

TEST REPORT

Report Number. : 14516849-E3V5

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

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	2023-04-18	Initial Issue	
V2	2023-05-05	Updated Section 6.3, 6.6 and 10.2	Kiya Kedida
V3	2023-05-09	Updated Section 9.4.2	Kiya Kedida
V4	2023-05-17	Updated Section 6.6	Kiya Kedida
V5	2023-05-25	Section 6.6 updated the setup diagram and the description of test setup cable #3	Glenn Escano

REPORT REVISION HISTORY 2

1. ATTESTATION OF TEST RESULTS 5

2. TEST RESULTS SUMMARY 7

3. TEST METHODOLOGY 8

4. FACILITIES AND ACCREDITATION 8

5. DECISION RULES AND MEASUREMENT UNCERTAINTY 9

 5.1. METROLOGICAL TRACEABILITY 9

 5.2. DECISION RULES 9

 5.3. MEASUREMENT UNCERTAINTY 9

 5.4. SAMPLE CALCULATION 10

6. EQUIPMENT UNDER TEST 11

 6.1. EUT DESCRIPTION 11

 6.2. MAXIMUM OUTPUT POWER 11

 6.3. DESCRIPTION OF AVAILABLE ANTENNAS 12

 6.4. SOFTWARE AND FIRMWARE 12

 6.5. WORST-CASE CONFIGURATION AND MODE 12

 6.6. DESCRIPTION OF TEST SETUP 13

7. MEASUREMENT METHOD 15

8. TEST AND MEASUREMENT EQUIPMENT 16

9. ANTENNA PORT TEST RESULTS 17

 9.1. ON TIME AND DUTY CYCLE 17

 9.2. 99% BANDWIDTH 19

 9.2.1. 802.11b MODE 19

 9.2.2. 802.11g MODE 21

 9.2.3. 802.11n HT20 MODE 25

 9.3. 6 dB BANDWIDTH 28

 9.3.1. 802.11b MODE 29

 9.3.2. 802.11g MODE 31

 9.3.3. 802.11n HT20 MODE 35

 9.4. OUTPUT POWER 38

 9.4.1. 802.11b MODE 41

 9.4.2. 802.11g MODE 42

 9.4.3. 802.11n HT20 MODE 43

 9.5. AVERAGE POWER 44

 9.5.1. 802.11b MODE 45

 9.5.2. 802.11g MODE 45

 9.5.3. 802.11n HT20 MODE 46

9.6.	<i>POWER SPECTRAL DENSITY</i>	47
9.6.1.	802.11b MODE.....	48
9.6.2.	802.11g MODE.....	50
9.6.3.	802.11n HT20 MODE	54
9.7.	<i>CONDUCTED SPURIOUS EMISSIONS</i>	58
9.7.1.	802.11b MODE.....	59
9.7.2.	802.11g MODE.....	61
9.7.3.	802.11n HT20 MODE	67
10.	RADIATED TEST RESULTS	71
10.1.	<i>TRANSMITTER ABOVE 1 GHz</i>	73
10.1.1.	TX ABOVE 1 GHz 802.11b MODE IN THE 2.4 GHz BAND.....	73
10.1.2.	TX ABOVE 1 GHz 802.11g MODE IN THE 2.4 GHz BAND.....	83
10.1.3.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 2.4 GHz BAND.....	108
10.2.	<i>WORST CASE BELOW 30MHz</i>	130
10.3.	<i>WORST CASE BELOW 1 GHz</i>	132
10.4.	<i>WORST CASE 18-26 GHz</i>	134
11.	AC POWER LINE CONDUCTED EMISSIONS	136
12.	SETUP PHOTOS	139

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: S44

BRAND: Sonos

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

SAMPLE RECEIPT DATE: 2023-02-13

DATE TESTED: 2023-02-13 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.

Approved & Released For
UL Verification Services Inc. By:



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

Prepared By:



Glenn Escano
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.

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, 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	550739
<input type="checkbox"/>	Building 2: 47266 Benicia Street Fremont, CA 94538, U.S.A	US0104	22541	550739
<input checked="" type="checkbox"/>	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 Frequency (Spectrum Analyzer)	141.16 Hz
Occupied Bandwidth	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	1.94 dB
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°C
Humidity	3.39%
DC Supply Voltages	0.57%

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 2.4GHz Wifi radio.

6.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

2.4GHz BAND

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2Tx			
2412 - 2462	802.11b	26.45	441.57
2412 - 2462	802.11g	28.71	743.02
2412 - 2462	802.11n HT20 CDD	28.81	760.33

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. 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.

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

802.11b mode: 1 Mbps

802.11g mode: 6 Mbps

802.11n HT20mode: MCS0

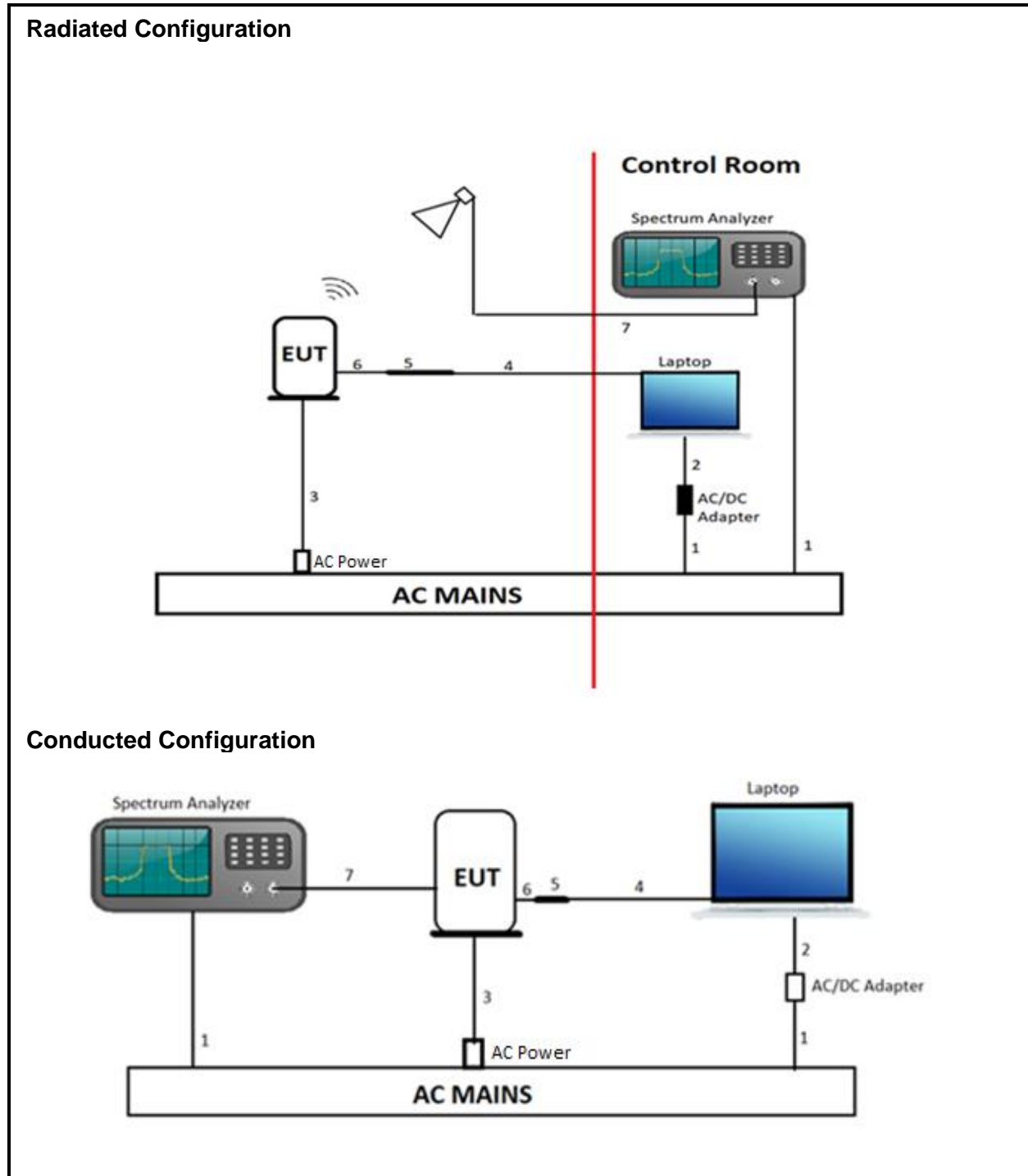
6.6. DESCRIPTION OF TEST SETUP

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		
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 Spectrum Analyzer/AC/DC Adapter
2	DC	1	DC	Un-shielded	1	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	0.05	USB Ethernet Adapter to USB
6	USB-C	1	USB-C	Shielded	0.05	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	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	0.05	USB Ethernet Adapter to USB
6	USB-C	1	USB-C	Shielded	0.05	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



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 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

<u>Band-edge:</u> ANSI C63.10 Subclause -11.13.3.2	Integration method -Peak detection
<u>Band-edge:</u> ANSI C63.10 Subclause -11.13.3.3	Integration method -Trace averaging with continuous transmission at full power
<u>Band-edge:</u> 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	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		

9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

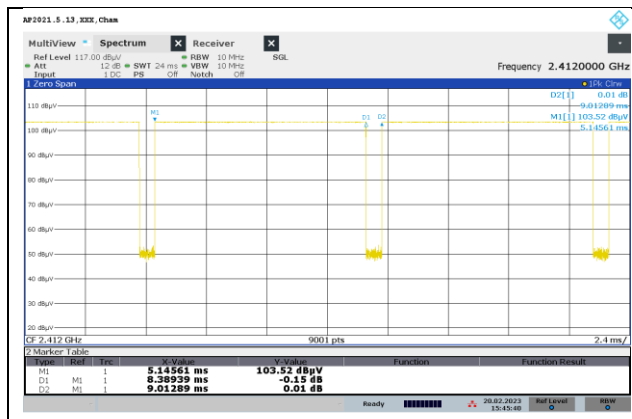
None; for reporting purposes only.

PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

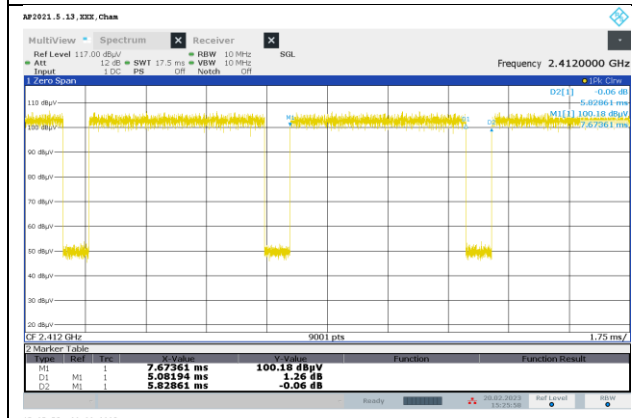
Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
2.4GHz Band						
802.11b	8.389	9.013	0.931	93.08	0.31	0.119
802.11g	2.75	3.42	0.805	80.53	0.94	0.363
802.11n HT20	5.08	5.83	0.872	87.20	0.60	0.197



DUTY CYCLE 802.11b MODE



DUTY CYCLE 802.11g MODE



DUTY CYCLE 802.11n HT20 MODE

9.2. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

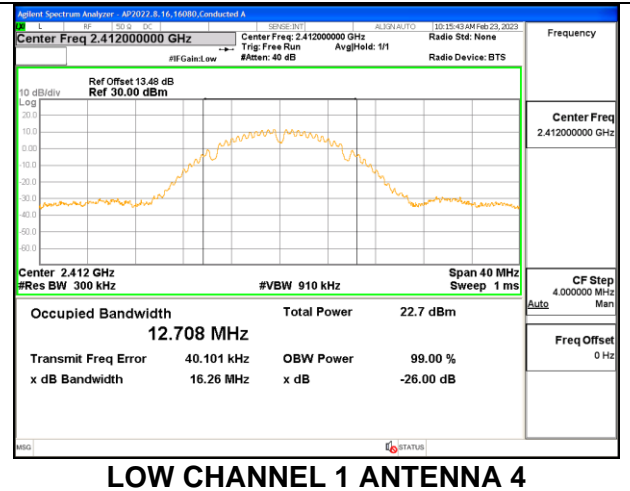
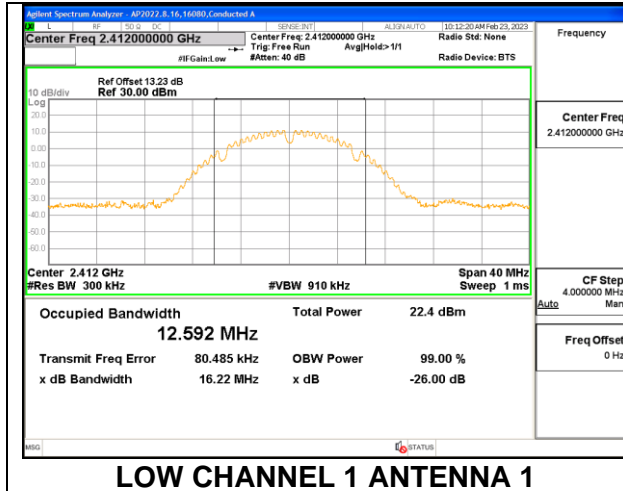
RESULTS

9.2.1. 802.11b MODE

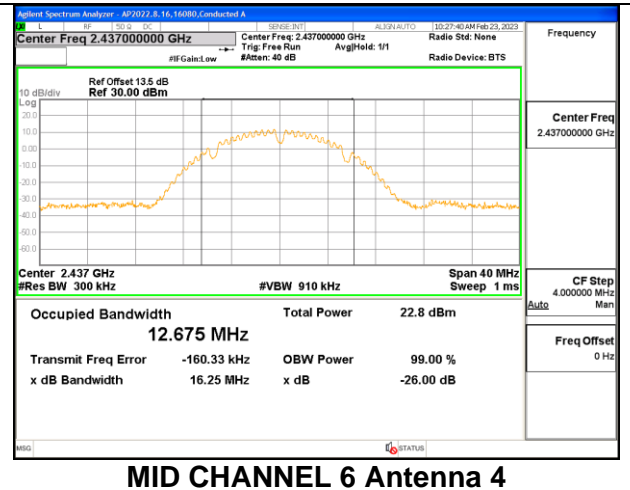
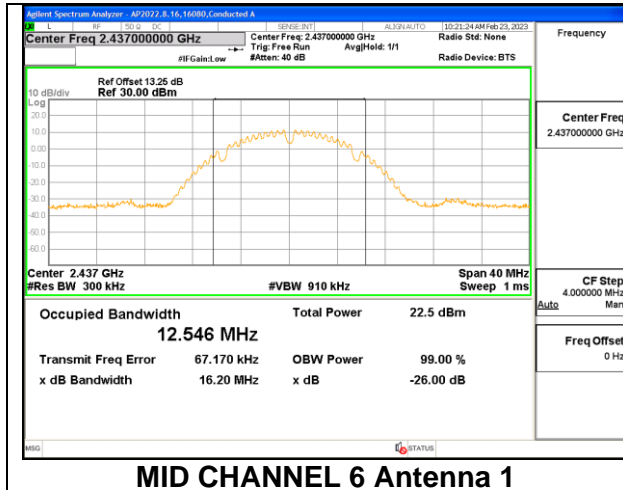
2TX Antenna 1 + Antenna 4 CDD MODE

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 4 (MHz)
Low 1	2412	12.592	12.708
Mid 6	2437	12.546	12.675
High 11	2462	12.868	12.854

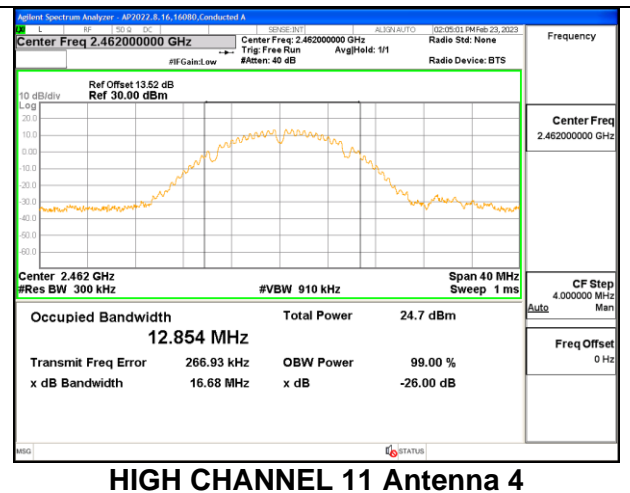
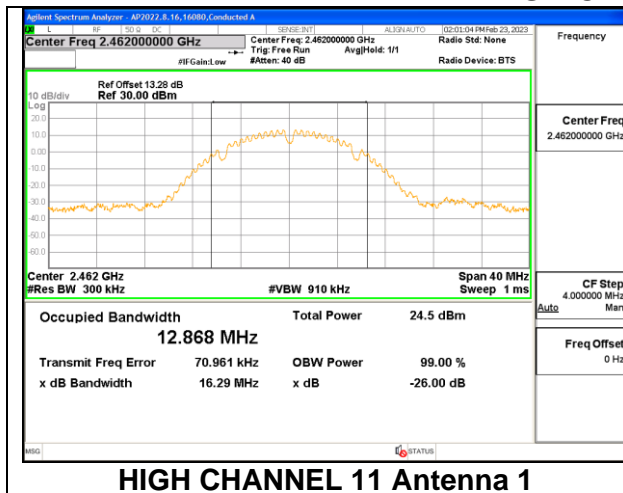
LOW CHANNEL 1



MID CHANNEL 6



HIGH CHANNEL 11

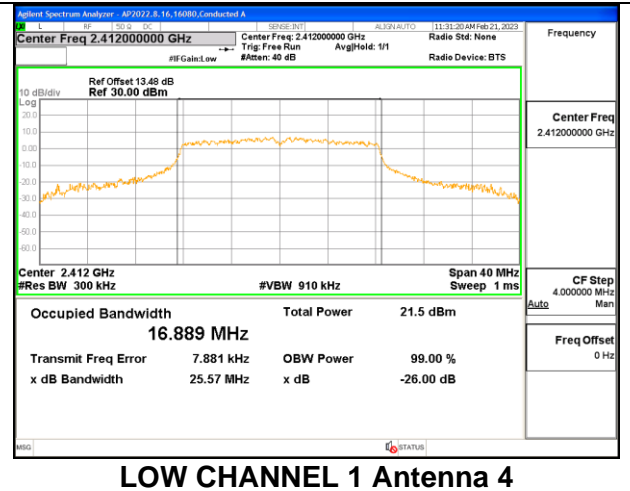
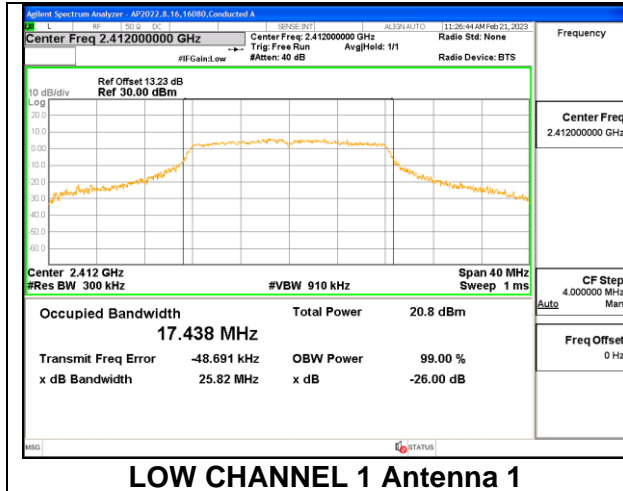


9.2.2. 802.11g MODE

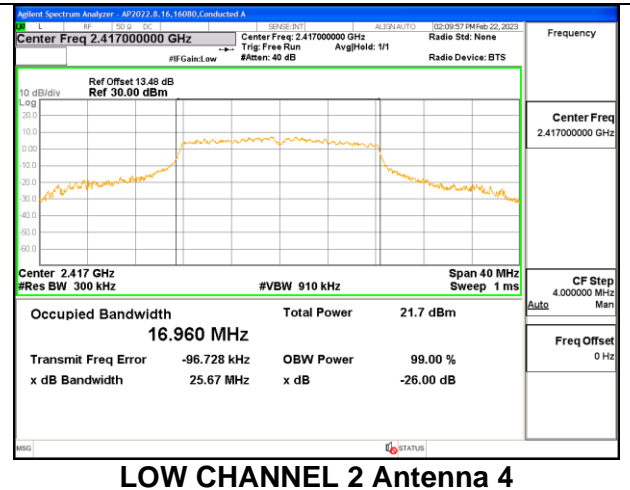
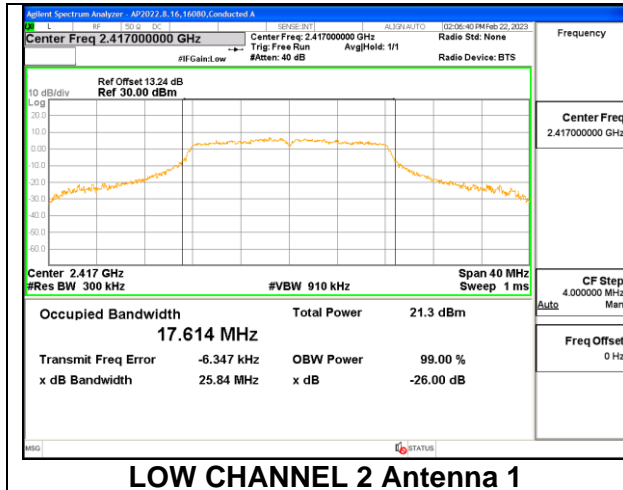
2TX Antenna 1 + Antenna 4 CDD MODE

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 4 (MHz)
Low 1	2412	17.438	16.889
Low 2	2417	17.614	16.960
Low 3	2422	17.554	16.958
Mid 6	2437	17.667	17.847
High 9	2452	17.619	17.200
High 10	2457	17.552	17.016
High 11	2462	17.540	16.912

