

# **TEST REPORT**

**Report Number.:** 14093504-E4V3

**Applicant :** SONOS INC.  
614 CHAPALA ST.  
SANTA BARBARA, CA, 93101, U.S.A.

**Model :** S39

**Brand :** SONOS

**FCC ID :** SBVRM039

**IC :** 5373A-RM039

**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:**  
2022-10-13

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



## REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2022-09-23	Initial Issue	---
V2	2022-10-03	Updated Section 6.3 and added section 9.5	K.Kedida
V3	2022-10-13	Updated Section 9.4	K.Kedida

## TABLE OF CONTENTS

<b>REPORT REVISION HISTORY .....</b>	<b>2</b>
<b>TABLE OF CONTENTS .....</b>	<b>3</b>
<b>1. ATTESTATION OF TEST RESULTS .....</b>	<b>5</b>
<b>2. TEST RESULTS SUMMARY .....</b>	<b>7</b>
<b>3. TEST METHODOLOGY .....</b>	<b>8</b>
<b>4. FACILITIES AND ACCREDITATION .....</b>	<b>8</b>
<b>5. DECISION RULES AND MEASUREMENT UNCERTAINTY .....</b>	<b>9</b>
5.1. METROLOGICAL TRACEABILITY .....	9
5.2. DECISION RULES.....	9
5.3. MEASUREMENT UNCERTAINTY.....	9
5.4. SAMPLE CALCULATION .....	9
<b>6. EQUIPMENT UNDER TEST .....</b>	<b>10</b>
6.1. EUT DESCRIPTION .....	10
6.2. MAXIMUM OUTPUT POWER.....	10
6.3. DESCRIPTION OF AVAILABLE ANTENNAS .....	10
6.4. SOFTWARE AND FIRMWARE.....	10
6.5. TEST REDUCTION CASE.....	11
6.6. WORST-CASE CONFIGURATION AND MODE.....	11
6.7. DESCRIPTION OF TEST SETUP.....	12
<b>7. MEASUREMENT METHOD.....</b>	<b>14</b>
<b>8. TEST AND MEASUREMENT EQUIPMENT .....</b>	<b>15</b>
<b>9. ANTENNA PORT TEST RESULTS .....</b>	<b>16</b>
9.1. ON TIME AND DUTY CYCLE.....	16
9.2. 6 dB BANDWIDTH.....	18
9.2.1. 802.11ax HE20 MODE 2TX.....	19
9.2.2. 802.11ax HE40 MODE 2TX.....	23
9.3. 99% BANDWIDTH.....	27
9.3.1. 802.11ax HE20 MODE 2TX.....	28
9.3.2. 802.11ax HE40 MODE 2TX.....	32
9.4. OUTPUT POWER.....	36
9.4.1. 802.11ax HE20 MODE 2TX.....	39
9.4.2. 802.11ax HE40 MODE 2TX.....	42

9.5.	AVERAGE POWER.....	45
9.5.1.	802.11ax HE20 MODE 2TX.....	46
9.5.2.	802.11ax HE40 MODE 2TX.....	48
9.6.	POWER SPECTRAL DENSITY.....	50
9.6.1.	802.11ax HE20 MODE 2TX.....	50
9.6.2.	802.11ax HE40 MODE 2TX.....	55
9.7.	CONDUCTED SPURIOUS EMISSIONS.....	60
9.7.1.	802.11ax HE20 MODE 2TX.....	61
9.7.2.	802.11ax HE40 MODE 2TX.....	67
<b>10.</b>	<b>RADIATED TEST RESULTS.....</b>	<b>73</b>
10.1.	TRANSMITTER ABOVE 1 GHz.....	75
10.1.1.	TX ABOVE 1 GHz 802.11ax HE20 MODE IN THE 2.4GHz BAND.....	75
10.1.2.	TX ABOVE 1 GHz 802.11ax HE40 MODE IN THE 2.4GHz BAND.....	95
10.2.	Worst Case Below 30MHz.....	115
10.3.	Worst Case Below 1 GHz.....	116
10.4.	Worst Case 18-26 GHz.....	118
<b>11.</b>	<b>AC POWER LINE CONDUCTED EMISSIONS.....</b>	<b>120</b>
<b>12.</b>	<b>SETUP PHOTOS.....</b>	<b>123</b>

## 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

**MODEL:** S39

**BRAND:** SONOS

**SERIAL NUMBER:** Radiated Sample: A100 2207CP F0-F6-C1-A0-0D-80:1 and  
A100 2207CP F0-F6-C1-A0-0D-CC:9  
Conducted Sample: 7885B

**SAMPLE RECEIPT DATE:** 2022-07-25

**DATE TESTED:** 2022-07-25 to 2022-08-23

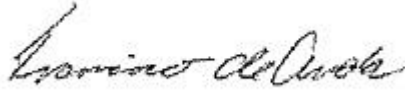
APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5 + A1 + A2	Complies

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. 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.

Approved & Released For  
UL Verification Services Inc. By:



---

Francisco de Anda  
Staff Engineer  
Consumer Technology Division  
UL Verification Services Inc.

Prepared By:



---

Glenn Escano  
Senior Test Engineer  
Consumer Technology Division  
UL Verification Services Inc.

1<sup>st</sup> Reviewed By:



---

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

2<sup>nd</sup> Reviewed By:



---

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

## 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.

Below is a list of the data provided by the customer:

1. Antenna gain and type (see section 6.3)

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.
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 CFR 47 Part 2, FCC CFR 47 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.

### 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
<input checked="" type="checkbox"/>	Building 1: 47173 Benicia Street Fremont, CA 94538, U.S.A	US0104	2324A	208313
<input type="checkbox"/>	Building 2: 47266 Benicia Street Fremont, CA 94538, U.S.A	US0104	22541	208313
<input checked="" type="checkbox"/>	Building 4: 47658 Kato Rd Fremont, CA 94538, U.S.A	US0104	2324B	208313



## 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 <sub>Lab</sub>
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

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

### 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)  
 $36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} = 28.9 \text{ dBuV/m}$

#### **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.  
 $36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} = 46.6 \text{ dBuV}$

## 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 peak conducted output power as follows:

#### 2.4GHz BAND 802.11 ax MODE 2TX

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
<b>2TX CDD</b>			
2412 - 2462	802.11ax HE20 SU	27.19	523.60
2412 - 2462	802.11ax HE20 RU size 242T	28.37	687.07
2412 - 2462	802.11ax HE20 RU size 26T	25.33	341.19
2422 - 2452	802.11ax HE40 SU	27.94	622.30
2422 - 2452	802.11ax HE40 RU size 484T	28.43	696.63
2422 - 2452	802.11ax HE40 RU size 26T	26.17	414.00

### 6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna gains and type, as provided by the manufacturer are as follows:

The radio utilizes PCB (onboard) antennas, with maximum gains as follows:

Frequency Range (MHz)	Peak Antenna Gain (dBi)			
	Chain 0		Chain 1	
	ANT1 (LOB) (dBi)	ANT2 (LRM) (dBi)	ANT3 (RRM) (dBi)	ANT4 (ROB) (dBi)
2400 – 2483.5	2.1	4.2	4.1	2.4

### 6.4. SOFTWARE AND FIRMWARE

The EUT software used during testing was 70.1-29190-diag.

The test utility software used during testing was GUI\_V8.

## 6.5. TEST REDUCTION CASE

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

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.

The fundamental of the EUT was investigated in the antenna combinations, it was determined that Antenna 2 and Antenna 3 was the worst case; therefore, all final radiated testing was performed with Antenna 2 and Antenna 3.

Worst-case data rates as provided by the manufacturer were:

802.11ax HE20mode: MCS0  
802.11ax HE40mode: MCS0

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

- Testing was performed on 802.11ax HE20 26T(Lowest Tones) and 242T (Full Tone) to cover HE20 52T and 106T.
- Testing was performed on 802.11ax HE40 26T (Lowest Tones) and 484T(Full Tone) to cover HE40 52T,106T and 242T.

