RADIO TEST REPORT

Product	:	Orbis Datalogger
Model Name	:	Orbis Datalogger
FCC ID	:	YQMGS610390
Test Regulation	:	FCC 47 CFR Part 15 Subpart C (Section 15.247)
	:	2023/8/30
Test Date	:	2023/8/31 ~ 2023/9/14
Issued Date	:	2023/11/23
Applicant	:	FARO Technologies, Inc. 125 Technology Park, Lake Mary, FL 32746, USA
Issued By	:	Underwriters Laboratories Taiwan Co., Ltd. Building A, B and E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan

Testing Laboratory
3398

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REVISION HISTORY

Original Test Report No.: 4790982166-US-R0-V0

Revision	Test report No.	Date	Page revised	Contents
Original	4790982166-US-R0-V0	2023/11/23	-	Initial issue

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1. Attestation of Test Results

APPLICANT:	FARO Technologies, Inc. 125 Technology Park, Lake Mary, FL 32746, USA
MANUFACTURER:	GeoSLAM Ltd. Innovation House, Nottingham NG11 6JS, UK
EUT DESCRIPTION:	Orbis Datalogger
BRAND:	FARO
MODEL:	Orbis Datalogger
SAMPLE STAGE:	Engineering Verification Test sample
DATE of TESTED:	2023/8/31 ~ 2023/9/14

APPLICABLE STANDARDS

STANDARD	Test Results
FCC 47 CFR PART 15 Subpart C (Section 15.247)	PASS

Underwriters Laboratories Taiwan Co., Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by Underwriters Laboratories Taiwan Co., Ltd. based on interpretations and/or observations of test results. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by Underwriters Laboratories Taiwan Co., Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by Underwriters Laboratories Taiwan Co., Ltd. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Prepared By:	Approved and Authorized By:
Cindy Hsin Date : 2023/11/23	Eric Lee Date : 2023/11/23
Project Handler	Senior Laboratory Engineer

2. Summary of Test Results

Summary of Test Results		
FCC Clause	**Test Items**	**Result**
15.247(a)(2)	6dB Bandwidth	PASS
15.247(b)	Conducted Output Power	PASS
15.247(e)	Power Spectral Density	PASS
15.247(d)	Antenna Port Emission	PASS
15.205 / 15.209 / 15.247(d)	Radiated Emissions and Band Edge Measurement	PASS
15.207	AC Power Conducted Emission	See Note 1
15.203	Antenna Requirement	PASS

Note 1: The EUT was supplied by battery only, and it was not directly or indirectly connected to the AC main system. So, the test item of AC power conducted emission was not evaluated.

3. Test Methodology and Reference Procedures

The tests documented in this report were performed in accordance with 47 CFR FCC Part 2, KDB558074 D01 Meas Guidance v05r02, KDB414788 D01 Radiated Test Site v01r01, ANSI C63.10-2013 and KDB 662911 D01 Multiple Transmitter Output v02r01.

4. Facilities and Accreditation

Test Location	Underwriters Laboratories Taiwan Co., Ltd.
Address	Building A, B and E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan
Accreditation Certificate	Underwriters Laboratories Taiwan Co., Ltd. is accredited by TAF, Laboratory Code 3398.

5. Measurement Uncertainty

For statement of conformity, simple acceptance (Section 3.1.4 of IEC Guide 115) was applied as decision rule for measurement in this test report.

The following uncertainties have been calculated to provide a confidence level of 95 % using a coverage factor k=2.

Determining compliance based on the results of the compliance measurement, not considering measurement instrumentation uncertainty.

Measurement	Frequency	Uncertainty
Conducted disturbance at mains terminals ports	150kHz ~ 30MHz	3.1 dB
RF Conducted	9 kHz - 40GHz	2.3 dB
Radiated disturbance below 30MHz	9 kHz - 30 MHz	3.2 dB
Radiated disturbance below 1 GHz	30MHz ~ 1GHz	6.1 dB
Radiated disturbance above 1 GHz	1GHz ~ 40GHz	5.1 dB

6. Equipment under Test

6.1. Description of EUT

Product	Orbis Datalogger
Brand Name	FARO
Model Name	Orbis Datalogger
Operating Frequency	2412MHz ~ 2462MHz
Modulation	CCK, DQPSK, DBPSK for DSSS 1024QAM, 64QAM, 16QAM, QPSK, BPSK
Transfer Rate	802.11b: up to 11 Mbps 802.11g: up to 54 Mbps 802.11n: up to MCS15 802.11ax: up to MCS11
Number of Channel	11 for 802.11b, 802.11g, 802.11n (HT20), 802.11ax (HE20) 7 for 802.11n (HT40), 802.11ax (HE40)
Maximum Output Power	**Non-Beamforming Mode:** 802.11b: 17.26 dBm 802.11g: 20.49 dBm 802.11ax (HE20): 21.63 dBm 802.11ax (HE40): 18.80 dBm **Beamforming Mode:** 802.11ax (HE20): 21.23 dBm 802.11ax (HE40): 18.40 dBm
Normal Voltage	14.8Vdc from battery
S/N	Compliance.06
Sample ID	Conducted Test: 6405690 Radiated Test: 6405690

Note:

1. The EUT incorporates a MIMO function. Physically, the EUT provides two completed transmitters and two receivers.

Modulation Mode	Tx,Rx Function
802.11b	2TX,2RX
802.11g	2TX,2RX
802.11n (HT20)	2TX,2RX
802.11n (HT40)	2TX,2RX
802.11ax (HE20)	2TX,2RX
802.11ax (HE40)	2TX,2RX

* The modulation and bandwidth are similar for 802.11n mode for HT20 / HT40 and 802.11ax mode for HE20 / HE40, therefore investigated worst case to representative mode in test report.

2. The EUT contains following accessory devices:

Product	Brand	Model	Description
Mobile Scanner	FARO	Orbis Mobile Scanner	N/A
Orbis main cable	FARO	Orbis Cable	1.5m
RJ45 Cable	FARO	Orbis Cable	2 m
Battery	PAG	9307V	90Wh 14.8V, 6.1Ah
Battery charger	PAG	Micro Charger	5-20V

3. The above EUT information is declared by manufacturer and for more detailed features description, please refer the manufacturer's or user's manual, the laboratory shall not be held responsible.

6.2. Channel List

11 channels are provided for 802.11b, 802.11g and 802.11n (HT20), 802.11ax (HE20):

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

7 channels are provided for 802.11n (HT40), 802.11ax (HE40):

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

6.3. Test Condition

Test Item	Test Site No.	Environmental Condition	Input Power	Test Date	Tested by
Antenna Port Conducted Measurement	SR4	21~27℃/ 51~66%RH	14.8Vdc	2023/09/07~ 2023/09/14	Rex Chen
Radiated Spurious Emission	966-2	21~28℃/ 51~68%RH	14.8Vdc	2023/08/31~ 2023/09/09	Rex Chen

FCC Test Firm Registration Number: 498077

Sample Calculation:

Antenna Port Conducted Measurement:

- Where relevant, the follow sample calculation is provided:
  Result Value (dBm) = Reading Value (dBm) +Attenuator Factor (dB) + Cable Loss (dB).
  Example: Result Value (10dBm) = Reading Value (-2dBm) +Attenuator Factor (10dB) + Cable Loss(2dB).
  *Test plot only shown the “Result Value”.

Radiated Spurious Emission:

- Where relevant, the follow sample calculation is provided:
  Result Value (dBuV/m) = Reading Value (dBuV) + Correction Factor (dB/m).
  Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Loss (dB) - Preamp Factor (dB).
  Example: Result Value (34.5dBuV/m) = Reading Value (40.1dBuV) + Antenna Factor (18.7dB/m) + Cable Loss (4.2dB) - Preamp Factor (28.5dB).

6.4. Description of Available Antennas

Ant. No.	Transmitter Circuit	Brand Name	Model Name	Ant. Type	Maximum Gain (dBi)
1	Chain (0)+ (1)	2J	2JF0102P	PCB	2.2

Note: The above antenna information was provided from customer and for more detailed features description, please refer the manufacturer's specification or user's manual, the laboratory shall not be held responsible.

6.5. Test Mode Applicability and Tested Channel Detail

- The fundamental of the EUT was investigated in three orthogonal axes X-Y/Y-Z/X-Z, it was determined that Y-Z plane was worst-case. Therefore, all final radiated testing was performed with the EUT in Y-Z plane.
- The EUT only battery mode the AC power line conducted emissions no need.
- For antenna port conducted measurement, this item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
- For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel), parallel and perpendicular are the worst orientations, therefore testing was performed on these two orientations only.
- For below 1 GHz radiated emission and AC power line conducted emission have performed all modes of operation were investigated and the worst-case emissions are reported.
- Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

Non-Beamforming Mode:

Test Item	Mode	Modulation Technology	Modulation Type	Available Channel	Test Channel	Data Rate
Radiated Emissions (Above 1GHz)	802.11b	DSSS	DBPSK	1 to 11	1,6,11	1 Mbps
	802.11g	OFDM	BPSK	1 to 11	1,6,11	6 Mbps
	802.11ax20	OFDMA	BPSK	1 to 11	1,6,11	MCS0 Nss1
	802.11ax40	OFDMA	BPSK	3 to 9	3,6,9	MCS0 Nss1
Radiated Emissions (Below 1GHz)	802.11ax20	OFDMA	BPSK	1 to 11	11	MCS0 Nss1
*Antenna Port Conducted Measurement	802.11b	DSSS	DBPSK	1 to 11	1,6,11	1 Mbps
	802.11g	OFDM	BPSK	1 to 11	1,6,11	6 Mbps
	802.11ax20	OFDMA	BPSK	1 to 11	1,6,11	MCS0 Nss1
	802.11ax40	OFDMA	BPSK	3 to 9	3,6,9	MCS0 Nss1

Beamforming Mode:

Test Item	Mode	Modulation Technology	Modulation Type	Available Channel	Test Channel	Data Rate
*Antenna Port Conducted Measurement	802.11ax20	OFDMA	BPSK	1 to 11	1,6,11	MCS0 Nss1
	802.11ax40	OFDMA	BPSK	3 to 9	3,6,9	MCS0 Nss1

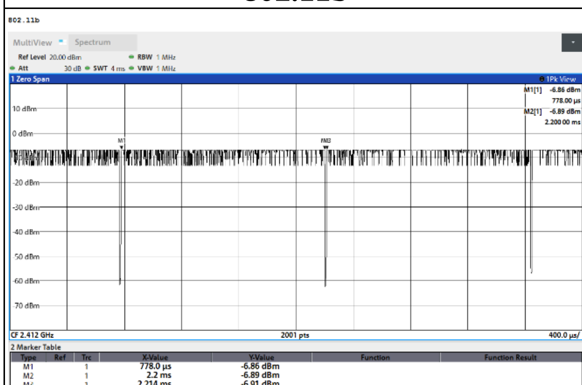
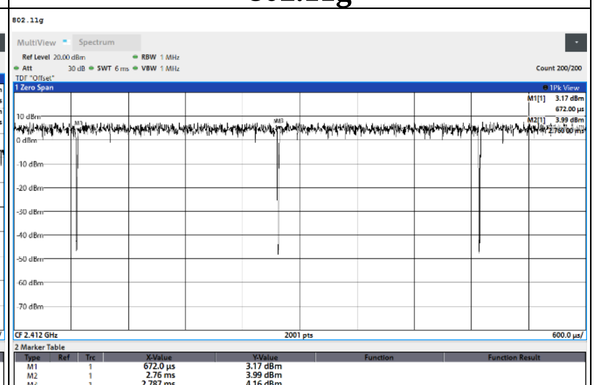
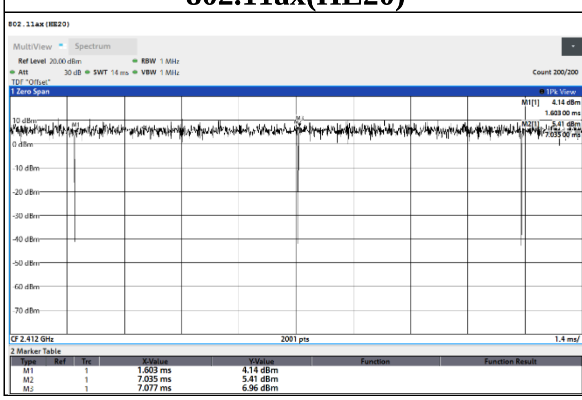
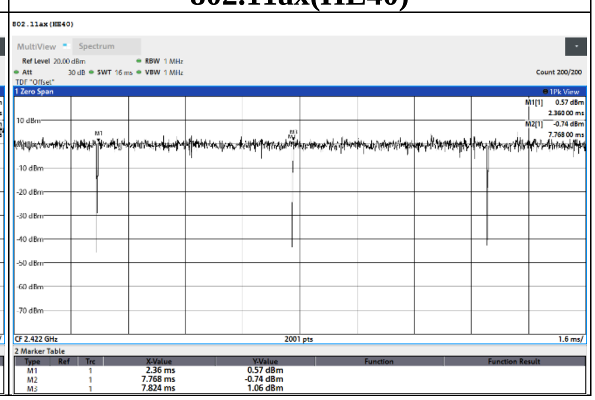
*Note: The worse spurious emissions test and maximum output power was found in Non-Beamforming Mode. Therefore Beamforming mode only the test data of the RF output power were recorded in this report.

Simultaneously transmission condition:

Condition	Technology	
1	WLAN (2.4GHz)	WLAN (5GHz)
Note: The emission of the simultaneous operation has been evaluated and no non-compliance was found.		

6.6. Duty cycle

Mode	On Time (ms)	On+Off Time (ms)	Duty Cycle	Duty Factor (dB)	VBW Set (above 1GHz)
802.11b	1.422	1.436	0.9903	N/A	10Hz
802.11g	2.088	2.115	0.9872	N/A	10Hz
802.11ax(HE20)	5.432	5.474	0.9923	N/A	10Hz
802.11ax(HE40)	5.408	5.464	0.9898	N/A	10Hz

802.11b	802.11g
	
802.11ax(HE20)	**802.11ax(HE40)**
	

7. Test Equipment

Test Equipment List					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Cal. Date**	**Expired date**
Radiated Spurious Emission					
Spectrum Analyzer	Keysight	N9010A	MY56070827	2023/4/7	2024/4/6
EMI Test Receiver	Rohde & Schwarz	ESR7	101754	2022/12/13	2023/12/12
Loop Antenna	ETS lindgren	6502	00213440	2023/1/4	2024/1/3
Trilog-Broadband Antenna with 5dB Attenuator	Schwarzbeck & EMCI	VULB 9168 & N-6-05	774 & AT-N0538	2023/2/13	2024/2/12
Horn Antenna (1-18 GHz)	Schwarzbeck	BBHA 9120 D	01690	2022/12/21	2023/12/20
Horn Antenna (18-40 GHz)	Schwarzbeck	BBHA 9170	781	2022/12/30	2023/12/29
Preamplifier (30-1000 MHz)	EMCI	EMC330E	980405	2023/6/7	2024/6/6
Preamplifier (1-18 GHz)	EMCI	EMC051835BE	980406	2023/2/17	2024/2/16
Preamplifier (18-40GHz)	EMCI	EMC184040SEE	980426	2023/5/9	2024/5/8
Cables	Hanyitek	K1K50-UP0264-K1K50-2500	170214-4 & 170425-2	2022/12/1	2023/11/30
Cables	Hanyitek	K1K50-UP0264-K1K50-2500	170214-1 & 170214-2	2022/12/1	2023/11/30
Antenna Port Conducted Measurement					
Spectrum Analyzer	Keysight	N9010A	MY56070834	2022/10/24	2023/10/23
Attenuator	EMCI	EMC-40ATK2W10	17002	2022/12/9	2023/12/8
Pulse Power Sensor	Anritsu	MA2411B	1531202	2023/1/4	2024/1/3
Power Meter	Anritsu	ML2495A	1645002	2023/1/4	2024/1/3

UL Software		
Description	**Name**	**Version**
Radiated measurement	e3	6.191211 (V6)
Conducted measurement	RF-Conducted-FCC 15247	ver 1.0

8. Description of Test Setup

Support Equipment

ID	Equipment	Brand Name	Model Name	S/N	Remark
A	Mobile Scanner	FARO	Orbis Mobile Scanner	NA	Supplied by Client
B	USB HUB	FUJEI	AJ0080	NA	Provided by Lab
C	Battery	PAG	9307V	NA	Supplied by Client

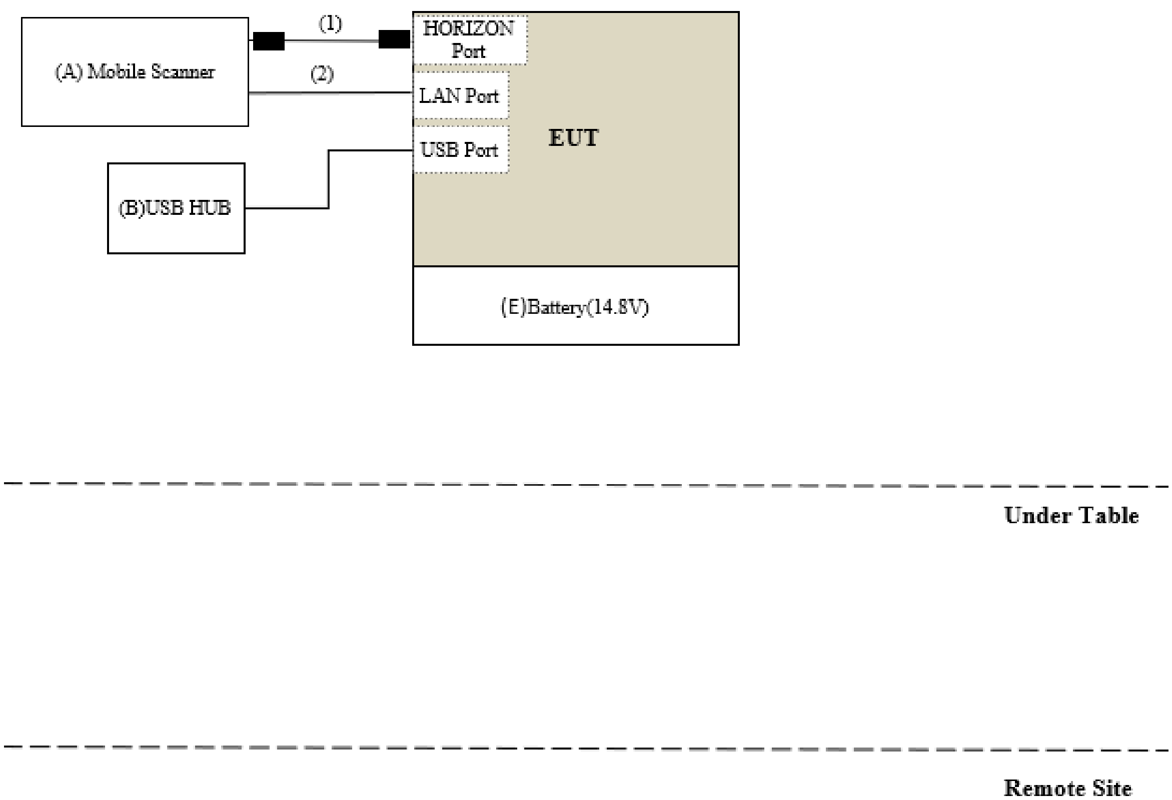
I/O Cables

ID	Equipment	Brand Name	Model Name	Length (m)	Remark
1	Orbis main cable	FARO	Orbis Cable	1.5	Supplied by Client
2	RJ45 Cable	FARO	Orbis Cable	2	Supplied by Client

Test Setup

Controlled using a bespoke application (QRCT_version 4.0.00185.0) on a test Notebook. The application was used to enable a continuous transmission mode and to select the test channels, data rates, modulation schemes and power setting as required.

