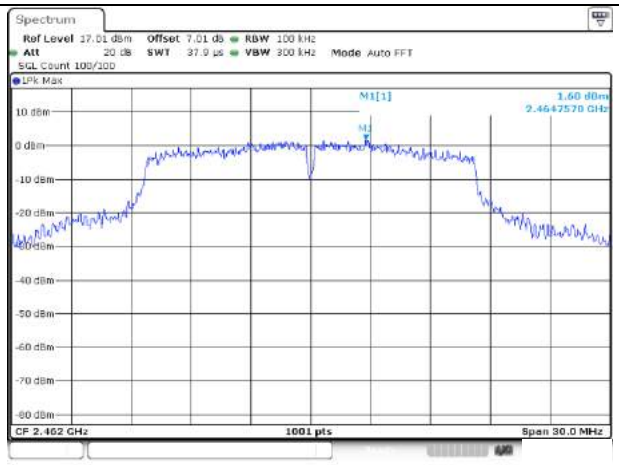	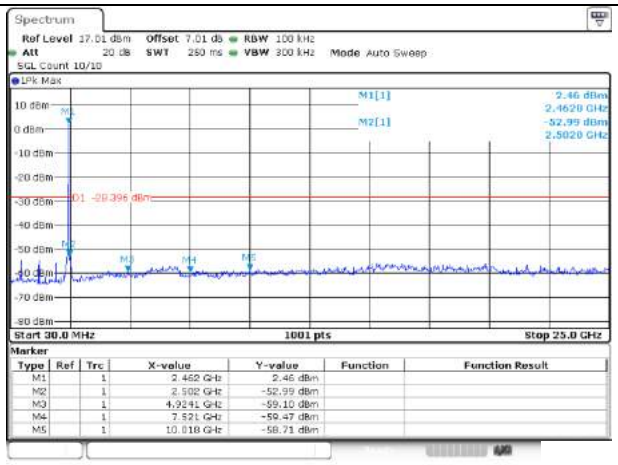

Tx. Spurious 802.11g 2412MHz Ant2 Emission

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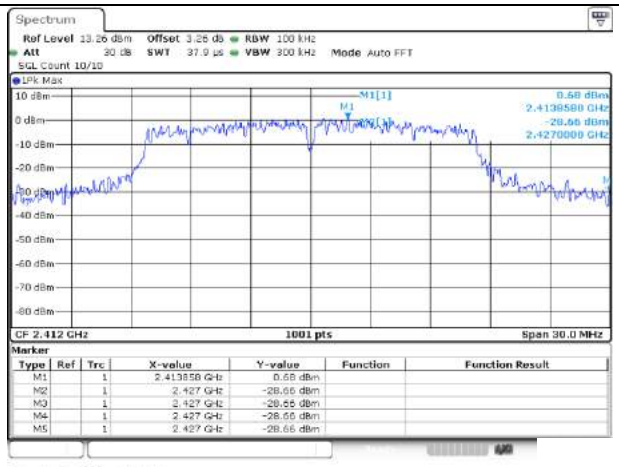	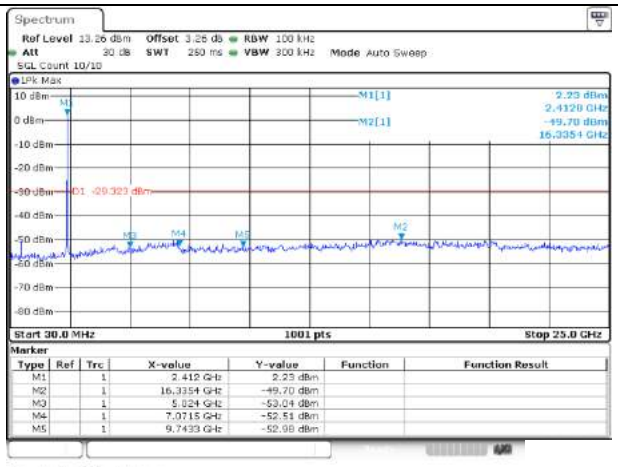

