TEST REPORT

Report Number. : 14093500-E3V2

Applicant	:	SONOS INC. 614 CHAPALA ST. SANTA BARBARA, CA, 93101, U.S.A.
Model	:	S41
Brand	:	SONOS
FCC ID	:	SBVRM041
IC	:	5373A-RM041
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:
2022-10-24

Prepared by:
UL VERIFICATION SERVICES
47173 Benicia Street
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CERT #0751.05

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2022-10-13	Initial Issue	
V2	2022-10-24	Updated Section 1, 6.3 and 9	K.Kedida

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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: S41

BRAND: SONOS

SERIAL NUMBER: Radiated Sample: 000E580AD3058 and 000E583B70D08
Conducted Sample: 000E5893E2BB2

SAMPLE RECEIPT DATE: 2022-09-12

DATE TESTED: 2022-09-14 to 2022-10-04

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.

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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.
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.

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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, 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
☐	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

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5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

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

5.2. DECISION RULES

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

5.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	U_{Lab}
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	2.84 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 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 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

MAINS CONDUCTED EMISSIONS

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

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6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

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

This report covers non-ax 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	25.47	352.37
2412 - 2462	802.11g	27.34	542.00
2412 - 2462	802.11n HT20	27.82	605.34
2422 - 2452	802.11n HT40	27.64	580.76

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

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

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

Frequency Range (MHz)	Peak Antenna Gain (dBi)			
	Chain 0		Chain 1	
	ANT1 (FR) (dBi)	ANT2 (RL) (dBi)	ANT3 (RR) (dBi)	ANT4 (FL) (dBi)
2400 – 2483.5	4.4	2.1	3.4	3.1

6.4. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was 70.1-29190-diag.

The test utility software used during testing was GUI_V8.

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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.

The fundamental of the EUT was investigated in the antenna combinations, it was determined that Antenna 1 and Antenna 3 was the worst case; therefore, all final radiated testing was performed with Antenna 1 and Antenna 3.

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

802.11b mode: 1 Mbps
802.11g mode: 6 Mbps
802.11n HT20mode: MCS0
802.11n HT40mode: MCS0

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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 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.

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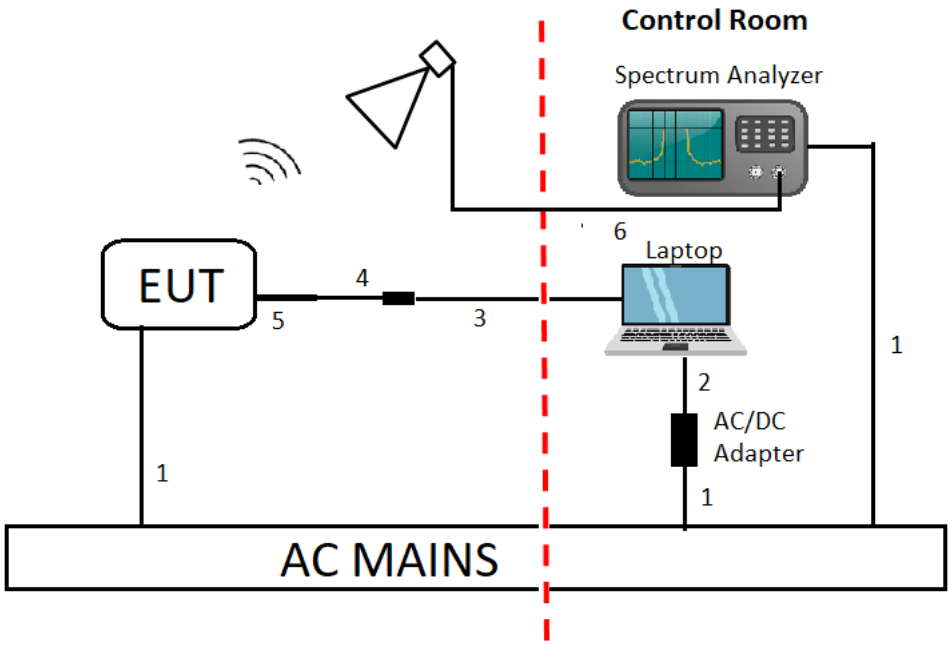
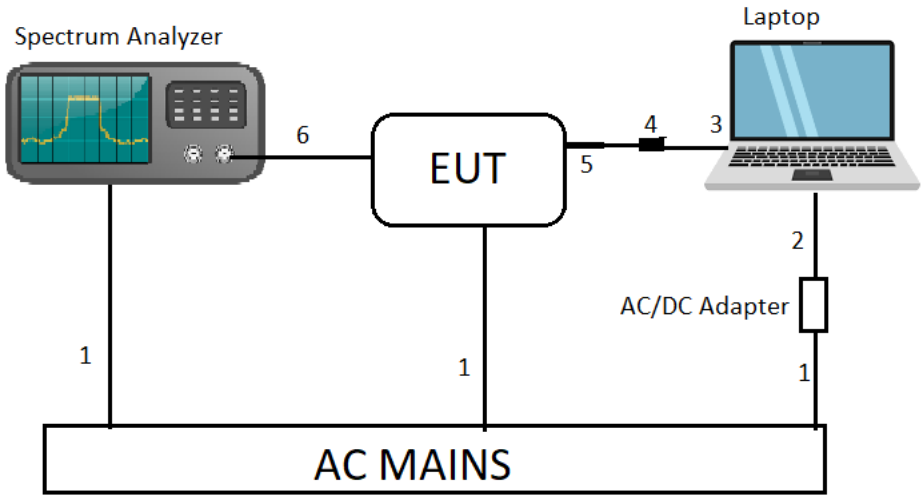
SETUP DIAGRAM

Radiated Configuration



Conducted Configuration



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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 -11.9.2.3.2 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

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8. TEST AND MEASUREMENT EQUIPMENT

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

TEST EQUIPMENT LIST					
Description	**Manufacturer**	**Model**	**ID Num**	**Cal Due**	**Last Cal**
Antenna, Broadband Hybrid, 30MHz to 3GHz	Sunol Sciences Corp.	JB3	171862	*2022-09-28	*2021-09-28
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
Antenna, Horn 1-18GHz	ETS-Lindgren (Cedar Park, Texas)	3117	80402	2023-07-05	2022-07-05
RF Filter Box, 1-18GHz	FREMONT	SAC-L1	171013	2023-03-09	2022-03-09
Amplifier, 100MHz-18GHz	AMPLICAL	AMP0.1G18-47-20	185686	2023-04-19	2022-04-19
EMI TEST RECEIVER, with B8 option	Rohde & Schwarz	ESW44	169937	2023-02-20	2022-02-20
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	169927	2023-02-13	2022-02-13
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	2023-01-02	2022-01-02
Power Meter, P-series single channel	Keysight Technologies Inc	N1911A	T1268	2023-02-03	2022-02-03
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc	N1921A	90419	2023-03-02	2022-03-02
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 2016-05-11, 2015-12-29, 2019-10-09, 2021-12-07, 2022-05-18, and 2022-07-06		
Antenna Port Software	UL	UL RF	Ver 2022.8.16		
AC Line Conducted Software	UL	UL EMC	Rev 9.5, 2022-02-17		

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9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

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	8.400	9.000	0.933	93.33	0.30	0.119
802.11g	1.391	2.014	0.691	69.06	1.61	0.719
802.11n HT20	1.300	1.920	0.677	67.69	1.69	0.769
802.11n HT40	0.648	1.280	0.506	50.58	2.96	1.544

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DUTY CYCLE PLOTS

802.11b MODE

802.11g MODE

802.11n HT20 MODE

802.11n HT40 MODE

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9.2. 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

RESULTS

9.2.1. 802.11b MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 3 (MHz)
Low 1	2412	12.839	12.672
Mid 6	2437	12.820	12.582
High 11	2462	12.765	12.627

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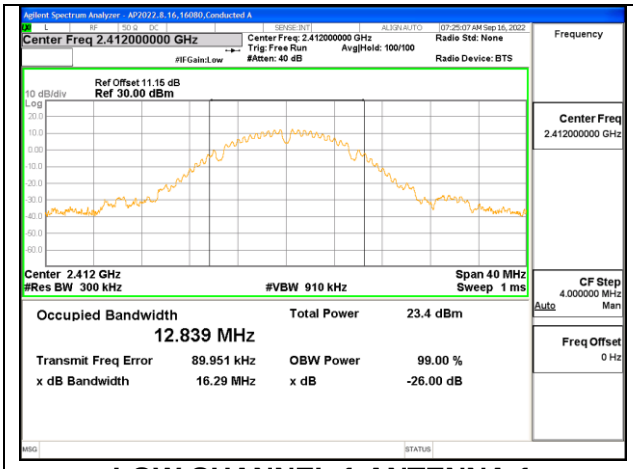
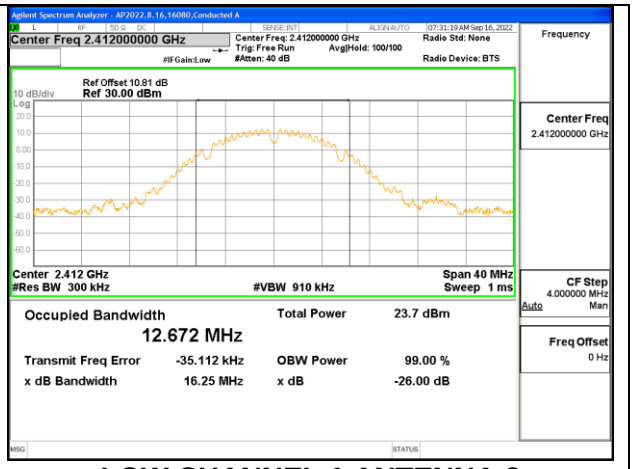
LOW CHANNEL 1

