Testing Tomorrow's Technology

Application For

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart E, paragraphs 15.401, 15.403, 15.405 and 15.407

And

Innovation, Science, and Economic Development Canada Certification Per
IC RSS-Gen General Requirements for Radio Apparatus
And
RSS-247Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and License-Exempt Local Area Network (LE-LAN) Devices

For the

Inventek Systems

Model: ISM4334X-M4G-L44

FCC ID: O7P-341
IC: 10147A-341

UST Project: 24-0073
Issue Date: July 18, 2024

Total Pages in This Report : 59

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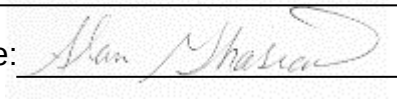
I certify that I am authorized to sign for the Test Agency and that the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible for Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date July 18, 2024

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Inventek Systems
MODEL: ISM4334X-M4G-L44
FCC ID: O7P-341
IC: 10147A-341
DATE: July 18, 2024

This report concerns (check one): Original grant
Class II change X

Equipment type: UNII Device

Technical:
IEEE Std. 802.11 a, n
5250 – 5350 MHz (Channels 52 - 64)
5470 – 5725 MHz (Channels 100 -140)
Type of modulation:
IEEE 802.11a (20 MHz), IEEE 802.11n (20MHz)
Data/Bit Rate:
802.11a= 6 - 54 Mbps, 802.11n= 150 Mbps
Antenna Gain: +2.3 (Chip Antenna)
Maximum Output Power: +8.88 dBm (AVG)
Software used to program EUT: eS-WiFi
EUT firmware number: N/A
Power setting: Maximum level

Report prepared by:

US Tech
3505 Francis Circle
Alpharetta, GA 30004

Phone Number: (770) 740-0717
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1 General Information

1.1 Purpose of this Report

This report is prepared to convey test results and information concerning the suitability of this exact product for Class II Permissive Change (C2PC) certification as an intentional transmitter device intended for public distribution according to the FCC Rules and Regulations Part 15, Section 407 and IC RSS 247 Issue 3.

The EUT is adding channels of operation using chip antenna:

- U-NII-2A
  - Channels 52-64 (5.26 – 5.32 GHz at 20 MHz bandwidth)
- U-NII-2C
  - Channels 100 – 116 (5.5 – 5.58 GHz at 20 MHz Bandwidth)
  - Channels 132 – 140 (5.66 – 5.7 GHz at 20 MHz Bandwidth)

No modification was made on the Wi-Fi module or adding channels with the use of the U. FL antenna.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on April 10, 2024 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Inventek Systems Model ISM4334X-M4G-L44 Module. The ISM4334X-M4G-L44 Module is an embedded wireless Internet connectivity module that operates in the 2.4 and 5.0 GHz spectrum. The Wi-Fi module's hardware consists of an ARM Cortex M4 host processor, Broadcom BCM43341/0 Dual-Band 802.11 g/n MAC/Baseband/Radio with integrated Bluetooth 4.0 and NFC support.

The Model Numbers to be included in the approval are:

ISM43340-M4G-L44-C
ISM43340-M4G-L44-U
ISM43341-M4G-L44-C
ISM43341-M4G-L44-U
ISM43340-M4G-L44-10CFH
ISM43340-M4G-L44-10UFH
ISM43341-M4G-L44-10CFH
ISM43341-M4G-L44-10UFH
ISM341-USB

The different model numbers for are marketing purposes: The ISM43340 does not support NFC, while the ISM43341 does support NFC. The C or U is for the antenna to be used, either the chip (C) or the external antenna path (U). The F is for an optional external flash memory, and the H is for Apple HomeKit. The final part number, ISM341-USB, is for a specific customer and includes the NFC filter circuit.

The EUT has two antenna options, a dual band chip antenna or a U. FL connector for use with an approved external antenna.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for the intentional radiator aspect of the device and *ANSI C63.4:2014, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014)* for the unintentional radiator aspect of the device as well as FCC subpart B and C of Part 15 and per FCC KDB Publication number 558074 v03r05 for Digital Transmission Systems Operating Under section 15.247.

A list of EUT and Peripherals is found in Table 1 below. A block diagram of the tested system is shown in Figure 1. Test configuration photographs are provided in separate Appendices.

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is US5301. Additionally, this site has also been fully described and submitted to Industry Canada (IC) and has been approved under file number 9900A-1.

