TEST REPORT

Report Number. : 14516849-E4V4

Applicant	:	SONOS INC. 614 CHAPALA ST. SANTA BARBARA, CA, 93101, U.S.A.
Model	:	S44
FCC ID	:	SBVRM044
IC	:	5373A-RM044
EUT Description	:	802.11 a/b/g/n/ac/ax 2x2 Client Device with BT and BLE
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART C ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5 + A1 + A2

Date Of Issue:
2023-05-25

Prepared by:
UL Verification Services Inc.
47173 Benicia Street
Fremont, CA 94538 U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888

CERT #0751.05

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2023-04-18	Initial Issue	--
V2	2023-05-05	Updated Table of contents, Section 6.3, 6.7, 9.1 and 10.2	Kiya Kedida
V3	2023-05-17	Updated Section 6.7	Kiya Kedida
V4	2023-05-25	Section 6.7 updated the setup diagram and the description of test setup cable #3	Glenn Escano

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

TABLE OF CONTENTS

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: SONOS INC.
614 Chapala St.
Santa Barbara, CA, 93101, U.S.A.

EUT DESCRIPTION: 802.11 a/b/g/n/ac/ax 2x2 Client Device with BT and BLE

BRAND: SONOS

MODEL: S44

SERIAL NUMBER: Radiated Sample: A100 2301WC C4-38-75-00-0F-40-9
Conducted: A100 2301WC C4-38-75-00-0E-7C:0,

DATE TESTED: 2023-02-23 to 2023-03-20

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC 47 CFR Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5 + A1 + A2	Complies

UL Verification Services Inc. 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 Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document.

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

Approved & Released For
UL Verification Services Inc. By:

Dan Coronia
Operations Leader
Consumer Technology Division
UL Verification Services Inc.

Prepared By:

Gerardo Abrego
Senior Test Engineer
Consumer Technology Division
UL Verification Services Inc.

1st Reviewed By:

Vien Tran
Senior Laboratory Engineer
Consumer Technology Division
UL Verification Services Inc.

2nd Reviewed By:

Kiya Kedida
Senior Project Engineer
Consumer Technology Division
UL Verification Services Inc.

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

2. TEST RESULTS SUMMARY

This report contains data provided by the customer which can impact the validity of results. UL Verification Services Inc. is only responsible for the validity of results after the integration of the data provided by the customer.

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	Compliant	None.
15.247 (b) (3)	RSS-247 5.4 (d)	Output Power	Compliant	None.
See Comment		Average power	Reporting purposes only	Per ANSI C63.10, Section 11.9.2.3.2.
15.247 (e)	RSS-247 5.2 (b)	PSD	Compliant	None.
15.247 (d)	RSS-247 5.5	Conducted Spurious Emissions	Compliant	None.
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions	Compliant	None.
15.207	RSS-Gen 8.8	AC Mains Conducted Emissions	Compliant	None.

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC 47 CFR Part 2, FCC 47 CFR Part 15, ANSI C63.10-2013, and KDB 558074 D01 15.247 Meas Guidance v05r02, KDB 414788 D01 Radiated Test Site v01r01, RSS-GEN Issue 5 + A1 + A2, and RSS-247 Issue 2

The scope of this report covers the 802.11ax modes in the 2.4GHz band of Model S44.

4. FACILITIES AND ACCREDITATION

UL Verification Services Inc. is accredited by A2LA, Certificate Number 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, U.S.A	US0104	2324A	550739
☐	Building 2: 47266 Benicia Street Fremont, CA 94538, U.S.A	US0104	22541	550739
☒	Building 4: 47658 Kato Rd Fremont, CA 94538, U.S.A	US0104	2324B	550739

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}
Radio Frequnecy (Spectrum Analyzer)	141.16 Hz
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	1.22%
Power Spectral Density	2.47 dB
RF Power Measurement Direct Method Using Power Meter	1.3 dB (PK) / 0.45 dB (AV)
Unwanted Emissions, Conducted	1.94dB
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
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.29 dB
Time Domain Measurements	3.39%
Temperature	0.57
Humidity	3.39%
DC Supply Voltages	0.57%

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

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

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

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The EUT is an 802.11 a/b/g/n/ac/ax 2x2 Client Device with BT and BLE.

This report covers ax 2.4GHz Wifi radio.

6.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

2.4GHz BAND 802.11 ax MODE 2TX

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2TX CDD			
2412 - 2462	802.11ax HE20 SU	25.64	366.44
2412 - 2462	802.11ax HE20 RU size 242T	28.35	683.91
2412 - 2462	802.11ax HE20 RU size 26T	27.23	528.45

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna(s) gain and type, as provided by the manufacturer' are as follows:

The radio utilizes a Monopole antenna, with a maximum gain as below table:

Frequency Range (MHz)	Peak Antenna Gain (dBi)			
	Chain 0		Chain 1	
	ANT1 (dBi)	ANT3 (dBi)	ANT2 (dBi)	ANT4 (dBi)
2412-2462	3.0	2.0	1.9	2.5

6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was 74.0-39150-1-41.
The test utility software installed during testing was PrimaComplianceGUIInstaller _TESTBUILD3_17Nov22.

6.5. TEST REDUCTIONS CASES

After investigation, the output power of single user (SU) was lower than RU size 242 tone and 26 tone. Therefore, the SU PSD data was omitted from the testing. See Maximum Output Power section.

6.6. WORST-CASE CONFIGURATION AND MODE

WORST-CASE CONFIGURATION AND MODE FOR FINAL TEST

Radiated emissions below 1GHz, above 18GHz, and power line conducted emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

Band edge and radiated emissions between 1GHz and 18GHz were performed with the EUT set to transmit at the highest power on low, middle, and high channels.

The EUT can only be setup in desktop orientation; therefore, all radiated testing was performed with the EUT in desktop orientation.

Worst-case data rate as provided by the client were:

802.11ax HE20 mode: MCS0

Preliminary Investigation were performed for 802.11ax modes were determined by the following:

- Testing was perfomed on 802.11ax HE20 26T(Lowest Tones) and 242T (Full Tone) to cover HE20 52T and 106T.

According to Preliminary Investigation, conducted power was performed to compare Full RU Tone modes and SU (Single User) Tone modes. It was determined that Full RU Tone modes were worst case over Single User modes in every instance. Therefore, only full tone modes were tested, and they represent SU modes as the worst-case scenario

6.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

SUPPORT TEST EQUIPMENT				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID/ DoC**
Laptop	Lenovo	T460s	PC0JMBF8	Doc
Laptop AC/DC AC/DC Adapter	Lenovo	ADLX90NLC2A	11S45N0247Z1ZSHH448JEY	Doc
AC Power	Sonos	CPS045180250U	N/A	Doc
Power Supply	Sonos	EC2Y5EB	N/A	Doc
USB-A to Ethernet Adapter	Plugable	USB2-E100	8CAE4CE46AFA	Doc

I/O CABLES (CONDUCTED TEST)						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	3	AC	Un-shielded	1.25	AC Mains to Spectrum Analyzer/AC/DC Adapter
2	DC	1	DC	Un-shielded	1.0	AC/DC Adapter to Laptop
3	USB-C	1	USB-C	Un-shielded	1.5	EUT to AC Power
4	Ethernet	1	RJ45	Un-shielded	1.5	Laptop to USB Ethernet Adapter
5	USB-A	1	USB-A	Shielded	0.1	USB Ethernet Adapter to USB
6	USB-C	1	USB-C	Shielded	0.1	EUT to USB-C/USB-A Female Adapter
7	SMA Cable	1	SMA	Un-Shielded	1.0	EUT to Spectrum Analyzer

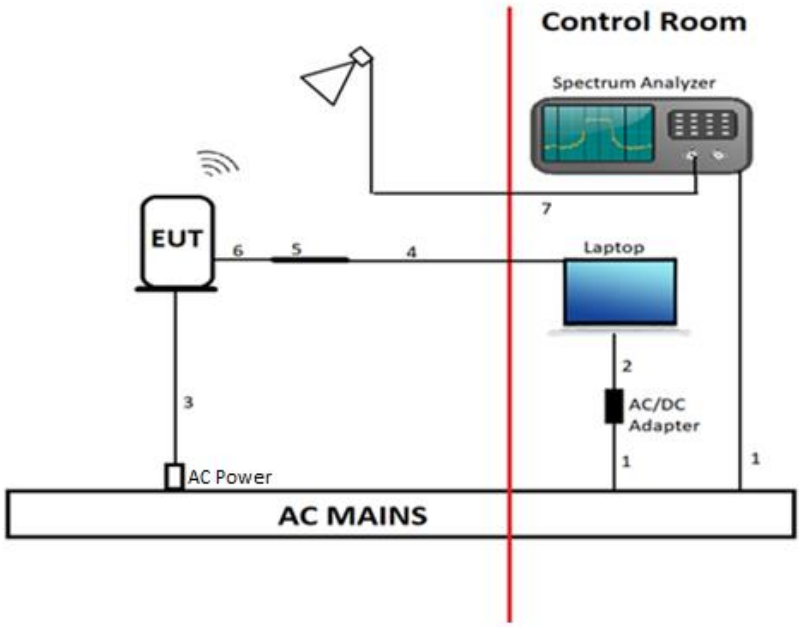
I/O CABLES (RADIATED TEST)						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length (m)**	**Remarks**
1	AC	3	AC	Un-shielded	1.25	AC Mains to Spectrum Analyzer/AC/DC Adapter
2	DC	1	DC	Un-shielded	1.0	AC/DC Adapter to Laptop
3	USB-C	1	USB-C	Un-shielded	1.5	EUT to AC Power
4	Ethernet	1	RJ45	Un-shielded	10	Laptop to USB Ethernet Adapter
5	USB-A	1	USB-A	Shielded	0.1	USB Ethernet Adapter to USB
6	USB-C	1	USB-C	Shielded	0.1	EUT to USB-C/USB-A Female Adapter
7	SMA Cable	1	SMA	Un-Shielded	10	EUT to Horn Antenna