Tx. Spurious 802.11g 2437MHz Ant2 Emission

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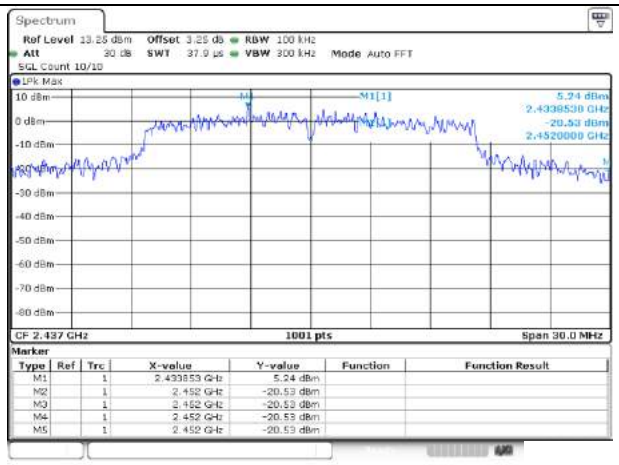	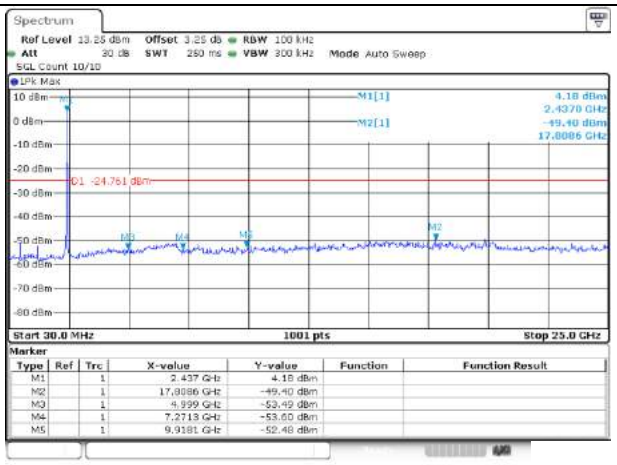

Tx. Spurious 802.11g 2462MHz Ant2 Emission

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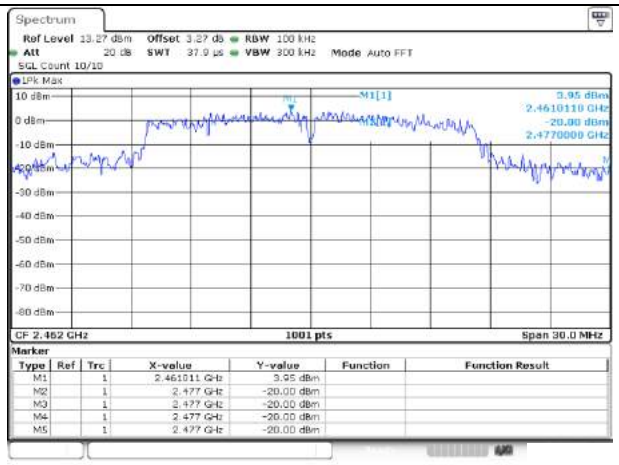	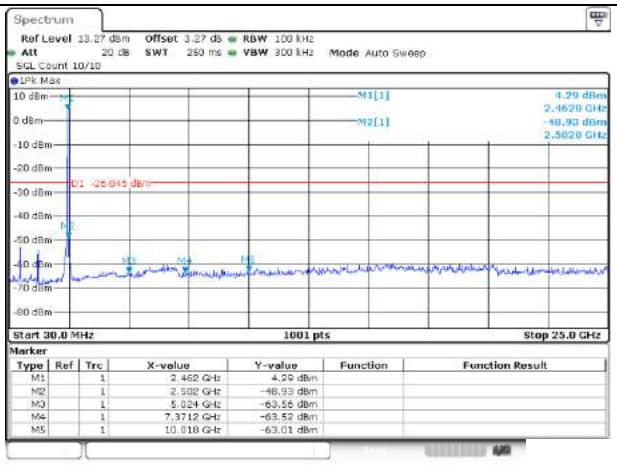