1.6 Related Submittals

The EUT is subject to the following FCC authorizations:

a) Certification under section 15.407 as a transmitter.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER.	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
Inventek Systems (EUT)	ISM4334X-M4G-L44 Module	Engineering Sample	O7P-341 10147A-341	PS/DS
Laptop Hewlett Packard	14-DQ0052DX	5CD404BR68	Contains FCC ID: TX2-RTL882CE Contains IC: 6317A-RTL8822CE	PS/DS
Antenna See antenna details	--	--	--	--

U= Unshielded
S= Shielded
P= Power
D= Data

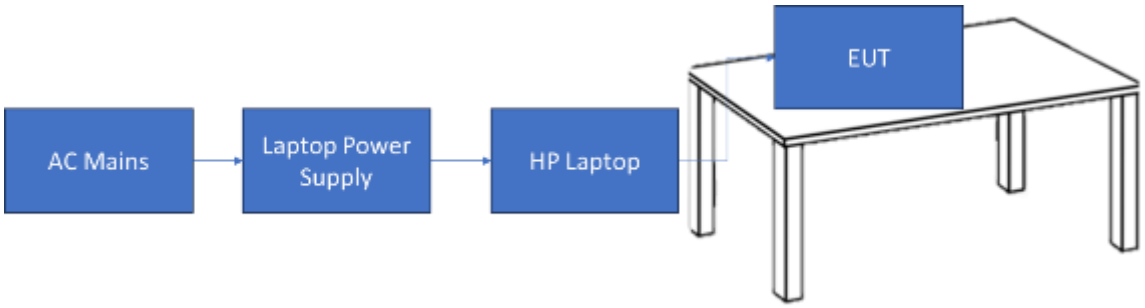


Figure 1. Block Diagram of Test Configuration

2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are indicated.

Table 2. Test Instruments

TEST INSTRUMENT	Manufacturer	Model	SERIAL NUMBER	DATE OF LAST CALIBRATION
Spectrum Analyzer	Agilent	E4440A	MY45304803	2/22/2026 2 yr.
Spectrum Analyzer	Agilent	E4407B	US41442935	9/21/2024 2 yr.
Spectrum Analyzer	Hewlett-Packard	8566B	2648A13875	5/07/2025
RF Preamp	Hewlett-Packard	8449B	3008A00914	3/4/2025
RF Preamp	Hewlett-Packard	8447D	1937A01611	6/17/2025
Mixer	Hewlett-Packard	11975A	2517A00647	4/09/2025
Biconical Antenna	EMCO	3110B	9307-1431	1/13/2025 2 yr.
Log Periodic Antenna	EMCO	3146	9305-3600	3/13/2026 2 yr.
Horn Antenna	EMCO	3115	9107-3723	3/13/2025 2 yr.
Environmental Chamber	Thermotron	SM16	17095	4/17/2025 2 yr.
LISN (x2)	Solar Electronics	8028-50-TS24-BNC	955824 & 955825	4/28/2025
Spectrum Analyzer	Rigol	DSA815	DSA8A180300138	2/22/2026 2 yr.

Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

2.2 Modifications to EUT Hardware

No physical modifications were made by US Tech to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

2.3 Number of Measurements for Intentional Radiators (15.31(m))

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in Table 3 below.

Table 3. Number of Test Frequencies for Intentional Radiators

Frequency Range Over Which the Device Operates	Number of Frequencies	Location in the Range of Operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near the top 1 near the bottom
Greater than 10 MHz	3	1 near top 1 near middle 1 near bottom

Because the EUT operates at 5.15 GHz to 5.85 MHz, at least 3 test frequencies were used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

The spectrum shall be investigated for the intentional radiator from the lowest RF signal generated in the EUT without going below 9 kHz to the 10th harmonic of the highest fundamental frequency generated or 40 GHz (whichever is the lowest).

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be 30 MHz to 1000 MHz or up to 5 times the highest internal clock frequency.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the following:

2.5.1 Detector Function and Associated Bandwidth

On frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR Quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the Quasi-peak device are used.

2.5.2 Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified, there is also a corresponding Peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth is at least 1 MHz.

2.5.3 Pulsed Transmitter Averaging

When the radiated emissions limit is expressed as an average value and the transmitter is pulsed, the measured field strength is determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may be expressed logarithmically in dB.

NOTE: If the transmitter was programmed to transmit at >98% duty cycle, then, wherever applicable (where the detection mode was AVG) the duty cycle factor calculated will be applied.