TEST SETUP

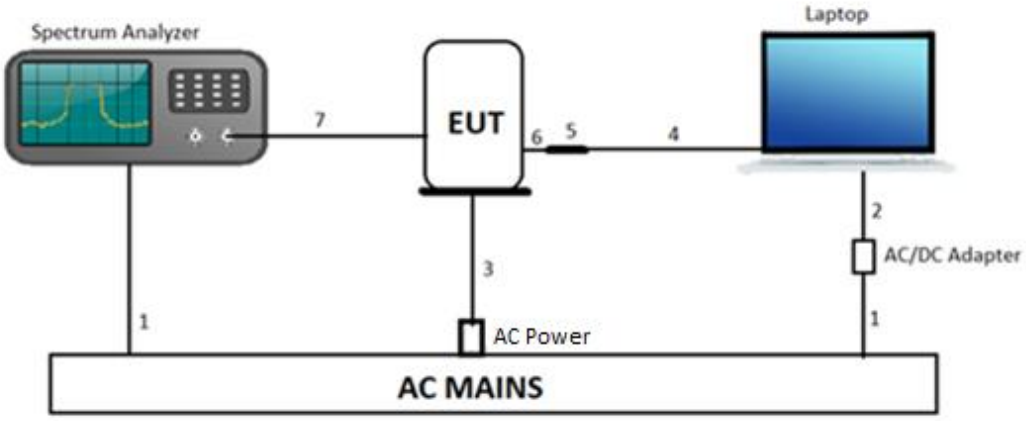
The EUT is a stand-alone unit, and the radio is exercised remotely by Sonos Compliance GUI test utility software via ethernet.

SETUP DIAGRAM

Radiated Configuration



Conducted Configuration



7. MEASUREMENT METHOD

On Time and Duty Cycle: ANSI C63.10 Section 11.6.

Occupied BW (99%): ANSI C63.10-2013 Section 6.9.3

6 dB BW: ANSI C63.10 Subclause -11.8.1 RBW ≥ DTS BW

Output Power: ANSI C63.10 Subclause -11.9.1.3 Method PKPM1 Peak-reading power meter

PSD: ANSI C63.10 Subclause -11.10.2 Method PKPSD (peak PSD)

Radiated emissions non-restricted frequency bands: ANSI C63.10 Subclause -11.11

Radiated emissions restricted frequency bands: ANSI C63.10 Subclause -11.12.1

Conducted emissions in restricted frequency bands: ANSI C63.10 Subclause -11.12.2

Band-edge: ANSI C63.10 Subclause -11.13.3.2	Integration method -Peak detection
Band-edge: ANSI C63.10 Subclause -11.13.3.3	Integration method -Trace averaging with continuous transmission at full power
Band-edge: ANSI C63.10 Subclause -11.13.3.4	Integration method -Trace averaging across ON and OFF times DC correction

AC Power Line Conducted Emissions: ANSI C63.10-2013, Section 6.2.

Radiated Spurious Emissions Below 30MHz: ANSI C63.10-2013 Section 6.4

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

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**	**Last Cal**
Antenna, Broadband Hybrid, 30MHz to 2GHz	Sunol Sciences Corp.	JB1	80293	2023-08-09	2022-08-09
Amplifier, 10KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310N	171202	2023-04-24	2022-04-24
Antenna, Horn 1-18GHz	ETS-Lindgren (Cedar Park, Texas)	3117	00240043	2023-10-07	2022-10-07
RF Filter Box, 1-18GHz	FREMONT	SAC-L1	171013	2023-06-24	2022-06-24
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	191429	2024-02-29	2023-02-28
Antenna, Horn 18 to 26.5GHz	ARA	MWH-1826/B	199659	2023-12-06	2022-12-06
Amplifier 18-26.5GHz, +5Vdc, 60dB min	AMPLICAL	AMP18G26.5-60	234683	2024-03-29	2023-03-18
Antenna, Passive Loop 30Hz - 1MHz	ELECTRO METRICS	EM-6871	170014	2023-07-19	2022-07-19
Antenna, Passive Loop 100KHz - 30MHz	ELECTRO METRICS	EM-6872	170015	2023-07-28	2022-07-28
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent Technologies	N9030A	80396	2024-01-31	2023-01-27
Power Meter, P-series single channel	Keysight Technologies Inc	N1911A	90718	2024-01-31	2023-01-26
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc	N1921A	90419	2024-01-31	2023-01-26
AC Line Conducted					
LISN	Fischer Custom Communications, Inc`	FCC-LISN-50/250-25-2-01-480V	175765	2024-01-31	2023-01-31
EMI TEST RECEIVER	Rohde & Schwarz	ESR	171646	2024-02-29	2023-02-29
Transient Limiter	TE	TBFL1	207996	2023-07-15	2022-07-15
UL TEST SOFTWARE LIST					
Radiated Software	UL	UL EMC	Rev 2015-12-29, 2020-04-15 & 2023-01-18		
Antenna Port Software	UL	UL RF	Ver 2022-08-16		
AC Line Conducted Software	UL	UL EMC	Rev 2022-02-17		

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

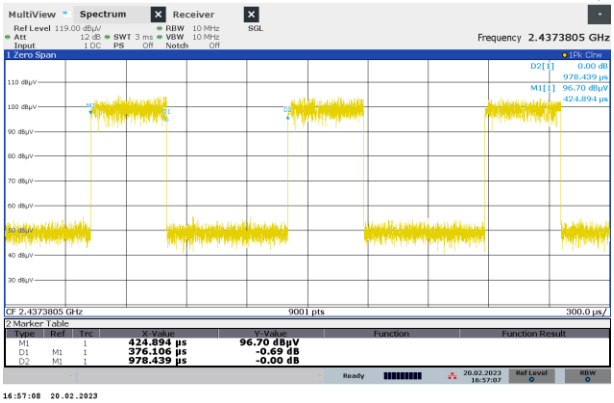
KDB 558074 D01 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

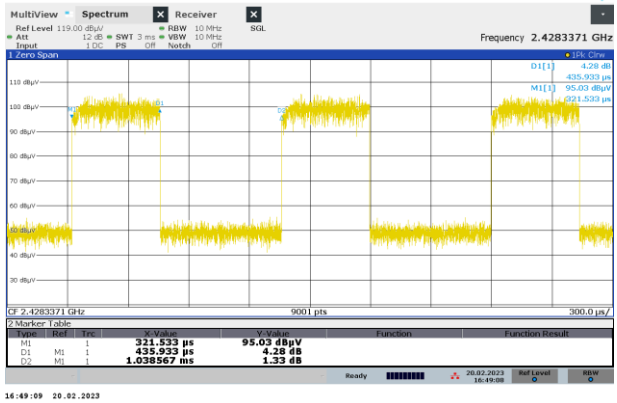
Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
2.4GHz Band						
802.11ax HE20 OFDMA, RU size 242T	0.376	0.978	0.384	38.44%	4.15	2.659
802.11ax HE20 OFDMA, RU size 106T	0.436	1.039	0.420	41.97%	3.77	2.294
802.11ax HE20 OFDMA, RU size 52T	0.495	0.666	0.743	74.34%	1.29	2.019
802.11ax HE20 OFDMA, RU size 26T	0.580	1.191	0.487	48.67%	3.13	1.725

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

DUTY CYCLE PLOTS



802.11ax HE20 OFDMA, RU index 242T MODE



802.11ax HE20 OFDMA, RU index 106T MODE

802.11ax HE20 OFDMA, RU index 52T MODE

802.11ax HE20 OFDMA, RU index 26T MODE

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.2. 6 dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

RSS-247 5.2 (a)

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

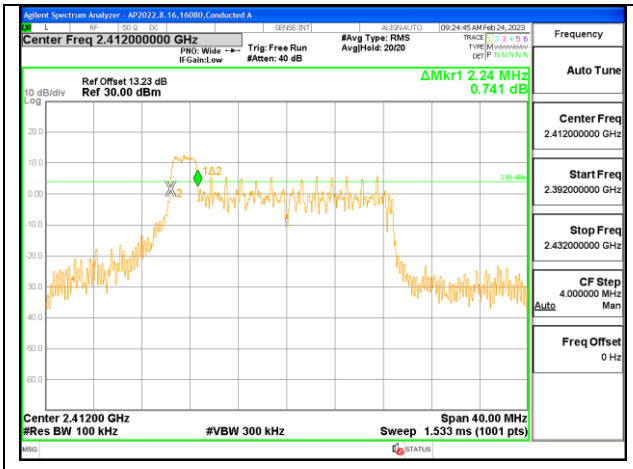
RESULTS

9.2.1. 802.11ax HE20 MODE 2TX

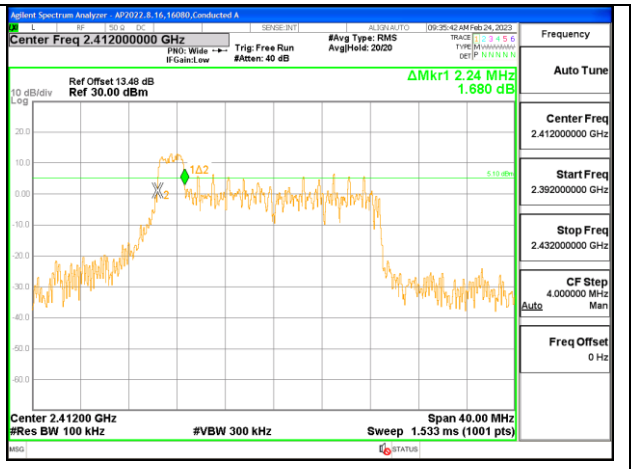
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 0