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

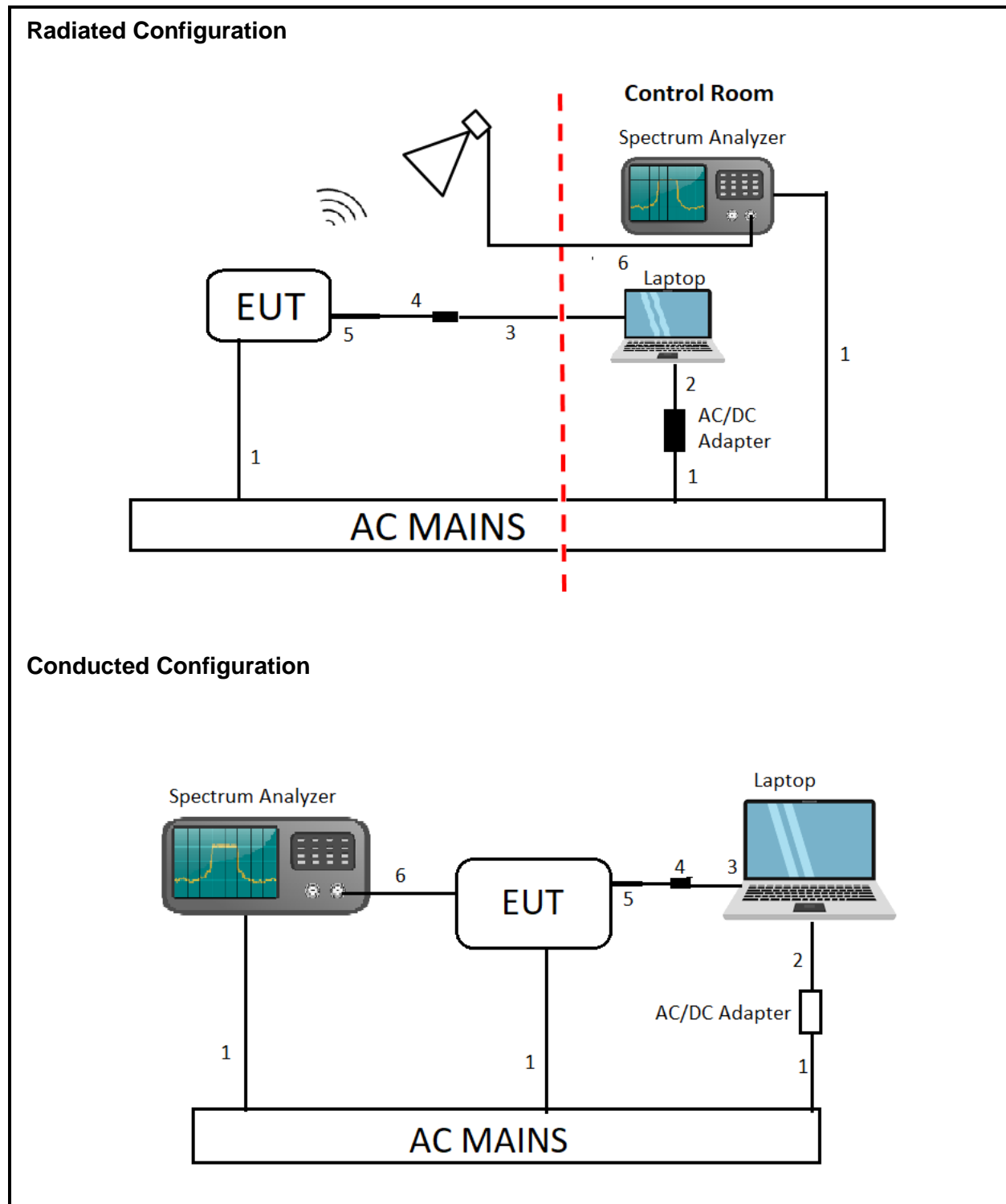
## 6.7. DESCRIPTION OF TEST SETUP

SUPPORT TEST EQUIPMENT						
Description		Manufacturer	Model	Serial Number		FCC ID/ DoC
Laptop		Lenovo	T460s	PC0JMBF8		Doc
Laptop AC/DC Adapter		Lenovo	ADLX90NLC2A	11S45N0247Z1ZSHH448JEY		Doc
USB-A to Ethernet Adapter		Plugable	USB2-E100	8CAE4CE46AFA		Doc
USB-C to USB-A Female Adapter		Amazon Basics	L6LUC160-CS-R	N/A		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 EUT/Spectrum Analyzer/AC/DC Adapter
2	DC	1	DC	Un-shielded	1	AC/DC Adapter to Laptop
3	Ethernet	1	RJ45	Un-shielded	1.5	Laptop to USB Ethernet Adapter
4	USB-A	1	USB-A	Shielded	0.05	USB EthernetAdapter to USB
5	USB-C	1	USB-C	Shielded	0.05	EUT to USB-C/USB-A Female Adapter
6	SMA Cable	1	SMA	Un-Shielded	0.1	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 EUT/Spectrum Analyzer/AC/DC Adapter
2	DC	1	DC	Un-shielded	1	AC/DC Adapter to Laptop
3	Ethernet	1	RJ45	Un-shielded	10	Laptop to USB Ethernet Adapter
4	USB-A	1	USB-A	Shielded	0.05	USB EthernetAdapter to USB
5	USB-C	1	USB-C	Shielded	0.05	EUT to USB-C/USB-A Female Adapter
6	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



## 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     $RBW \geq DTS \text{ BW}$

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

## 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	82258	2022-10-01	2021-10-01
Amplifier, 10KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	175953	2023-02-08	2022-02-08
Amplifier, 10KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310N	29654	2023-04-24	2022-04-24
Antenna, Horn 1-18GHz	ETS-Lindgren (Cedar Park, Texas)	3117	80707	2023-04-28	2022-04-28
RF Filter Box, 1-18GHz	FREMONT	SAC-L1	171013	2023-06-24	2022-06-24
EMI TEST RECEIVER, with B8 option	Rohde & Schwarz	ESW44	169937	2023-02-20	2022-02-20
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	169927	2023-02-16	2022-02-16
Antenna, Horn 18 to 26.5GHz	ARA	MWH-1826/B	81138	2022-10-13	2021-10-13
Amplifier 18-26.5GHz, +5Vdc, 60dB min	AMPLICAL	AMP18G26.5-60	215705	2023-02-26	2022-02-26
Antenna, Passive Loop 30Hz - 1MHz	ELECTRO METRICS	EM-6871	219909	2023-05-10	2022-05-10
Antenna, Passive Loop 100KHz - 30MHz	ELECTRO METRICS	EM-6872	219911	2023-05-10	2022-05-10
Spectrum Analyzer, PXA, 3Hz to 44GHz	Agilent Technologies	N9030A	80396	2023-05-10	2022-05-10
Power Meter, P-series single channel	Keysight Technologies Inc	N1911A	T1268	2023-01-02	2022-01-02
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc	N1921A	90419	2023-02-03	2022-02-03
AC Line Conducted					
LISN	Fischer Custom Communications, Inc	FCC-LISN-50/250-25-2-01-480V	175765	2023-01-26	2022-01-26
EMI TEST RECEIVER	Rohde & Schwarz	ESR	93091	2023-02-21	2022-02-21
Transient Limiter	Com-Power	LIT-930	127455	2023-02-02	2022-02-02
UL TEST SOFTWARE LIST					
Radiated Software	UL	UL EMC	Ver 2014-07-15, 2016-08-23, 2020-06-04, 2022-05-05, 2022-05-18, and 2022-07-06		
Antenna Port Software	UL	UL RF	Ver 2022-05-31		
AC Line Conducted Software	UL	UL EMC	Rev 9.5, 2022-02-17		

## 9. ANTENNA PORT TEST RESULTS

### 9.1. ON TIME AND DUTY CYCLE

#### LIMITS

None; for reporting purposes only.

#### PROCEDURE

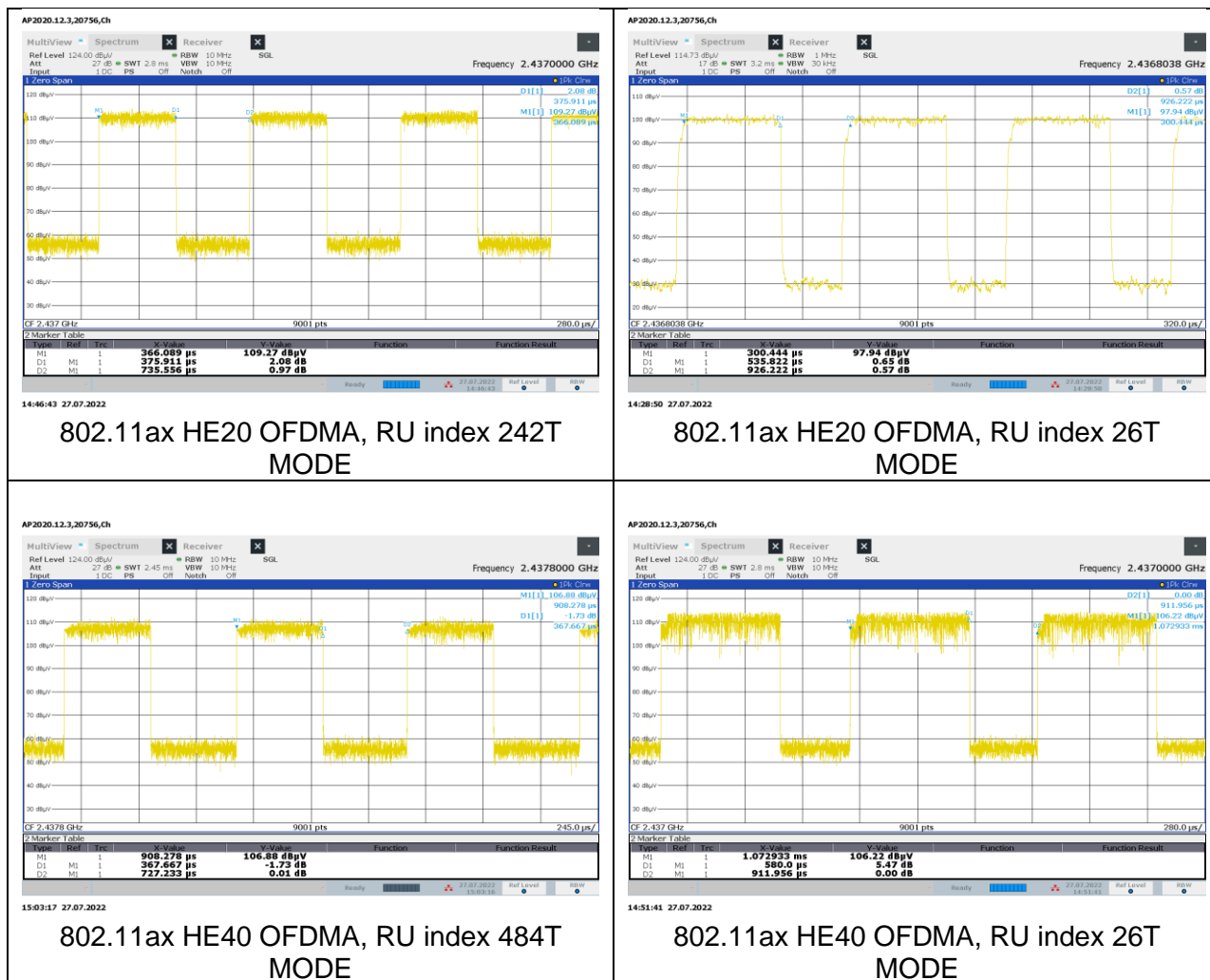
KDB 558074 D01 Zero-Span Spectrum Analyzer Method.