2.6 EUT Antenna Requirements (CFR 15.203)

An intentional radiator is designed to ensure that no antenna other than that furnished by the responsible party will be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator is considered sufficient to comply with the provisions of this section. Only the antenna(s) listed in Table 4 will be used with this module.

Table 4. Allowed Antenna(s)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	TYPE OF CONNECTOR
1	Unictron Technologies Corp.	Chip	AA077	2.3	Chip

2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious emissions cannot exceed the limits of 15.209. Radiated harmonics and other spurious emissions are examined for this requirement.

2.8 Transmitter Duty Cycle (CFR 35 (c))

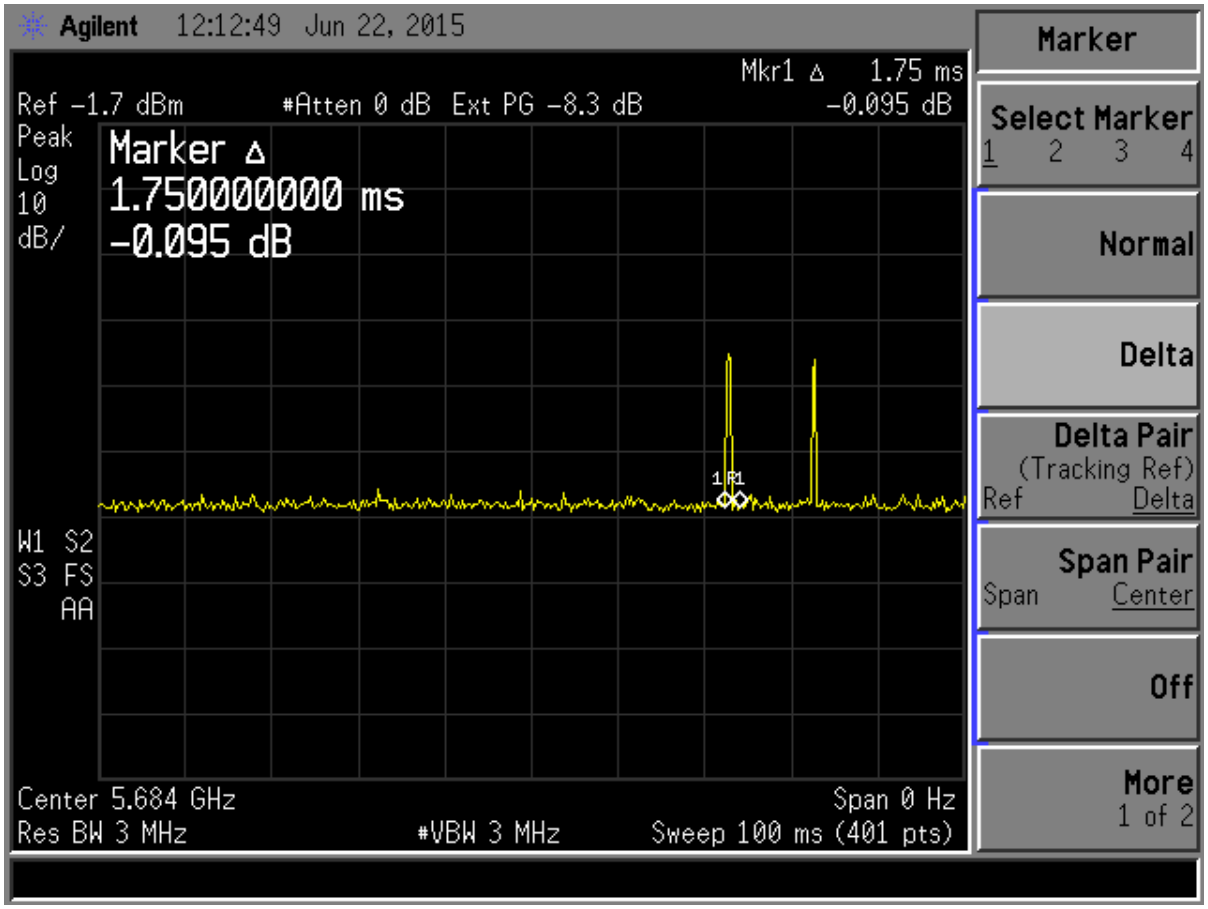


Figure 2. Duty Cycle 100ms Sweep

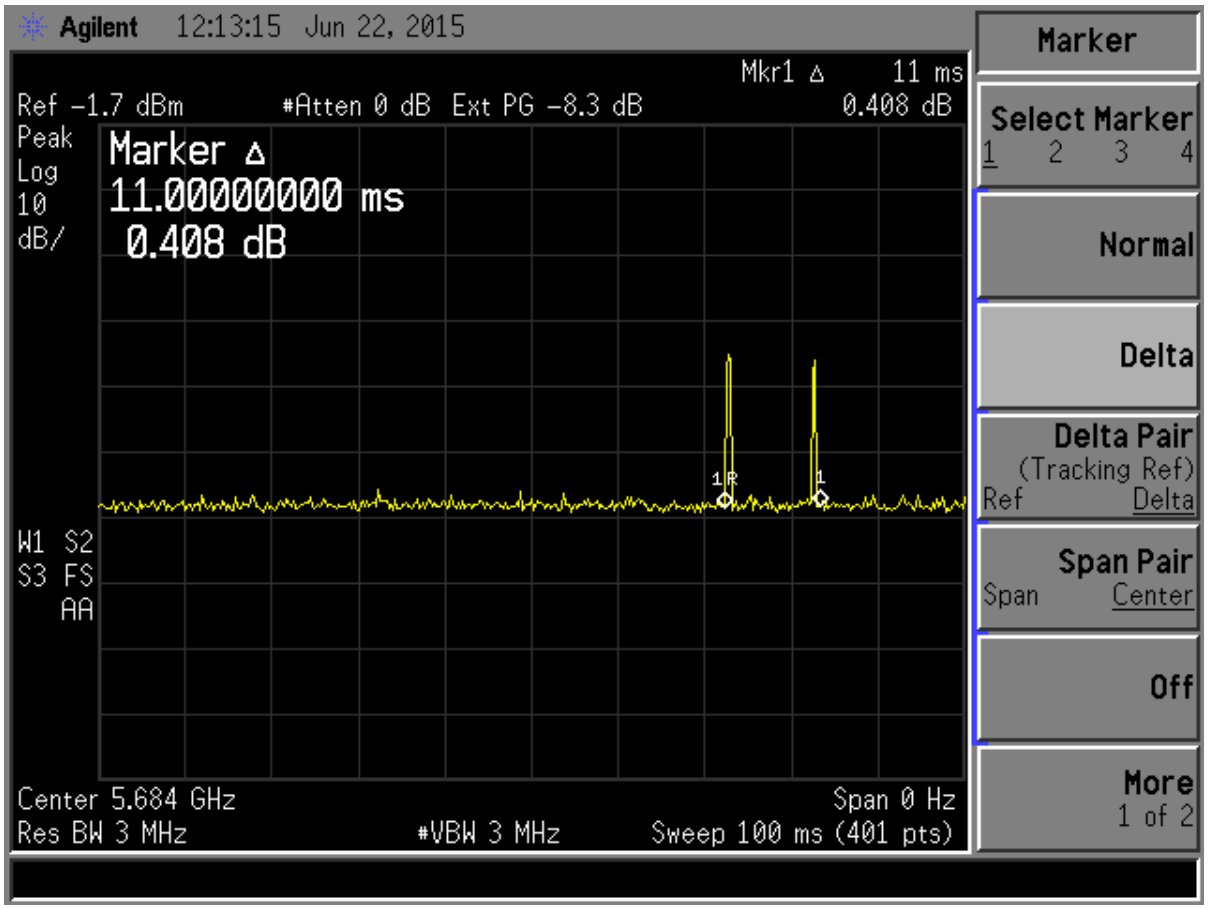


Figure 3. Transmitter Pulse Width

Total Time on from Figure 2 = 1.75 ms (Transmitter Pulse Width)
Total Pulse Train from Figure 3 = 11.00 ms (Pulse Train)

(1.75 ms Total Time On)/ (11.00 ms Total Pulse Train) = 0.16 Numeric Duty Cycle
Duty Cycle = 20 Log (0.16) = -15.97 dB

NOTE: The transmitter was programmed to transmit at >98% duty cycle, therefore wherever applicable (where the detection mode was AVG) the duty cycle factor calculated above will be applied.

2.9 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207)

The EUT is powered by 3.3 VDC through a host device. The host was connected to the AC mains, and the power line conducted emissions testing was performed to ensure that the EUT in operation (exercising all transmitter functions) and the complete system continues to meet the applicable requirements for CFR 15.207. These measurements were completed and are displayed along with the 15.107 power line test data in the sections below.