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 4 (MHz)	Minimum Limit (MHz)
Low 1	2412	2.24	2.24	0.5

LOW CHANNEL 1



LOW CHANNEL 1 Antenna 1

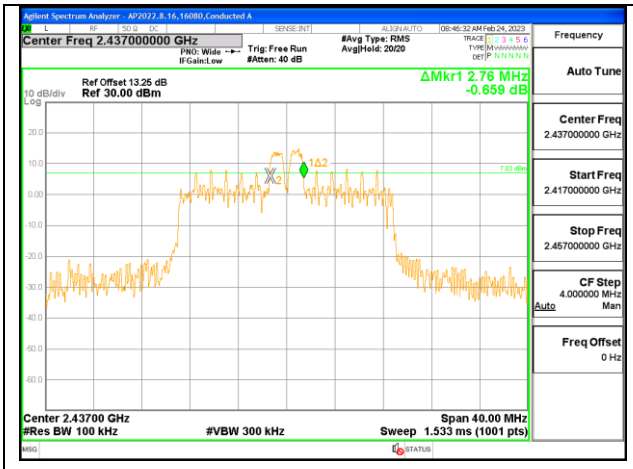


LOW CHANNEL 1 Antenna 4

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 4

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 4 (MHz)	Minimum Limit (MHz)
Mid 6	2437	2.76	2.72	0.5

MID CHANNEL 6



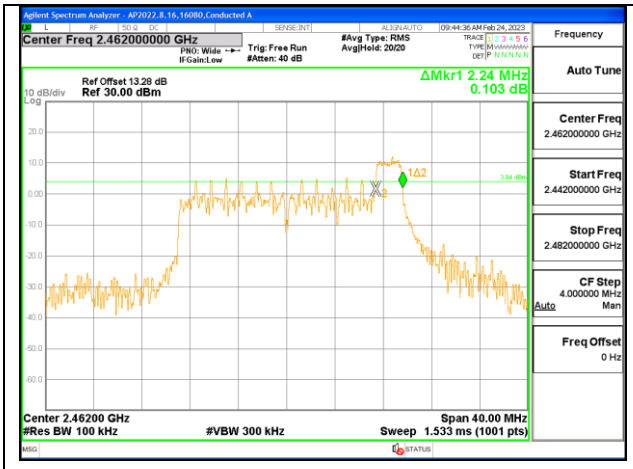
MID CHANNEL 6 Antenna 1

MID CHANNEL 6 Antenna 4

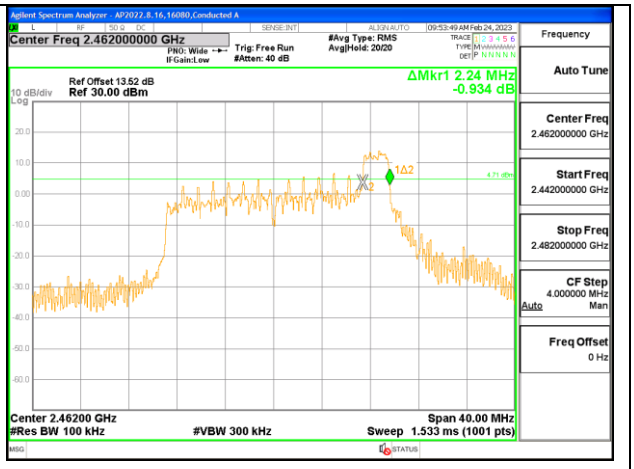
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 8

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 4 (MHz)	Minimum Limit (MHz)
High 11	2462	2.24	2.24	0.5

HIGH CHANNEL 11



HIGH CHANNEL 11 Antenna 1

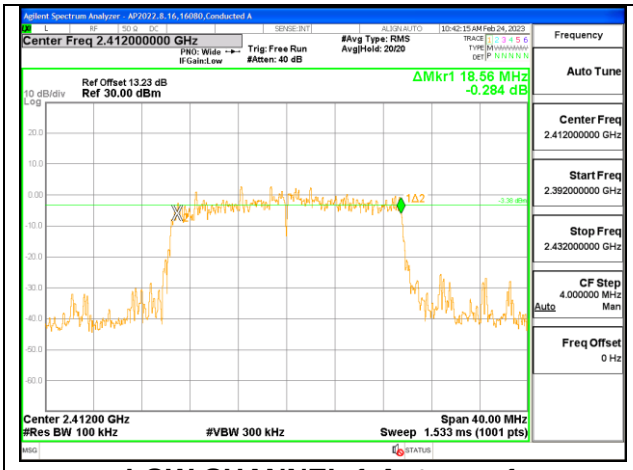


HIGH CHANNEL 11 Antenna 4

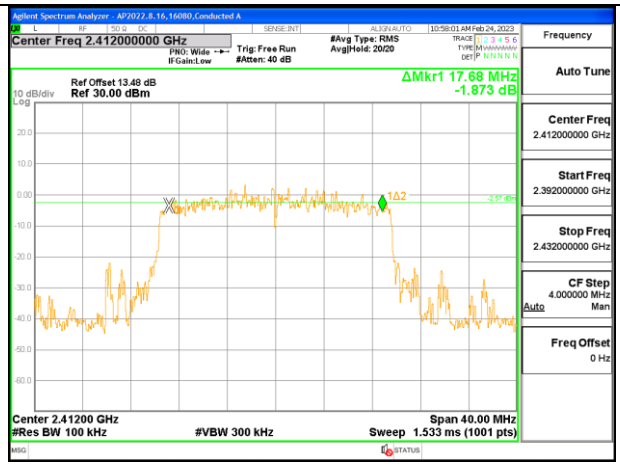
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 242-Tones, RU Index 61

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 4 (MHz)	Minimum Limit (MHz)
Low 1	2412	18.56	17.68	0.5
Low 2	2417	18.48	18.76	0.5
Low 3	2422	19.04	18.48	0.5
Low 4	2427	18.60	18.56	0.5
Mid 6	2437	18.56	18.80	0.5
High 9	2452	18.60	18.12	0.5
High 10	2457	18.20	18.76	0.5
High 11	2462	18.80	18.28	0.5