Setup Diagram for Test



9. Test Results

9.1. 6dB Bandwidth

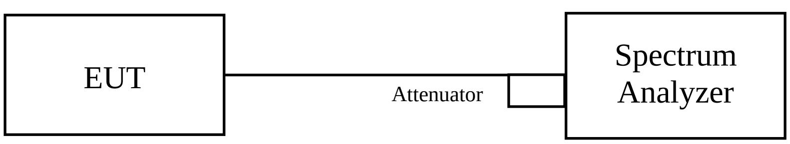
Requirements

The minimum 6 dB bandwidth shall be at least 500 kHz.

Test procedure

a. Set resolution bandwidth (RBW) = 100kHz.
b. Set the video bandwidth (VBW) ≥ 3 x RBW, Detector = Peak.
c. Trace mode = max hold.
d. Sweep = auto couple.
e. Measure the maximum width of the emission that is constrained by the frequencies associated with the two amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.
f. The plot of the test result only shows the worst case of channels as a representative.

Test Setup

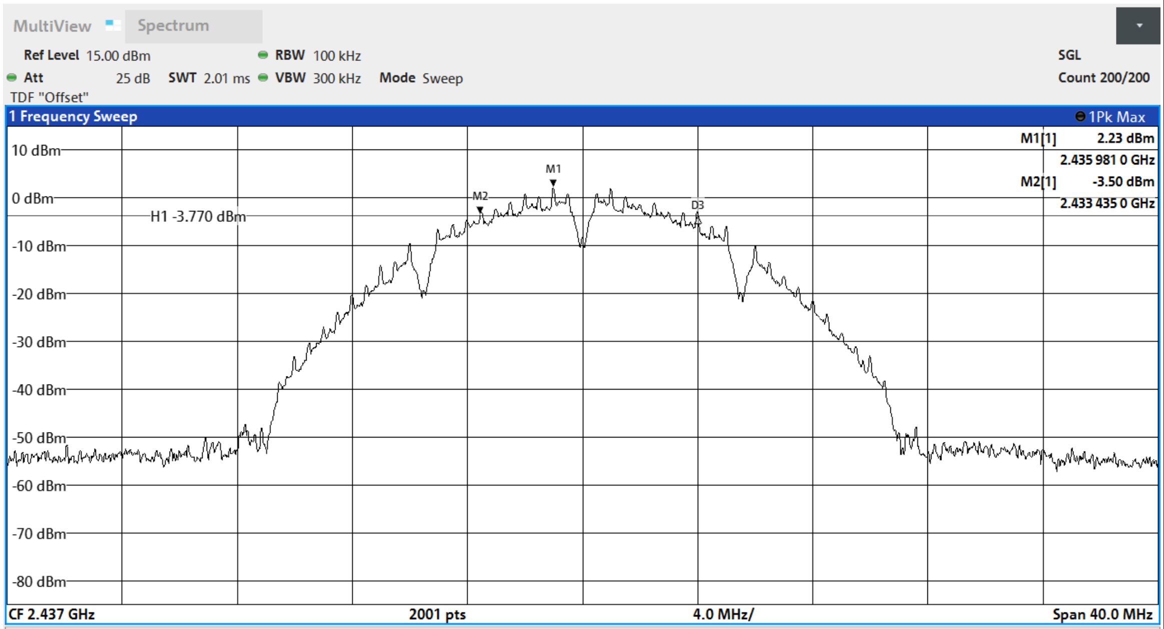


The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

Mode	CH	Freq (MHz)	6dB BW (MHz)		Limit (MHz)	Result
			Chain 0	Chain 1		
802.11b	1	2412	7.594	8.069	0.5	PASS
	6	2437	8.107	7.586	0.5	PASS
	11	2462	7.589	8.086	0.5	PASS

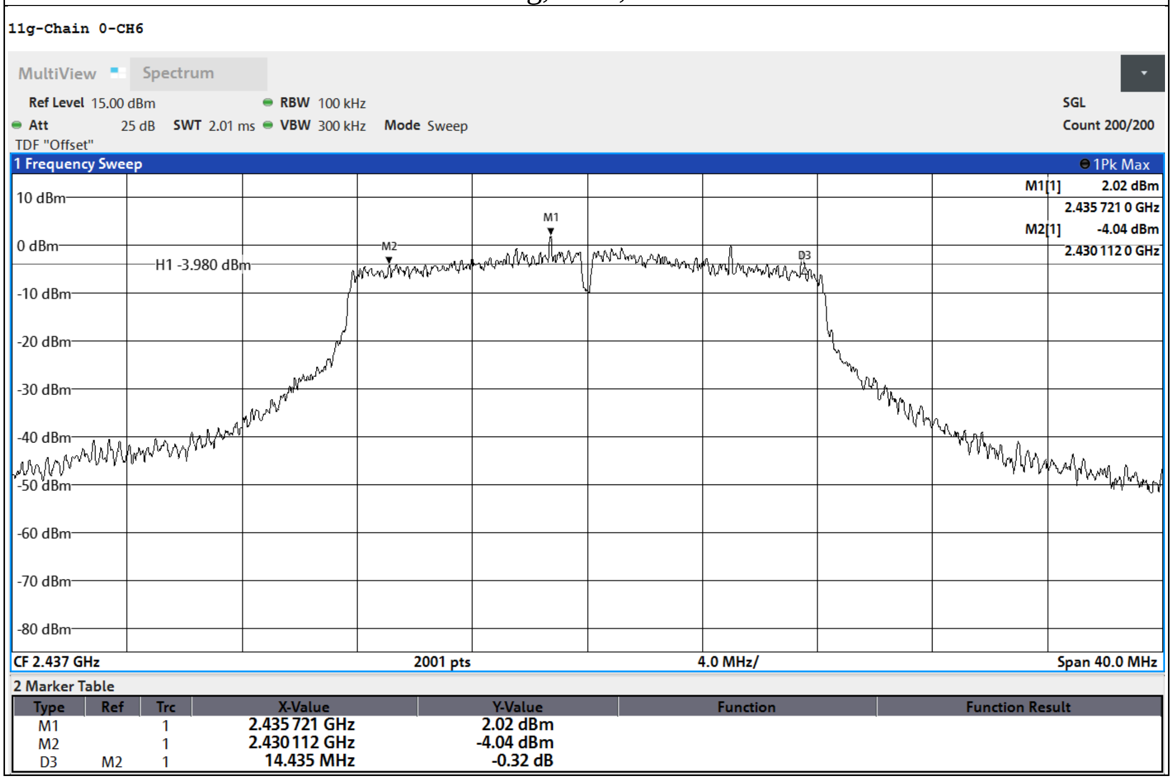
802.11b, CH6, Chain 1



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	2.435 981 GHz	2.23 dBm		
M2		1	2.433 435 GHz	-3.50 dBm		
D3	M2	1	7.586 MHz	-0.23 dB		

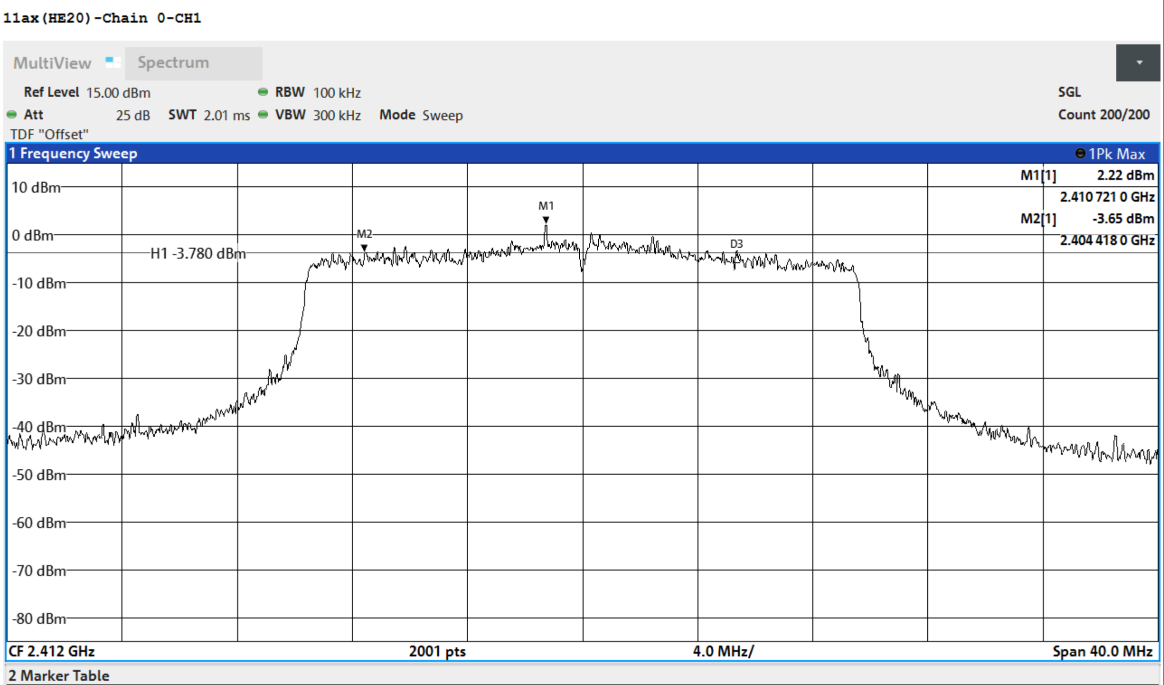
Mode	CH	Freq (MHz)	6dB BW (MHz)		Limit (MHz)	Result
			Chain 0	Chain 1		
802.11g	1	2412	15.385	15.089	0.5	PASS
	6	2437	14.435	16.045	0.5	PASS
	11	2462	15.147	15.341	0.5	PASS

802.11g, CH6, Chain 0



Mode	CH	Freq (MHz)	6dB BW (MHz)		Limit (MHz)	Result
			Chain 0	Chain 1		
802.11ax(HE20)	1	2412	12.953	18.323	0.5	PASS
	6	2437	18.245	17.414	0.5	PASS
	11	2462	15.474	17.923	0.5	PASS

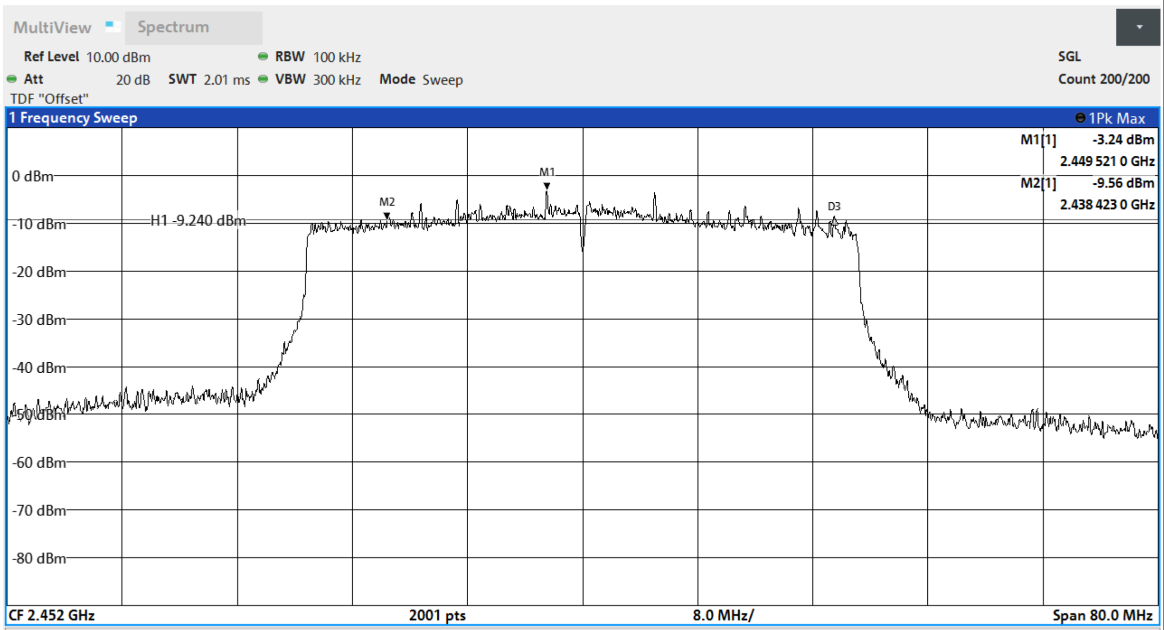
802.11ax(HE20), CH1, Chain 0



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	2.410 721 GHz	2.22 dBm		
M2		1	2.404 418 GHz	-3.65 dBm		
D3	M2	1	12.953 MHz	-0.49 dB		

Mode	CH	Freq (MHz)	6dB BW (MHz)		Limit (MHz)	Result
			Chain 0	Chain 1		
802.11ax(HE40)	3	2422	36.455	36.031	0.5	PASS
	6	2437	37.861	37.528	0.5	PASS
	9	2452	31.107	35.624	0.5	PASS

802.11ax(HE40), CH9, Chain 0



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	2.449 521 GHz	-3.24 dBm		
M2		1	2.438 423 GHz	-9.56 dBm		
D3	M2	1	31.107 MHz	0.88 dB		

9.2. Conducted Output Power

Requirements

For systems using digital modulation in the 2400-2483.5 MHz bands: 1 Watt.

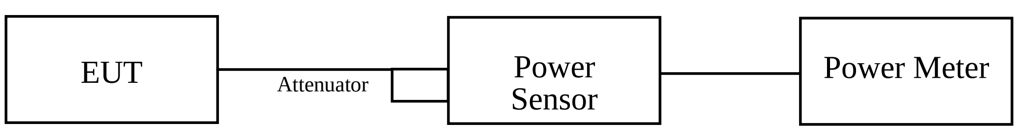
Note:

1. P_{Out} = maximum conducted output power in dBm, G_{TX} = the maximum transmitting antenna directional gain in dBi, B is the 26 dB emission bandwidth in megahertz
2. Directional Gain = 10 log[($10^{G1/20} + 10^{G2/20} +...+10^{Gn/20})^2$ / Nant] dBi.
   N*a*nt: Number of Transmit Antennas
   G1, G2,..., Gn: Gain of Individual Antennas
   Example: two antenna and gain 2.2 dBi / 2.2 dBi, so if it was used for power density measurement
   Directional Gain = 10 log[($10^{2.2/20} + 10^{2.2/20})^2$ / 2] dBi = 5.21 dBi
   Per KDB 662911 Method of conducted output power measurement on IEEE 802.11 devices, CDD
   Array Gain = 0 dB (i.e., no array gain) for $N_{ANT} \leq 4$;
   Array Gain = 0 dB (i.e., no array gain) for channel widths ≥ 40 MHz for any N_{ANT};
   Array Gain = 5 log(N_{ANT}/N_{SS}) dB or 3 dB, whichever is less for 20-MHz channel widths with $N_{ANT} \geq 5$.
   Example: Maximum antenna gain = 2.2 dBi and $N_{ANT} \leq 4$, so if it was used for CDD power measurement
   Directional Gain = 2.2 dBi + Array Gain = 2.2 dBi + 0 dB = 2.2 dBi
3. For power measurement of KDB 662911 is used with multiple transmitter output. Total conducted power is the sum of the conducted power levels measured at the various output ports.
4. The plot of the test result only shows the worst case of channels as a representative.

