Tonal

REVISED TEST REPORT TO 110825-14

Apollo Board, Model: 500-0806
Trainer, Model: T2

Tested to The Following Standards:

FCC Part 15 Subpart C Section(s)

15.207 & 15.247
(DTS 2400-2483.5 MHz)

Report No.: 110825-14A

Date of issue: February 17, 2025

This test report bears the accreditation symbol indicating that the testing performed herein meets the test and reporting requirements of ISO/IEC 17025 under the applicable scope of testing for CKC Laboratories, Inc.

We strive to create long-term, trust based relationships by providing sound, adaptive, customer first testing services. We embrace each of our customers' unique EMC challenges, not as an interruption to set processes, but rather as the reason we are in business.

Test Certificate # 803.01

TABLE OF CONTENTS

Administrative Information

Test Report Information

REPORT PREPARED FOR:

Tonal
69 Converse, Suite 200
San Francisco, CA 94103

Representative: Lars Gilstrom
Customer Reference Number: PO3317

REPORT PREPARED BY:

Lisa Bevington
CKC Laboratories, Inc.
5046 Sierra Pines Drive
Mariposa, CA 95338

Project Number: 110825

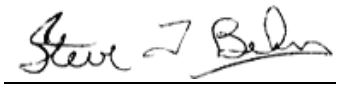
DATE OF EQUIPMENT RECEIPT: October 7, 2024
DATE(S) OF TESTING: October 7-9, 2024, November 8, 2024 and January 12, 13 & 15, 2025

Revision History

Original: Testing of Testing of Apollo Board, Model: 500-0806 and Trainer, Model: T2 to FCC Part 15 Subpart C Section(s) 15.207 & 15.247 (DTS 2400-2483.5 MHz).
Revision A: To replace correct plot to page 52 from page 58.

Report Authorization

The test data contained in this report documents the observed testing parameters pertaining to and are relevant for only the equipment provided by the client, tested in the agreed upon operational mode(s) and configuration(s) as identified herein. Compliance assessment remains the client's responsibility. This report may not be used to claim product endorsement by A2LA or any government agencies. This test report has been authorized for release under quality control from CKC Laboratories, Inc.



Steve Behm
Director of Quality Assurance & Engineering Services
CKC Laboratories, Inc.

Test Facility Information

Our laboratories are configured to effectively test a wide variety of product types. CKC utilizes first class test equipment, anechoic chambers, data acquisition and information services to create accurate, repeatable and affordable test results.

TEST LOCATION(S):
CKC Laboratories, Inc.
110 North Olinda Place
Brea, CA 92823

CKC Laboratories, Inc.
1120 Fulton Place
Fremont, CA 94539

Software Versions

CKC Laboratories Proprietary Software	Version
EMITest Emissions	5.03.20

Site Registration & Accreditation Information

Location	*NIST CB #	FCC	Canada	Japan
Canyon Park, Bothell, WA	US0103	US1024	3082C	A-0136
Brea, CA	US0103	US1024	3082D	A-0136
Fremont, CA	US0103	US1024	3082B	A-0136
Mariposa, CA	US0103	US1024	3082A	A-0136

*CKC's list of NIST designated countries can be found at: https://standards.gov/cabs/designations.html

Summary of Results

Standard / Specification: FCC Part 15 Subpart C - 15.247 (DTS 2400-2483.5 MHz)

Test Procedure	Description	Modifications	Results
15.247(a)(2)	6dB Bandwidth	NA	NA1
15.247(b)(3)	Output Power	NA	Pass
15.247(e)	Power Spectral Density	NA	Pass
15.247(d)	RF Conducted Emissions & Band Edge	NA	NA1
15.247(d)	Radiated Emissions & Band Edge	MOD1	Pass
15.207	AC Conducted Emissions	NA	NA1

NA = Not Applicable
NA1 = Not applicable for PCII, only relevant sections were tested/recalculate.

ISO/IEC 17025 Decision Rule
The equipment sample utilized for testing is selected by the manufacturer. The declaration of pass or fail herein is a binary statement for simple acceptance rule (ILAC G8) based upon assessment to the specification(s) listed above, without consideration of measurement uncertainties. For performance related tests, equipment was monitored for specified criteria identified in that section of testing.

Modifications During Testing

This list is a summary of the modifications made to the equipment during testing.

Summary of Conditions
Modification 1 (MOD1) = Reduce RF output power to 12dBm in the software for 802.11n HT40 Chain 0 Added a ferrite (Wurth: 742 712 21) on lower resistor wire Green Resistor

Modifications listed above must be incorporated into all production units.

Conditions During Testing

This list is a summary of the conditions noted to the equipment during testing.

Summary of Conditions
Test Condition #1: Evaluation for PCII, with MIMO enabled. Conducted power and Conducted PSD were calculated from original testing. Radiated emissions were re-measured. The unit is mounted to a floor standing rack as to simulate typical wall mounted setup. One weight line is extended to the floor. Camera is on. WiFi transmitting continuously with modulation type as listed with pattern of 0s and 1s at power level 14 except for 802.11n HT40 which was reduced to 12dBm. Worst case tested: 802.11b 11 Mbits/s 802.11g 18 Mbit/s 802.11n HT20 MCS2 802.11n HT20 MCS0

Equipment Under Test (EUT)

During testing, numerous configurations may have been utilized. The configurations listed below support compliance to the standard(s) listed in the Summary of Results section.

Configuration A

Equipment Under Test **(* = EUT):**

Device Name	Manufacturer	Model #	S/N
Apollo Board	Tonal System	500-0806	080600030001263

Support Devices:

Device Name	Manufacturer	Model #	S/N
MCB Board	Tonal Systems	500-0131	500-0131_rev003_00001286_20240909_17
Laptop	Dell	XPS	22E00911
AC/DC Adapter for Laptop	Dell	DA130PM130	CN-06TTY6-48661-4CO-27M7-A00

Configuration 1

Equipment Under Test **(* = EUT):**

Device Name	Manufacturer	Model #	S/N
Trainer	Tonal System	T2	4000055

Support Devices:

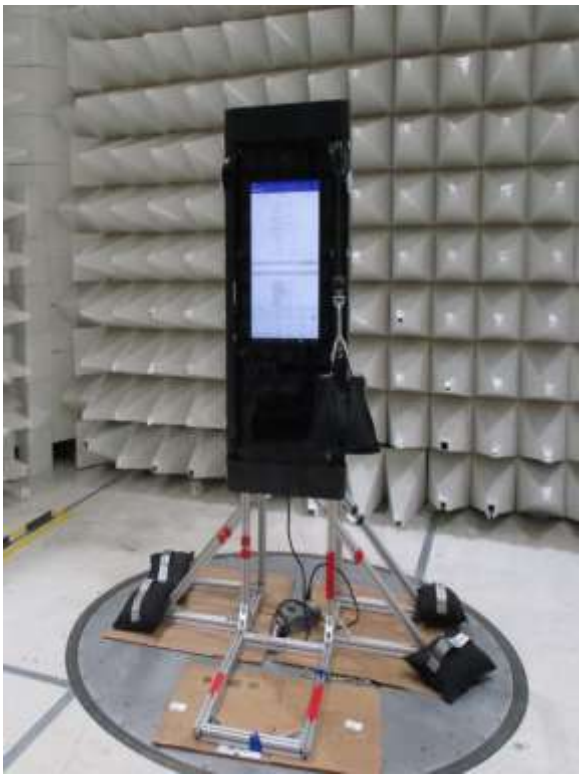
Device Name	Manufacturer	Model #	S/N
Laptop	Dell	XPS	22E00911
AC/DC Adapter for Laptop	Dell	DA130PM130	CN-06TTY6-48661-4CO-27M7-A00

General Product Information:

Description of EUT
Exercise Trainer

Product Information	Manufacturer-Provided Details
Operating Frequencies Tested:	2402-2480MHz
Equipment Type:	Stand-Alone Equipment
Type of Wideband System:	802.11
Maximum Duty Cycle:	100%
Modulation Type(s):	802,11b (DBPSK, DQPSK, QPSK) 802.11g (BPSK, QPSK, 16QAM, 64QAM) 802.11n HT20 (BPSK, QPSK, 16QAM, 64QAM) 802.11n HT40 (BPSK, QPSK, 16QAM, 64QAM)
Number of TX Chains:	2 MIMO enabled
Beamforming Type:	NA
Antenna Type(s) and Gain:	External 3.76dBi
Antenna Connection Type:	External Connector
Nominal Input Voltage:	12VDC
Firmware / Software Version(s):	QRCT (Qualcomm Radio Control Toolkit) Version 4.1
Firmware / Software Description:	Using C-Prompt and QRCT application to control all modulation types and frequencies to continuously transmit or receive as intended
Firmware / Software Setting(s):	NA
Tune-up or Adjustment(s):	NA
The validity of results is dependent on the stated product details, the accuracy of which the manufacturer assumes full responsibility.	

EUT and Accessory Photo(s)



EUT

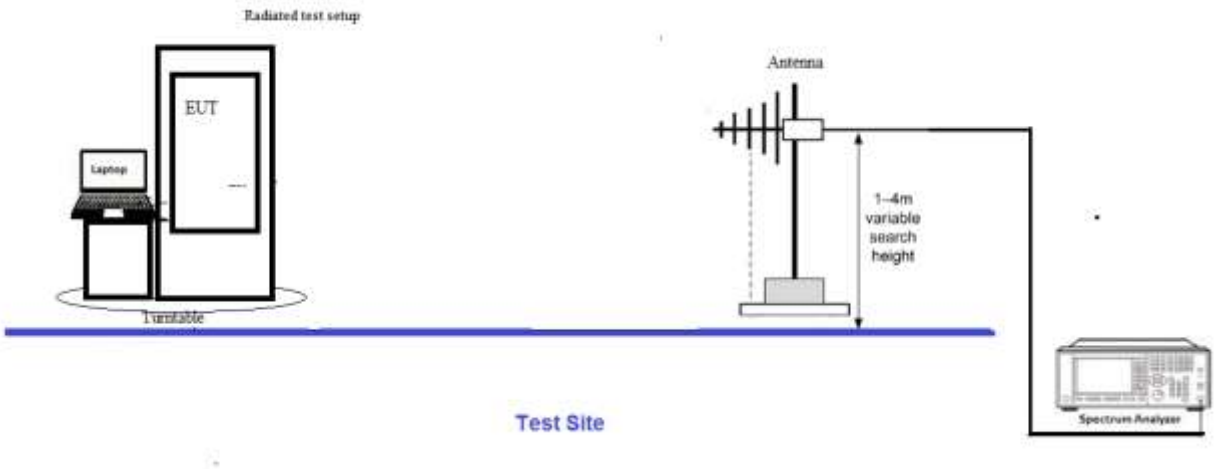
Support Equipment Photo(s)

Laptop

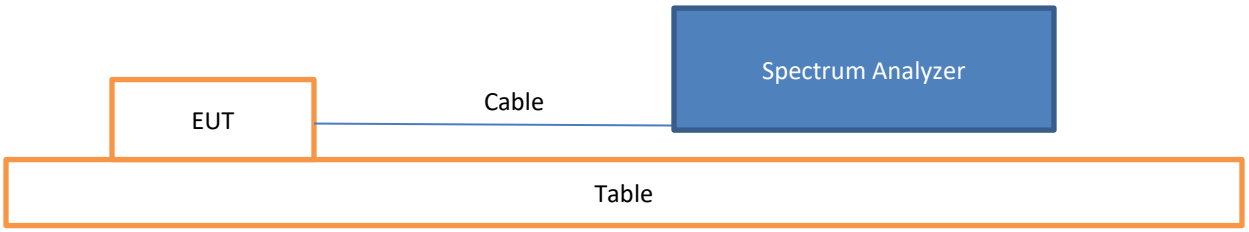
Block Diagram of Test Setup(s)

Configuration#	Setup Description of Block Diagram
1	Radiated Measurement: The Antenna is set up at 3meter distance from the EUT according to ANSI C63.10 2020. The EUT is set up and operated as intended.
A	Conducted Measurement: The EUT is placed non-conducted table. It is operated as intended. It is connected straight to a Spectrum Analyzer.

Radiated Method Setup



Conducted Method Setup



FCC Part 15 Subpart C

15.247(b)(3) Output Power

Test Setup/Conditions			
Test Location:	Fremont Lab Bench	Test Engineer:	Hieu Song Nguyenpham & E. Wong
Test Method:	ANSI C63.10 (2020), KDB 558074 662911 D01 Multiple Transmitter Output v02r01	Test Date(s):	10/7-9/2024 11/08/2024
Configuration:	A		
Test Setup:	The EUT is placed non-conducted table. It is operated as intended. It is connected straight to a Spectrum Analyzer		

Environmental Conditions			
Temperature (ºC)	20.8	Relative Humidity (%):	37

Test Equipment					
Asset#	**Description**	**Manufacturer**	**Model**	**Cal Date**	**Cal Due**
03013	Cable	Astrolab	32022-2-2909K-36TC	1/9/2024	1/9/2026
P07365	Attenuator	Weinschel	54A-10	5/26/2023	5/26/2025
03471	Spectrum Analyzer	Agilent	E4440A	2/23/2024	2/23/2026

Test Data Summary - Voltage Variations					
Frequency (MHz)	**Modulation / Ant Port**	**$V_{Minimum}$ (dBm)**	**$V_{Nominal}$ (dBm)**	**$V_{Maximum}$ (dBm)**	**Max Deviation from $V_{Nominal}$ (dB)**
2412	802.11g/1	17.60	17.61	17.61	0.01
2447	802.11g/1	17.07	17.07	17.07	0.00
2462	802.11g/1	16.95	16.95	16.96	0.01

Test performed using operational mode with the highest output power, representing worst case.

Parameter Definitions:

Measurements performed at input voltage Vnominal ± 15%.

Parameter	Value
$V_{Nominal}$:	12VDC
$V_{Minimum}$:	10.2VDC
$V_{Maximum}$:	13.8VDC

Test Data Summary - RF Conducted Measurement-CHAIN 0							
Measurement Option: AVGSA-1							
Frequency (MHz)	Modulation	Ant. Type / Gain (dBi)	RF Conducted (dBm)		EIRP (dBm)		Results
			Measured	Limit	Calculated	Limit	
2412	802.11b	External Connector /3.76	13.6	≤30	17.36	≤36	Pass
2447	802.11b	External Connector /3.76	13.45	≤30	17.21	≤36	Pass
2462	802.11b	External Connector /3.76	13.20	≤30	16.96	≤36	Pass
2412	802.11g	External Connector /3.76	13.79	≤30	17.55	≤36	Pass
2447	802.11g	External Connector /3.76	13.44	≤30	17.2	≤36	Pass
2462	802.11g	External Connector /3.76	13.40	≤30	17.16	≤36	Pass
2412	802.11n HT20	External Connector /3.76	13.22	≤30	16.98	≤36	Pass
2447	802.11n HT20	External Connector /3.76	13.39	≤30	17.15	≤36	Pass
2462	802.11n HT20	External Connector /3.76	13.29	≤30	17.05	≤36	Pass
2422	802.11n HT40	External Connector /3.76	11.01	≤30	16.76	≤36	Pass
2447	802.11n HT40	External Connector /3.76	11.29	≤30	14.77	≤36	Pass
2452	802.11n HT40	External Connector /3.76	11.43	≤30	15.05	≤36	Pass

Test Data Summary - RF Conducted Measurement-CHAIN 1							
Measurement Option: AVGSA-1							
Frequency (MHz)	Modulation	Ant. Type / Gain (dBi)	RF Conducted (dBm)		EIRP (dBm)		Results
			Measured	Limit	Calculated	Limit	
2412	802.11b	External Connector /3.76	14.56	≤30	18.32	≤36	Pass
2442	802.11b	External Connector /3.76	13.95	≤30	17.71	≤36	Pass
2462	802.11b	External Connector /3.76	14.21	≤30	17.97	≤36	Pass
2412	802.11g	External Connector /3.76	15.28	≤30	19.04	≤36	Pass
2442	802.11g	External Connector /3.76	14.61	≤30	18.37	≤36	Pass
2462	802.11g	External Connector /3.76	14.42	≤30	18.18	≤36	Pass
2412	802.11n HT20	External Connector /3.76	15.14	≤30	18.9	≤36	Pass
2442	802.11n HT20	External Connector /3.76	14.45	≤30	18.21	≤36	Pass
2462	802.11n HT20	External Connector /3.76	14.24	≤30	18	≤36	Pass
2422	802.11n HT40	External Connector /3.76	14.94	≤30	18.7	≤36	Pass
2442	802.11n HT40	External Connector /3.76	14.33	≤30	18.09	≤36	Pass
2452	802.11n HT40	External Connector /3.76	14.58	≤30	18.34	≤36	Pass

Test Data Summary - RF Conducted Measurement (MIMO Total Power)										
Measurement Option: AVGSA-1										
Frequency (MHz)	Modulation	Cond Power (dBm)		EIRP (dBm)		Total RF Conducted (dBm)		Total EIRP (dBm)		Results
		Ch0	Ch1	Ch0	Ch1	Measured	Limit	Calculated	Limit	
2412	802.11b	13.60	14.56	17.36	18.32	17.12	≤30	20.88	≤36	Pass
2442	802.11b	13.45	13.95	17.21	17.71	16.72	≤30	20.48	≤36	Pass
2462	802.11b	13.20	14.21	16.96	17.97	16.74	≤30	20.50	≤36	Pass
2412	802.11g	13.79	15.28	17.55	19.04	17.61	≤30	21.37	≤36	Pass
2442	802.11g	13.44	14.61	17.20	18.37	17.07	≤30	20.83	≤36	Pass
2462	802.11g	13.40	14.42	17.16	18.18	16.95	≤30	20.71	≤36	Pass
2412	802.11n HT20	13.22	15.14	16.98	18.90	17.30	≤30	21.06	≤36	Pass
2442	802.11n HT20	13.39	14.45	17.15	18.21	16.96	≤30	20.72	≤36	Pass
2462	802.11n HT20	13.29	14.24	17.05	18.00	16.80	≤30	20.56	≤36	Pass
2422	802.11n HT40	11.01	14.94	16.76	18.70	16.42	≤30	20.85	≤36	Pass
2442	802.11n HT40	11.29	14.33	14.77	18.09	16.08	≤30	19.75	≤36	Pass
2452	802.11n HT40	11.43	14.58	15.05	18.34	16.29	≤30	20.01	≤36	Pass

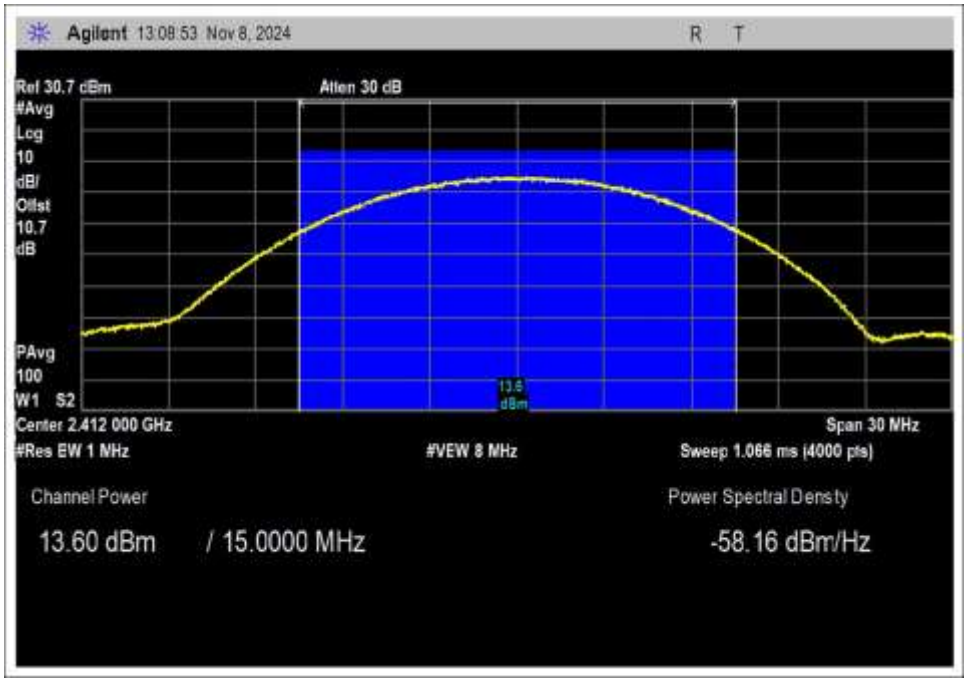
Antenna gain =3.76dBi
Ch0=Chain0
Ch1=Chain1

662911 D01 Multiple Transmitter Output v02r01 E 1) In-Band Power Measurements The measure-and-sum technique shall be used for measuring in-band transmit power of a device. Total power is the sum of the conducted power levels measured at the various output ports.

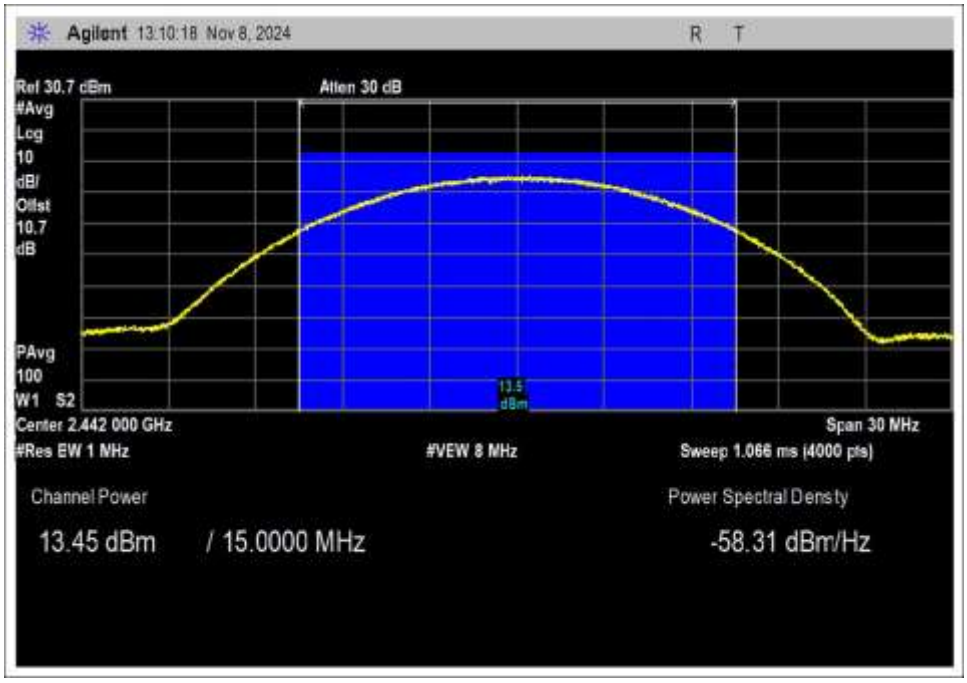
EIRP is calculated as RF conducted power (dBm) + antenna gain (dBi)