LOW CHANNEL 1

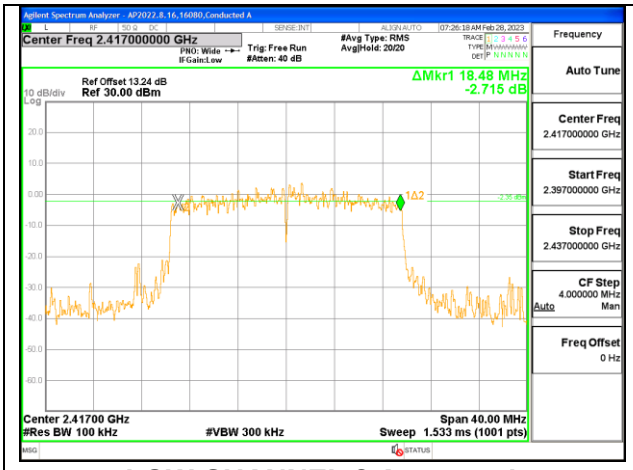


LOW CHANNEL 1 Antenna 1

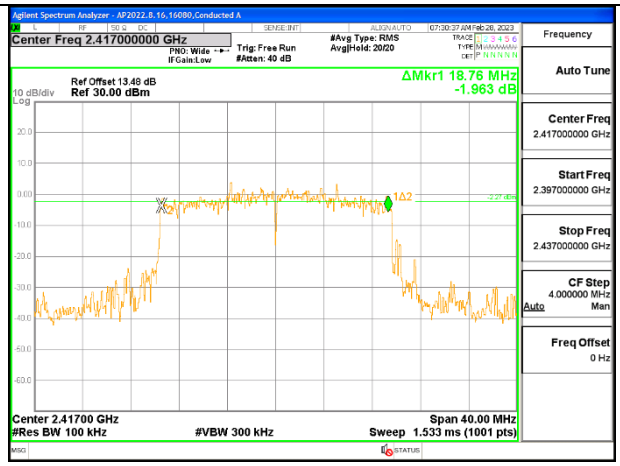


LOW CHANNEL 1 Antenna 4

LOW CHANNEL 2

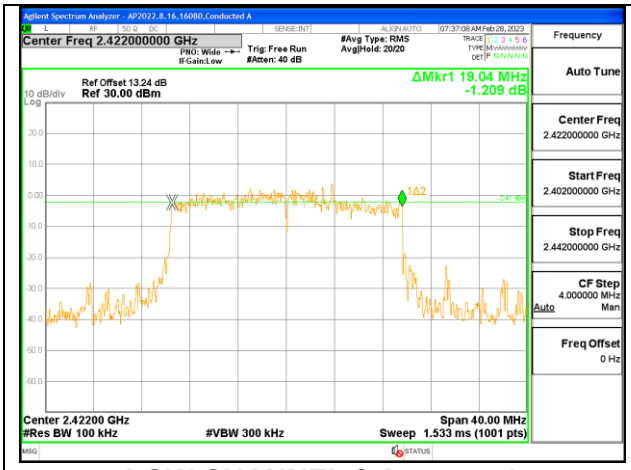


LOW CHANNEL 2 Antenna 1

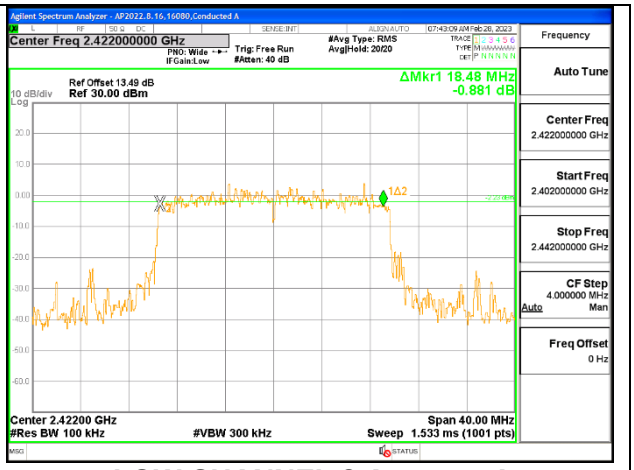


LOW CHANNEL 2 Antenna 4

LOW CHANNEL 3

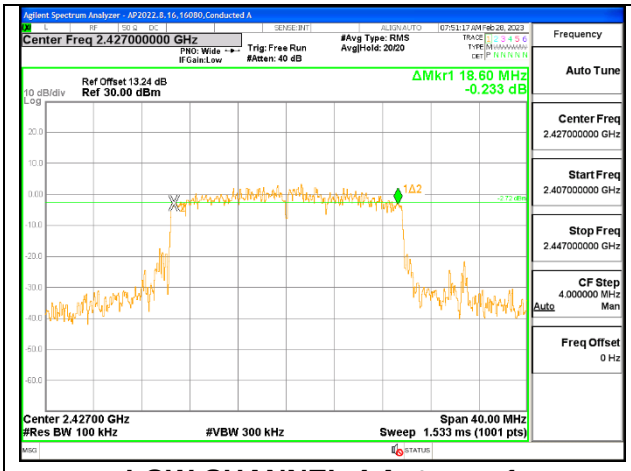


LOW CHANNEL 3 Antenna 1

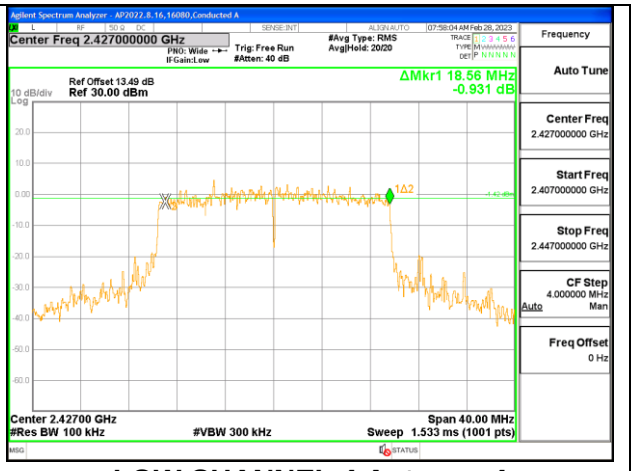


LOW CHANNEL 3 Antenna 4

LOW CHANNEL 4

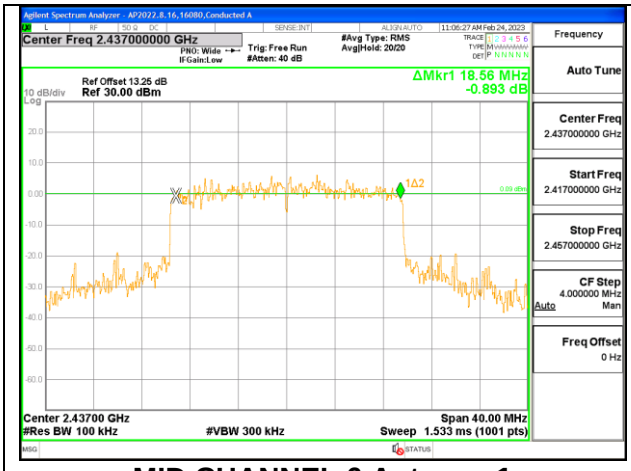


LOW CHANNEL 4 Antenna 1

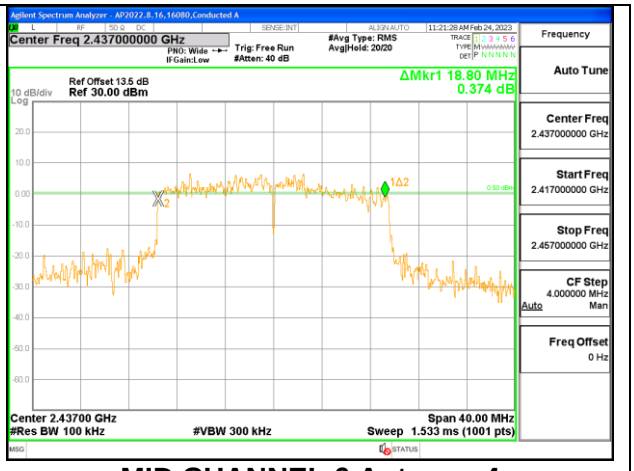


LOW CHANNEL 4 Antenna 4

MID CHANNEL 6

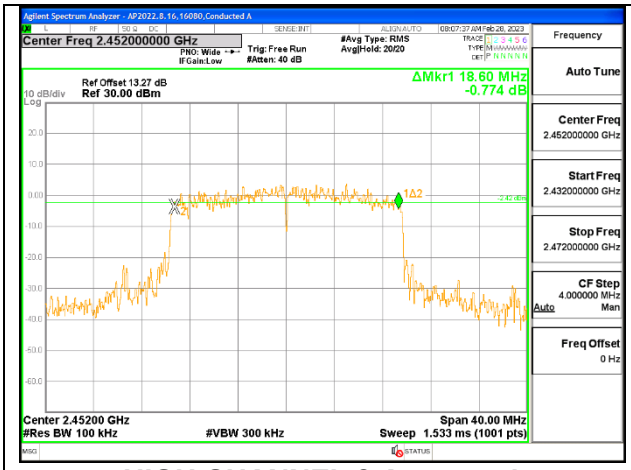


MID CHANNEL 6 Antenna 1

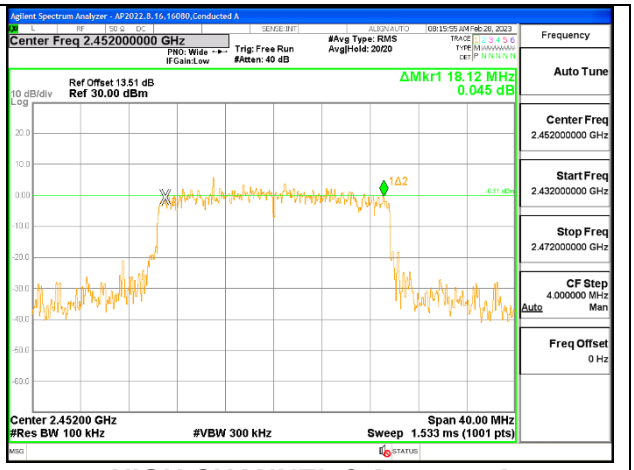


MID CHANNEL 6 Antenna 4

HIGH CHANNEL 9

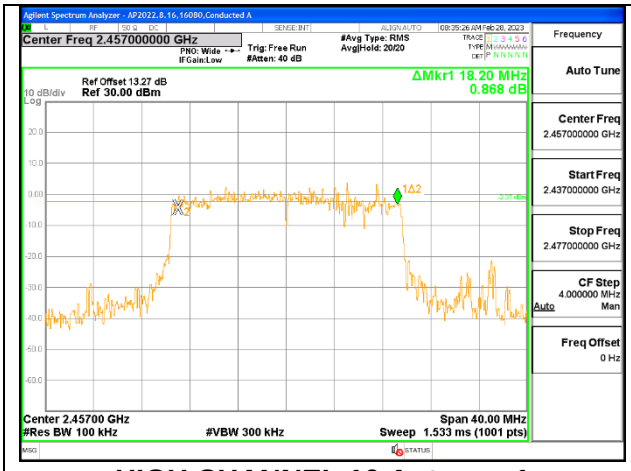


HIGH CHANNEL 9 Antenna 1

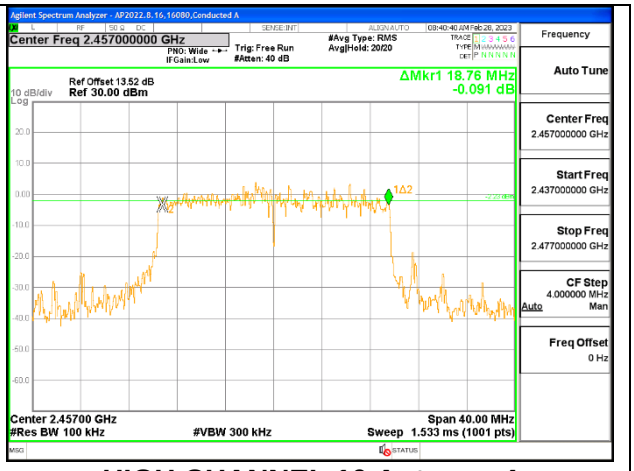


HIGH CHANNEL 9 Antenna 4

HIGH CHANNEL 10

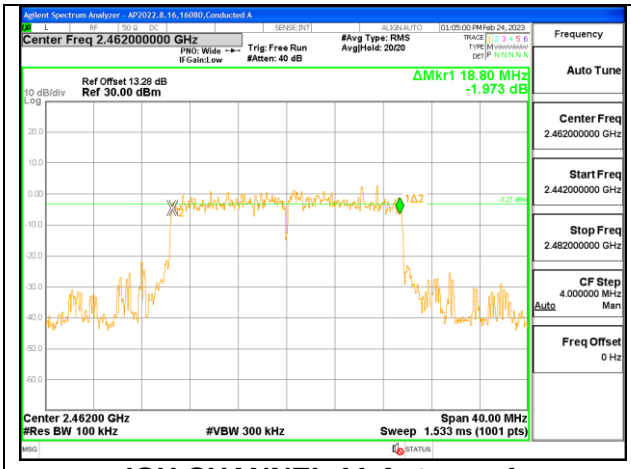


HIGH CHANNEL 10 Antenna 1



HIGH CHANNEL 10 Antenna 4

HIGH CHANNEL 11



IGH CHANNEL 11 Antenna 1

HIGH CHANNEL 11 Antenna 4