#### 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)
<b>2.4GHz Band</b>						
802.11ax HE20 OFDMA, RU size 242T	0.376	0.736	0.511	51.11	2.92	2.660
802.11ax HE20 OFDMA, RU size 26T	0.536	0.926	0.579	57.85	2.38	1.866
802.11ax HE40 OFDMA, RU size 484T	0.368	0.727	0.506	50.56	2.96	2.720
802.11ax HE40 OFDMA, RU size 26T	0.580	0.912	0.636	63.60	1.97	1.724



## DUTY CYCLE PLOTS



## **9.2. 6 dB BANDWIDTH**

### **LIMITS**

FCC §15.247 (a) (2)

ISED RSS-247 Clause 5.2 (a)

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

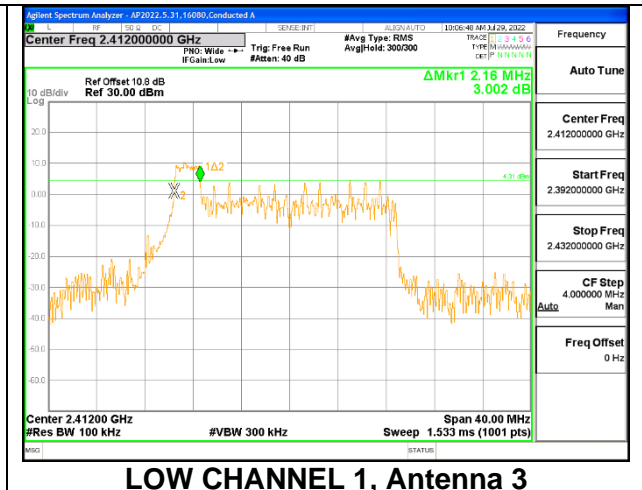
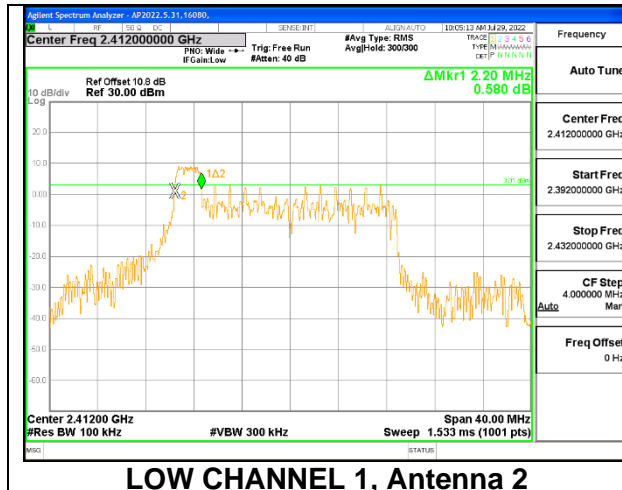
### **RESULTS**

## 9.2.1. 802.11ax HE20 MODE 2TX

### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0

Channel	Frequency (MHz)	6 dB BW Antenna 2 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Low 1	2412	2.20	2.16	0.5

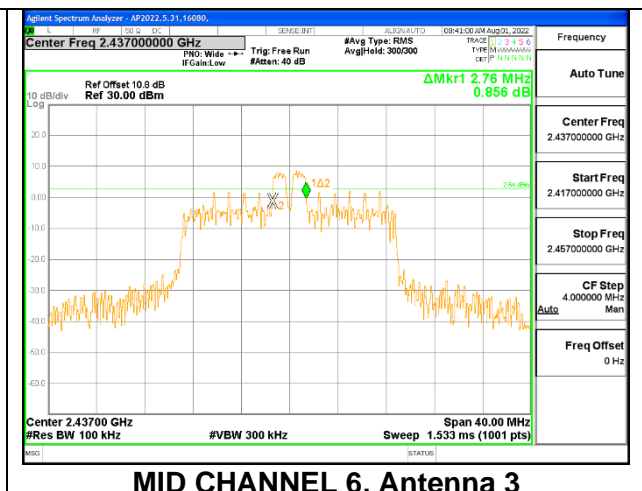
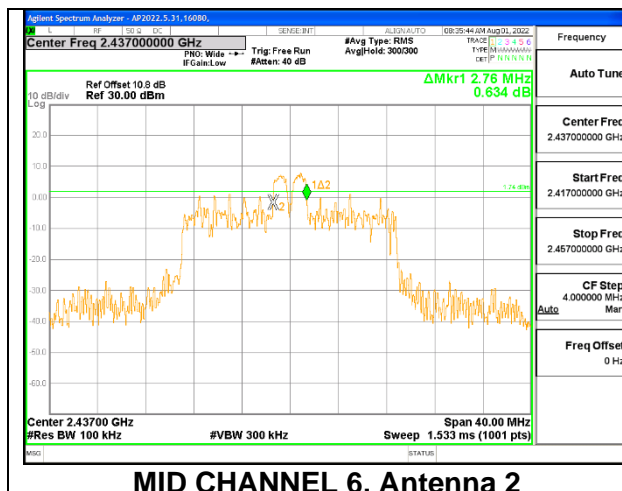
### LOW CHANNEL 1



### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 4

Channel	Frequency (MHz)	6 dB BW Antenna 2 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Mid 6	2437	2.76	2.76	0.5

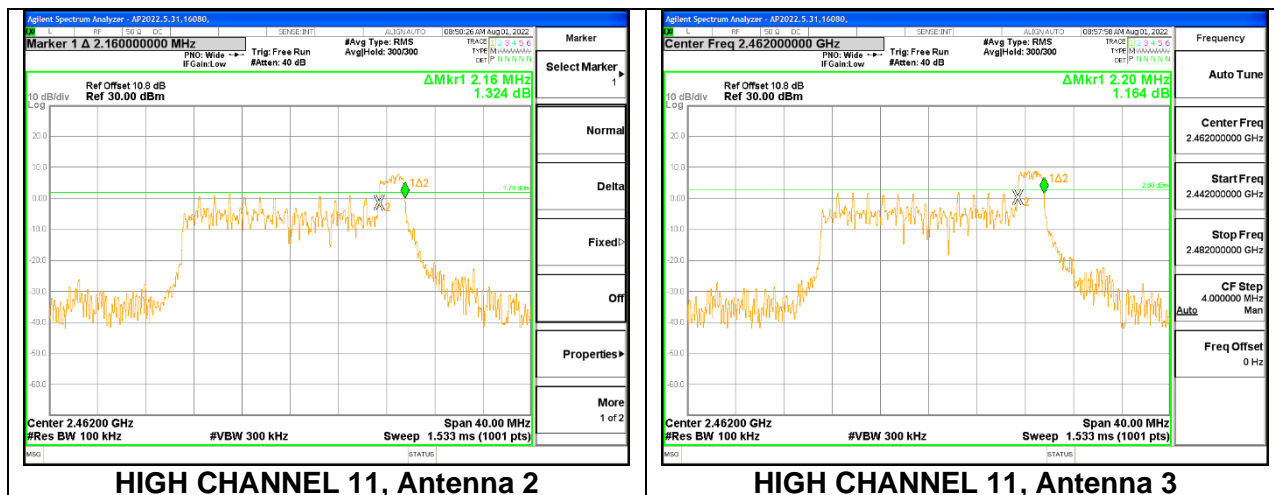
### MID CHANNEL 6



**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 8**

Channel	Frequency (MHz)	6 dB BW Antenna 2 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
High 11	2462	2.16	2.20	0.5

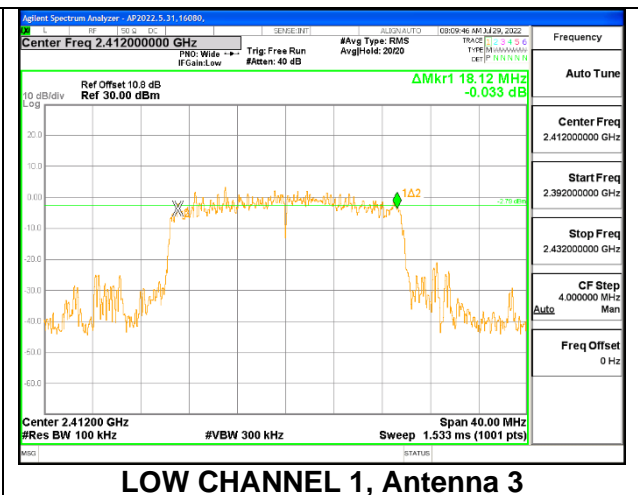
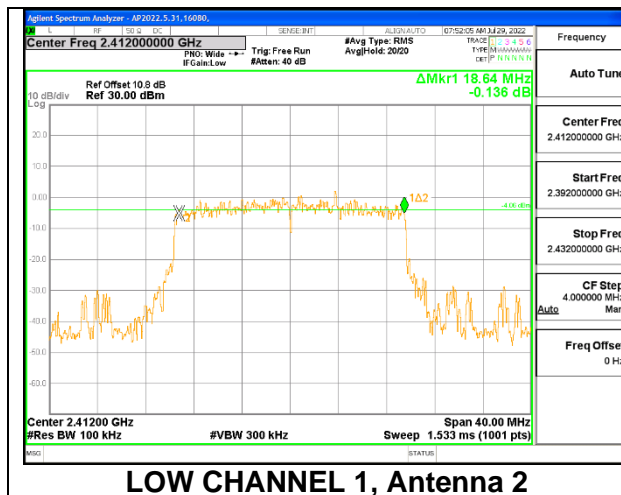
**HIGH CHANNEL 11**