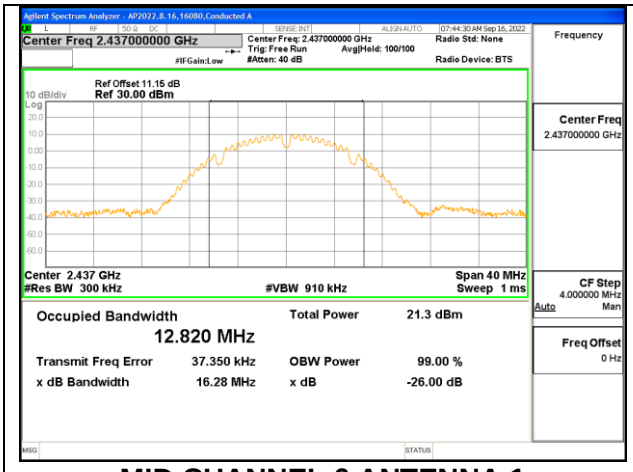


LOW CHANNEL 1 ANTENNA 1

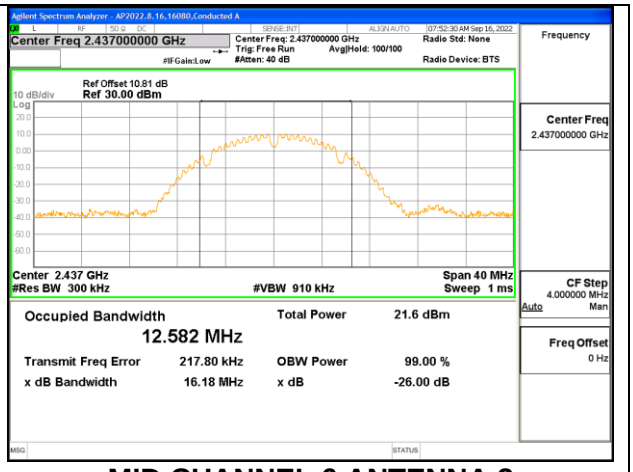


LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6

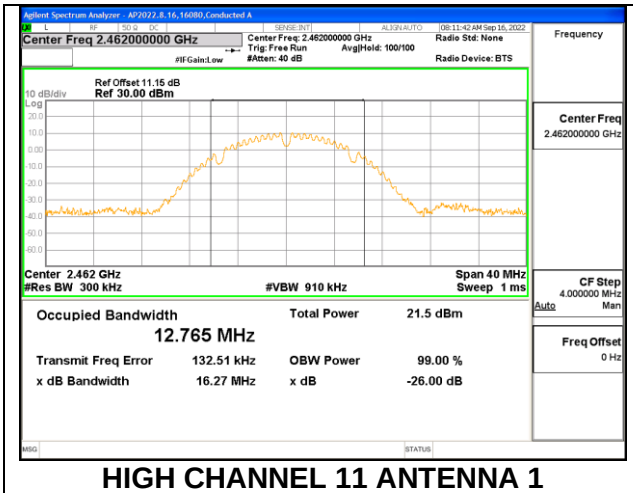


MID CHANNEL 6 ANTENNA 1

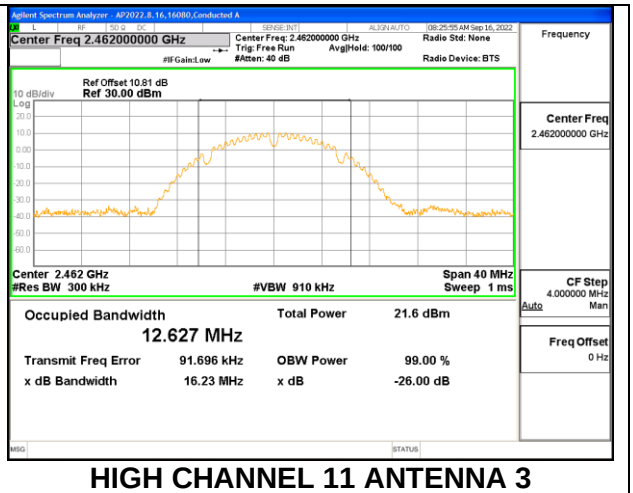


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 11



HIGH CHANNEL 11 ANTENNA 1



HIGH CHANNEL 11 ANTENNA 3

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9.2.2. 802.11g MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 3 (MHz)
Low 1	2412	17.181	17.217
Mid 6	2437	17.153	17.070
High 11	2462	17.107	16.830

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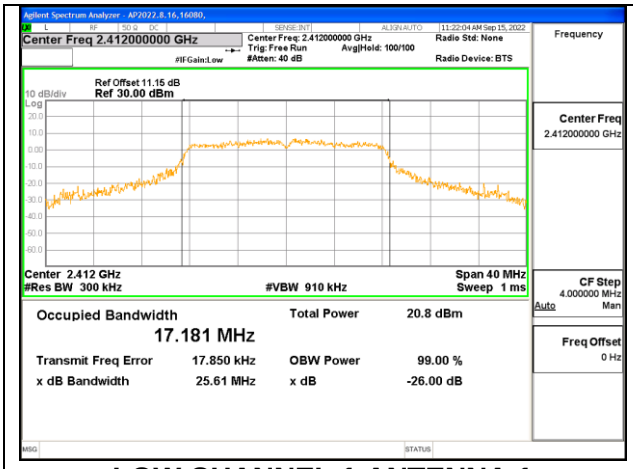
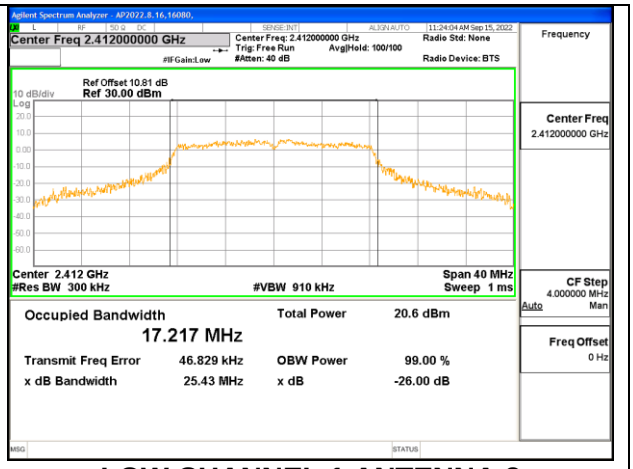
LOW CHANNEL 1

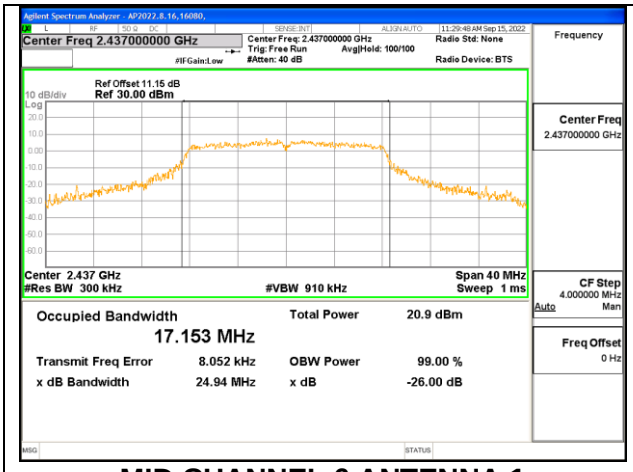


LOW CHANNEL 1 ANTENNA 1

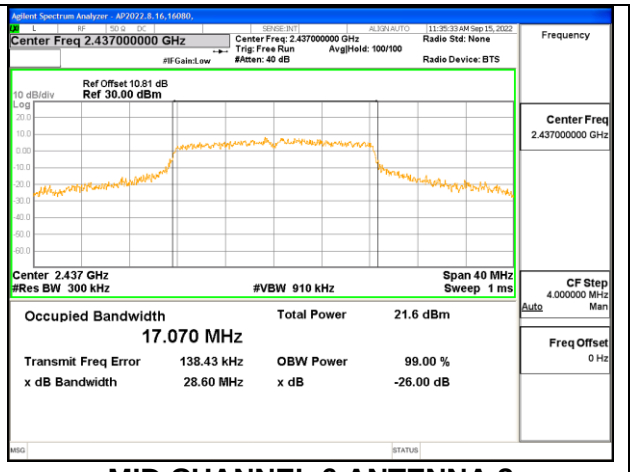


LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6

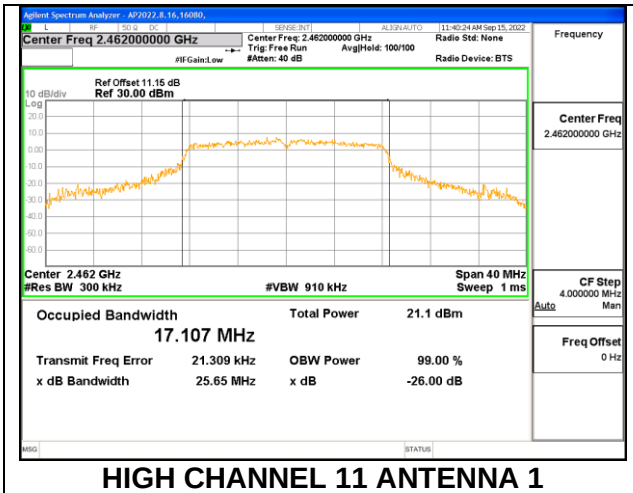


MID CHANNEL 6 ANTENNA 1

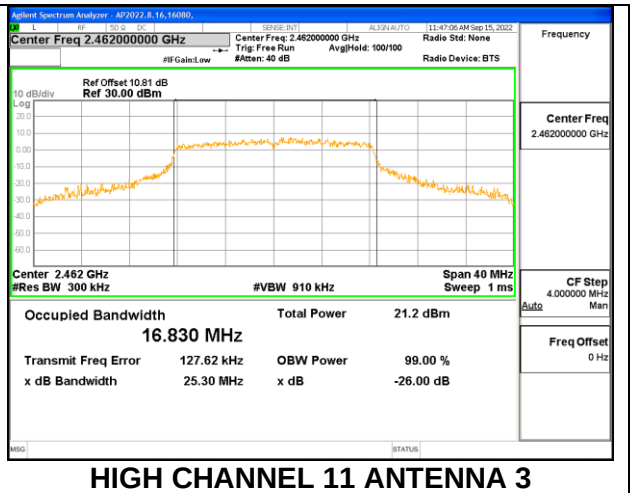


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 11



HIGH CHANNEL 11 ANTENNA 1



HIGH CHANNEL 11 ANTENNA 3

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9.2.3. 802.11n HT20 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 3 (MHz)
Low 1	2412	18.068	17.734
Mid 6	2437	18.079	17.821
High 11	2462	18.068	17.812