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.3. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

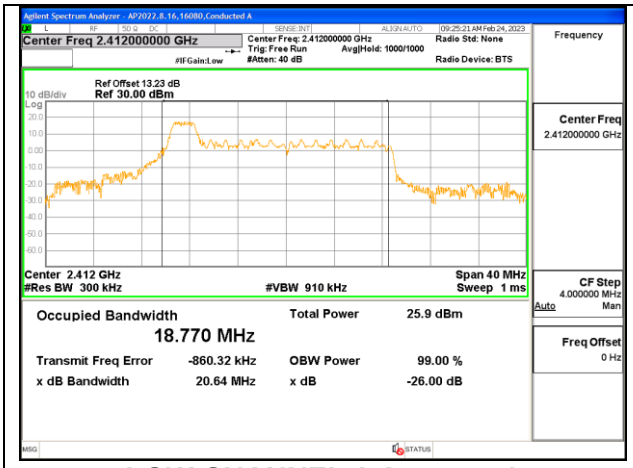
RESULTS

9.3.1. 802.11ax HE20 MODE 2TX

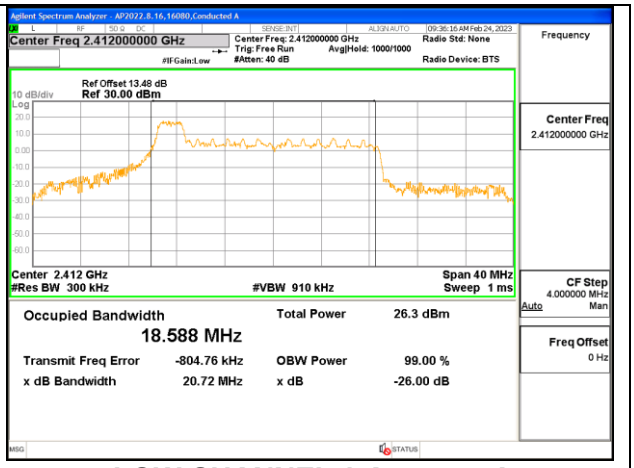
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 0

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 4 (MHz)
Low 1	2412	18.770	18.588

LOW CHANNEL 1



LOW CHANNEL 1 Antenna 1

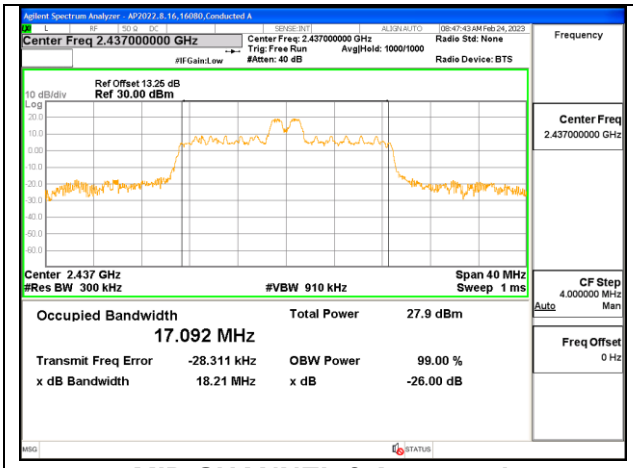


LOW CHANNEL 1 Antenna 4

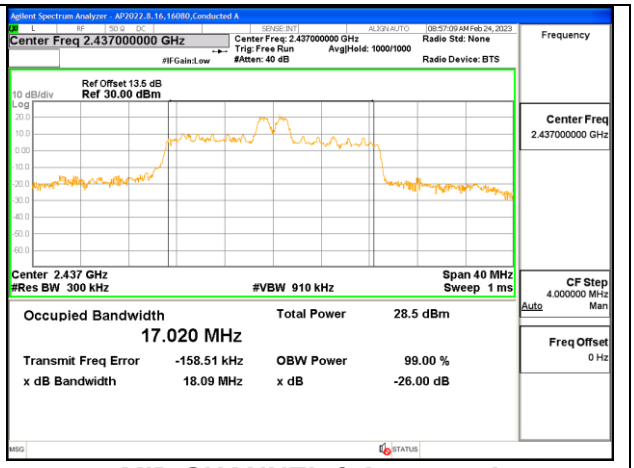
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 4

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 4 (MHz)
Mid 6	2437	17.092	17.020

MID CHANNEL 6



MID CHANNEL 6 Antenna 1

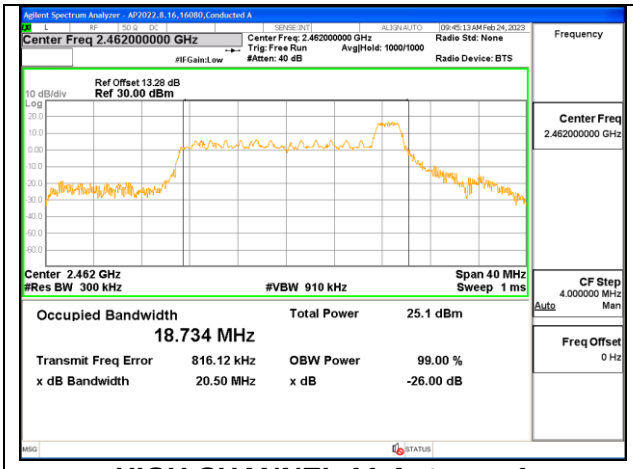


MID CHANNEL 6 Antenna 4

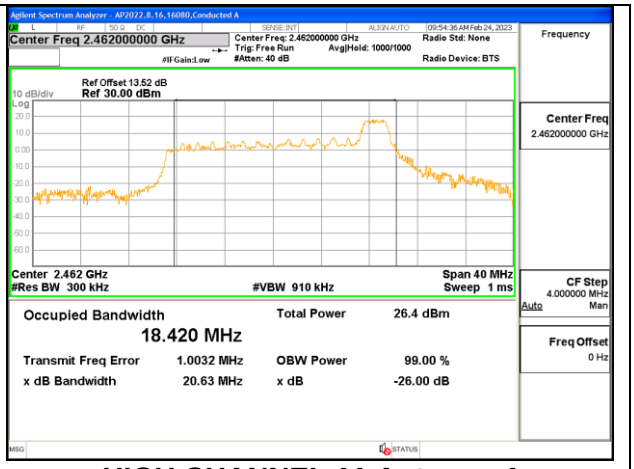
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 8

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 4 (MHz)
High 11	2462	18.734	18.420

HIGH CHANNEL 11



HIGH CHANNEL 11 Antenna 1

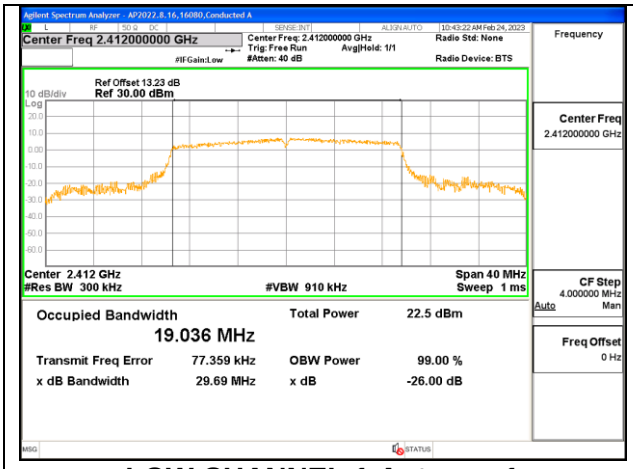


HIGH CHANNEL 11 Antenna 4

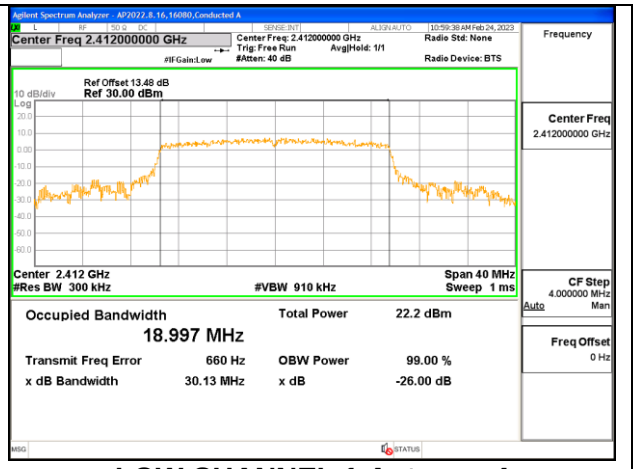
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 242-Tones, RU Index 61