Test Procedure

A peak power sensor was used on the output port of the EUT. A power meter was used to read the response of the peak power sensor. Record the power level.

Test Setup



The loss between RF output port of the EUT and the input port of the Power Meter has been taken into consideration.

Test Data

Non-Beamforming mode:

Peak Power

802.11b

Channel	Frequency (MHz)	Peak Power (dBm)		Total Power (mW)	Total Power (dBm)	Limit (dBm)	Pass / Fail
		Chain 0	Chain 1				
1	2412	15.08	13.18	52.966	17.24	30	PASS
6	2437	14.81	13.06	50.466	17.03	30	PASS
11	2462	15.14	13.14	53.211	17.26	30	PASS

802.11g

Channel	Frequency (MHz)	Peak Power (dBm)		Total Power (mW)	Total Power (dBm)	Limit (dBm)	Pass / Fail
		Chain 0	Chain 1				
1	2412	17.45	16.49	100.231	20.01	30	PASS
6	2437	18.00	16.40	106.66	20.28	30	PASS
11	2462	18.33	16.41	111.944	20.49	30	PASS

802.11ax (HE20)

Channel	Frequency (MHz)	Peak Power (dBm)		Total Power (mW)	Total Power (dBm)	Limit (dBm)	Pass / Fail
		Chain 0	Chain 1				
1	2412	18.72	18.06	138.357	21.41	30	PASS
6	2437	18.75	17.85	135.831	21.33	30	PASS
11	2462	19.44	17.60	145.546	21.63	30	PASS

802.11ax (HE40)

Channel	Frequency (MHz)	Peak Power (dBm)		Total Power (mW)	Total Power (dBm)	Limit (dBm)	Pass / Fail
		Chain 0	Chain 1				
3	2422	15.78	15.23	71.121	18.52	30	PASS
6	2437	15.80	15.66	74.817	18.74	30	PASS
9	2452	16.03	15.53	75.858	18.80	30	PASS

Average Power (Reference Only)

802.11b

Channel	Frequency (MHz)	Average Power (dBm)		Total Power (mW)	Total Power (dBm)
		Chain 0	Chain 1		
1	2412	12.62	10.56	29.648	14.72
6	2437	12.47	10.57	29.04	14.63
11	2462	12.69	10.59	30.061	14.78

802.11g

Channel	Frequency (MHz)	Average Power (dBm)		Total Power (mW)	Total Power (dBm)
		Chain 0	Chain 1		
1	2412	12.28	10.65	28.51	14.55
6	2437	12.18	10.42	27.542	14.40
11	2462	12.56	10.43	29.04	14.63

802.11ax (HE20)

Channel	Frequency (MHz)	Average Power (dBm)		Total Power (mW)	Total Power (dBm)
		Chain 0	Chain 1		
1	2412	12.42	10.77	29.376	14.68
6	2437	12.55	10.95	30.409	14.83
11	2462	12.98	10.79	31.842	15.03

802.11ax (HE40)

Channel	Frequency (MHz)	Average Power (dBm)		Total Power (mW)	Total Power (dBm)
		Chain 0	Chain 1		
3	2422	9.70	9.34	17.906	12.53
6	2437	9.72	9.28	17.865	12.52
9	2452	9.87	9.30	18.197	12.60

Beamforming Mode:

Peak Power

802.11ax (HE20)

Channel	Frequency (MHz)	Peak Power (dBm)		Total Power (mW)	Total Power (dBm)	Limit (dBm)	Pass / Fail
		Chain 0	Chain 1				
1	2412	18.42	17.63	127.35	21.05	30	PASS
6	2437	18.33	17.37	122.744	20.89	30	PASS
11	2462	19.01	17.26	132.739	21.23	30	PASS

802.11ax (HE40)

Channel	Frequency (MHz)	Peak Power (dBm)		Total Power (mW)	Total Power (dBm)	Limit (dBm)	Pass / Fail
		Chain 0	Chain 1				
3	2422	15.44	14.74	64.714	18.11	30	PASS
6	2437	15.32	15.18	66.988	18.26	30	PASS
9	2452	15.62	15.14	69.183	18.40	30	PASS

Average Power (Reference Only)

802.11ax (HE20)

Channel	Frequency (MHz)	Average Power (dBm)		Total Power (mW)	Total Power (dBm)
		Chain 0	Chain 1		
1	2412	11.96	10.46	26.792	14.28
6	2437	12.17	10.47	27.606	14.41
11	2462	12.64	10.41	29.376	14.68

802.11ax (HE40)

Channel	Frequency (MHz)	Average Power (dBm)		Total Power (mW)	Total Power (dBm)
		Chain 0	Chain 1		
3	2422	9.29	8.86	16.181	12.09
6	2437	9.35	8.79	16.181	12.09
9	2452	9.48	8.86	16.558	12.19

9.3. Power Spectral Density

Requirements

The Maximum of Power Spectral Density Measurement is 8dBm in any 3 kHz (If G_{TX} > 6 dBi, then PSD = 8 – (G_{TX} – 6)).

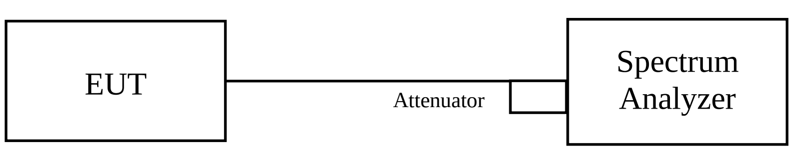
Note:

1. PSD = power spectral density that he same method as used to determine the conducted output power shall be used to determine the power spectral density. And power spectral density in dBm/MHz.
2. G_{TX} = the maximum transmitting antenna directional gain in dBi.
3. Directional Gain = $10 \log[(10^{G1/20} + 10^{G2/20} +...+10^{Gn/20})^2 / Nant]$ dBi.
   Nant: Number of Transmit Antennas
   G1, G2,..., Gn: Gain of Individual Antennas
   Example: two antenna and gain 2.2 dBi / 2.2 dBi, so if it was used for power density measurement
   Directional Gain = $10 \log[(10^{2.2/20} + 10^{2.2/20})^2 / 2]$ dBi = 5.21 dBi
4. "PSD per chain" of the report shown is maximum value for each chain, at the "Total PSD" is summing entire spectra across corresponding frequency bins on the various outputs by computer, refer KDB 662911 Method a) for calculating total power density.
5. Method a) of power density measurement of KDB 662911 is used for calculating total power density with multiple transmitter output. Total power density is summing entire spectra across corresponding frequency bins on the various outputs by computer.

Test procedure

a. Set analyzer center frequency to DTS channel center frequency.
b. Set the span to 1.5 times the DTS bandwidth.
c. Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
d. Set the VBW ≥ 3 × RBW.
e. Detector = peak.
f. Sweep time = auto couple.
g. Trace mode = max hold.
h. Allow trace to fully stabilize.
i. Use the peak marker function to determine the maximum amplitude level within the RBW.
j. The plot of the test result only shows the worst case of channels as a representative.

Test Setup



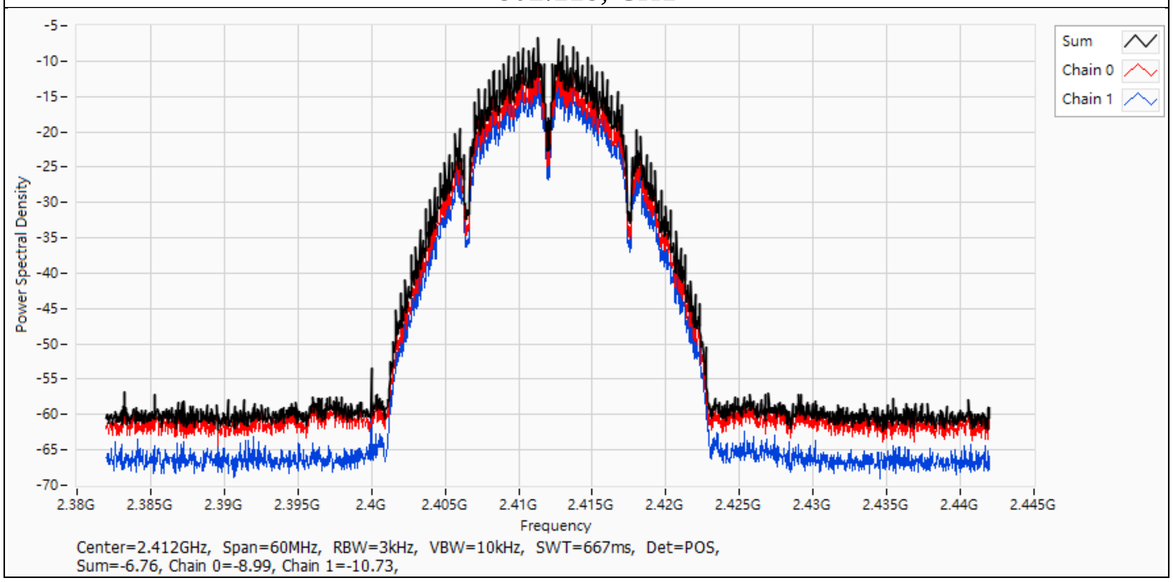
The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

Mode	CH	Freq (MHz)	Total PSD (dBm/3kHz)	Limit (dBm/3kHz)	Directional Gain (dBi)	Result
802.11b	1	2412	-6.76	8	5.21	PASS
	6	2437	-7.79	8	5.21	PASS
	11	2462	-7.99	8	5.21	PASS

Mode	CH	Freq (MHz)	PSD per Chain (dBm/3kHz)	
			Chain 0	Chain 1
802.11b	1	2412	-8.985	-10.726
	6	2437	-9.884	-11.729
	11	2462	-9.878	-12.331

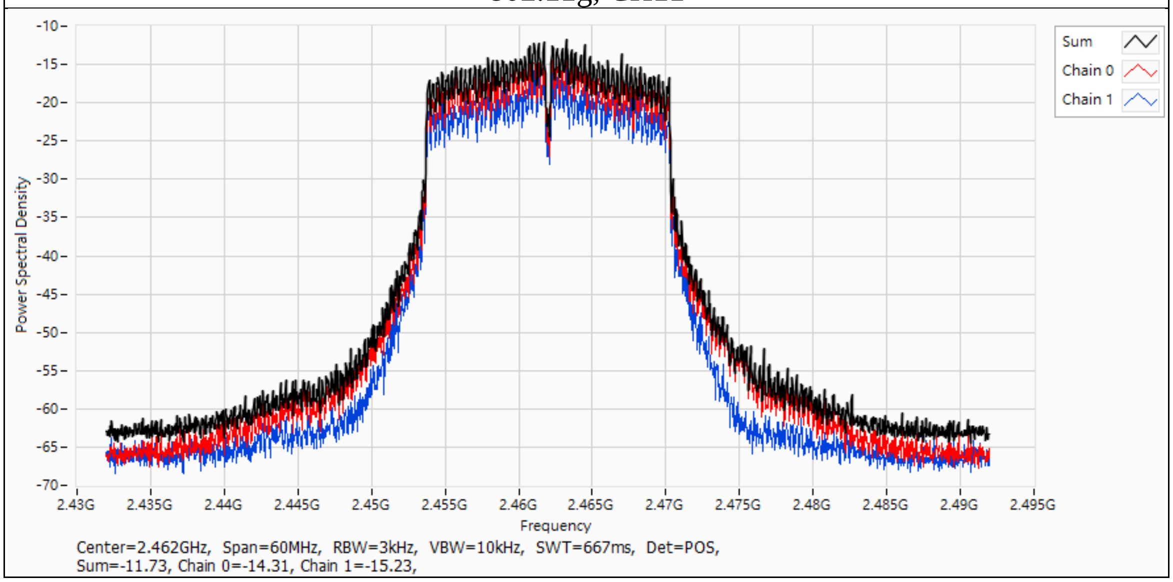
802.11b, CH1



Mode	CH	Freq (MHz)	Total PSD (dBm/3kHz)	Limit (dBm/3kHz)	Directional Gain (dBi)	Result
802.11g	1	2412	-11.86	8	5.21	PASS
	6	2437	-12.51	8	5.21	PASS
	11	2462	-11.73	8	5.21	PASS

Mode	CH	Freq (MHz)	PSD per Chain (dBm/3kHz)	
			Chain 0	Chain 1
802.11g	1	2412	-13.289	-14.306
	6	2437	-13.919	-15.478
	11	2462	-14.203	-14.138

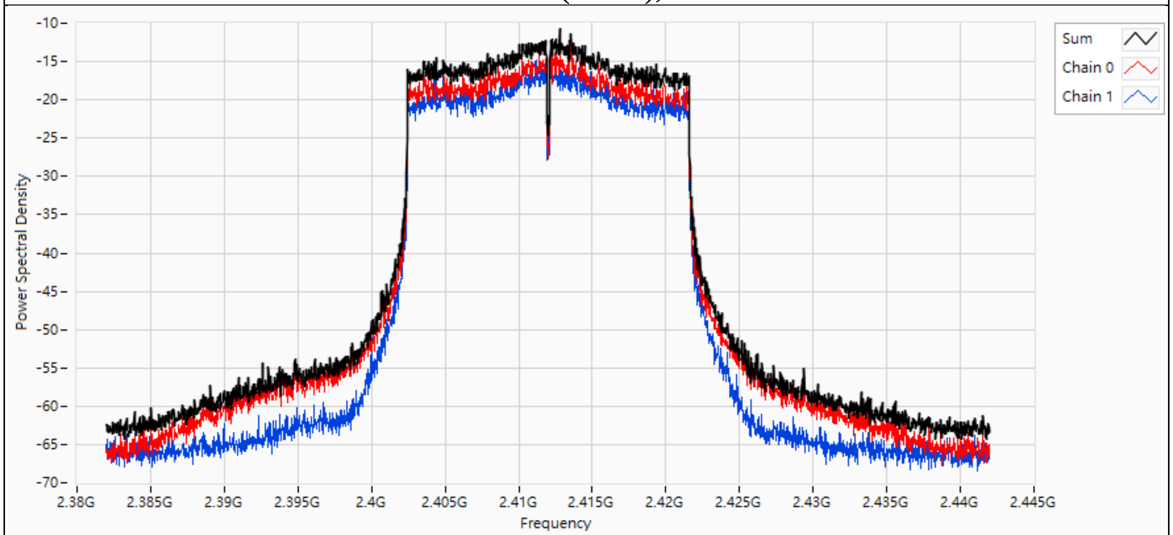
802.11g, CH11



Mode	CH	Freq (MHz)	Total PSD (dBm/3kHz)	Limit (dBm/3kHz)	Directional Gain (dBi)	Result
802.11ax(HE20)	1	2412	-10.75	8	5.21	PASS
	6	2437	-11.04	8	5.21	PASS
	11	2462	-11.5	8	5.21	PASS

Mode	CH	Freq (MHz)	PSD per Chain (dBm/3kHz)	
			Chain 0	Chain 1
802.11ax(HE20)	1	2412	-12.666	-14.492
	6	2437	-12.398	-13.82
	11	2462	-12.825	-14.808

802.11ax(HE20), CH1

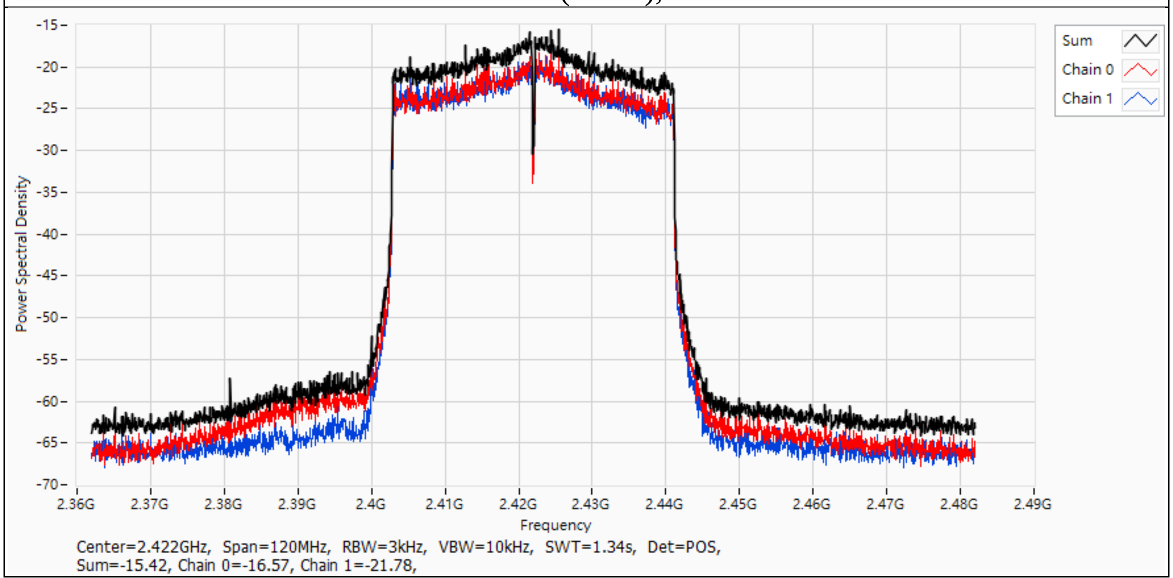


Center=2.412GHz, Span=60MHz, RBW=3kHz, VBW=10kHz, SWT=667ms, Det=POS,
Sum=-10.75, Chain 0=-12.82, Chain 1=-14.95,

Mode	CH	Freq (MHz)	Total PSD (dBm/3kHz)	Limit (dBm/3kHz)	Directional Gain (dBi)	Result
802.11ax(HE40)	3	2422	-15.42	8	5.21	PASS
	6	2437	-16.11	8	5.21	PASS
	9	2452	-15.6	8	5.21	PASS

Mode	CH	Freq (MHz)	PSD per Chain (dBm/3kHz)	
			Chain 0	Chain 1
802.11ax(HE40)	3	2422	-16.567	-18.626
	6	2437	-17.76	-19.201
	9	2452	-18.245	-17.742

802.11ax(HE40), CH3



9.4. Conducted Out of Band Emission

Requirements

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.