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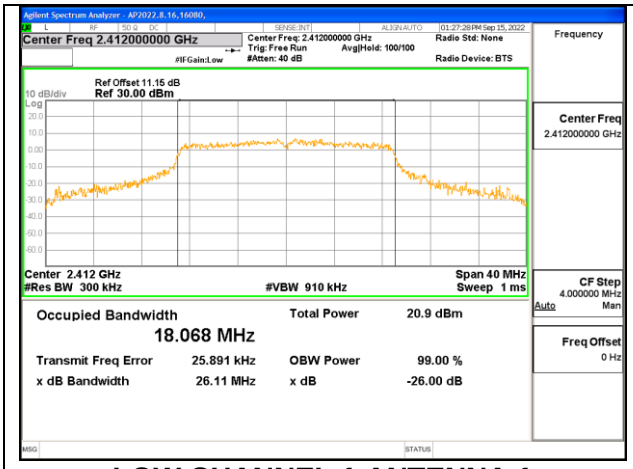
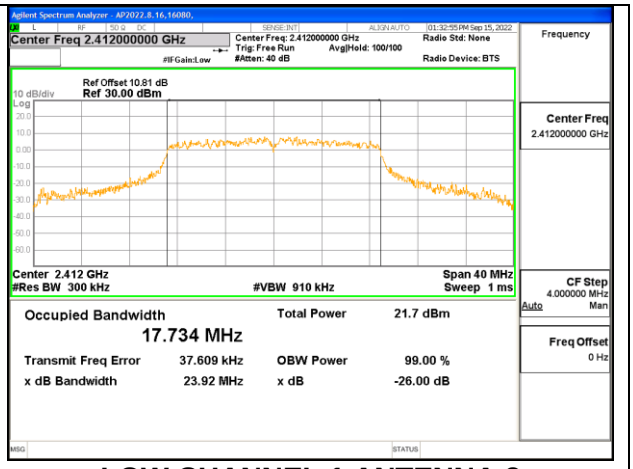
LOW CHANNEL 1

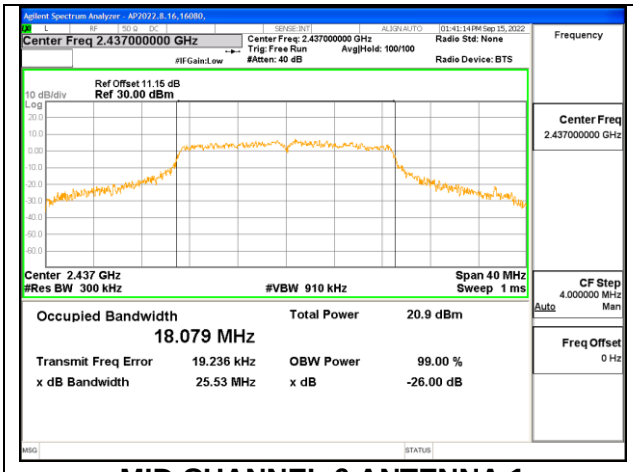


LOW CHANNEL 1 ANTENNA 1

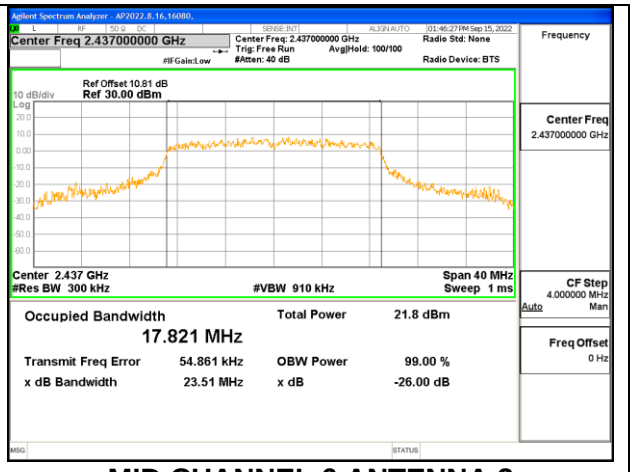


LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6

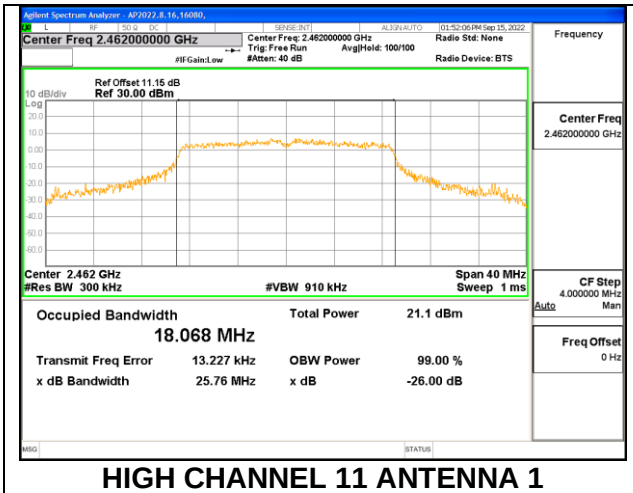


MID CHANNEL 6 ANTENNA 1

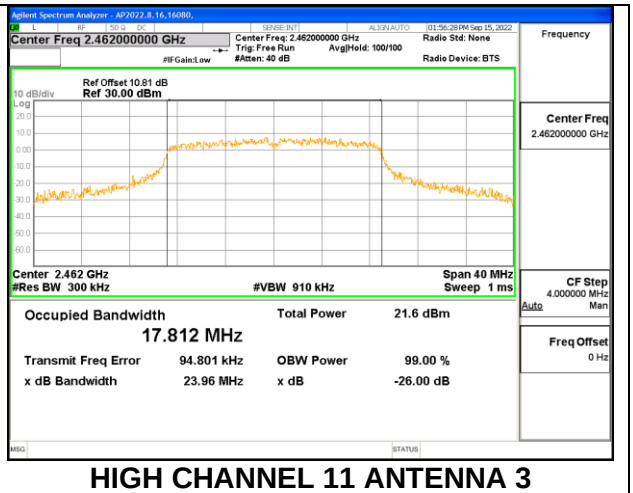


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 11



HIGH CHANNEL 11 ANTENNA 1



HIGH CHANNEL 11 ANTENNA 3

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9.2.4. 802.11n HT40 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Channel	Frequency (MHz)	99% Bandwidth Antenna 1 (MHz)	99% Bandwidth Antenna 3 (MHz)
Low 3	2422	36.013	36.069
Mid 6	2437	35.991	36.087
High 9	2452	35.948	36.119

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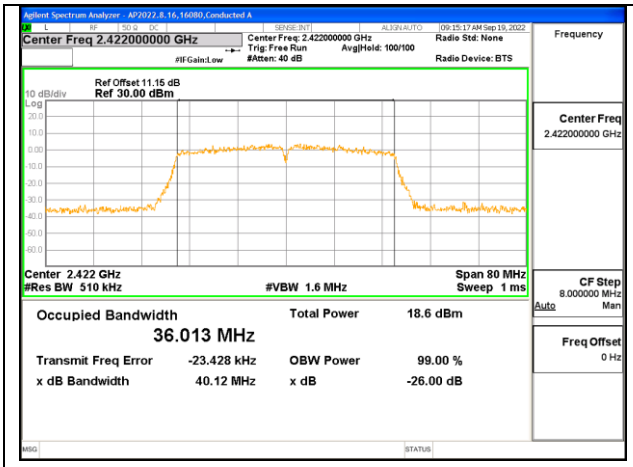
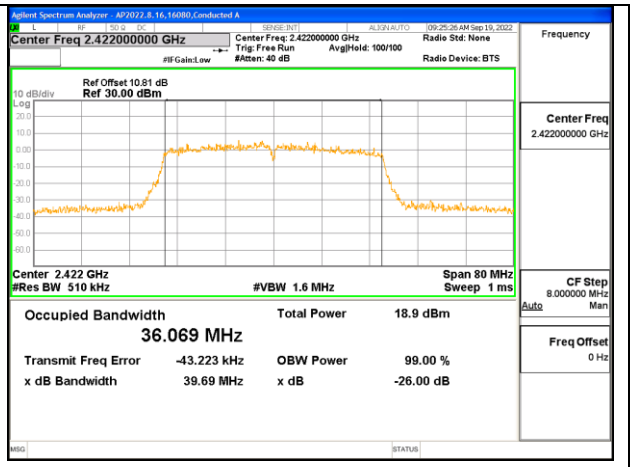
LOW CHANNEL 3

