TEST REPORT

Report Number : 14982484-E4V2

Applicant : APPLE, INC.
1 APPLE PARK WAY
CUPERTINO, CA 95014, U.S. A

Model : A3081 (Parent Model)
A3286, A3287, A3288 (Variant Models)

FCC ID : BCG-E8688A (Parent Model)
BCG-E8689A, BCG-E8690A, BCG-8691A
(Variant Models)

IC ID : 579C-E8688A (Parent Model)
579C-E8689A, 579C-E8690A, 579C-E8691A
(Variant Models)

EUT Description : SMARTPHONE

Test Standard(s) : FCC 47 CFR PART 15 SUBPART C
ISED RSS-247 ISSUE 3
ISED RSS-GEN ISSUE 5 + A1 + A2

Date Of Issue:
2024/07/15

Prepared by:
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CERT #0751.05

REPORT REVISION HISTORY

Rev.		Issue Date		Revisions		Revised By
V1		2024/07/09		Initial Issue		Chris Xiong
V2		2024/07/15		Address TCB's Questions		Chin Pang

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME:	APPLE INC. 11 APPLE PARK WAY CUPERTINO, CA 95014, U.S.A.
EUT DESCRIPTION:	SMARTPHONE
MODEL:	A3081 (Parent Model) A3286, A3287, A3288 (Variant Models)
BRAND:	APPLE
FCC ID :	BCG-E8688A (Parent Model) BCG-E8689A, BCG-E8690A, BCG-8691A (Variant Models)
IC ID:	579C-E8688A (Parent Model) 579C-E8689A, 579C-E8690A, 579C-E8691A (Variant Models)
SERIAL NUMBER:	C07H5X000700000FGP, V7QCNQFGF0, WXWQLPF6GQ
SAMPLE RECEIPT DATE:	2024/01/02
DATE TESTED:	2024/01/25 – 2024/07/01

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 3	Complies
ISED RSS-GEN Issue 5 + A1 + A2	Complies

UL Verification Inc.is tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL Verification Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Inc. 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 A2LA, NIST, any agency of the Federal Government, or any agency of the U.S. government.

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Approved & Released For
UL Verification Inc. By:

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Senior Lab Engineer
Consumer Technology Division
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Prepared By:

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2. TEST RESULTS SUMMARY

FCC Clause	ISED Clause	Requirement	Result	Comment
See Comment		Duty Cycle	Reporting purposes only	ANSI C63.10 Section 11.6
-	RSS-GEN 6.7	99% OBW	Reporting purposes only	ANSI C63.10 Section 6.9.3
15.247 (a) (2)	RSS-247 5.2 (a)	6dB BW	Complies	None
15.247 (b) (3)	RSS-247 5.4 (d)	Output Power (Average)	Complies	Per ANSI C63.10 Section 11.9.2.3.2
15.247 (e)	RSS-247 5.2 (b)	PSD	Complies	None
15.247 (d)	RSS-247 5.5	Conducted Spurious Emissions	Complies	None
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions	Complies	None
15.207	RSS-Gen 8.8	AC Mains Conducted Emissions	Complies	None

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with:

- FCC CFR 47 Part 2
- FCC CFR 47 Part 15
- FCC KDB 558074 D01 v05r02 15.247 Meas Guidance
- ANSI C63.10-2013
- RSS-GEN Issue 5 + A1 + A2
- KDB 414788 D01 Radiated Test Site v01r01
- RSS-247 Issue 3

4. FACILITIES AND ACCREDITATION

UL Verification Inc. is accredited by A2LA, certification #0751.05, for all testing performed within the scope of this report. Testing was performed at the locations noted below.

	Address	ISED CABID	ISED Company Number	FCC Registration
☐	Building 1: 47173 Benicia Street, Fremont, CA 94538, USA	US0104	2324A	550739
☒	Building 2: 47266 Benicia Street, Fremont, CA 94538, USA			
☒	Building 3: 843 Auburn Court, Fremont, CA 94538 USA			
☒	Building 4: 47658 Kato Rd, Fremont, CA 94538 USA			
☐	Building 5: 47670 Kato Rd, Fremont, CA 94538 USA			

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5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	U_{LAB}
Conducted Antenna Port Emission Measurement	1.94
Power Spectral Density	2.466
Time Domain Measurements Using SA	3.39
RF Power Measurement Direct Method Using Power Meter	0.45 (Peak) 1.30 (Ave)
Radio Frequency (Spectrum Analyzer)	141.16 Hz
Occupied Bandwidth	1.20%
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.78 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.40 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.87 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	6.01 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.73 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.51 dB

Uncertainty figures are valid to a confidence level of 95%.

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5.4. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:
Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)
36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:
Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss
36.5 dBuV + 0 dB +10.1 dB+ 0 dB = 46.6 dBuV

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6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The Apple iPhone is a smartphone with cellular GSM, GPRS, EGPRS, WCDMA, LTE, 5GNR1, 5GNR2, IEEE 802.11a/b/g/n/ac/ax/be, Bluetooth (BT), Ultra-Wideband (UWB), Global Positioning System (GPS), Near-Field Communication (NFC), Narrow-Band (NB) UNII, 802.15.4, 802.15.4ab-Narrow Band (NB), Wireless Power Transfer (WPT) and Mobile Satellite Service (MSS) technologies. The rechargeable battery is not user accessible. This device is not user-serviceable and requires special tools to disassemble.

6.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
1TX			
2412 - 2472	802.11b	21.35	136.46
	802.11g	Covered by 802.11n HT20 1TX	
	802.11n HT20	21.26	133.66
	802.11ax HE20	Covered by 802.11be HE20 1TX	
	802.11be EHT20	21.35	136.46

2TX			
2412 - 2472	802.11g SDM/STBC	Covered by 802.11n HT20 CDD	
	802.11n HT20 CDD	24.34	271.64
	802.11ax HE20 OFDMA	Covered by 802.11be HE20 OFDMA	
	802.11be EHT20 OFDMA	24.31	269.77

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

Antenna Type is IFA.

The antennas' gains, as provided by the manufacturer, are as follows:

Frequency Range (MHz)	ANT 4 (dBi)	ANT 3 (dBi)
2400 – 2483.5	0.50	-1.60

The SMA Cable losses used for RF antenna port tests are as follow:
ANT 4 = 1.96 dB
ANT 3 = 2.18 dB
The cables were used for RF antenna port tests that had been offset to the test equipment during testing.

6.4. SOFTWARE AND FIRMWARE

The EUT firmware and software installed during testing was 27_20_111_38.

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6.5. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations: X (Flatbed), Y (Landscape) and Z (Portrait) on ANT 4, ANT 3, and 2TX. It was determined that X (Flatbed) orientation was the worst-case orientation for ANT 3, ANT 4 and 2TX.

With same power on Full RU and SU higher data rate, investigation was performed on both band edge to determine the worst case. SU mode was determined to be the worst case.

Radiated band edge, harmonic, and spurious emissions from 1GHz to 18GHz were performed with the EUT set to transmit at highest power on Low/Middle/High channels.

Radiated emissions below 1GHz, 18-26GHz and power line conducted emissions were performed with the EUT transmits at the channel with the highest output power as worst-case scenario. There were no emissions found below 30MHz within 20dB of the limit.

For radiated harmonics spurious below 1GHz, 1-18GHz L/M/H channels, 18-26GHz, and power line conducted emissions were performed with the EUT set at the 2TX CDD mode among the CDD/SDM modes and 2TX EHT mode with power setting equal or higher than SISO modes as worst-case scenario. G mode covered by HT20 mode since it has the same power as HT20.

Below 30MHz, 30-1000MHz emission spurious test were performed with EUT connected to AC power adapter and set EUT on X orientation as the worst case; and for above 1GHz tests, the worst-case configuration reported was with EUT only. For AC line conducted emission, test was investigated with AC power adapter and with laptop.

The modulation and bandwidth of 802.11ax and 802.11be modes are similar, and the target power of 802.11ax mode is equal to or lower than that of 802.11be mode. The data rate of 802.11be mode is higher than 802.11ax mode, therefore, 802.11be mode is performed in the test to represent worst-case reporting.

The output power and psd for the 802.11be mode were investigated between all different tones and we found that SU mode had the highest output power and RU26 had the highest PSD readings. After investigation, antenna port conducted tests were performed on both SU and lowest tones; radiated spurious emission and radiated band edge tests were performed on SU and lowest tones. Please see worst case summary table below.

WIFI DTS 2.4GHz - 802.11be					
BW (MHz)	Tone (T)	RU Index	RU Index (Chipset support)	Worst Case Tone	
				Power	PSD
20	26	0 ~ 8	0 ~ 8		X
	52	37 ~ 40	37 ~ 40		
	52 + 26	70 ~ 81	70, 71, 72		
	106	53 ~ 54	53 ~ 54		
	106 + 26	82 ~ 89	82, 83		
	242	61	61		
	SU	--	--	X	

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Low data rate was used to test on antenna port conducted tests and radiated spurious emissions since it has the highest maximum power. For radiated band-edge, the following are the worst-case data rates set for test:

802.11b mode : 1 Mbps
802.11n HT20 mode : MCS7
802.11be EHT RU26 mode: MCS9
802.11be EHT SU mode: MCS9

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6.6. DESCRIPTION OF TEST SETUP

SUPPORT TEST EQUIPMENT				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID/ DoC**
Laptop	Apple	MacBook Pro	C02VD7SAHV22	BCGA1708
Laptop AC/DC adapter	Liteon Technology	A1424	NSW25679	DoC
EUT AC/DC adapter	Apple	A1720	C3D8417A7R93KVPA8	DoC

I/O CABLES (RF CONDUCTED TEST)						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	SMA	1	SMA	Shielded	0.75	To spectrum Analyzer
2	Antenna	2	SMA	Un-shielded	0.2	To Conducted Switch Box
3	USB-C	1	USB-C	Shielded	1.0	N/A
4	AC	1	AC	Un-shielded	2	N/A

I/O CABLES (RF RADIATED AND AC LINE CONDUCTED TEST)						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	1	AC	Un-shielded	2	N/A
2	USB	1	USB	Shielded	1	N/A

TEST SETUP

The EUT setup is shown as below. Test software exercised the radio card.

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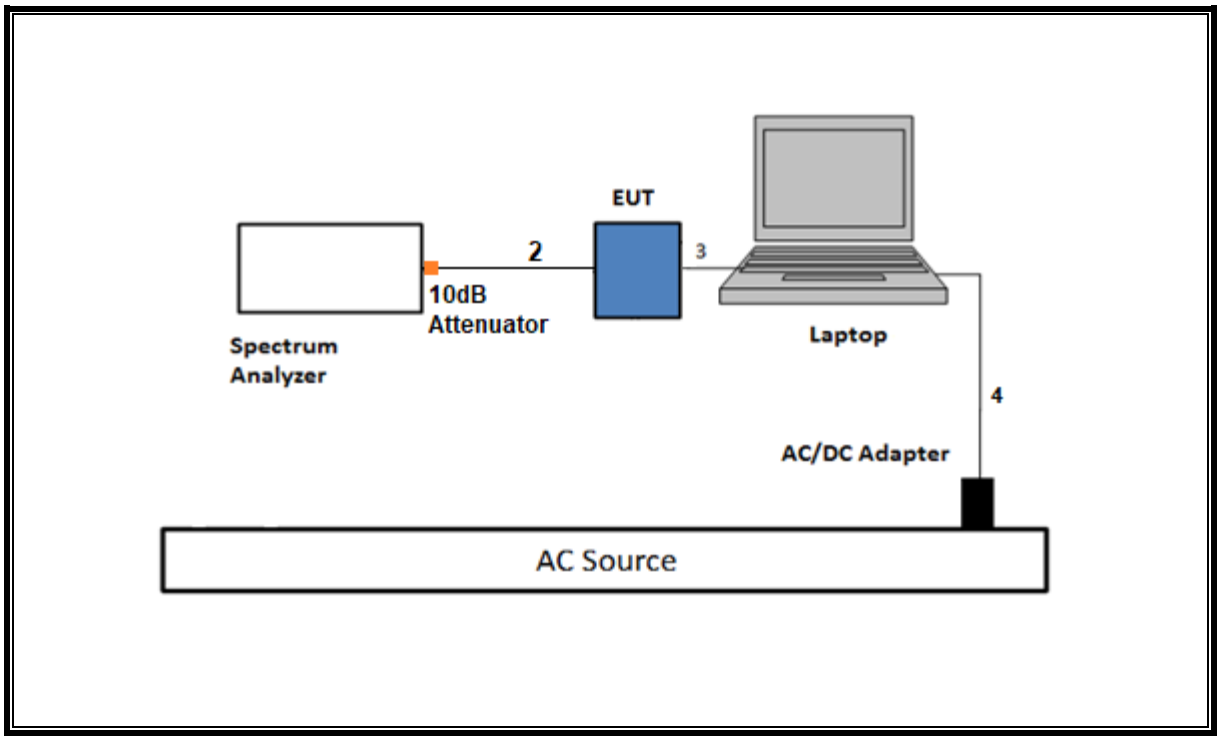
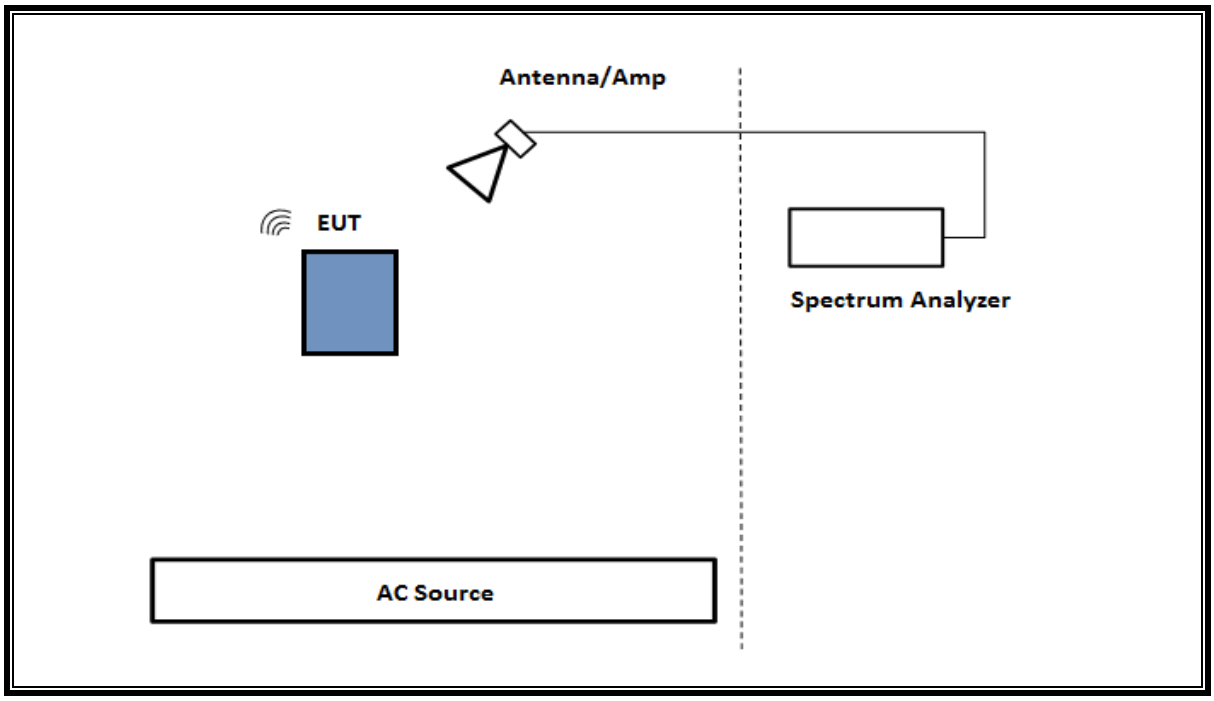
SETUP DIAGRAM FOR CONDUCTED TESTS



SETUP DIAGRAM FOR RADIATED TESTS (1 GHz – 26 GHz)