Tx. Spurious 802.11n(HT20) 2412MHz MIMO Emission

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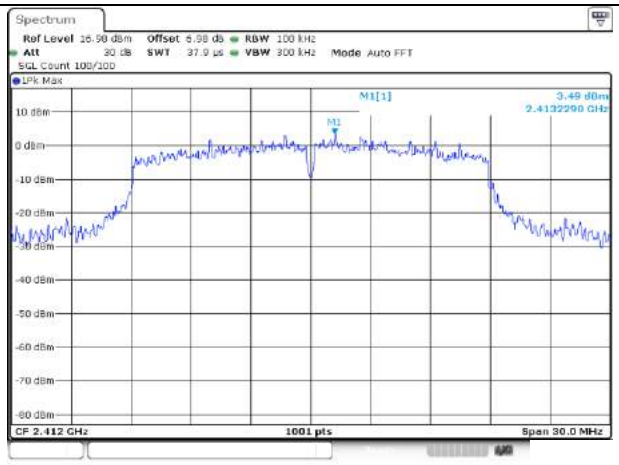	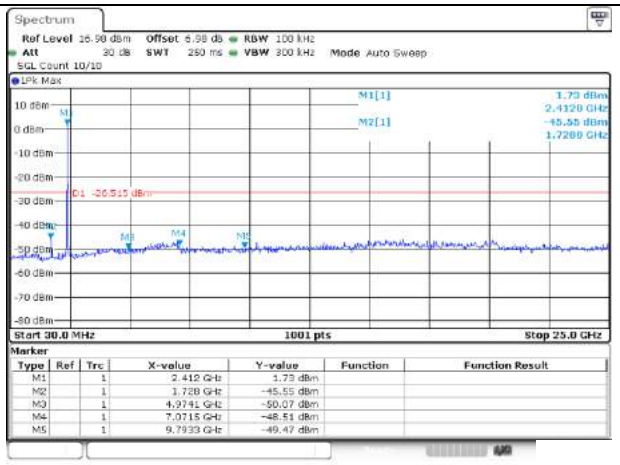

Tx. Spurious 802.11n(HT20) 2437MHz MIMO Emission

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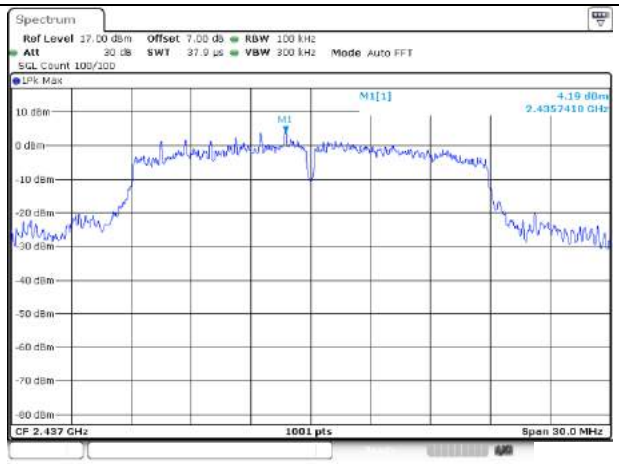	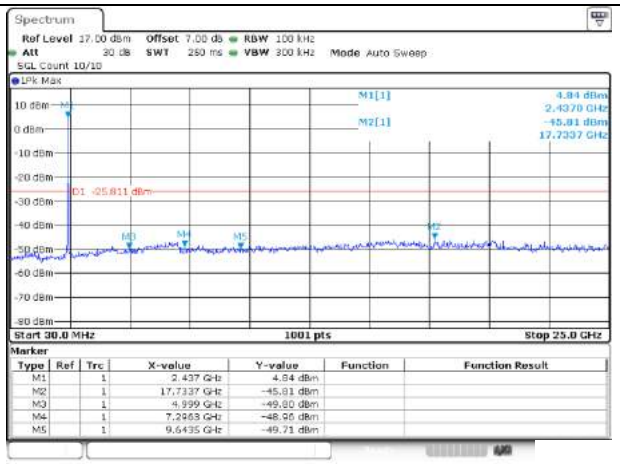