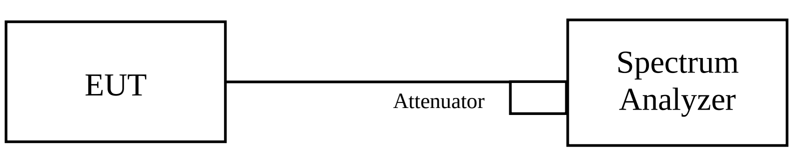
Test procedure

Measurement Procedure REF

1. Set the RBW = 100 kHz.
2. Set the VBW ≥ 300 kHz.
3. Set the span to 1.5 times the DTS bandwidth.
4. Detector = peak.
5. Sweep time = auto couple.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

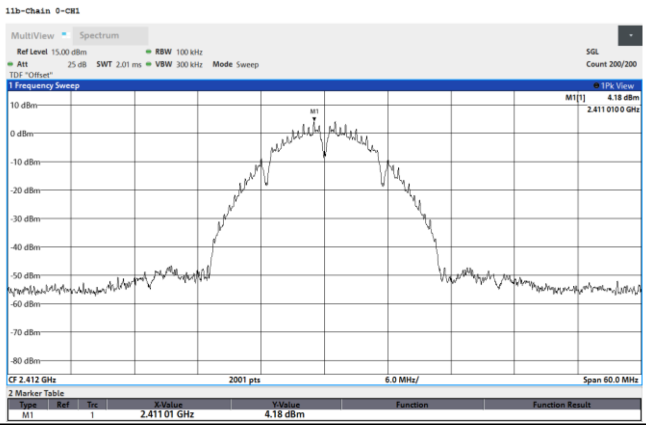
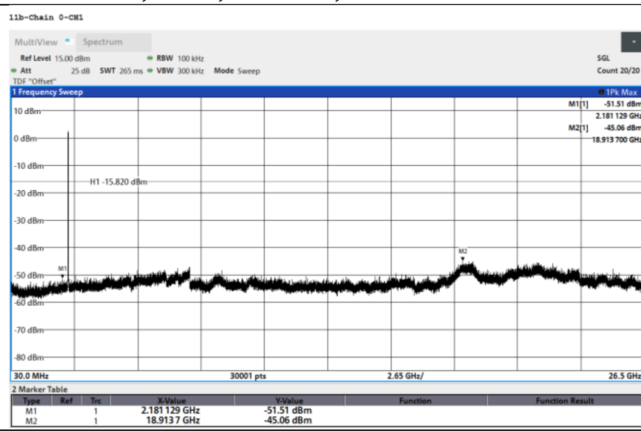
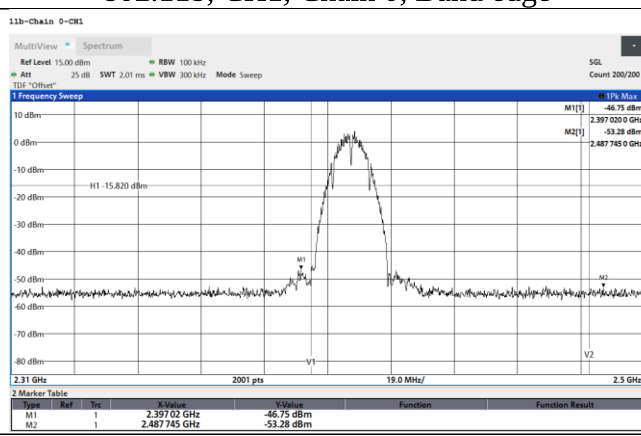
Measurement Procedure OOBE
1. Set RBW = 100 kHz.
2. Set VBW ≥ 300 kHz.
3. Detector = peak.
4. Sweep = auto couple.
5. Trace Mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum amplitude level.

Test Setup

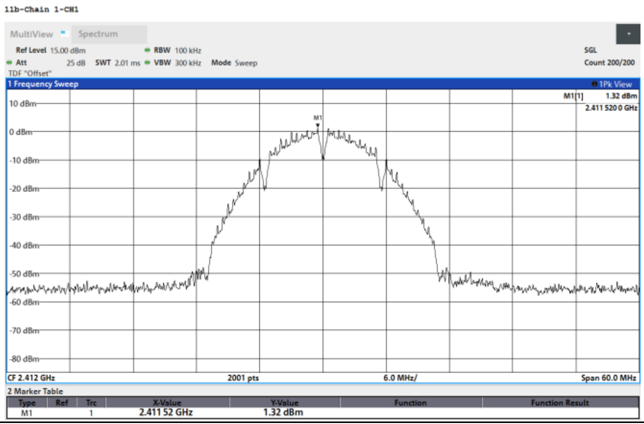


The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

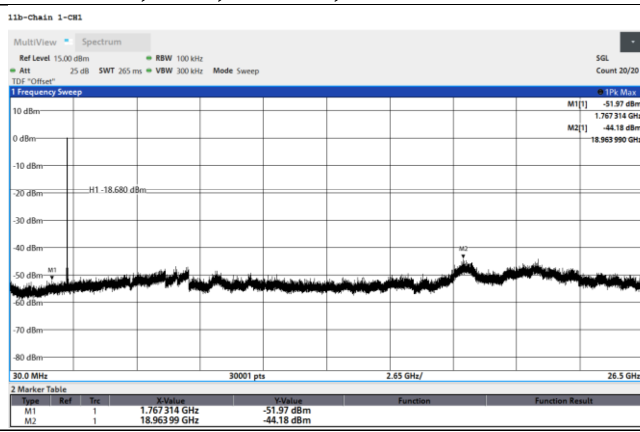
Test Data

802.11b, CH1, Chain 0, Reference

802.11b, CH1, Chain 0, Conducted Emission

802.11b, CH1, Chain 0, Band edge


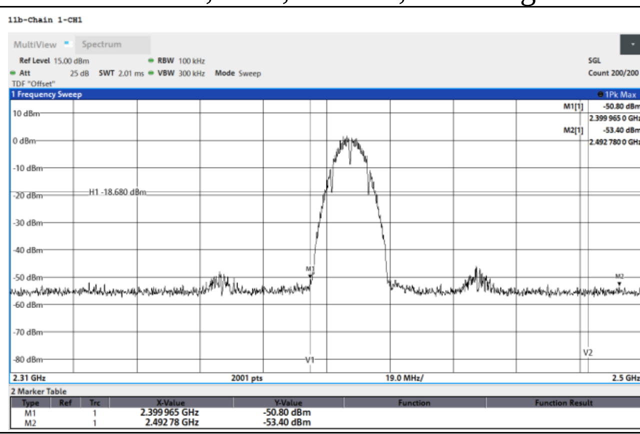
802.11b, CH1, Chain 1, Reference



802.11b, CH1, Chain 1, Conducted Emission



802.11b, CH1, Chain 1, Band edge



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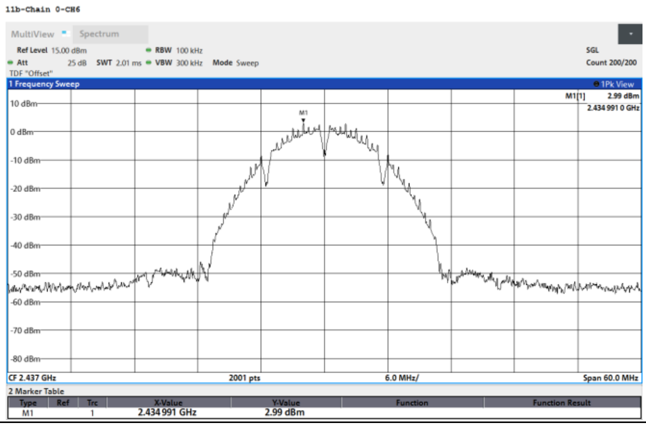
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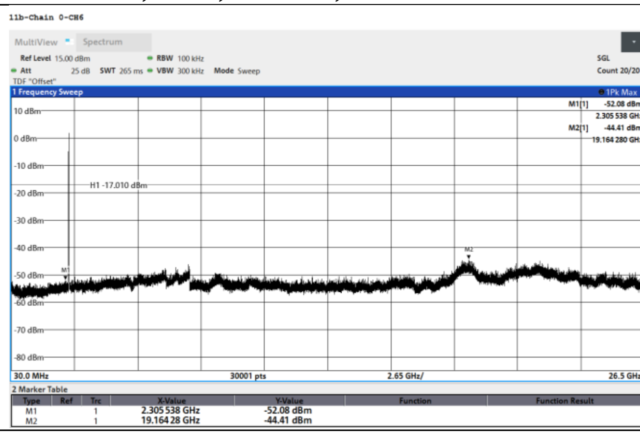
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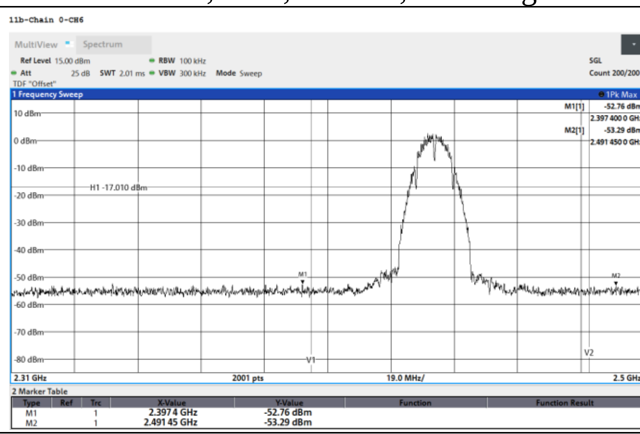

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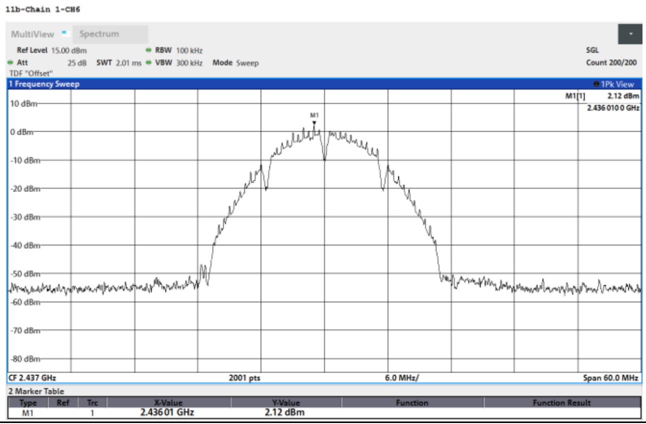

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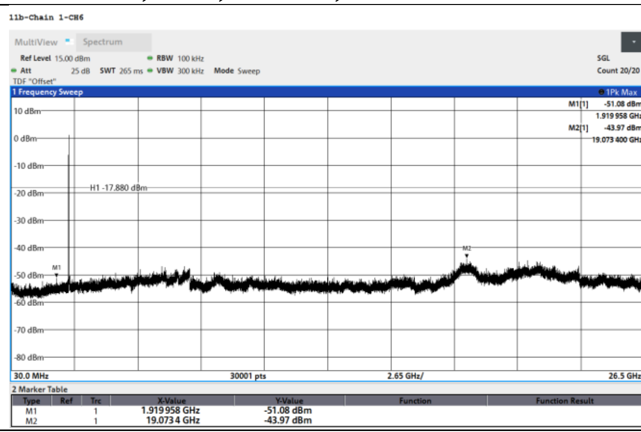
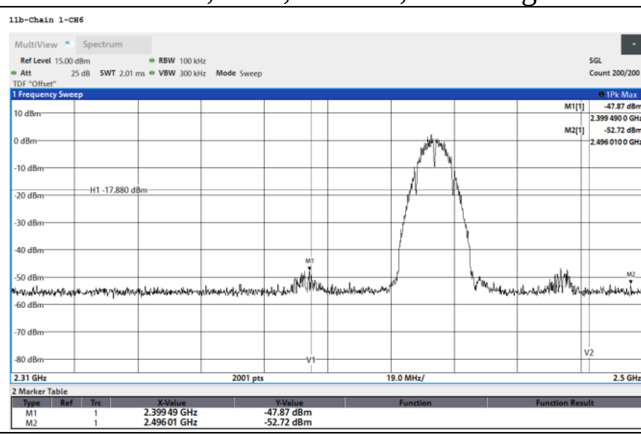
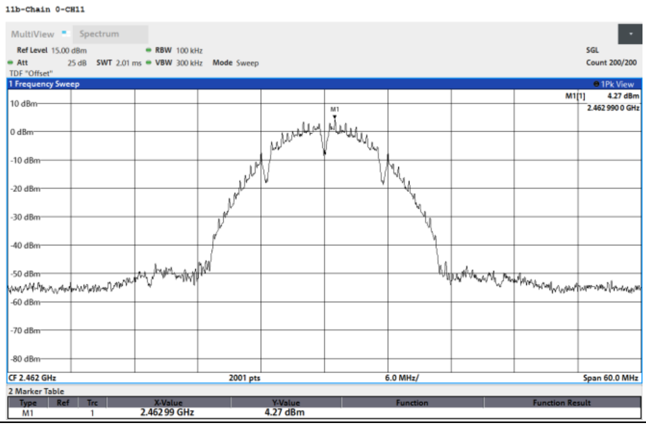
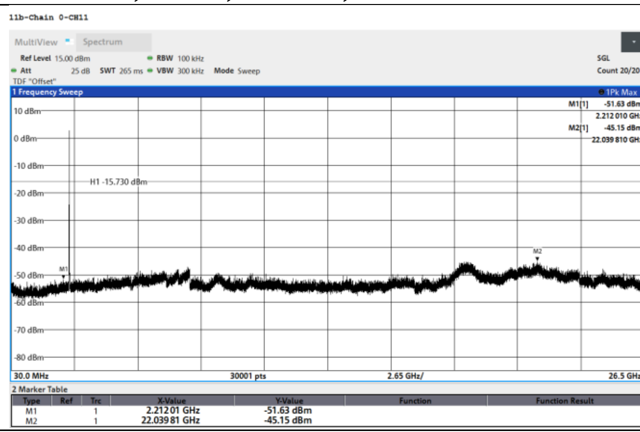


802.11b, CH6, Chain 1, Band edge



802.11b, CH11, Chain 0, Reference

802.11b, CH11, Chain 0, Conducted Emission

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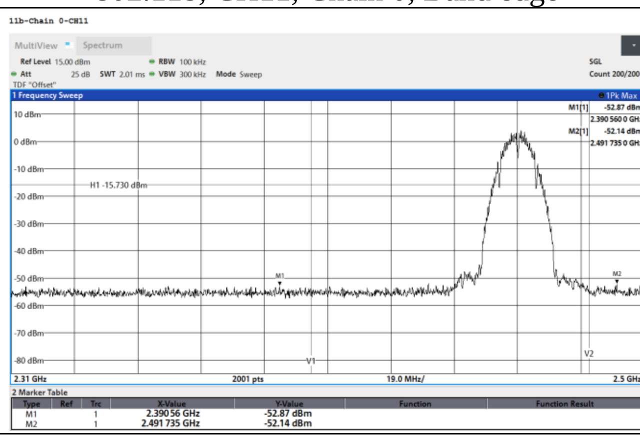
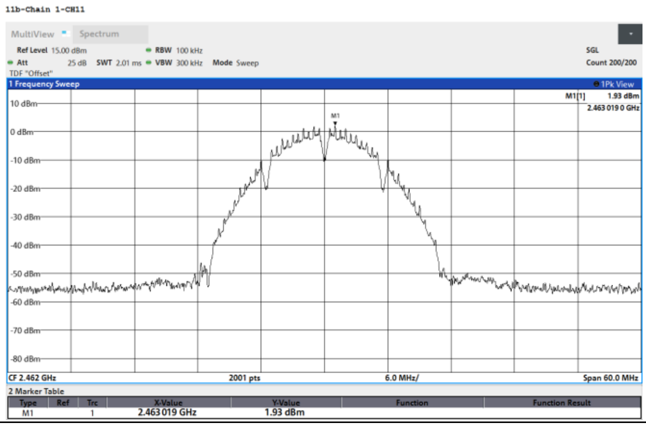
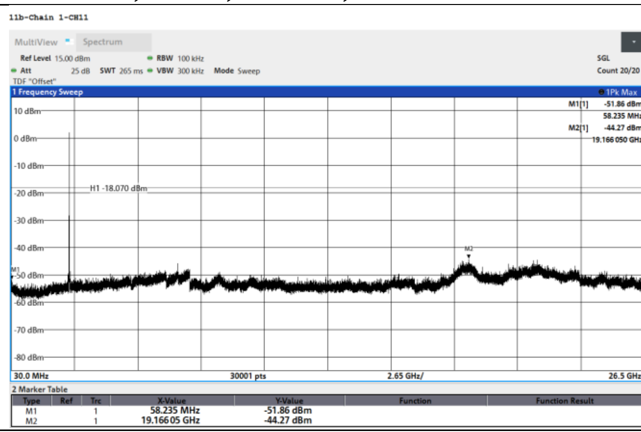