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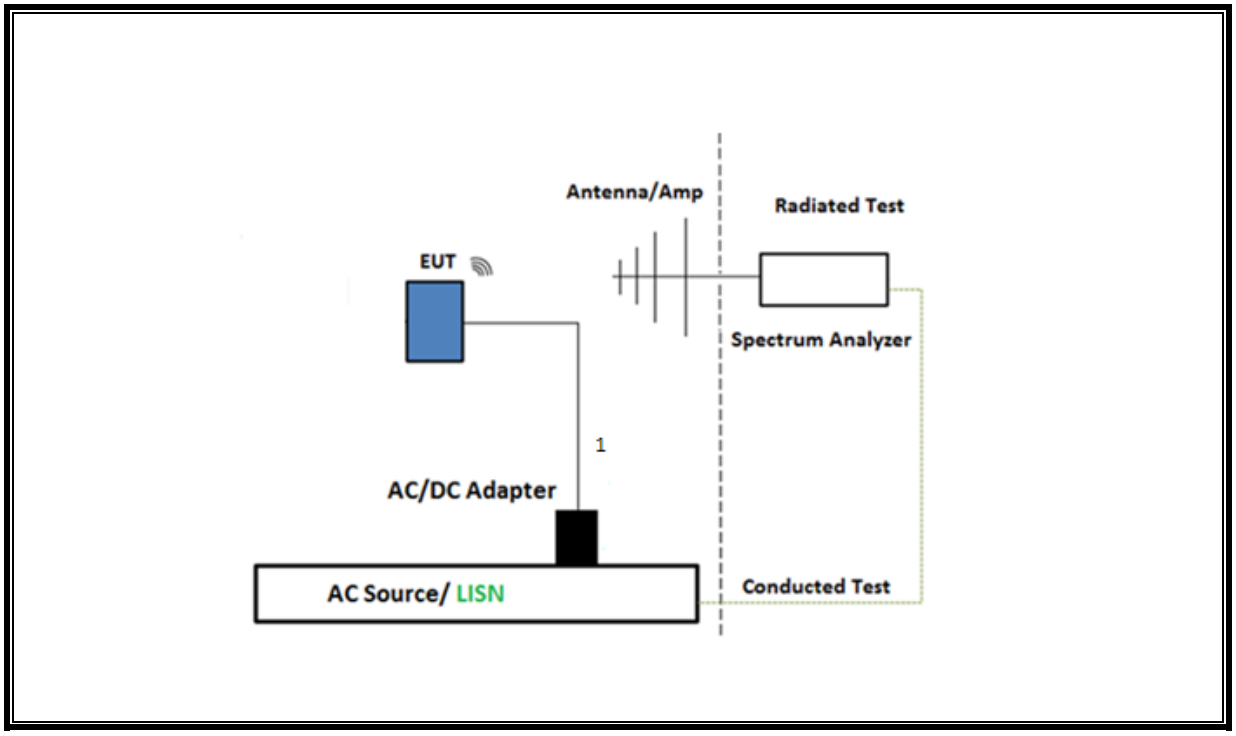
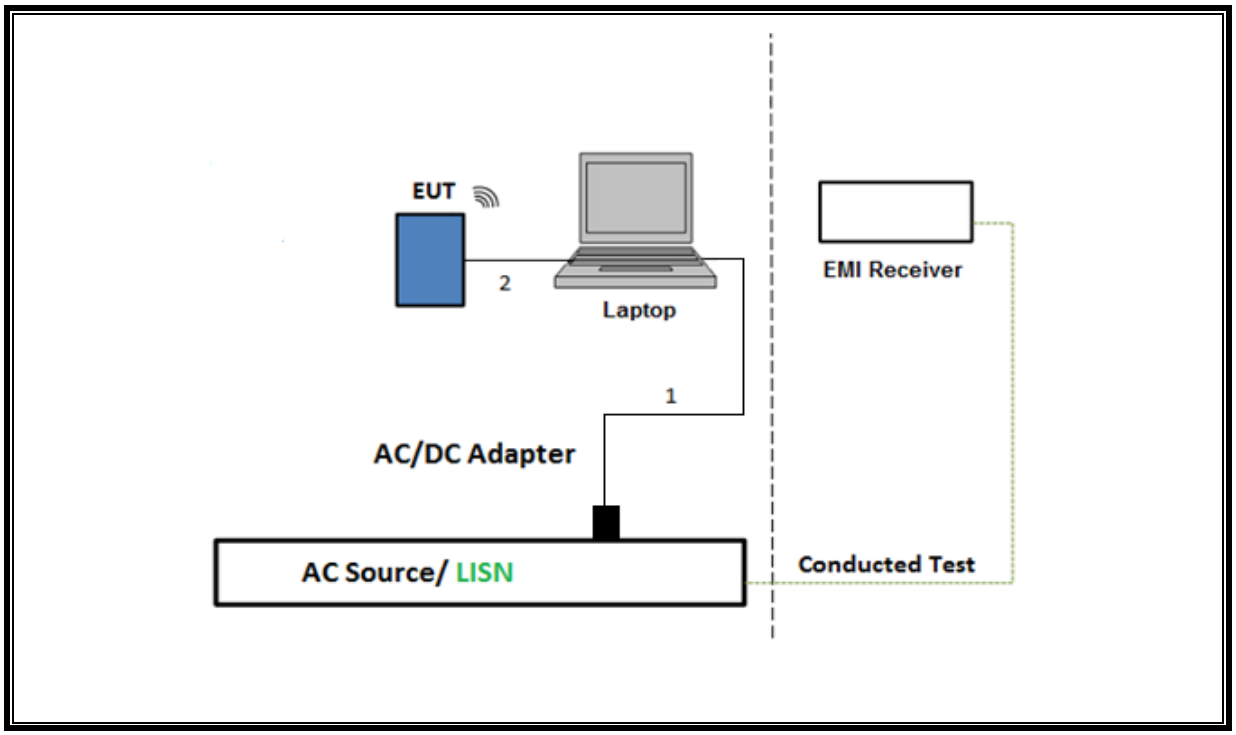
SETUP DIAGRAM FOR RADIATED TESTS (30-1000MHz) and AC LINE CONDUCTED TEST



SETUP DIAGRAM FOR AC LINE CONDUCTED TEST (LAPTOP CONFIGURATION)



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7. MEASUREMENT METHOD

TEST ITEM	TEST METHOD
6 dB Bandwidth	ANSI C63.10 Subclause - 11.8.1 RBW ≥ DTS BW
99% Bandwidth	ANSI C63.10-2013, Subclause 6.9.3
Output Power	ANSI C63.10 Subclause - 11.9.2.3.2 Method AVGPM G (Measurement using an RF average-reading power meter)
Peak Spectral Density (PSD)	ANSI C63.10 Subclause - 11.10.3 Method AVGPSD-1
Radiated Emissions Non-Restricted Frequency Bands	ANSI C63.10 Subclause - 11.11 & Clause 13
Radiated Emissions Restricted Frequency Bands	ANSI C63.10 Subclause - 11.12.1 & Clause 13
Conducted Emissions in Restricted Frequency Bands	ANSI C63.10 Subclause - 11.12.2
Band-edge	ANSI C63.10 Subclause - 11.13.3.2 & Clause 13 Integration method - Peak detection
Band-edge	ANSI C63.10 Subclause - 11.13.3.3 & Clause 13 Integration method - Trace averaging with continuous transmission at full power
Radiated Spurious Emissions Below 30MHz	ANSI C63.10-2013 Subclause 6.4 & Clause 13
AC Power Line Conducted Emissions	ANSI C63.10-2013, Subclause 6.2

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8. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**ID Num**	**Cal Due**
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc	N9030A	125178	2025/01/31
10dB Fixed Attenuator, 2 Watts Up to 26.5 GHz	Pasternack Enterprises	PE7024-10	236353	2024/08/31
Spectrum Analyzer, PXA, 3Hz to 50GHz w/Ext. Mixer	Keysight Technologies Inc	N9030A	80400	2025/02/28
10dB Fixed Attenuator, 2 Watts Up to 26.5 GHz	Pasternack Enterprises	PE7024-10	236355	2024/08/31
Power Meter, P-series single channel	Keysight Technologies Inc	N1911A	90719	2025/01/31
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc	N1921A	90389	2025/01/31
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	201501	2024/11/30
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	81886	2025/03/31
RF Filter Box, 1-18GHz, 12 Ports	UL-FR1	Frankenstein	217521	2024/08/31
EMI Test Receiver	Rohde & Schwarz	ESW44	201500	2025/02/28
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	206807	2025/02/29
RF Filter Box, 1-18GHz	Miteq	UL-FR1	216812	2025/01/30
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	169936	2025/02/28
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	226673	2025/02/28
RF Filter Box, 1-18GHz, 12 Port.	UL-FR1	Frankenstein	231874	2024/08/30
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	170063	2024/11/30
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	230300	2025/01/31
*RF Filter Box, 1-18GHz	Miteq	UL-FR1	171389	2024/05/31
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	223461	2025/02/28
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	84796	2024/09/30
RF Filter Box, 1-18GHz, 17 Ports	UL-FR1	RATS 2	224478	2025/01/31
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	201497	2025/02/28
Antenna, Broadband Hybrid, 30MHz to 2000MHz	Sunol Sciences Corp.	JB3	80714	2024/10/31
Link File, @3m, 9kHz-1000MHz Hybrid Path Loss	UL-FR1	Port 0 Factors	226862	2025/01/31
Antenna, Horn 18 to 26.5GHz	A.R.A.	MWH-1826/B	172354	2024/10/31
Link File, RF Amplifier Assembly, 18-26.5GHz, 60dB Gain	AMPLICAL	AMP18G26.5-60	221832	2025/03/31
*Antenna, Passive Loop 30Hz - 1MHz	ELECTRO-METRICS	EM-6871	170013	2024/07/31
*Antenna, Passive Loop 100kHz to 30MHz	ELECTRO-METRICS	EM-6872	170015	2024/07/31
Amplifier, 9KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	79584	2024/12/28

AC LINE CONDUCTED				
Description	**Manufacturer**	**Model**	**ID Number**	**Cal Due**
EMI Test Receiver 9kHz-7GHz	Rohde & Schwarz	ESR	93091	2025/02/28
LISN for Conducted Emissions CISPR-16	FISCHER CUSTOM COMMUNICATIONS	FCC-LISN-50/250-25-2-01-480V	175765	2025/01/31
Transient Limiter	TE	TBFL1	207996	2024/08/31

UL AUTOMATION SOFTWARE			
Radiated Software	UL	UL EMC	Ver 9.5, May 1, 2023
Conducted Software	UL	UL EMC	2024.2.23
AC Line Conducted Software	UL	UL EMC	Ver 9.5, Mar 3, 2023

* Testing was completed before equipment calibration date

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9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

Test Engineer:	33300
Test Date:	02/27/2024

ON TIME AND DUTY CYCLE RESULTS

Mode	Tone (T)	Data Rate (Mbps)	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
b	--	6Mb/s	1.2070	1.2240	0.9861	98.61%	0.00	0.010
HT20	--	MCS0	0.9836	1.0050	0.9787	97.87%	0.09	1.017
	--	MCS7	0.1358	0.1613	0.8419	84.19%	0.75	7.364
EHT20	SU	MCS0	1.5010	1.5210	0.9869	98.69%	0.00	0.010
		MCS9	0.1820	0.2033	0.8952	89.52%	0.48	5.495
	26	MCS0	3.9760	4.0570	0.9800	98.00%	0.00	0.010
		MCS9	0.3496	0.3992	0.8758	87.58%	0.58	2.860

Note: Duty Cycle is the same for 1TX and 2TX.

DUTY CYCLE PLOT

802.11n HT20 MODE (MCS0)

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9.2. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

RESULTS

Only MID channel plot is reported to show setting parameter compliance with testing method/procedure.

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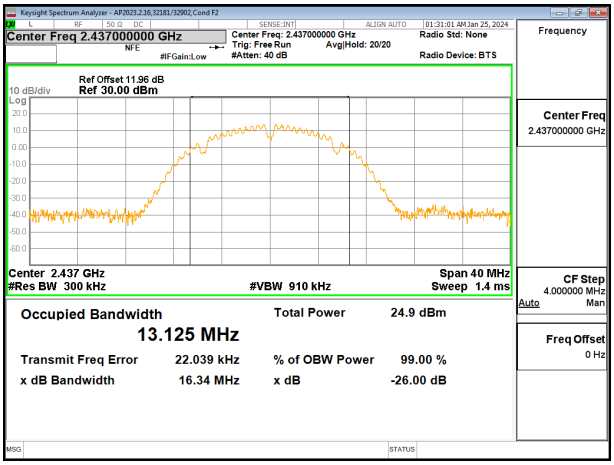
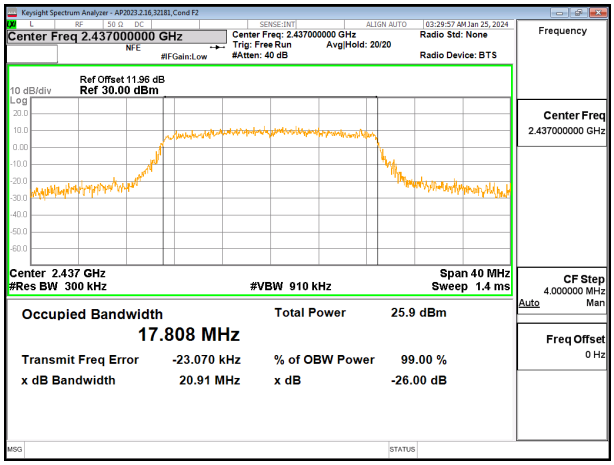
9.2.1. 802.11b/n/be SISO MODE

Mode (SISO)	Frequency (MHz)	Channel Number	Tone	RU Index	99% Bandwidth (MHz)	
					ANT 4	ANT 3
b	2412	1	--	--	13.126	13.293
	2437	6	--	--	13.125	13.112
	2472	13	--	--	13.053	13.094
HT20	2412	1	--	--	17.746	17.840
	2437	6	--	--	17.808	17.838
	2472	13	--	--	17.739	17.778
EHT20	2412	1	SU	--	18.889	18.975
			26	0	18.057	18.505
				4	16.832	17.220
				8	18.499	18.472
	2437	6	SU	--	18.895	18.943
			26	0	18.459	18.231
				4	16.901	16.892
				8	18.381	18.570
	2472	13	SU	--	18.912	18.829
			26	0	18.361	18.465
				4	17.067	17.102
				8	18.689	18.688



b - Channel 6 [ANT 4]



HT20 - Channel 6 [ANT 4]

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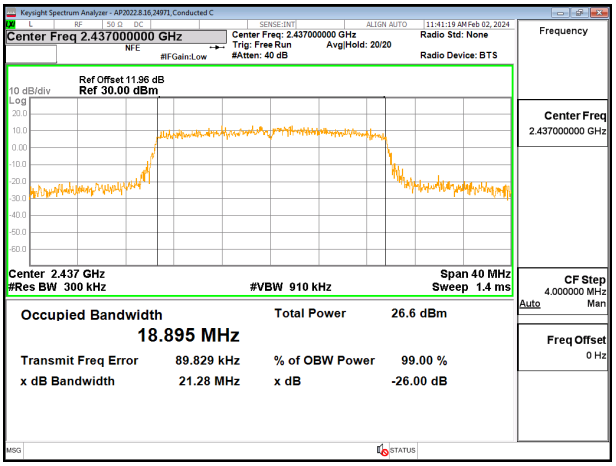
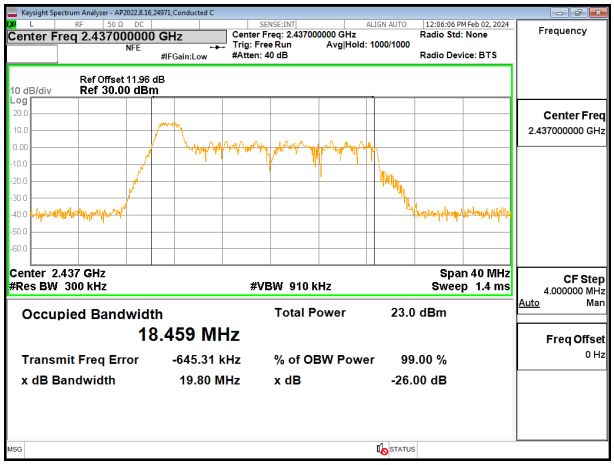


EHT20 - Channel 6 – SU [ANT 4]



EHT20 - Channel 6 – 26T Index 0 [ANT 4]

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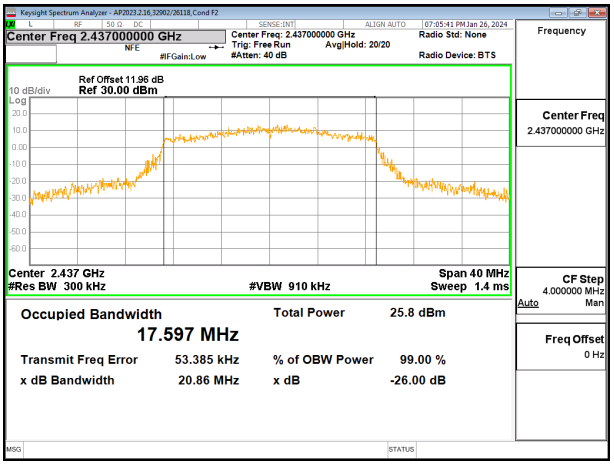
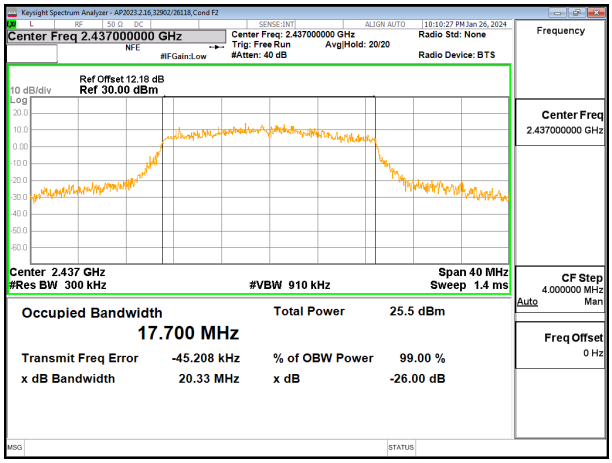
9.2.2. 802.11n/be MIMO CDD MODE