Tx. Spurious 802.11n(HT20) 2462MHz MIMO Emission

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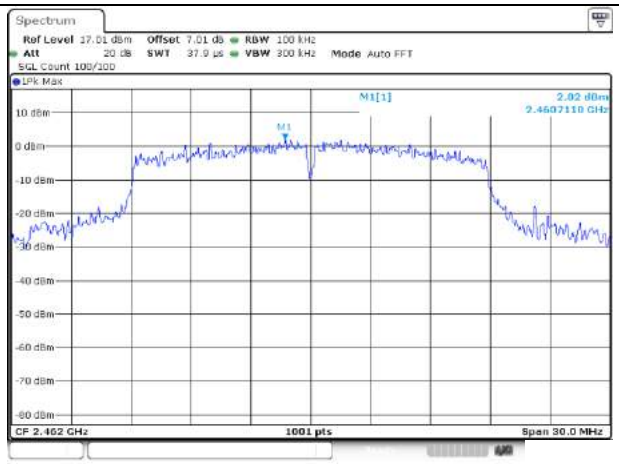
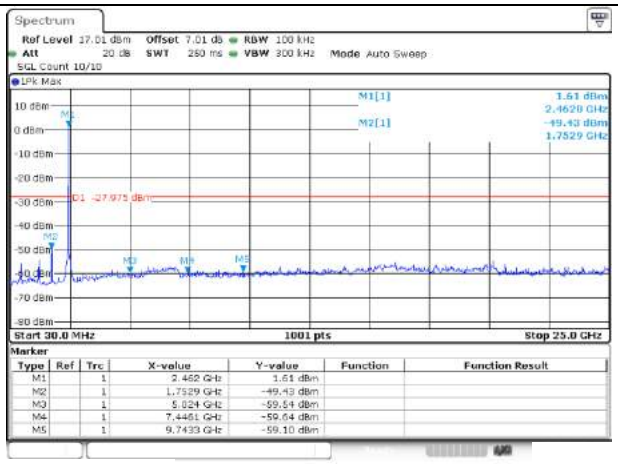
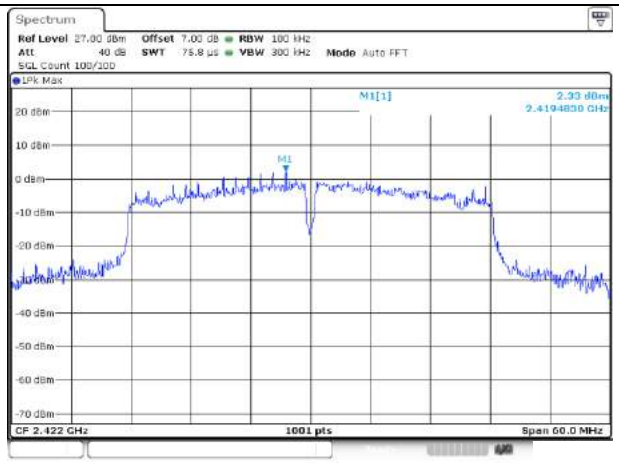
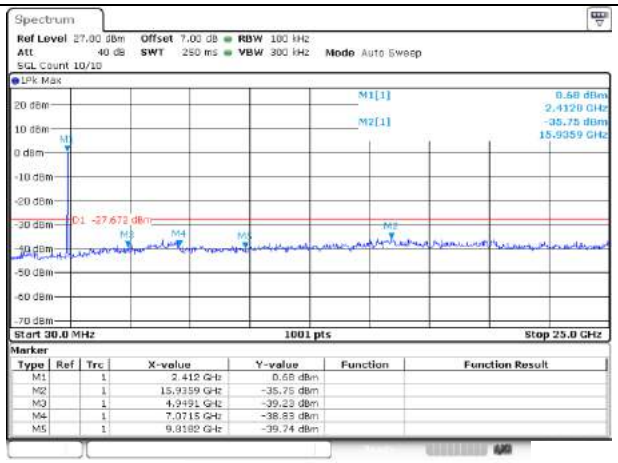
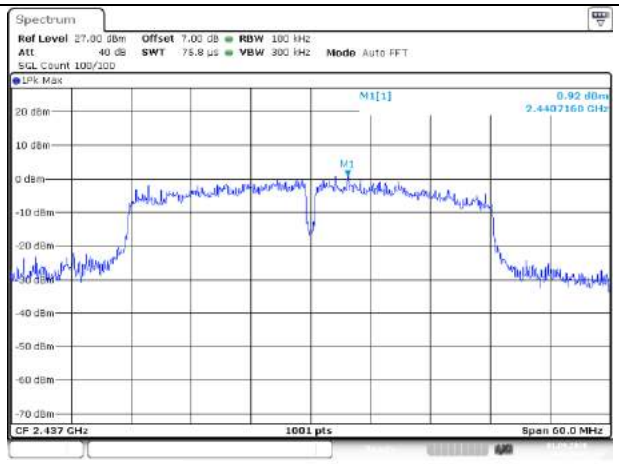
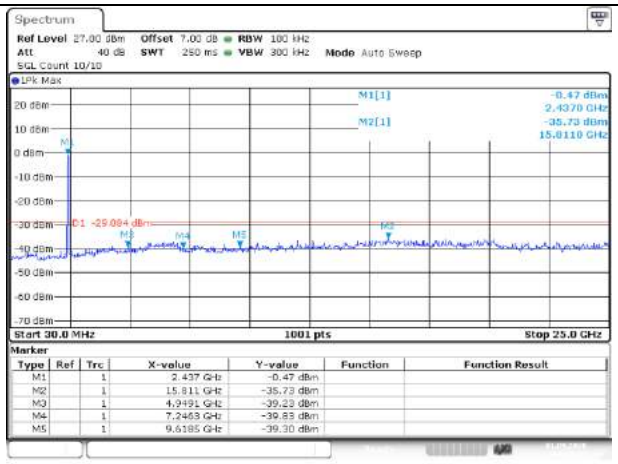
	