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 4 (MHz)
Low 1	2412	19.036	18.997
Low 2	2417	19.018	19.040
Low 3	2422	19.040	19.018
Low 4	2427	19.035	19.036
Mid 6	2437	19.070	19.053
High 9	2452	19.019	19.017
High 10	2457	19.039	19.020
High 11	2462	18.996	18.942

LOW CHANNEL 1

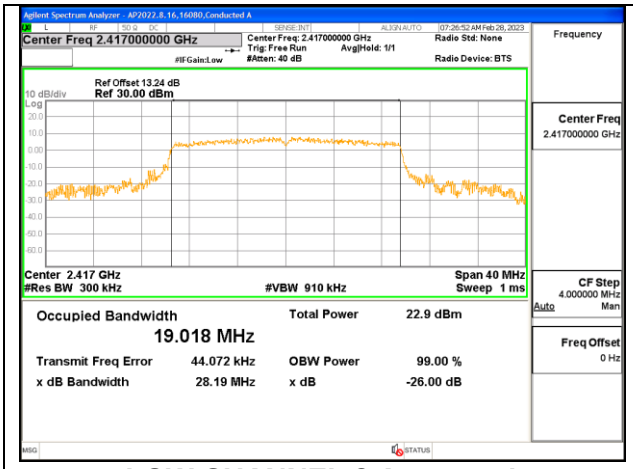


LOW CHANNEL 1 Antenna 1

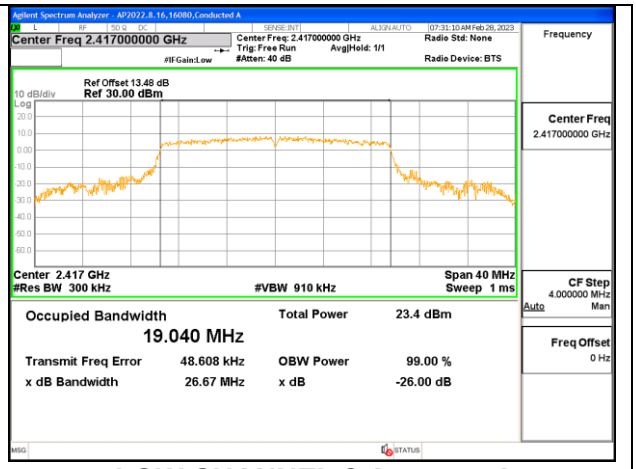


LOW CHANNEL 1 Antenna 4

LOW CHANNEL 2

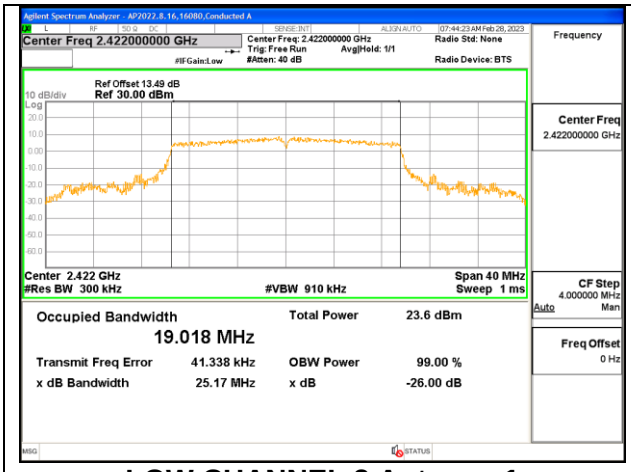


LOW CHANNEL 2 Antenna 1

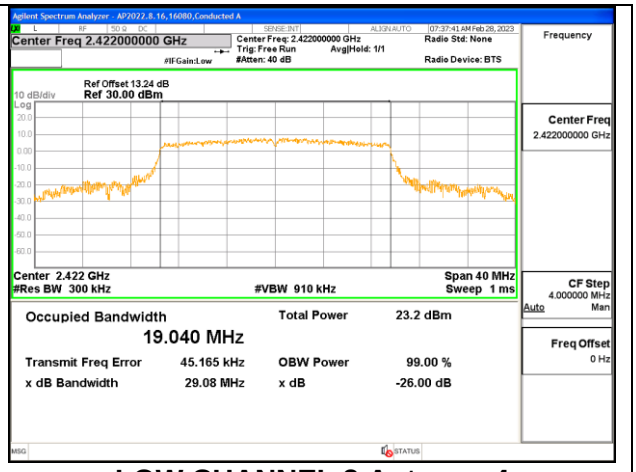


LOW CHANNEL 2 Antenna 4

LOW CHANNEL 3

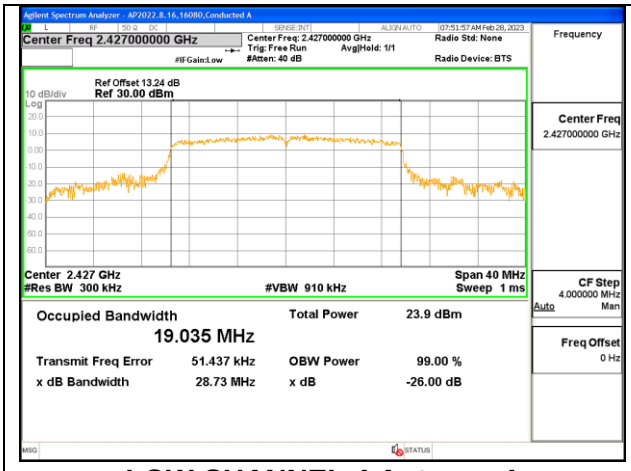


LOW CHANNEL 3 Antenna 1

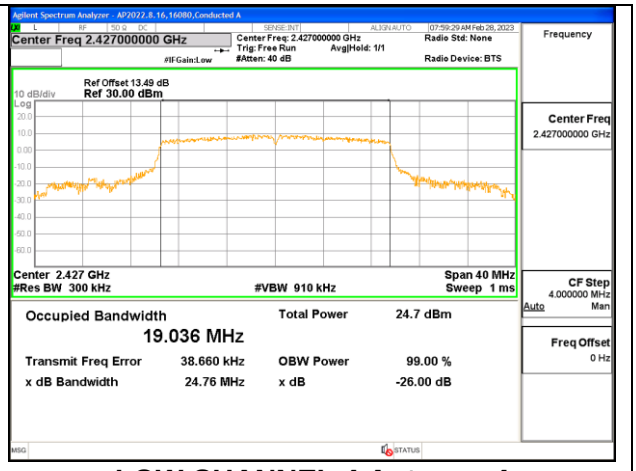


LOW CHANNEL 3 Antenna 4

LOW CHANNEL 4

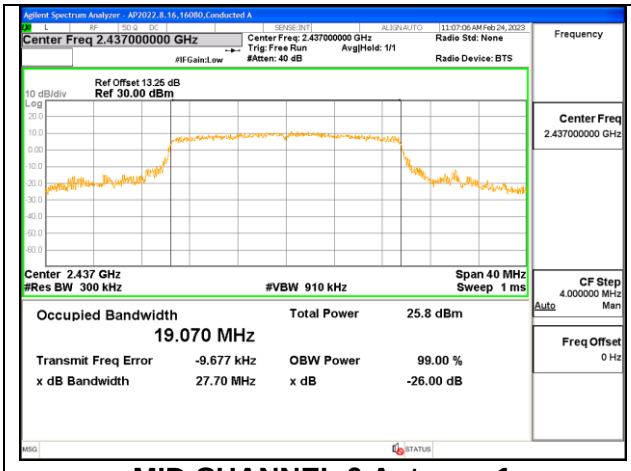


LOW CHANNEL 4 Antenna 1

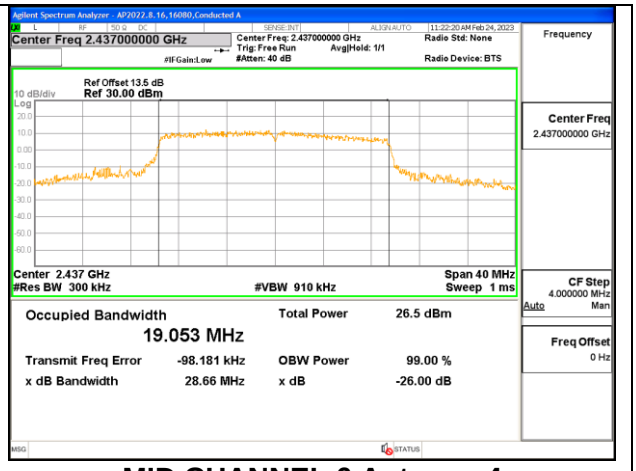


LOW CHANNEL 4 Antenna 4

MID CHANNEL 6

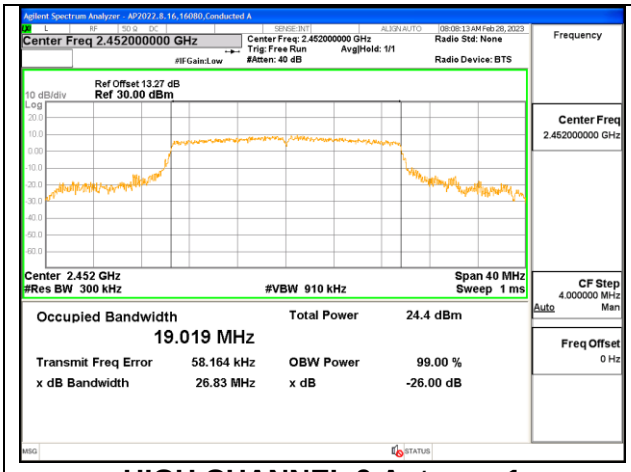


MID CHANNEL 6 Antenna 1

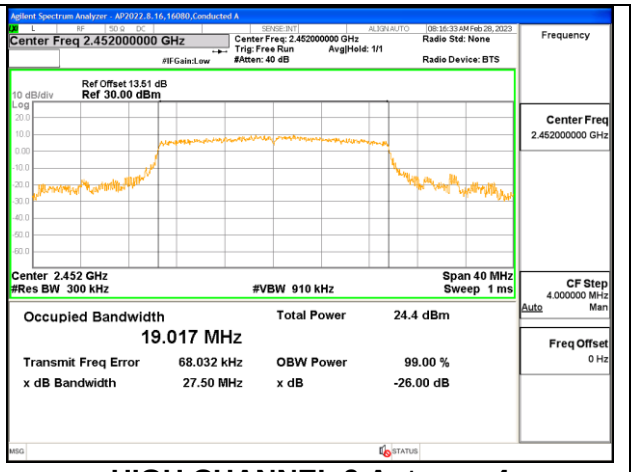


MID CHANNEL 6 Antenna 4

HIGH CHANNEL 9

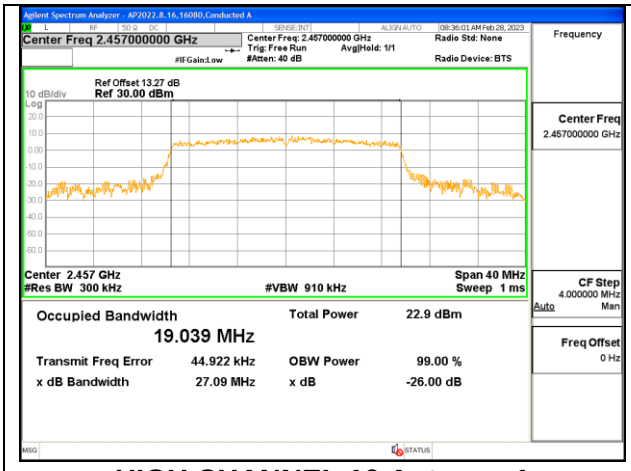


HIGH CHANNEL 9 Antenna 1

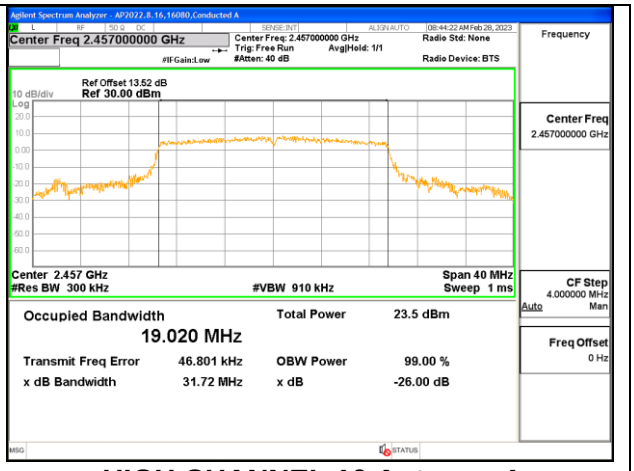


HIGH CHANNEL 9 Antenna 4

HIGH CHANNEL 10

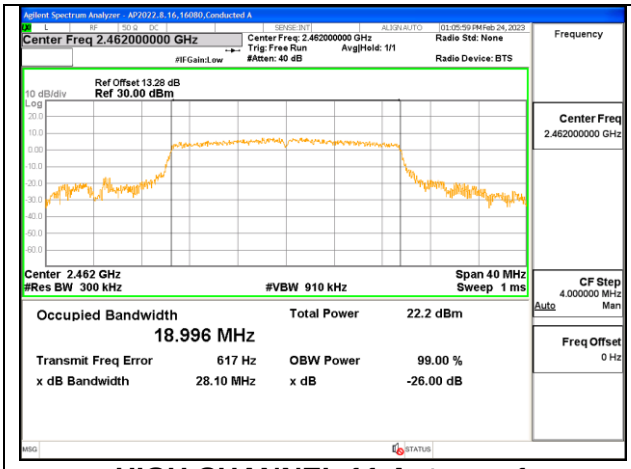


HIGH CHANNEL 10 Antenna 1

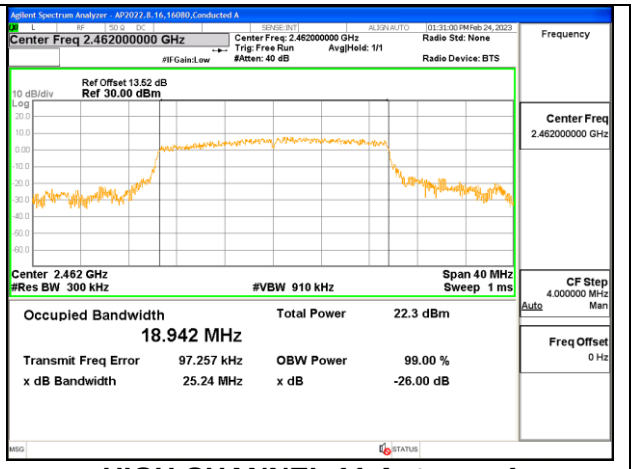


HIGH CHANNEL 10 Antenna 4

HIGH CHANNEL 11



HIGH CHANNEL 11 Antenna 1



HIGH CHANNEL 11 Antenna 4

9.4. OUTPUT POWER

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.

TEST PROCEDURE

The transmitter output is connected to a power meter. The cable assembly insertion loss was entered as an offset in the power meter to allow for a peak reading of power.

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. Peak output power was read directly from power meter.

Power Measurement:

- For full allocation for low / mid / high in each band
- For smallest RU allocation (26 RU) for low, mid, and high channels (for low channel use lowest RU, for high channel use highest and for center channel use center)

If power varies with RU index on center channel, record power for the different RU allocations

Confirm rated power levels for RUs are the same for different channel bandwidths – if it is then 26 / 52 / 102 / 242 test cases are all covered by the 20MHz tests and 484 can be covered by 40MHz MHz

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

DIRECTIONAL 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:

NOTE: Antenna 1 and Antenna 4 are the worst-case combinations.

Antenna 1 + **Antenna 2**

Vertical Polarity

Band (GHz)	Chain 0 Antenna Gain (dBi)	Chain 1 Antenna Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	3.00	1.90	2.48	5.48

Antenna 1 + Antenna 4 (Worst-case)

Vertical Polarity

Band (GHz)	Chain 0 Antenna Gain (dBi)	Chain 1 Antenna Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	3.00	2.50	2.76	5.76

Antenna 3 + Antenna 2

Vertical Polarity

Band (GHz)	Chain 0 Antenna Gain (dBi)	Chain 1 Antenna Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	2.00	1.90	1.95	4.96