Mode (MIMO)	Frequency (MHz)	Channel Number	Tone	RU Index	99% Bandwidth (MHz)	
					ANT 4	ANT 3
HT20	2412	1	--	--	17.743	17.810
	2437	6	--	--	17.597	17.700
	2472	13	--	--	17.722	17.798
EHT20	2412	1	SU	--	18.865	19.013
			26	0	18.320	18.464
				4	16.910	16.790
				8	18.524	18.214
	2437	6	SU	--	18.908	18.951
			26	0	18.478	18.165
				4	17.081	16.623
				8	18.438	18.518
	2472	13	SU	--	18.898	18.822
			26	0	18.252	18.285
				4	16.990	16.958
				8	18.583	18.571



HT20 - Channel 6 [ANT 4]



HT20 - Channel 6 [ANT 3]

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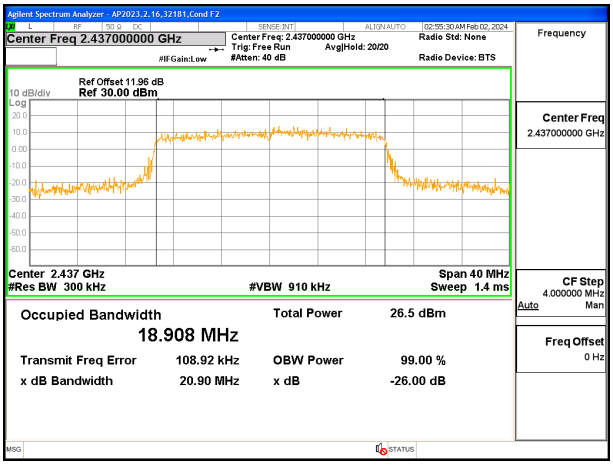
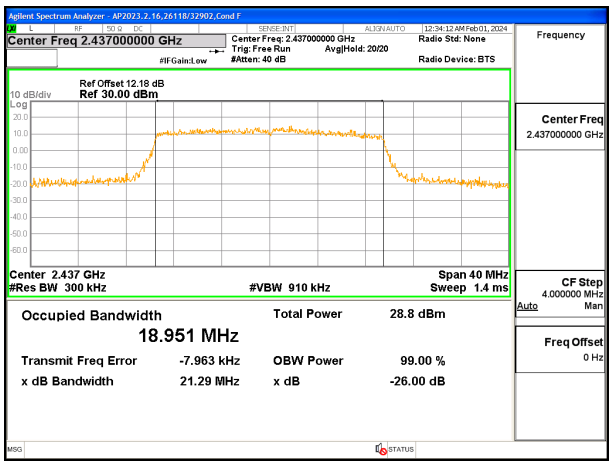
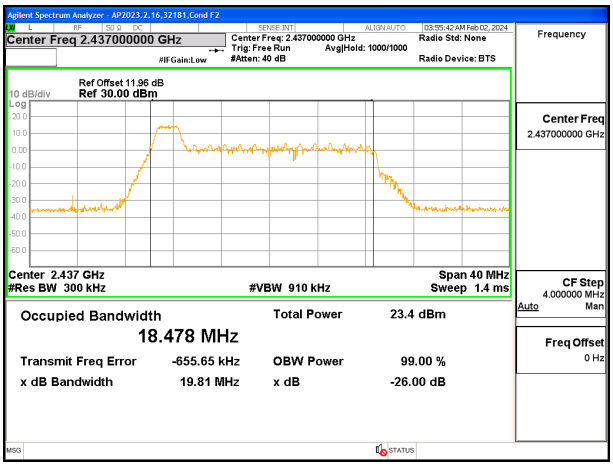


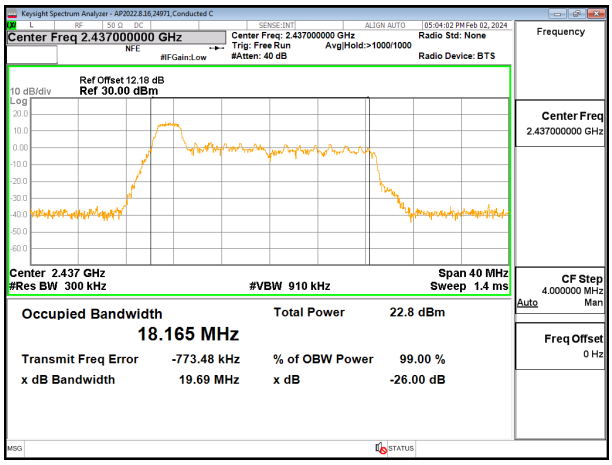
EHT20 - Channel 6 – SU [ANT 4]



EHT20 - Channel 6 – SU [ANT 3]



EHT20 - Channel 6 – 26T Index 0 [ANT 4]



EHT20 - Channel 6 – 26T Index 0 [ANT 3]

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9.3. 6dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

RSS-247 5.2 (a)

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

RESULTS

The 6dB bandwidth was measured for the narrowest bandwidth mode, b Mode and be EHT20 Mode 26-Tone as worst case to demonstrate compliance with the minimum required bandwidth of 500 kHz to cover all OFDMA modes.

Only MID channel plot is reported to show setting parameter compliance with testing method/procedure.

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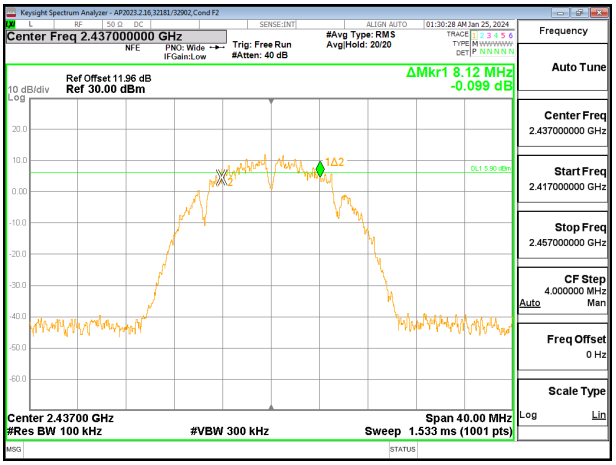
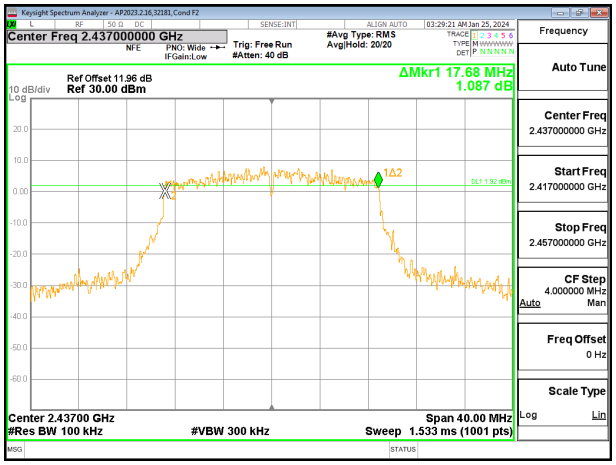
9.3.1. 802.11b/n/be SISO MODE

Mode (SISO)	Frequency (MHz)	Channel Number	Tone	RU Index	6dB Bandwidth (MHz)	
					ANT 4	ANT 3
b	2412	1	--	--	8.20	8.08
	2437	6	--	--	8.12	8.28
	2472	13	--	--	8.72	8.20
HT20	2412	1	--	--	17.68	17.76
	2437	6	--	--	17.68	17.72
	2472	13	--	--	17.00	17.28
EHT20	2412	1	SU	--	18.72	18.68
			26	0	2.12	2.12
				4	2.68	2.64
				8	2.04	2.12
	2437	6	SU	--	19.00	18.08
			26	0	2.00	2.16
				4	2.68	2.64
				8	2.16	2.16
	2472	13	SU	--	18.84	18.48
			26	0	2.04	2.12
				4	2.64	2.64
				8	2.12	2.12



b – Channel 6 [ANT 4]



HT20 – Channel 6 [ANT 4]

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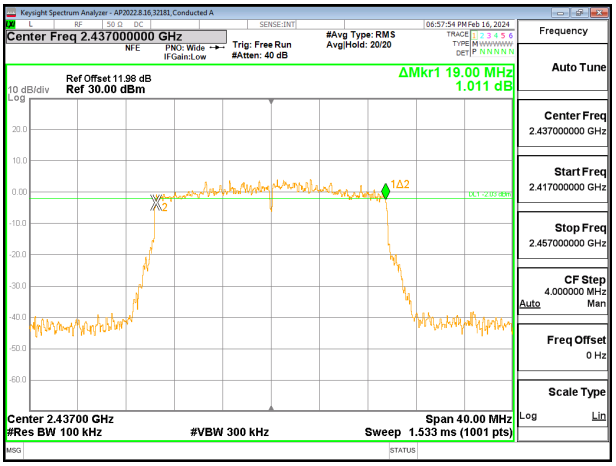
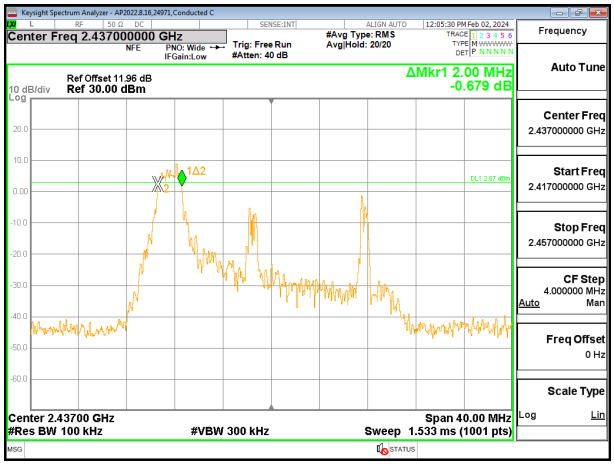


EHT20 – Channel 6 – SU [ANT 4]



EHT20 – Channel 6 – 26 Tone Index 0 [ANT 4]

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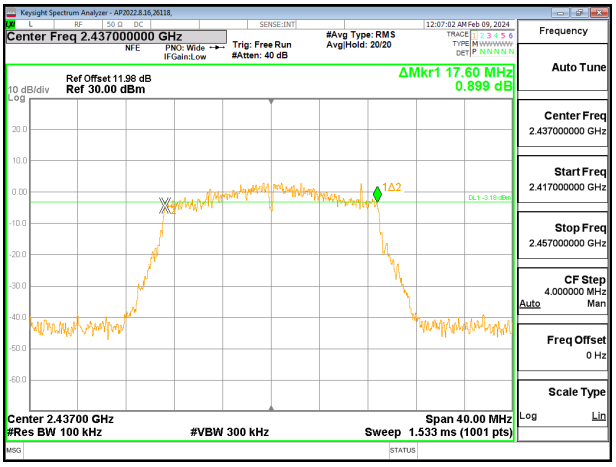
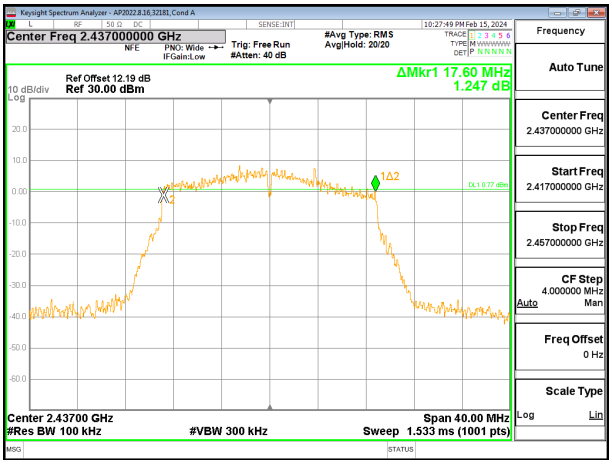
9.3.2. 802.11n/be MIMO CDD MODE

Mode (MIMO)	Frequency (MHz)	Channel Number	Tone	RU Index	6dB Bandwidth (MHz)	
					ANT 4	ANT 3
HT20	2412	1	--	--	17.72	17.32
	2437	6	--	--	17.60	17.60
	2472	13	--	--	17.68	17.24
EHT20	2412	1	SU	--	18.92	18.96
			26	0	2.16	2.2
				4	2.68	2.64
				8	2.2	2.16
	2437	6	SU	--	18.52	18.6
			26	0	2.08	2.16
				4	2.64	2.64
				8	2.24	2.16
	2472	13	SU	--	18.36	18.72
			26	0	2.12	2.12
				4	2.64	2.72
				8	2.08	2.00



HT20 – Channel 6 [ANT 4]



HT20 – Channel 6 [ANT 3]

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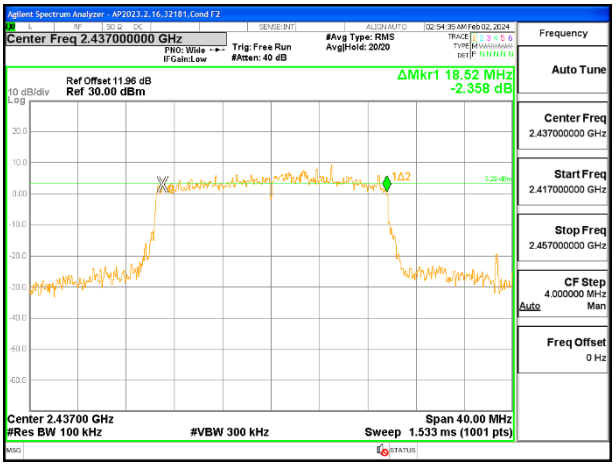
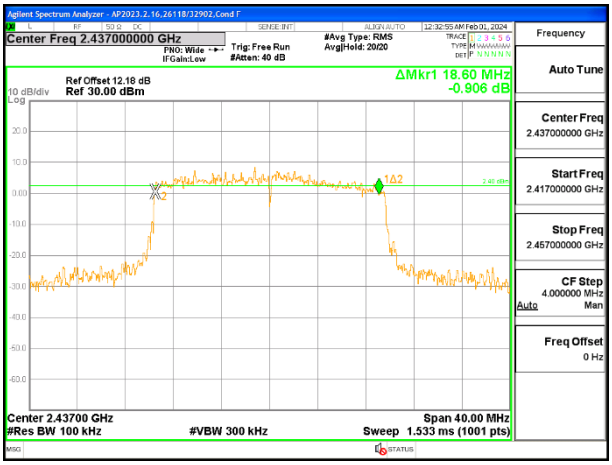
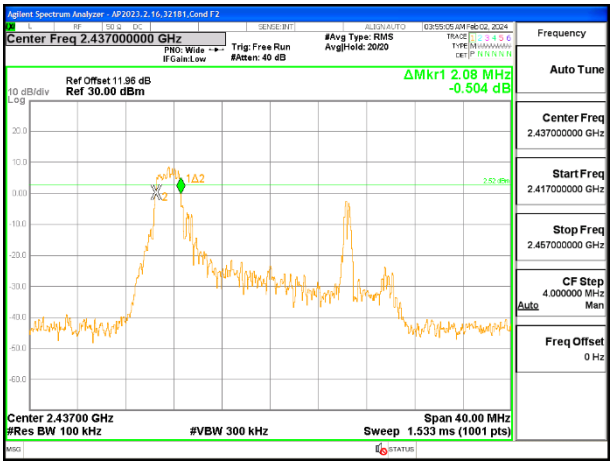


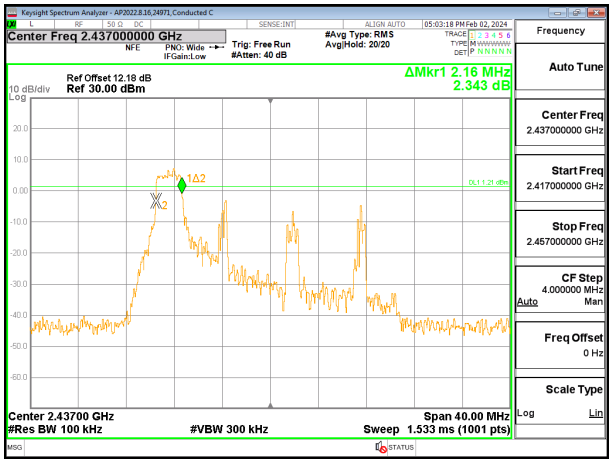
EHT20 - Channel 6 – SU [ANT 4]



EHT20 - Channel 6 – SU [ANT 3]



EHT20 - Channel 6 – 26 Tone Index 0 [ANT 4]



EHT20 - Channel 6 – 26 Tone Index 0 [ANT 3]

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9.4. OUTPUT POWER AND POWER SPECTRAL DENSITY

LIMITS

FCC §15.247 (b) (3)

RSS-247 5.4 (d)

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt, 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 by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

FCC §15.247 (e)

RSS-247 (5.2) (b)

The power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

TEST PROCEDURE

Measurements perform using a wideband RF power meter.