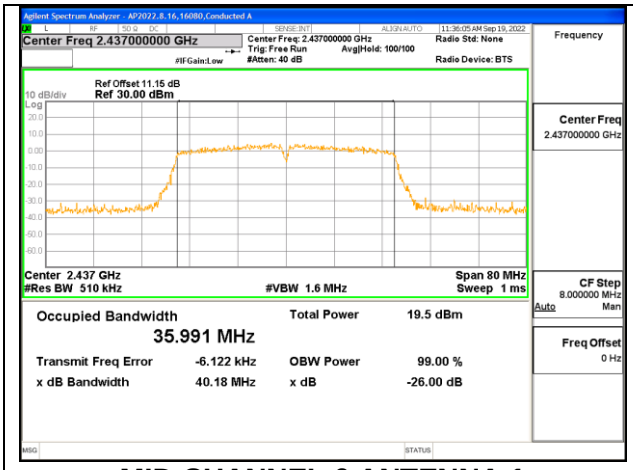


LOW CHANNEL 3 ANTENNA 1

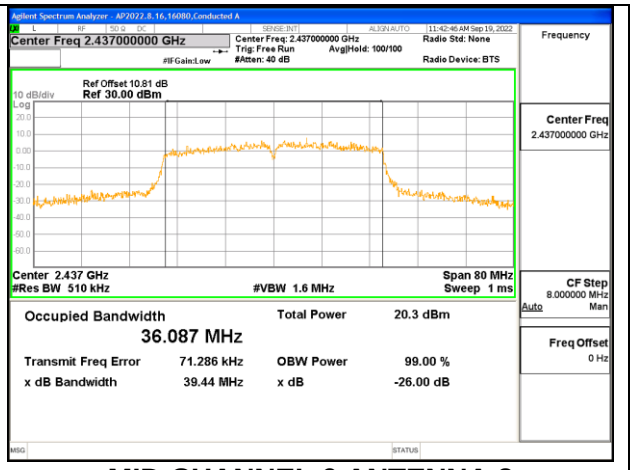


LOW CHANNEL 3 ANTENNA 3

MID CHANNEL 6

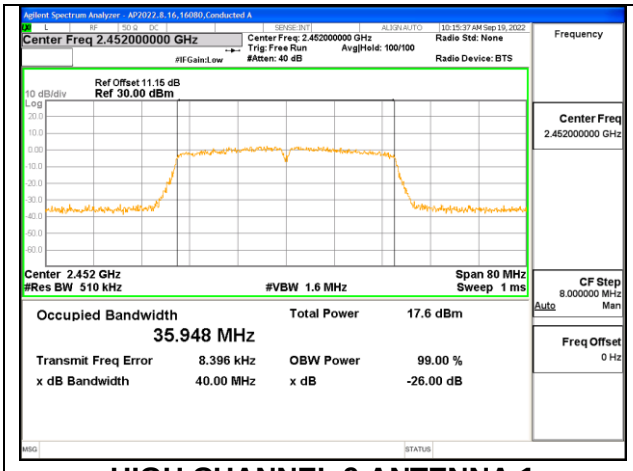


MID CHANNEL 6 ANTENNA 1

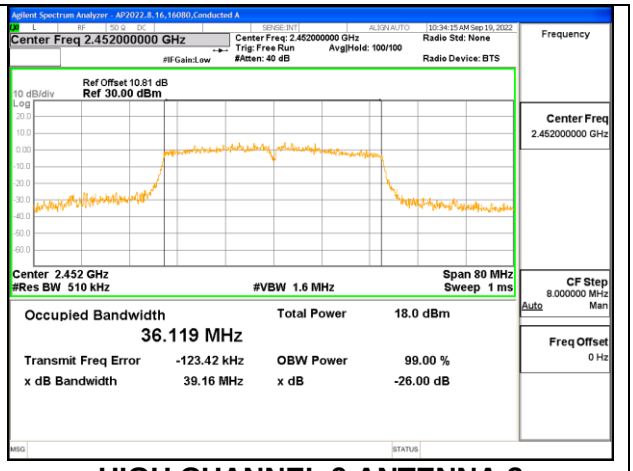


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 9



HIGH CHANNEL 9 ANTENNA 1



HIGH CHANNEL 9 ANTENNA 3

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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 3 CDD MODE

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Low 1	2412	8.64	8.12	0.5
Mid 6	2437	8.32	8.12	0.5
High 11	2462	8.20	8.16	0.5

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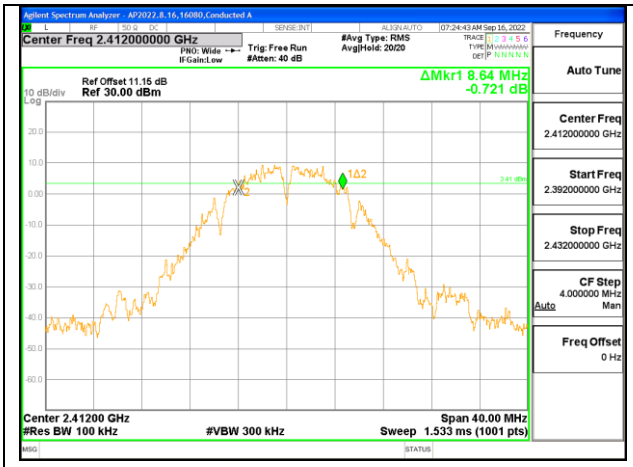
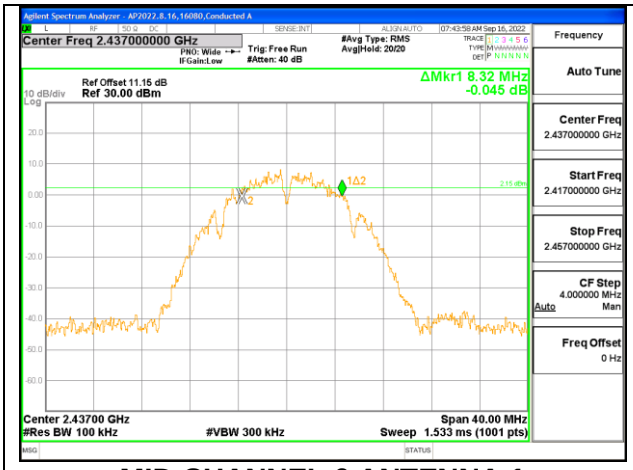
LOW CHANNEL 1



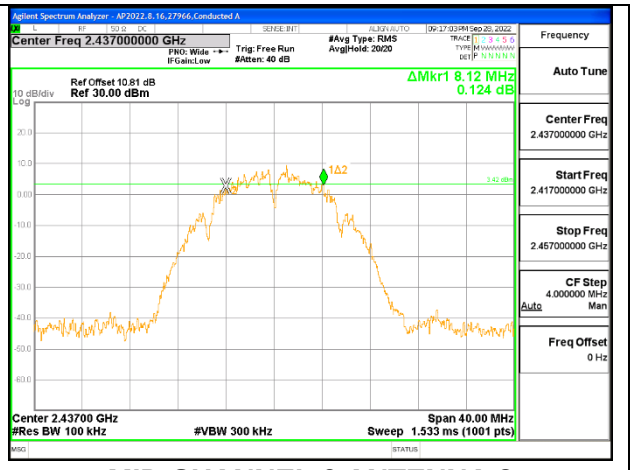
LOW CHANNEL 1 ANTENNA 1

LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6

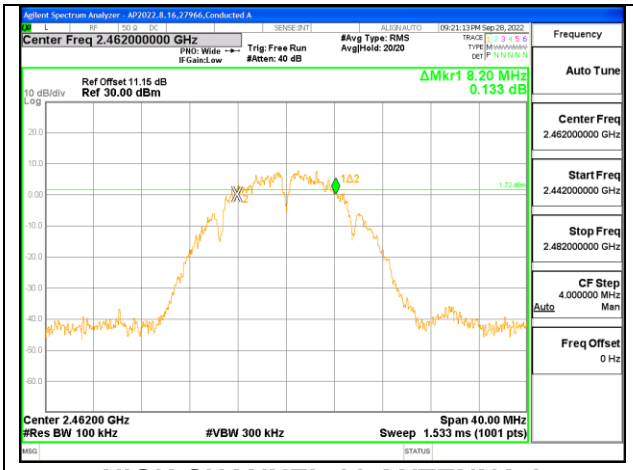


MID CHANNEL 6 ANTENNA 1

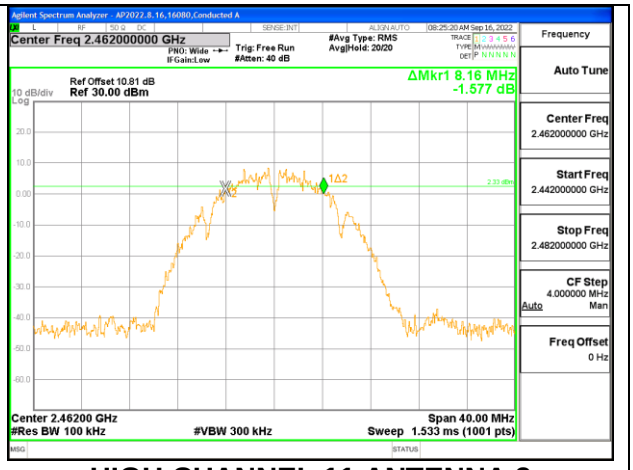


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 11



HIGH CHANNEL 11 ANTENNA 1



HIGH CHANNEL 11 ANTENNA 3

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9.3.2. 802.11g MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Low 1	2412	16.44	16.52	0.5
Mid 6	2437	16.48	16.44	0.5
High 11	2462	16.52	16.48	0.5

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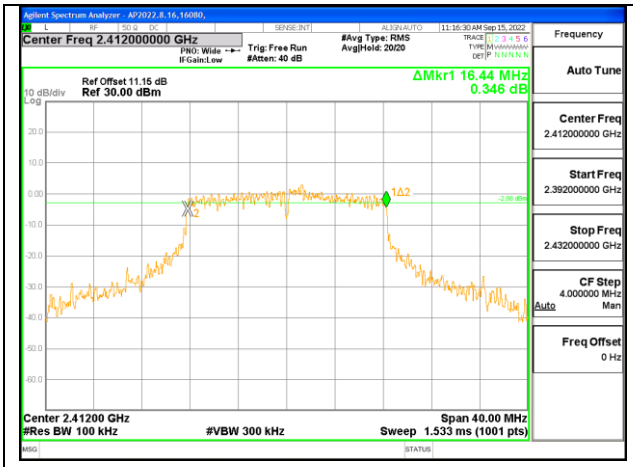
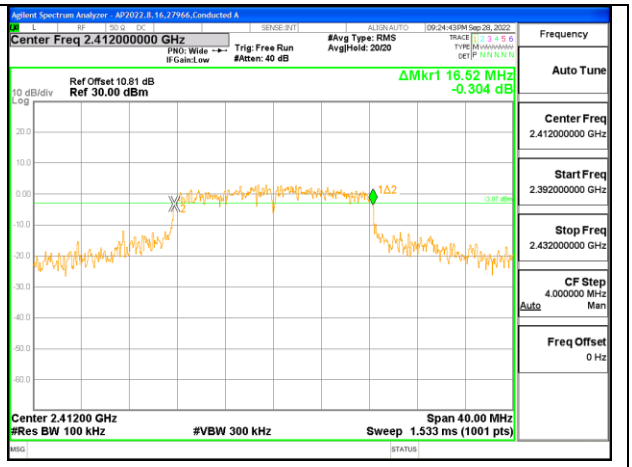
LOW CHANNEL 1