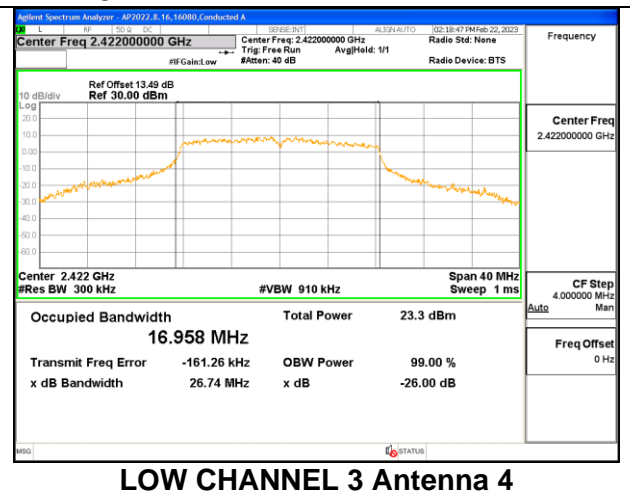
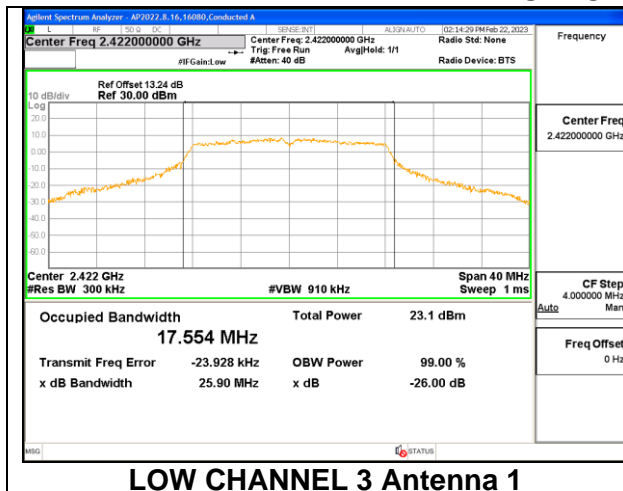
LOW CHANNEL 1



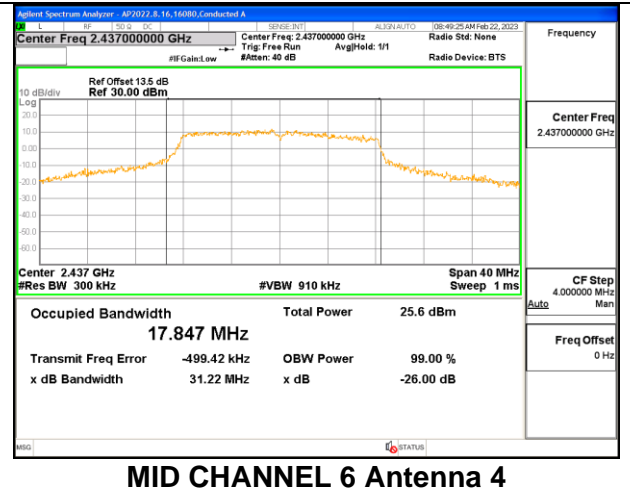
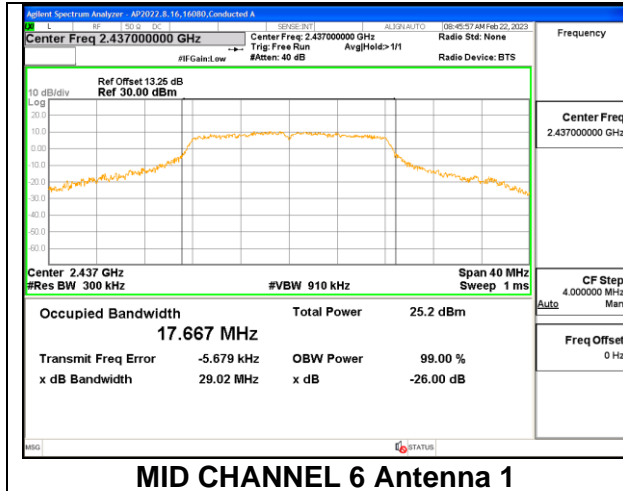
LOW CHANNEL 2



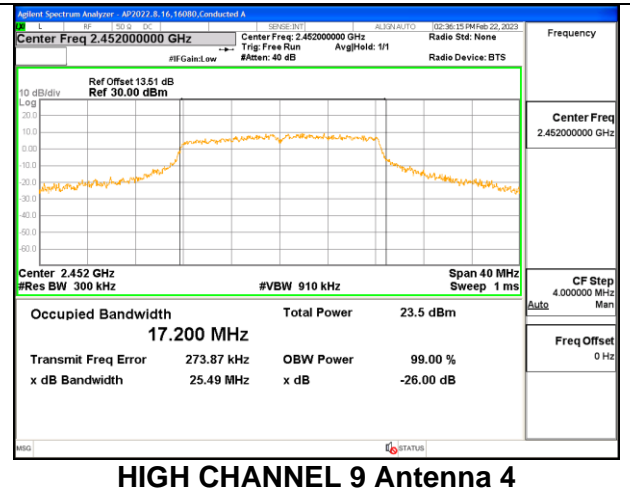
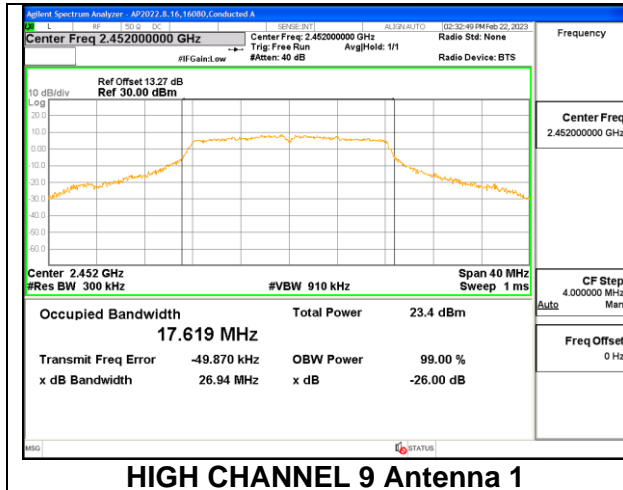
LOW CHANNEL 3



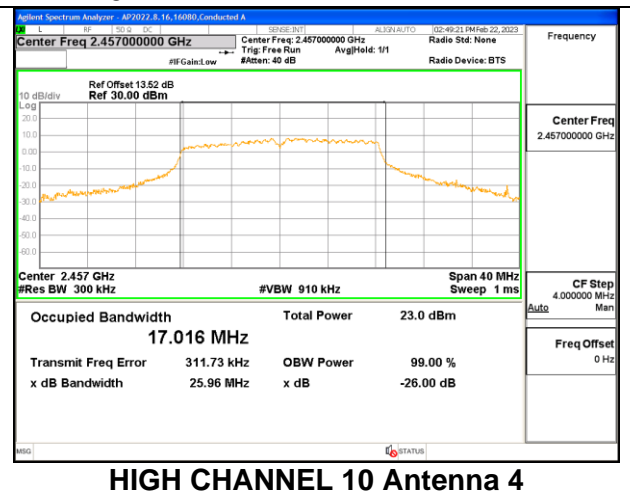
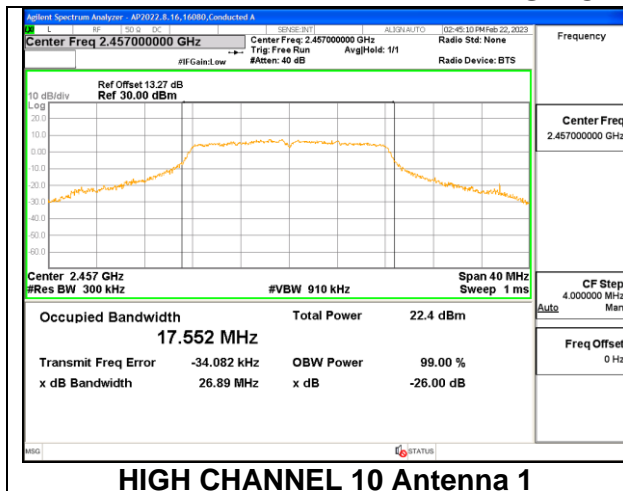
MID CHANNEL 6



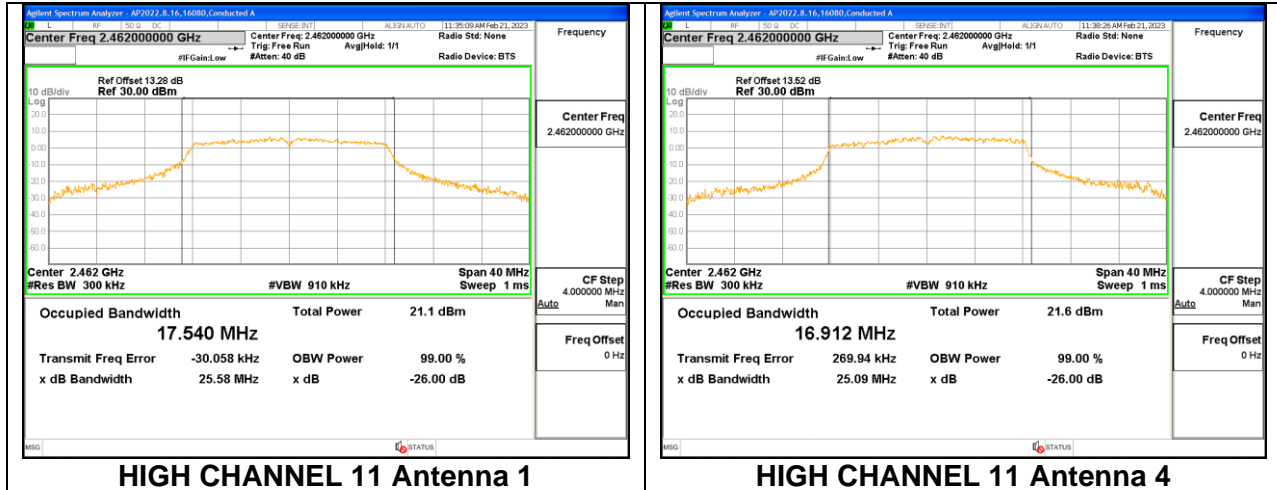
HIGH CHANNEL 9



HIGH CHANNEL 10



HIGH CHANNEL 11

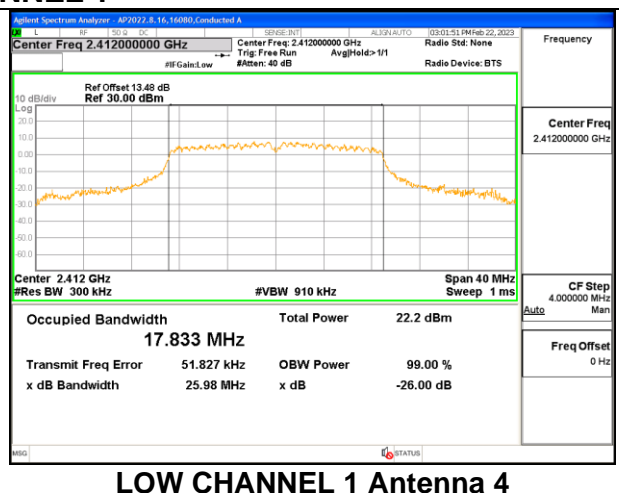
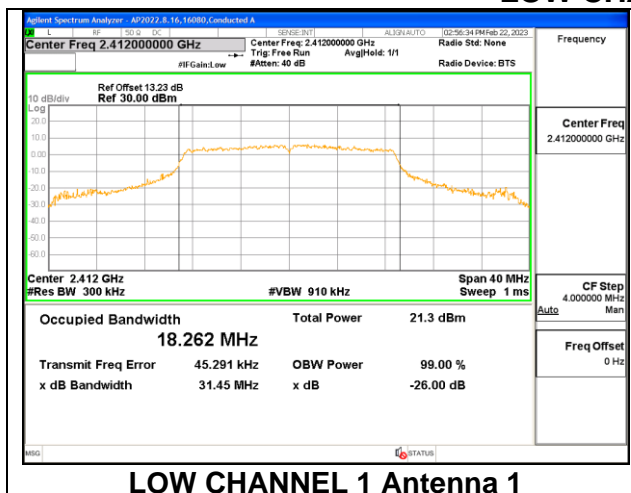