The power output was measured on the EUT antenna port using SMA cable with 10dB attenuator connected to a power meter via wideband power sensor. Average output power was read directly from the power meter.

Only MID channel plot is reported to show setting parameter compliance with testing method/procedure.

Note: RBW setting greater than 3kHz is used on PSD measurement

DIRECTIONAL ANTENNA GAIN

For 1 TX:
There is only one transmitter output therefore the directional gain is equal to the antenna gain.

For 2 TX:
Tx chains are uncorrelated for Power and correlated for PSD due to the device supporting CDD in all MIMO modes. The directional gains are as follows:

Band (GHz)	Gain ANT 4 (dBi)	Gain ANT 3 (dBi)	Uncorrelated Directional Gain (dBi)	Correlated Directional Gain (dBi)
2.4	0.50	-1.60	-0.42	2.52

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DIRECTIONAL GAIN CALCULATION:

ANSI C63.10-2013 section 14.4.3

Uncorrelated Directional Gain $= 10 * \mathrm{LOG}\left[\frac{10^{\frac{\mathrm{ANT4}}{10}} + 10^{\frac{\mathrm{ANT3}}{10}}}{2}\right]$

Correlated Directional Gain $= 10 * \mathrm{LOG}\left[\frac{\left(10^{\frac{\mathrm{ANT4}}{20}} + 10^{\frac{\mathrm{ANT3}}{20}}\right)^2}{2}\right]$

Sample Calculation:

ANT 4 = 0.50 dB
ANT 3 = -1.60 dB

Uncorrelated Directional Gain $= 10 * \mathrm{LOG}\left[\frac{10^{\frac{0.50}{10}} + 10^{\frac{-1.60}{10}}}{2}\right] = -0.42\ \mathrm{dBi}$

Correlated Directional Gain $= 10 * \mathrm{LOG}\left[\frac{\left(10^{\frac{0.50}{20}} + 10^{\frac{-1.60}{20}}\right)^2}{2}\right] = 2.52\ \mathrm{dBi}$

RESULTS

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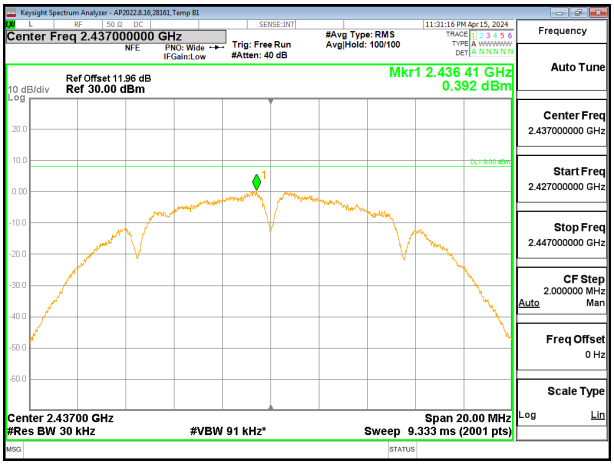
9.4.1. 802.11b SISO MODE

DCCF (MCS0) (dB)	0.00
ANT 4 (dBi)	0.50
ANT 3 (dBi)	-1.60

Mode (SISO)	Freq (MHz)	Ch. #	Power Limit (dBm)		Output Power (Gated) (dBm)		Total Corrected Power (dBm)		PSD Limit (dBm/3kHz)		PSD (dBm/kHz)		Total Corrected PSD (dBm/kHz)	
			ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3
b	2412	1	30.00	30.00	20.29	20.25	20.29	20.25	8.000	8.000	-0.832	-0.870	-0.832	-0.870
	2437	6			21.21	21.22	21.21	21.22			0.392	0.272	0.392	0.272
	2462	11			21.29	21.35	21.29	21.35			0.301	0.274	0.301	0.274
	2467	12			20.35	20.33	20.35	20.33			-0.715	-0.764	-0.715	-0.764
	2472	13			17.83	17.85	17.83	17.85			-3.341	-3.299	-3.341	-3.299



Channel 6 [ANT 4]

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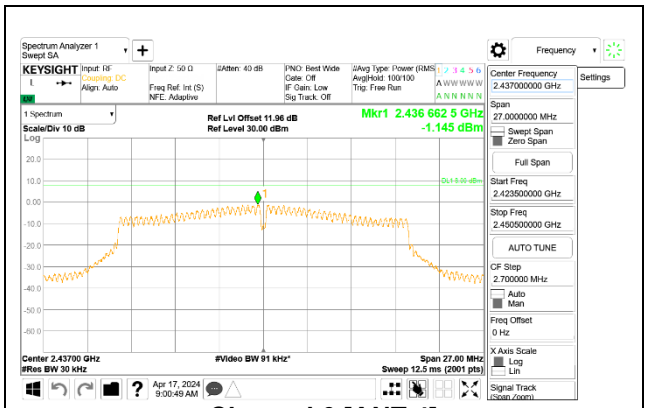
9.4.2. 802.11n HT20 SISO MODE

DCCF (MCS0) (dB)	0.09
ANT 4 (dBi)	0.50
ANT 3 (dBi)	-1.60

Mode (SISO)	Freq (MHz)	Ch. #	Power Limit (dBm)		Output Power (Gated) (dBm)		Total Corrected Power (dBm)		PSD Limit (dBm/3kHz)		PSD (dBm/kHz)		Total Corrected PSD (dBm/kHz)	
			ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3
HT20	2412	1	30.00	30.00	17.76	17.78	17.76	17.78	8.000	8.000	-5.063	-5.360	-4.973	-5.270
	2417	2			19.18	19.08	19.18	19.08			-4.562	-4.664	-4.472	-4.574
	2422	3			21.21	21.25	21.21	21.25			-1.274	-1.026	-1.184	-0.936
	2437	6			21.26	21.22	21.26	21.22			-1.145	-1.203	-1.055	-1.113
	2452	9			20.85	20.83	20.85	20.83			-1.699	-1.896	-1.609	-1.806
	2457	10			19.25	19.18	19.25	19.18			-3.263	-3.350	-3.173	-3.260
	2462	11			18.18	18.28	18.18	18.28			-4.822	-4.572	-4.732	-4.482
	2467	12			15.73	15.83	15.73	15.83			-6.320	-6.210	-6.230	-6.120
	2472	13			12.69	12.68	12.69	12.68			-10.655	-10.535	-10.565	-10.445



Channel 6 [ANT 4]

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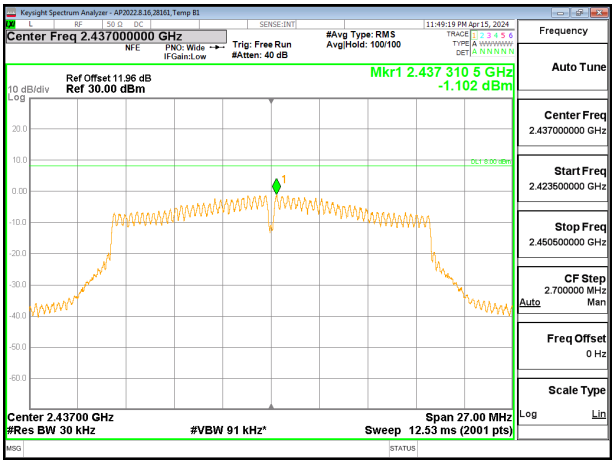
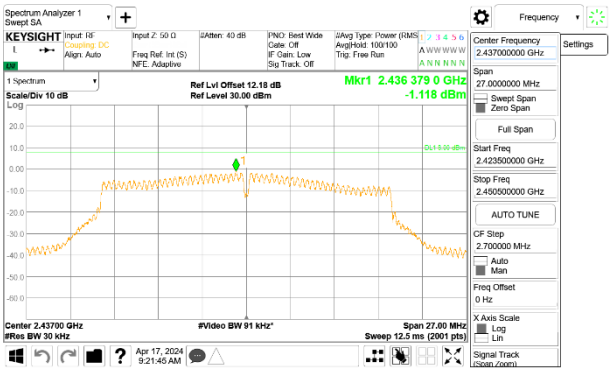
9.4.3. 802.11n HT20 MIMO MODE

DCCF (MCS0) (dB)	0.09
Uncorrelated Gain	-0.42
Correlated Gain	2.52

Mode (SISO)	Freq (MHz)	Ch. #	Power Limit (dBm)	Output Power (Gated) (dBm)		Total MIMO Corrected Power (dBm)	PSD Limit (dBm/3kHz)	PSD (dBm/kHz)		Total Corrected PSD (dBm/kHz)
				ANT 4	ANT 3			ANT 4	ANT 3	
HT20	2412	1	30.00	17.25	17.10	20.19	8.000	-6.060	-6.149	-3.004
	2417	2		18.25	18.17	21.22		-4.101	-3.889	-0.893
	2422	3		19.76	19.81	22.80		-2.521	-2.519	0.580
	2437	6		21.35	21.30	24.34		-1.102	-1.118	1.990
	2447	8		21.25	21.35	24.31		-1.324	-1.320	1.778
	2452	9		19.35	19.18	22.28		-3.129	-3.258	-0.093
	2457	10		18.33	18.25	21.30		-4.107	-4.123	-1.015
	2462	11		17.32	17.34	20.34		-5.391	-5.223	-2.206
	2467	12		14.90	14.85	17.89		-7.454	-7.310	-4.281
	2472	13		11.85	11.73	14.80		-11.518	-11.536	-8.427



Channel 6 [ANT 4]



Channel 6 [ANT 3]

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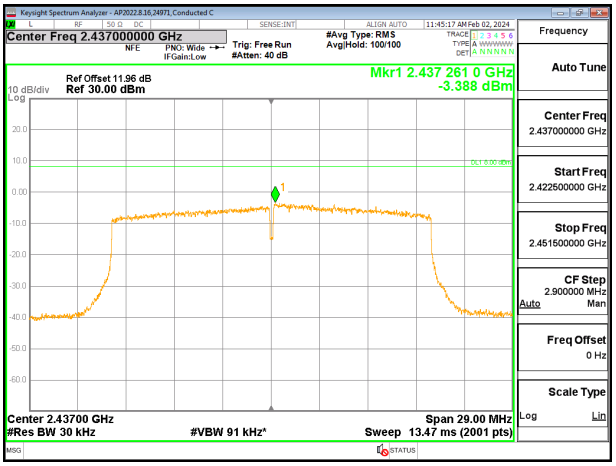
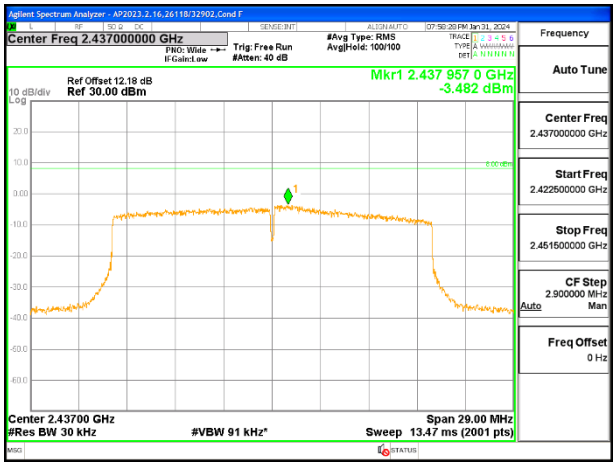
9.4.4. 802.11be EHT20 SISO MODE

	SU	26 Tone
DCCF (MCS0) (dB)	0.00	0.00
ANT 4 (dBi)	0.50	
ANT 3 (dBi)	-1.60	

Mode (SISO)	Freq (MHz)	Ch. #	Tone	RU Index	Power Limit (dBm)		Output Power (Gated) (dBm)		Total Corrected Power (dBm)		PSD Limit (dBm/3kHz)		PSD (dBm/kHz)		Total Corrected PSD (dBm/kHz)	
					ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3	ANT 4	ANT 3
EHT20	2412	1	SU	--	30.00	30.00	16.83	16.84	16.83	16.84	8.000	8.000	-7.726	-7.852	-7.726	-7.852
			26	0			11.72	11.71	11.72	11.71			-5.094	-5.176	-5.094	-5.176
				4			11.83	11.79	11.83	11.79			-4.970	-4.849	-4.970	-4.849
				8			11.86	11.69	11.86	11.69			-4.930	-5.303	-4.930	-5.303
	2417	2	SU	--			17.72	17.74	17.72	17.74			-6.846	-6.879	-6.846	-6.879
	2422	3	SU	--			21.27	21.15	21.27	21.15			-3.347	-3.633	-3.347	-3.633
	2437	6	SU	--			21.33	21.27	21.33	21.27			-3.388	-3.482	-3.388	-3.482
			26	0			11.76	11.78	11.76	11.78			-5.197	-5.290	-5.197	-5.290
				4			11.78	11.69	11.78	11.69			-5.052	-5.230	-5.052	-5.230
				8			11.72	11.81	11.72	11.81			-5.198	-4.865	-5.198	-4.865
	2452	9	SU	--			21.35	21.29	21.35	21.29			-3.198	-3.266	-3.198	-3.266
	2457	10	SU	--			17.85	17.77	17.85	17.77			-6.648	-6.546	-6.648	-6.546
	2462	11	SU	--			16.86	16.74	16.86	16.74			-7.990	-7.759	-7.990	-7.759
			26	0			11.86	11.68	11.86	11.68			-5.156	-5.091	-5.156	-5.091
				4			11.83	11.80	11.83	11.80			-5.028	-5.067	-5.028	-5.067
				8			11.77	11.70	11.77	11.70			-5.153	-4.955	-5.153	-4.955
	2467	12	SU	--			14.84	14.71	14.84	14.71			-9.445	-9.485	-9.445	-9.485
			26	0			11.79	11.82	11.79	11.82			-4.729	-4.856	-4.729	-4.856
				4			11.83	11.71	11.83	11.71			-5.199	-5.008	-5.199	-5.008
				8			11.81	11.85	11.81	11.85			-4.807	-4.945	-4.807	-4.945
	2472	13	SU	--			8.71	8.84	8.71	8.84			-15.543	-15.437	-15.543	-15.437
			26	0			-0.13	-0.09	-0.13	-0.09			-16.402	-17.090	-16.402	-17.090
				4			-0.15	-0.14	-0.15	-0.14			-16.608	-16.733	-16.608	-16.733
				8			-0.17	-0.23	-0.17	-0.23			-16.839	-16.881	-16.839	-16.881



Channel 6 – SU [ANT 4]



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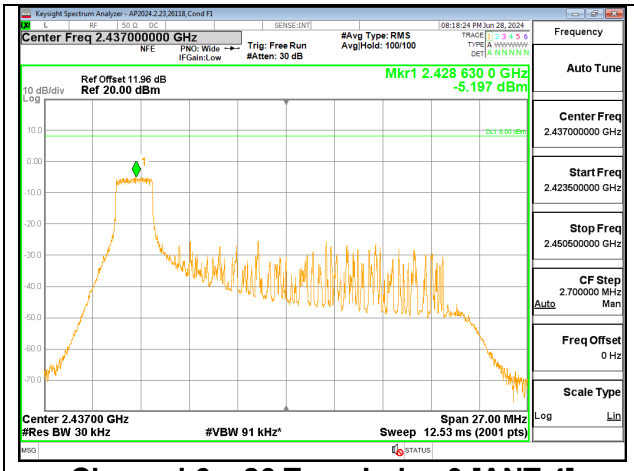
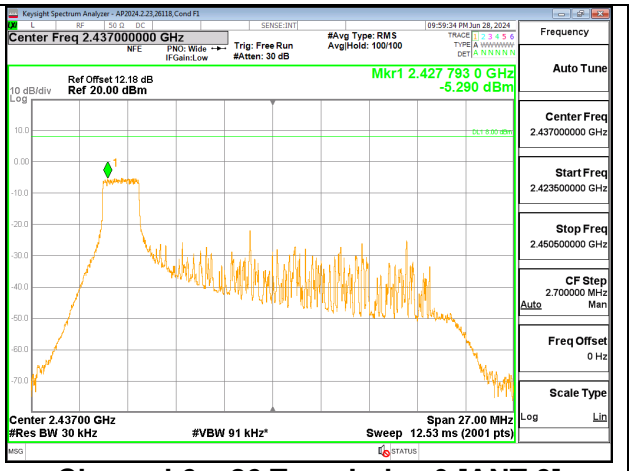