Plots

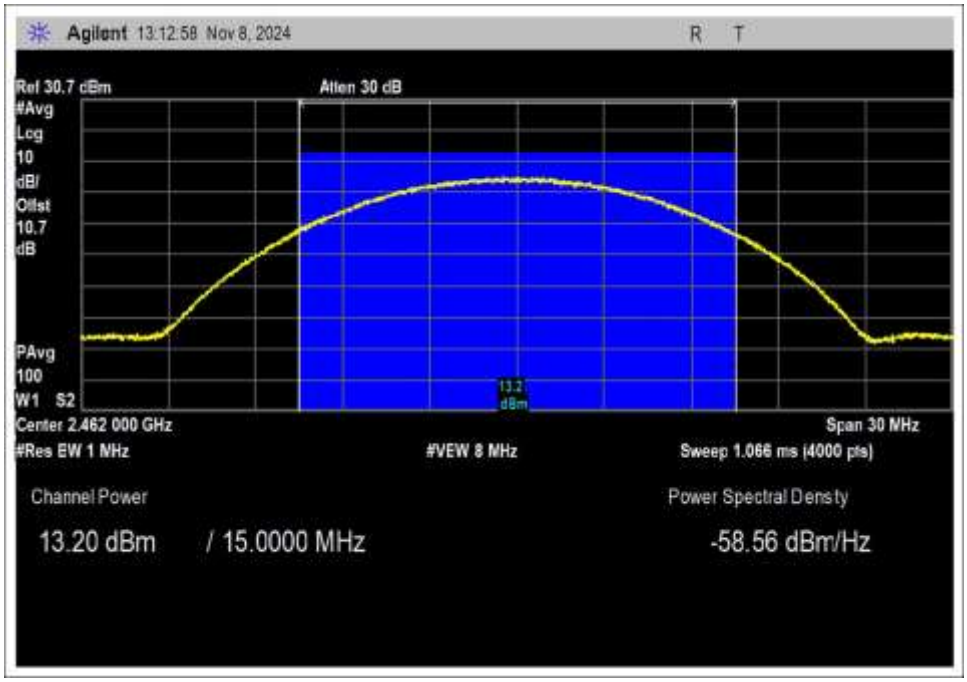
Chain 0



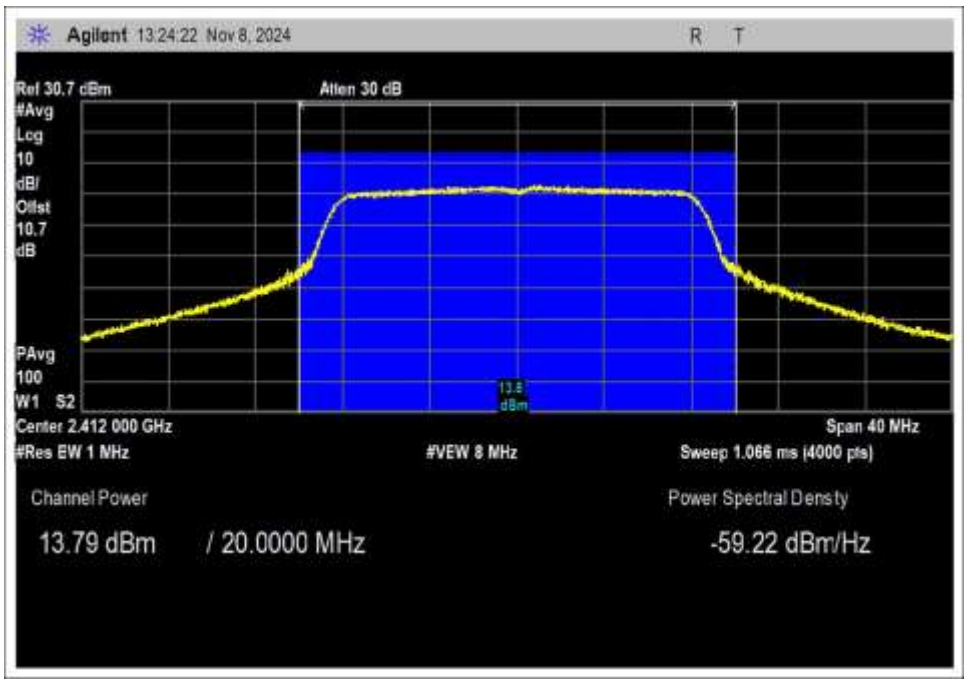
802.11b, Low Channel



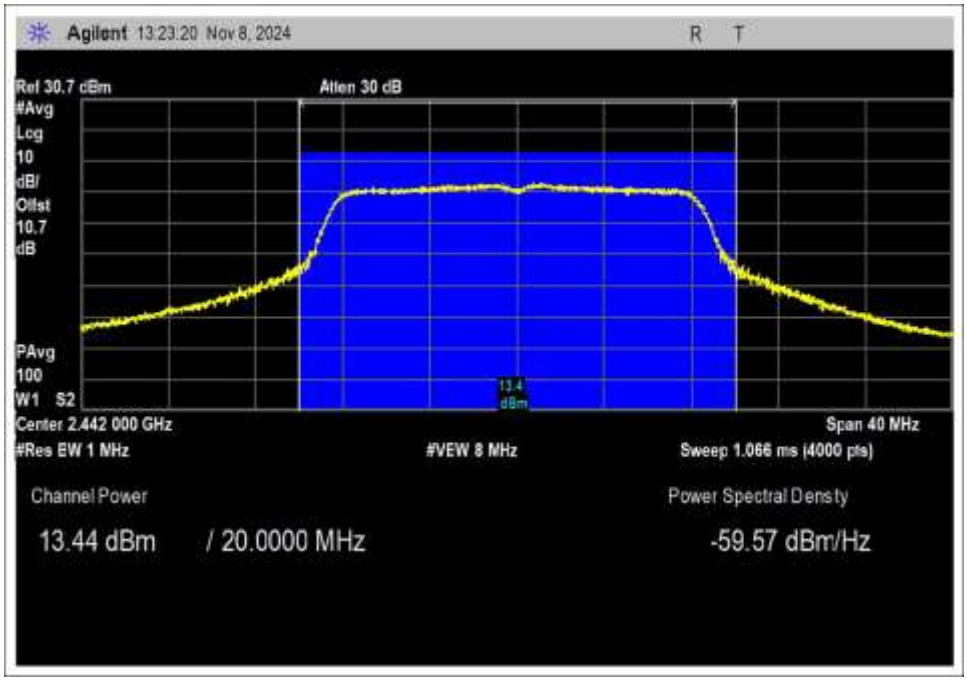
802.11b, Middle Channel



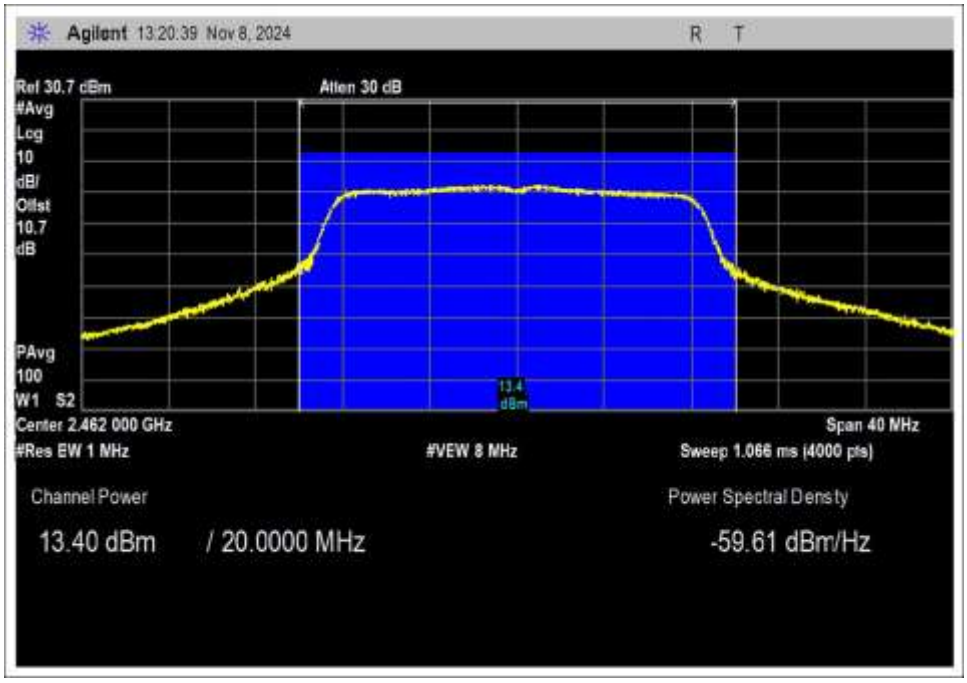
802.11b, High Channel



802.11g, Low Channel



802.11g, Middle Channel



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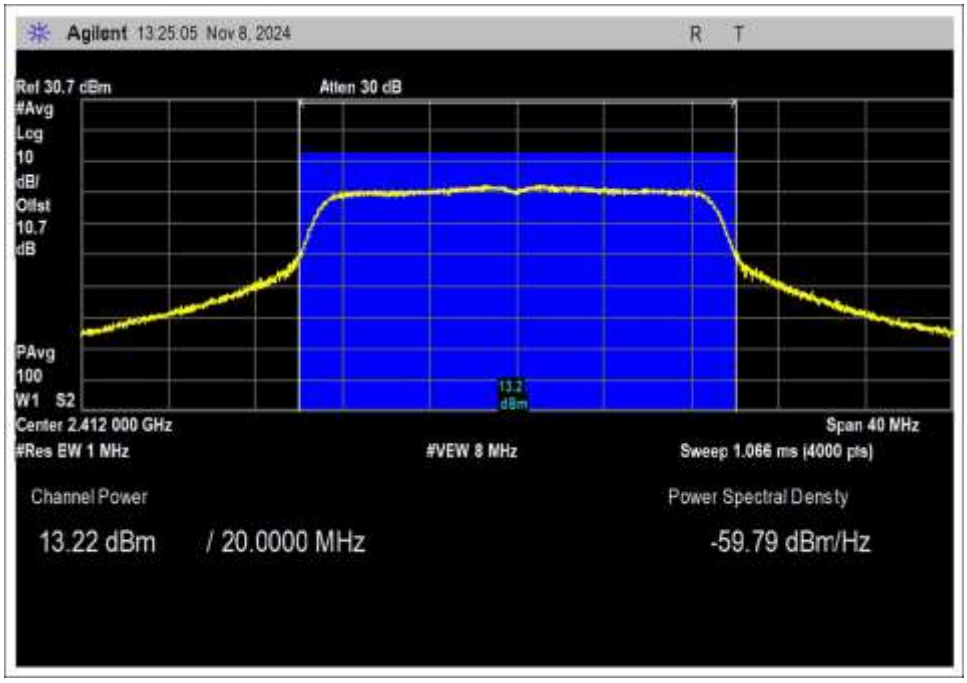
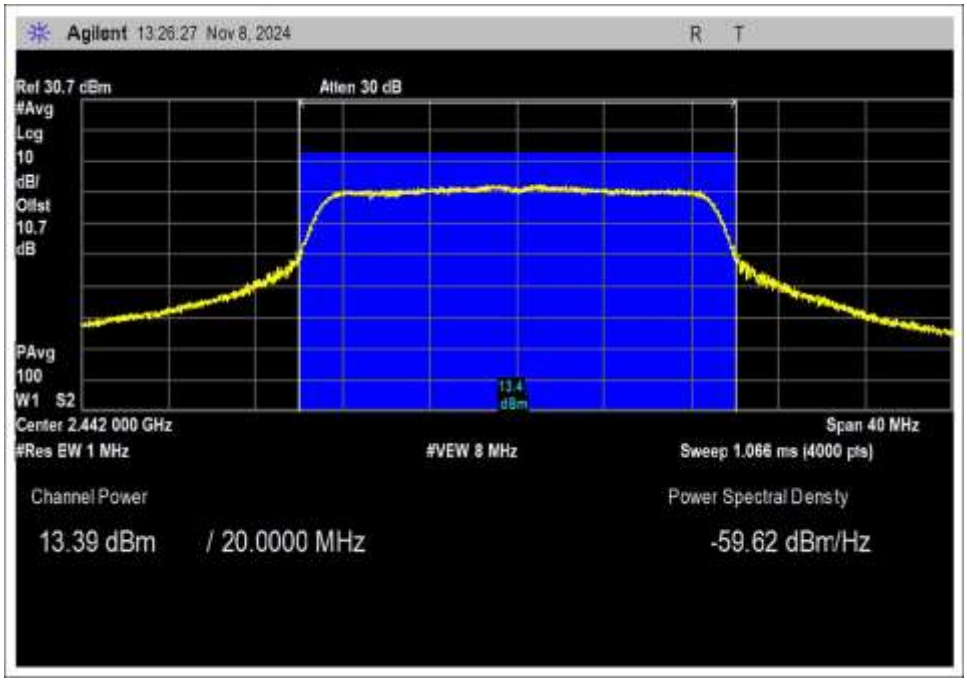


802.11n20, Low Channel



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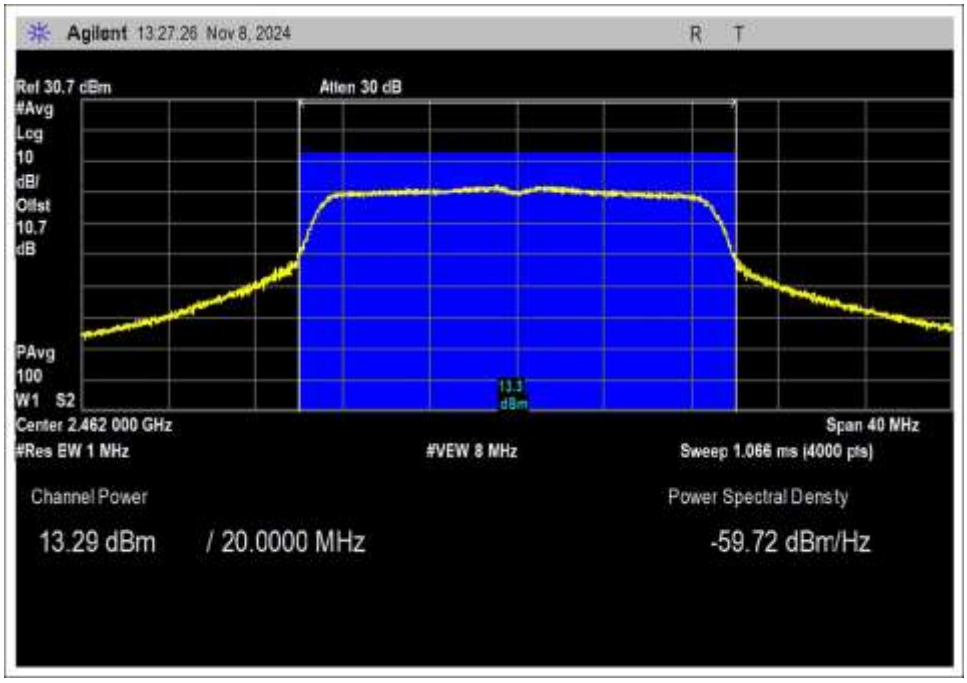

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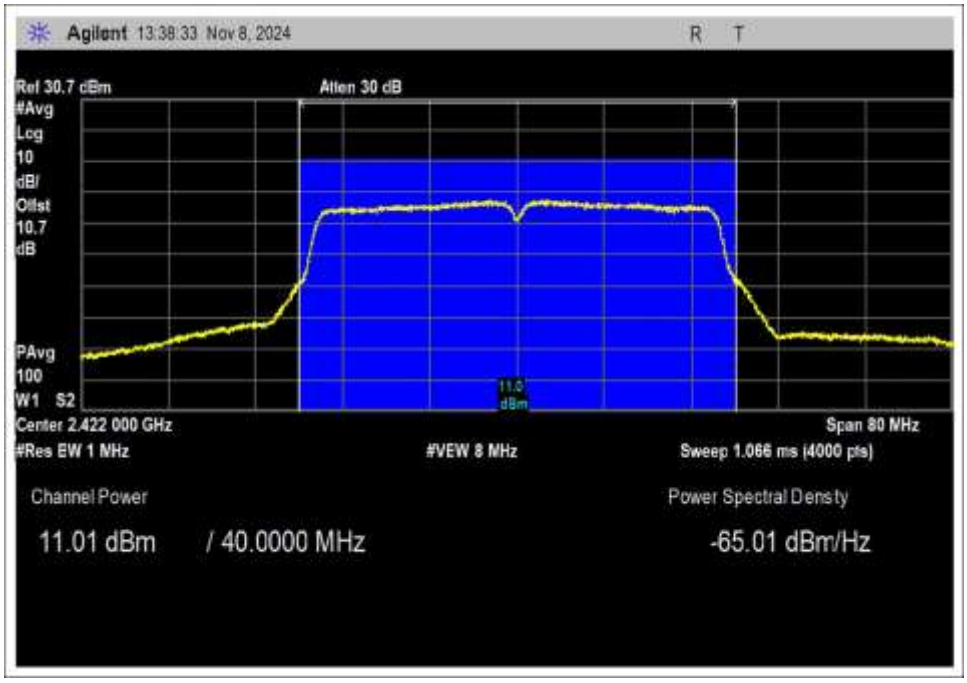
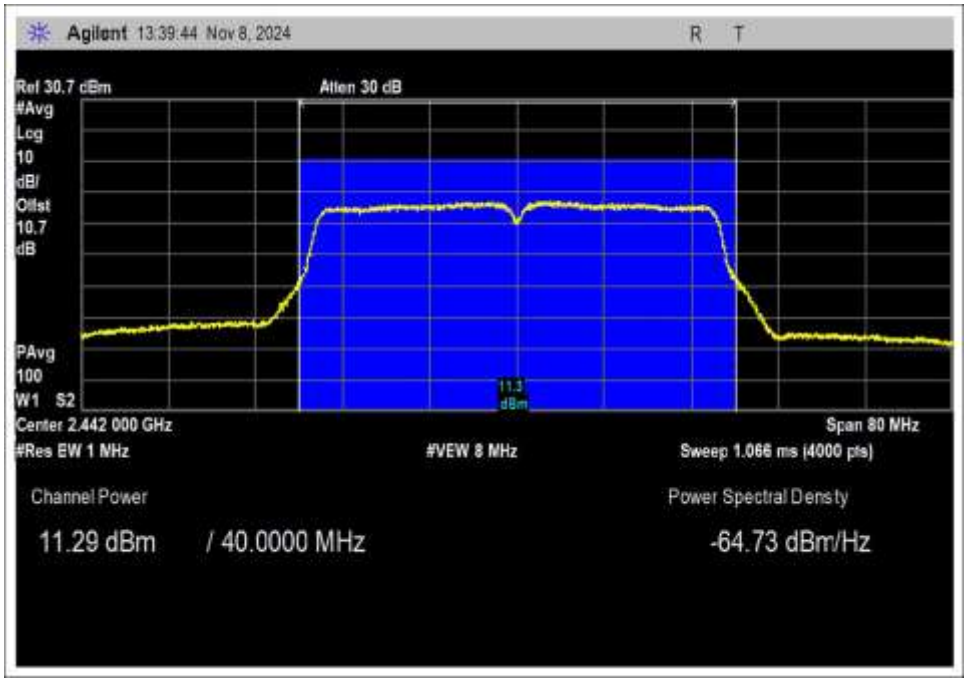
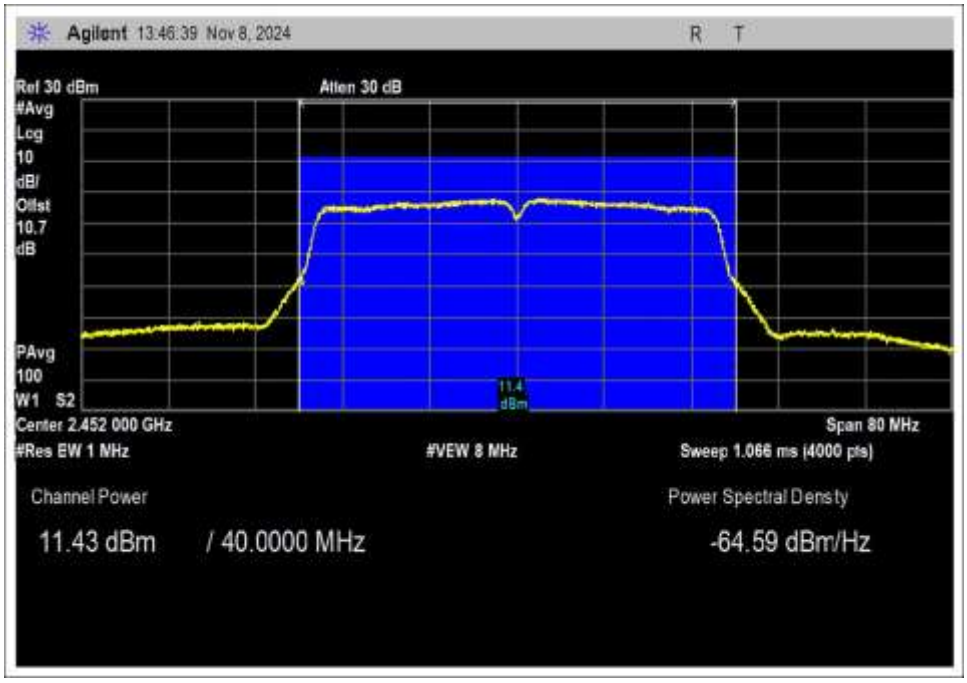