Antenna 3 + Antenna 4

Vertical Polarity

Band (GHz)	Chain 0 Antenna Gain (dBi)	Chain 1 Antenna Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	2.00	2.50	2.26	5.26

The Directional Gain value was determined by using the following formulas:

1/ Uncorrelated Directional Gain dBi = 10*log((10^(Ant 1/10)+10^(Ant 2/10))/2)

2/ Correlated Directional Gain dBi = 10*log(((10^(Ant 1/20)+10^(Ant 2/20))^2)/2)

Sample Calculation:

1/ Uncorrelated Directional Gain: 2.66 dBi = 10*log((10^(2.9/10)+10^(2.4/10))/2]

2/ Correlated Directional Gain: 5.66 dBi = 10*log(((10^(2.9/20)+10^(2.4/20))^2)/2)

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

RESULT

9.4.1. 802.11ax HE20 MODE 2TX

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 0

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	2.76	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 4 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 1	2412	24.12	24.12	27.13	30.00	-2.87

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 4

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Mid 6	2437	2.76	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 4 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Mid 6	2437	24.21	24.23	27.23	30.00	-2.77

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 8

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
High 11	2462	2.76	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 4 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
High 11	2462	23.26	23.51	26.40	30.00	-3.60

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 242-Tones, RU Index 61

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	2.76	30.00	36	30.00
Low 2	2417	2.76	30.00	36	30.00
Low 3	2422	2.76	30.00	36	30.00
Low 4	2427	2.76	30.00	36	30.00
Mid 6	2437	2.76	30.00	36	30.00
High 9	2452	2.76	30.00	36	30.00
High 10	2457	2.76	30.00	36	30.00
High 11	2462	2.76	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 4 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 1	2412	22.34	22.17	25.27	30.00	-4.73
Low 2	2417	22.92	22.78	25.86	30.00	-4.14
Low 3	2422	22.93	22.57	25.76	30.00	-4.24
Low 4	2427	23.87	23.67	26.78	30.00	-3.22
Mid 6	2437	25.20	25.47	28.35	30.00	-1.65
High 9	2452	23.87	24.88	27.41	30.00	-2.59
High 10	2457	23.11	23.67	26.41	30.00	-3.59
High 11	2462	22.53	22.72	25.64	30.00	-4.36

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: SU, Single User

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	2.76	30.00	36	30.00
Mid 6	2437	2.76	30.00	36	30.00
High 11	2462	2.76	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 4 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margin (dB)
Low 1	2412	22.30	22.10	25.21	30.00	-4.79
Mid 6	2437	22.60	22.65	25.64	30.00	-4.36
High 11	2462	22.48	22.63	25.57	30.00	-4.43

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

9.5. AVERAGE POWER

LIMITS

None; for reporting purposes only

TEST PROCEDURE

The transmitter output is connected to a 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. Gated average output power was read directly from power meter.