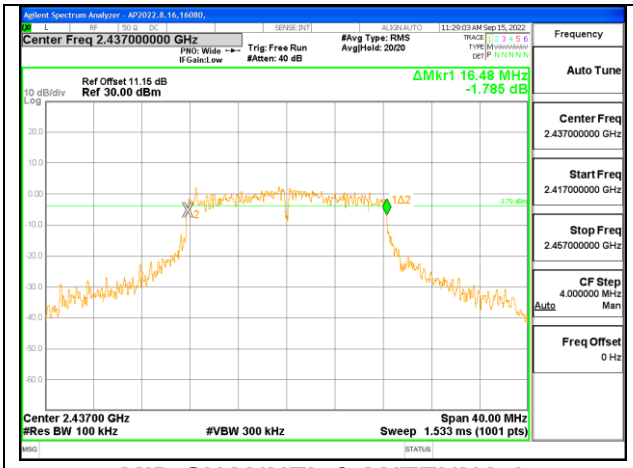


LOW CHANNEL 1 ANTENNA 1

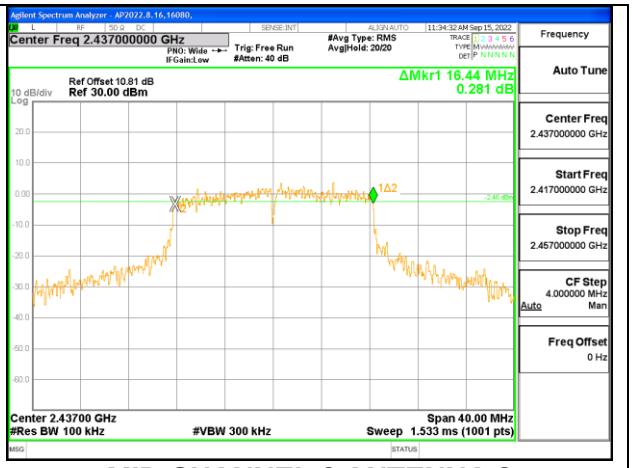


LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6

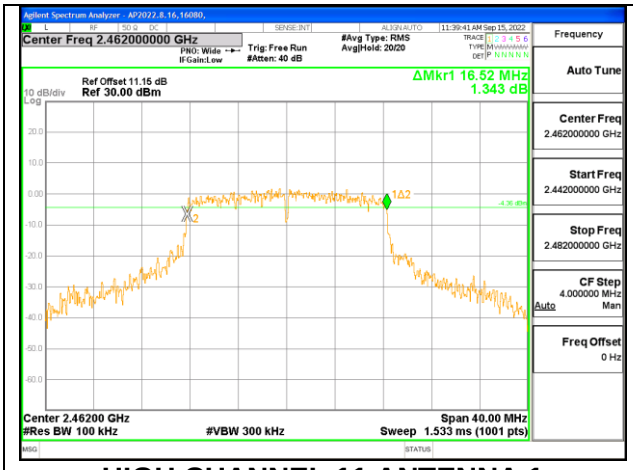


MID CHANNEL 6 ANTENNA 1

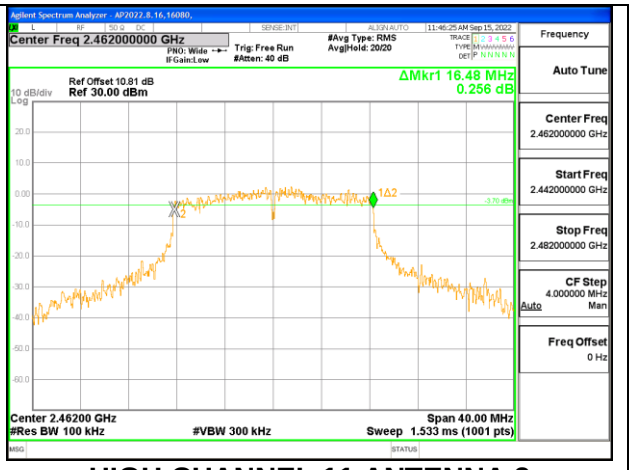


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 11



HIGH CHANNEL 11 ANTENNA 1



HIGH CHANNEL 11 ANTENNA 3

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9.3.3. 802.11n HT20 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Low 1	2412	17.44	17.44	0.5
Mid 6	2437	17.40	17.72	0.5
High 11	2462	17.72	17.68	0.5

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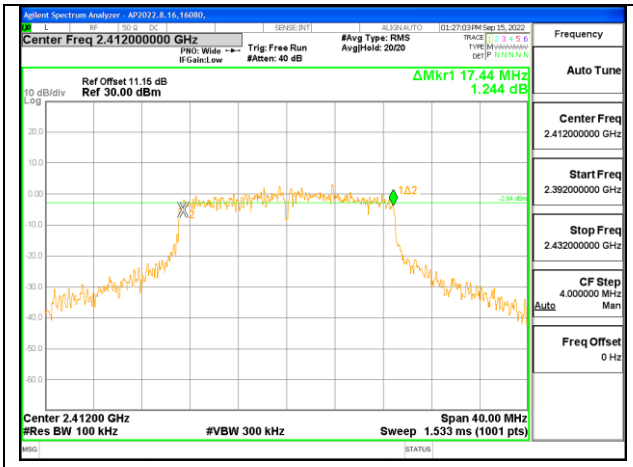
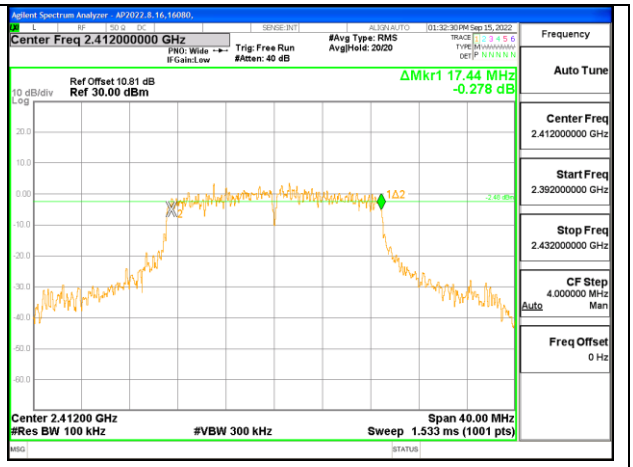
LOW CHANNEL 1

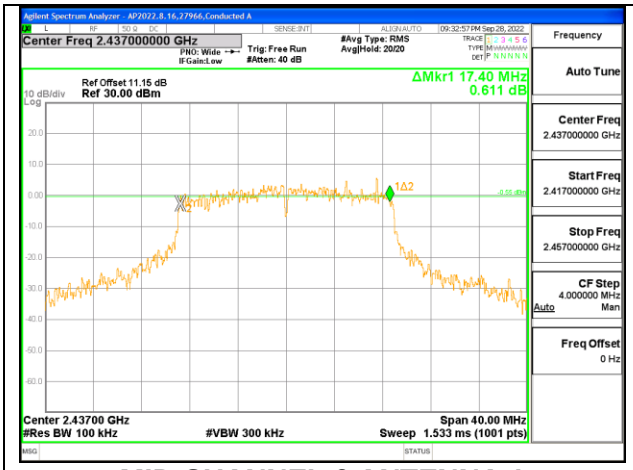


LOW CHANNEL 1 ANTENNA 1

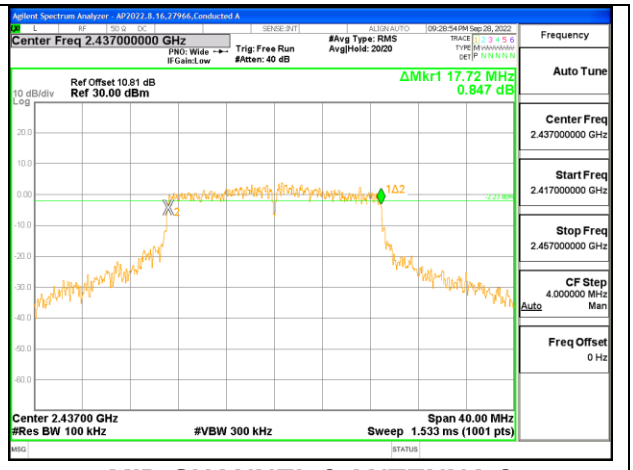


LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6

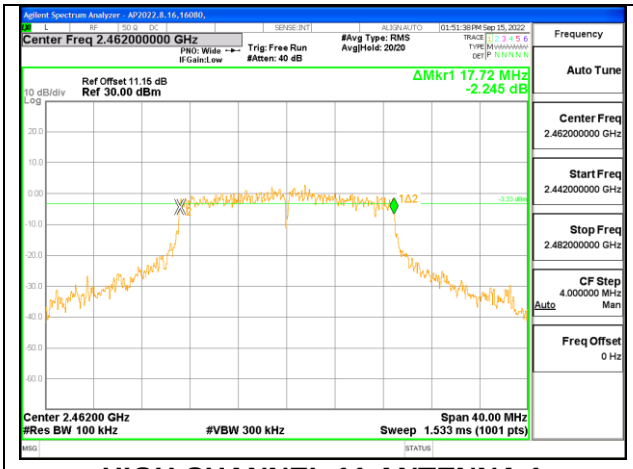


MID CHANNEL 6 ANTENNA 1

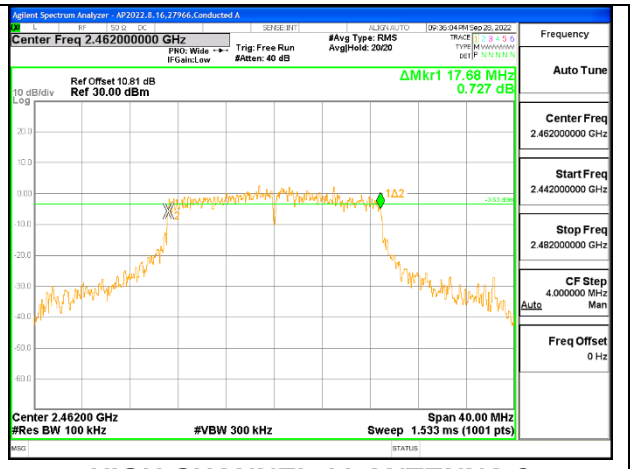


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 11



HIGH CHANNEL 11 ANTENNA 1



HIGH CHANNEL 11 ANTENNA 3

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9.3.4. 802.11n HT40 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Channel	Frequency (MHz)	6 dB BW Antenna 1 (MHz)	6 dB BW Antenna 3 (MHz)	Minimum Limit (MHz)
Low 3	2422	36.08	36.48	0.5
Mid 6	2437	36.40	36.48	0.5
High 9	2452	36.16	36.32	0.5