802.11n40, Low Channel

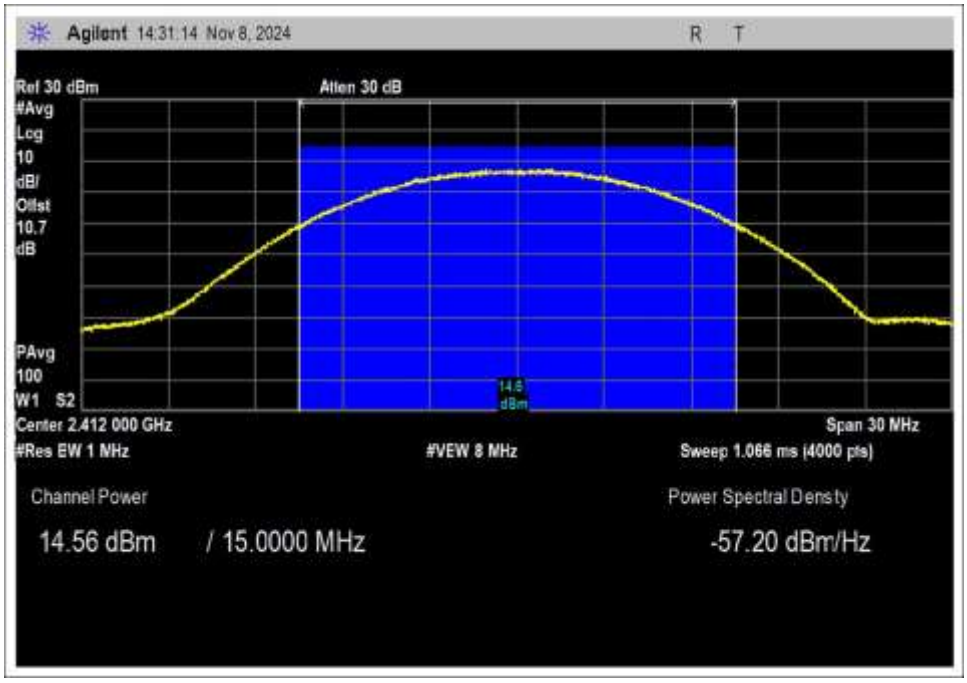


802.11n40, Middle Channel

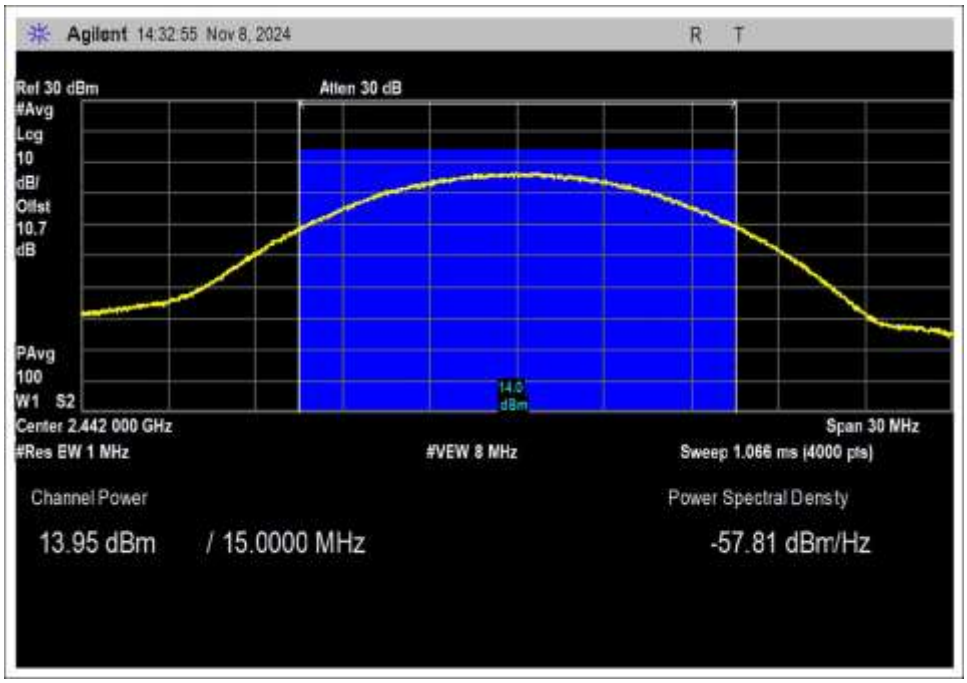


802.11n40, High Channel

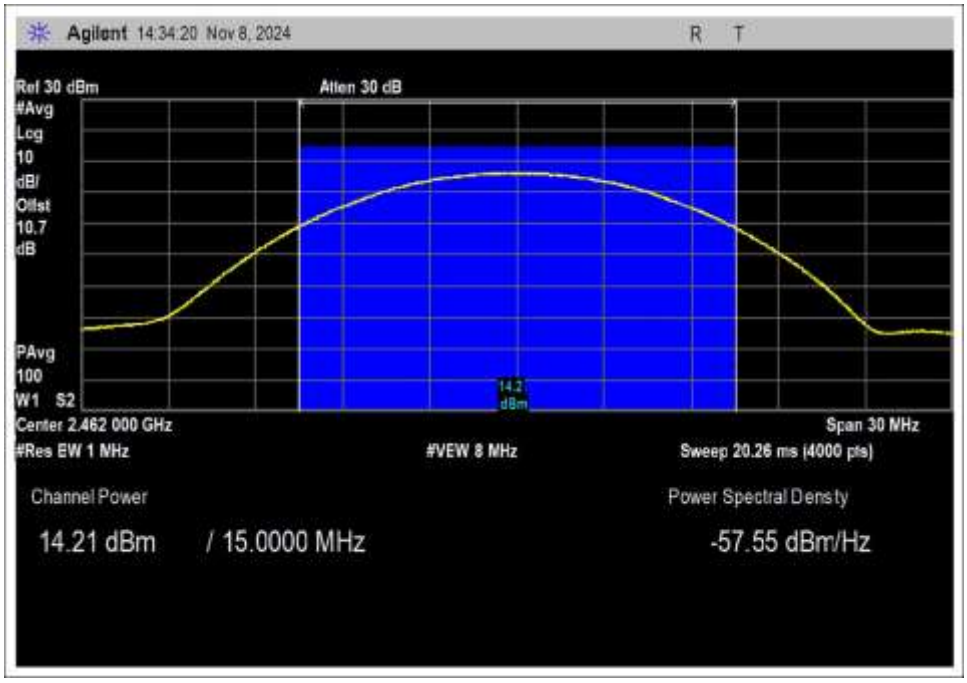
Chain 1



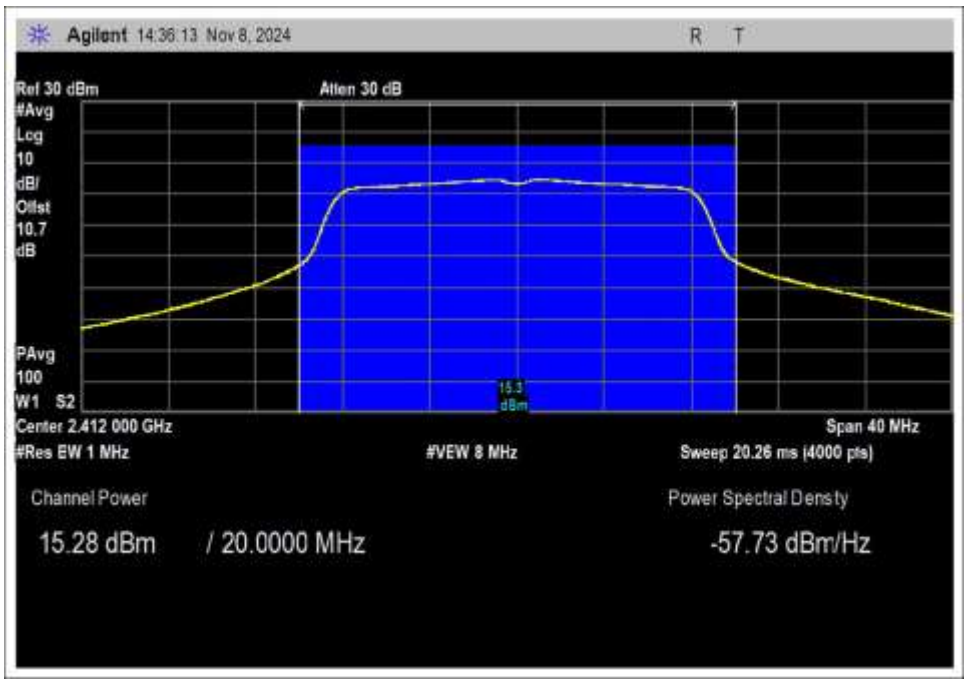
802.11b, Low Channel



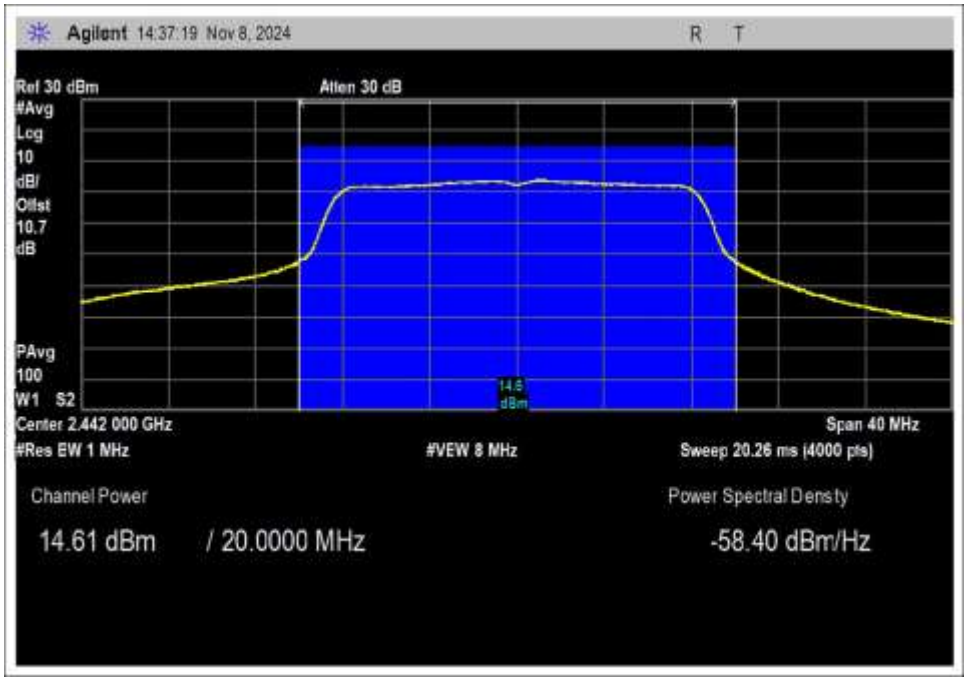
802.11b, Middle Channel



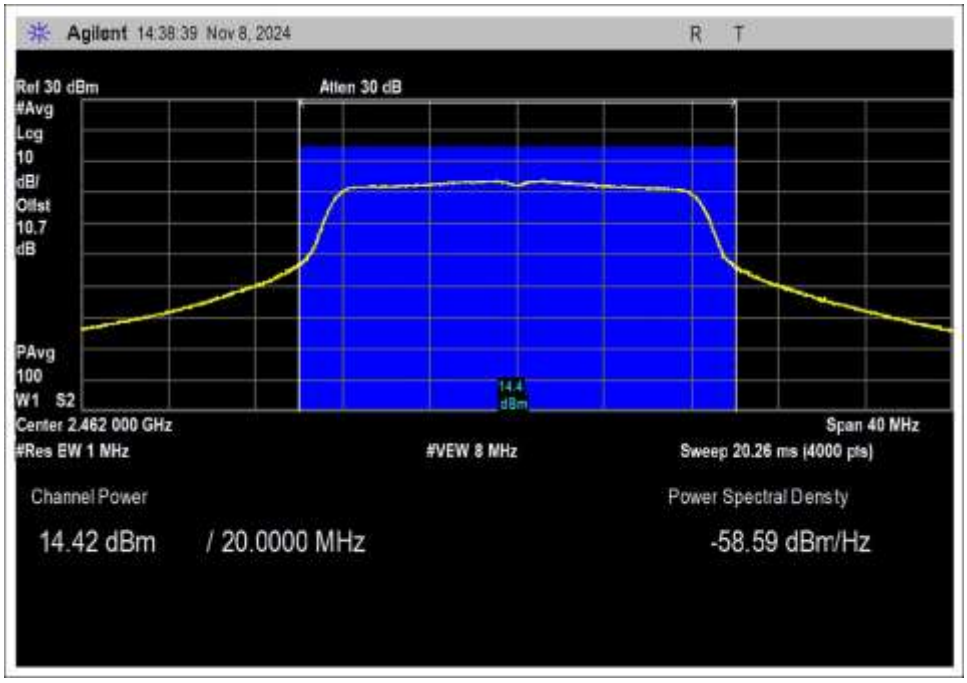
802.11b, High Channel



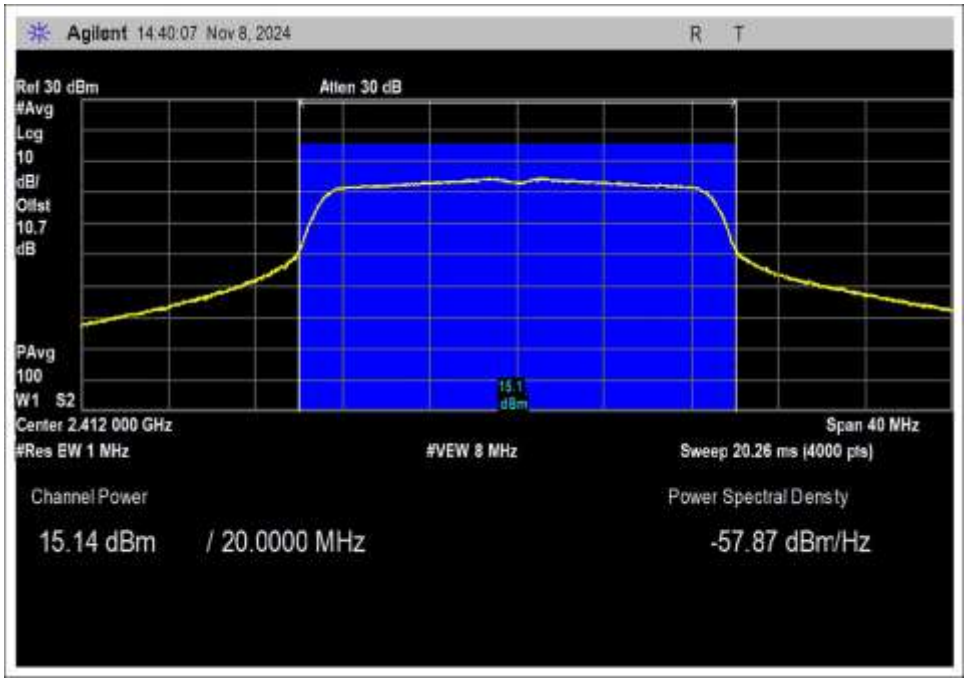
802.11g, Low Channel



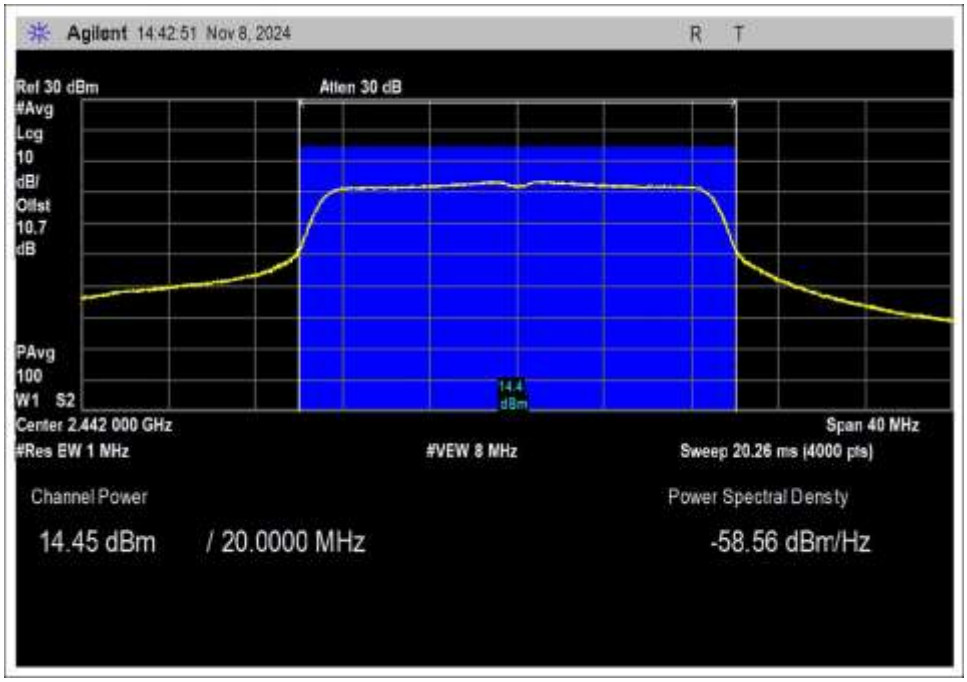
802.11g, Middle Channel



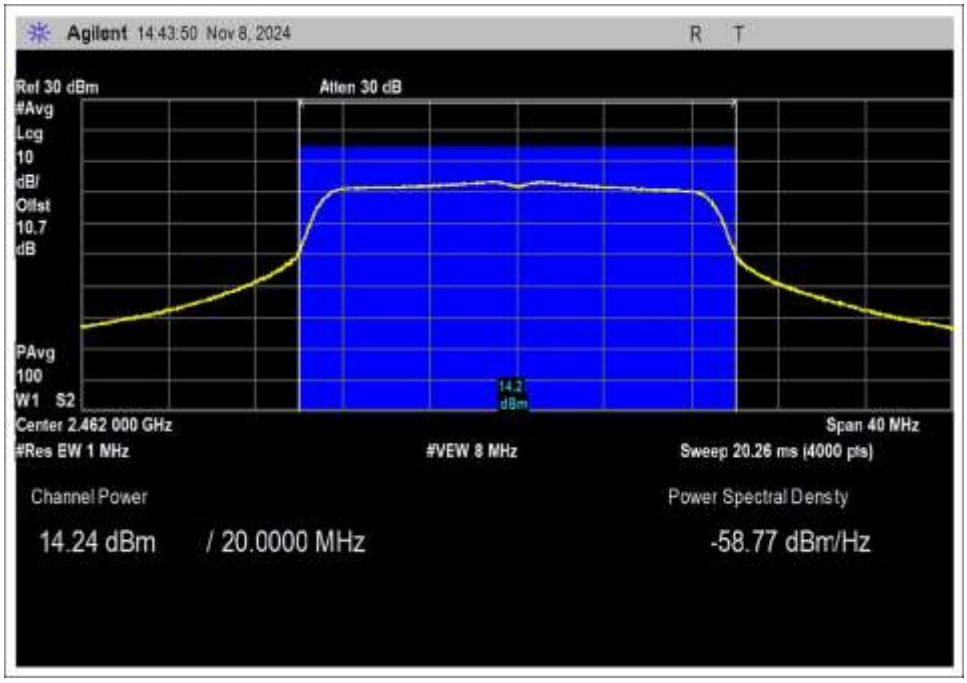
802.11g, High Channel



802.11n HT20, Low Channel



802.11n NT20, Middle Channel



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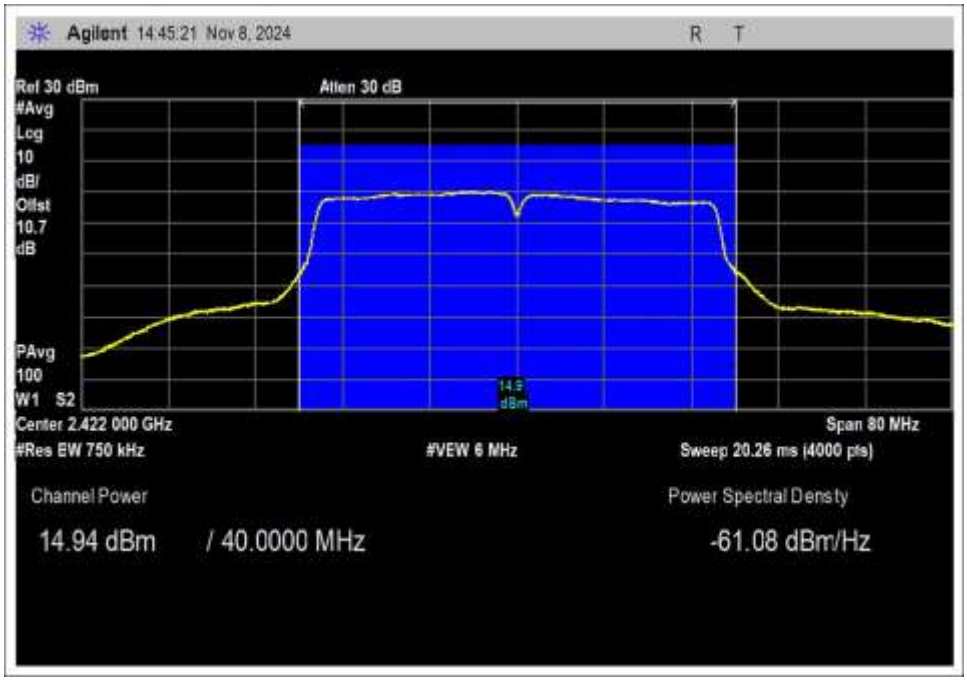
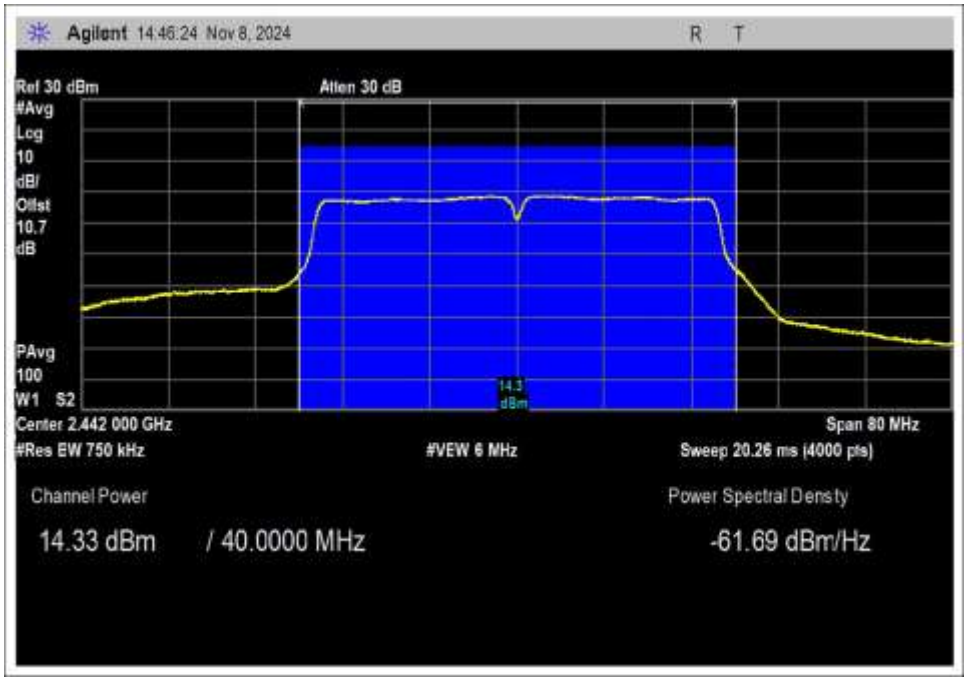
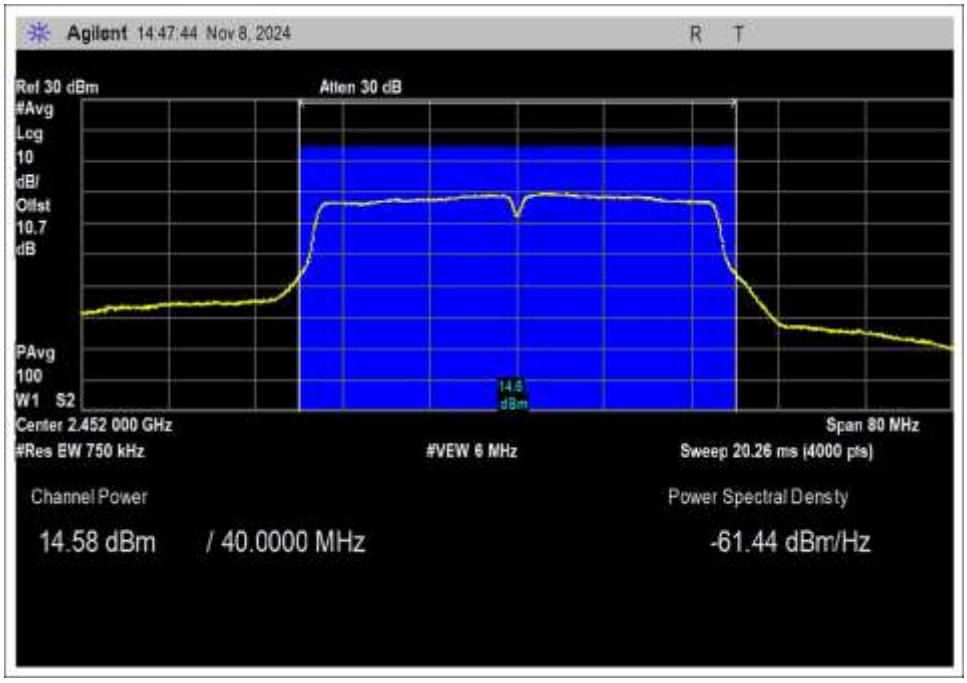


802.11n HT40, Low Channel



802.11n HT40, Middle Channel



802.11n HT40, High Channel

Test Setup / Conditions / Data

Overall Test Setup

Test Setup, Closeup View

15.247(e) Power Spectral Density

Test Setup/Conditions			
Test Location:	Bothell Lab C3	Test Engineer:	Hieu Song Nguyenpham & E. Wong
Test Method:	ANSI C63.10 (2020), KDB 558074 662911 D01 Multiple Transmitter Output v02r01	Test Date(s):	10/7-9/2024 11/08/2024
Configuration:	A		
Test Setup:	The EUT is placed non-conducted table. It is operated as intended. It is connected straight to a Spectrum Analyzer.		

Environmental Conditions			
Temperature (ºC)	20.8	Relative Humidity (%):	37

Test Equipment					
Asset#	**Description**	**Manufacturer**	**Model**	**Cal Date**	**Cal Due**
03013	Cable	Astrolab	32022-2-2909K-36TC	1/9/2024	1/9/2026
P07365	Attenuator	Weinschel	54A-10	5/26/2023	5/26/2025
03471	Spectrum Analyzer	Agilent	E4440A	2/23/2024	2/23/2026

Test Data Summary - RF Conducted Measurement-Chain 0				
Measurement Method: AVGPSD-1				
Frequency (MHz)	**Modulation**	**Measured (dBm/100kHz)**	**Limit (dBm/3kHz)**	**Results**
2412	802.11b	-3.372	≤8	Pass
2442	802.11b	-3.020	≤8	Pass
2462	802.11b	-3.073	≤8	Pass
2412	802.11g	-5.496	≤8	Pass
2442	802.11g	-5.103	≤8	Pass
2462	802.11g	-5.465	≤8	Pass
2412	802.11n HT20	-5.461	≤8	Pass
2442	802.11n HT20	-5.462	≤8	Pass
2462	802.11n HT20	-5.922	≤8	Pass
2422	802.11n HT40	-10.324	≤8	Pass
2442	802.11n HT40	-10.642	≤8	Pass
2452	802.11n HT40	-10.900	≤8	Pass

Test Data Summary - RF Conducted Measurement-Chain 1				
Measurement Method: AVGPSD-1				
Frequency (MHz)	**Modulation**	**Measured (dBm/100kHz)**	**Limit (dBm/3kHz)**	**Results**
2412	802.11b	-1.869	≤8	Pass
2442	802.11b	-2.586	≤8	Pass
2462	802.11b	-2.131	≤8	Pass
2412	802.11g	-3.330	≤8	Pass
2442	802.11g	-4.598	≤8	Pass
2462	802.11g	-4.470	≤8	Pass
2412	802.11n HT20	-3.946	≤8	Pass
2442	802.11n HT20	-4.875	≤8	Pass
2462	802.11n HT20	-4.842	≤8	Pass
2422	802.11n HT40	-6.623	≤8	Pass
2442	802.11n HT40	-7.963	≤8	Pass
2452	802.11n HT40	-6.925	≤8	Pass

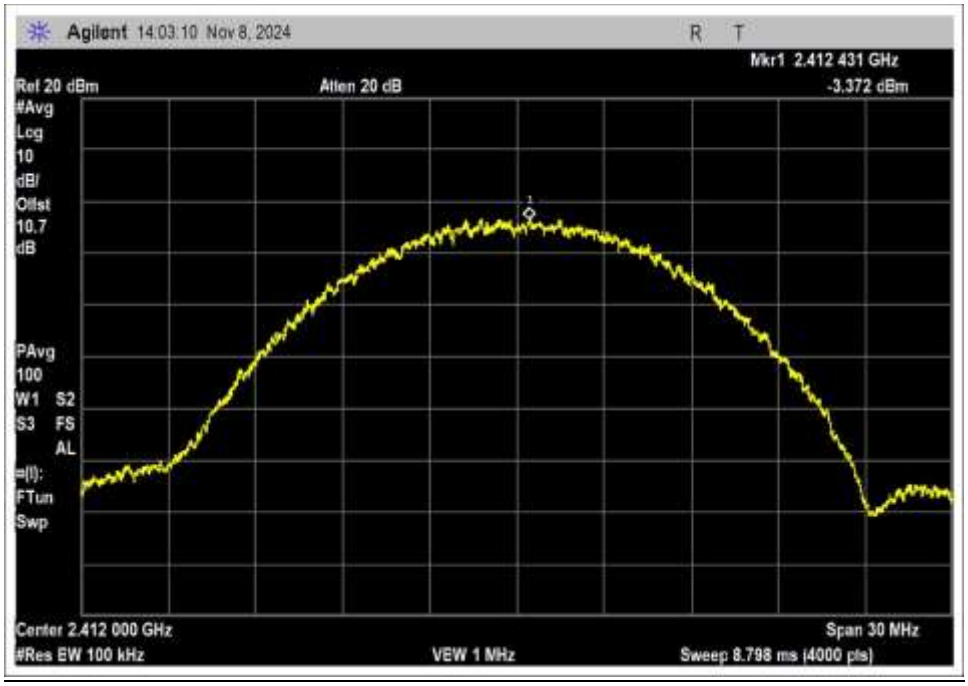
Test Data Summary - RF Conducted Measurement- MIMO Total PSD						
Measurement Method: AVGPSD-1						
Frequency (MHz)	**Modulation**	**Measured (dBm/100kHz)**		**Measured Total (dBm/100kHz)**	**Limit (dBm/3kHz)**	**Results**
		Ch0	**Ch1**			
2412	802.11b	-3.372	-1.869	0.45	≤8	Pass
2442	802.11b	-3.02	-2.586	0.21	≤8	Pass
2462	802.11b	-3.073	-2.131	0.43	≤8	Pass
2412	802.11g	-5.496	-3.33	-1.27	≤8	Pass
2442	802.11g	-5.103	-4.598	-1.83	≤8	Pass
2462	802.11g	-5.465	-4.47	-1.93	≤8	Pass
2412	802.11n HT20	-5.461	-3.946	-1.63	≤8	Pass
2442	802.11n HT20	-5.462	-4.875	-2.15	≤8	Pass
2462	802.11n HT20	-5.922	-4.842	-2.34	≤8	Pass
2422	802.11n HT40	-10.324	-6.623	-5.08	≤8	Pass
2442	802.11n HT40	-10.642	-7.963	-6.09	≤8	Pass
2452	802.11n HT40	-10.9	-6.925	-5.46	≤8	Pass

Ch0=Chain0
Ch1=Chain1

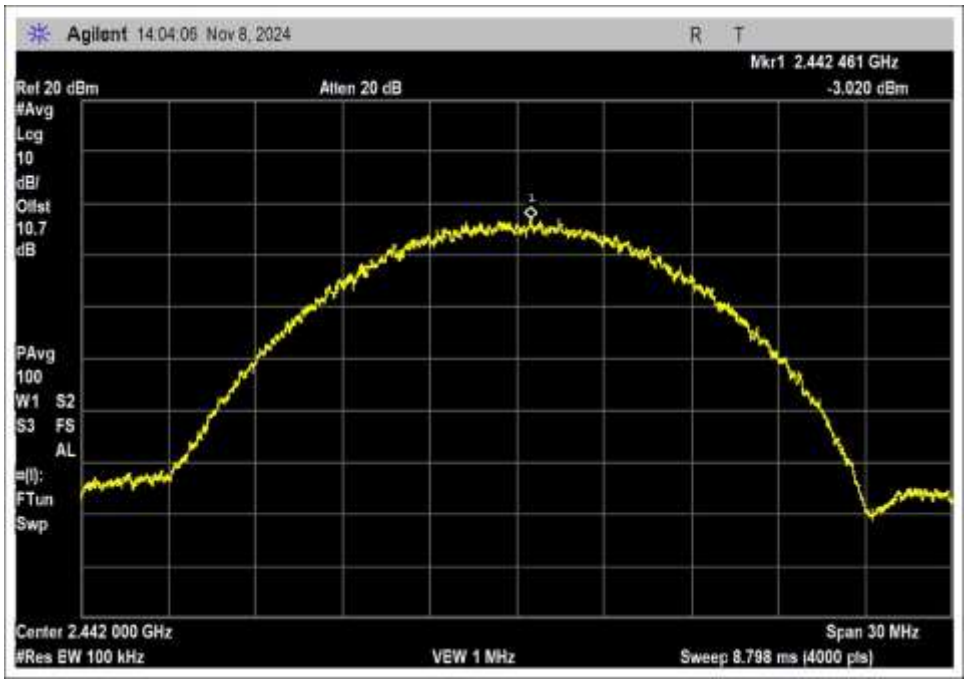
662911 D01 Multiple Transmitter Output v02r01 E 2 b) Measure and sum spectral maxima across the outputs.