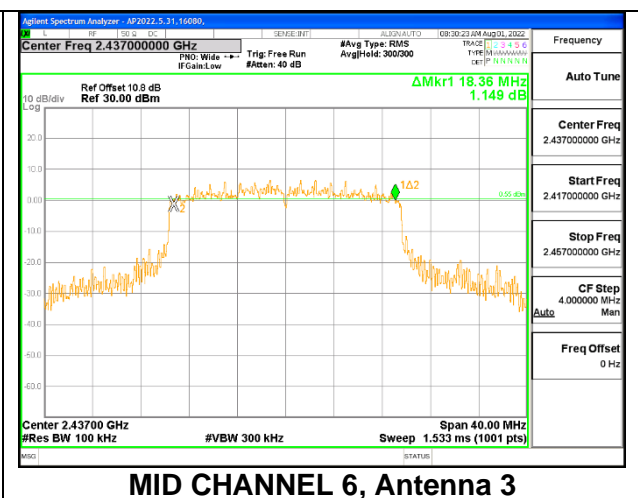
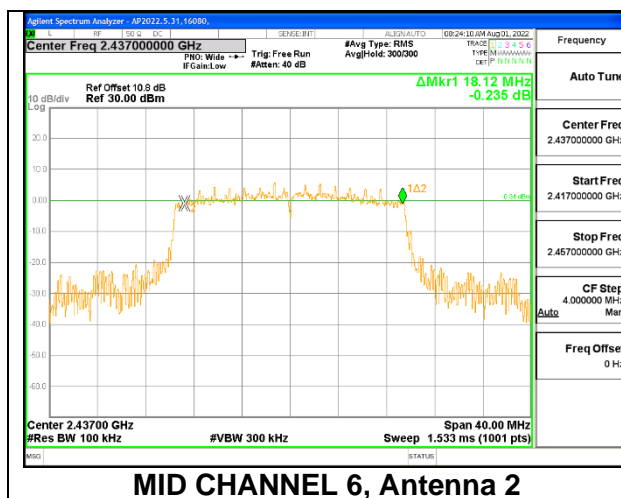
**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 242-Tones, RU Index 61**

Channel	Frequency (MHz)	6 dB BW Antenna 2 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Low 1	2412	18.64	18.12	0.5
Mid 6	2437	18.12	18.36	0.5
High 11	2462	18.56	18.76	0.5

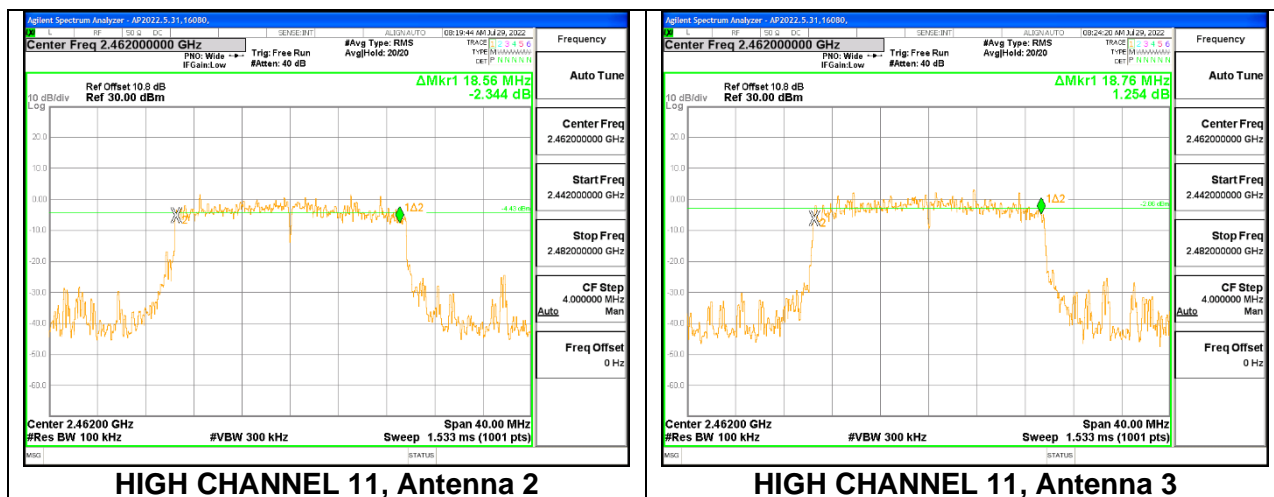
**LOW CHANNEL 1**



**MID CHANNEL 6**



## HIGH CHANNEL 11

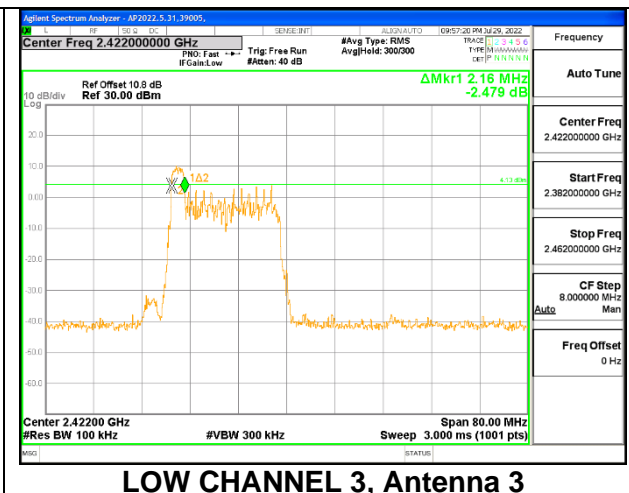
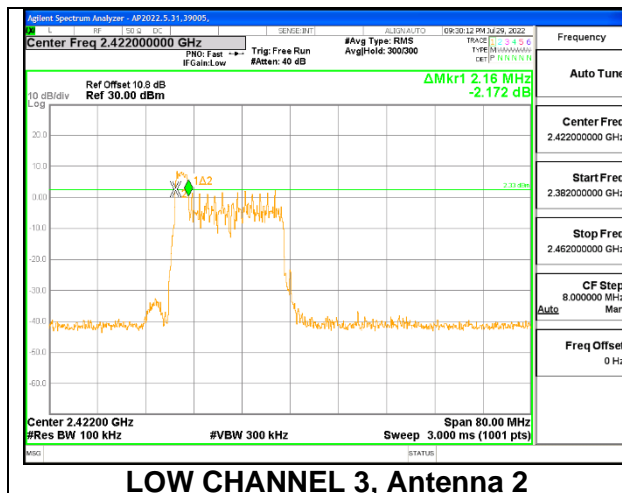


## 9.2.2. 802.11ax HE40 MODE 2TX

### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0

Channel	Frequency (MHz)	6 dB BW Antenna 2 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Low 3	2422	2.16	2.16	0.5

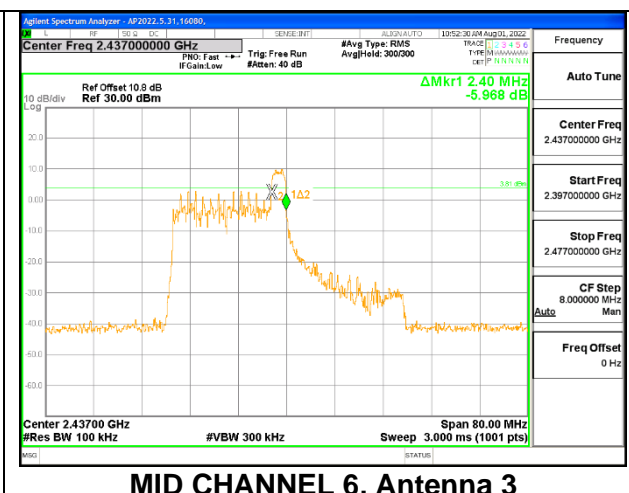
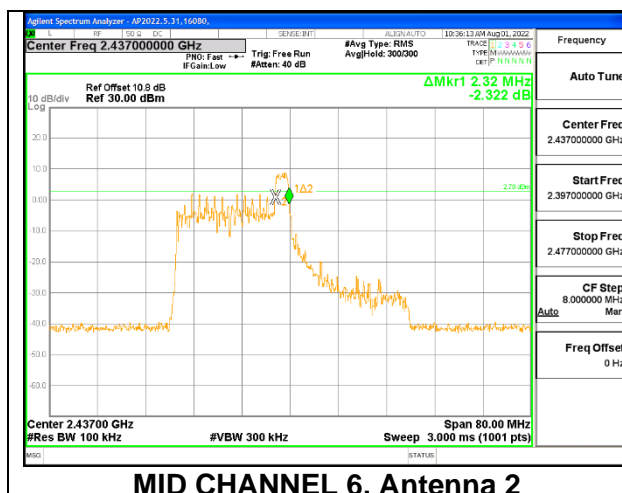
### LOW CHANNEL 3



### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 8

Channel	Frequency (MHz)	6 dB BW Antenna 2 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Mid 6	2437	2.32	2.40	0.5

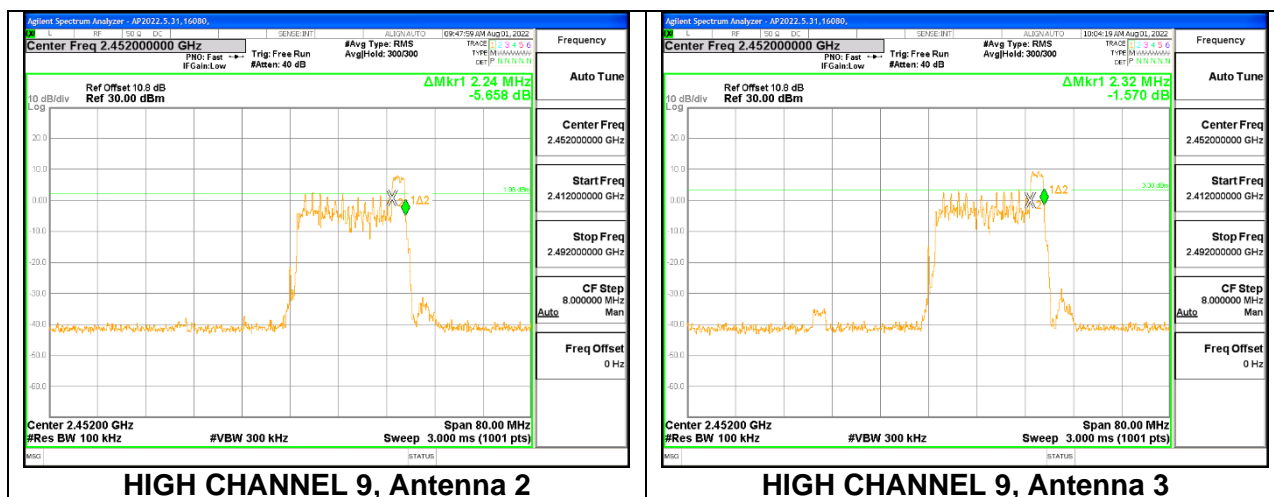
### MID CHANNEL 6



**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 17**

Channel	Frequency (MHz)	6 dB BW Antenna 2 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
High 9	2452	2.24	2.32	0.5