9.2.3. 802.11n HT20 MODE

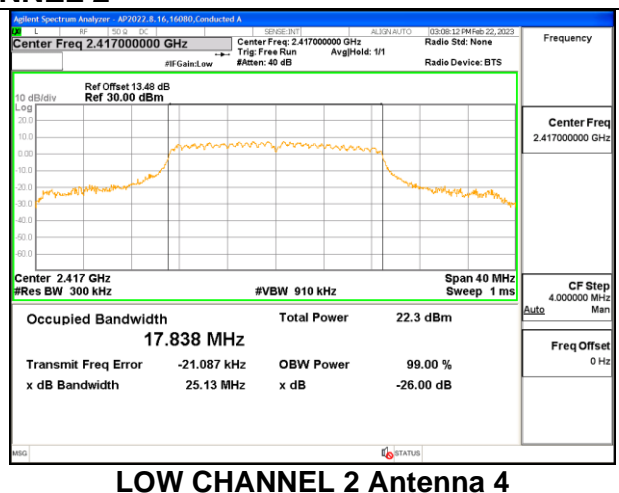
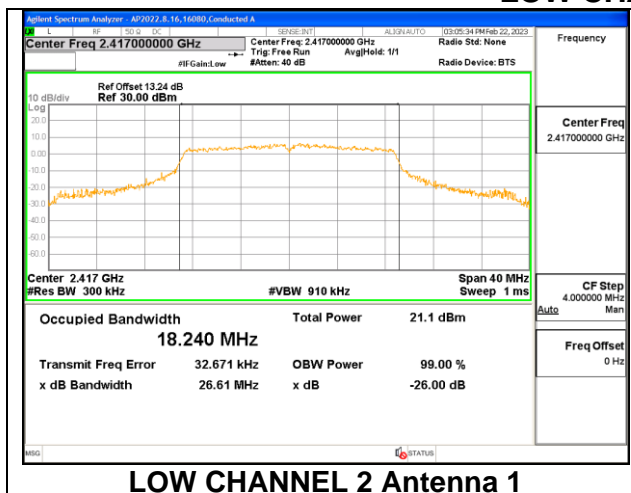
2TX Antenna 1 + Antenna 4 CDD MODE

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 4 (MHz)
Low 1	2412	18.262	17.833
Low 2	2417	18.240	17.838
Low 3	2422	18.232	17.870
Mid 6	2437	18.337	18.705
High 10	2457	18.243	17.943
High 11	2462	18.265	17.831

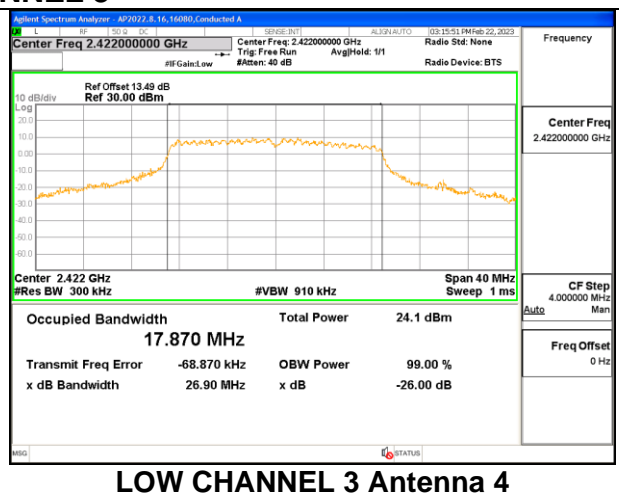
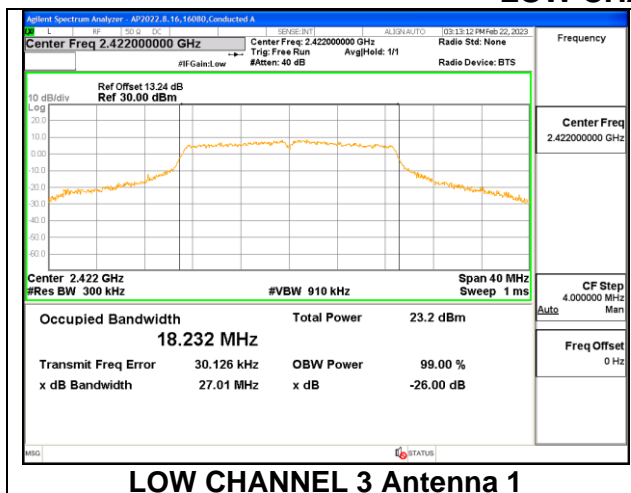
LOW CHANNEL 1



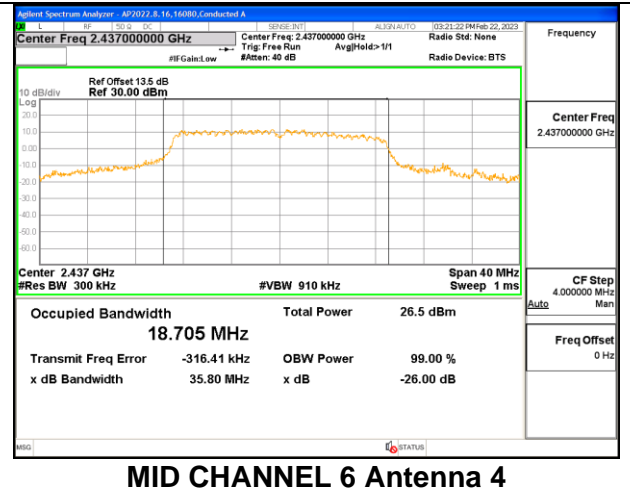
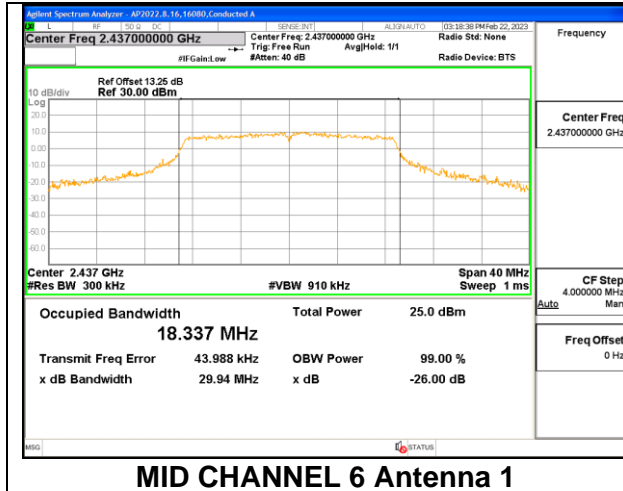
LOW CHANNEL 2



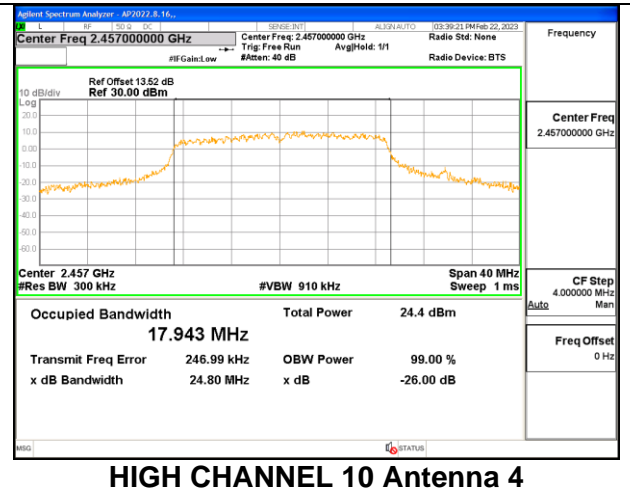
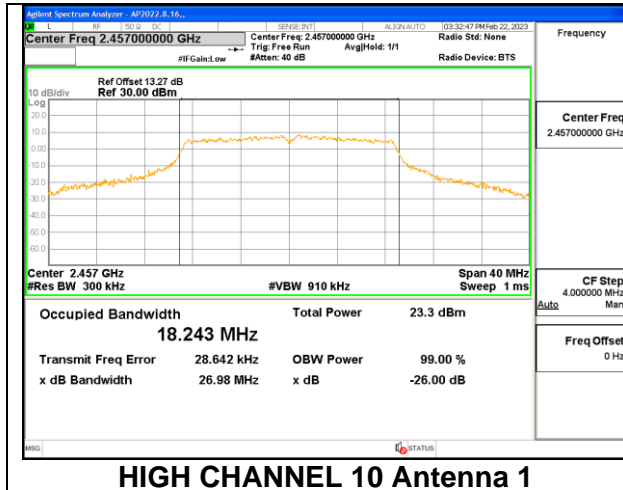
LOW CHANNEL 3



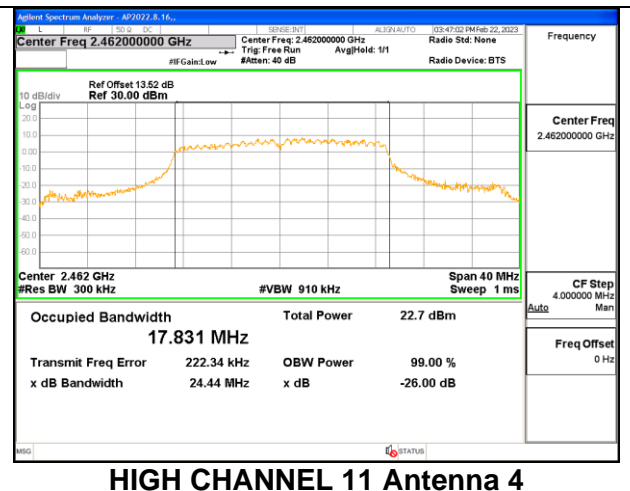
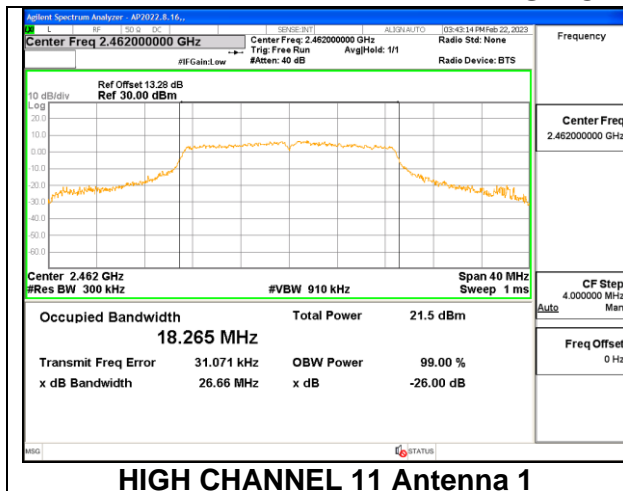
MID CHANNEL 6



HIGH CHANNEL 10



HIGH CHANNEL 11



9.3. 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.