Channel 6 – 26 Tone Index 0 [ANT 4]



Channel 6 – 26 Tone Index 0 [ANT 3]

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9.4.5. 802.11be EHT20 MIMO MODE

	SU	26 Tone
DCCF (MCS0) (dB)	0.00	0.00
Uncorrelated Gain	-0.42	
Correlated Gain	2.52	

Mode (MIMO)	Freq (MHz)	Ch. #	Tone	RU Index	Power Limit (dBm)	Output Power (Gated) (dBm)		Total MIMO Corrected Power (dBm)	PSD Limit (dBm/3kHz)	PSD (dBm/kHz)		Total Corrected PSD (dBm/kHz)
						ANT 4	ANT 3			ANT 4	ANT 3	
EHT20	2412	1	SU	--	30.00	15.76	15.80	18.79	8.000	-8.774	-8.652	-5.702
			26	0		11.81	11.75	14.79		-4.782	-5.193	-1.972
				4		11.69	11.70	14.71		-5.060	-5.112	-2.076
				8		11.79	11.89	14.85		-4.921	-5.041	-1.970
	2417	2	SU	--		16.72	16.76	19.75		-7.704	-7.479	-4.580
	2422	3	SU	--		18.81	18.79	21.81		-5.522	-5.618	-2.559
	2427	4	SU	--		21.20	21.30	24.26		-3.069	-3.120	-0.084
	2437	6	SU	--		21.35	21.25	24.31		-3.216	-3.398	-0.296
			26	0		11.71	11.70	14.72		-4.981	-5.075	-2.017
				4		11.75	11.76	14.77		-4.995	-5.331	-2.149
				8		11.87	11.72	14.81		-4.827	-4.832	-1.819
	2447	8	SU	--		21.35	21.17	24.27		-3.383	-3.483	-0.422
	2452	9	SU	--		18.32	18.29	21.32		-6.373	-6.574	-3.462
	2457	10	SU	--		16.70	16.77	19.75		-7.554	-7.459	-4.496
	2462	11	SU	--		15.84	15.64	18.75		-8.689	-8.847	-5.757
			26	0		11.74	11.76	14.76		-5.162	-5.025	-2.083
				4		11.76	11.70	14.74		-4.992	-5.024	-1.998
				8		11.80	11.83	14.83		-4.855	-4.929	-1.882
	2467	12	SU	--		13.85	13.84	16.86		-9.967	-9.781	-6.863
			26	0		11.77	11.72	14.76		-5.077	-5.168	-2.112
				4		11.83	11.76	14.81		-5.183	-5.176	-2.169
				8		11.86	11.78	14.83		-4.779	-4.974	-1.865
	2472	13	SU	--		8.21	8.22	11.23		-16.434	-16.260	-13.336
			26	0		-0.07	-0.17	2.89		-16.848	-16.808	-13.818
				4		-0.14	-0.07	2.91		-16.858	-16.380	-13.602
				8		-0.15	-0.13	2.87		-17.019	-17.109	-14.053

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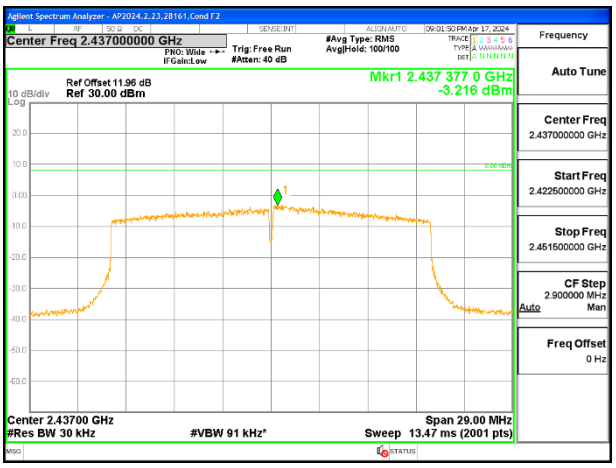
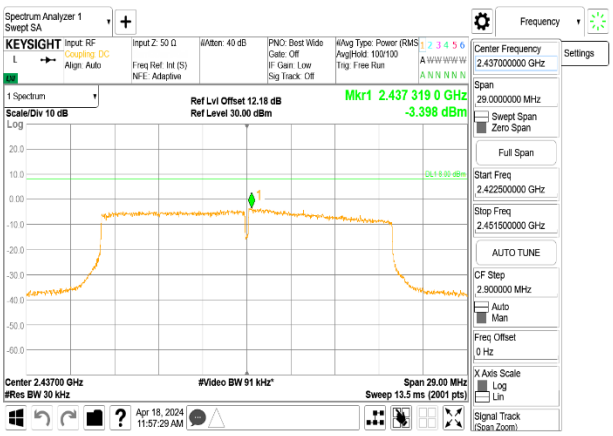
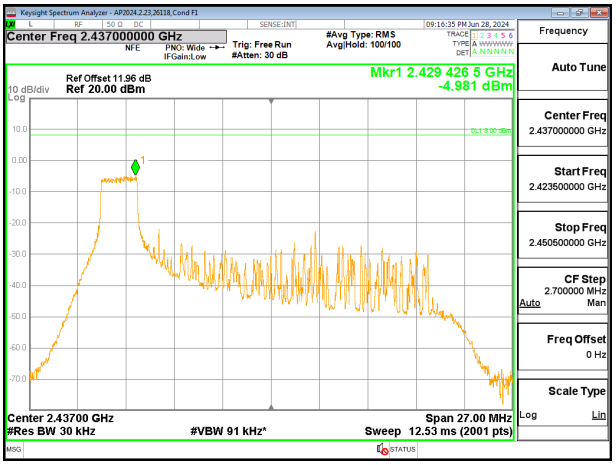


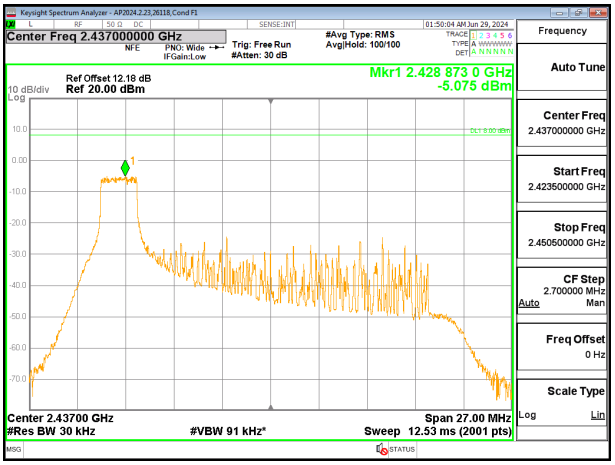
Channel 6 – SU [ANT 4]



Channel 6 – SU [ANT 3]



Channel 6 – 26 Tone Index 0 [ANT 4]



Channel 6 – 26 Tone Index 0 [ANT 3]

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9.5. CONDUCTED SPURIOUS EMISSIONS

LIMITS

FCC §15.247 (d)

RSS-247 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RESULTS

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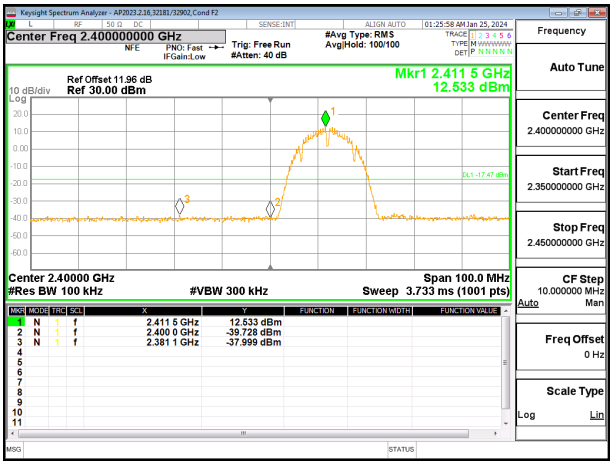
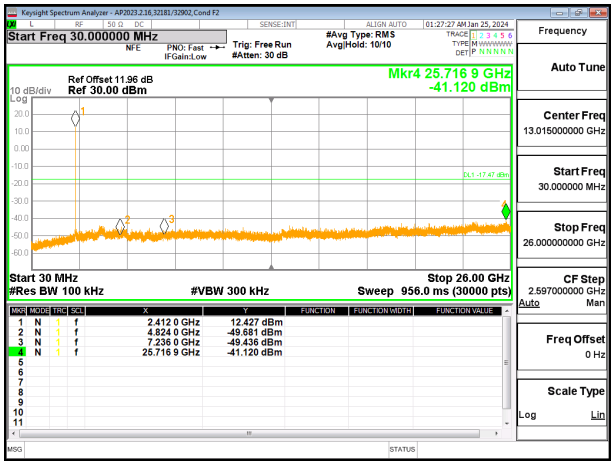
9.5.1. 802.11b SISO MODE

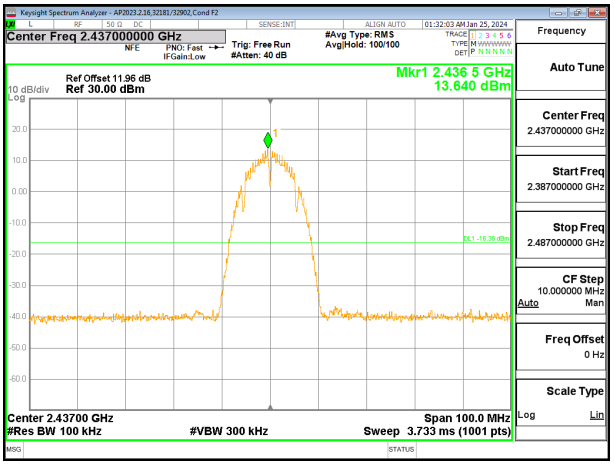
ANT 4



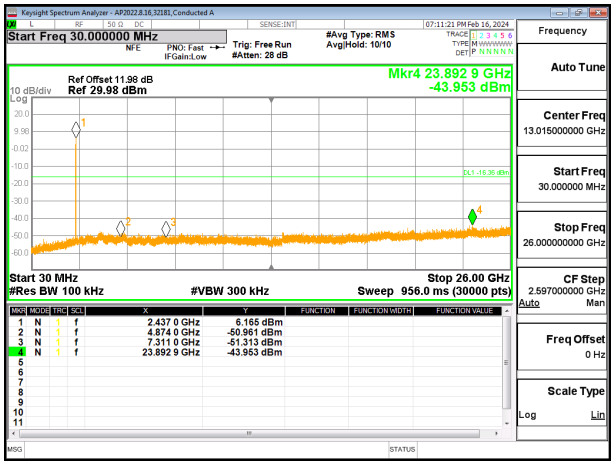
LOW CHANNEL 1, BAND-EDGE



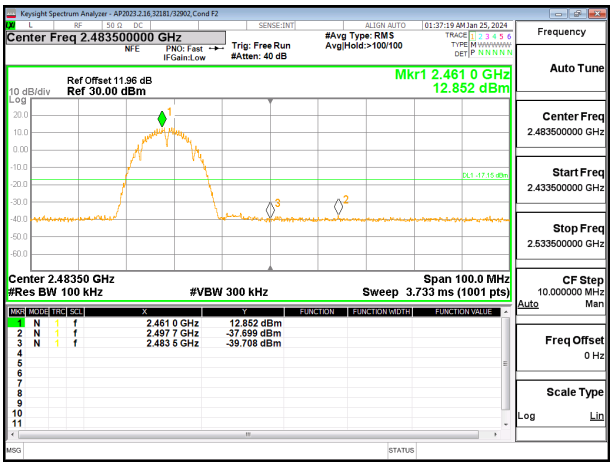
LOW CHANNEL 1, OUT-OF-BAND



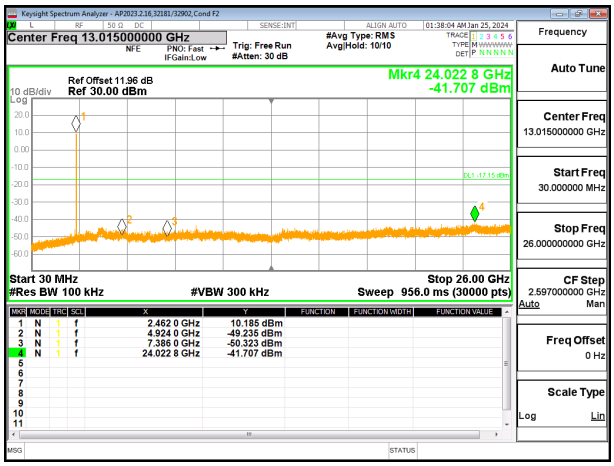
IN-BAND REFERNCE LEVEL



MID CHANNEL 6, OUT-OF-BAND



HIGH CHANNEL 11, BAND-EDGE



HIGH CHANNEL 11, OUT-OF-BAND

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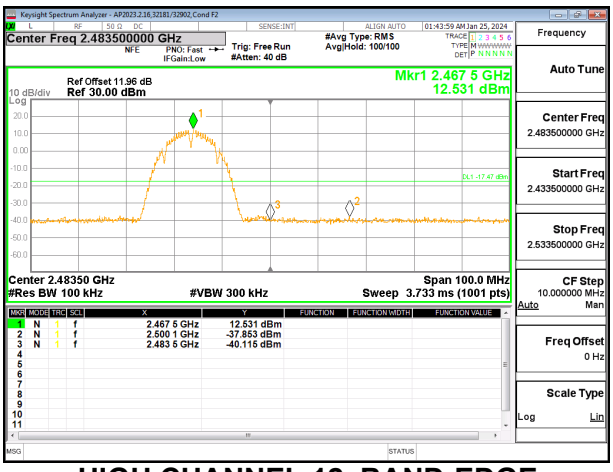
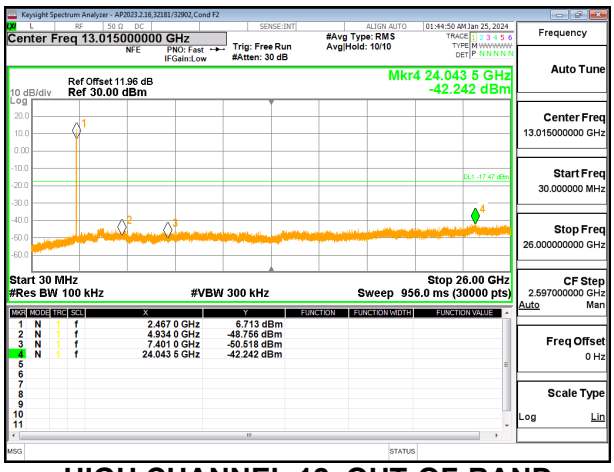
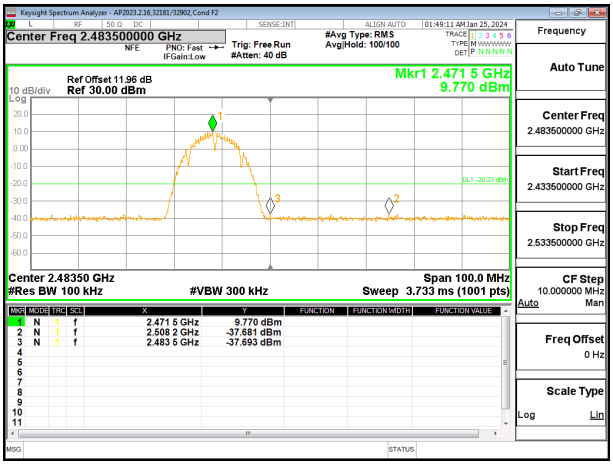


HIGH CHANNEL 12, BAND-EDGE



HIGH CHANNEL 12, OUT-OF-BAND



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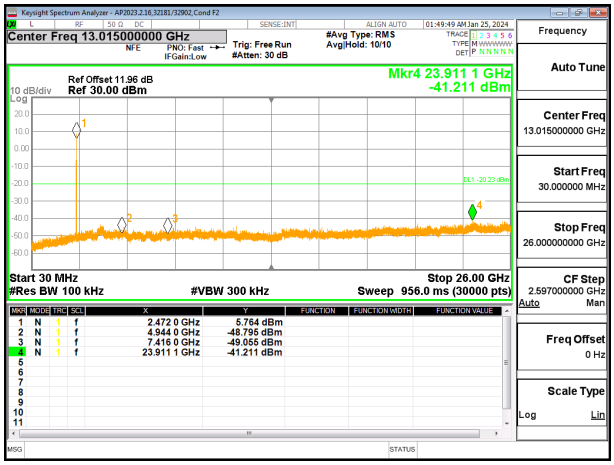