Plot(s)

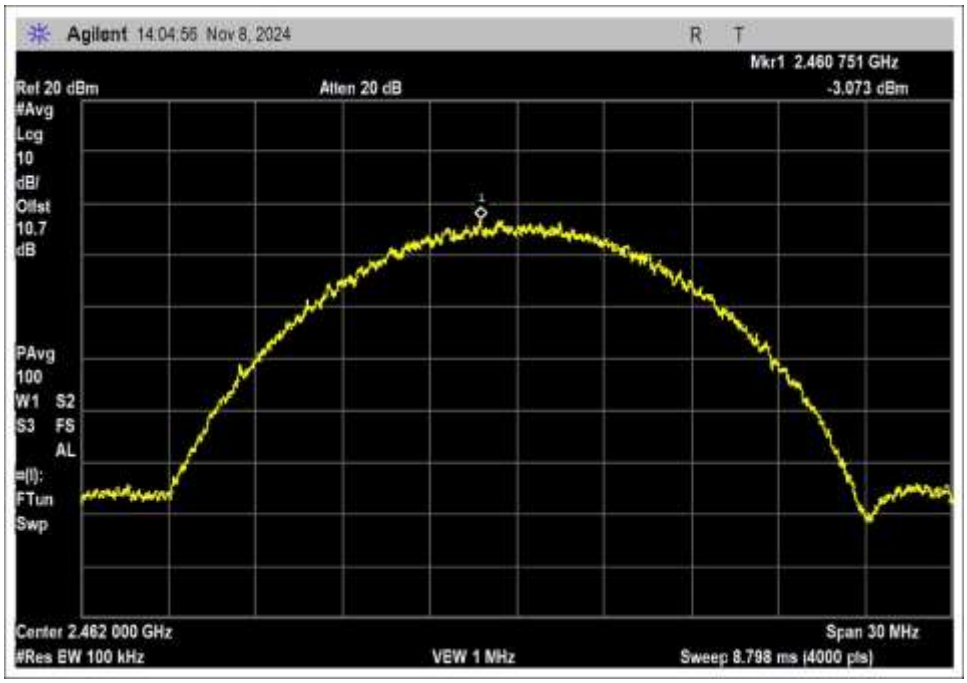
Chain 0



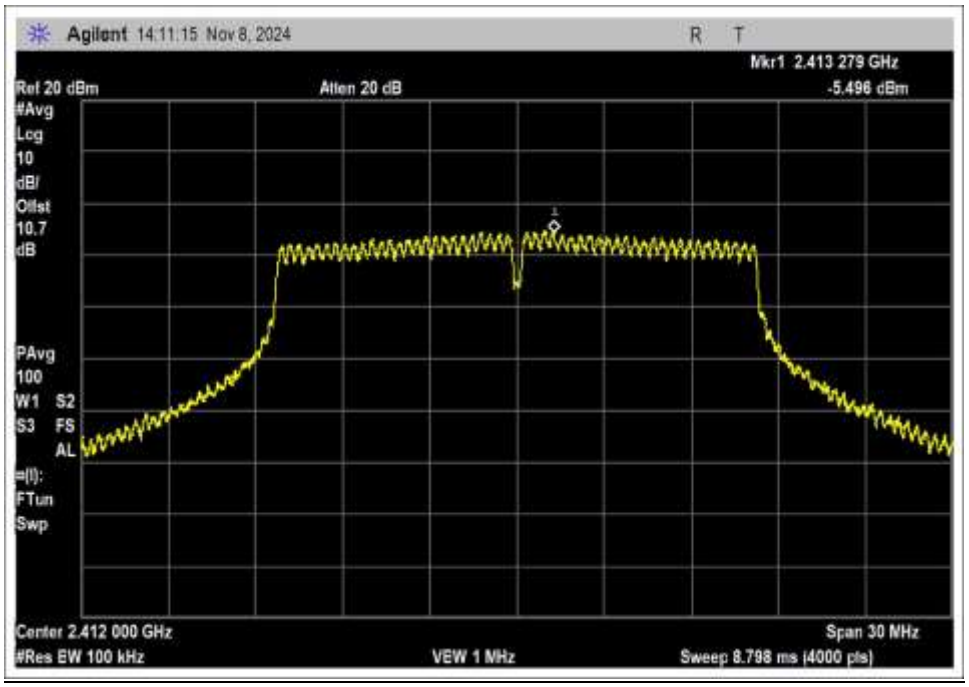
802.11b, Low Channel



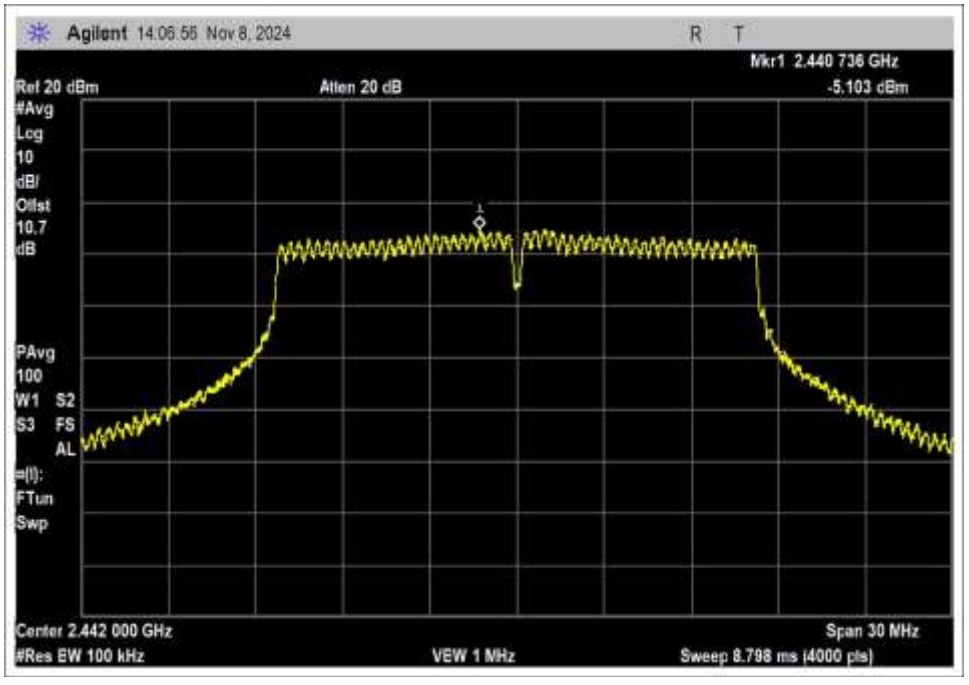
802.11b, Middle Channel



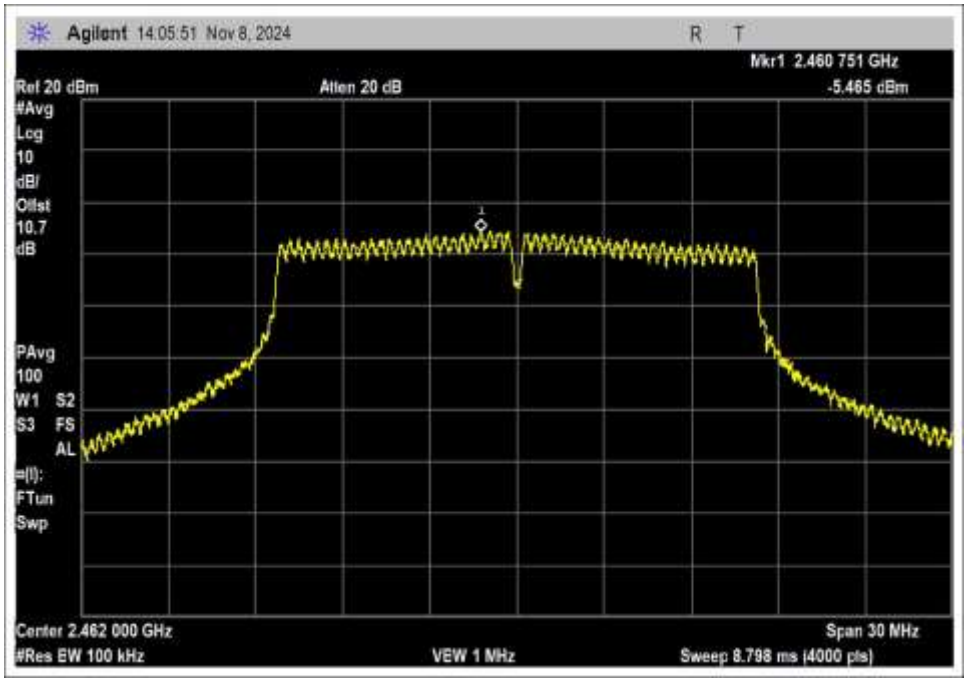
802.11b, High Channel



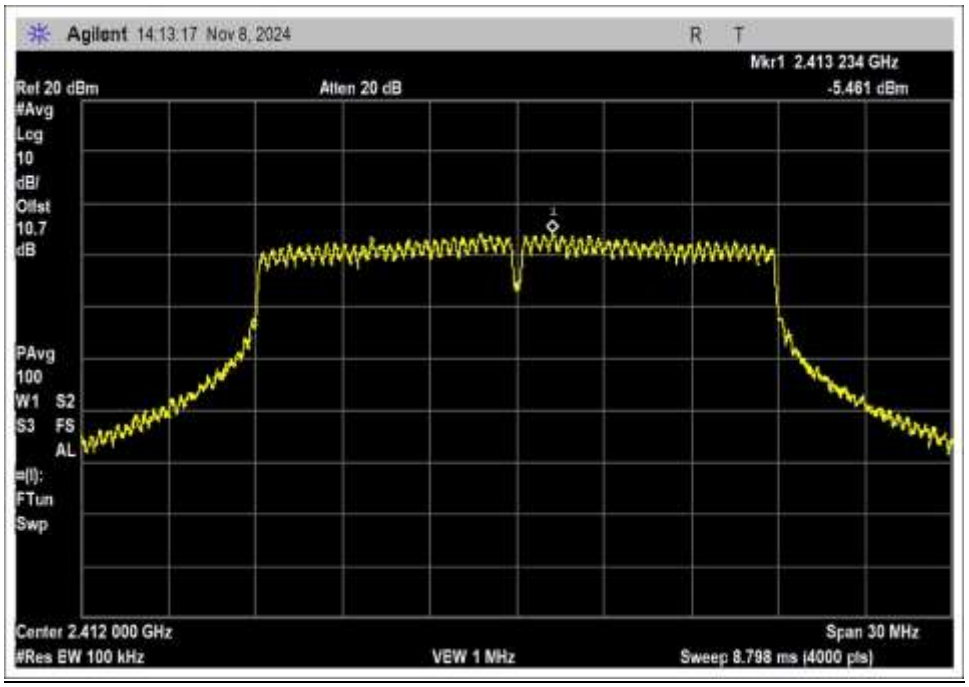
802.11g, Low Channel



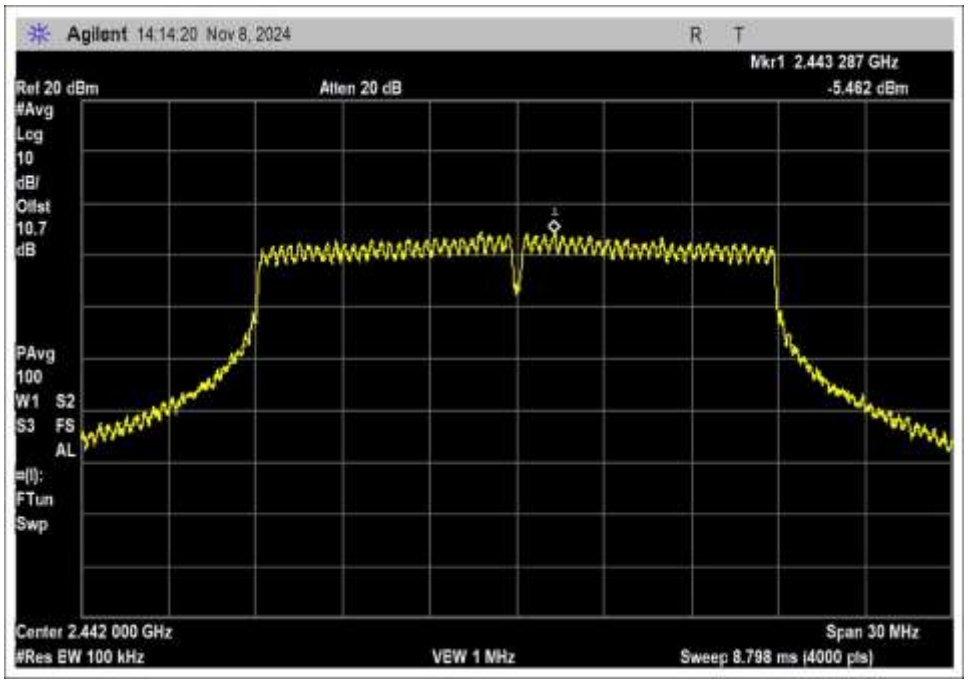
802.11g, Middle Channel



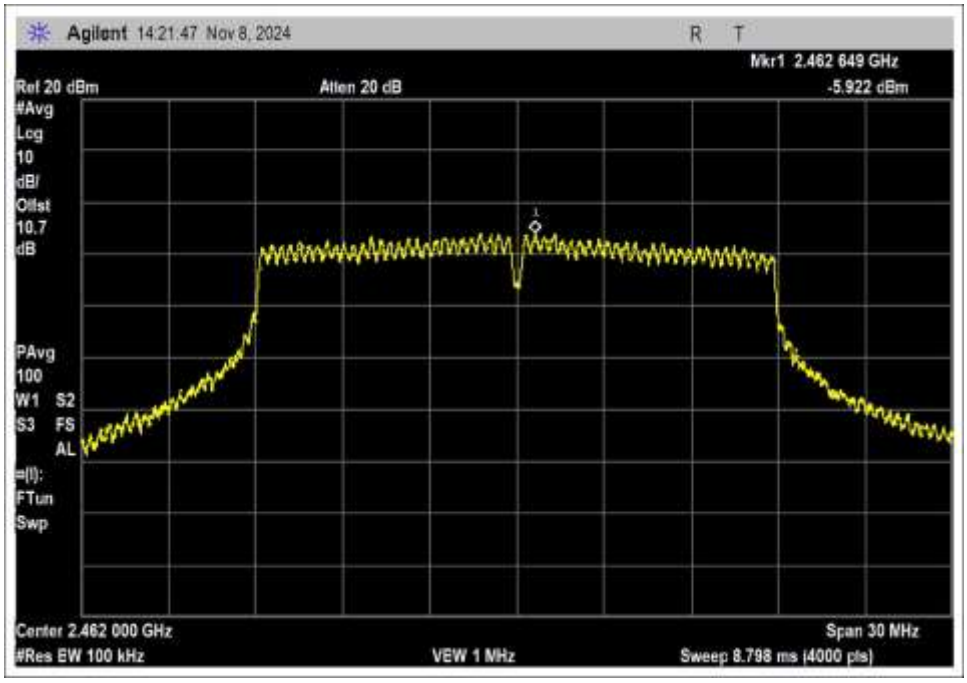
802.11g, High Channel



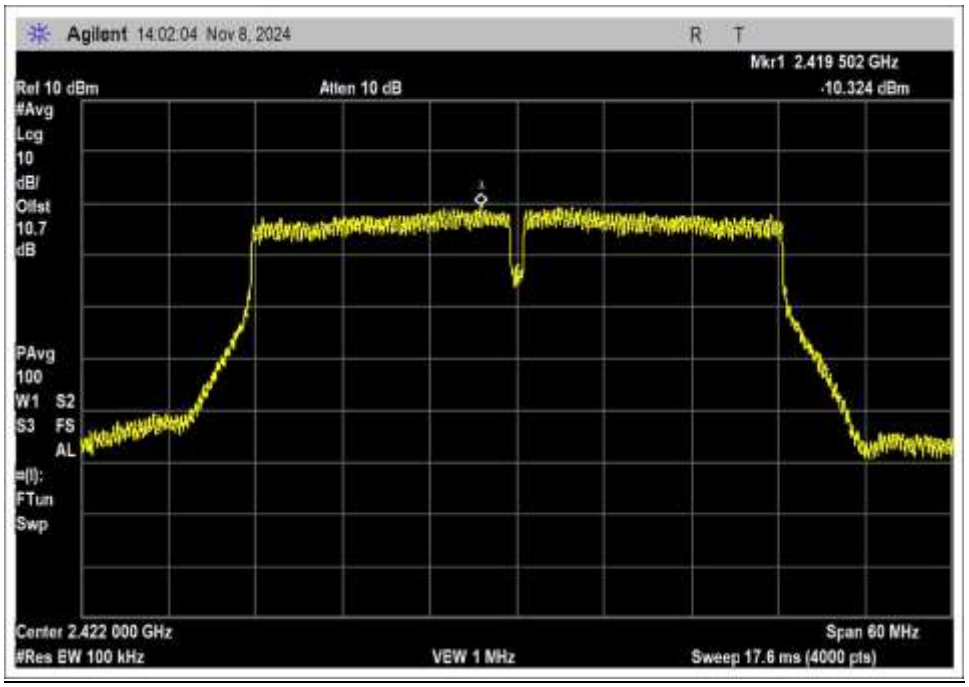
802.11n HT20, Low Channel



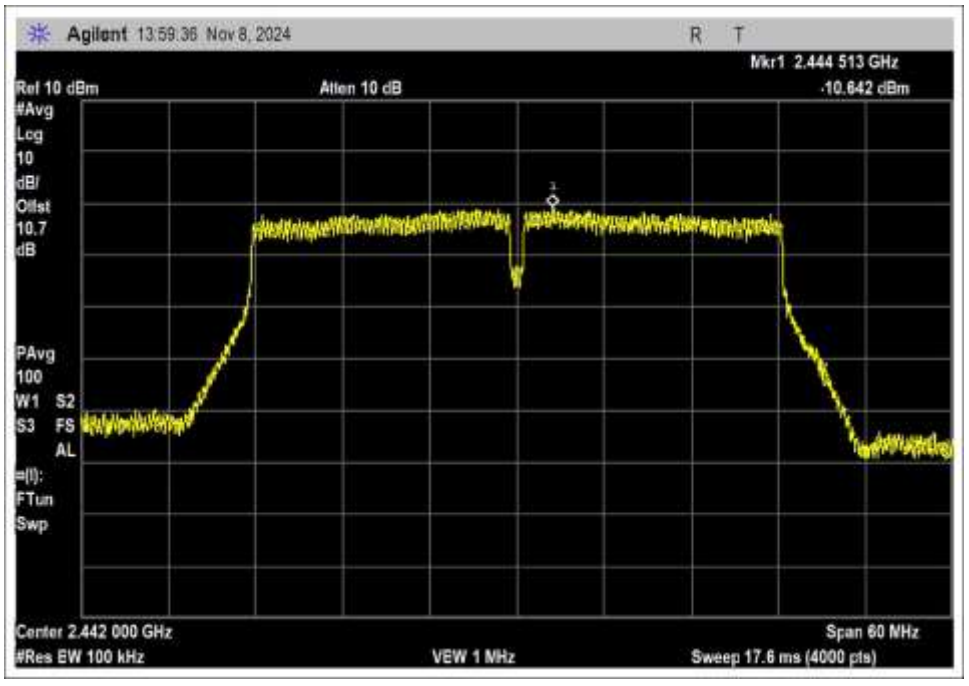
802.11n HT20, Middle Channel



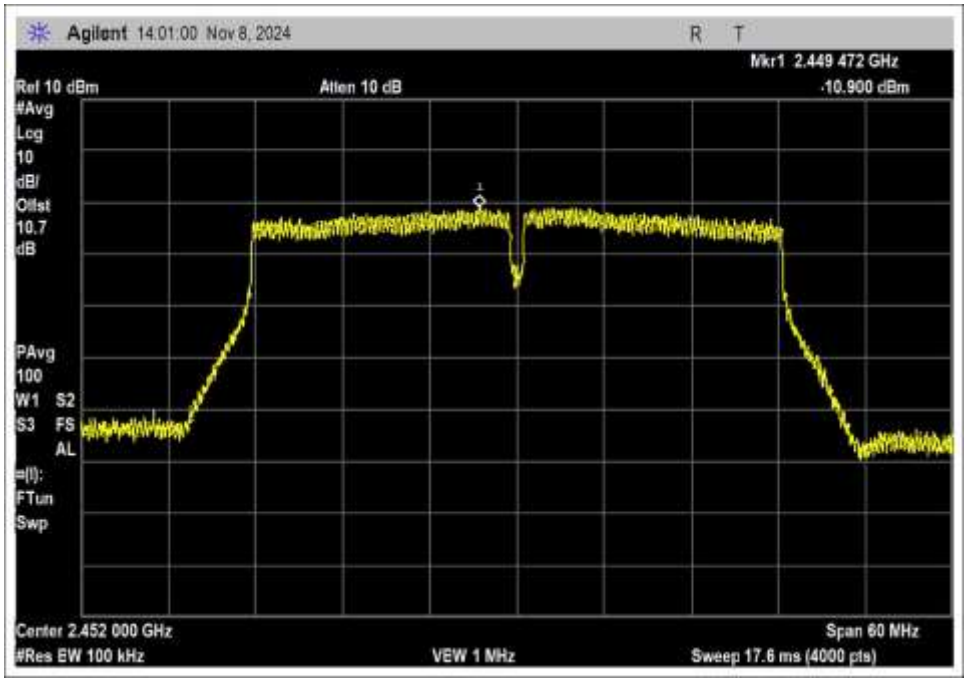
802.11n HT20, High Channel



802.11n HT40, Low Channel

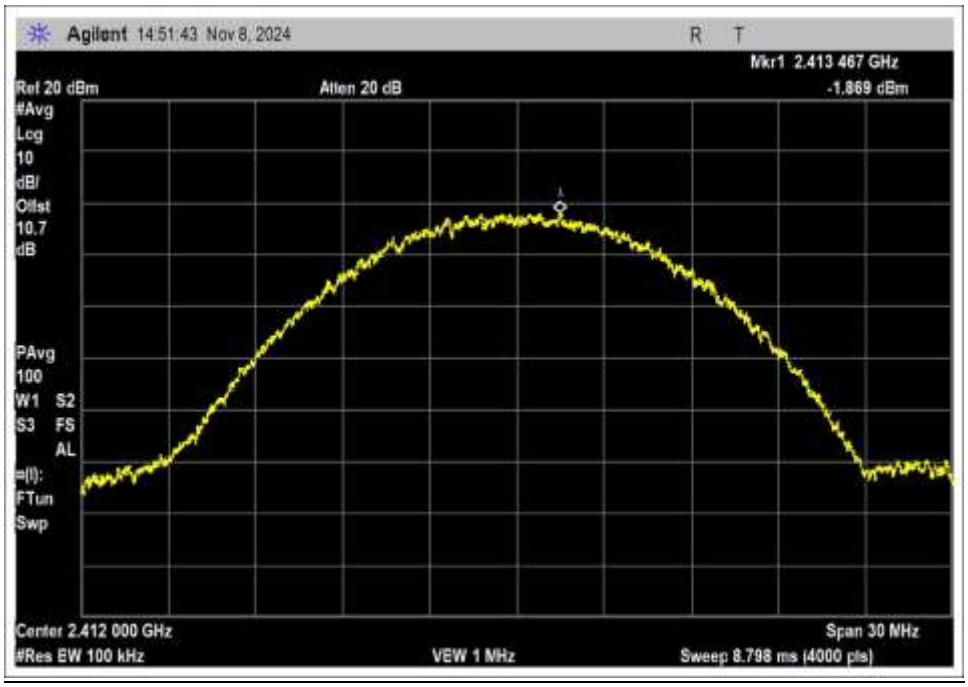


802.11n HT40, Middle Channel

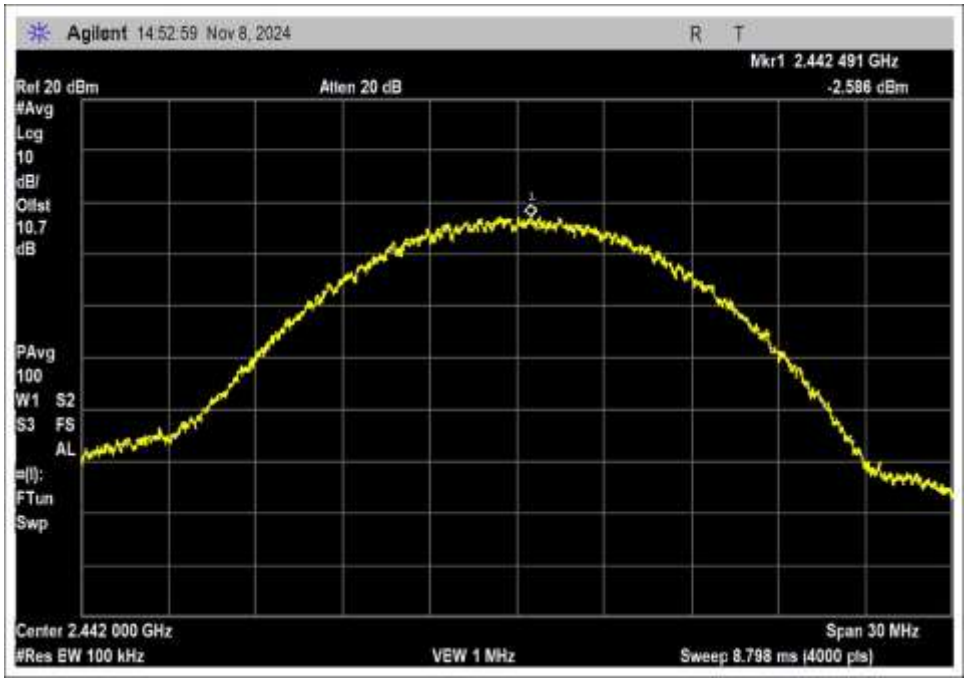


802.11n HT40, High Channel

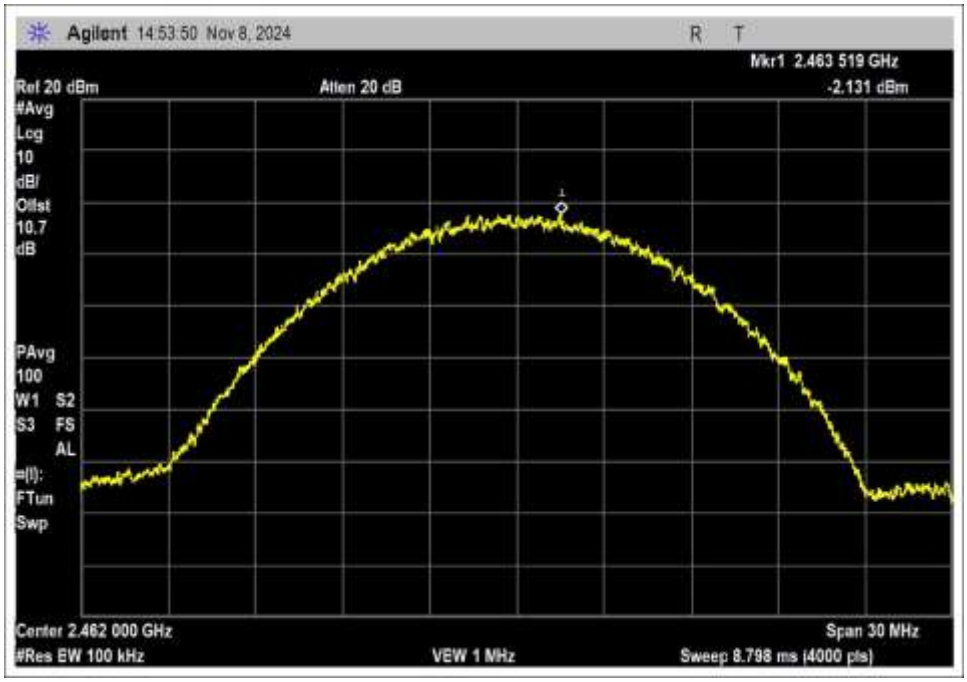
Chain 1



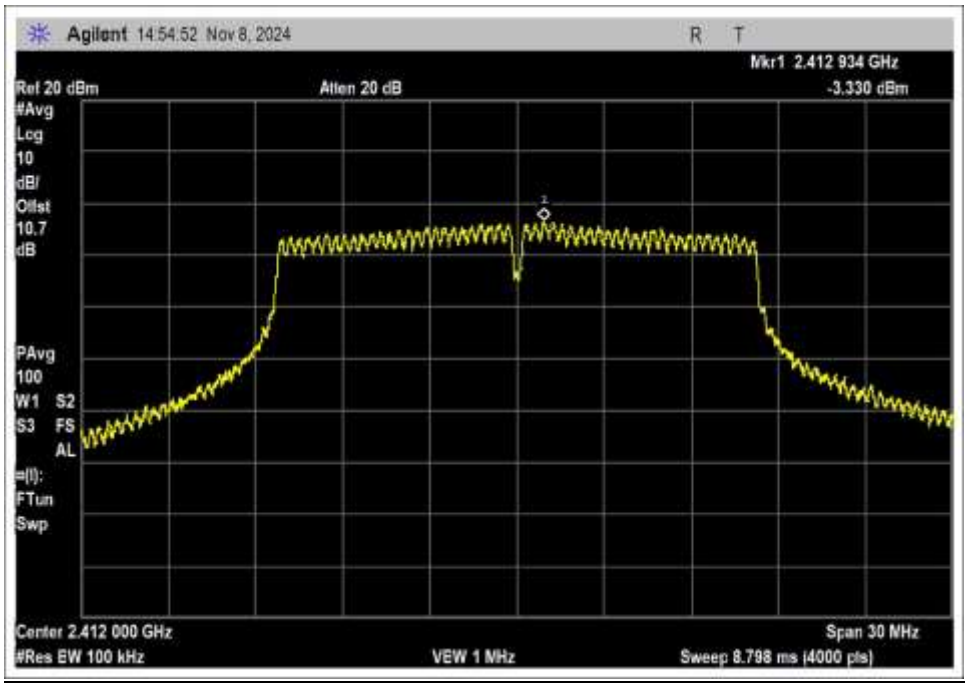
802.11b, Low Channel



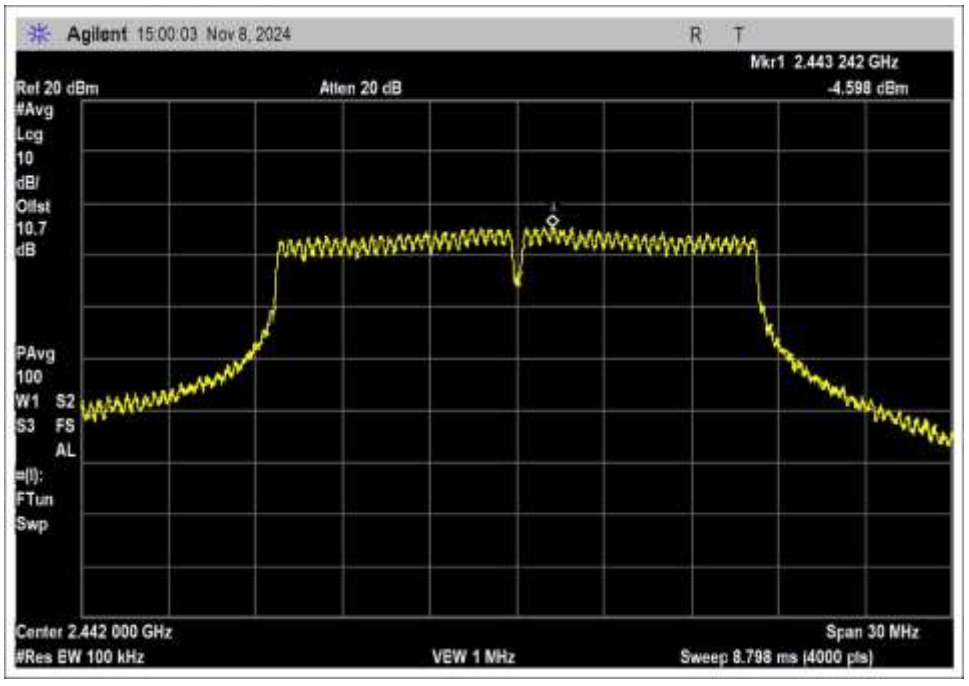
802.11b, Middle Channel



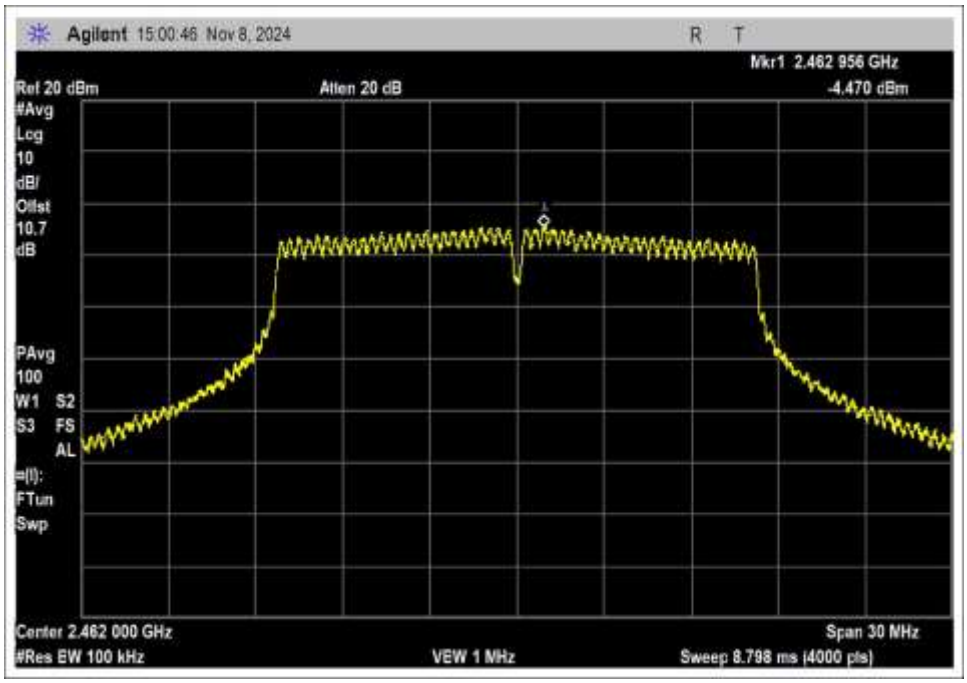
802.11b, High Channel



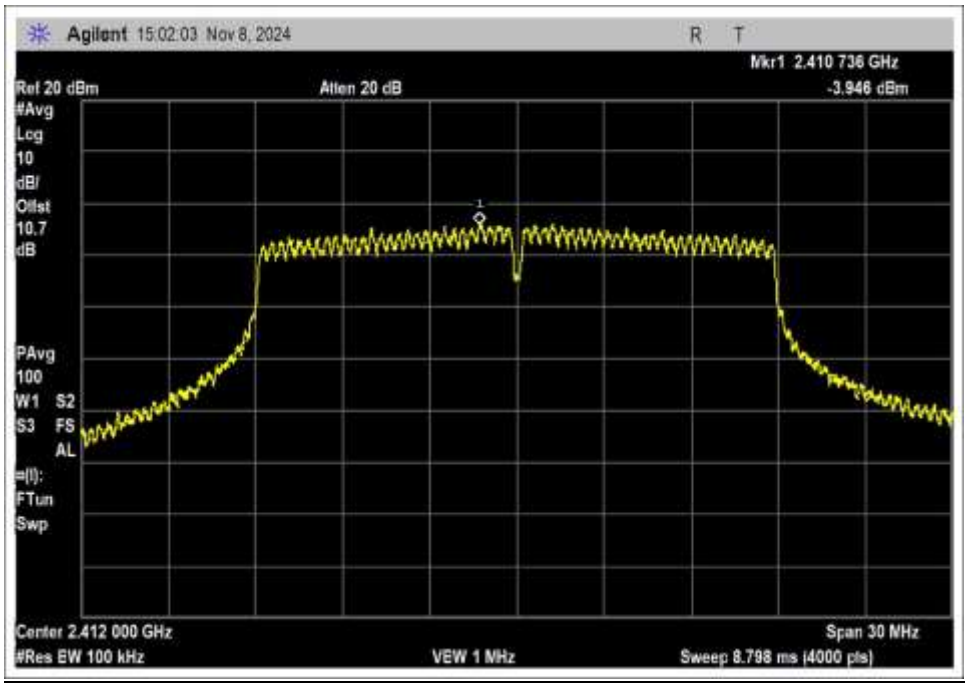
802.11g, Low Channel