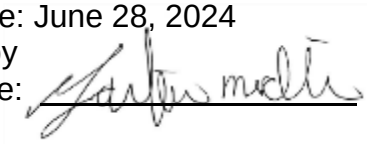
Figure 4.Transmitter Power Line Conducted Emissions Test Data, Part 15.207

150 kHz to 30 MHz with Class B Limits						
Frequency (MHz)	**Test Data (dBuV)**	**LISN+CL-PA (dB)**	**Results (dBuV)**	**AVG Limits (dBuV)**	**Margin (dB)**	**Detector PK, QP, or AVG**
120 VAC, 60 Hz Phase						
0.3752	42.66	0.52	43.18	48.4	5.2	**PK**
0.5058	36.37	0.38	36.75	46.0	9.2	**PK**
3.2267	36.78	0.29	37.07	46.0	8.9	**PK**
6.3250	40.06	0.39	40.45	50.0	9.6	**PK**
16.0333	46.77	0.44	47.20	60.0*	12.8	**PK**
16.0333	37.83	0.44	38.26	50.0	11.7	**AVG**
21.2500	41.42	0.72	42.14	50.0	7.9	**PK**
120VAC, 60 Hz Neutral						
0.1693	55.80	1.78	57.58	65.0*	7.4	**PK**
0.1693	36.00	1.78	37.78	55.0	17.2	**AVG**
0.7833	38.32	0.46	38.78	46.0	7.2	**PK**
1.8133	38.42	0.44	38.86	46.0	7.1	**PK**
6.6333	36.97	0.56	37.53	50.0	12.5	**PK**
15.9333	47.72	0.43	48.15	60.0*	11.9	**PK**
15.9333	36.28	0.43	36.71	50.0	13.3	**AVG**
20.3833	42.92	0.43	43.35	50.0	6.6	**PK**

Note: * denotes QP Limits

Sample Calculation at 0.3752 MHz:

Magnitude of Measured Frequency	42.66	dBuV
+ Cable Loss+ LISN Loss	0.52	dB
=Corrected Result	43.18	dBuV

Test Date: June 28, 2024
Tested by
Signature:  Name: Gabriel Medina

2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.407(d)) (IC RSS 247, 6.2)

Regarding radiated spurious measurements, the EUT was placed into a continuous transmit mode of operation (>98% duty cycle) and tested per FCC KDB Publication 789033 D02 v02 and ANSI C63.10:2013. A preliminary scan was performed on the EUT to find signal frequencies caused by the transmitter part of the device. To obtain worst-case results, the EUT was tested in X, Y, and Z axes or in the orientation of normal operation if the device was designed to operate in a fixed position.

Radiated measurements were then conducted between the frequency range of 9KHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (no greater than 40 GHz). In the band below 1 GHz, emissions were tested with a RBW of 120 kHz. Emissions above 1 GHz were tested with a RBW of 1 MHz. All video bandwidth settings were at least three times the RBW value.

The EUT was investigated to CFR 15.209 for below 1 GHz, General requirements for unwanted spurious emissions. Above 1 GHz, all unwanted spurious emissions were investigated to CFR 15.407.

The results are displayed in the plots below. Radiated emissions per CFR 15.209 were performed to address the concerns of unwanted emissions that may radiate from the EUT cabinet, control circuits, or power leads. The results for this test can be found in section 2.16 below.

Table 5. Peak Radiated Fundamental & Harmonic Emissions, 802.11a with Chip Antenna

Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Channel 52								
5261.00	57.75	--	39.04	96.79	--	3.0m./VERT	--	**PK**
Channel 64								
5320.00	57.87	--	38.98	96.85	--	3.0m./VERT	--	**PK**
Channel 100								
5499.00	56.55	--	39.50	96.05	--	3.0m./VERT	--	**PK**
Channel 116								
5578.00	54.82	--	39.67	94.49	--	3.0m./VERT	--	**PK**
Channel 132								
5661.00	52.58	--	39.82	92.40	--	3.0m./VERT	--	**PK**
Channel 140								
5701.00	51.53	--	39.78	91.31	--	3.0m./VERT	--	**PK**

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 5261.00 MHz:

Magnitude of Measured Frequency	57.75	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	39.04	dB/m
Corrected Result	96.79	dBuV/m

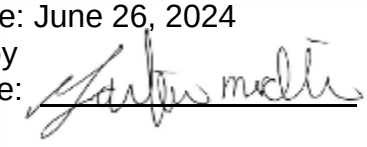
Test Date: June 26, 2024
Tested by
Signature:  Name: Gabriel Medina