HIGH CHANNEL 13, OUT-OF-BAND

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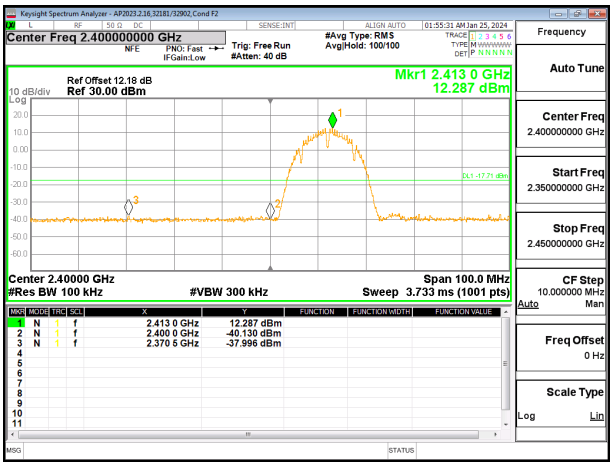
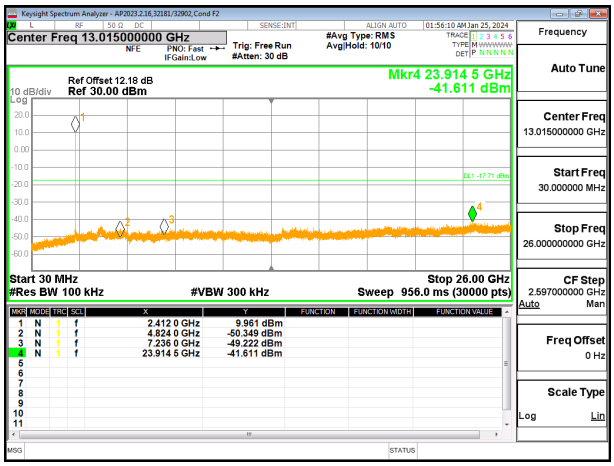
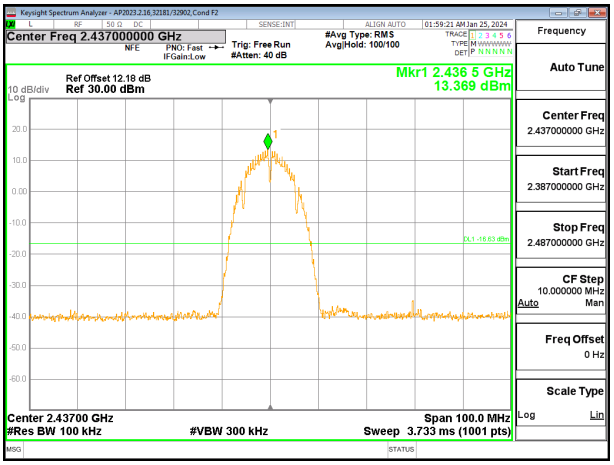
ANT 3



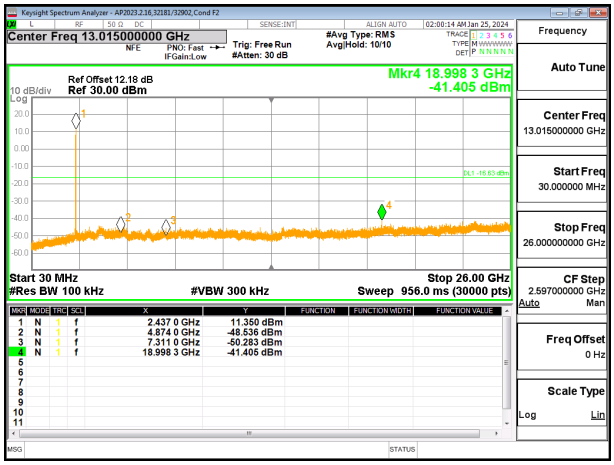
LOW CHANNEL 1, BAND-EDGE



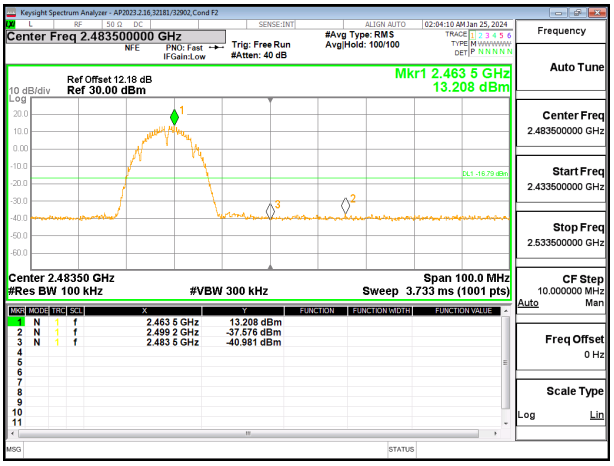
LOW CHANNEL 1, OUT-OF-BAND



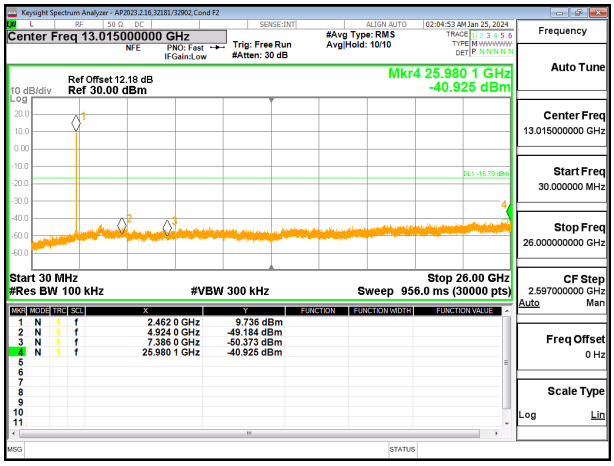
IN-BAND REFERNCE LEVEL



MID CHANNEL 6, OUT-OF-BAND



HIGH CHANNEL 11, BAND-EDGE



HIGH CHANNEL 11, OUT-OF-BAND

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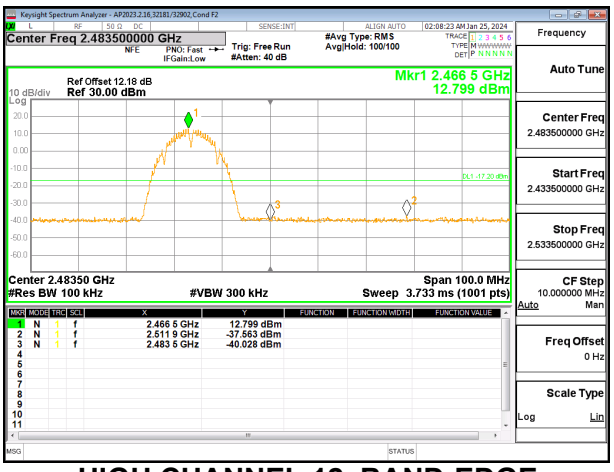
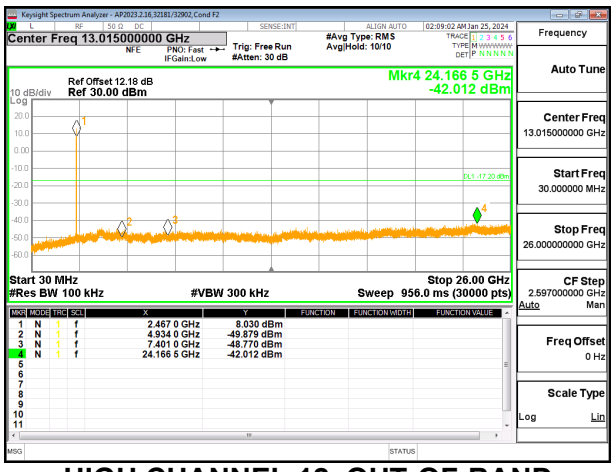
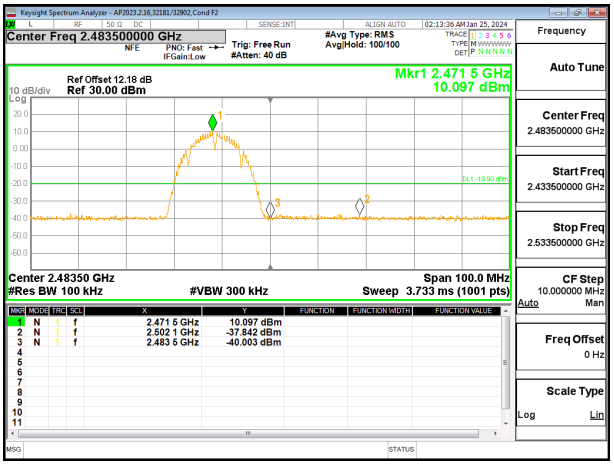


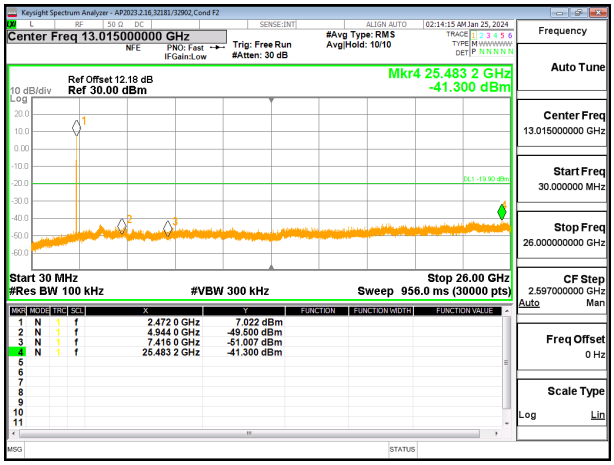
HIGH CHANNEL 12, BAND-EDGE



HIGH CHANNEL 12, OUT-OF-BAND



HIGH CHANNEL 13, BAND-EDGE



HIGH CHANNEL 13, OUT-OF-BAND

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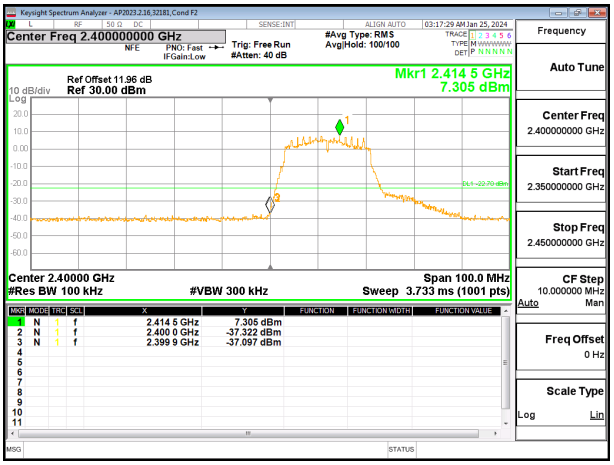
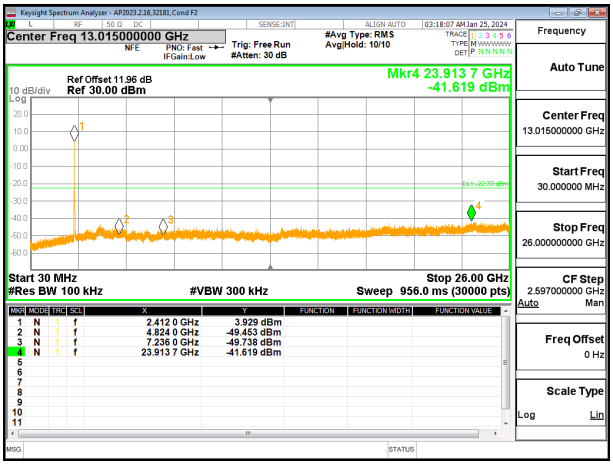
9.5.2. 802.11n HT20 SISO MODE

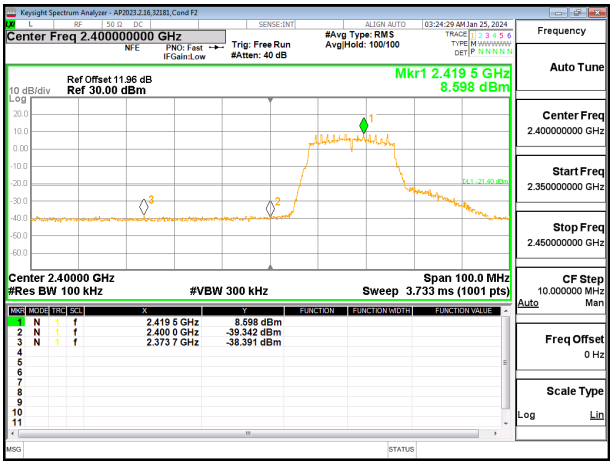
ANT 4



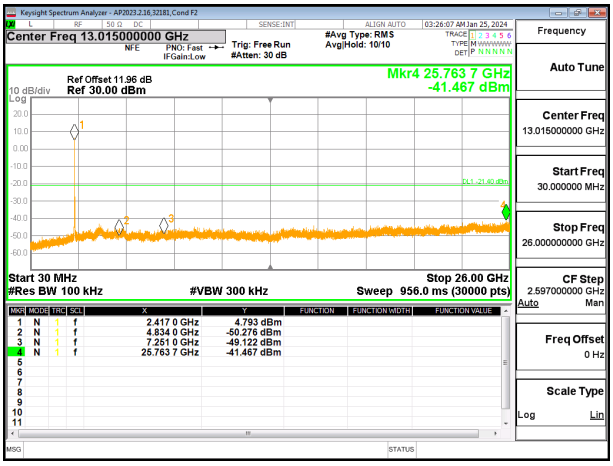
LOW CHANNEL 1, BAND-EDGE



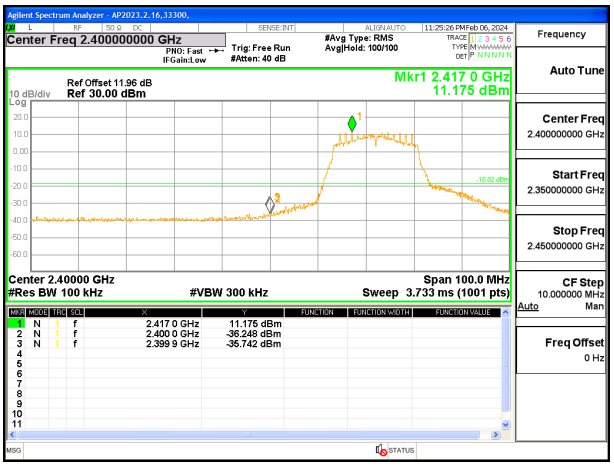
LOW CHANNEL 1, OUT-OF-BAND



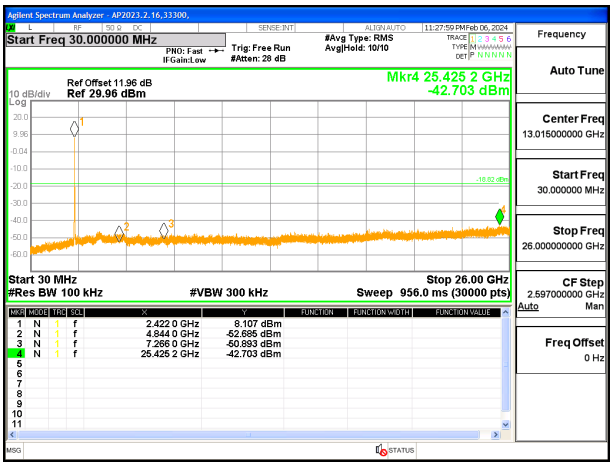
LOW CHANNEL 2, BAND-EDGE



LOW CHANNEL 2, OUT-OF-BAND



LOW CHANNEL 3, BAND-EDGE



LOW CHANNEL 3, OUT-OF-BAND

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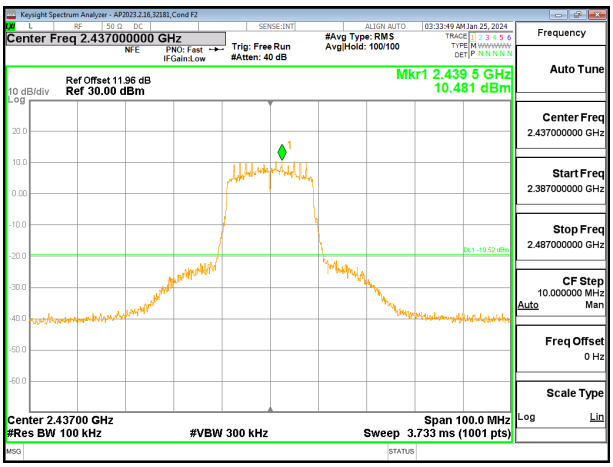
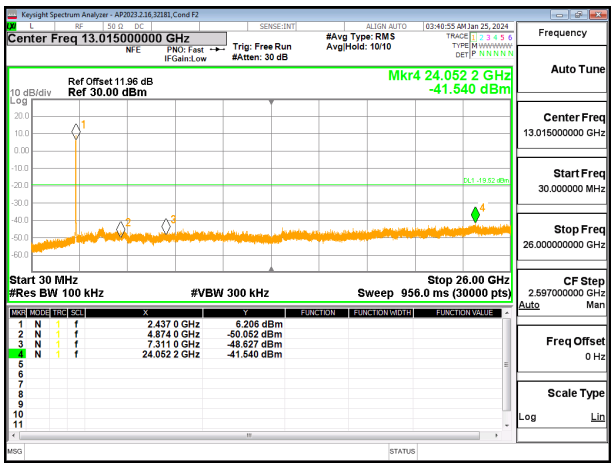
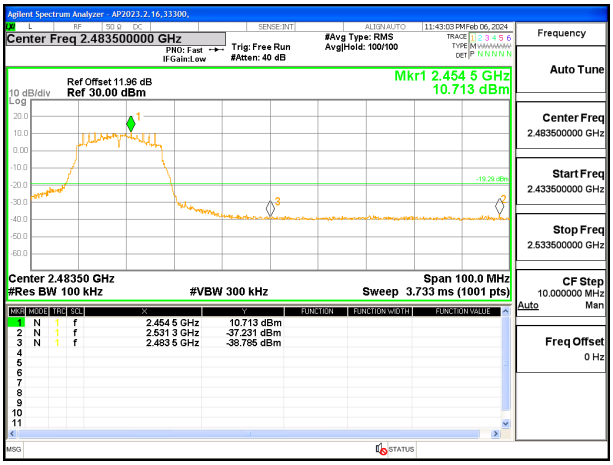