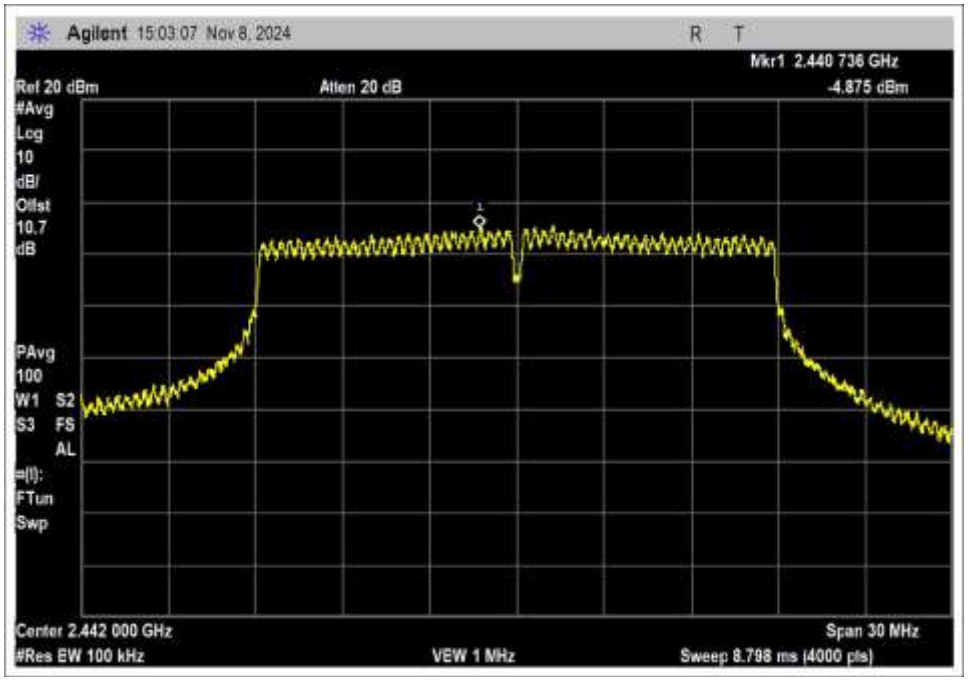
802.11g, Middle Channel



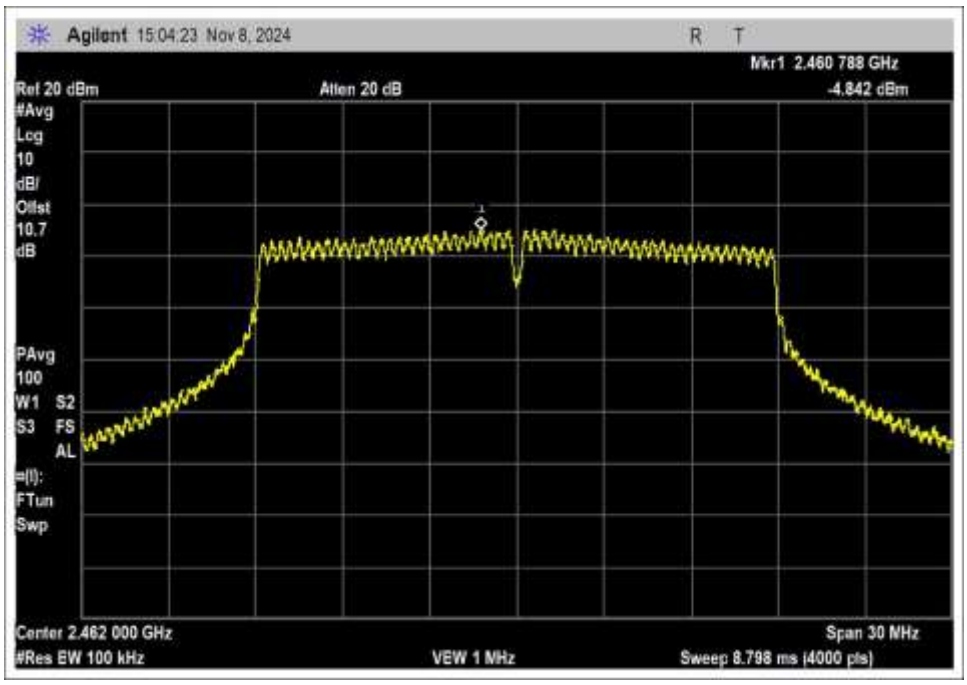
802.11g, High Channel



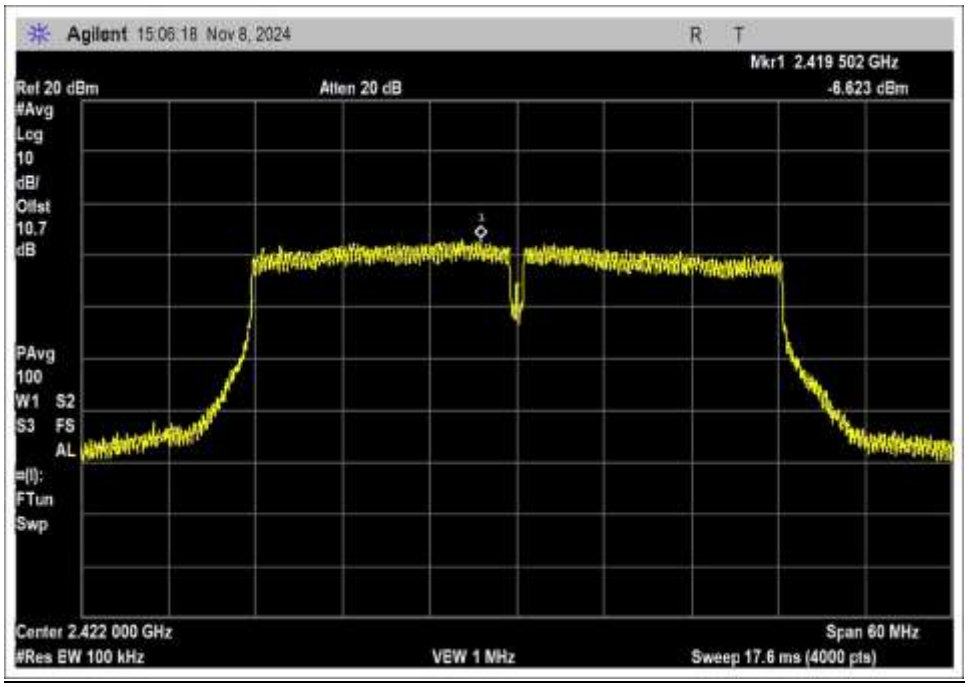
802.11n HT20, Low Channel



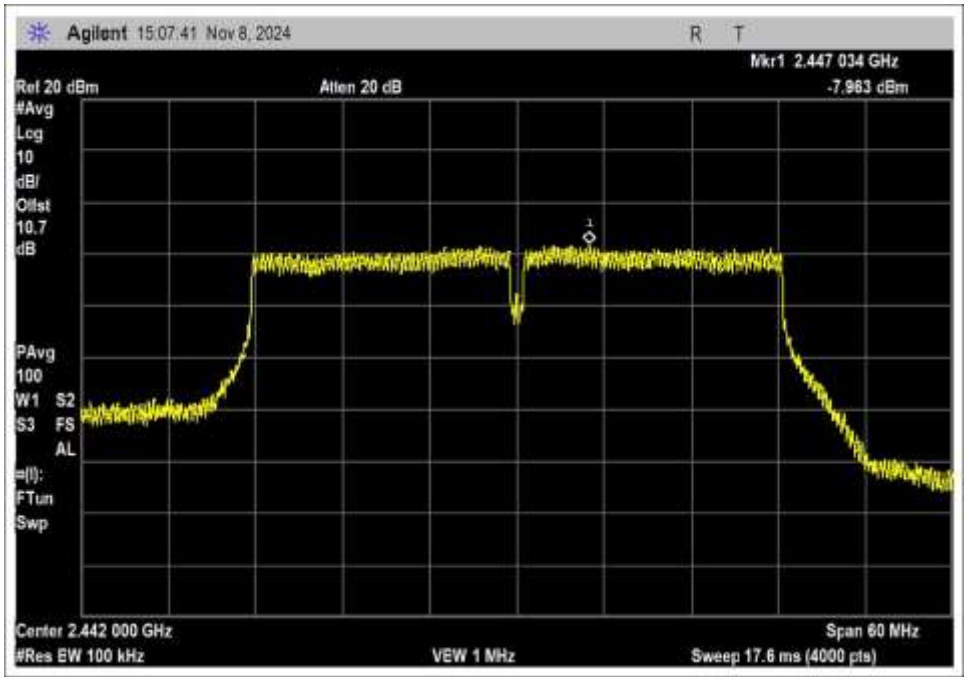
802.11n HT20, Middle Channel



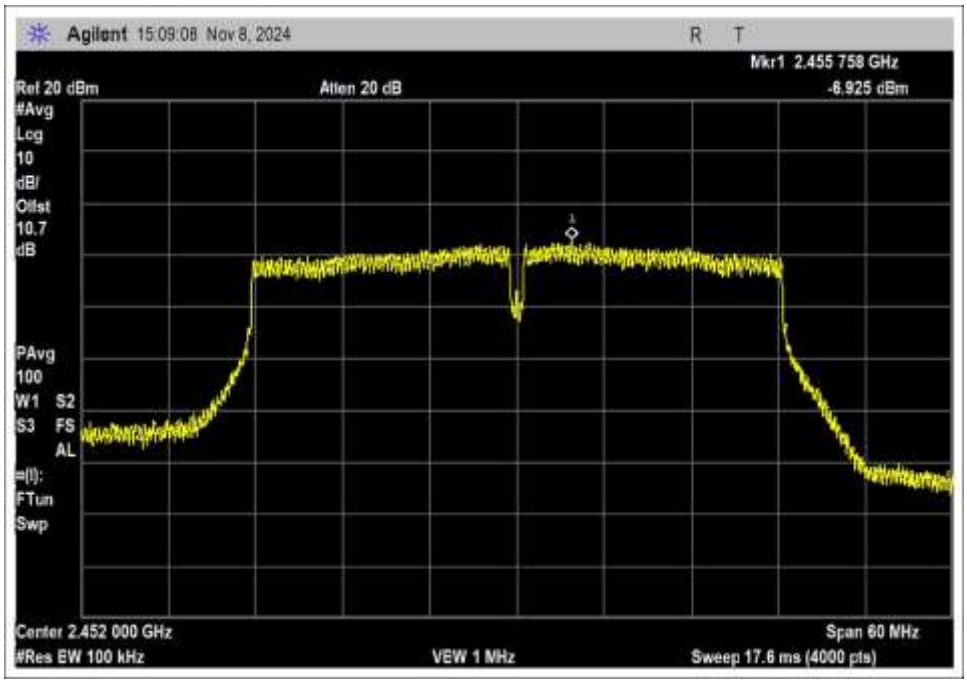
802.11n HT20, High Channel



802.11n HT40, Low Channel



802.11n HT40, Middle Channel



802.11n HT40, High Channel

Test Setup Photo(s)

Overall Test Setup

Test Setup, Close View

15.247(d) Radiated Emissions & Band Edge

Test Data

Test Location:	CKC Laboratories, Inc • 110 N. Olinda Place • Brea, CA • (714) 993 6112		
Customer:	**Tonal**		
Specification:	**15.247(d) / 15.209 Radiated Spurious Emissions**		
Work Order #:	**110825**	Date:	1/15/2025
Test Type:	**Radiated Scan**	Time:	08:32:33
Tested By:	E. Wong	Sequence#:	25
Software:	EMITest 5.03.20		

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 1			

Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 1			

Test Conditions / Notes:

Test Condition #1

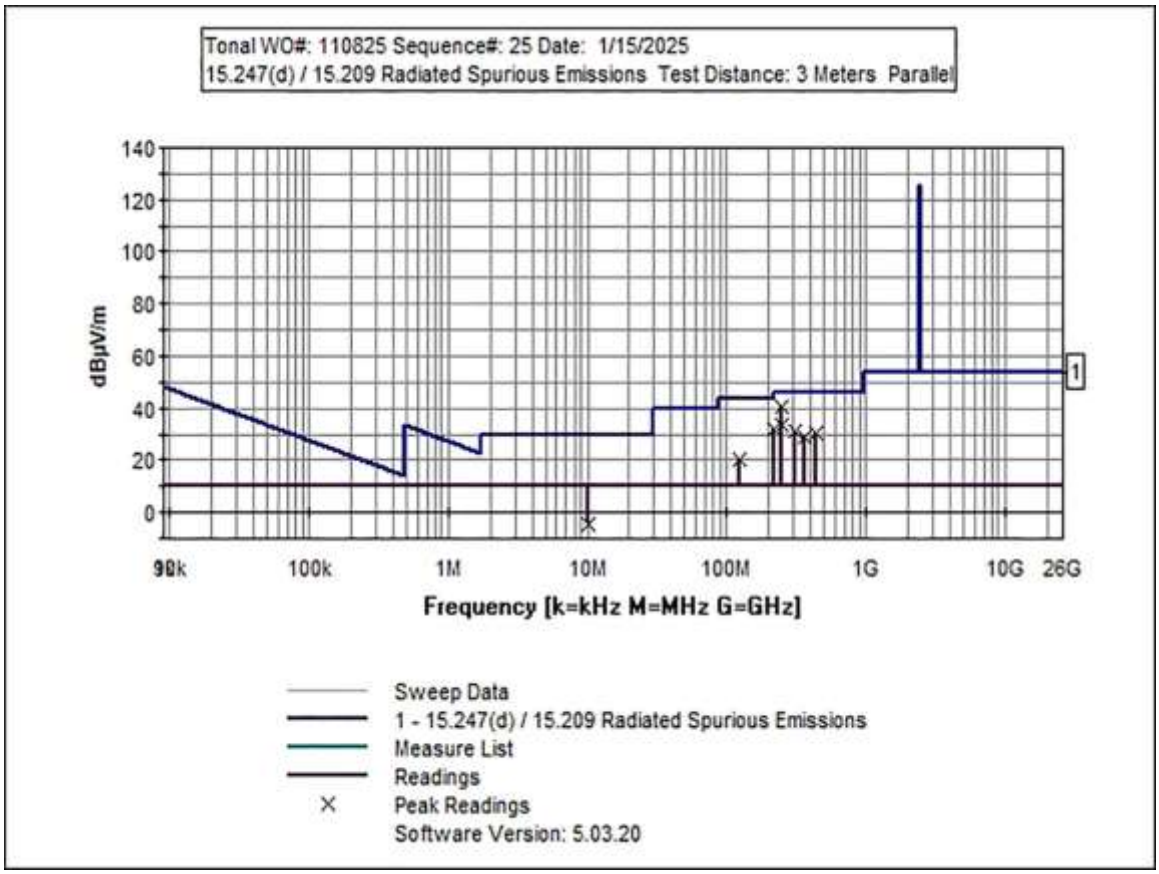
Tx Frequency:
802.11b: 2442MHz
802.11g: 2442MHz
802.11n20: 2442MHz
802.11n40: 2442MHz