**HIGH CHANNEL 9**

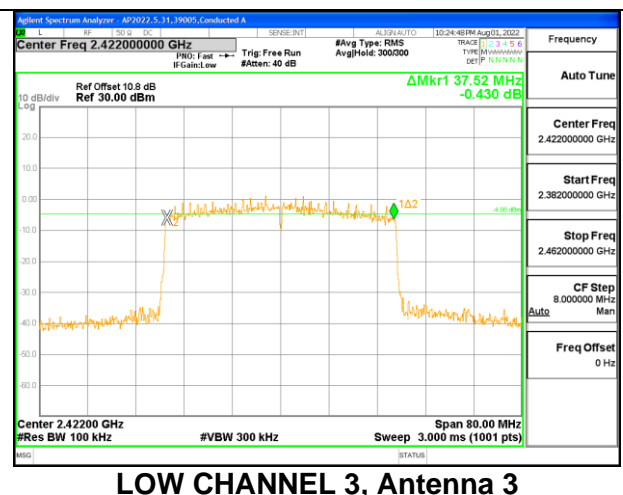
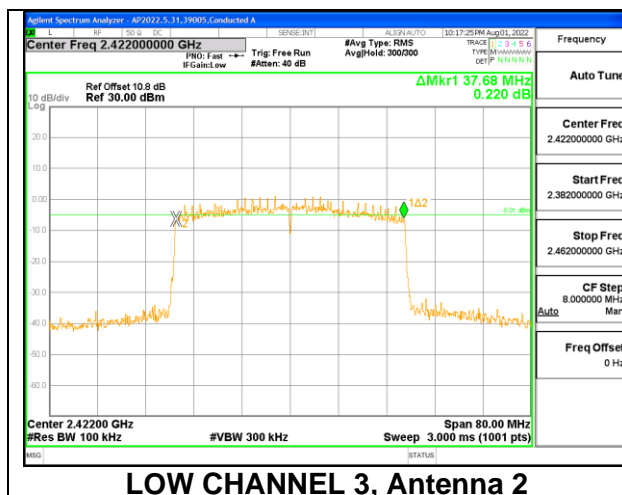




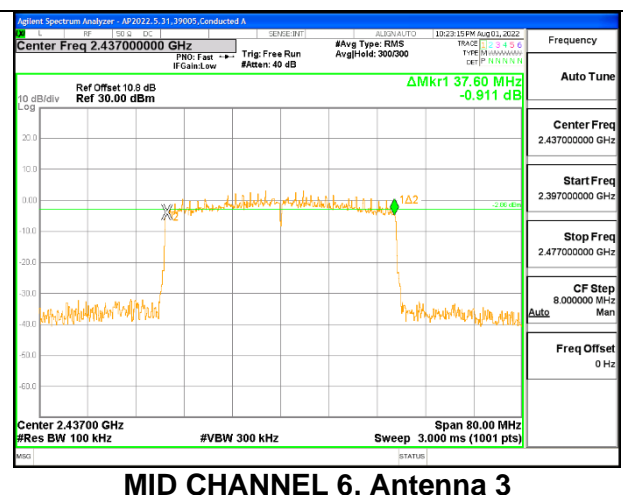
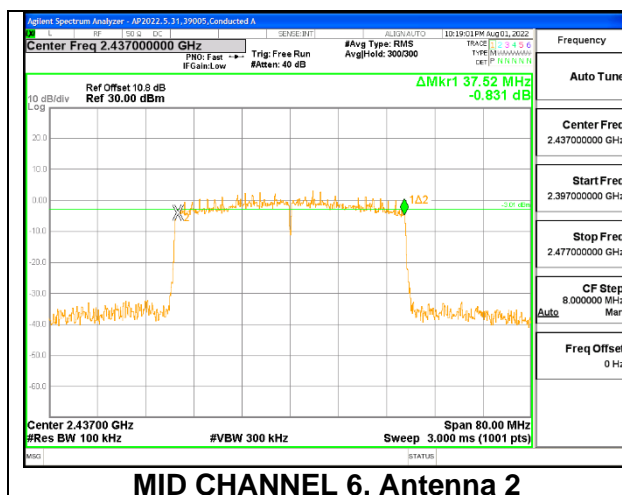
**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 484-Tones, RU Index 65**

Channel	Frequency (MHz)	6 dB BW Antenna 2 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Low 3	2422	37.68	37.52	0.5
Mid 6	2437	37.52	37.60	0.5
High 9	2452	37.60	37.60	0.5

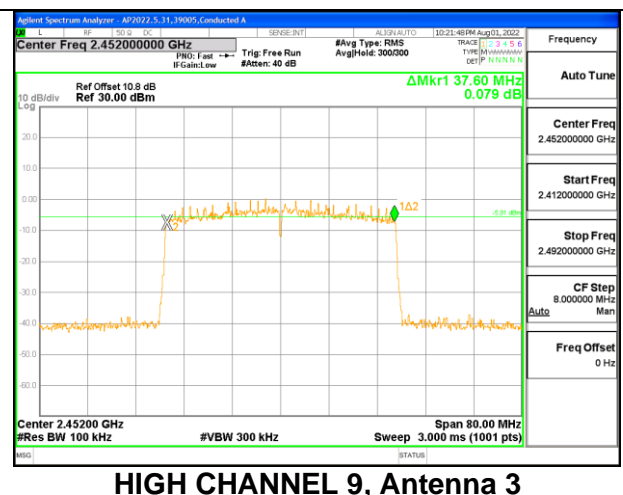
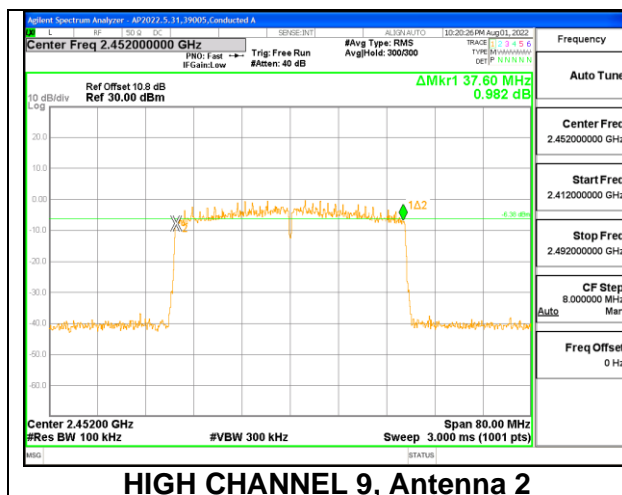
**LOW CHANNEL 3**



**MID CHANNEL 6**



## HIGH CHANNEL 9



### **9.3. 99% BANDWIDTH**

#### **LIMITS**

None; for reporting purposes only.

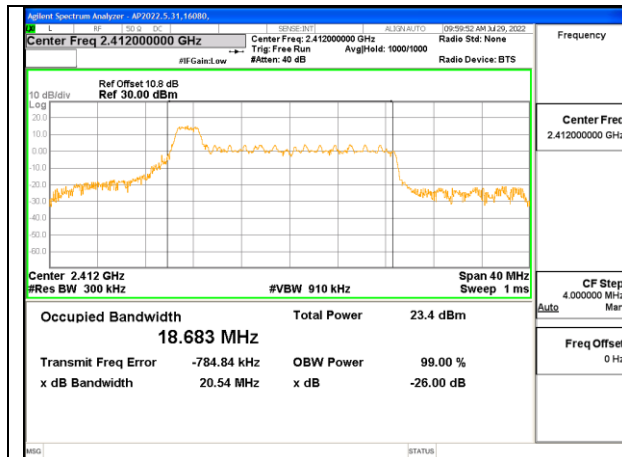
#### **RESULTS**

### 9.3.1. 802.11ax HE20 MODE 2TX

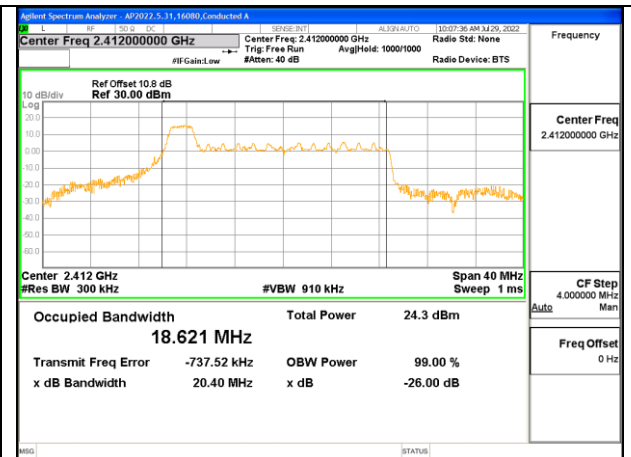
#### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0

Channel	Frequency (MHz)	99% Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 3 (MHz)
Low 1	2412	18.683	18.621