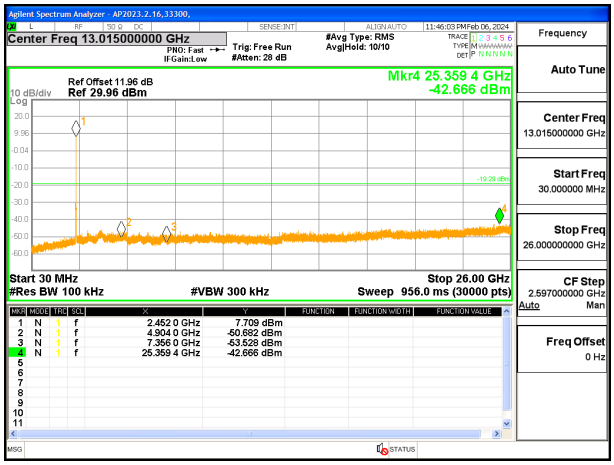
IN-BAND REFERNCE LEVEL



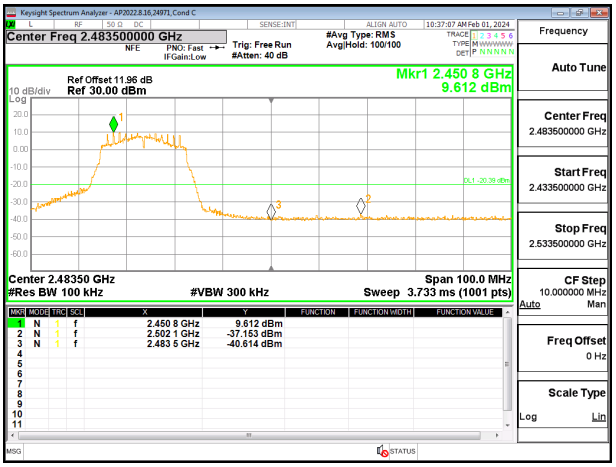
MID CHANNEL 6, OUT-OF-BAND



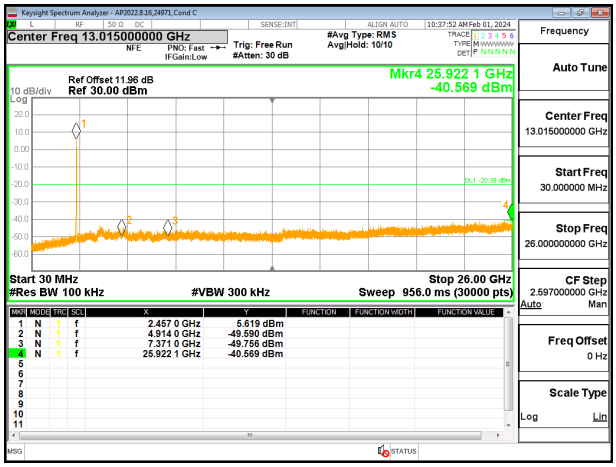
HIGH CHANNEL 9, BAND-EDGE



HIGH CHANNEL 9, OUT-OF-BAND



HIGH CHANNEL 10, BAND-EDGE



HIGH CHANNEL 10, OUT-OF-BAND

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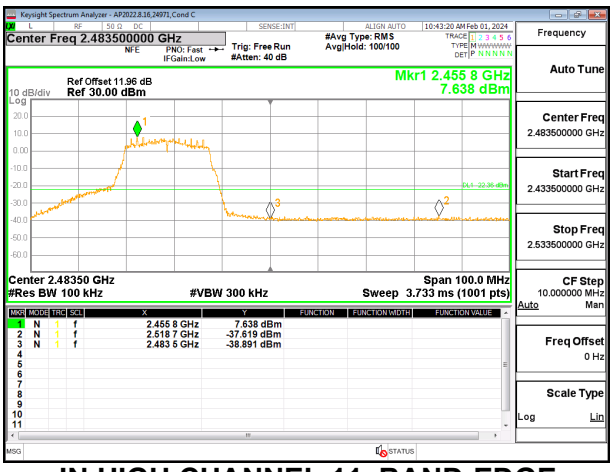
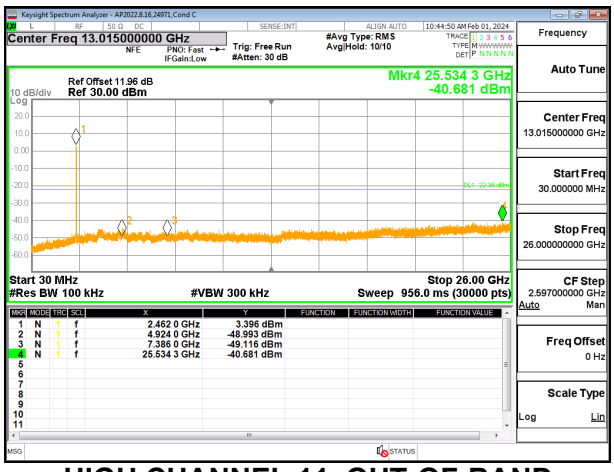
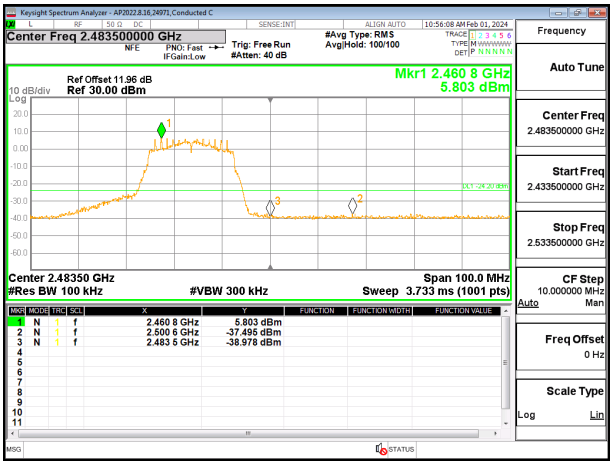


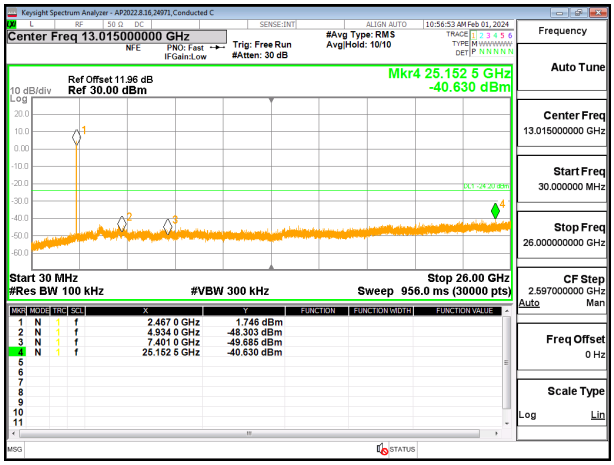
IN HIGH CHANNEL 11, BAND-EDGE



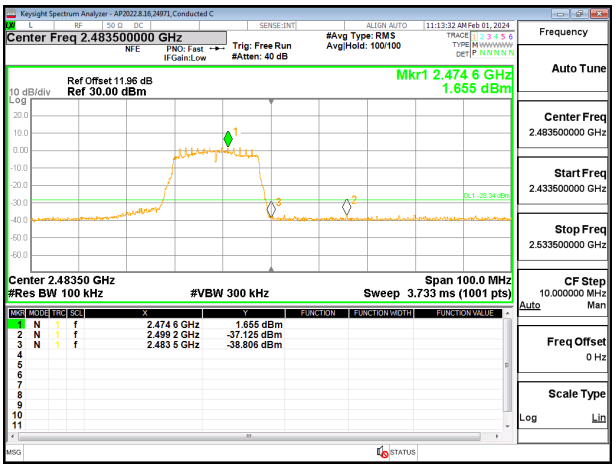
HIGH CHANNEL 11, OUT-OF-BAND



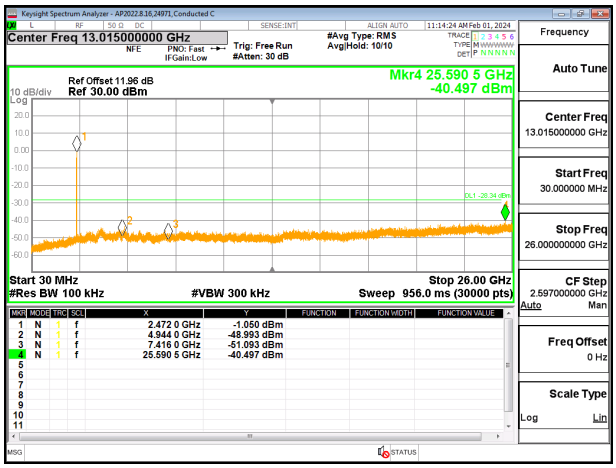
HIGH CHANNEL 12, BAND-EDGE



HIGH CHANNEL 12, OUT-OF-BAND



HIGH CHANNEL 13, BAND-EDGE



HIGH CHANNEL 13, OUT-OF-BAND

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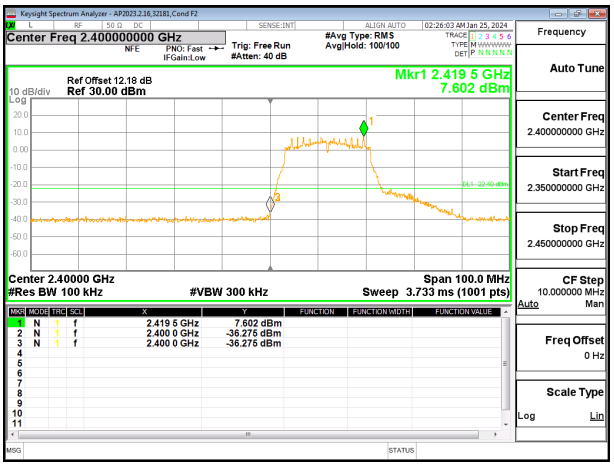
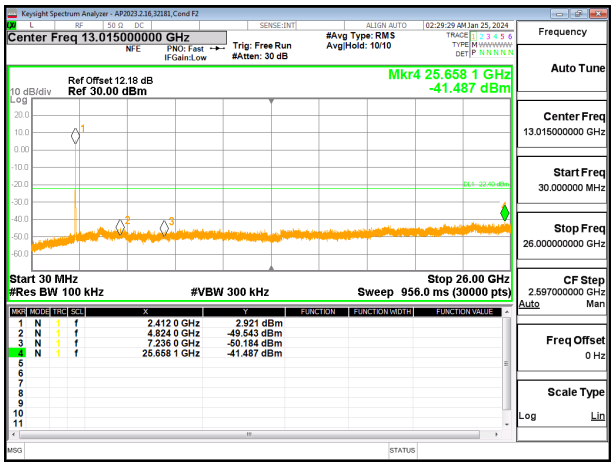
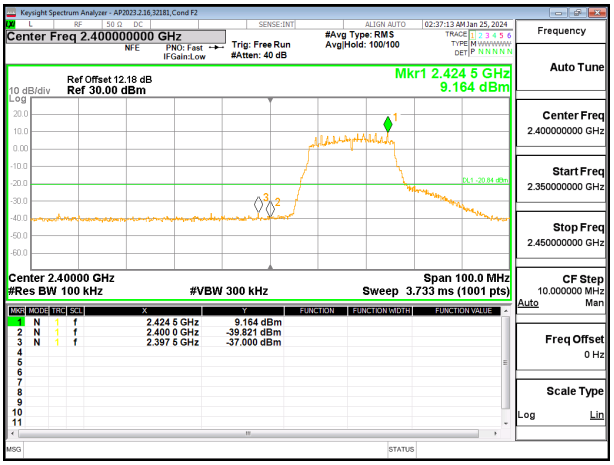
ANT 3



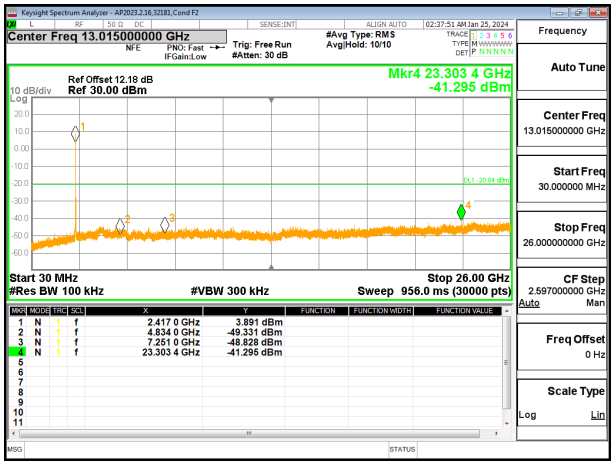
LOW CHANNEL 1, BAND-EDGE



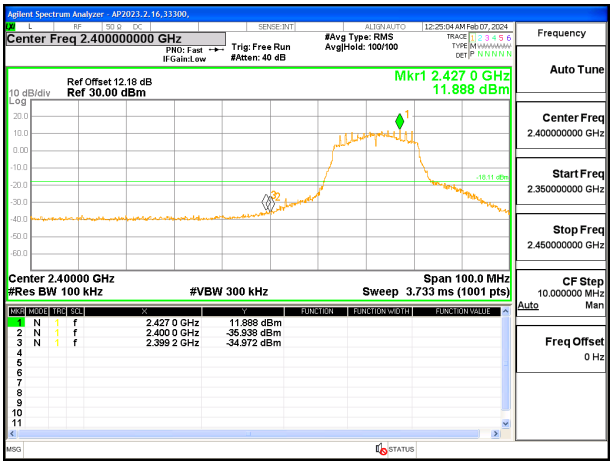
LOW CHANNEL 1, OUT-OF-BAND



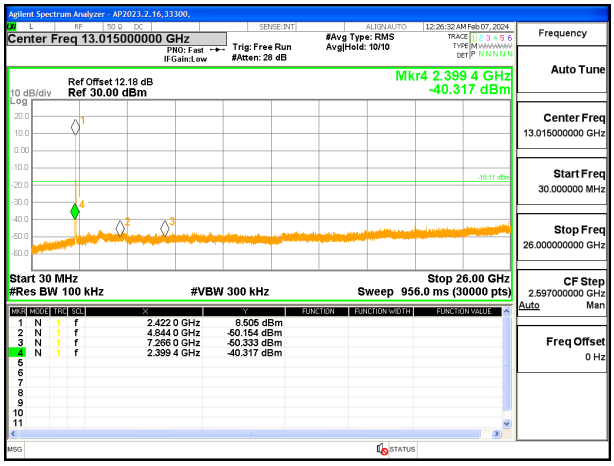
LOW CHANNEL 2, BAND-EDGE



LOW CHANNEL 2, OUT-OF-BAND



LOW CHANNEL 3, BAND-EDGE



LOW CHANNEL 3, OUT-OF-BAND

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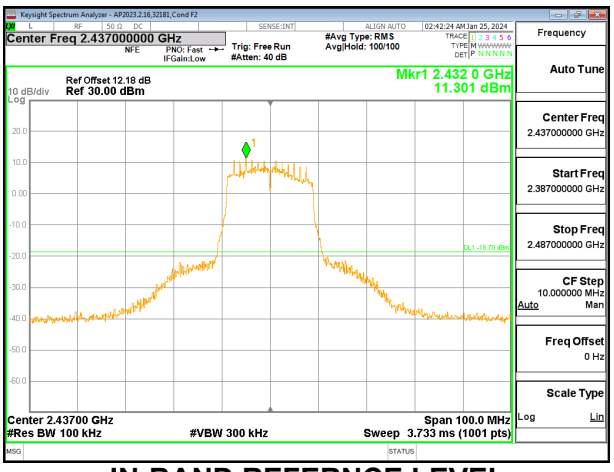
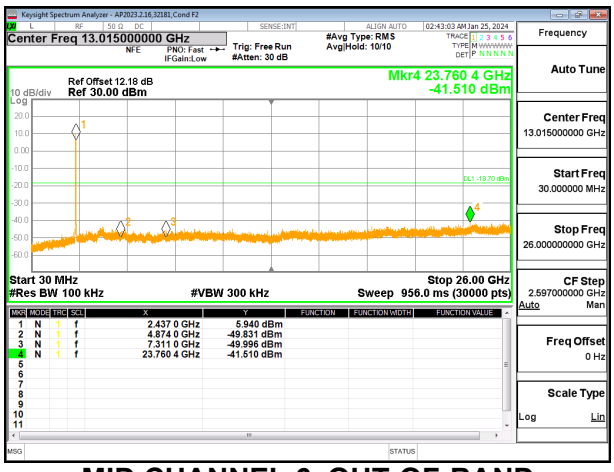
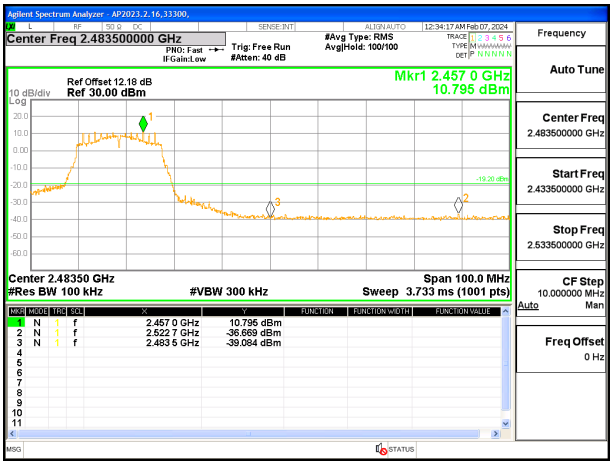