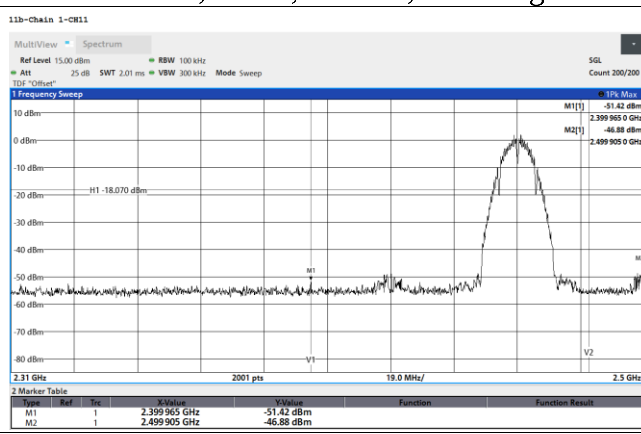
802.11b, CH11, Chain 1, Reference

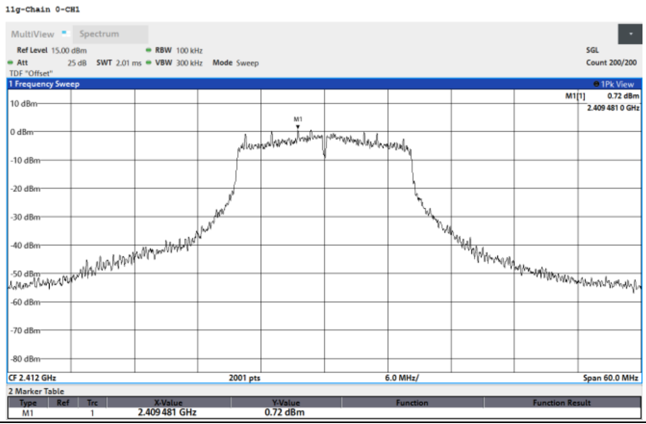


802.11b, CH11, Chain 1, Conducted Emission



802.11b, CH11, Chain 1, Band edge



802.11g, CH1, Chain 0, Reference

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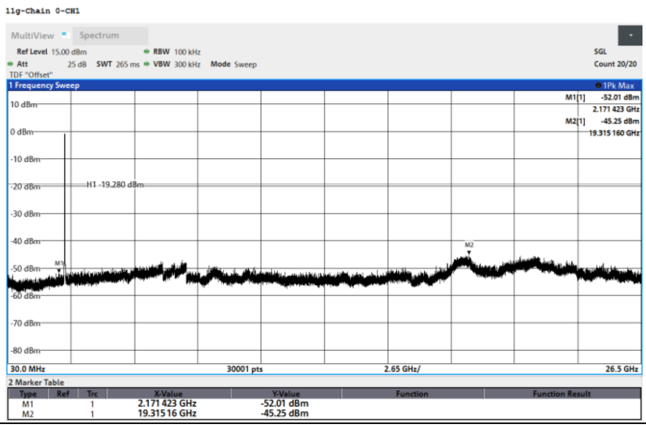
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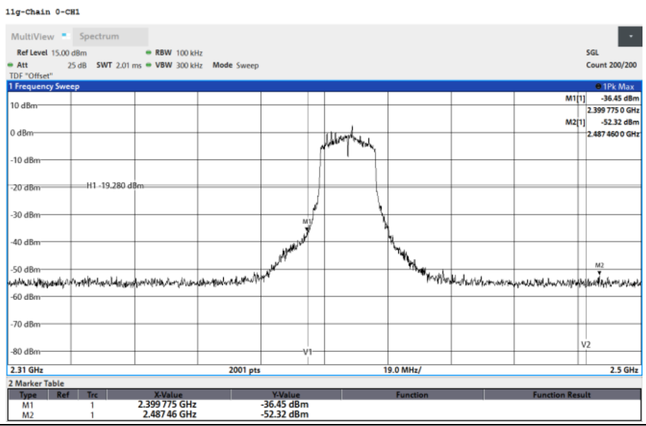

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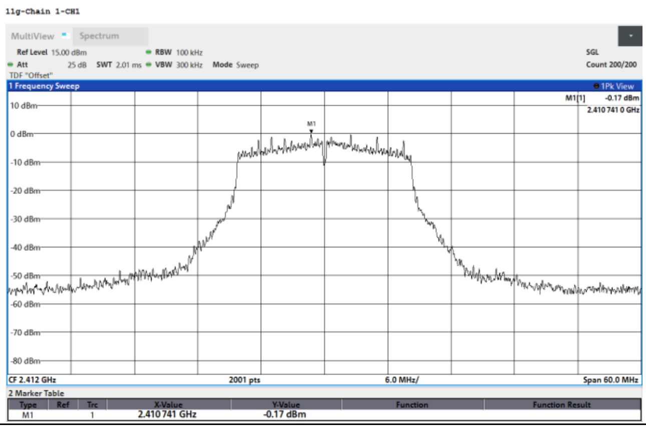
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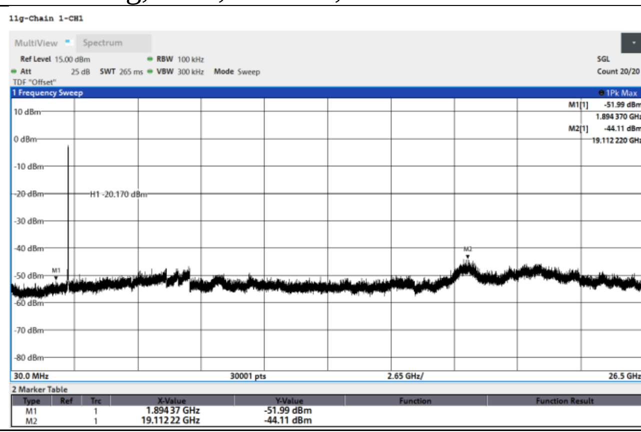
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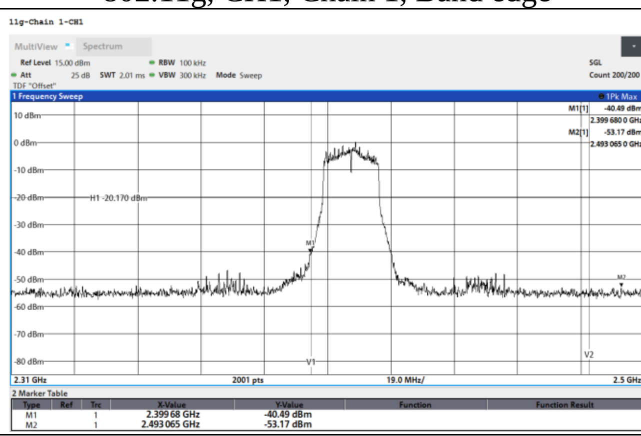

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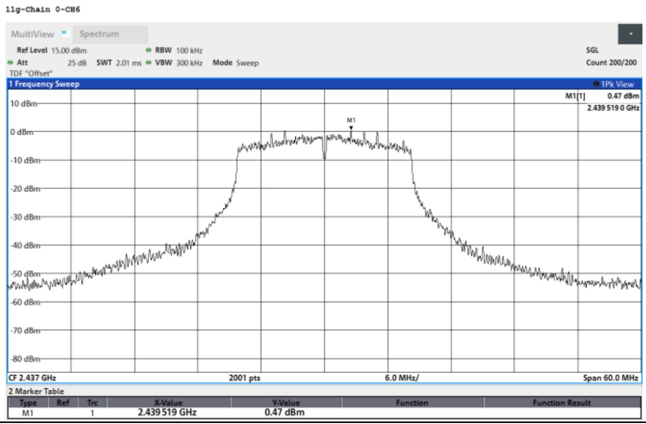
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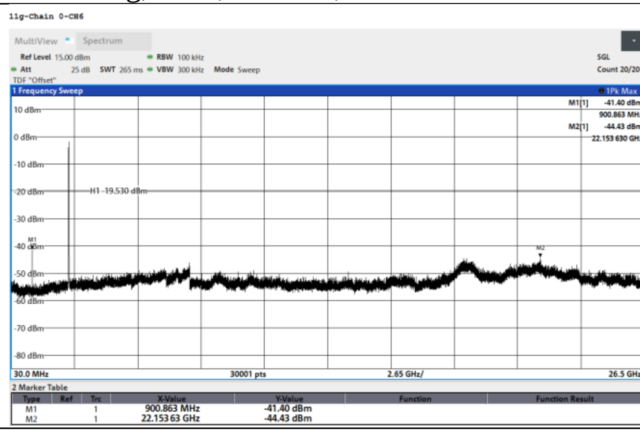
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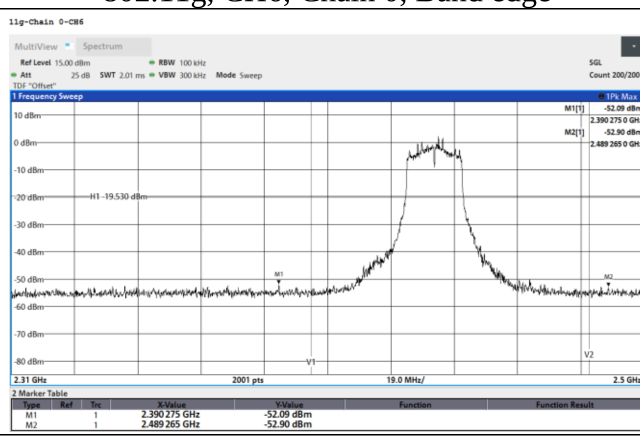

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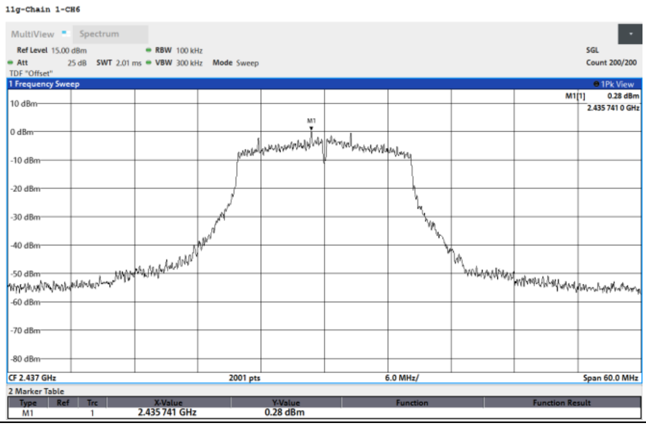
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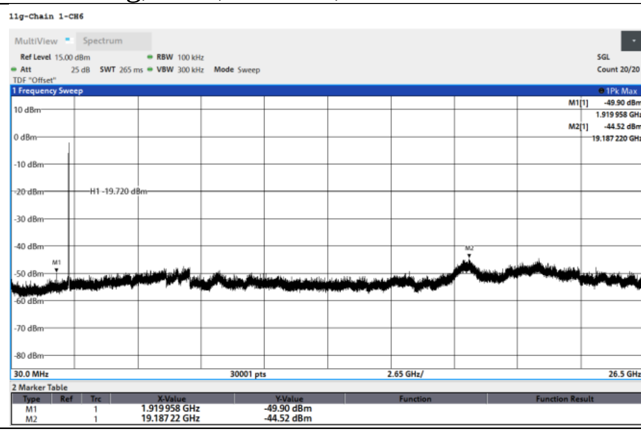
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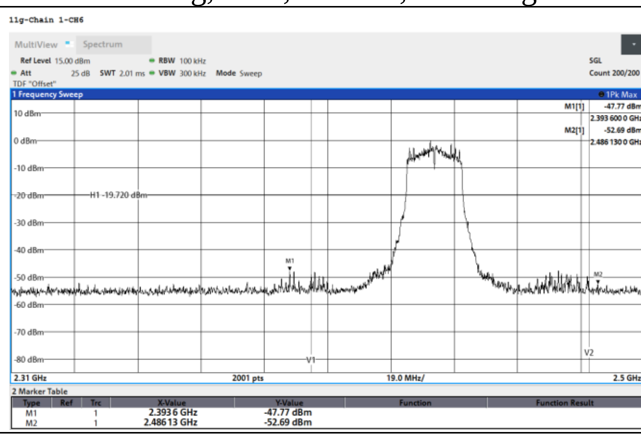
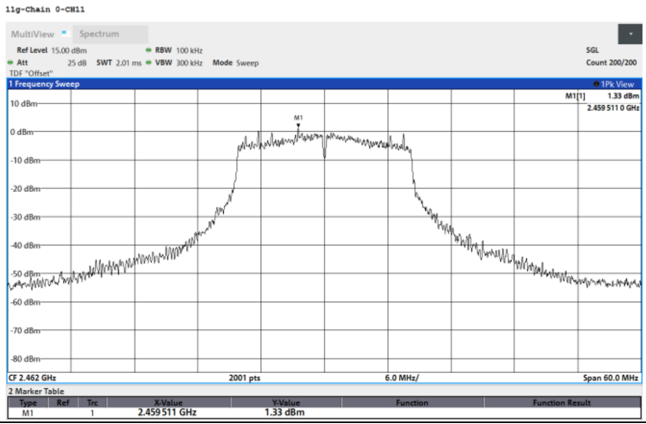
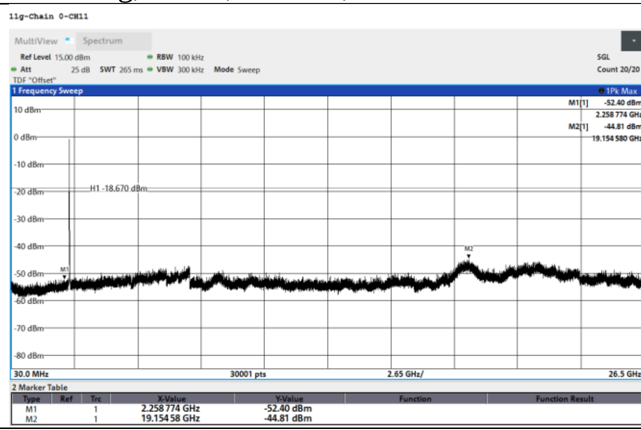


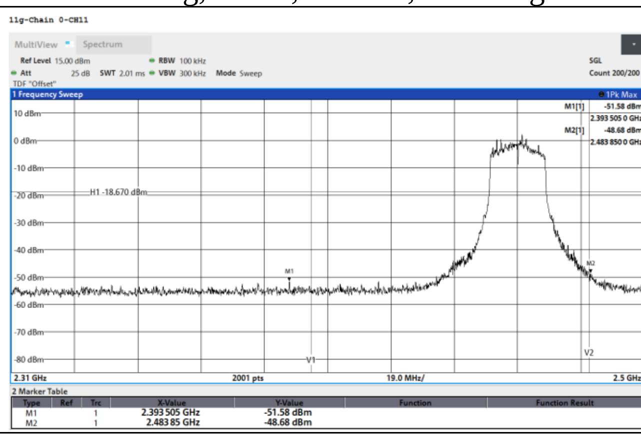
802.11g, CH11, Chain 0, Reference



802.11g, CH11, Chain 0, Conducted Emission



802.11g, CH11, Chain 0, Band edge



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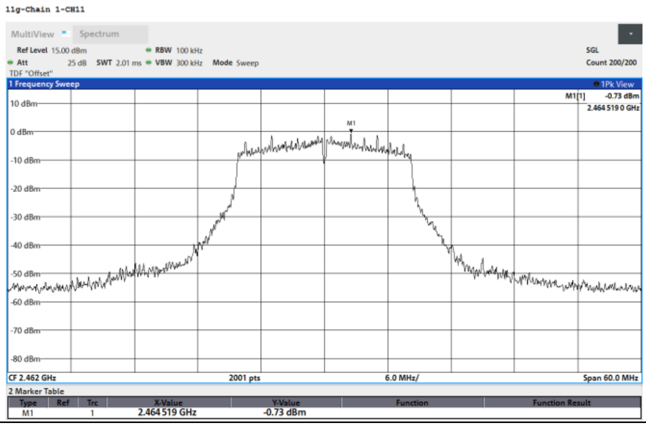
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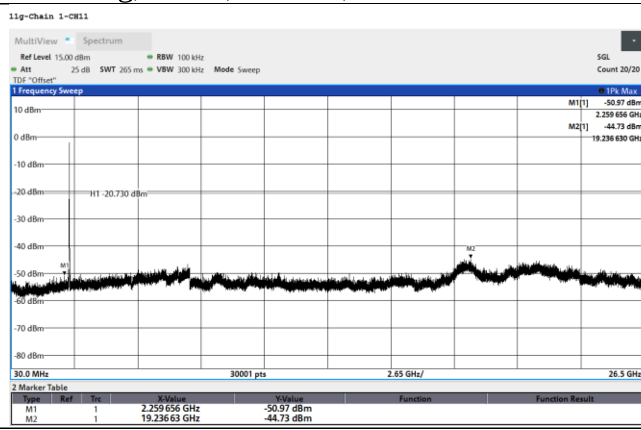
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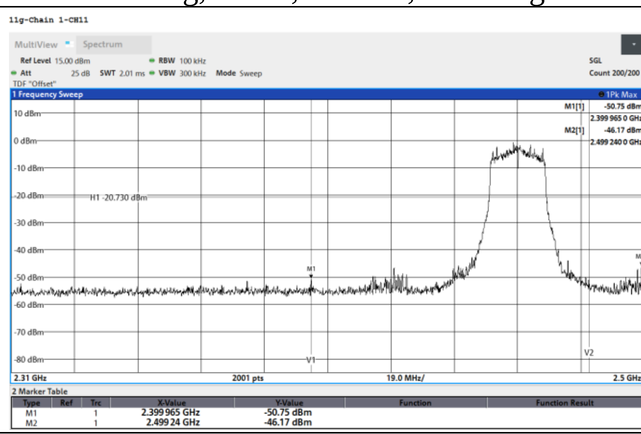
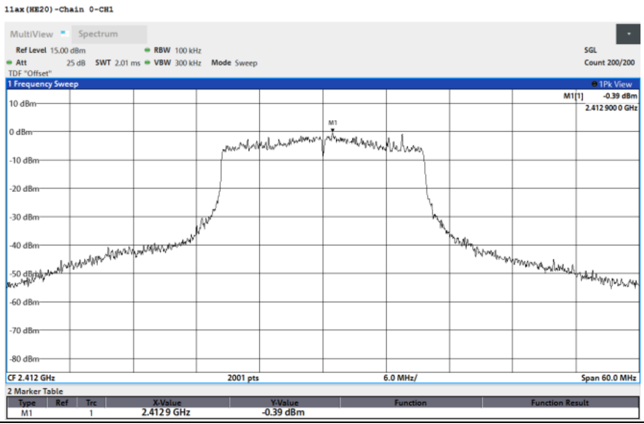
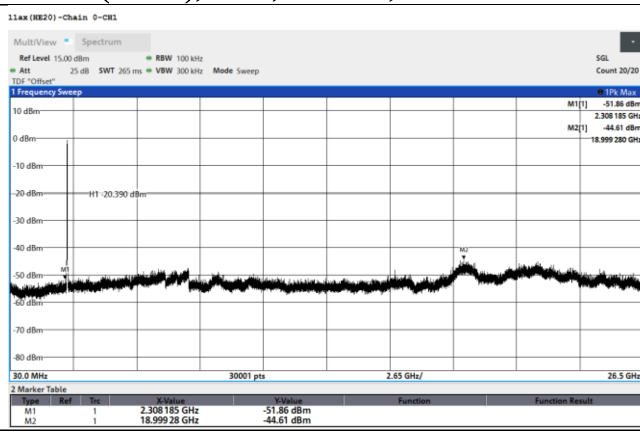