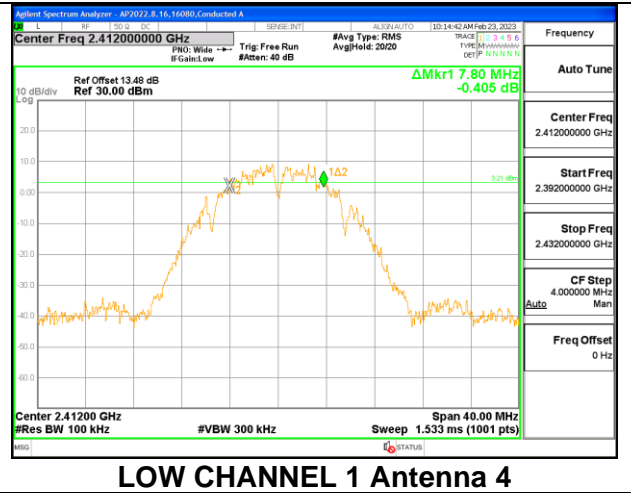
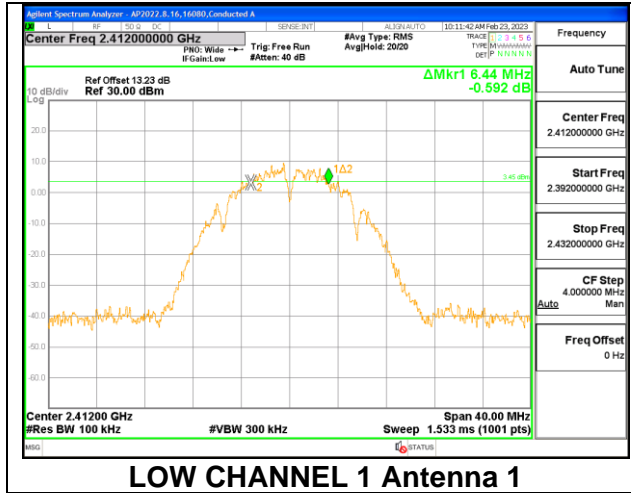
RESULTS

9.3.1. 802.11b MODE

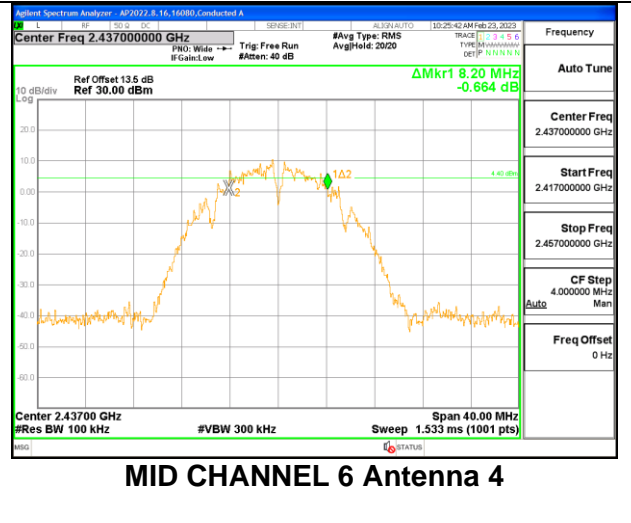
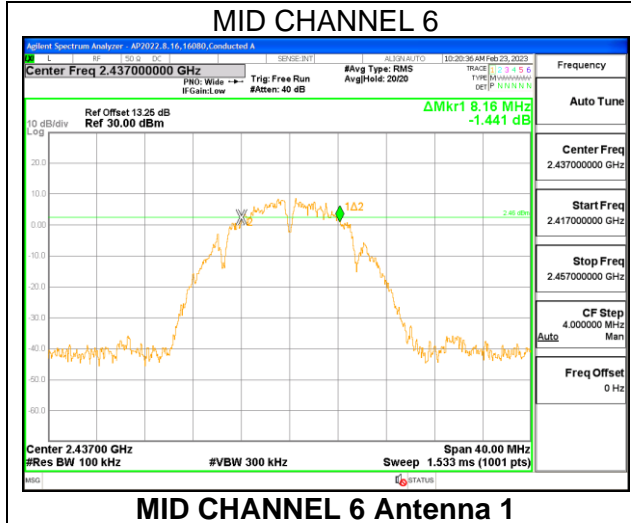
2TX Antenna 1 + Antenna 4 CDD MODE

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 4 (MHz)	Minimum Limit (MHz)
Low 1	2412	6.440	7.800	0.5
Mid 6	2437	8.160	8.200	0.5
High 11	2462	7.680	6.400	0.5

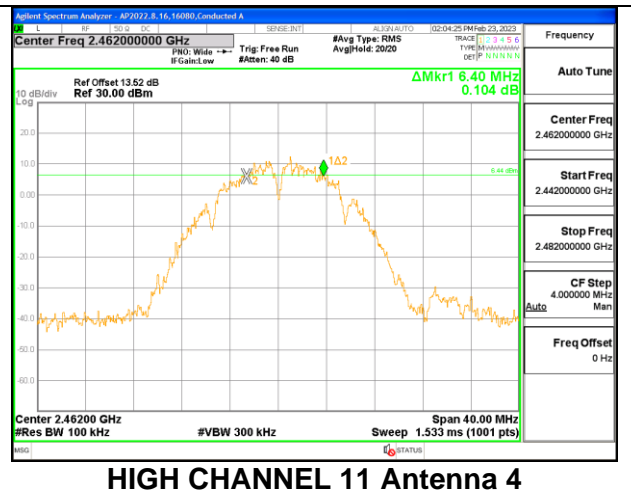
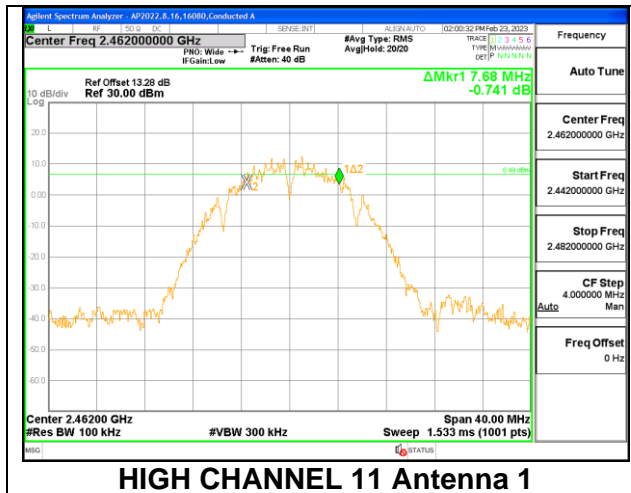
LOW CHANNEL 1



MID CHANNEL 6



HIGH CHANNEL 11

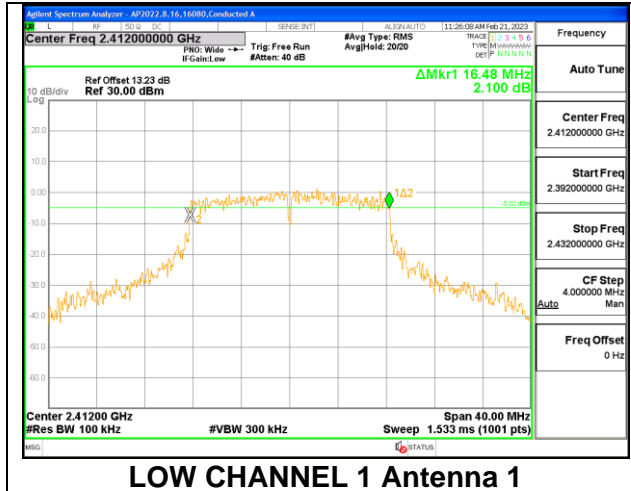


9.3.2. 802.11g MODE

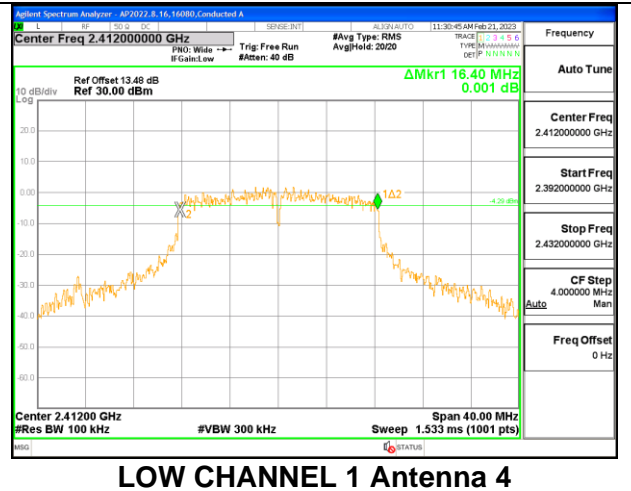
2TX Antenna 1 + Antenna 4 CDD MODE

Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 4 (MHz)	Minimum Limit (MHz)
2412	16.480	16.400	0.5
2417	16.480	16.520	0.5
2422	16.480	16.400	0.5
2437	16.480	16.440	0.5
2452	16.520	16.240	0.5
2457	16.480	16.040	0.5
2462	16.400	16.200	0.5