Frequency range of measurement = 9 kHz- 1 GHz.
9 kH -150 kHz;RBW=200 Hz,VBW=600 Hz;
150 kHz-30 MHz;RBW=9 kHz,VBW=27 kHz;
30 MHz-1000 MHz;RBW=120 kHz,VBW=360 kHz,

Test Environment Conditions:
Temperature: 20°C
Humidity: 15%
Pressure: 100kPa

Modification #1 (MOD1) was in place during testing:
Reduce RF output power to 12dBm in the software for 802.11n HT40 Chain 0.
Added a ferrite (Wurth: 742 712 21) on lower resistor wire. Green Resistor

Site D
ANSI C63.10-2020



Test Equipment:

ID	Asset #	Description	Model	Calibration Date	Cal Due Date
T1	AN03834	Spectrum Analyzer	E4448A	5/6/2024	5/6/2026
T2	AN03628	Biconilog Antenna	CBL6111C	5/16/2024	5/16/2026
T3	ANP01911	Cable-Amplitude +15C to +45C (dB)	RG214/U	1/4/2024	1/4/2026
T4	ANP04382	Cable	LDF-50	6/4/2024	6/4/2026
T5	AN00010	Preamp	8447D	1/2/2024	1/2/2026
T6	ANP06985	Cable	Sucoflex 104A	9/12/2024	9/12/2026
T7	AN00314	Loop Antenna	6502	5/3/2024	5/3/2026

Measurement Data: Reading listed by margin. Test Distance: 3 Meters

#	Freq	Rdng	T1 T5	T2 T6	T3 T7	T4	Dist	Corr	Spec	Margin	Polar
	MHz	dBµV	dB	dB	dB	dB	Table	dBµV/m	dBµV/m	dB	Ant
1	245.970M	45.6	+0.0 -26.5	+17.9 +0.2	+1.5 +0.0	+1.6	+0.0	40.3	46.0	-5.7	Horiz
2	245.700M	38.5	+0.0 -26.5	+17.9 +0.2	+1.5 +0.0	+1.6	+0.0	33.2	46.0	-12.8	Vert
3	220.020M	39.3	+0.0 -26.6	+16.5 +0.1	+1.4 +0.0	+1.5	+0.0	32.2	46.0	-13.8	Horiz
4	312.000M	35.0	+0.0 -26.6	+19.0 +0.2	+1.7 +0.0	+1.8	+0.0	31.1	46.0	-14.9	Horiz
5	434.720M	31.2	+0.0 -27.6	+22.8 +0.2	+2.0 +0.0	+2.2	+0.0	30.8	46.0	-15.2	Vert
6	360.000M	30.6	+0.0 -27.0	+21.4 +0.2	+1.8 +0.0	+1.9	+0.0	28.9	46.0	-17.1	Horiz
7	124.700M	32.2	+0.0 -27.0	+13.2 +0.1	+1.0 +0.0	+1.1	+0.0	20.6	43.5	-22.9	Vert
8	10.147M	26.3	+0.0 +0.0	+0.0 +0.0	+0.3 +8.7	+0.2	-40.0	-4.5	29.5	-34.0	Paral

Test Location:	CKC Laboratories, Inc • 110 N. Olinda Place • Brea, CA • (714) 993 6112		
Customer:	**Tonal**		
Specification:	**15.247(d) / 15.209 Radiated Spurious Emissions**		
Work Order #:	**110825**	Date:	1/13/2025
Test Type:	**Radiated Scan**	Time:	10:15:53
Tested By:	E. Wong	Sequence#:	15
Software:	EMITest 5.03.20		

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 1			

Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 1			

Test Conditions / Notes:

Test Condition #1

Frequency range of measurement = 1GHz- 25 GHz.
1000 MHz-25 000 MHz;RBW=1MHz,VBW=3 MHz.

Test Environment Conditions:
Temperature: 20°C,
Humidity: 29%,
Pressure: 100kPa

Modification #1 (MOD1) was in place during testing:
Reduce RF output power to 12dBm in the software for 802.11n HT40 Chain 0.
Added a ferrite (Wurth: 742 712 21) on lower resistor wire. Green Resistor

Site D
ANSI C63.10-2020

Test Equipment:

ID	Asset	Description	Model	Calibration Date	Cal Due Date
T1	AN03834	Spectrum Analyzer	E4448A	5/6/2024	5/6/2026
T2	AN01646	Horn Antenna	3115	3/8/2024	3/8/2026
T3	ANP07660	Cable	32022-29094K-29094K-24TC	7/20/2024	7/20/2026
T4	AN00787	Preamp	83017A	6/27/2023	6/27/2025
T5	ANP04382	Cable	LDF-50	6/4/2024	6/4/2026
T6	ANP08191	Cable	ANDL1-PNMNM-50	11/11/2024	11/11/2026
T7	AN03385	High Pass Filter	11SH10-3000/T10000-O/O	5/15/2023	5/15/2025
	AN03367	Horn Antenna	62-GH-62-25.	8/10/2023	8/10/2025
	ANP08087	Cable	32022-29094K-29094K-120TC	12/1/2023	12/1/2025
	ANP08088	Cable	32022-29094K-29094K-120TC	12/1/2023	12/1/2025
	AN01413	Horn Antenna	84125-80008	10/15/2024	10/15/2026

Measurement Data: Reading listed by margin. Test Distance: 3 Meters

#	Freq	Rdng	T1	T2	T3	T4	Dist	Corr	Spec	Margin	Polar
			T5	T6	T7						
	MHz	dBµV	dB	dB	dB	dB	Table	dBµV/m	dBµV/m	dB	Ant
1	4823.600M	37.3	+0.0	+33.0	+0.6	-39.5	+0.0	44.9	54.0	-9.1	Horiz
			+8.4	+4.8	+0.3				802.11g_L		
2	4823.200M	36.9	+0.0	+33.0	+0.6	-39.5	+0.0	44.5	54.0	-9.5	Horiz
			+8.4	+4.8	+0.3				802.11b_L		
3	4883.800M	36.0	+0.0	+33.2	+0.6	-39.5	+0.0	44.0	54.0	-10.0	Horiz
			+8.5	+4.9	+0.3				802.11g_M		
4	4921.200M	36.0	+0.0	+33.2	+0.6	-39.5	+0.0	44.0	54.0	-10.0	Horiz
			+8.5	+4.9	+0.3				802.11g_H		
5	4923.300M	36.0	+0.0	+33.2	+0.6	-39.5	+0.0	44.0	54.0	-10.0	Horiz
			+8.5	+4.9	+0.3				802.11b_H		
6	4883.800M	35.7	+0.0	+33.2	+0.6	-39.5	+0.0	43.7	54.0	-10.3	Horiz
			+8.5	+4.9	+0.3				802.11n20_M		
7	4883.650M	35.6	+0.0	+33.2	+0.6	-39.5	+0.0	43.6	54.0	-10.4	Horiz
			+8.5	+4.9	+0.3				802.11n40_M		
8	4882.400M	35.5	+0.0	+33.2	+0.6	-39.5	+0.0	43.5	54.0	-10.5	Horiz
			+8.5	+4.9	+0.3				802.11b_M		
9	4843.600M	35.6	+0.0	+33.1	+0.6	-39.5	+0.0	43.3	54.0	-10.7	Horiz
			+8.4	+4.8	+0.3				802.11n40_L		
10	4823.800M	35.4	+0.0	+33.0	+0.6	-39.5	+0.0	43.0	54.0	-11.0	Horiz
			+8.4	+4.8	+0.3				802.11n20_L		
11	4924.700M	34.9	+0.0	+33.2	+0.6	-39.5	+0.0	42.9	54.0	-11.1	Horiz
			+8.5	+4.9	+0.3				802.11n20_H		
12	4903.800M	34.8	+0.0	+33.2	+0.6	-39.5	+0.0	42.8	54.0	-11.2	Horiz
			+8.5	+4.9	+0.3				802.11n40_H		
13	1658.223M	40.5	+0.0	+25.7	+0.3	-39.6	+0.0	34.1	54.0	-19.9	Horiz
	Ave		+4.5	+2.7	+0.0				802.11b_L		
^	1658.223M	61.4	+0.0	+25.7	+0.3	-39.6	+0.0	55.0	54.0	+1.0	Horiz
			+4.5	+2.7	+0.0				802.11b_L		
15	1711.723M	38.1	+0.0	+26.2	+0.3	-39.6	+0.0	32.4	54.0	-21.6	Horiz
	Ave		+4.6	+2.8	+0.0				802.11b_H		
^	1711.723M	57.1	+0.0	+26.2	+0.3	-39.6	+0.0	51.4	54.0	-2.6	Horiz
			+4.6	+2.8	+0.0				802.11b_H		
17	1677.160M	36.6	+0.0	+26.0	+0.3	-39.6	+0.0	30.6	54.0	-23.4	Horiz
	Ave		+4.6	+2.7	+0.0				802.11n40_L		
^	1677.160M	55.1	+0.0	+26.0	+0.3	-39.6	+0.0	49.1	54.0	-4.9	Horiz
			+4.6	+2.7	+0.0				802.11n40_L		
19	1700.933M	36.2	+0.0	+26.1	+0.3	-39.6	+0.0	30.4	54.0	-23.6	Horiz
	Ave		+4.6	+2.8	+0.0				802.11n40_H		
^	1700.933M	56.5	+0.0	+26.1	+0.3	-39.6	+0.0	50.7	54.0	-3.3	Horiz
			+4.6	+2.8	+0.0				802.11n40_H		

21	1711.723M	35.8	+0.0	+26.2	+0.3	-39.6	+0.0	30.1	54.0	-23.9	Vert
	Ave		+4.6	+2.8	+0.0				802.11b_H		
^	1711.723M	52.1	+0.0	+26.2	+0.3	-39.6	+0.0	46.4	54.0	-7.6	Vert
			+4.6	+2.8	+0.0				802.11b_H		
23	1352.302M	37.7	+0.0	+25.4	+0.3	-40.1	+0.0	29.8	54.0	-24.2	Horiz
	Ave		+4.0	+2.5	+0.0				802.11b_H		
^	1352.302M	55.1	+0.0	+25.4	+0.3	-40.1	+0.0	47.2	54.0	-6.8	Horiz
			+4.0	+2.5	+0.0				802.11b_H		
25	1356.223M	36.7	+0.0	+25.4	+0.3	-40.1	+0.0	28.8	54.0	-25.2	Horiz
	Ave		+4.0	+2.5	+0.0				802.11b_L		
^	1356.223M	55.4	+0.0	+25.4	+0.3	-40.1	+0.0	47.5	54.0	-6.5	Horiz
			+4.0	+2.5	+0.0				802.11b_L		
27	1354.783M	35.4	+0.0	+25.4	+0.3	-40.1	+0.0	27.5	54.0	-26.5	Horiz
	Ave		+4.0	+2.5	+0.0				802.11n40_H		
^	1354.800M	54.5	+0.0	+25.4	+0.3	-40.1	+0.0	46.6	54.0	-7.4	Horiz
			+4.0	+2.5	+0.0				802.11n40_H		

Band Edge

Band Edge Summary							
Limit applied at restricted bands: 15.209 Limit applied for other than restricted bands: Max Power/100kHz - 30dB (When average power limit is applied).							
Frequency (MHz)	**Modulation**	**Ant. Type / Gain (dBi)**	**Average (dBuV/m @3m)**		**Peak (dBuV/m @3m)**		**Results**
			Measured	**Limit**	**Measured**	**Limit**	
2390.0	802.11b	Ext/ /3.76	35.3	≤54	54.1	≤74	Pass
2400.0	802.11b	Ext/ /3.76	NA2	NA2	51.7	≤ 74	Pass
2483.5	802.11b	Ext/ /3.76	35.5	≤54	50.4	≤74	Pass
2390.0	802.11g	Ext/ /3.76	46.8	≤54	64.7	≤74	Pass
2400.0	802.11g	Ext/ /3.76	NA2	NA2	71.0	≤ 73	Pass
2483.5	802.11g	Ext/ /3.76	52.6	≤54	72.0	≤74	Pass
2390.0	802.11n HT20	Ext/ /3.76	50.1	≤54	68.2	≤74	Pass
2400.0	802.11n HT20	Ext/ /3.76	NA2	NA2	69.3	≤ 76	Pass
2483.5	802.11n HT20	Ext/ /3.76	53.8	≤54	72.2	≤74	Pass
2390.0	802.11n HT40	Ext/ /3.76	53.3	≤54	72.9	≤74	Pass
2400.0	802.11n HT40	Ext/ /3.76	NA2	NA2	66.2	≤ 73	Pass
2483.5	802.11n HT40	Ext/ /3.76	53.5	≤54	67.2	≤74	Pass

NA1 = Peak measurement meets average limit.
NA2 = Average limit not applicable when applying 30dBc limit.
NA3 = Peak limit not applicable when applying 30dBc limit.

Band Edge Test Data

Test Location:	CKC Laboratories, Inc • 110 N. Olinda Place • Brea, CA • (714) 993 6112		
Customer:	**Tonal**		
Specification:	**15.247(d) / 15.209 Radiated Spurious Emissions**		
Work Order #:	**110825**	Date:	1/12/2025
Test Type:	**Radiated Scan**	Time:	09:55:35
Tested By:	E. Wong	Sequence#:	5
Software:	EMITest 5.03.20		

Equipment Tested:

Device	Manufacturer	Model #	S/N
Configuration 1			

Support Equipment:

Device	Manufacturer	Model #	S/N
Configuration 1			

Test Conditions / Notes:

Test Condition #1

Frequency range of measurement = Bandedge
RBW=1MHz,VBW=3 MHz.

Test Environment Conditions:
Temperature: 23°C
Humidity: 20% r
Pressure: 100kPa

Modification #1 (MOD1) was in place during testing:
Reduce RF output power to 12dBm in the software for 802.11n HT40 Chain 0.
Added a ferrite (Wurth: 742 712 21) on lower resistor wire. Green Resistor

Site D
ANSI C63.10-2020

Test Equipment:

ID	Asset #	Description	Model	Calibration Date	Cal Due Date
T1	AN03834	Spectrum Analyzer	E4448A	5/6/2024	5/6/2026
T2	AN01646	Horn Antenna	3115	3/8/2024	3/8/2026
T3	ANP07660	Cable	32022-29094K-29094K-24TC	7/20/2024	7/20/2026
T4	AN00787	Preamp	83017A	6/27/2023	6/27/2025
T5	ANP04382	Cable	LDF-50	6/4/2024	6/4/2026
T6	ANP08191	Cable	ANDL1-PNMNM-50	11/11/2024	11/11/2026

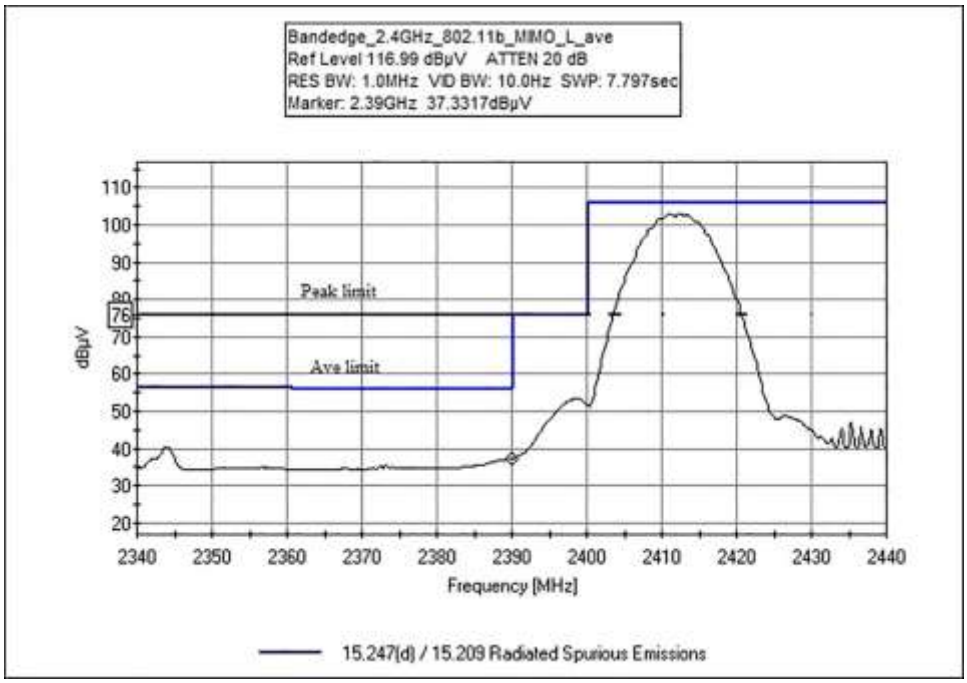
Measurement Data: Reading listed by margin. Test Distance: 3 Meters

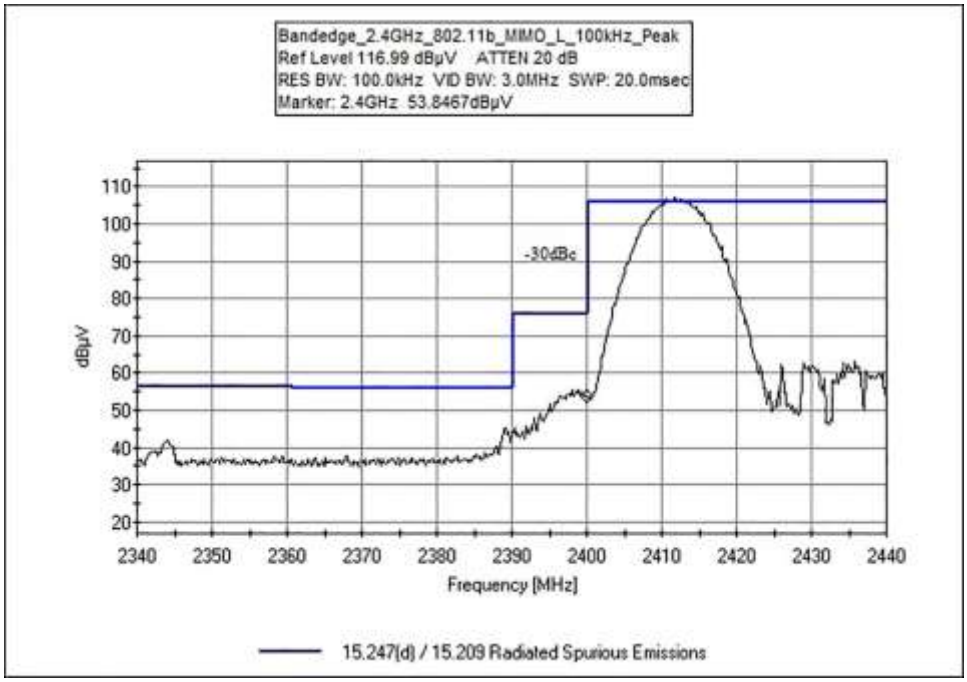
#	Freq	Rdng	T1 T5	T2 T6	T3	T4	Dist	Corr	Spec	Margin	Polar
	MHz	dBµV	dB	dB	dB	dB	Table	dBµV/m	dBµV/m	dB	Ant
1	2483.500M Ave	55.9	+0.0 +5.7	+28.3 +3.5	+0.4	-40.0	+0.0	53.8	54.0 802.11n20_Bandedge_H	-0.2	Horiz
2	2483.500M Ave	55.6	+0.0 +5.7	+28.3 +3.5	+0.4	-40.0	+0.0	53.5	54.0 802.11n40_Bandedge_H	-0.5	Horiz
3	2390.000M Ave	55.3	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	53.3	54.0 802.11n40_Bandedge_L	-0.7	Horiz
4	2483.500M Ave	54.7	+0.0 +5.7	+28.3 +3.5	+0.4	-40.0	+0.0	52.6	54.0 802.11g_Bandedge_H	-1.4	Horiz
5	2396.970M	73.5	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	71.5	73.0 802.11n40_RBW=100kHz	-1.5	Horiz
6	2390.000M Ave	52.1	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	50.1	54.0 802.11n_Bandedge_L	-3.9	Horiz
7	2400.000M QP	71.4	+0.0 +5.7	+28.3 +3.4	+0.4	-39.9	+0.0	69.3	76.0 802.11n20_Bandedge_L_RBW=100kHz	-6.7	Horiz
^	2400.000M	73.1	+0.0 +5.7	+28.3 +3.4	+0.4	-39.9	+0.0	71.0	73.0 802.11g_Bandedge_L_RBW=100kHz	-2.0	Horiz
^	2400.000M	68.3	+0.0 +5.7	+28.3 +3.4	+0.4	-39.9	+0.0	66.2	73.0 802.11n40_Bandedge_L_RBW=100kHz	-6.8	Horiz
^	2400.000M	53.8	+0.0 +5.7	+28.3 +3.4	+0.4	-39.9	+0.0	51.7	74.0 802.11b_Bandedge_L_RBW=100kHz	-22.3	Horiz
11	2390.670M	68.2	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	66.2	73.0 802.11n40_RBW=100kHz	-6.8	Horiz

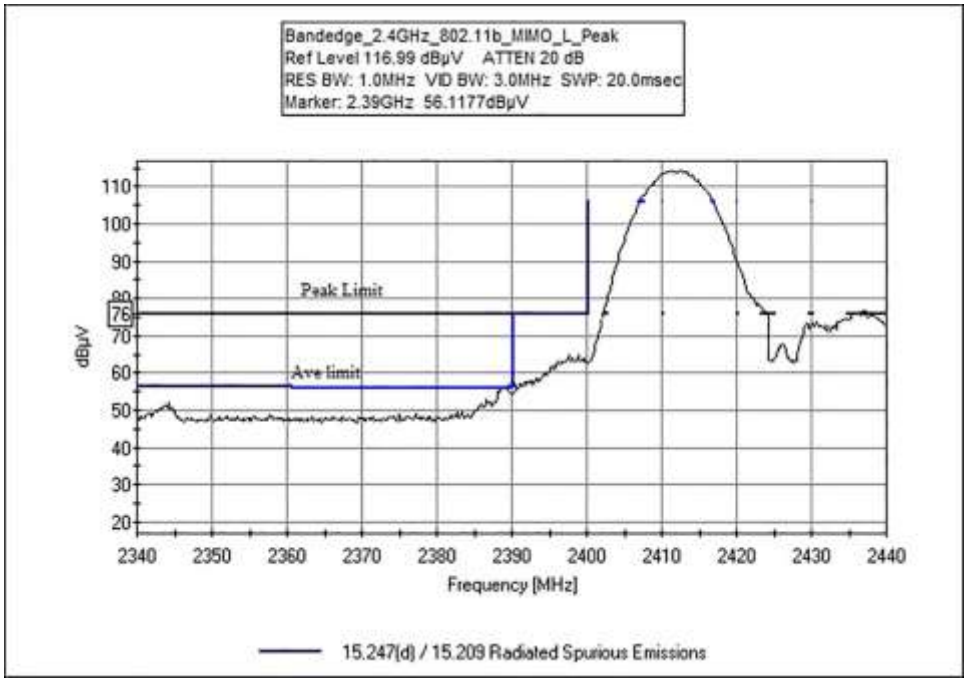
12	2390.000M Ave	48.8	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	46.8	54.0	-7.2	802.11g_Bandedge_L	Horiz
13	2483.500M Ave	37.6	+0.0 +5.7	+28.3 +3.5	+0.4	-40.0	+0.0	35.5	54.0	-18.5	802.11b_Bandedge_H	Horiz
^	2483.500M	74.3	+0.0 +5.7	+28.3 +3.5	+0.4	-40.0	+0.0	72.2	54.0	+18.2	802.11n20_Bandedge_H	Horiz
^	2483.500M	74.1	+0.0 +5.7	+28.3 +3.5	+0.4	-40.0	+0.0	72.0	54.0	+18.0	802.11g_Bandedge_H	Horiz
^	2483.500M	69.3	+0.0 +5.7	+28.3 +3.5	+0.4	-40.0	+0.0	67.2	54.0	+13.2	802.11n40_Bandedge_H	Horiz
^	2483.500M	52.5	+0.0 +5.7	+28.3 +3.5	+0.4	-40.0	+0.0	50.4	54.0	-3.6	802.11b_Bandedge_H	Horiz
18	2390.000M Ave	37.3	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	35.3	54.0	-18.7	802.11b_Bandedge_L	Horiz
^	2390.000M	74.9	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	72.9	54.0	+18.9	802.11n40_Bandedge_L	Horiz
^	2390.000M	70.2	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	68.2	54.0	+14.2	802.11n_Bandedge_L	Horiz
^	2390.000M	66.7	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	64.7	54.0	+10.7	802.11g_Bandedge_L	Horiz
^	2390.000M	56.1	+0.0 +5.7	+28.4 +3.4	+0.4	-39.9	+0.0	54.1	54.0	+0.1	802.11b_Bandedge_L	Horiz