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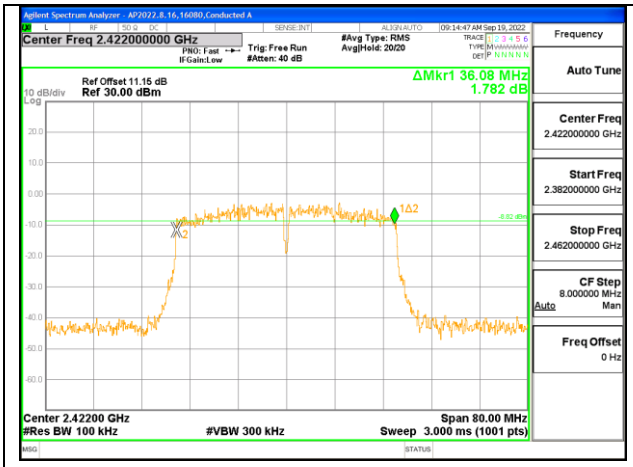
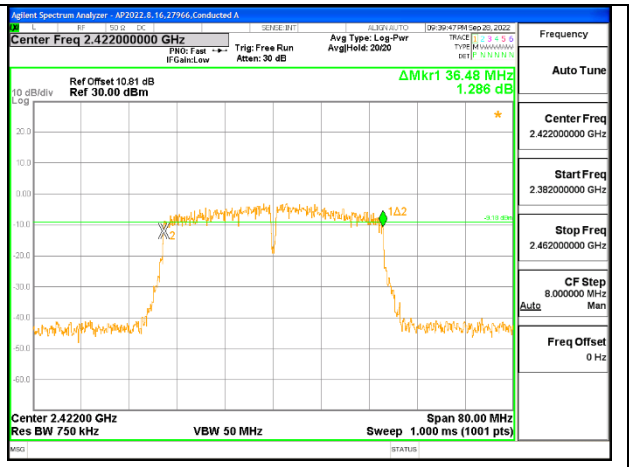
LOW CHANNEL 3

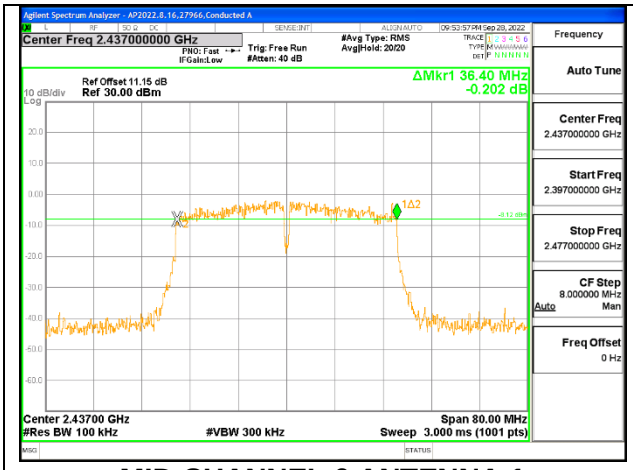


LOW CHANNEL 3 ANTENNA 1

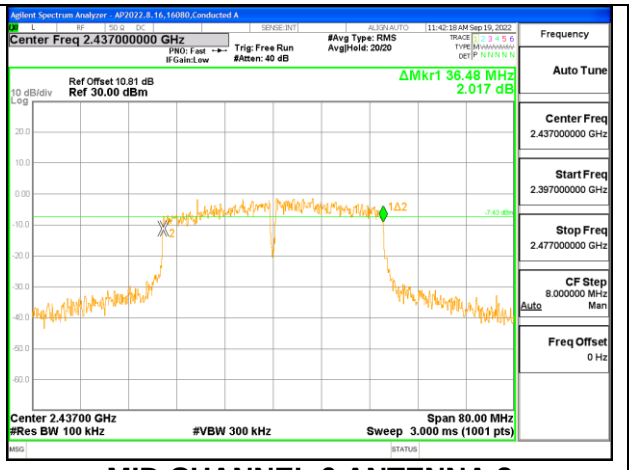


LOW CHANNEL 3 ANTENNA 3

MID CHANNEL 6

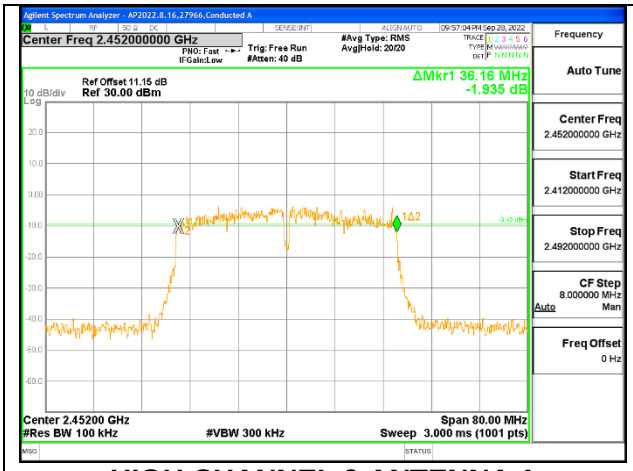


MID CHANNEL 6 ANTENNA 1

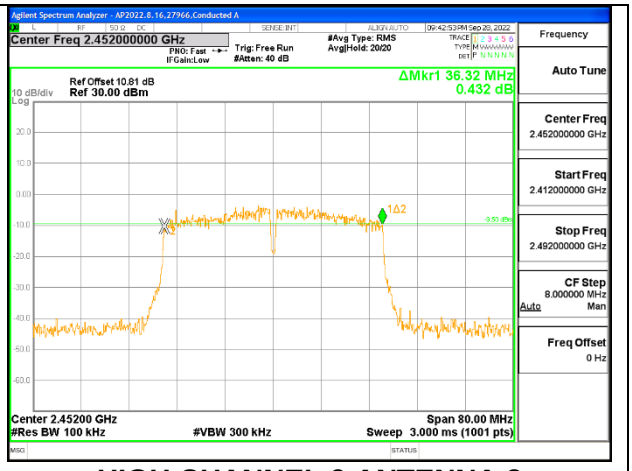


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 9



HIGH CHANNEL 9 ANTENNA 1



HIGH CHANNEL 9 ANTENNA 3

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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.

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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 1 and Antenna 3 are the worst-case combinations.

Antenna 1 and Antenna 3 (Worst-case):

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	4.40	3.40	3.93	6.92

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	4.40	3.10	3.80	6.78

Antenna 2 and Antenna 3:

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	2.10	3.40	2.80	5.78

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	2.10	3.10	2.63	5.62

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Directional Gain value was determined using the following formula:

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

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

Uncorrelated Directional Gain sample calculation:

2.63 dBi = 10 log [(10^(2.1/10) + 10^(3.1/10)/2]

Correlated Directional Gain sample calculation:

5.62 dBi = 10 log [(10^(2.1/20) + 10^ (3.1/20)^2)/2]

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RESULTS

9.4.1. 802.11b MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Test Engineer:	ZS16080 and PV27966
Test Date:	2022-09-15

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	3.93	30.00	36	30.00
Mid 6	2437	3.93	30.00	36	30.00
High 11	2462	3.93	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 1	2412	22.35	22.56	25.47	30.00	-4.53
Mid 6	2437	20.47	20.71	23.60	30.00	-6.40
High 11	2462	20.33	20.58	23.47	30.00	-6.53

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9.4.2. 802.11g MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Test Engineer:	ZS16080 and PV27966
Test Date:	2022-09-15 to 2022-10-04

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	3.93	30.00	36	30.00
Mid 6	2437	3.93	30.00	36	30.00
High 11	2462	3.93	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 1	2412	23.35	23.42	26.40	30.00	-3.60
Mid 6	2437	24.10	24.55	27.34	30.00	-2.66
High 11	2462	23.72	23.30	26.53	30.00	-3.47

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9.4.3. 802.11n HT20 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Test Engineer:	ZS16080 and PV27966
Test Date:	2022-09-15 to 2022-10-04

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 1	2412	3.93	30.00	36	30.00
Mid 6	2437	3.93	30.00	36	30.00
High 11	2462	3.93	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 1	2412	24.11	24.01	27.07	30.00	-2.93
Mid 6	2437	24.57	25.03	27.82	30.00	-2.18
High 11	2462	24.04	24.08	27.07	30.00	-2.93

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9.4.4. 802.11n HT40 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Test Engineer:	ZS16080 and PV27966
Test Date:	2022-09-15

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC/ISED Power Limit (dBm)	ISED EIRP Limit (dBm)	Max Power (dBm)
Low 3	2422	3.93	30.00	36	30.00
Mid 6	2437	3.93	30.00	36	30.00
High 9	2452	3.93	30.00	36	30.00

Results

Channel	Frequency (MHz)	Antenna 1 Meas Power (dBm)	Antenna 3 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margi (dB)
Low 3	2422	24.15	24.26	27.22	30.00	-2.78
Mid 6	2437	24.34	24.91	27.64	30.00	-2.36
High 9	2452	22.02	21.90	24.97	30.00	-5.03

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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.