#### LOW CHANNEL 1



LOW CHANNEL 1, Antenna 2

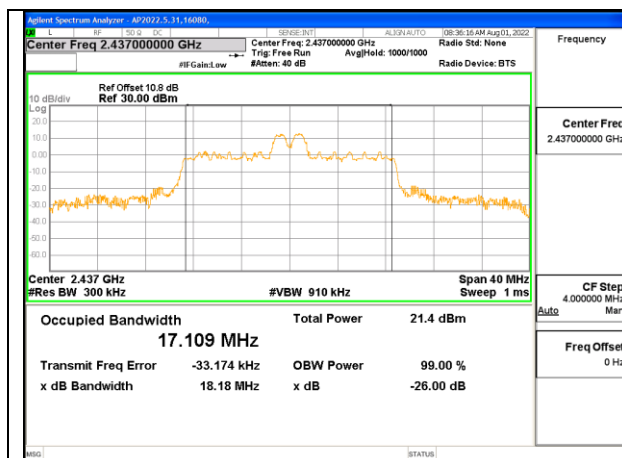


LOW CHANNEL 1, Antenna 3

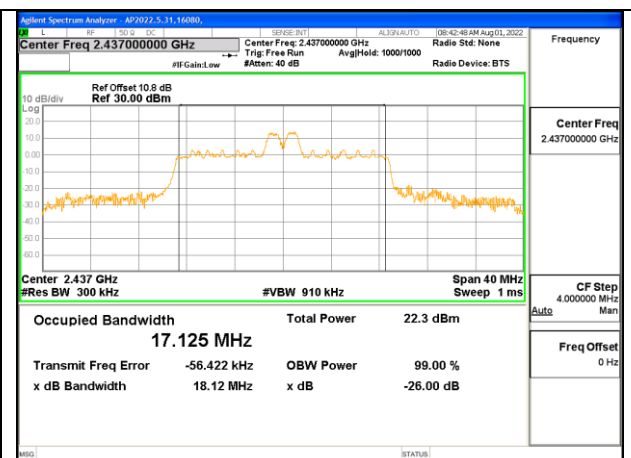
#### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 4

Channel	Frequency (MHz)	99% Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 3 (MHz)
Mid 6	2437	17.109	17.125

#### MID CHANNEL 6



MID CHANNEL 6, Antenna 2

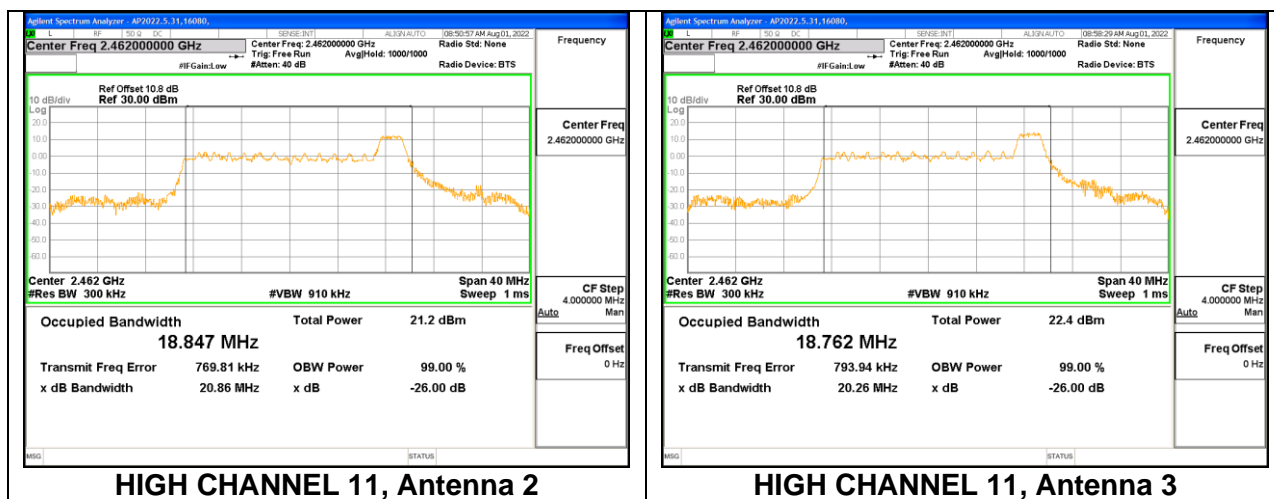


MID CHANNEL 6, Antenna 3

**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 8**

Channel	Frequency (MHz)	99% Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 3 (MHz)
High 11	2462	18.847	18.762

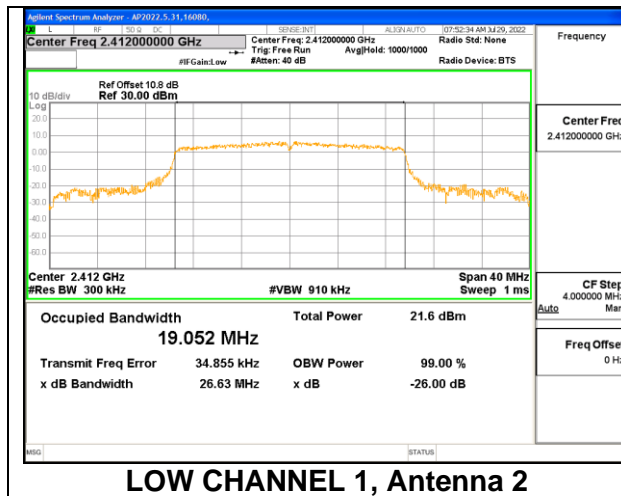
**HIGH CHANNEL 11**



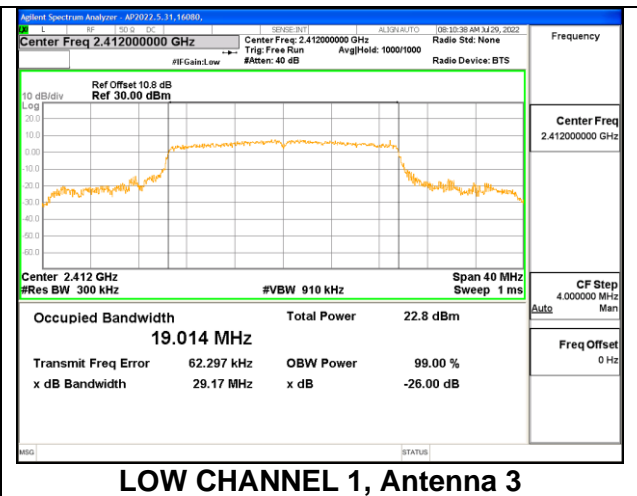
**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 242-Tones, RU Index 61**

Channel	Frequency (MHz)	99% Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 3 (MHz)
Low 1	2412	19.052	19.014
Mid 6	2437	19.086	19.043
High 11	2462	19.023	19.060

**LOW CHANNEL 1**

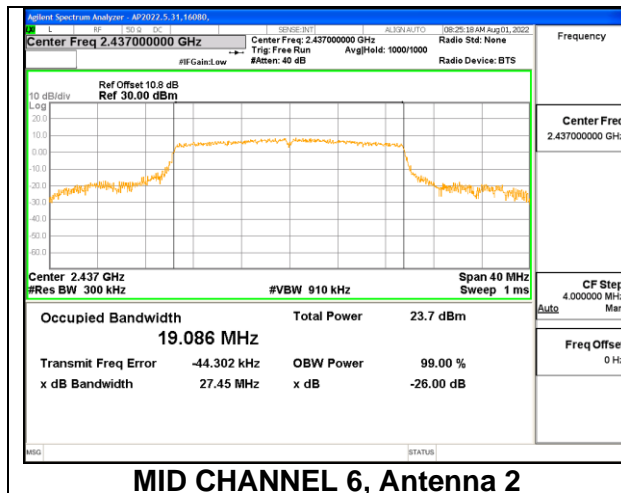


**LOW CHANNEL 1, Antenna 2**

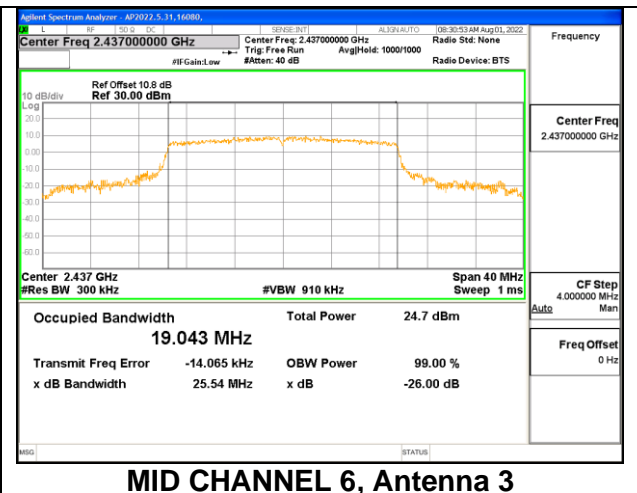


**LOW CHANNEL 1, Antenna 3**

**MID CHANNEL 6**

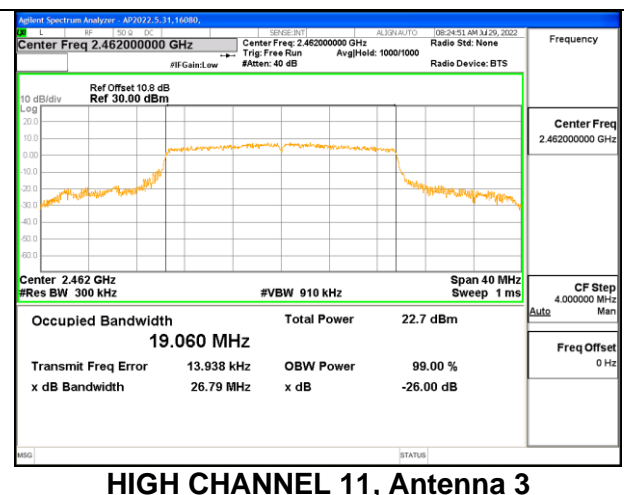
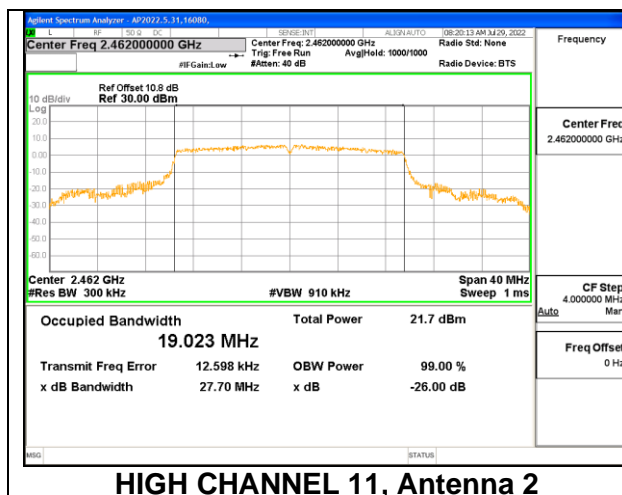