LOW CHANNEL 1

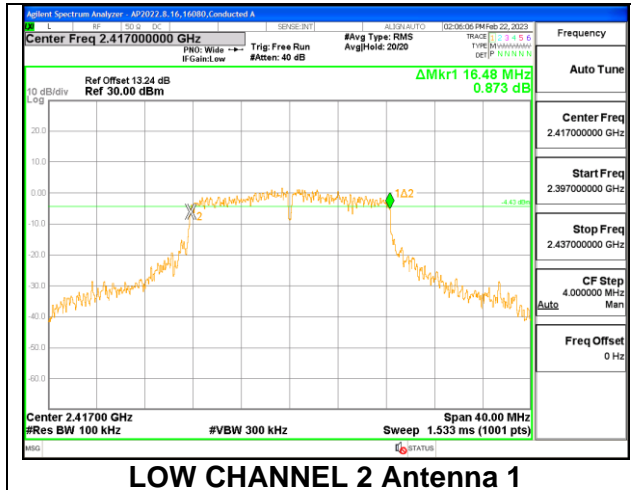


LOW CHANNEL 1 Antenna 1

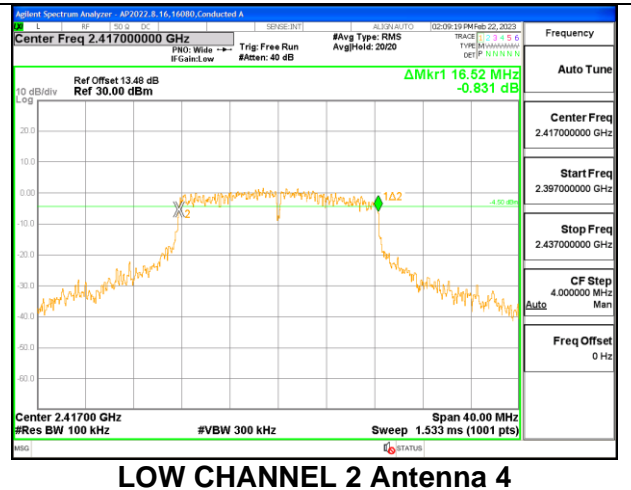


LOW CHANNEL 1 Antenna 4

LOW CHANNEL 2

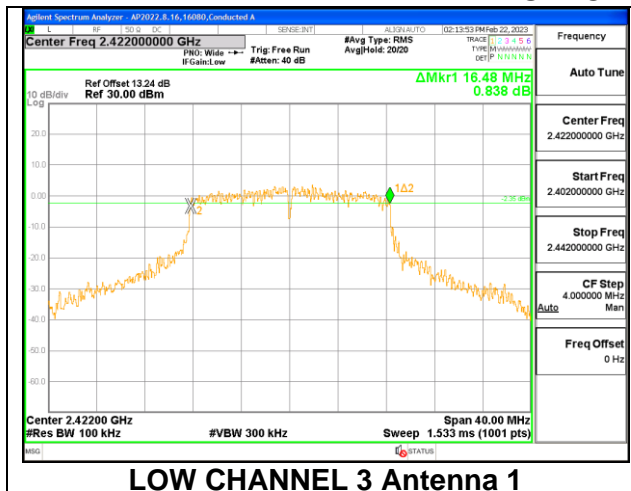


LOW CHANNEL 2 Antenna 1

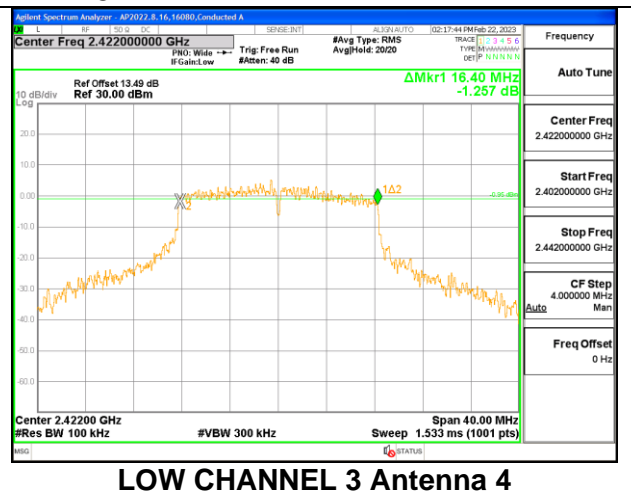


LOW CHANNEL 2 Antenna 4

LOW CHANNEL 3

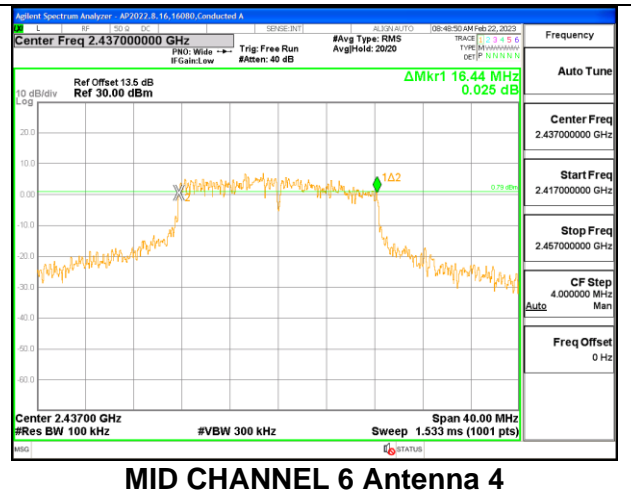
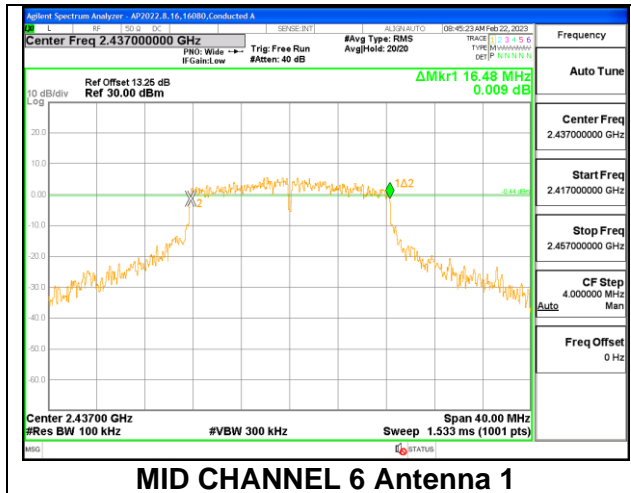


LOW CHANNEL 3 Antenna 1

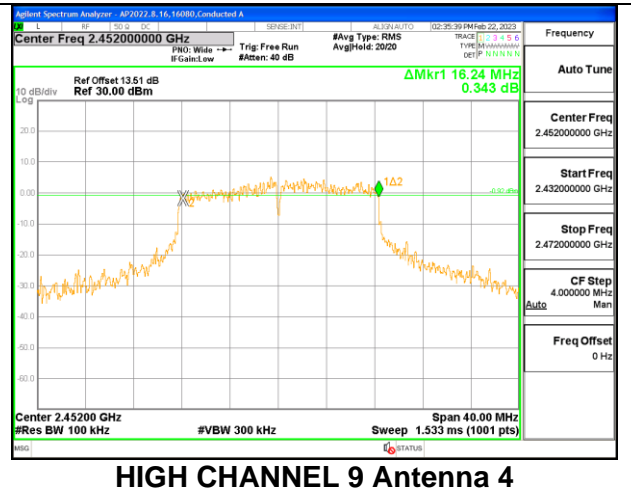
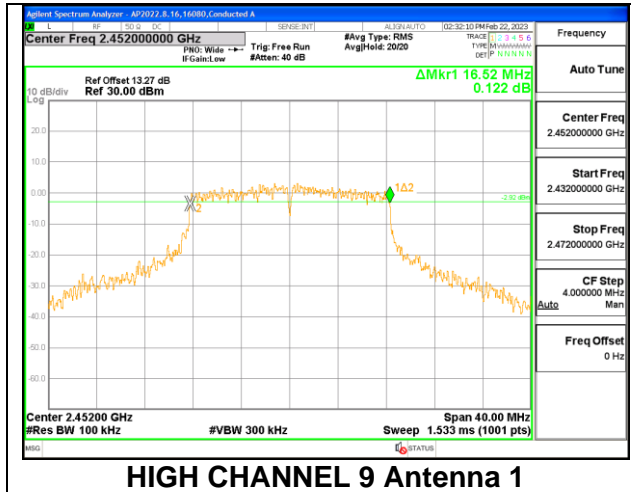


LOW CHANNEL 3 Antenna 4

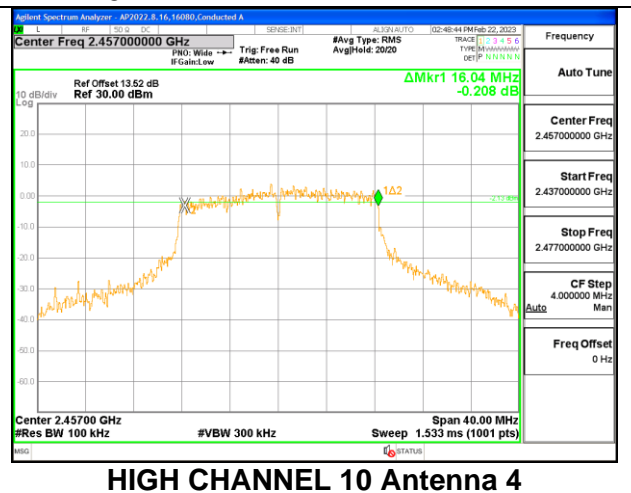
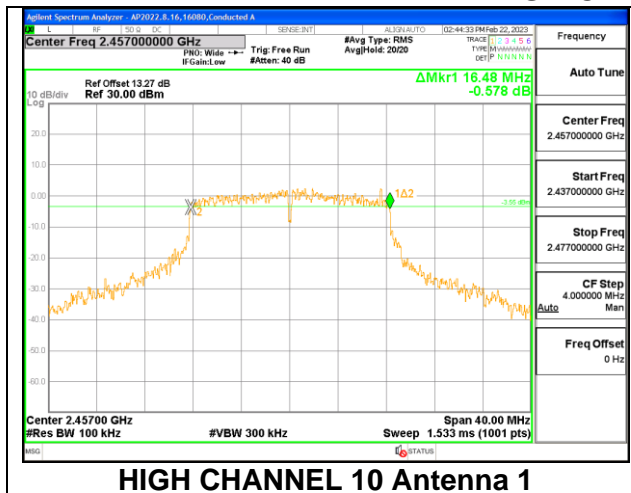
MID CHANNEL 6



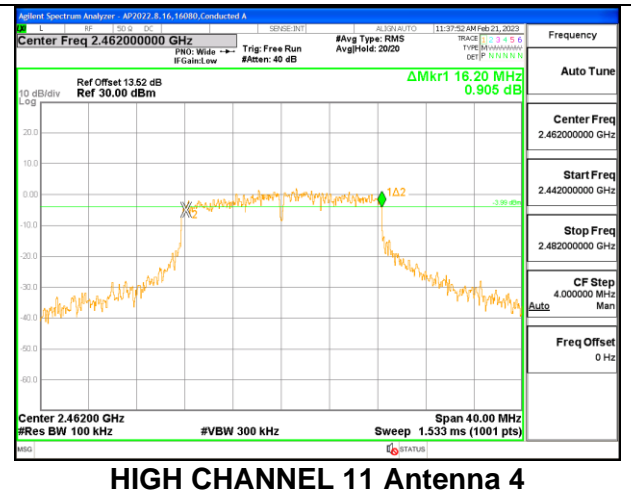
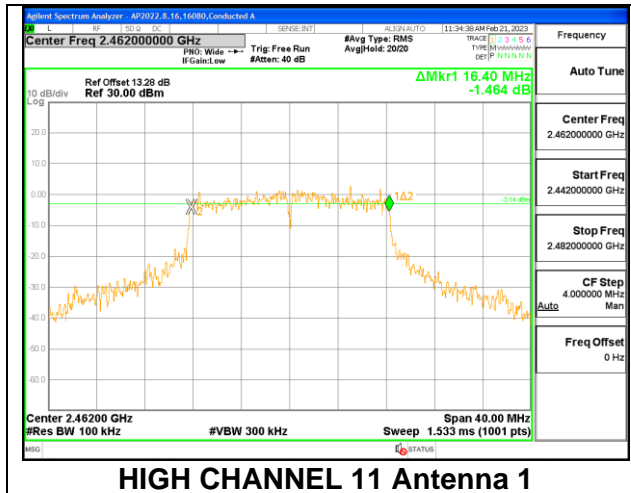
HIGH CHANNEL 9



HIGH CHANNEL 10



HIGH CHANNEL 11

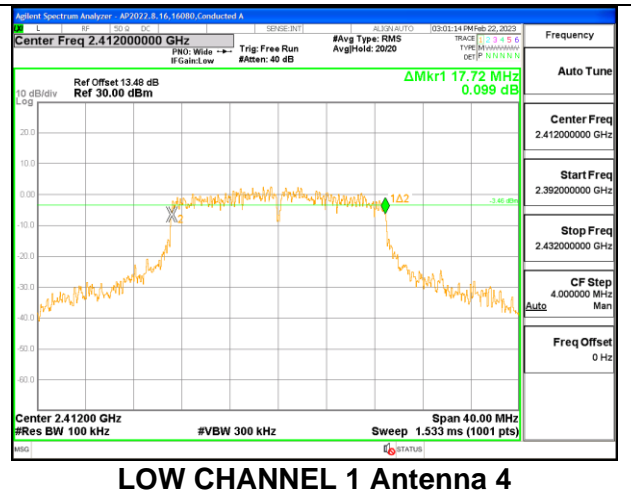
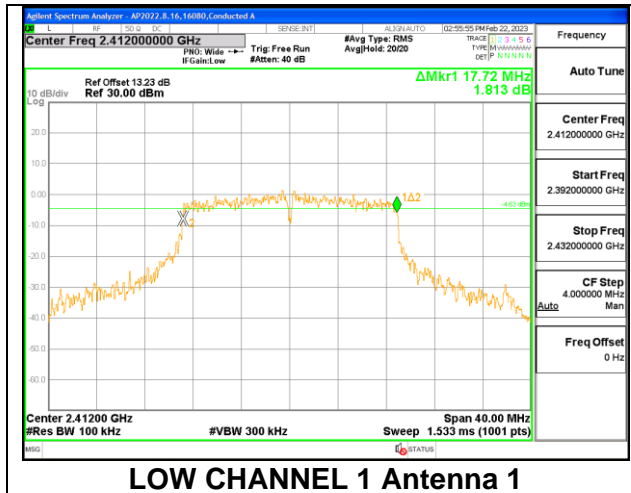