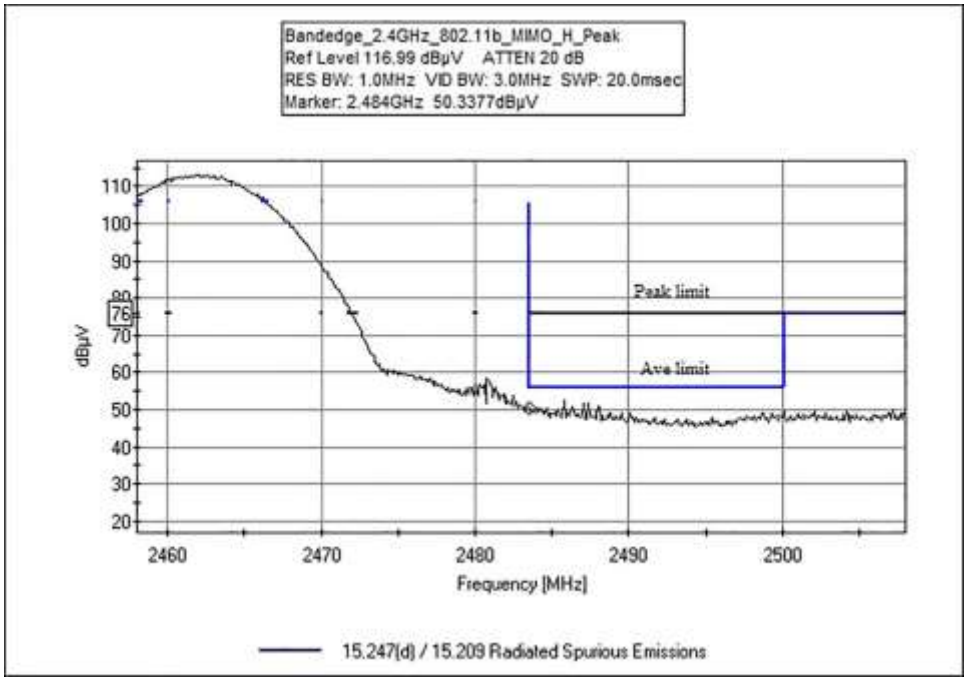
Band Edge Plots

802.11b

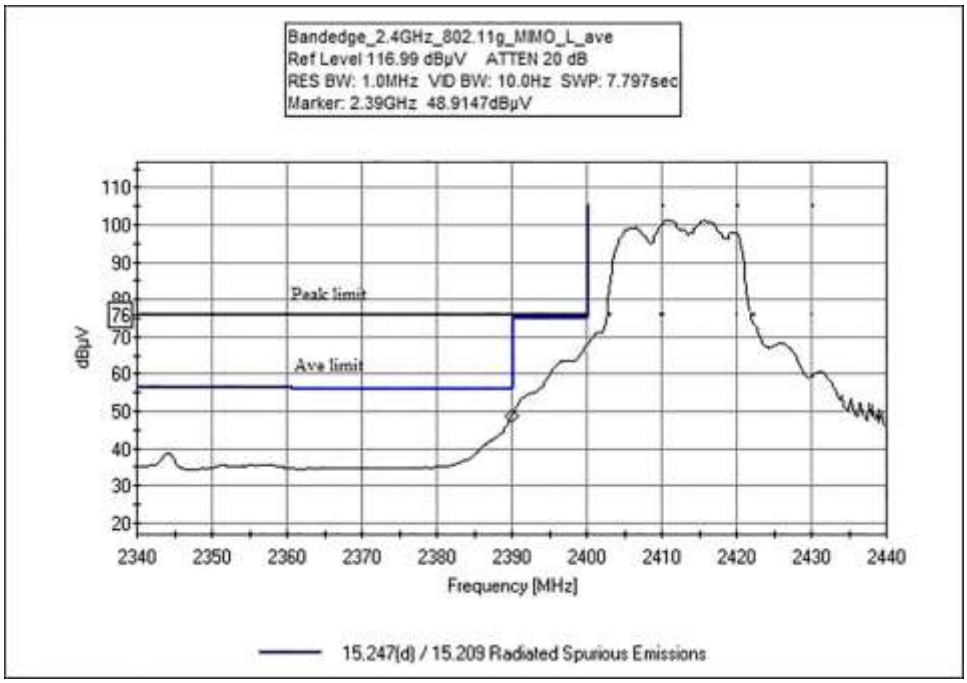


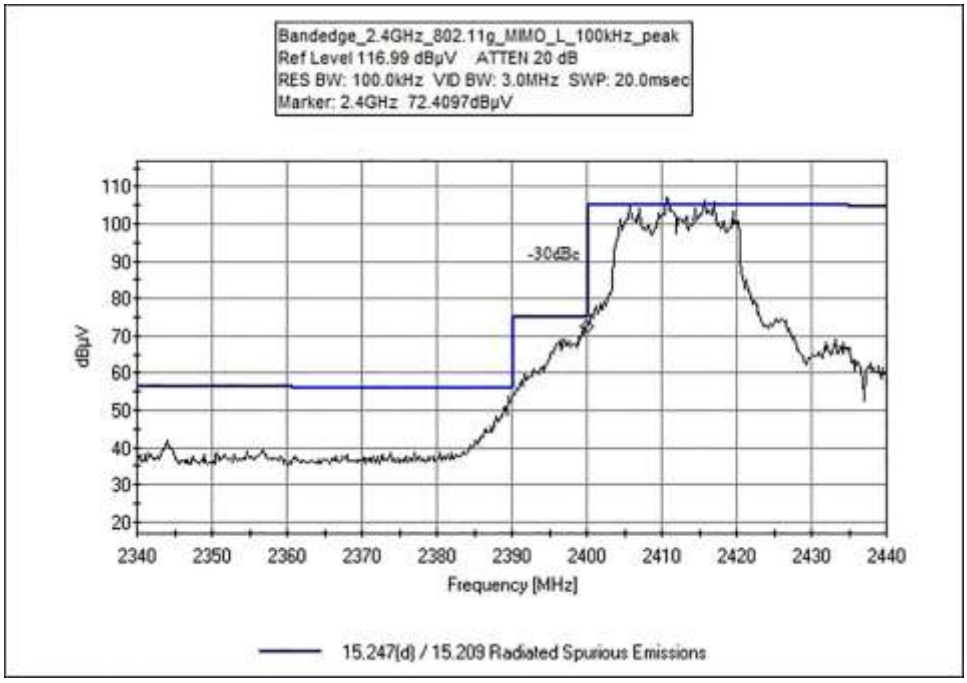


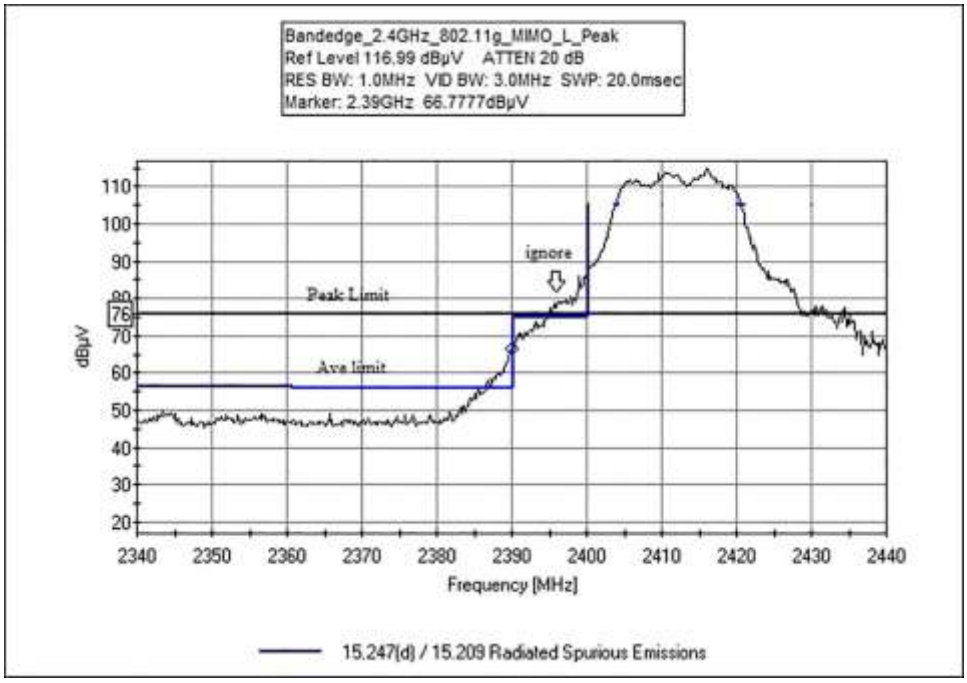

Bandedge_2.4GHz_802.11b_MIMO_L_Peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 3.0MHz SWP: 20.0msec
Marker: 2.39GHz 56.1177dBµV
Peak Limit
Ave limit
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

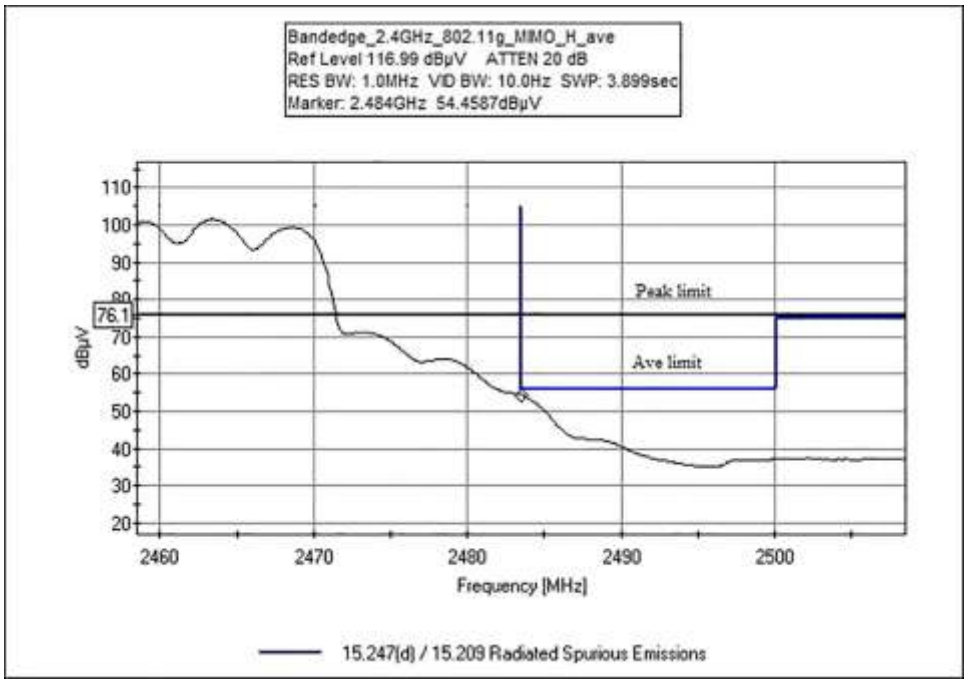

Bandedge_2.4GHz_802.11b_MIMO_H_Peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 3.0MHz SWP: 20.0msec
Marker: 2.484GHz 50.3377dBµV
Peak limit
Ave limit
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

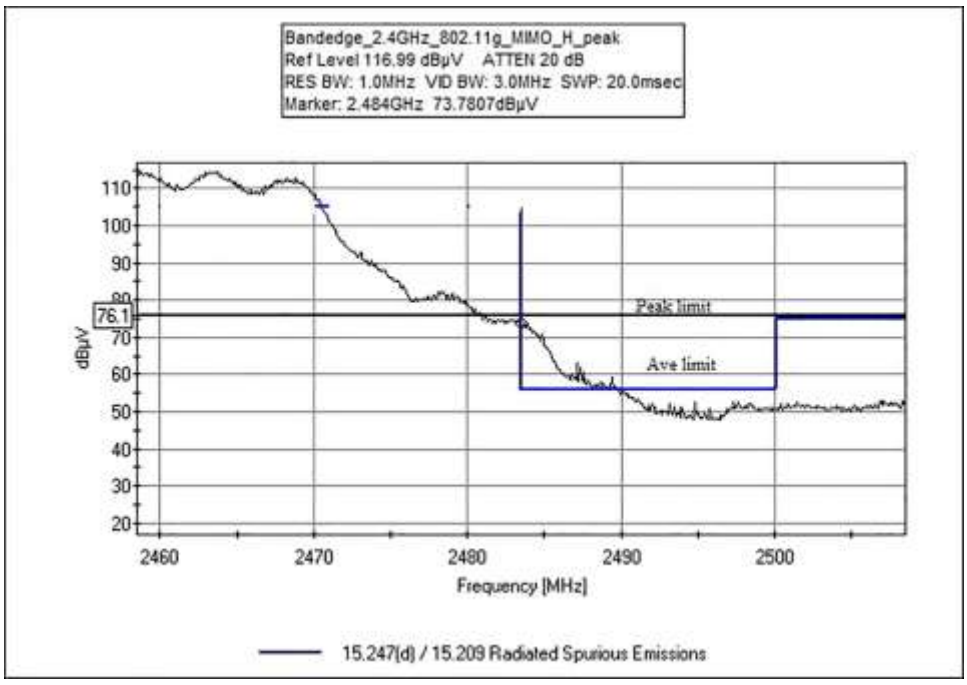
802.11g


Bandedge_2.4GHz_802.11g_MIMO_L_ave
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 10.0Hz SWP: 7.797sec
Marker: 2.39GHz 48.9147dBµV
Peak limit
Ave limit
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

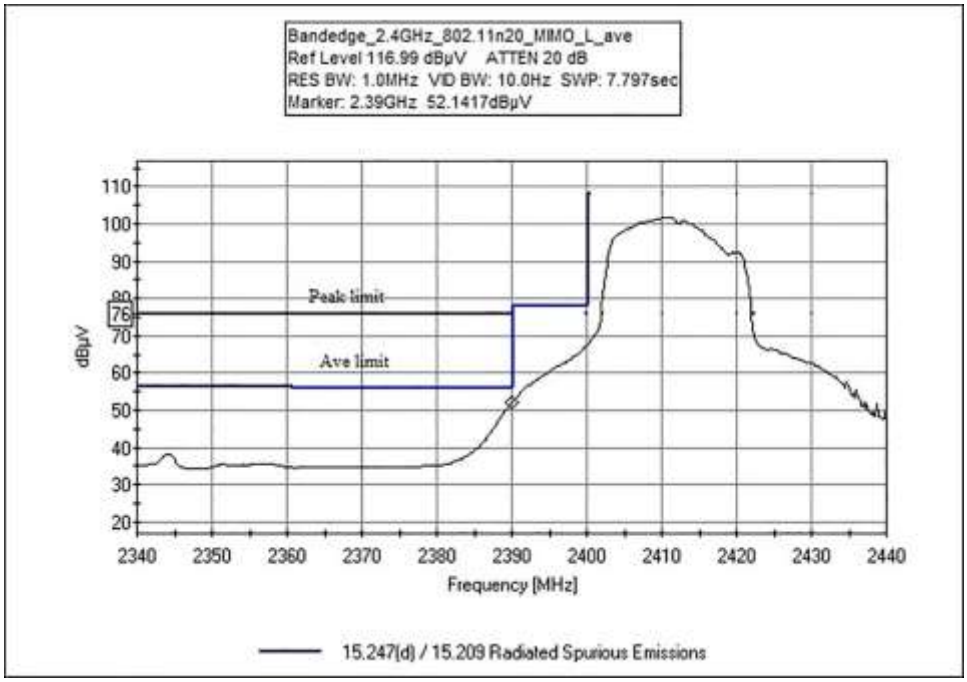

Bandedge_2.4GHz_802.11g_MIMO_L_100kHz_peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 100.0kHz VID BW: 3.0MHz SWP: 20.0msec
Marker: 2.4GHz 72.4097dBµV
-30dBc
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

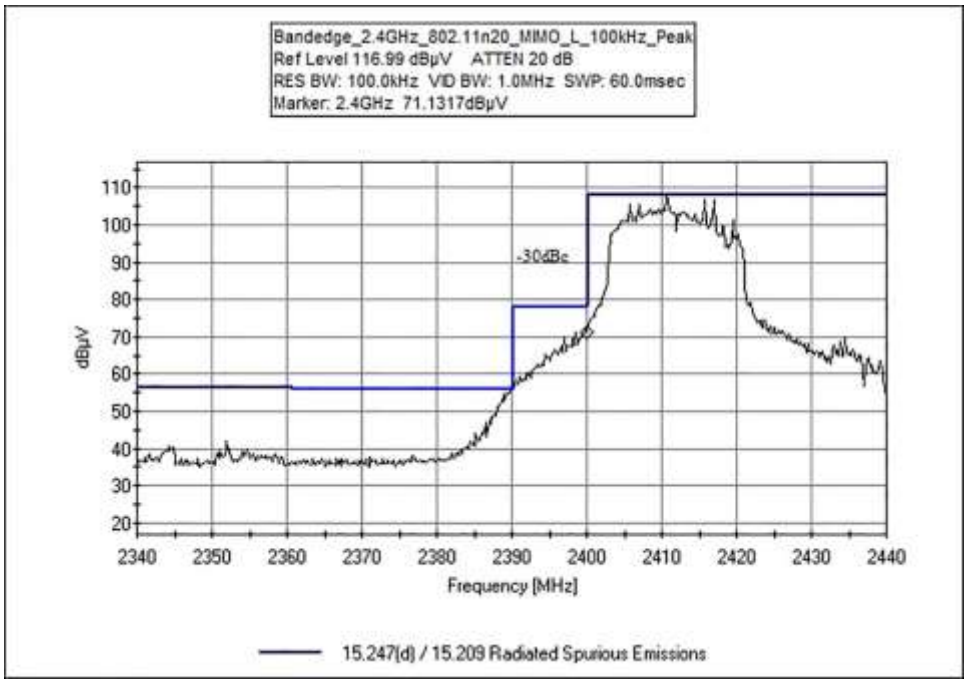

Bandedge_2.4GHz_802.11g_MIMO_L_Peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 3.0MHz SWP: 20.0msec
Marker: 2.39GHz 66.7777dBµV
ignore
Peak Limit
Ave limit
76
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

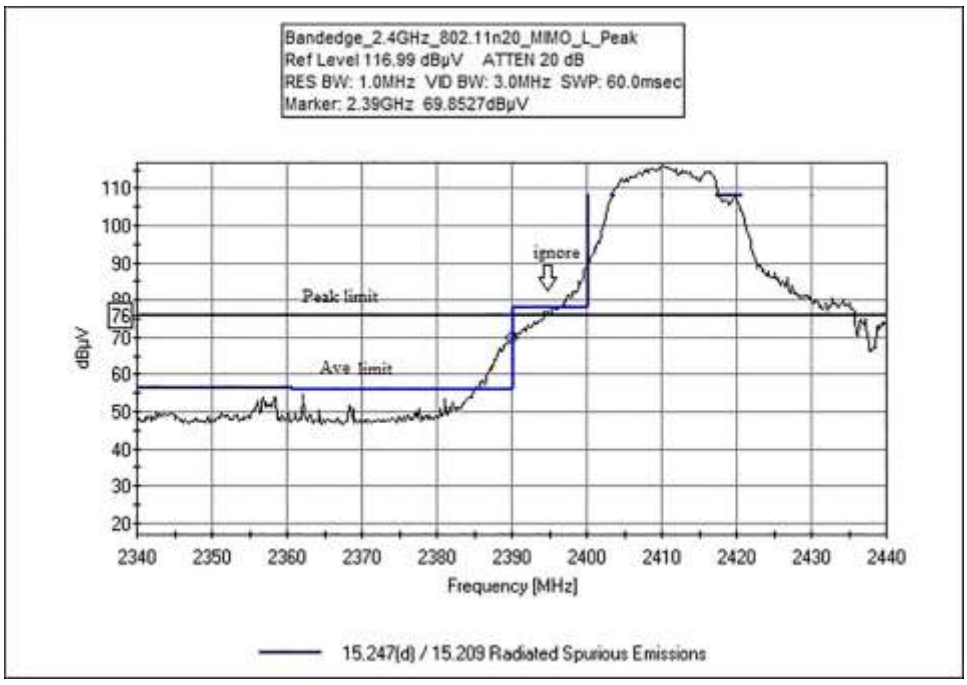

Bandedge_2.4GHz_802.11g_MIMO_H_ave
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 10.0Hz SWP: 3.899sec
Marker: 2.484GHz 54.4587dBµV
Peak limit
Ave limit
76.1
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

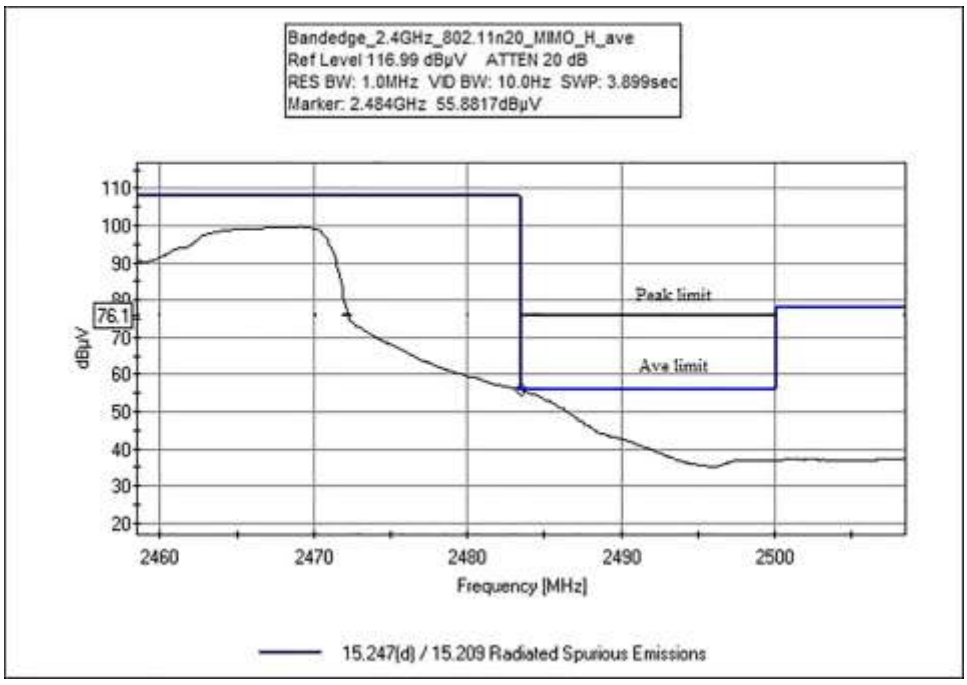

Bandedge_2.4GHz_802.11g_MIMO_H_peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 3.0MHz SWP: 20.0msec
Marker: 2.484GHz 73.7807dBµV
110
100
90
80
76.1
70
60
50
40
30
20
dBµV
Peak limit
Ave limit
2460
2470
2480
2490
2500
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

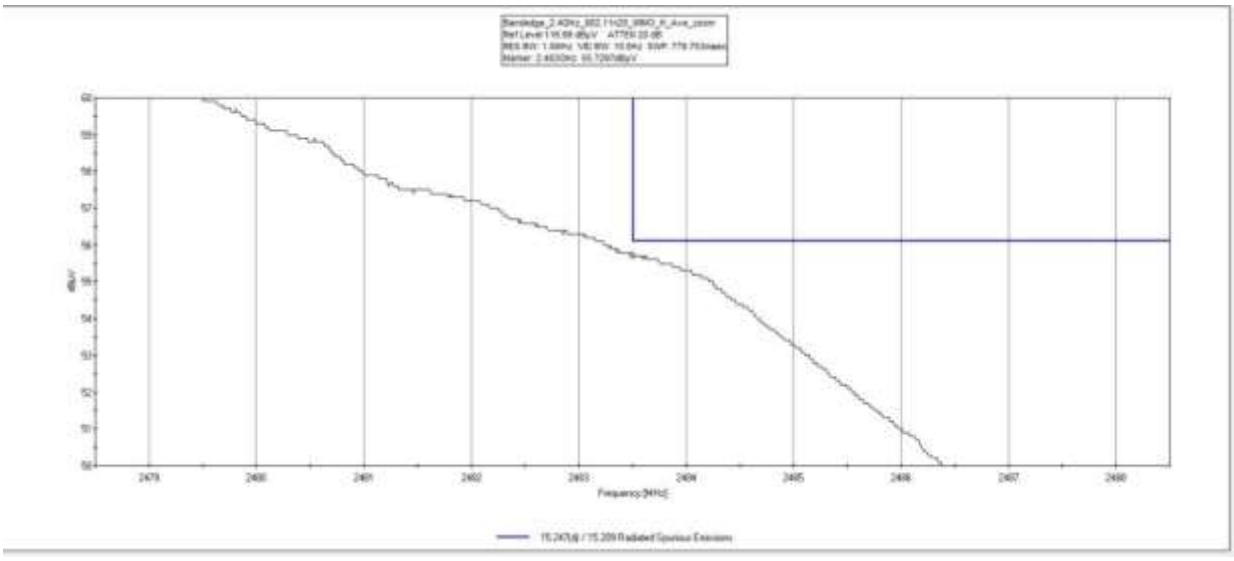
802.11n HT20


Bandedge_2.4GHz_802.11n20_MIMO_L_ave
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 10.0Hz SWP: 7.797sec
Marker: 2.39GHz 52.1417dBµV
Peak limit
Ave limit
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