**MID CHANNEL 6, Antenna 2**



**MID CHANNEL 6, Antenna 3**

## HIGH CHANNEL 11

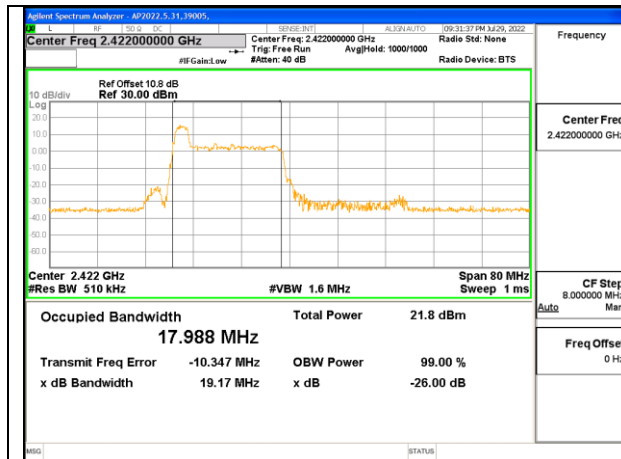


### 9.3.2. 802.11ax HE40 MODE 2TX

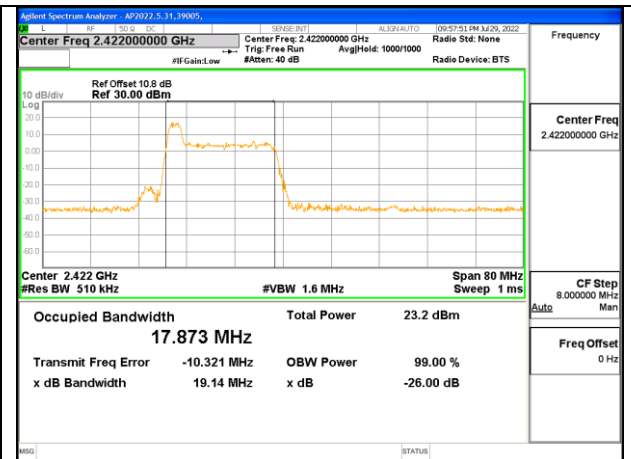
#### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0

Channel	Frequency (MHz)	99% Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 3 (MHz)
Low 3	2422	17.988	17.873

#### LOW CHANNEL 3



LOW CHANNEL 3, Antenna 2

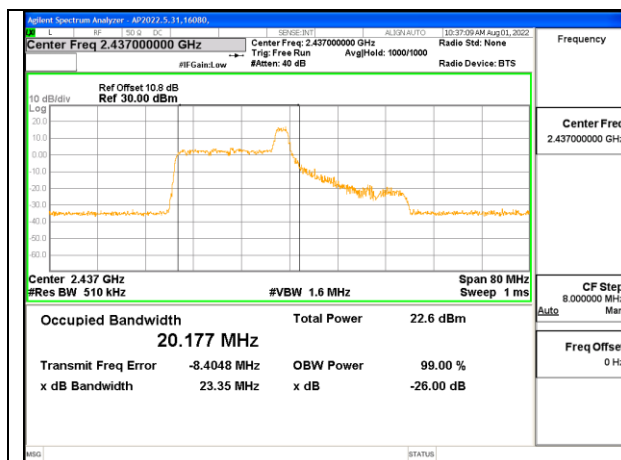


LOW CHANNEL 3, Antenna 3

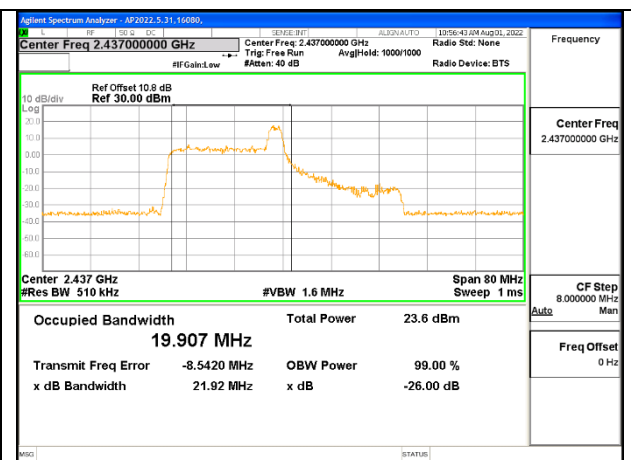
#### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 8

Channel	Frequency (MHz)	99% Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 3 (MHz)
Mid 6	2437	20.177	19.907

#### MID CHANNEL 6



MID CHANNEL 6, Antenna 2



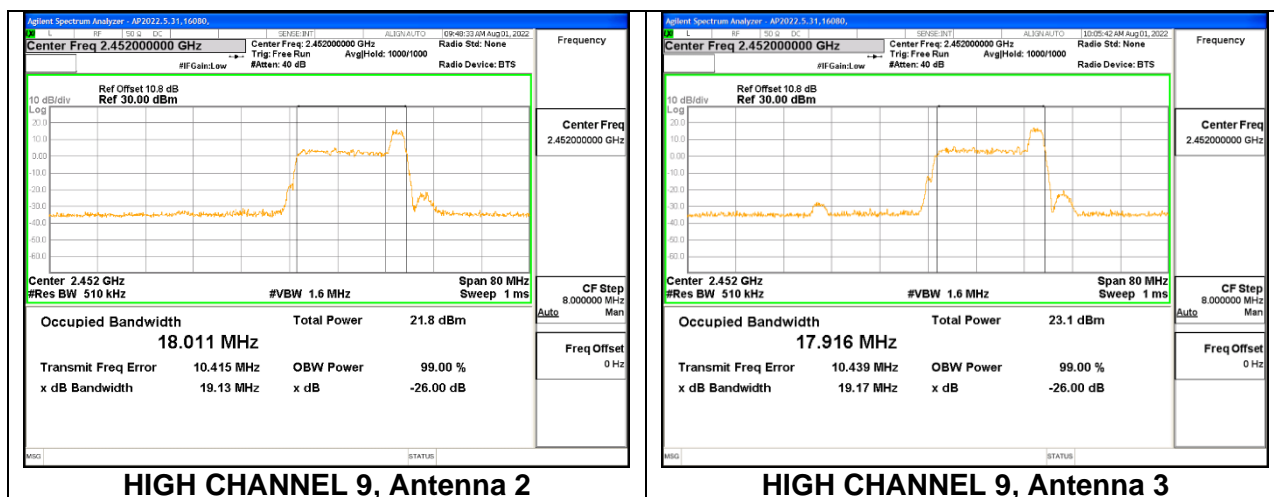
MID CHANNEL 6, Antenna 3



**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 17**

Channel	Frequency (MHz)	99% Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 3 (MHz)
High 9	2452	18.011	17.916

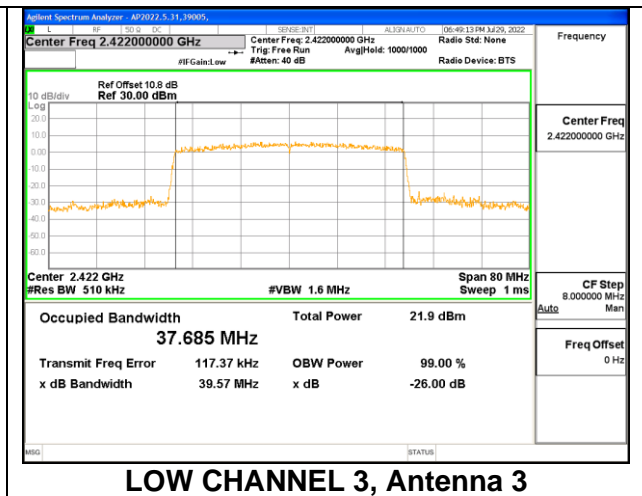
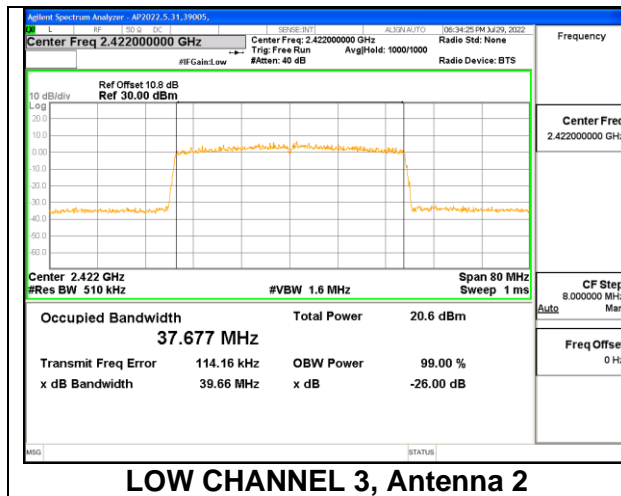
**HIGH CHANNEL 9**



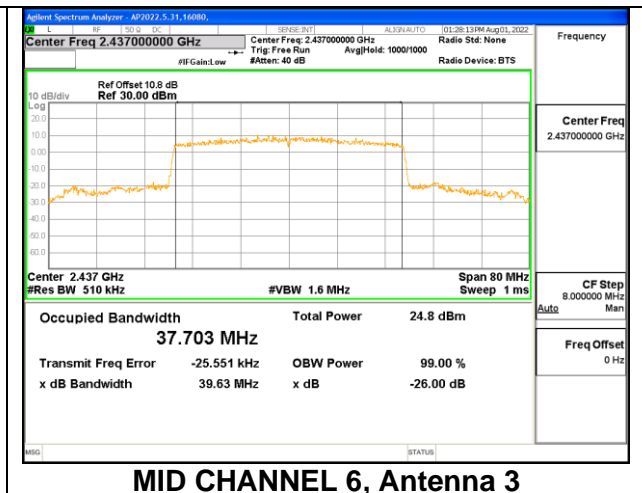
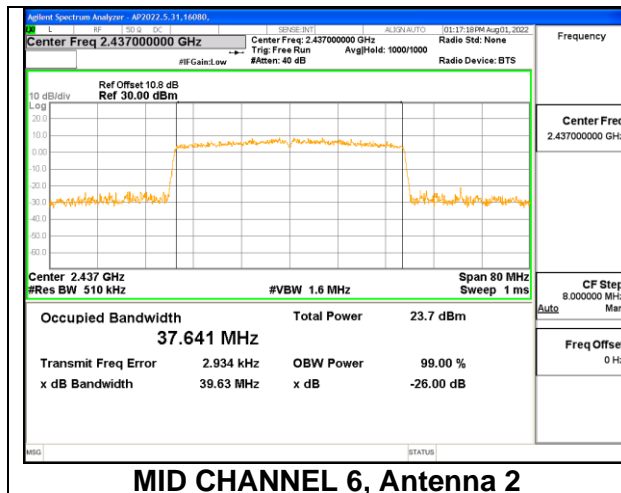
**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 484-Tones, RU Index 65**