9.3.3. 802.11n HT20 MODE

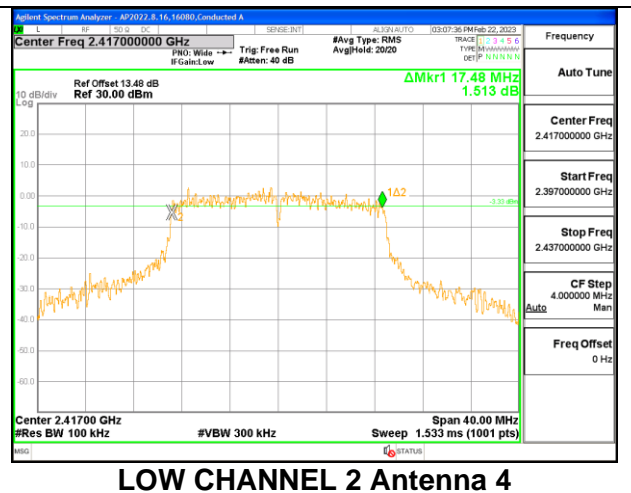
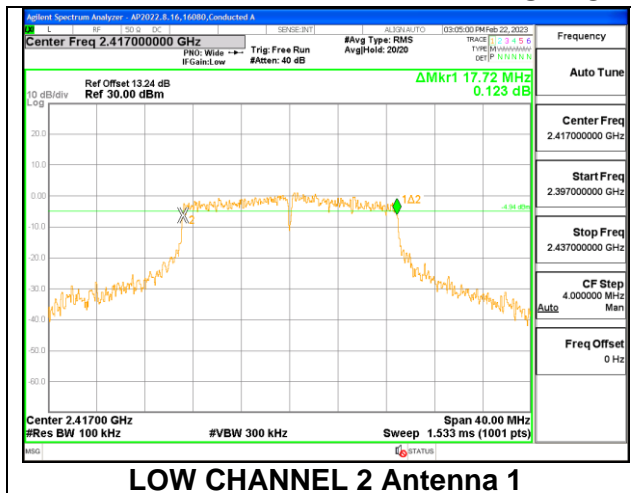
2TX Antenna 1 + Antenna 4 CDD MODE

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 4 (MHz)	Minimum Limit (MHz)
Low 1	2412	17.720	17.720	0.5
Low 2	2417	17.720	17.480	0.5
Low 3	2422	17.720	17.720	0.5
Mid 6	2437	17.680	17.440	0.5
High 10	2457	17.720	16.720	0.5
High 11	2462	17.760	17.320	0.5

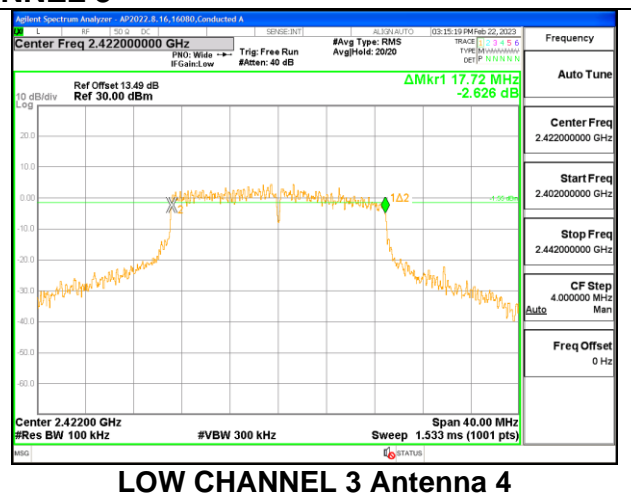
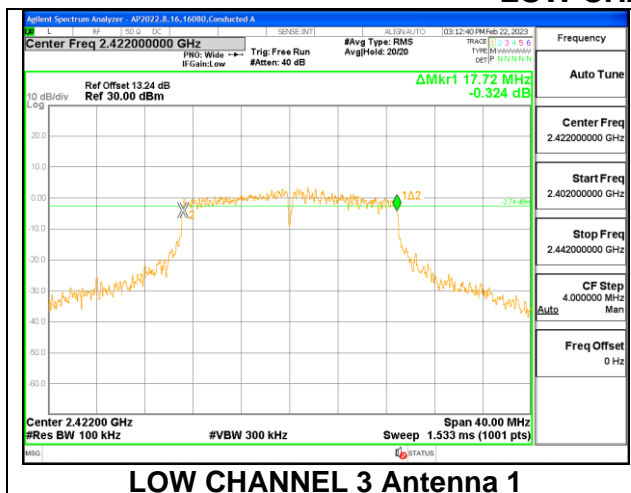
LOW CHANNEL 1



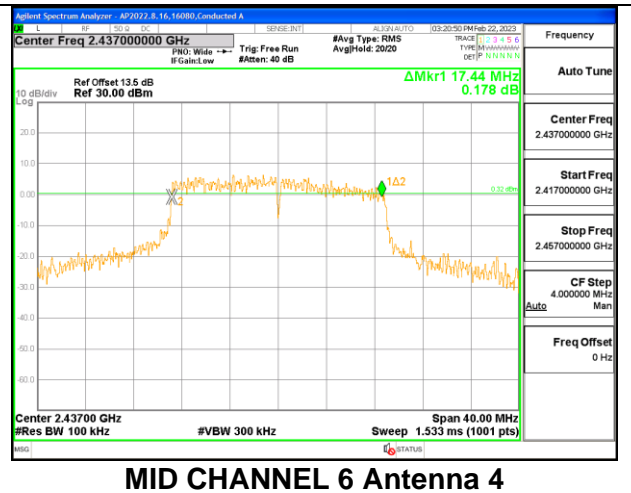
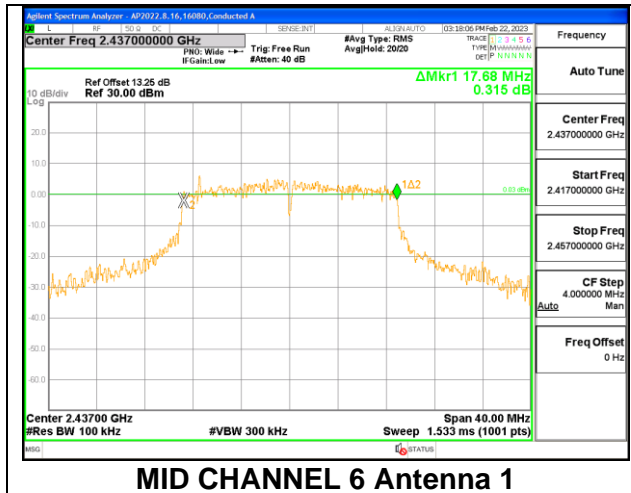
LOW CHANNEL 2



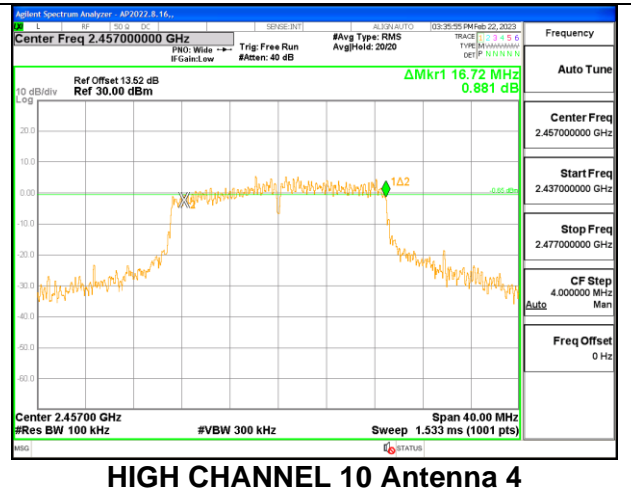
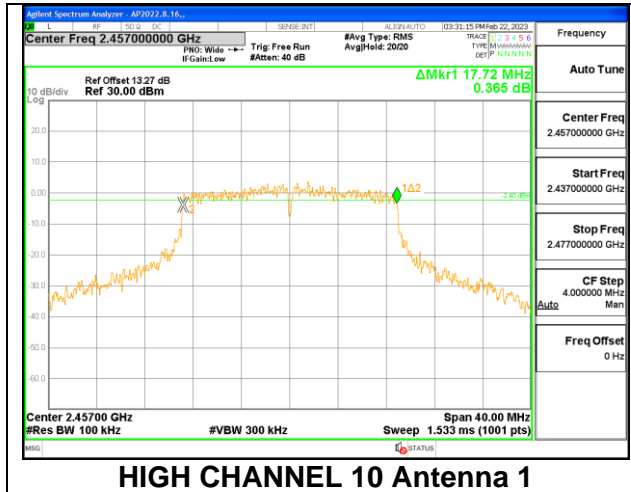
LOW CHANNEL 3



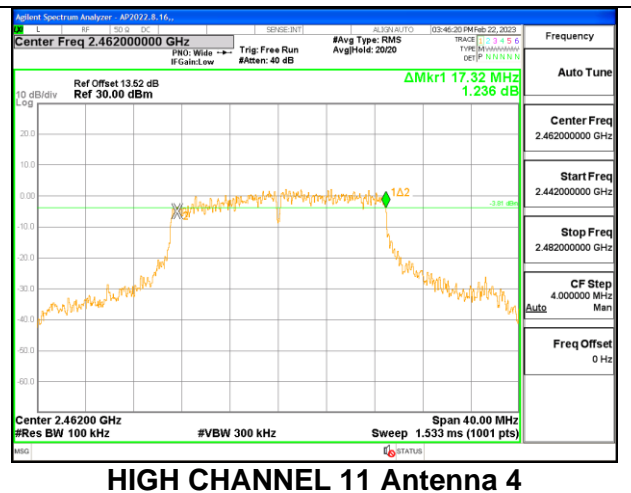
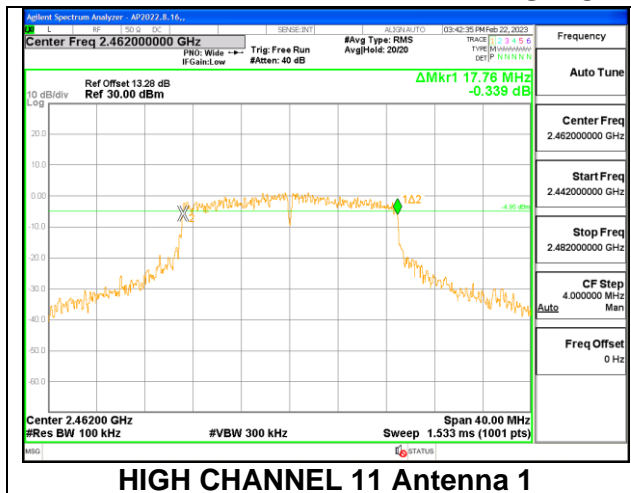
MID CHANNEL 6



HIGH CHANNEL 10



HIGH CHANNEL 11



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 wideband power sensor. Peak output power was read directly from power meter.