Tx. Spurious 802.11n(HT40) 2422MHz MIMO Emission

Reference	Emission
	

Tx. Spurious 802.11n(HT40) 2437MHz MIMO Emission

Reference	Emission
	

Tx. Spurious 802.11n(HT40) 2452MHz MIMO Emission

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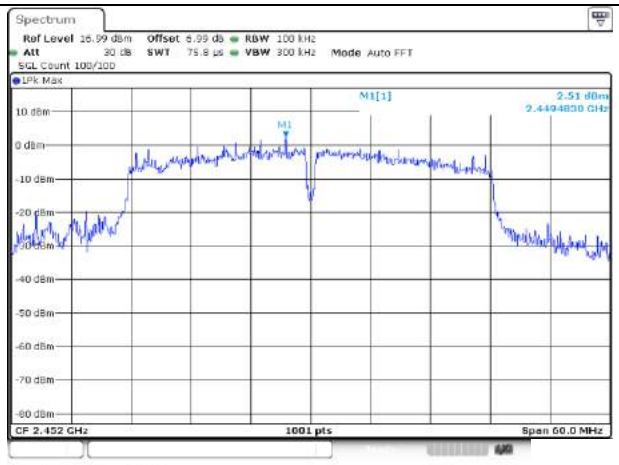	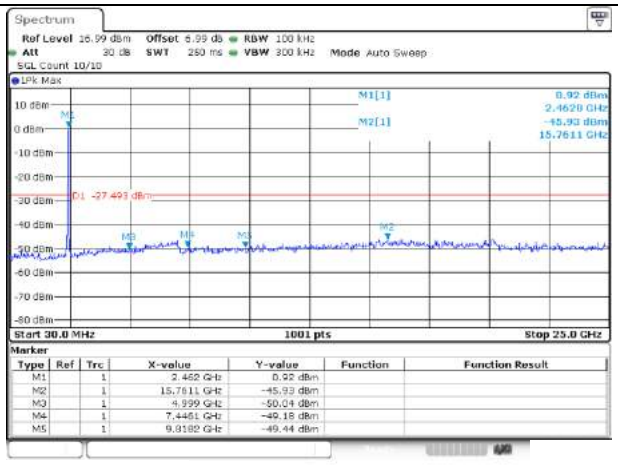

15. Antenna Application

15.1 Antenna Requirement

For intentional device, according to FCC 47 CFR Section 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. And according to FCC 47 CFR Section 15.247 (b), if 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 6dBi.

15.2 Result

The EUT'S antenna are external antennas. The antenna's gain is 2dBi and meets the requirement.The antenna Connector is IPEX ANT Connector.

16. Photos of EUT

Please refer to external photos.pdf and internal photos.pdf.