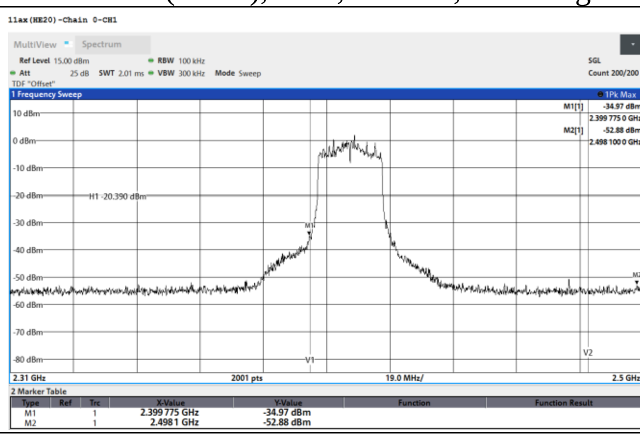
802.11ax(HE20), CH1, Chain 0, Reference

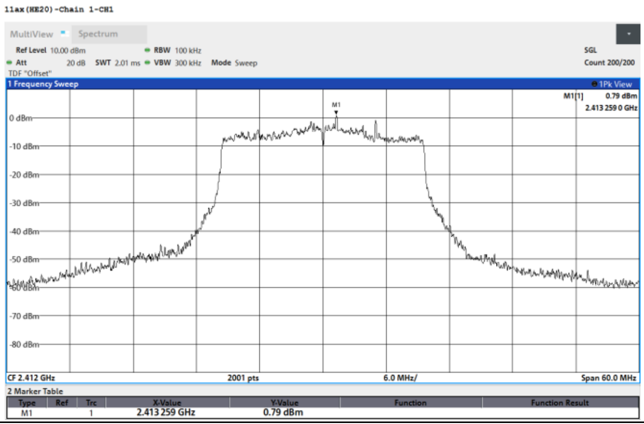


802.11ax(HE20), CH1, Chain 0, Conducted Emission



802.11ax(HE20), CH1, Chain 0, Band edge



802.11ax(HE20), CH1, Chain 1, Reference

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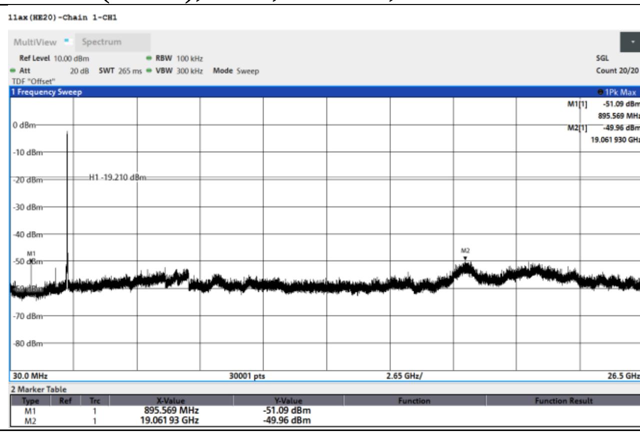
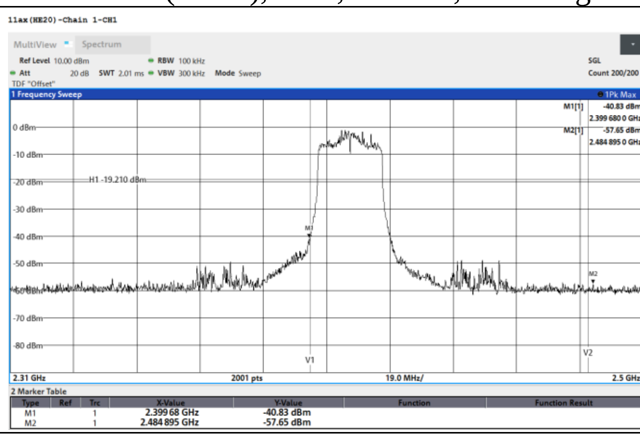
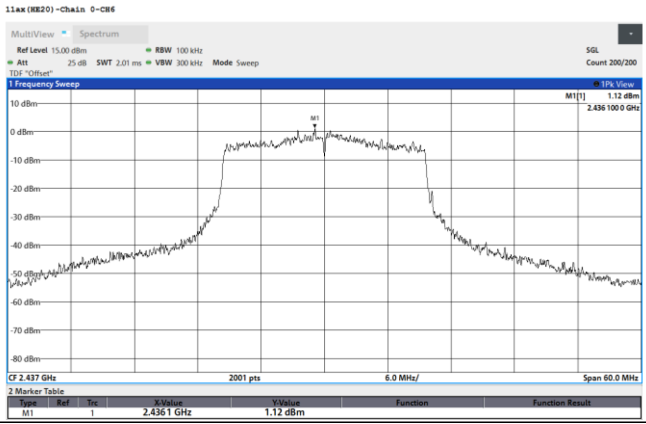
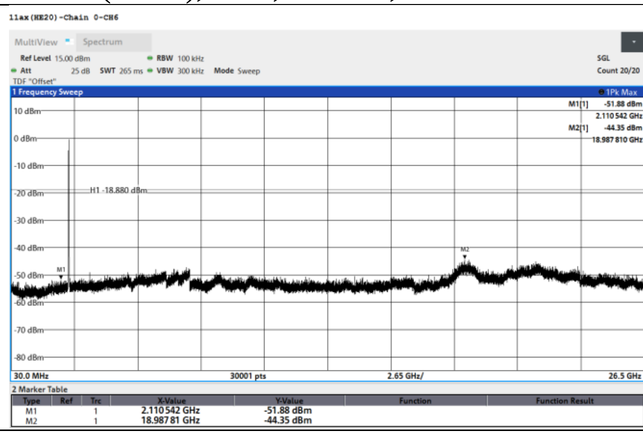

802.11ax(HE20), CH1, Chain 1, Band edge


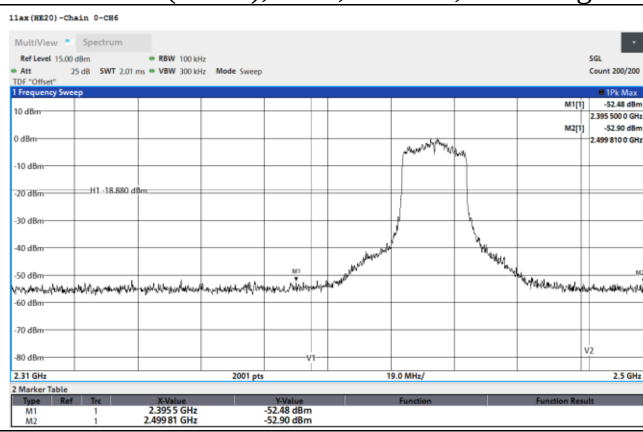
802.11ax(HE20), CH6, Chain 0, Reference



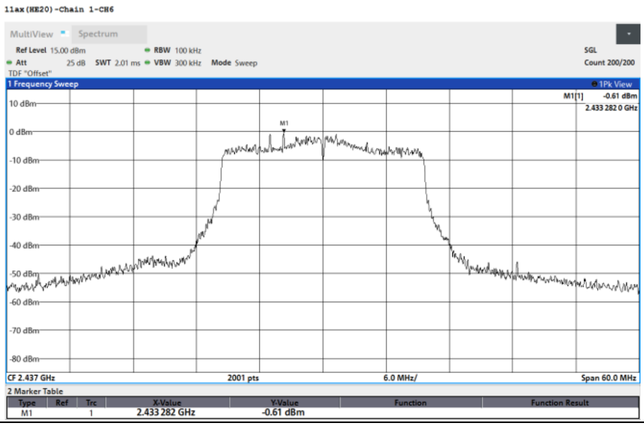
802.11ax(HE20), CH6, Chain 0, Conducted Emission



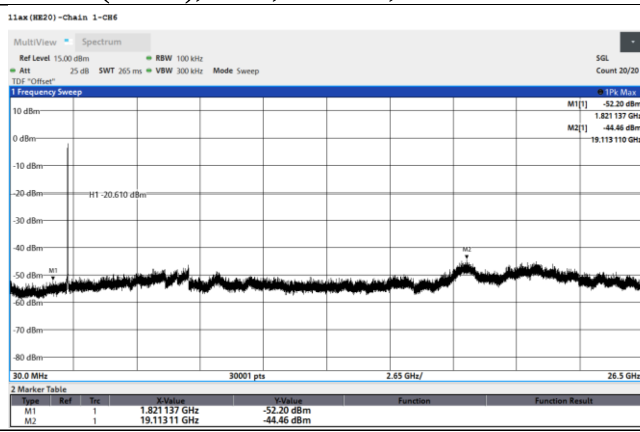
802.11ax(HE20), CH6, Chain 0, Band edge



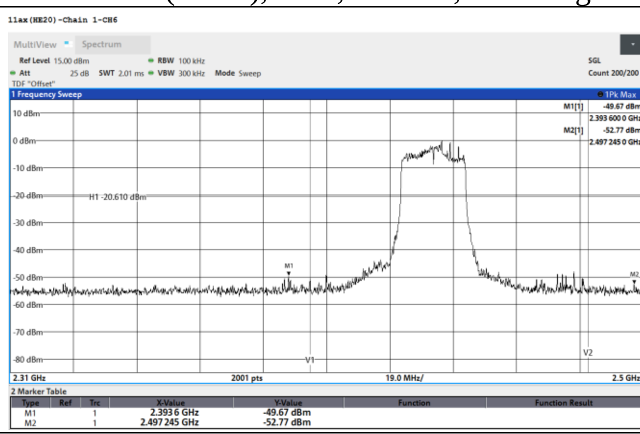
802.11ax(HE20), CH6, Chain 1, Reference

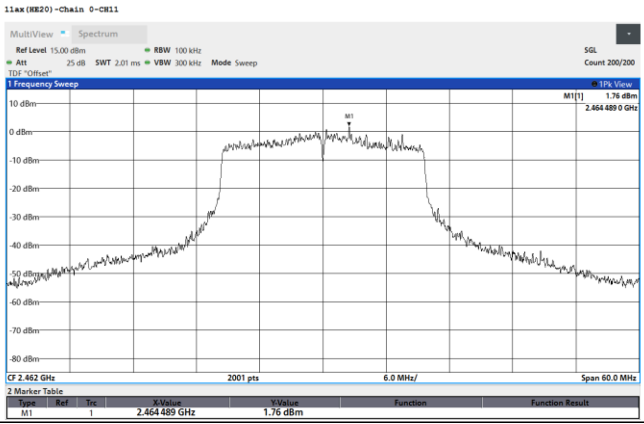
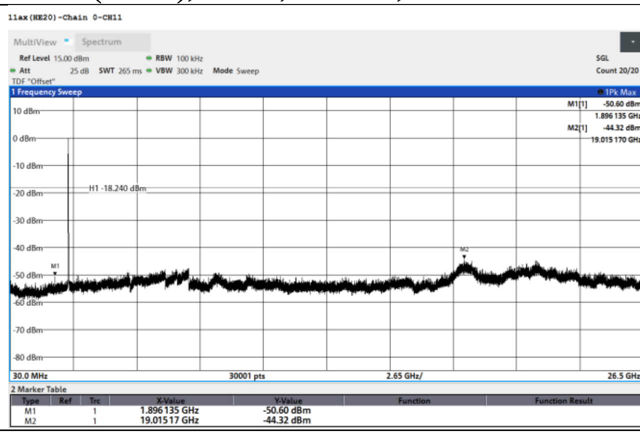
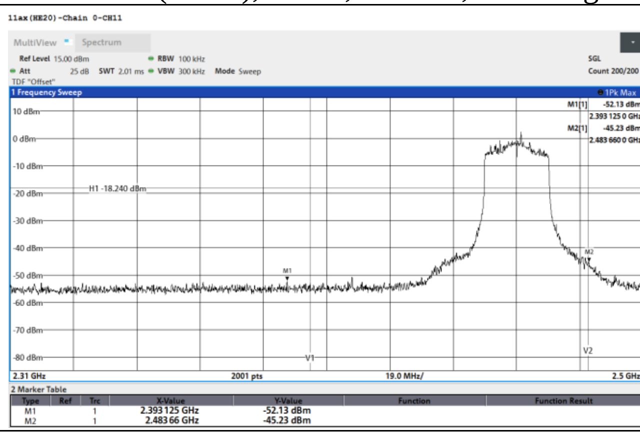


802.11ax(HE20), CH6, Chain 1, Conducted Emission

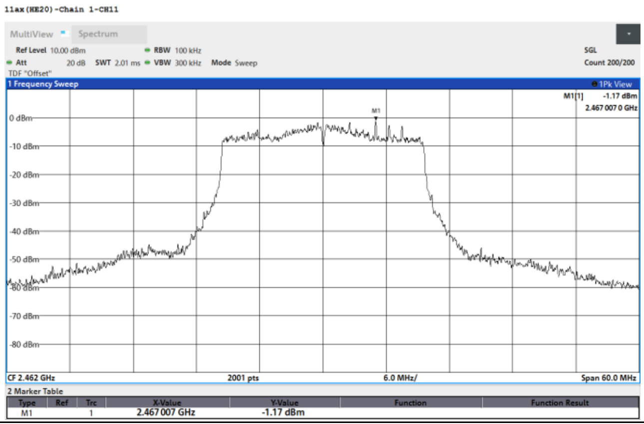


802.11ax(HE20), CH6, Chain 1, Band edge

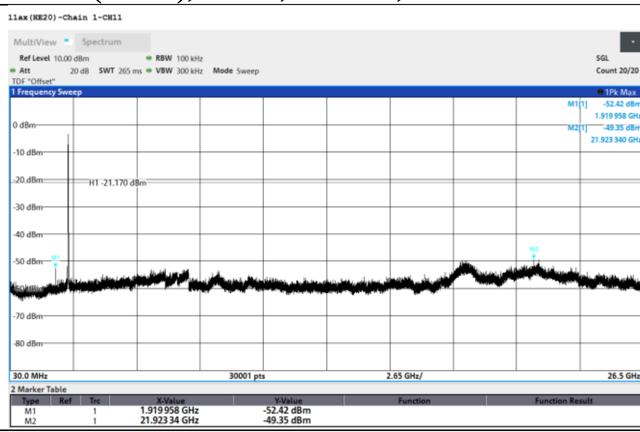


802.11ax(HE20), CH11, Chain 0, Reference

802.11ax(HE20), CH11, Chain 0, Conducted Emission

802.11ax(HE20), CH11, Chain 0, Band edge


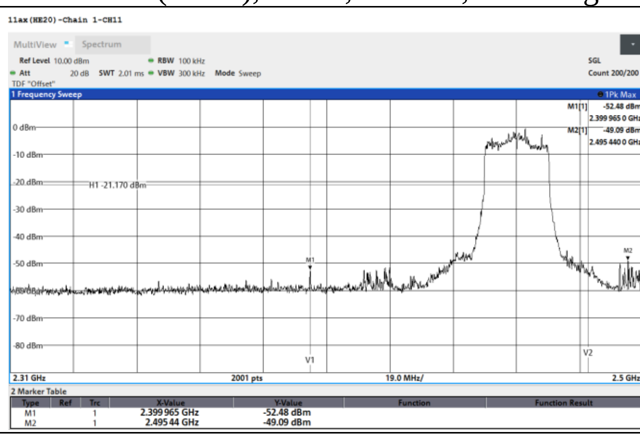
802.11ax(HE20), CH11, Chain 1, Reference