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

Directional Gain value was determined using the following formula:

$$\text{Uncorrelated Directional Gain dBi} = 10 \cdot \log\left(\frac{10^{\text{Ant 1/10}} + 10^{\text{Ant 2/10}}}{2}\right)$$

$$\text{Correlated Directional Gain dBi} = 10 \cdot \log\left(\frac{(10^{\text{Ant 1/20}} + 10^{\text{Ant 2/20}})^2}{2}\right)$$

Uncorrelated Directional Gain sample calculation:

$$2.66 \text{ dBi} = 10 \cdot \log\left(\frac{10^{2.9/10} + 10^{2.4/10}}{2}\right)$$

Correlated Directional Gain sample calculation:

$$5.66 \text{ dBi} = 10 \cdot \log\left(\frac{(10^{2.9/20} + 10^{2.4/20})^2}{2}\right)$$

RESULTS

9.4.1. 802.11b MODE

2TX Antenna 1 + Antenna 4 CDD MODE

Test Engineer:	16080 ZS
Test Date:	2023-02-20

	(MHz)	(dBi)	Limit (dBm)	Limit (dBm)	(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

Duty Cycle CF (dB)	0.31	Included in Calculations of Corr'd Power
---------------------------	------	---

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	22.25	22.25	25.26	30.00	-4.74
Mid 6	2437	22.30	22.20	25.26	30.00	-4.74
High 11	2462	23.57	23.30	26.45	30.00	-3.55

9.4.2. 802.11g MODE

2TX Antenna 1 + Antenna 4 CDD MODE

Test Engineer:	16080 ZS
Test Date:	2023-02-20

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
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

Duty Cycle CF (dB)	0.94	Included in Calculations of Corr'd Power
---------------------------	------	---

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	22.72	22.66	25.70	30.00	-4.30
Low 2	2417	23.04	22.82	25.94	30.00	-4.06
Low 3	2422	24.67	24.67	27.68	30.00	-2.32
Mid 6	2437	25.72	25.68	28.71	30.00	-1.29
High 9	2452	23.74	25.58	27.77	30.00	-2.23
High 10	2457	25.03	25.33	28.19	30.00	-1.81
High 11	2462	23.63	23.30	26.48	30.00	-3.52

9.4.3. 802.11n HT20 MODE

2TX Antenna 1 + Antenna 4 CDD MODE

Test Engineer:	16080 ZS
Test Date:	2023-02-20

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
Mid 6	2437	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

Duty Cycle CF (dB)	0.60	Included in Calculations of Corr'd Power
---------------------------	------	---

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	22.87	23.10	26.00	30.00	-4.00
Low 2	2417	23.05	22.87	25.97	30.00	-4.03
Low 3	2422	24.44	24.33	27.40	30.00	-2.60
Mid 6	2437	25.93	25.66	28.81	30.00	-1.19
High 10	2457	24.95	25.89	28.46	30.00	-1.54
High 11	2462	22.79	23.67	26.26	30.00	-3.74

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.

RESULTS

9.5.1. 802.11b MODE

2TX Antenna 1 + Antenna 4 CDD MODE

Test Engineer:	16080 ZS
Test Date:	2023-02-20

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 4 Power (dBm)	Total Power (dBm)
Low 1	2412	19.71	19.73	22.73
Mid 6	2437	19.72	19.74	22.74
High 11	2462	21.07	20.93	24.01

9.5.2. 802.11g MODE

2TX Antenna 1 + Antenna 4 CDD MODE

Test Engineer:	16080 ZS
Test Date:	2023-02-20

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 4 Power (dBm)	Total Power (dBm)
Low 1	2412	15.76	15.81	18.80
Low 2	2417	15.77	15.80	18.80
Low 3	2422	17.67	17.74	20.72
Mid 6	2437	19.73	20.04	22.90
High 9	2452	17.73	17.96	20.86
High 10	2457	16.71	16.91	19.82
High 11	2462	15.98	16.16	19.08

9.5.3. 802.11n HT20 MODE

2TX Antenna 1 + Antenna 4 CDD MODE

Test Engineer:	16080 ZS
Test Date:	2023-02-20

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 4 Power (dBm)	Total Power (dBm)
Low 1	2412	15.72	15.92	18.83
Low 2	2417	15.73	16.21	18.99
Low 3	2422	17.64	17.82	20.74
Mid 6	2437	19.66	20.03	22.86
High 10	2457	17.53	17.84	20.70
High 11	2462	15.72	16.16	18.96

9.6. POWER SPECTRAL DENSITY

LIMITS

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.

RESULTS

9.6.1. 802.11b MODE

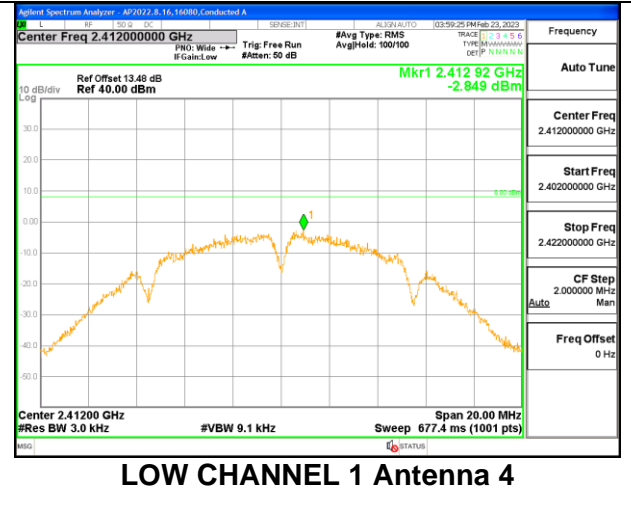
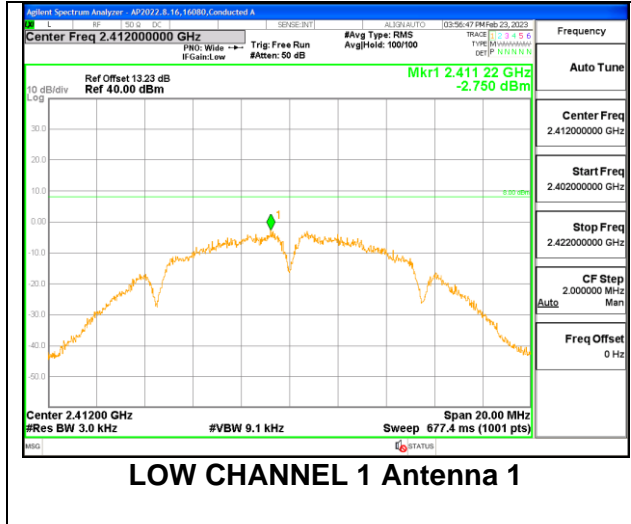
2TX Antenna 1 + Antenna 4 CDD MODE

Duty Cycle CF (dB)	0.31	Included in Calculations of Corr'd PSD
---------------------------	------	---

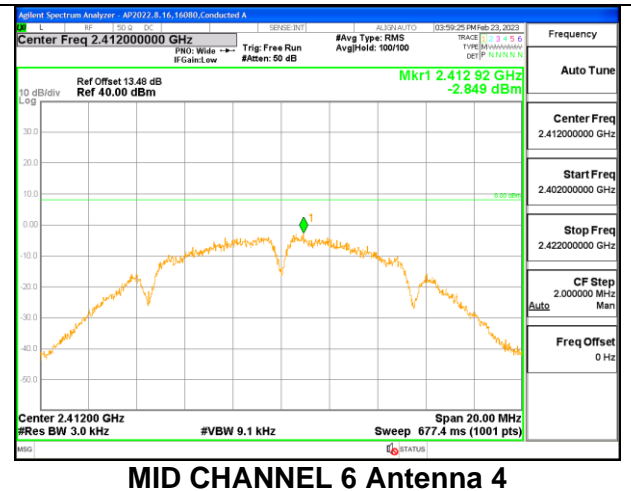
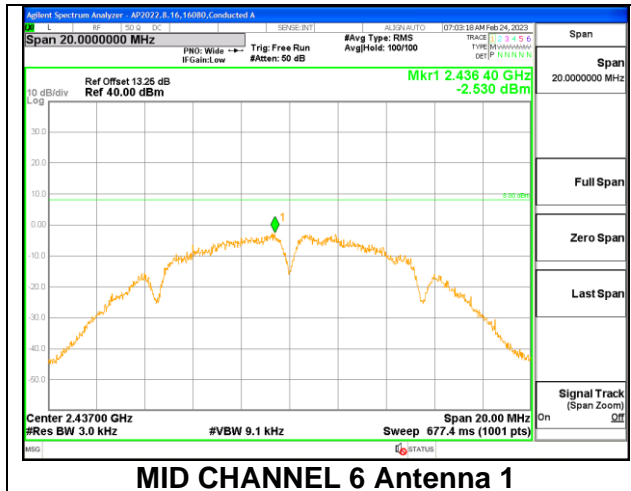
PSD Results

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	-2.75	-2.85	0.52	8.0	-7.5
Mid 6	2437	-2.53	-2.85	0.63	8.0	-7.4
High 11	2462	-0.29	0.48	3.43	8.0	-4.6

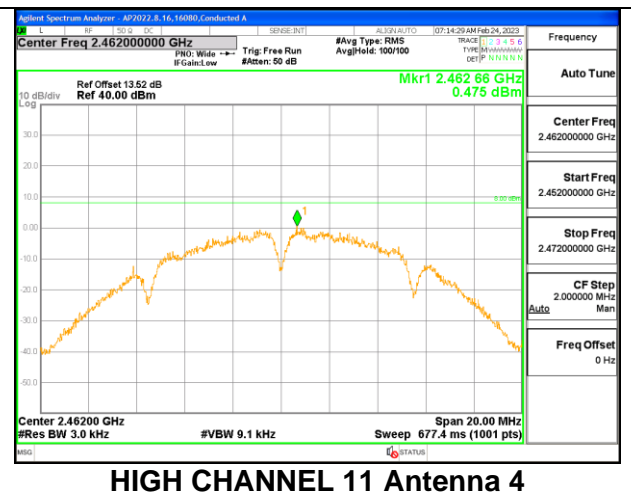
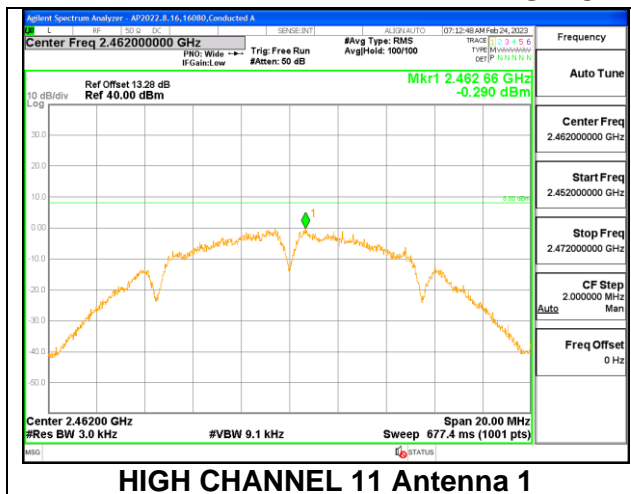
LOW CHANNEL 1



MID CHANNEL 6



HIGH CHANNEL 11



9.6.2. 802.11g MODE

2TX Antenna 1 + Antenna 4 CDD MODE

Duty Cycle CF (dB)	0.94	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	-10.51	-10.80	-6.70	8.0	-14.7
Low 2	2417	-10.43	-7.95	-5.06	8.0	-13.1
Low 3	2422	-8.29	-8.11	-4.25	8.0	-12.2
Mid 6	2437	-6.08	-5.56	-1.87	8.0	-9.9
High 9	2452	-8.39	-7.82	-4.14	8.0	-12.1
High 10	2457	-9.47	-8.02	-4.73	8.0	-12.7
High 11	2462	-9.10	-9.77	-5.47	8.0	-13.5