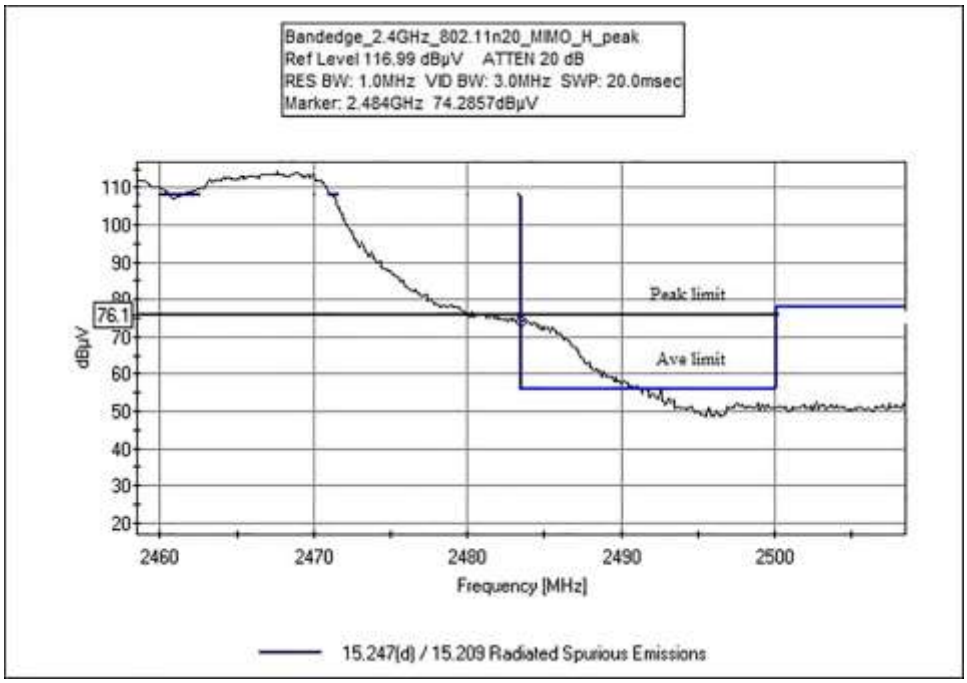

Bandedge_2.4GHz_802.11n20_MIMO_L_100kHz_Peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 100.0kHz VID BW: 1.0MHz SWP: 60.0msec
Marker: 2.4GHz 71.1317dBµV
-30dBc
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions


Bandedge_2.4GHz_802.11n20_MIMO_L_Peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 3.0MHz SWP: 60.0msec
Marker: 2.39GHz 69.8527dBµV
ignore
Peak limit
Ave limit
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

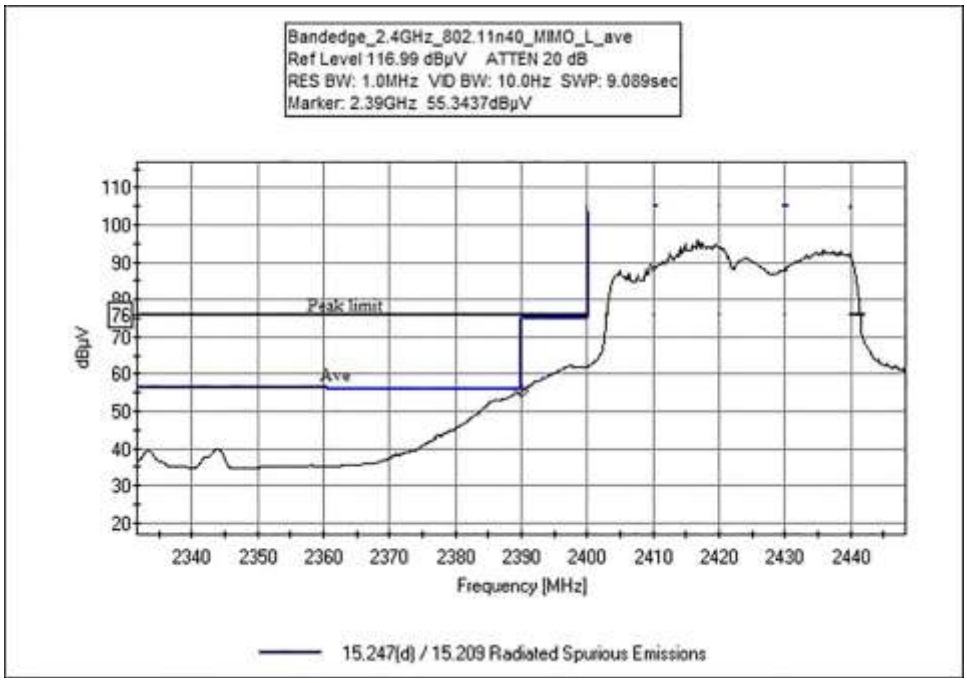

Bandedge_2.4GHz_802.11n20_MIMO_H_ave
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 10.0Hz SWP: 3.899sec
Marker: 2.484GHz 55.8817dBµV
110
100
90
80
76.1
70
60
50
40
30
20
dBµV
Peak limit
Ave limit
2460
2470
2480
2490
2500
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

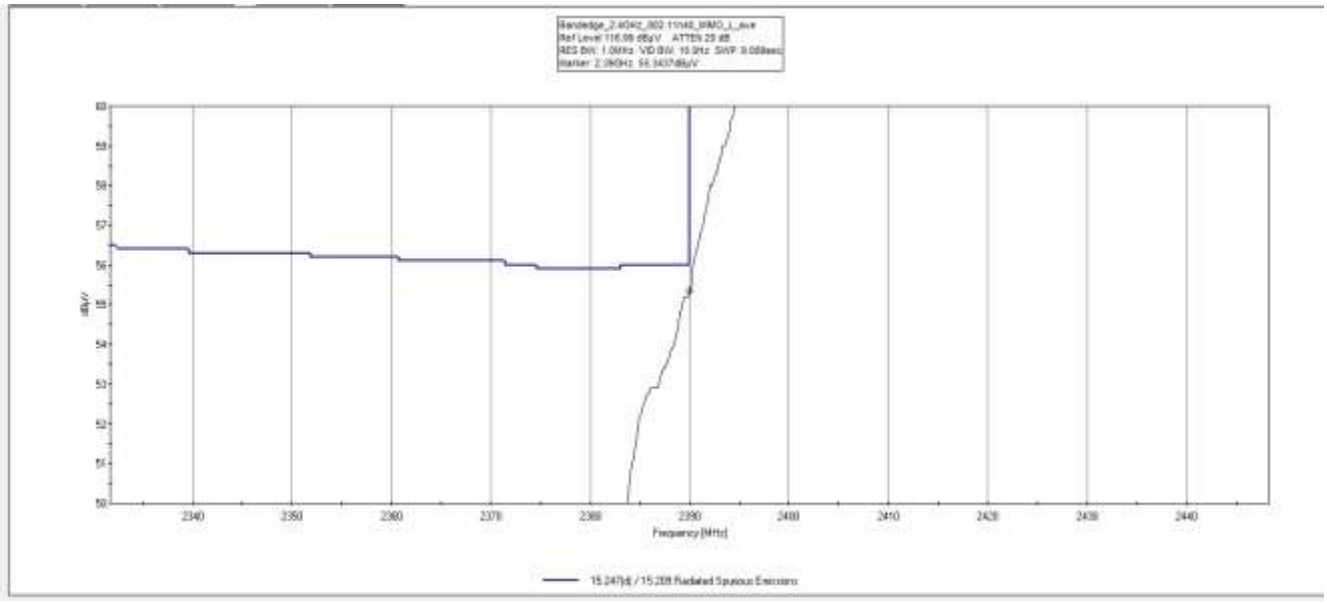


Zoom in view

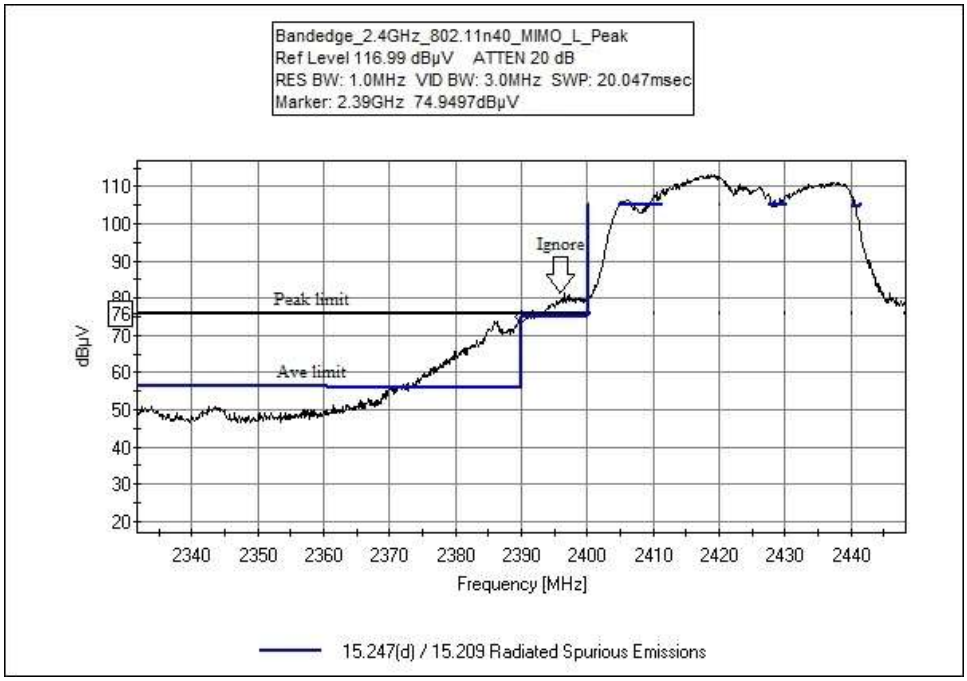

Bandedge_2.4GHz_802.11n20_MIMO_H_peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 3.0MHz SWP: 20.0msec
Marker: 2.484GHz 74.2857dBµV
110
100
90
80
76.1
70
60
50
40
30
20
dBµV
Peak limit
Ave limit
2460
2470
2480
2490
2500
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

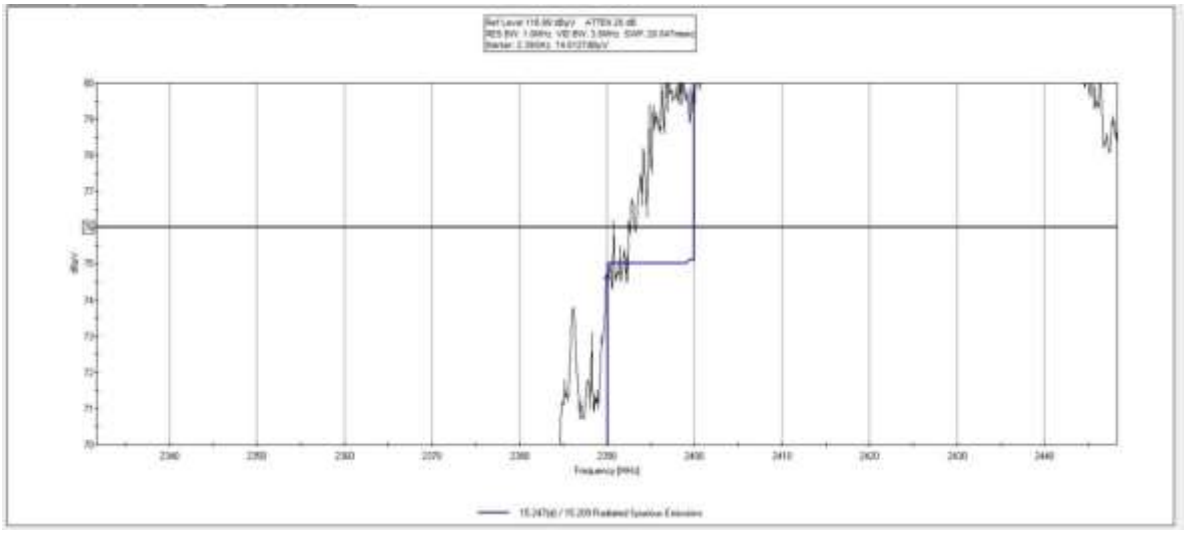
802.11n HT40





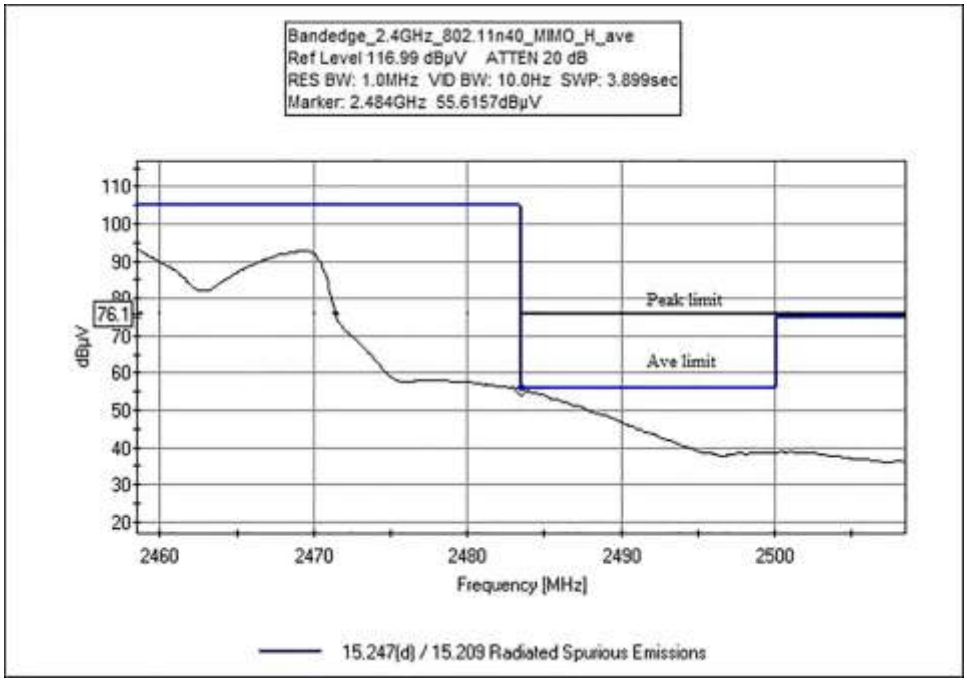
Zoom in view

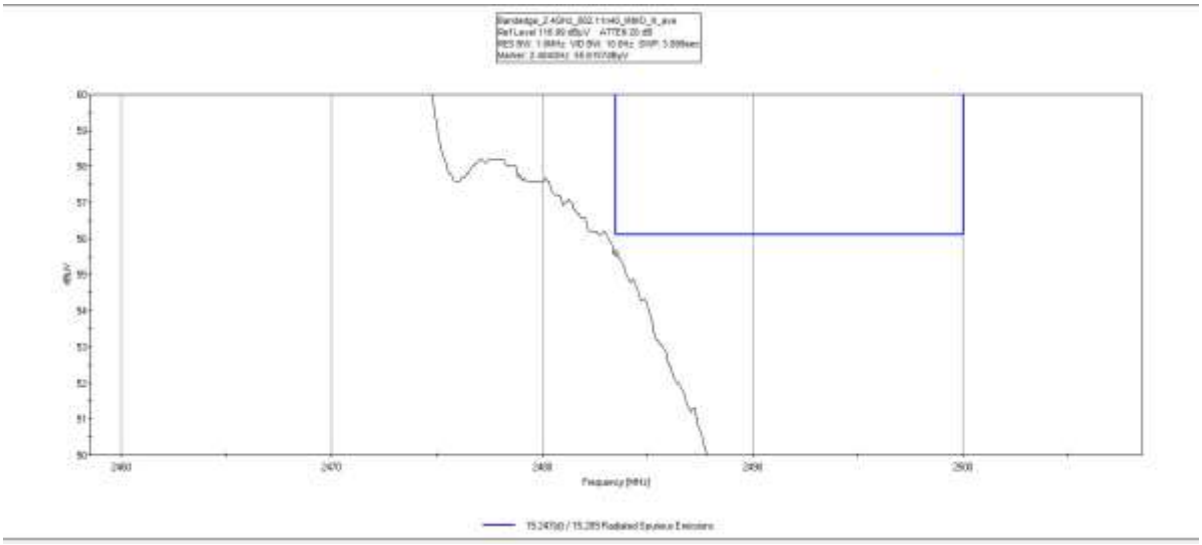

Bandedge_2.4GHz_802.11n40_MIMO_L_Peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 3.0MHz SWP: 20.047msec
Marker: 2.39GHz 74.9497dBµV
Ignore
Peak limit
Ave limit
76
dBµV
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions



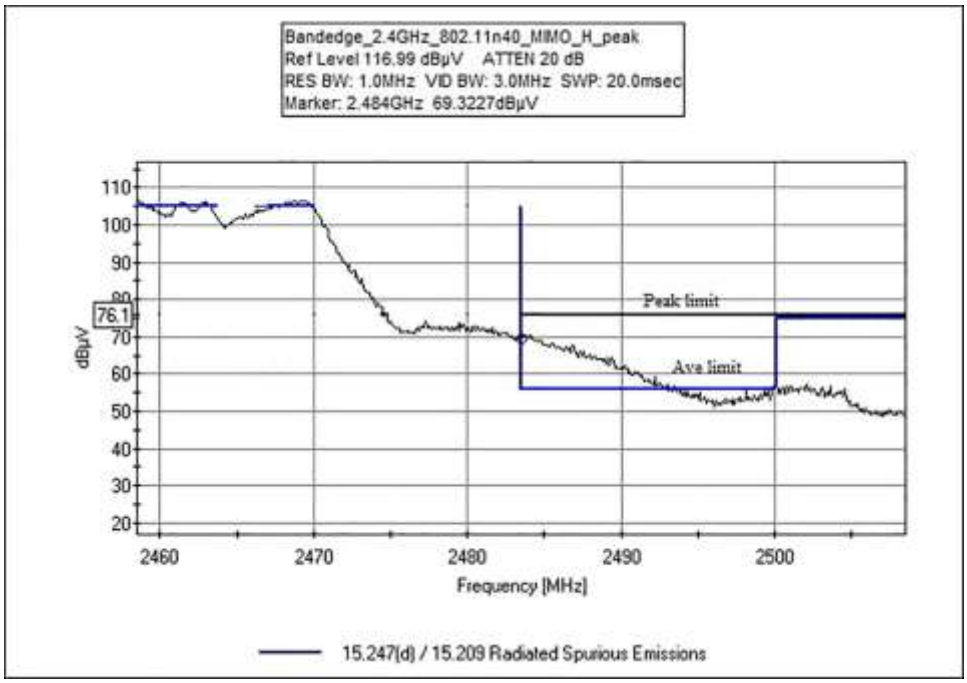
Zoom in view


Bandedge_2.4GHz_802.11n40_MIMO_L_100kHz_Peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 100.0kHz VID BW: 3.0MHz SWP: 20.047msec
Marker: 2.4GHz 68.3147dBµV
-30dBc
Ignore
dBµV
110
100
90
80
70
60
56
50
40
30
20
2340
2350
2360
2370
2380
2390
2400
2410
2420
2430
2440
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

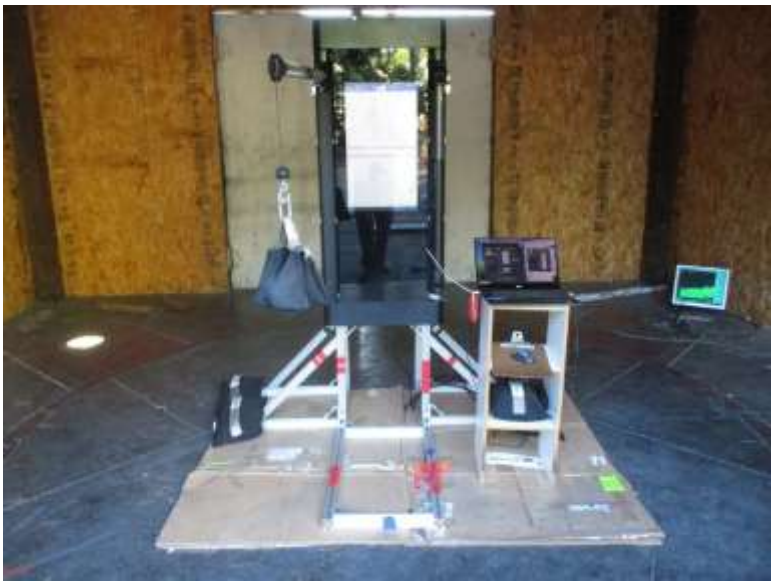

Bandedge_2.4GHz_802.11n40_MIMO_H_ave
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 10.0Hz SWP: 3.899sec
Marker: 2.484GHz 55.6157dBµV
110
100
90
80
76.1
70
60
50
40
30
20
dBµV
Peak limit
Ave limit
2460
2470
2480
2490
2500
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions



Zoom in view


Bandedge_2.4GHz_802.11n40_MIMO_H_peak
Ref Level 116.99 dBµV ATTEN 20 dB
RES BW: 1.0MHz VID BW: 3.0MHz SWP: 20.0msec
Marker: 2.484GHz 69.3227dBµV
110
100
90
80
76.1
70
60
50
40
30
20
dBµV
Peak limit
Ave limit
2460
2470
2480
2490
2500
Frequency [MHz]
15.247(d) / 15.209 Radiated Spurious Emissions

Test Setup Photo(s)



Below 1GHz, View 1

Below 1GHz, View 2

Above 1GHz, View 1

Above 1GHz, View 2

APPENDIX A: MODIFICATIONS MADE DURING TESTING

Modification 1 (MOD1)
Reduce RF output power to 12dBm in the software for 802.11n HT40 Chain 0
Added a ferrite (Wurth: 742 712 21) on lower resistor wire
Green Resistor

Test Setup Photo(s)

Supplemental Information

Measurement Uncertainty

Uncertainty Value	Parameter
5.77 dB	Radiated Emissions
0.673 dB	RF Conducted Measurements
5.77 x 10^{-10}	Frequency Deviation
0.00005 s	Time Deviation
3.18 dB	Mains Conducted Emissions

Uncertainties reported are worst case for all CKC Laboratories' sites and represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k=2. Compliance is deemed to occur provided measurements are below the specified limits.

Emissions Test Details

TESTING PARAMETERS

Unless otherwise indicated, the following configuration parameters are used for equipment setup: The cables were routed consistent with the typical application by varying the configuration of the test sample. Interface cables were connected to the available ports of the test unit. The effect of varying the position of the cables was investigated to find the configuration that produced maximum emissions. Cables were of the type and length specified in the individual requirements. The length of cable that produced maximum emissions was selected.

The equipment under test (EUT) was set up in a manner that represented its normal use, as shown in the setup photographs. Any special conditions required for the EUT to operate normally are identified in the comments that accompany the emissions tables.

The emissions data was taken with a spectrum analyzer or receiver. Incorporating the applicable correction factors for distance, antenna, cable loss and amplifier gain, the data was reduced as shown in the table below. The corrected data was then compared to the applicable emission limits. Preliminary and final measurements were taken in order to ensure that all emissions from the EUT were found and maximized.

CORRECTION FACTORS

The basic spectrum analyzer reading was converted using correction factors as shown in the highest emissions readings in the tables. For radiated emissions in dBµV/m, the spectrum analyzer reading in dBµV was corrected by using the following formula. This reading was then compared to the applicable specification limit. Individual measurements were compared with the displayed limit value in the margin column. The margin was calculated based on subtracting the limit value from the corrected measurement value; a positive margin represents a measurement exceeding the limit, while a negative margin represents a measurement less than the limit.

SAMPLE CALCULATIONS		
	Meter reading	(dBµV)
+	Antenna Factor	(dB/m)
+	Cable Loss	(dB)
-	Distance Correction	(dB)
-	Preamplifier Gain	(dB)
=	Corrected Reading	(dBµV/m)

TEST INSTRUMENTATION AND ANALYZER SETTINGS

The test instrumentation and equipment listed were used to collect the emissions data. A spectrum analyzer or receiver was used for all measurements. Unless otherwise specified, the following table shows the measuring equipment bandwidth settings that were used in designated frequency bands. For testing emissions, an appropriate reference level and a vertical scale size of 10 dB per division were used.

MEASURING EQUIPMENT BANDWIDTH SETTINGS PER FREQUENCY RANGE			
TEST	BEGINNING FREQUENCY	ENDING FREQUENCY	BANDWIDTH SETTING
CONDUCTED EMISSIONS	150 kHz	30 MHz	9 kHz
RADIATED EMISSIONS	9 kHz	150 kHz	200 Hz
RADIATED EMISSIONS	150 kHz	30 MHz	9 kHz
RADIATED EMISSIONS	30 MHz	1000 MHz	120 kHz
RADIATED EMISSIONS	1000 MHz	>1 GHz	1 MHz

SPECTRUM ANALYZER/RECEIVER DETECTOR FUNCTIONS

The notes that accompany the measurements contained in the emissions tables indicate the type of detector function used to obtain the given readings. Unless otherwise noted, all readings were made in the "positive peak" detector mode. Whenever a "quasi-peak" or "average" reading was recorded, the measurement was annotated with a "QP" or an "Ave" on the appropriate rows of the data sheets. In cases where quasi-peak or average limits were employed and data exists for multiple measurement types for the same frequency then the peak measurement was retained in the report for reference, however the numbering for the affected row was removed and an arrow or caret ("^") was placed in the far left-hand column indicating that the row above takes precedence for comparison to the limit. The following paragraphs describe in more detail the detector functions and when they were used to obtain the emissions data.

Peak

In this mode, the spectrum analyzer or receiver recorded all emissions at their peak value as the frequency band selected was scanned. By combining this function with another feature called "peak hold," the measurement device had the ability to measure intermittent or low duty cycle transient emission peak levels. In this mode the measuring device made a slow scan across the frequency band selected and measured the peak emission value found at each frequency across the band.

Quasi-Peak

Quasi-peak measurements were taken using the quasi-peak detector when the true peak values exceeded or were within 2 dB of a quasi-peak specification limit. Additional QP measurements may have been taken at the discretion of the operator.

Average

Average measurements were taken using the average detector when the true peak values exceeded or were within 2 dB of an average specification limit. Additional average measurements may have been taken at the discretion of the operator. If the specification or test procedure requires trace averaging, then the averaging was performed using 100 samples or as required by the specification. All other average measurements are performed using video bandwidth averaging. To make these measurements, the test engineer reduces the video bandwidth on the measuring device until the modulation of the signal is filtered out. At this point, the measuring device is set into the linear mode and the scan time is reduced.

End of Report