UL VERIFICATION SERVICES
47173 Benicia Street, Fremont, CA 94538; USA TEL:(510) 319-4000 FAX:(510) 661-0888

RESULTS

9.5.1. 802.11ax HE20 MODE 2TX

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 0

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 4 Power (dBm)	Total Power (dBm)
Low 1	2412	17.32	17.48	20.41

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 4

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 4 Power (dBm)	Total Power (dBm)
Mid 6	2437	17.41	17.62	20.53

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 8

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 4 Power (dBm)	Total Power (dBm)
High 11	2462	16.42	16.71	19.58

2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 242-Tones, RU Index 61

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 4 Power (dBm)	Total Power (dBm)
Low 1	2412	15.30	15.51	18.42
Low 2	2417	16.31	16.27	19.30
Low 3	2422	16.37	16.35	19.37
Low 4	2427	17.47	17.49	20.49
Mid 6	2437	19.33	19.60	22.48
High 9	2452	17.55	17.77	20.67
Mid 6	2437	16.60	16.71	19.67
High 11	2462	15.69	15.71	18.71

2TX Antenna 1 + Antenna 3 CDD OFDMA MODE: SU, Single User

Test Engineer:	16080 ZS
Test Date:	2023-02-27

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 4 Power (dBm)	Total Power (dBm)
Low 1	2412	15.30	15.52	18.42
Mid 6	2437	19.33	19.39	22.37
High 11	2462	15.60	15.69	18.66

9.6. POWER SPECTRAL DENSITY

LIMITS

FCC §15.407 (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.

RESULTS

9.6.1. 802.11ax HE20 MODE 2TX

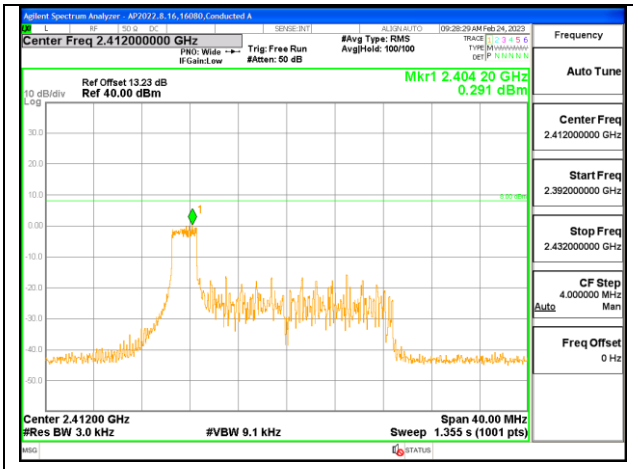
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 0

Duty Cycle CF (dB)	3.13	Included in Calculations of Corr'd PSD

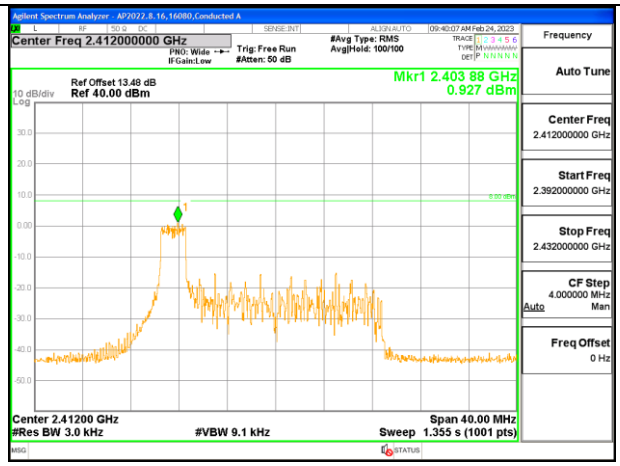
PSD Results

Channel	Frequency (MHz)	Antenna 1 Meas (dBm/ 3kHz)	Antenna 4 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low 1	2412	0.29	0.93	6.76	8.0	-1.2

LOW CHANNEL 1



LOW CHANNEL 1 Antenna 1



LOW CHANNEL 1 Antenna 4

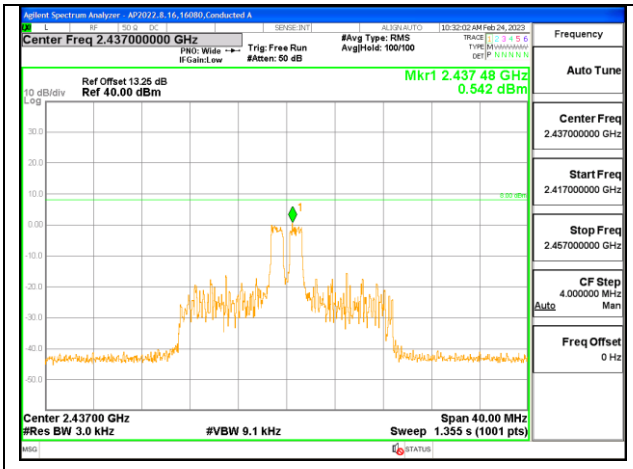
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 4

Duty Cycle CF (dB)	3.13	Included in Calculations of Corr'd PSD	

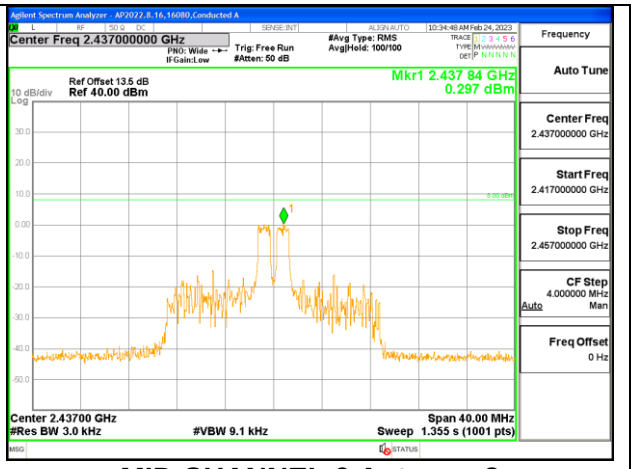
PSD Results

Channel	Frequency (MHz)	Antenna 1 Meas (dBm/ 3kHz)	Antenna 4 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Mid 6	2437	0.54	0.30	6.56	8.0	-1.4

MID CHANNEL 6



MID CHANNEL 6 Antenna 1



MID CHANNEL 6 Antenna 2

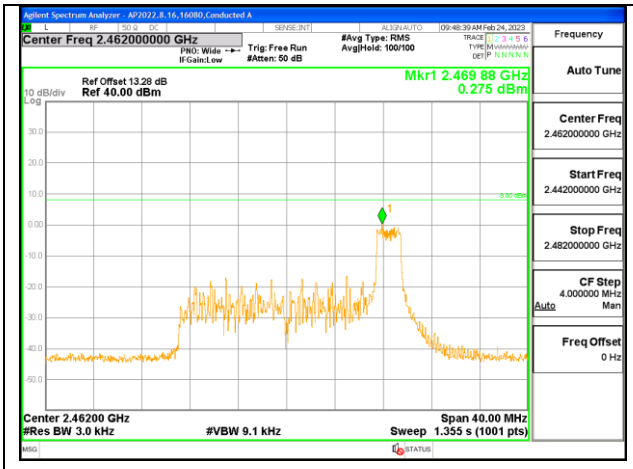
2TX Antenna 1 + Antenna 4 CDD OFDMA MODE: 26-Tones, RU Index 8

Duty Cycle CF (dB)	3.13	Included in Calculations of Corr'd PSD	

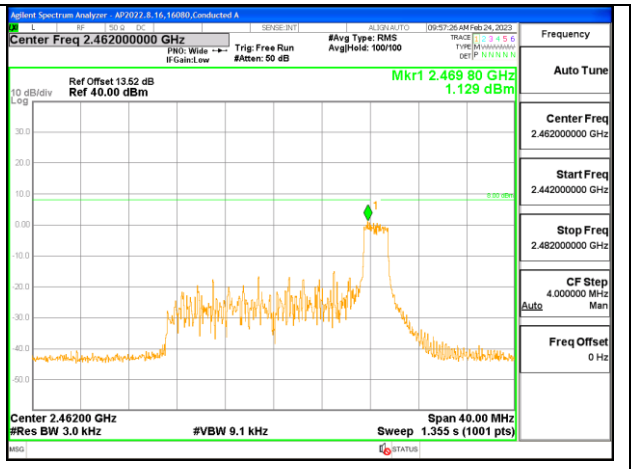
PSD Results

Channel	Frequency (MHz)	Antenna 1 Meas (dBm/ 3kHz)	Antenna 4 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
High 11	2462	0.28	1.13	6.86	8.0	-1.1

HIGH CHANNEL 11



HIGH CHANNEL 11 Antenna 1



HIGH CHANNEL 11 Antenna 4