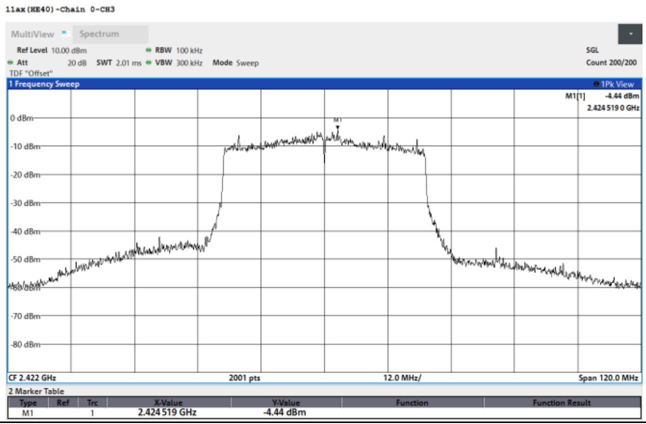


802.11ax(HE20), CH11, Chain 1, Conducted Emission



802.11ax(HE20), CH11, Chain 1, Band edge



802.11ax(HE40), CH3, Chain 0, Reference

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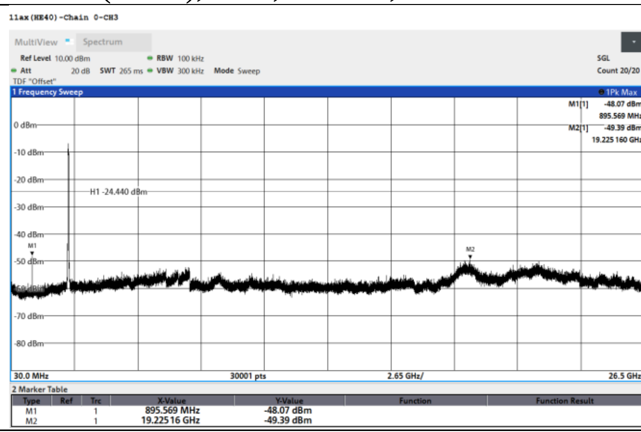
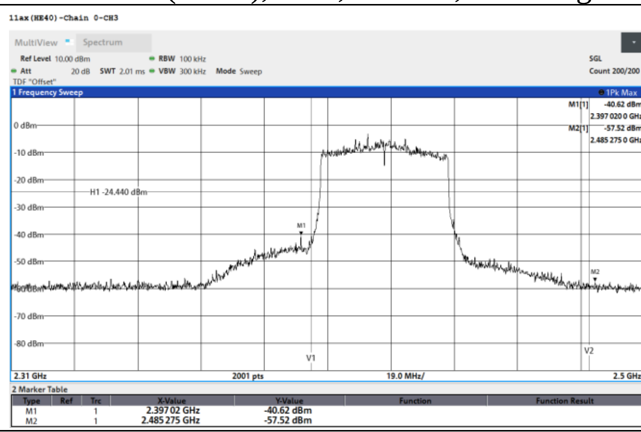
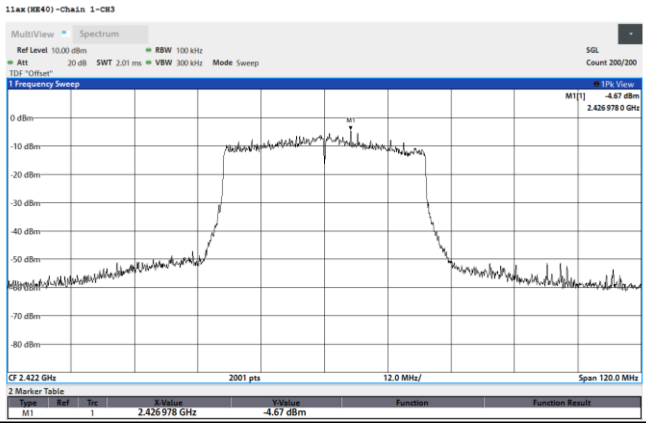
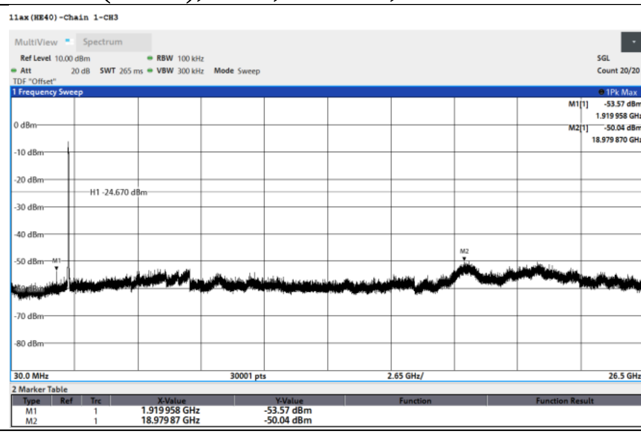

802.11ax(HE40), CH3, Chain 0, Band edge


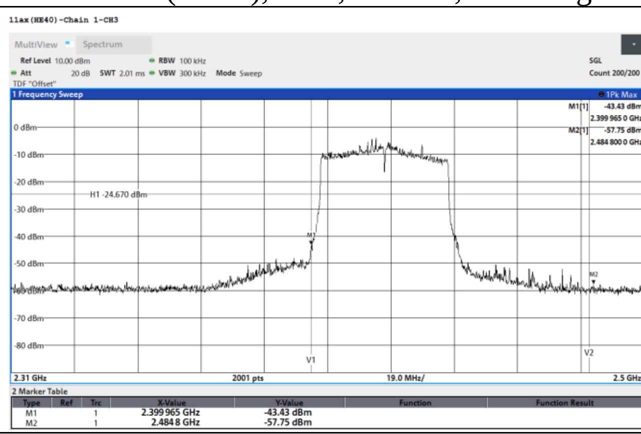
802.11ax(HE40), CH3, Chain 1, Reference

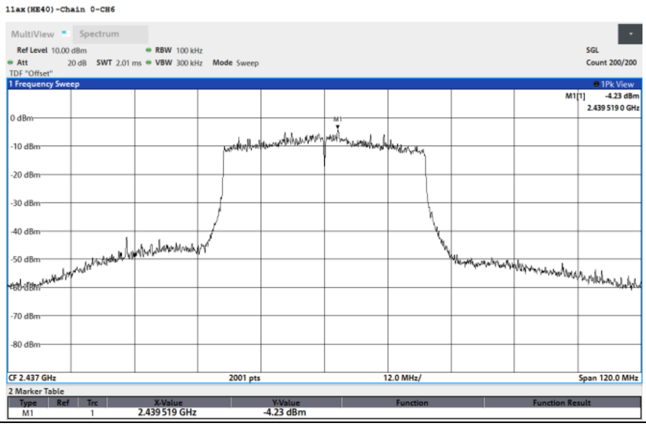
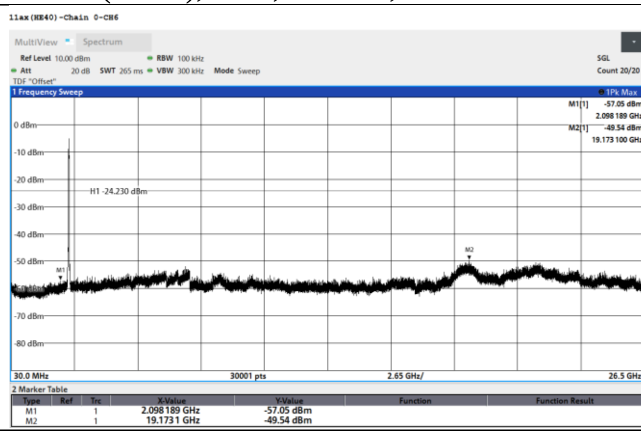
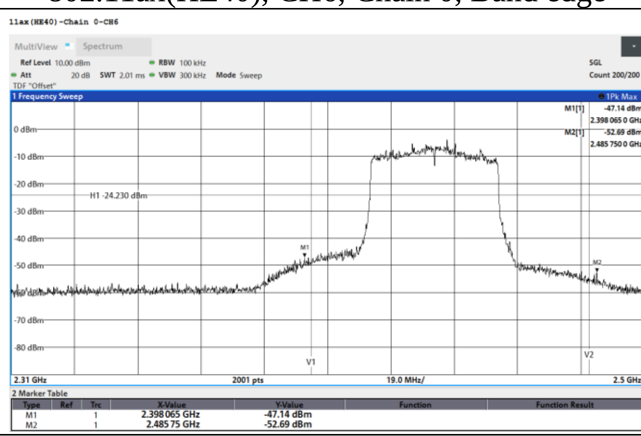


802.11ax(HE40), CH3, Chain 1, Conducted Emission

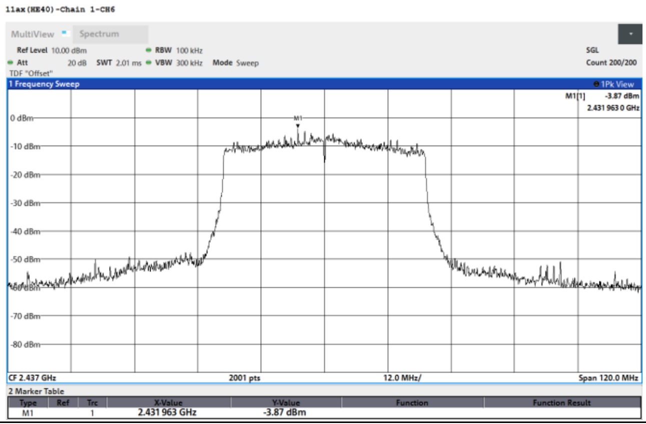


802.11ax(HE40), CH3, Chain 1, Band edge

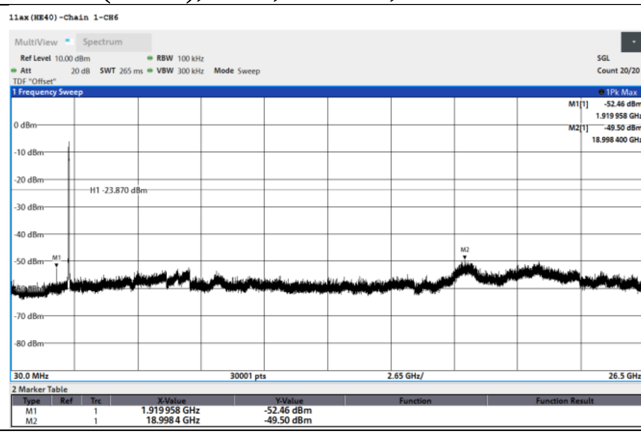


802.11ax(HE40), CH6, Chain 0, Reference

802.11ax(HE40), CH6, Chain 0, Conducted Emission

802.11ax(HE40), CH6, Chain 0, Band edge


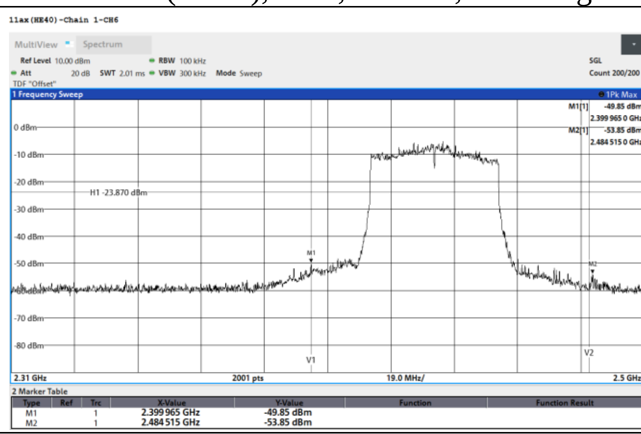
802.11ax(HE40), CH6, Chain 1, Reference



802.11ax(HE40), CH6, Chain 1, Conducted Emission

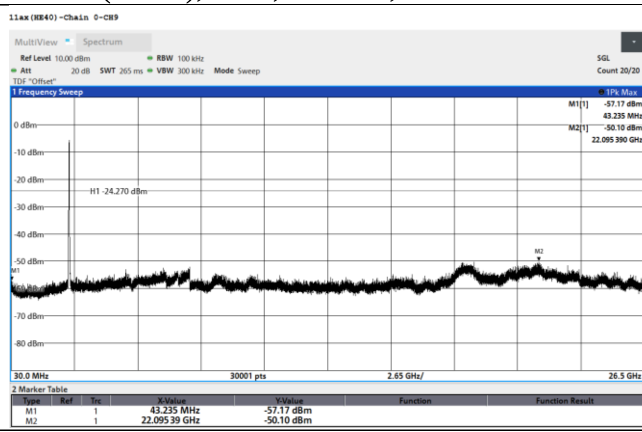


802.11ax(HE40), CH6, Chain 1, Band edge

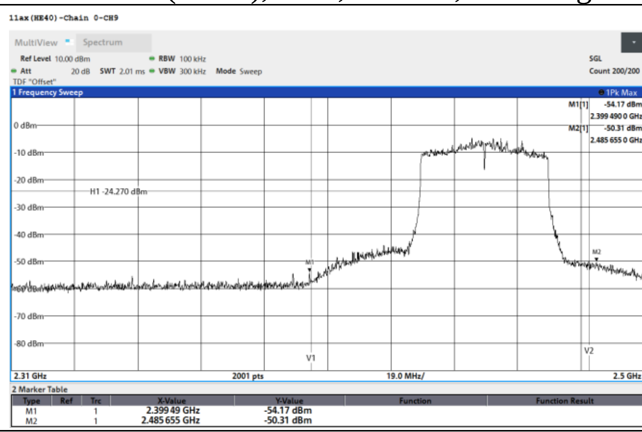


802.11ax(HE40), CH9, Chain 0, Reference

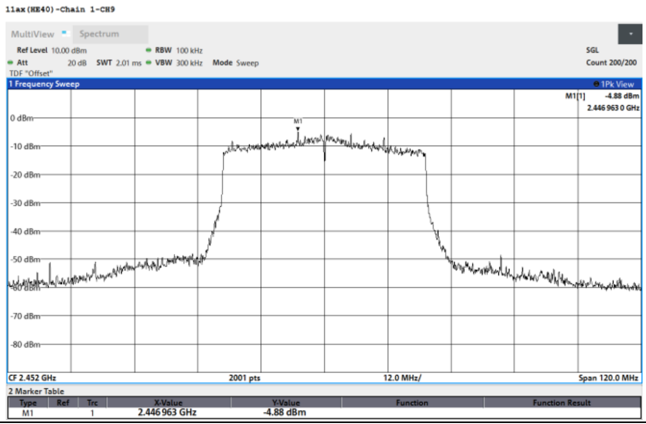
802.11ax(HE40), CH9, Chain 0, Conducted Emission



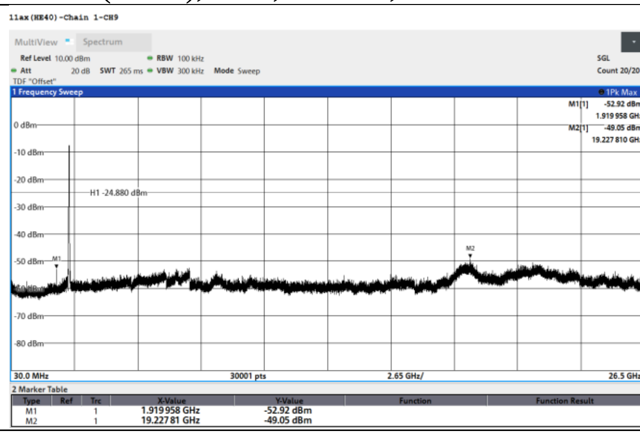
802.11ax(HE40), CH9, Chain 0, Band edge



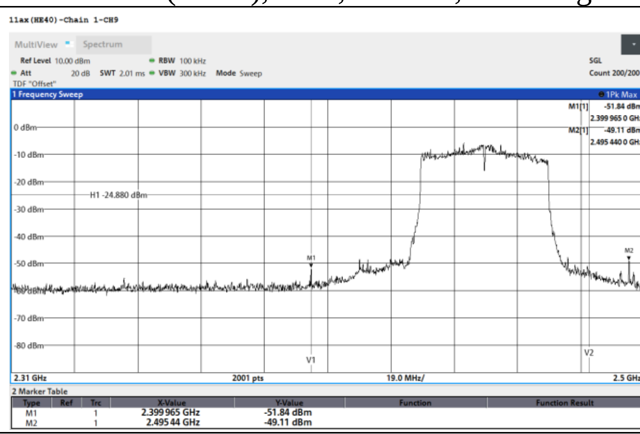
802.11ax(HE40), CH9, Chain 1, Reference



802.11ax(HE40), CH9, Chain 1, Conducted Emission



802.11ax(HE40), CH9, Chain 1, Band edge



9.5. Radiated Spurious Emission

Requirements

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 20dB below the highest level of the desired power:

Frequency(MHz)	Field strength (microvolts/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

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.

Test Procedures

[For 9 kHz ~ 30 MHz]

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.
b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
c. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.
d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
e. For measurement below 30MHz, the initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then Quasi Peak detector mode re-measured. If the emission level of the EUT measured by the peak detector is 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.

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9kHz at frequency below 30MHz.