Channel	Frequency (MHz)	99% Bandwidth Antenna 2 (MHz)	99% Bandwidth Antenna 3 (MHz)
Low 3	2422	37.677	37.685
Mid 6	2437	37.641	37.703
High 9	2452	37.638	37.607

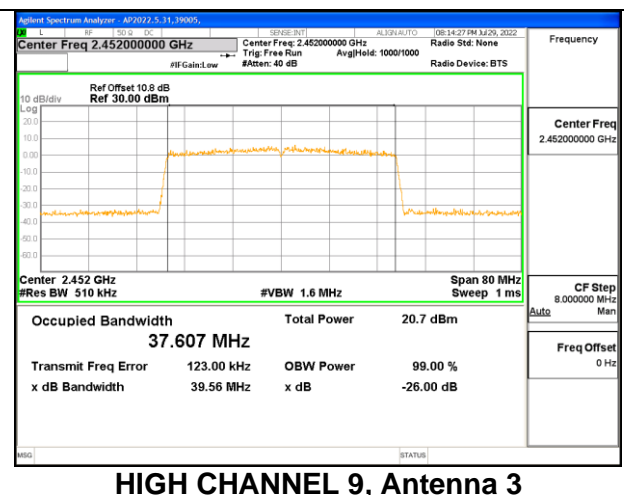
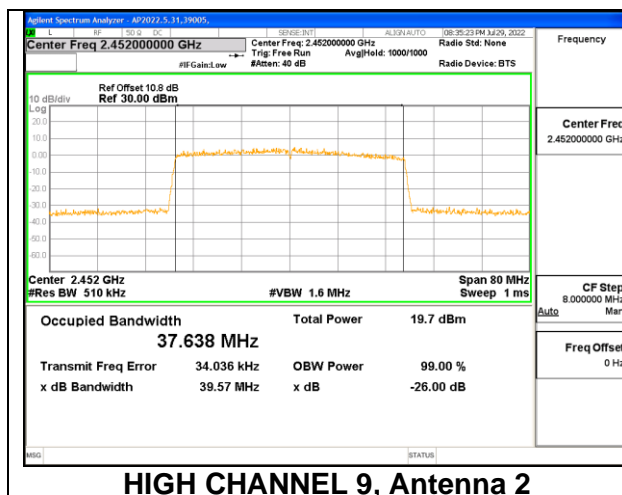
**LOW CHANNEL 3**



**MID CHANNEL 6**



## HIGH CHANNEL 9



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

### **DIRECTIONAL ANTENNA GAIN**

For 2TX:

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 2 and Antenna 3 are the worst-case combinations.

#### **Antenna 1 and Antenna 3:**

Band (GHz)	Chain 0 Antenna 1 Gain (dBi)	Chain 1 Antenna 3 Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	2.10	4.10	3.21	6.17

#### **Antenna 1 and Antenna 4:**

Band (GHz)	Chain 0 Antenna 1 Gain (dBi)	Chain 1 Antenna 4 Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	2.10	2.40	2.25	5.26

#### **Antenna 2 and Antenna 3 (Worst-case):**

Band (GHz)	Chain 0 Antenna 2 Gain (dBi)	Chain 1 Antenna 3 Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	4.20	4.10	4.15	7.16

#### **Antenna 2 and Antenna 4:**

Band (GHz)	Chain 0 Antenna 2 Gain (dBi)	Chain 1 Antenna 4 Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)	Correlated Chains Directional Gain (dBi)
2.4	4.20	2.40	3.39	6.36

Directional Gain value was determined using the following formula:

Uncorrelated Directional Gain dBi =  $10 \log [(10^{(\text{Ant } 1/10)} + 10^{(\text{Ant } 2/10)})/2]$

Correlated Directional Gain dBi =  $10 \log [(10^{(\text{Ant } 1/20)} + 10^{(\text{Ant } 2/20)^2})/2]$

Uncorrelated Directional Gain sample calculation:

3.39 dBi =  $10 \log [(10^{(4.2/10)} + 10^{(2.4/10)})/2]$

Correlated Directional Gain sample calculation:

6.36 dBi =  $10 \log [(10^{(4.2/20)} + 10^{(2.4/20)^2})/2]$

## RESULT

### 9.4.1. 802.11ax HE20 MODE 2TX

#### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0

Test Engineer:	RA39005
Test Date:	2022-08-04

#### Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	4.15	30.00	36	30.00

#### Results

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 1	2412	21.72	22.67	25.23	30.00	-4.77

#### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 4

Test Engineer:	RA39005
Test Date:	2022-08-04

#### Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Mid 6	2437	4.15	30.00	36	30.00

#### Results

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Mid 6	2437	21.75	22.83	25.33	30.00	-4.67

**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 8**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

**Limits**

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
High 11	2462	4.15	30.00	36	30.00

**Results**

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
High 11	2462	21.80	22.70	25.28	30.00	-4.72

**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 242-Tones, RU Index 61**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

**Limits**

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	4.15	30.00	36	30.00
Mid 6	2437	4.15	30.00	36	30.00
High 11	2462	4.15	30.00	36	30.00

**Results**

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 1	2412	23.92	24.30	27.12	30.00	-2.88
Mid 6	2437	25.22	25.50	28.37	30.00	-1.63
High 11	2462	23.62	24.31	26.99	30.00	-3.01



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

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

**Limits**

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	4.15	30.00	36	30.00
Mid 6	2437	4.15	30.00	36	30.00
High 11	2462	4.15	30.00	36	30.00

**Results**

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 1	2412	22.80	23.82	26.35	30.00	-3.65
Mid 6	2437	23.42	24.83	27.19	30.00	-2.81
High 11	2462	22.83	23.22	26.04	30.00	-3.96

### 9.4.2. 802.11ax HE40 MODE 2TX

#### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

#### Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 3	2422	4.15	30.00	36	30.00

#### Results

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 3	2422	22.52	23.56	26.08	30.00	-3.92

#### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 8

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Mid 6	2437	4.15	30.00	36	30.00

#### Results

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Mid 6	2437	22.64	23.63	26.17	30.00	-3.83

**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 17**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

**Limits**

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
High 9	2452	4.15	30.00	36	30.00

**Results**

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
High 9	2452	22.40	23.52	26.01	30.00	-3.99

**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 484-Tones, RU Index 65**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

**Limits**

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 3	2422	4.15	30.00	36	30.00
Mid 6	2437	4.15	30.00	36	30.00
High 9	2452	4.15	30.00	36	30.00

**Results**

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 3	2422	23.77	24.44	27.13	30.00	-2.87
Mid 6	2437	25.21	25.62	28.43	30.00	-1.57
High 9	2452	22.22	22.79	25.52	30.00	-4.48

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

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

**Limits**

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 3	2422	4.15	30.00	36	30.00
Mid 6	2437	4.15	30.00	36	30.00
High 9	2452	4.15	30.00	36	30.00

**Results**

Channel	Frequency (MHz)	Antenna 2 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 3	2422	23.16	24.47	26.87	30.00	-3.13
Mid 6	2437	24.30	25.48	27.94	30.00	-2.06
High 9	2452	21.90	22.53	25.24	30.00	-4.76

## **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 power sensor. Gated average output power was read directly from power meter.

## **RESULTS**

### **9.5.1. 802.11ax HE20 MODE 2TX**

#### **2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 1	2412	12.88	13.86	16.41

#### **2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 4**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Mid 6	2437	12.86	13.89	16.42

#### **2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 8**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
High 11	2462	12.84	13.87	16.40

**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 242-Tones, RU Index 61**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 1	2412	14.59	15.55	18.11
Mid 6	2437	16.45	17.40	19.96
High 11	2462	14.65	15.44	18.07

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

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 1	2412	14.58	15.55	18.10
Mid 6	2437	16.40	17.40	19.94
High 11	2462	14.62	15.44	18.06

## 9.5.2. 802.11ax HE40 MODE 2TX

### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0

Test Engineer:	RA39005
Test Date:	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 3	2422	13.45	14.43	16.98

### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 8

Test Engineer:	RA39005
Test Date:	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Mid 6	2437	13.79	14.88	17.38

### 2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 17

Test Engineer:	RA39005
Test Date:	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
High 9	2452	13.42	14.39	16.94



**2TX Antenna 2 + Antenna 3 CDD OFDMA MODE: 484-Tones, RU Index 65**

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 3	2422	14.70	15.81	18.30
Mid 6	2437	16.40	17.49	19.99
High 9	2452	12.88	13.70	16.32

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

<b>Test Engineer:</b>	RA39005
<b>Test Date:</b>	2022-08-04

Channel	Frequency (MHz)	Antenna 2 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 3	2422	14.60	15.80	18.25
Mid 6	2437	16.37	17.48	19.97
High 9	2452	12.77	13.60	16.22

## 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 2 + Antenna 3 CDD OFDMA MODE: 26-Tones, RU Index 0

Duty Cycle CF (dB)	2.38	Included in Calculations of Corr'd PSD
--------------------	------	--

#### PSD Results

Channel	Frequency (MHz)	Antenna 2 Meas (dBm/ 3kHz)	Antenna 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low 1	2412	-3.991	-3.800	1.50	8.0	-6.5

### LOW CHANNEL 1