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RESULTS

9.5.1. 802.11b MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Test Engineer:	ZS16080 and PV27966
Test Date:	2022-09-15

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 1	2412	19.89	20.16	23.04
Mid 6	2437	18.02	18.26	21.15
High 11	2462	17.97	18.08	21.04

9.5.2. 802.11g MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Test Engineer:	ZS16080 and PV27966
Test Date:	2022-09-15 to 2022-10-04

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 1	2412	15.85	16.14	19.01
Mid 6	2437	15.93	16.10	19.03
High 11	2462	16.34	16.09	19.23

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9.5.3. 802.11n HT20 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Test Engineer:	ZS16080 and PV27966
Test Date:	2022-09-15 to 2022-10-04

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 1	2412	15.83	16.05	18.95
Mid 6	2437	15.82	16.29	19.07
High 11	2462	15.92	16.13	19.04

9.5.4. 802.11n HT40 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Test Engineer:	ZS16080 and PV27966
Test Date:	2022-09-15

Channel	Frequency (MHz)	Antenna 1 Power (dBm)	Antenna 3 Power (dBm)	Total Power (dBm)
Low 3	2422	13.71	13.92	16.83
Mid 6	2437	14.88	14.96	17.93
High 9	2452	12.85	12.77	15.82

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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

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9.6.1. 802.11b MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Duty Cycle CF (dB)	0.30	Included in Calculations of Corr'd PSD

PSD Results

Channel	Frequency (MHz)	Antenna 1 Meas (dBm/ 3kHz)	Antenna 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low 1	2412	-2.045	-1.989	1.29	8.0	-6.7
Mid 6	2437	-3.304	-3.566	-0.12	8.0	-8.1
High 11	2462	-3.864	-3.557	-0.40	8.0	-8.4

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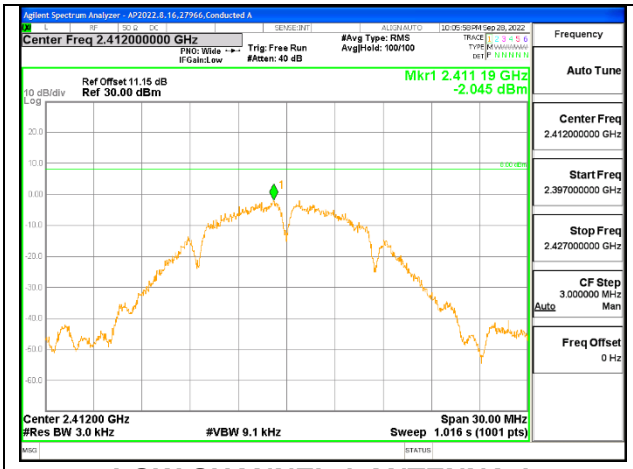
LOW CHANNEL 1



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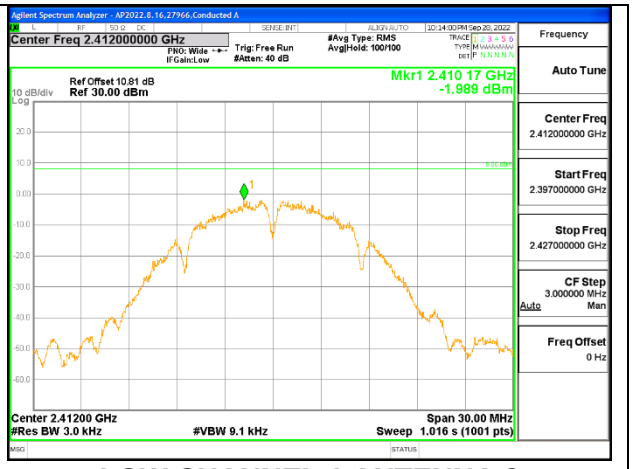
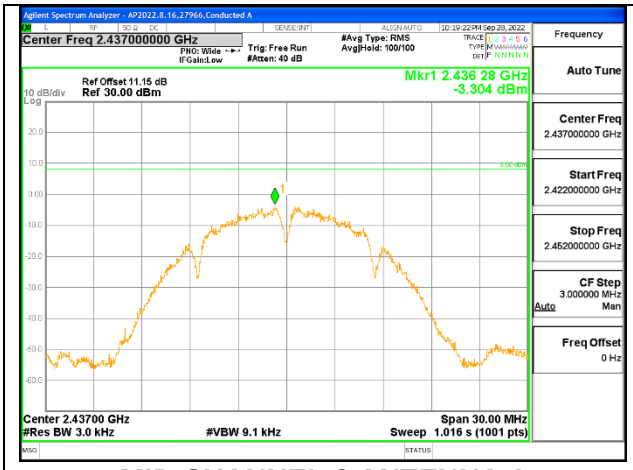


LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6



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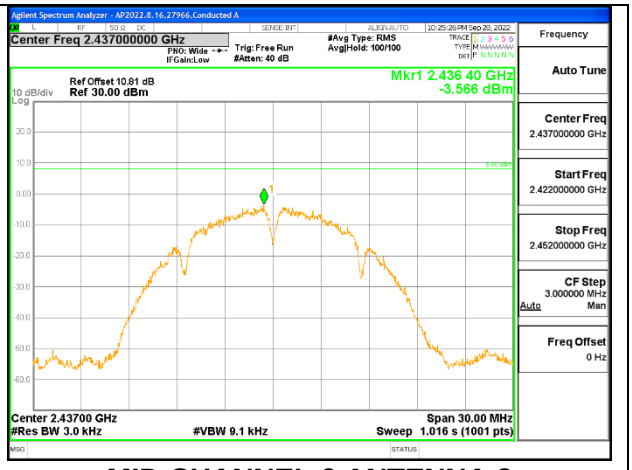
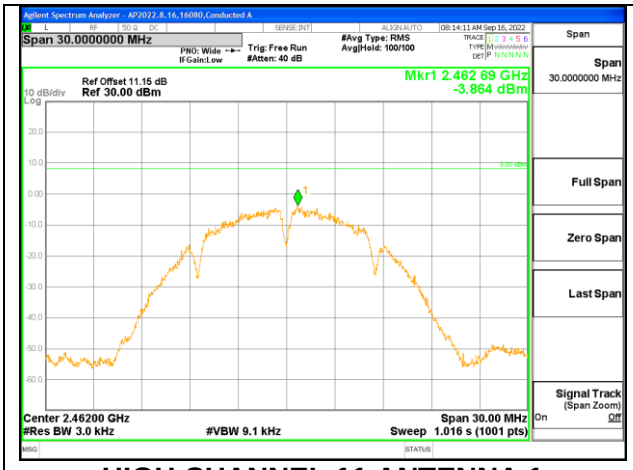


MID CHANNEL 6 ANTENNA 3

HIGH CHANNEL 11



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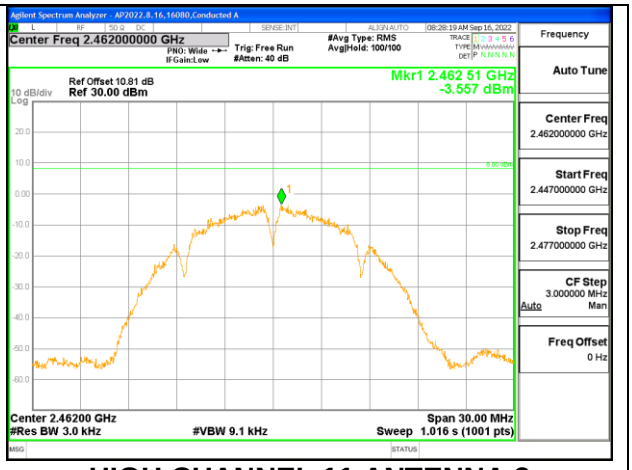

HIGH CHANNEL 11 ANTENNA 3

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9.6.2. 802.11g MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Duty Cycle CF (dB)	1.61	Included in Calculations of Corr'd PSD

PSD Results

Channel	Frequency (MHz)	Antenna 1 Meas (dBm/ 3kHz)	Antenna 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low 1	2412	-9.885	-9.557	-5.10	8.0	-13.1
Mid 6	2437	-9.512	-9.498	-4.88	8.0	-12.9
High 11	2462	-9.618	-9.853	-5.11	8.0	-13.1

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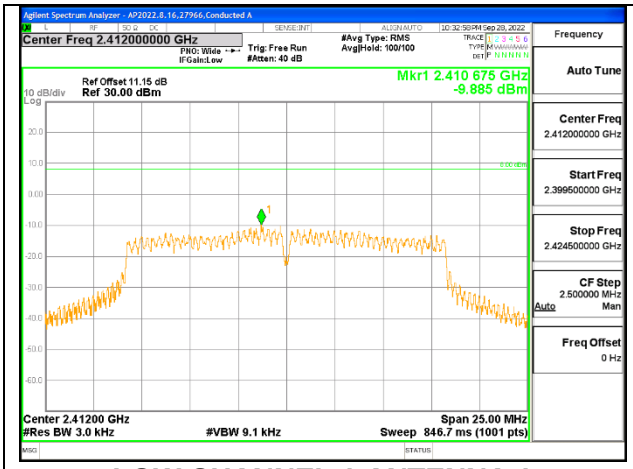
LOW CHANNEL 1



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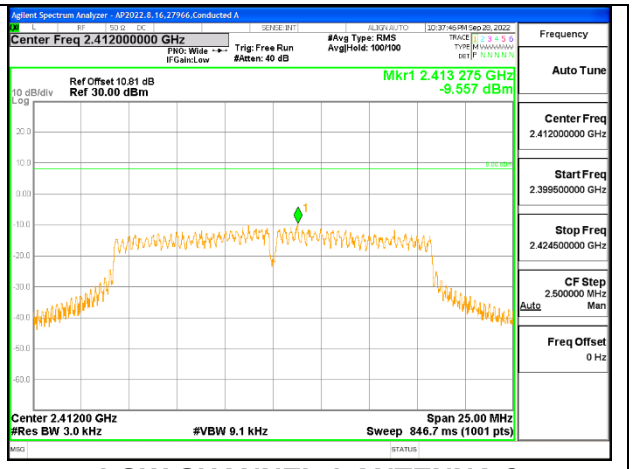
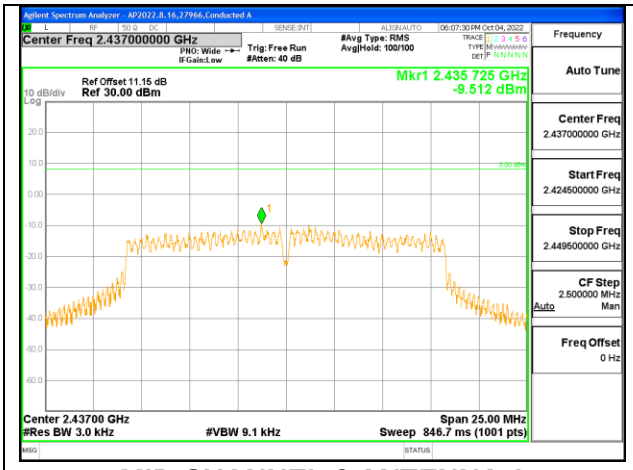


LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6



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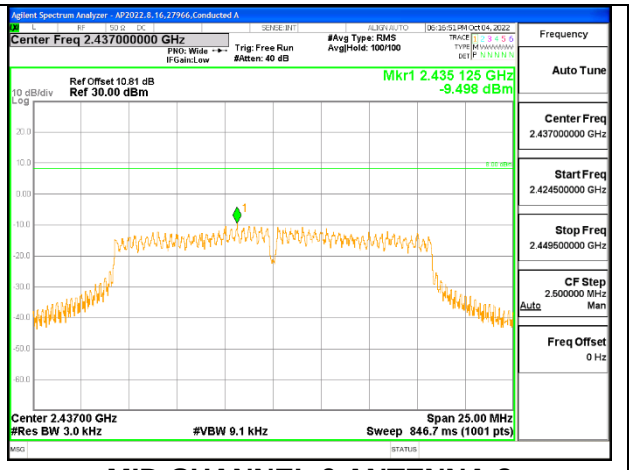

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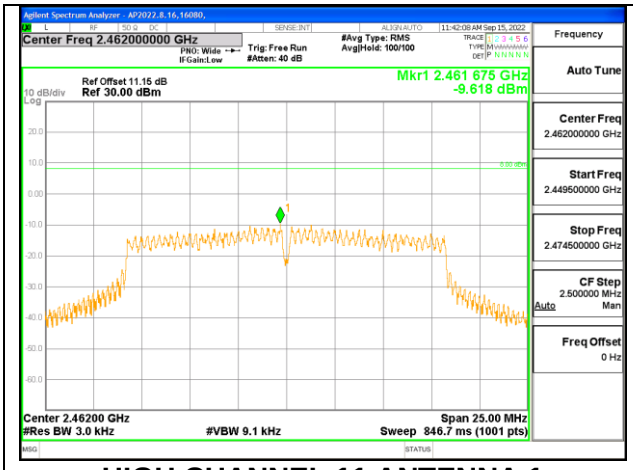
HIGH CHANNEL 11



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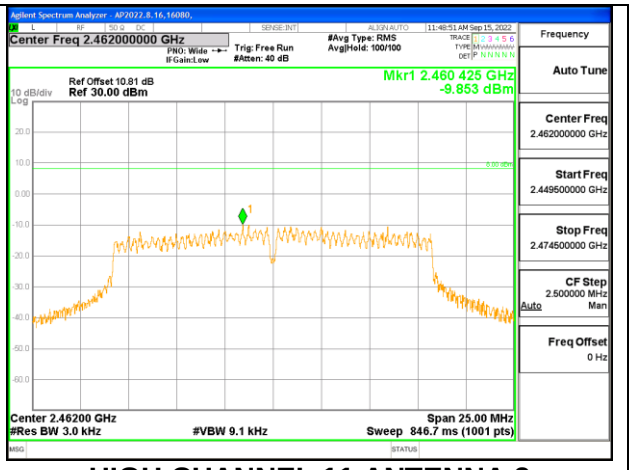

HIGH CHANNEL 11 ANTENNA 3

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9.6.3. 802.11n HT20 MODE

2TX Antenna 1 + Antenna 3 CDD MODE

Duty Cycle CF (dB)	1.69	Included in Calculations of Corr'd PSD

PSD Results

Channel	Frequency (MHz)	Antenna 1 Meas (dBm/ 3kHz)	Antenna 3 Meas (dBm/ 3kHz)	Total Corr'd PSD (dBm/ 3kHz)	Limit (dBm/ 3kHz)	Margin (dB)
Low 1	2412	-9.647	-9.281	-4.76	8.0	-12.8
Mid 6	2437	-9.763	-9.419	-4.89	8.0	-12.9
High 11	2462	-9.660	-9.515	-4.89	8.0	-12.9

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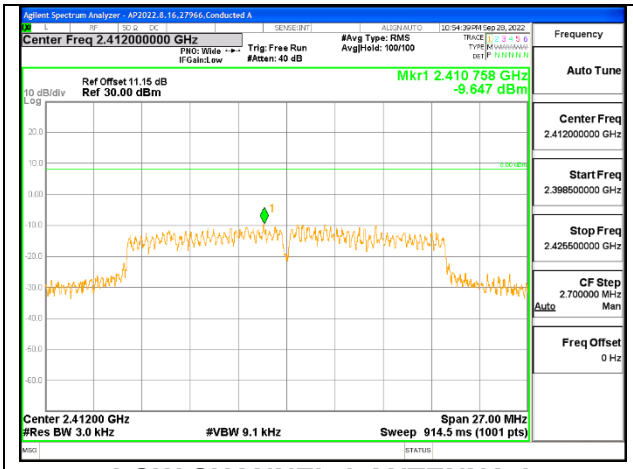
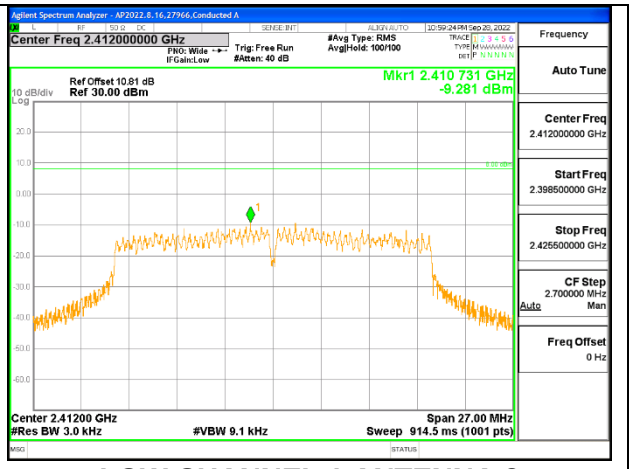
LOW CHANNEL 1

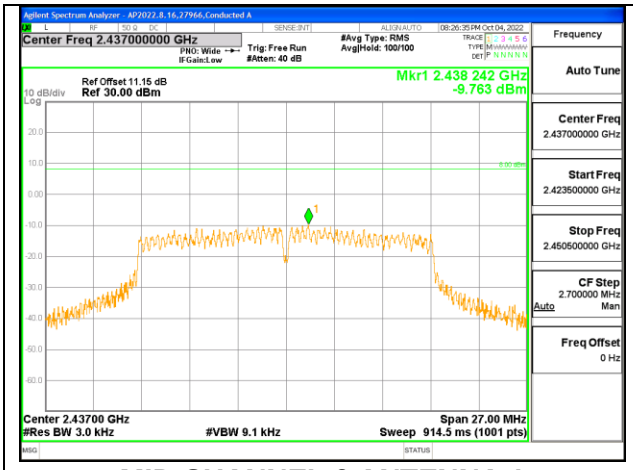


LOW CHANNEL 1 ANTENNA 1



LOW CHANNEL 1 ANTENNA 3

MID CHANNEL 6



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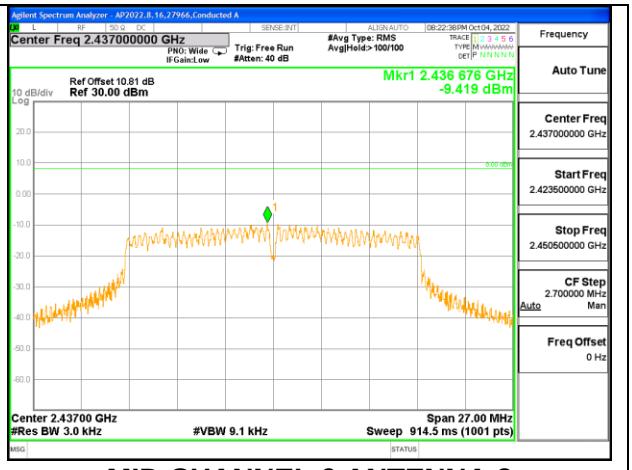

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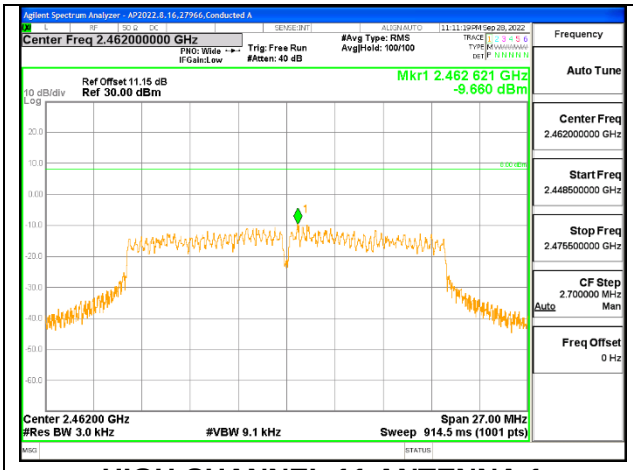
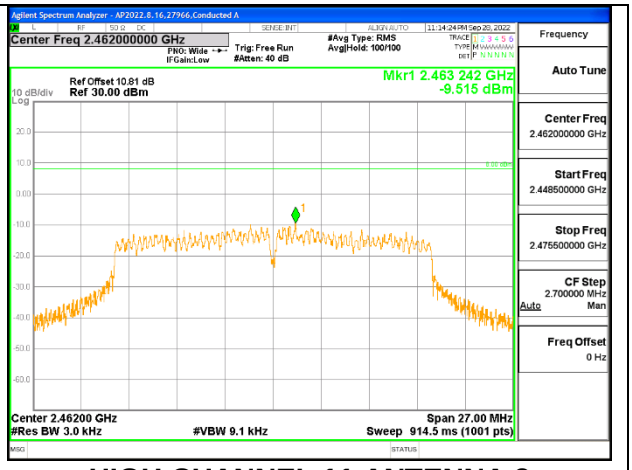
HIGH CHANNEL 11



HIGH CHANNEL 11 ANTENNA 1



HIGH CHANNEL 11 ANTENNA 3

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