[For above 30 MHz]

a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
e. For measurement below 1GHz, the initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then Quasi Peak detector mode re-measured. If the emission level of the EUT measured by the peak detector is 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.
f. The test-receiver system was set to peak and average detects function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

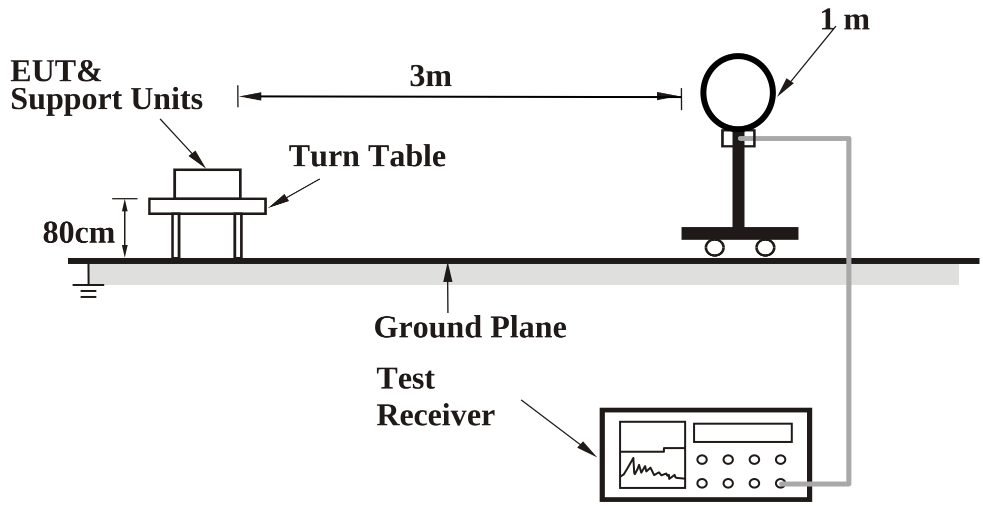
a. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
b. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
c. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is ≥ 1/T (Duty cycle < 98%) or 10Hz (Duty cycle ≥ 98%) for Average detection (AV) at frequency above 1GHz.

Configuration	Average	
	RBW	VBW
802.11b	1MHz	Refer to section 6.6 for duty cycle.
802.11g		
802.11ax (HE20)		
802.11ax (HE40)		

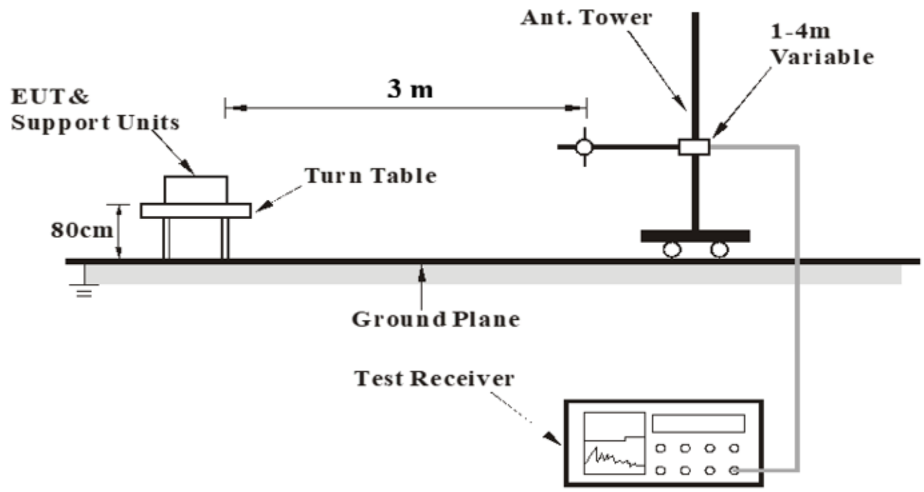
d. All modes of operation were investigated (includes all external accessories) and the worst-case emissions are reported, the other emission levels were low against the limit.
e. Test data of Result value (dBuV/m) = Reading value (dBuV/m) + Correction Factor (dB/m).
f. Test data of Margin(dB) = Result value (dBuV/m) - Limit value (dBuV/m).
g. Test data of Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Loss (dB) - Preamp Factor (dB).
h. Test data of Notation "@" = Fundamental Frequency
i. Test data of Notation " * " = The peak result under 20 dB above and complies with AVG limit, AVG result is deemed to comply with AVG limit.

Test Setup

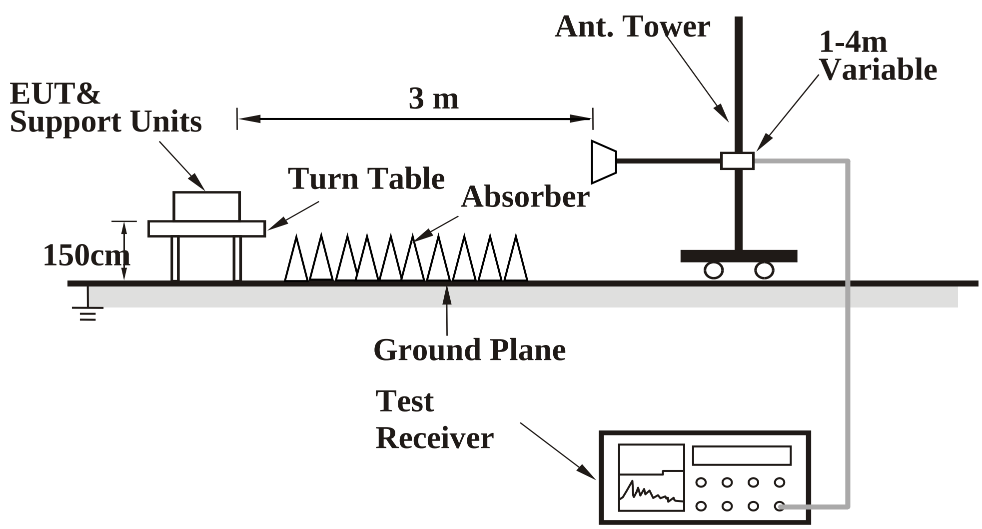
<Frequency Range 9 kHz ~ 30 MHz>



<Frequency Range 30 MHz ~ 1 GHz >



<Frequency Range above 1 GHz>



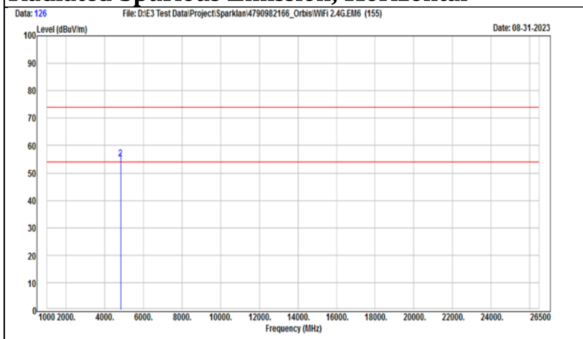
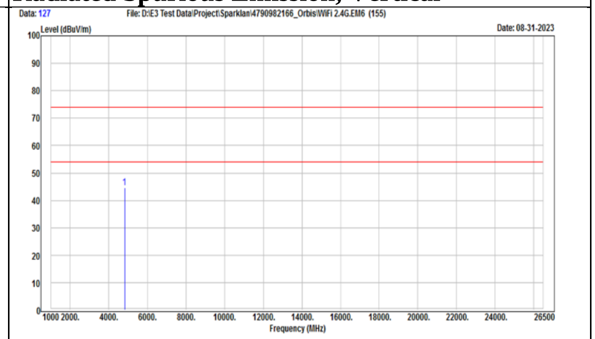
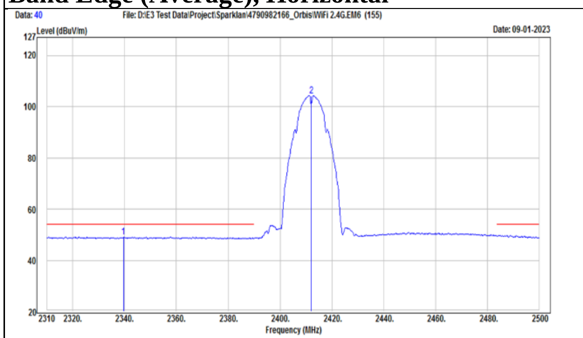
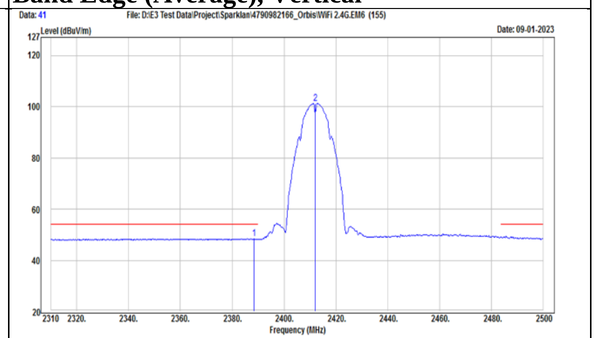
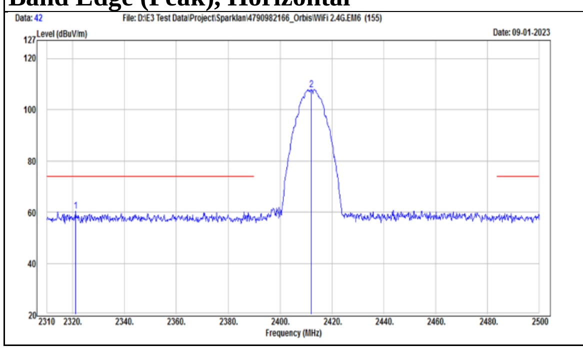
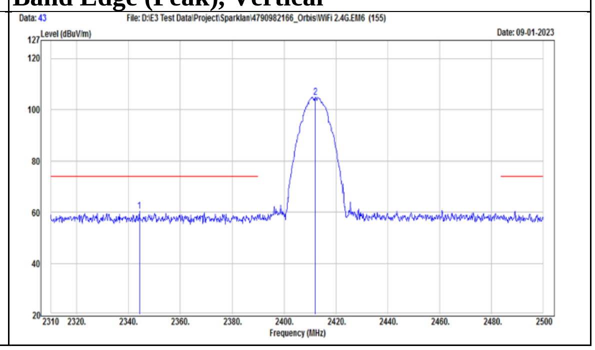
For the actual test configuration, please refer to the Setup Configurations.

Test Data

Above 1 GHz

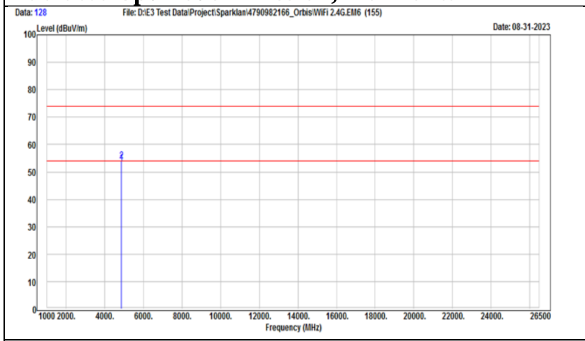
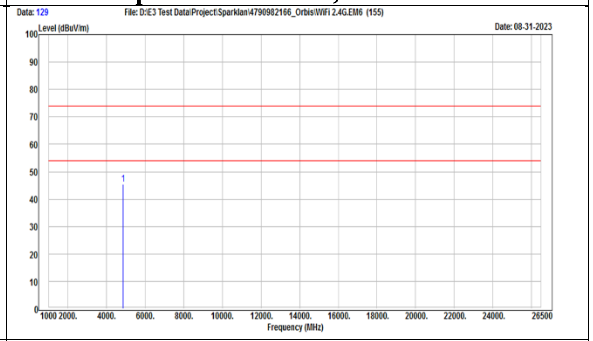
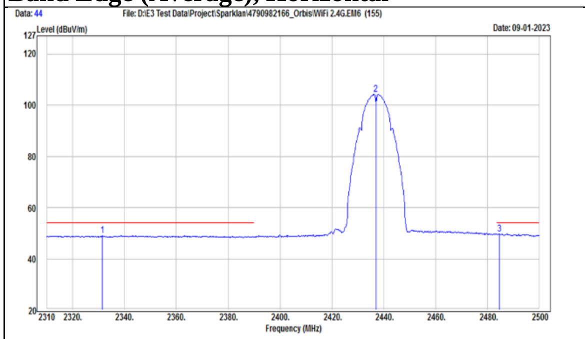
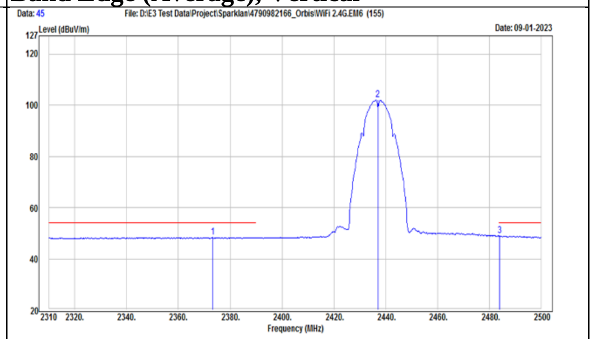
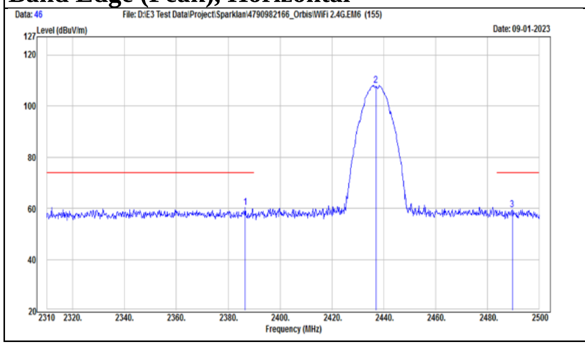
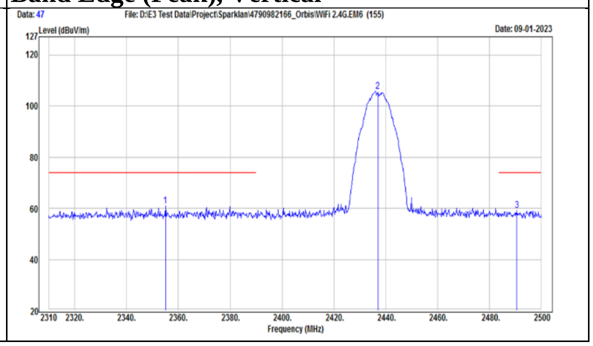
Mode	802.11b	Channel	1

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2321.21	41.26	18.96	60.22	74	-13.78	PK
		2339.64	30.2	18.95	49.15	54	-4.85	AVG
	@	2412	88.91	18.88	107.79	N/A	N/A	PK
	@	2412	85.41	18.88	104.29	N/A	N/A	AVG
		4824	52.89	2.16	55.05	74	-18.95	PK
		4824	51.8	2.16	53.96	54	-0.04	AVG
Vertical		2344.2	41.48	18.95	60.43	74	-13.57	PK
		2388.47	29.63	18.87	48.5	54	-5.5	AVG
	@	2412	85.94	18.88	104.82	N/A	N/A	PK
	@	2412	82.41	18.88	101.29	N/A	N/A	AVG
	*	4824	42.44	2.16	44.6	74	-29.4	PK

TX, 802.11b (Ch 1) Radiated Spurious Emission, Horizontal	TX, 802.11b (Ch 1) Radiated Spurious Emission, Vertical
	
TX, 802.11b (Ch 1) Band Edge (Average), Horizontal	**TX, 802.11b (Ch 1) Band Edge (Average), Vertical**
	
TX, 802.11b (Ch 1) Band Edge (Peak), Horizontal	**TX, 802.11b (Ch 1) Band Edge (Peak), Vertical**
	

Mode	802.11b	Channel	6

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		2331.47	29.99	18.96	48.95	54	-5.05	AVG
		2386.57	41.44	18.87	60.31	74	-13.69	PK
	@	2437	88.98	18.97	107.95	N/A	N/A	PK
	@	2437	85.32	18.97	104.29	N/A	N/A	AVG
		2484.61	30.89	18.8	49.69	54	-4.31	AVG
		2489.55	40.57	18.77	59.34	74	-14.66	PK
		4874	51.92	2.2	54.12	74	-19.88	PK
		4874	50.86	2.2	53.06	54	-0.94	AVG
Vertical		2355.03	42.02	18.94	60.96	74	-13.04	PK
		2373.27	29.42	18.9	48.32	54	-5.68	AVG
	@	2437	86.65	18.97	105.62	N/A	N/A	PK
	@	2437	83.07	18.97	102.04	N/A	N/A	AVG
		2483.85	30.1	18.81	48.91	54	-5.09	AVG
		2490.5	40.39	18.77	59.16	74	-14.84	PK
	*	4874	43.3	2.2	45.5	74	-28.5	PK

TX, 802.11b (Ch 6) Radiated Spurious Emission, Horizontal	TX, 802.11b (Ch 6) Radiated Spurious Emission, Vertical
	
TX, 802.11b (Ch 6) Band Edge (Average), Horizontal	**TX, 802.11b (Ch 6) Band Edge (Average), Vertical**
	
TX, 802.11b (Ch 6) Band Edge (Peak), Horizontal	**TX, 802.11b (Ch 6) Band Edge (Peak), Vertical**
	

Mode	802.11b	Channel	11

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal	@	2462	89	18.95	107.95	N/A	N/A	PK
	@	2462	85.31	18.95	104.26	N/A	N/A	AVG
		2485.37	31.05	18.8	49.85	54	-4.15	AVG
		2490.88	41.67	18.76	60.43	74	-13.57	PK
		4924	52.51	2.25	54.76	74	-19.24	PK
		4924	51.46	2.25	53.71	54	-0.29	AVG
Vertical	@	2462	86.23	18.95	105.18	N/A	N/A	PK
	@	2462	82.69	18.95	101.64	N/A	N/A	AVG
		2487.08	30.33	18.79	49.12	54	-4.88	AVG
		2489.17	40.71	18.78	59.49	74	-14.51	PK
	*	4924	42.8	2.25	45.05	74	-28.95	PK