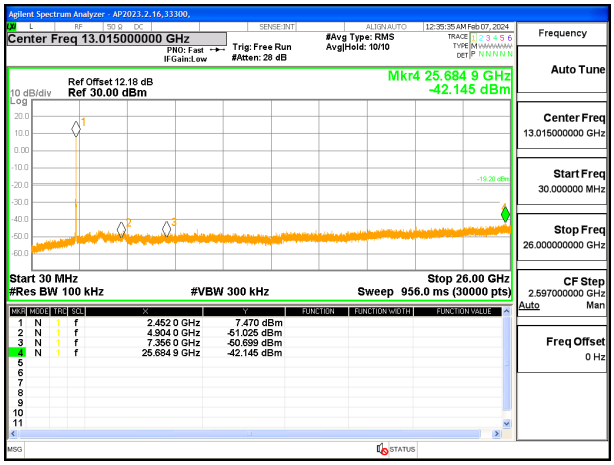
IN-BAND REFERNCE LEVEL



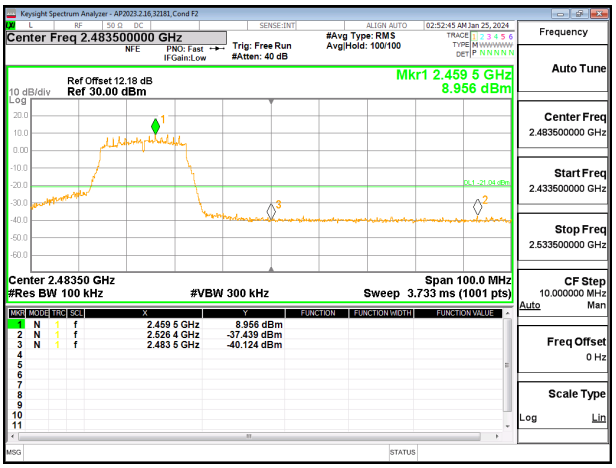
MID CHANNEL 6, OUT-OF-BAND



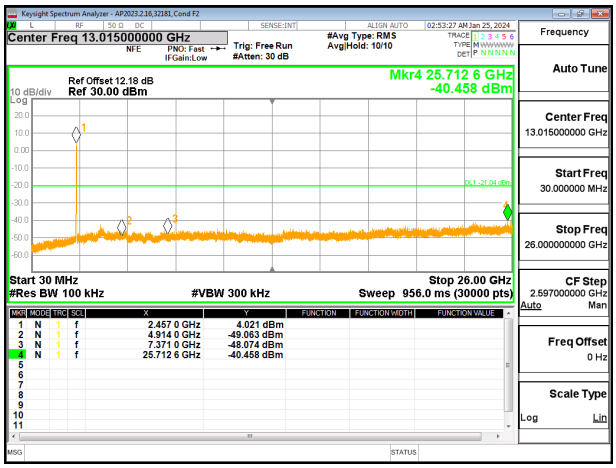
HIGH CHANNEL 9, BAND-EDGE



HIGH CHANNEL 9, OUT-OF-BAND



HIGH CHANNEL 10, BAND-EDGE



HIGH CHANNEL 10, OUT-OF-BAND

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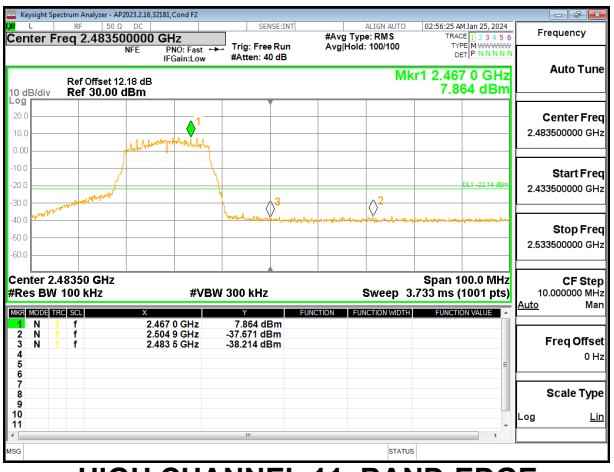
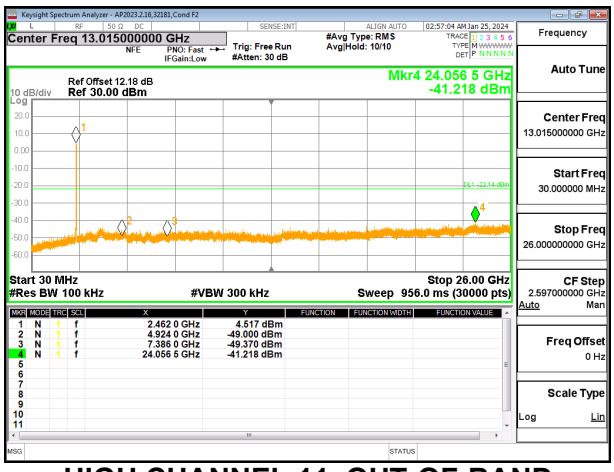
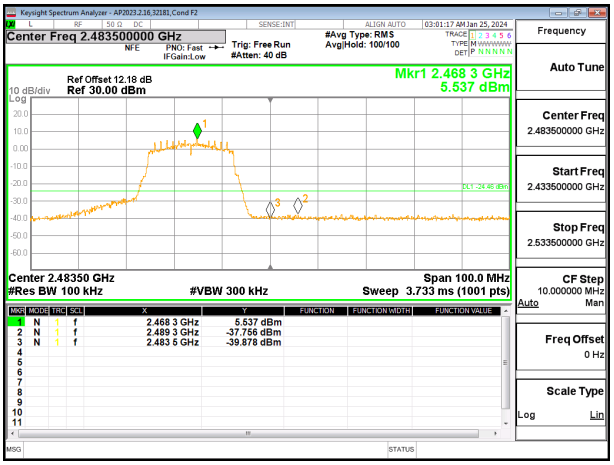


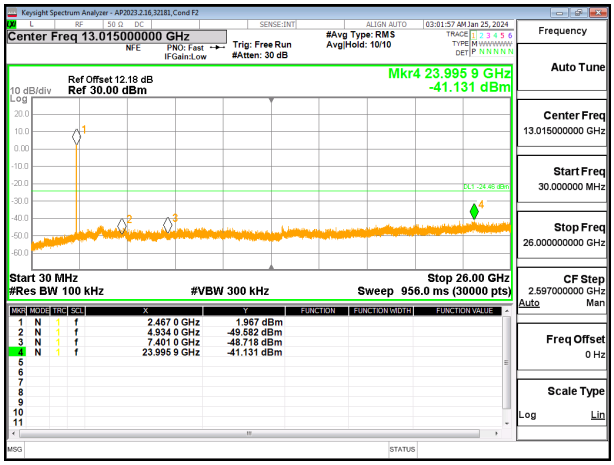
HIGH CHANNEL 11, BAND-EDGE



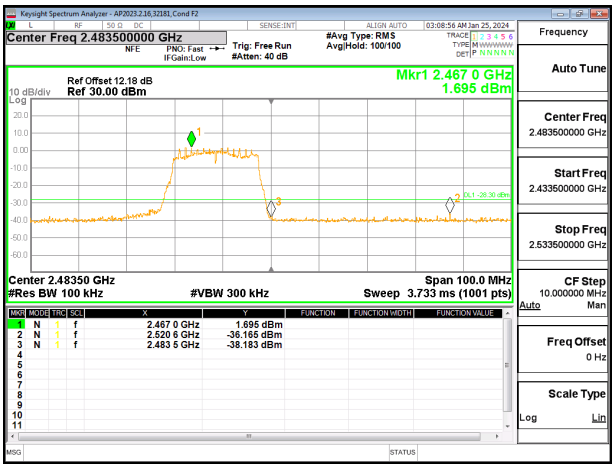
HIGH CHANNEL 11, OUT-OF-BAND



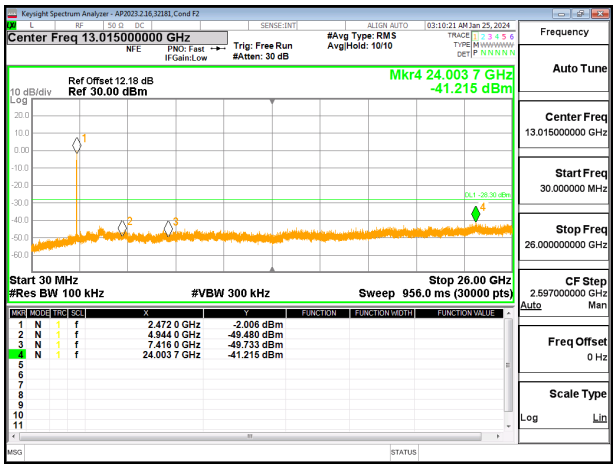
HIGH CHANNEL 12, BAND-EDGE



HIGH CHANNEL 12, OUT-OF-BAND



HIGH CHANNEL 13, BAND-EDGE



HIGH CHANNEL 13, OUT-OF-BAND

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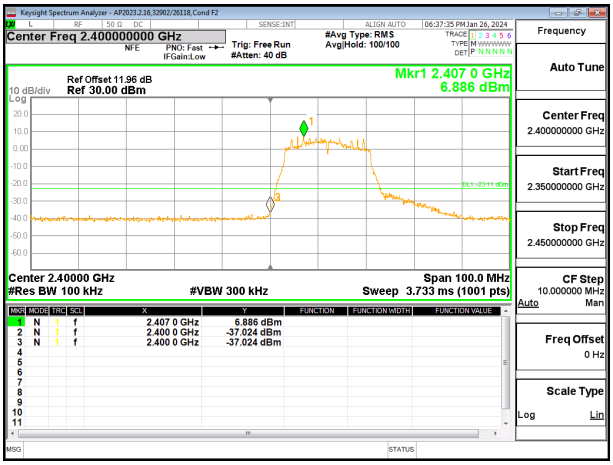
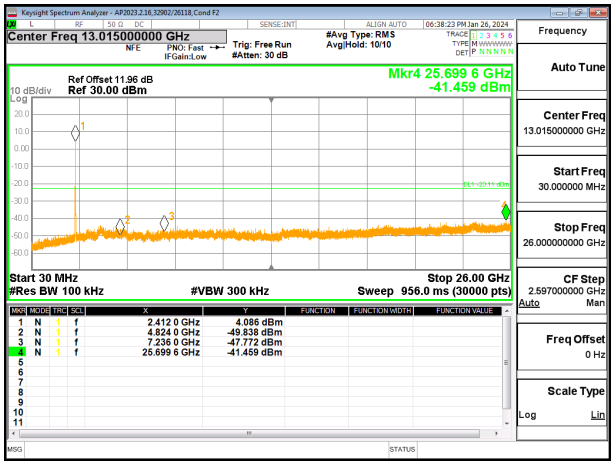
9.5.3. 802.11n HT20 MIMO MODE

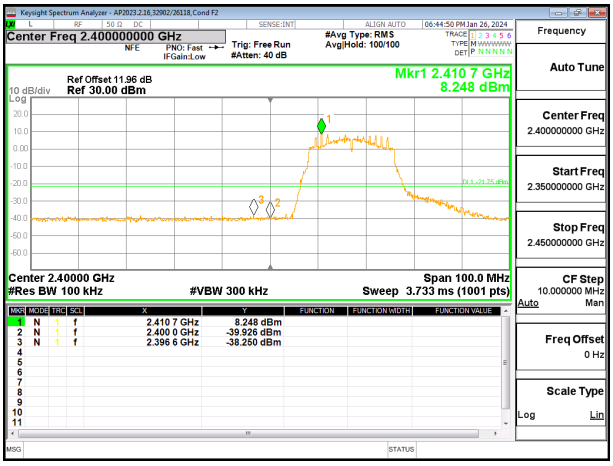
ANT 4 + ANT 3



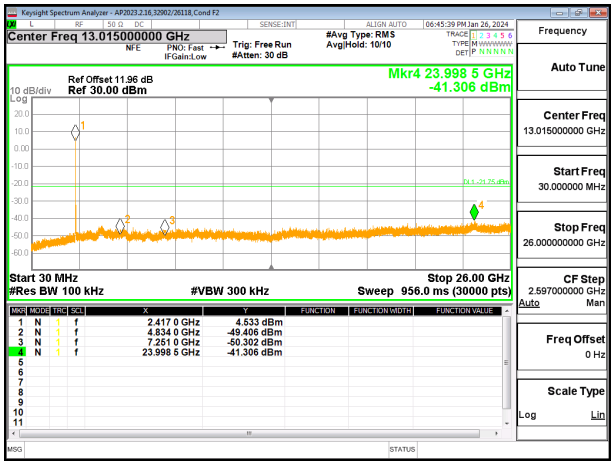
LOW CHANNEL 1, BAND-EDGE [ANT 4]



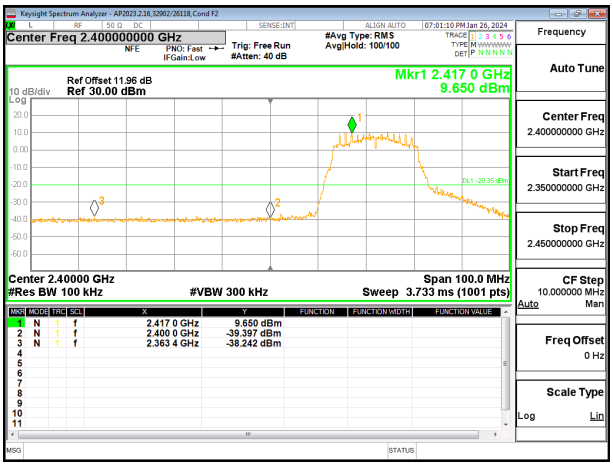
LOW CHANNEL 1, OUT-OF-BAND [ANT 4]



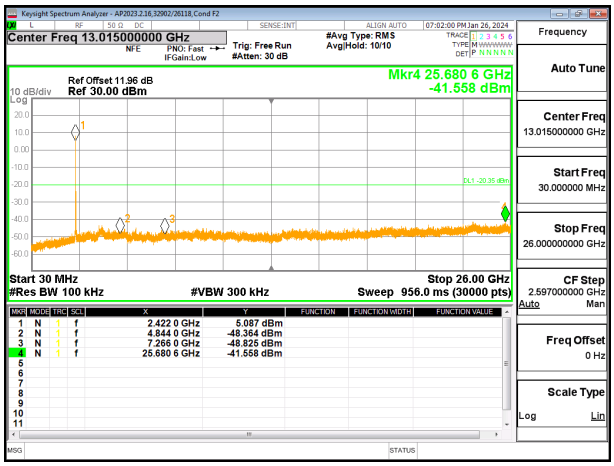
LOW CHANNEL 2, BAND-EDGE [ANT 4]



LOW CHANNEL 2, OUT-OF-BAND [ANT 4]



LOW CHANNEL 3, BAND-EDGE [ANT 4]



LOW CHANNEL 3, OUT-OF-BAND [ANT 4]

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