Table 6. Average Radiated Fundamental & Harmonic Emissions 802.11a with Chip Antenna

Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Channel 52								
5261.00	57.75	-15.97	39.04	80.82	--	3.0m./VERT	--	**PK**
Channel 64								
5320.00	57.87	-15.97	38.98	80.88	--	3.0m./VERT	--	**PK**
Channel 100								
5499.00	56.55	-15.97	39.50	80.08	--	3.0m./VERT	--	**PK**
Channel 116								
5578.00	54.82	-15.97	39.67	78.52	--	3.0m./VERT	--	**PK**
Channel 132								
5661.00	52.58	-15.97	39.82	76.43	--	3.0m./VERT	--	**PK**
Channel 140								
~5701.00	51.53	-15.97	39.78	75.34	-	3.0m./VERT	--	**PK**

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. Duty cycle correction factor was used (-15.97 dB). See column 3 above.
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 5261.00 MHz:

Magnitude of Measured Frequency	57.75	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	39.04	dB/m
-Duty Cycle	-15.97	dB
Corrected Result	39.04	dBuV/m

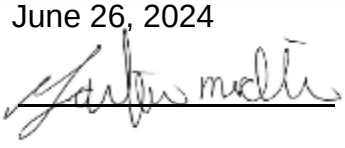
Test Date: June 26, 2024
Tested by
Signature:  Name: Gabriel Medina

Table 7. Peak Radiated Fundamental & Harmonic Emissions, 802.11n with Chip Antenna

Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Channel 52								
5259.00	57.11	--	39.04	96.15	--	3.0m./VERT	--	**PK**
Channel 64								
5321.00	57.58	--	38.98	96.56	--	3.0m./VERT	--	**PK**
Channel 100								
5497.00	56.62	--	39.50	96.12	--	3.0m./VERT	--	**PK**
Channel 116								
5581.00	54.92	--	39.67	94.59	--	3.0m./VERT	--	**PK**
Channel 132								
5661.00	52.70	--	39.82	92.52	--	3.0m./VERT	--	**PK**
Channel 140								
5698.00	51.01	--	39.82	90.83	--	3.0m./VERT	--	**PK**

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 5180 MHz:

Magnitude of Measured Frequency	66.83	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	38.07	dB/m
Corrected Result	107.90	dBuV/m

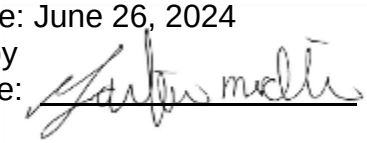
Test Date: June 26, 2024
Tested by
Signature:  Name: Gabriel Medina

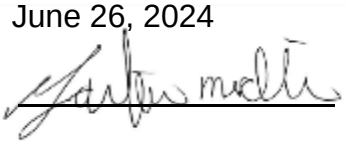
Table 8. Average Radiated Fundamental & Harmonic Emissions 802.11n with Chip Antenna

Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Channel 52								
5259.00	57.11	-15.97	39.04	80.18	--	3.0m./VERT	--	**PK**
Channel 64								
5321.00	57.58	-15.97	38.98	80.59	--	3.0m./VERT	--	**PK**
Channel 100								
5497.00	56.62	-15.97	39.50	80.15	--	3.0m./VERT	--	**PK**
Channel 116								
5581.00	54.92	-15.97	39.67	78.62	--	3.0m./VERT	--	**PK**
Channel 132								
5661.00	52.70	-15.97	39.82	76.55	--	3.0m./VERT	--	**PK**
Channel 140								
5698.00	51.01	-15.97	39.82	74.86	--	3.0m./VERT	--	**PK**

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. (~) Duty cycle correction factor was used (-15.97 dB).
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 5259.00 MHz:

Magnitude of Measured Frequency	57.11	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	39.04	dB/m
-Duty Cycle	-15.97	dB
Corrected Result		dBuV/m

Test Date: June 26, 2024
Tested by
Signature:  Name: Gabriel Medina

2.11 Band Edge Measurements – (CFR 15.407 (b))

Band Edge measurements are made following the guidelines in ANSI C63.10, Clause 12.7.4.4 and FCC KDB Publication No. 789033 D02 v02 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation for all modes of operation. Radiated measurements are performed to demonstrate compliance with the requirement of 15.407(b) that all emissions outside of the band edges do not exceed an E.I.R.P of -27 dBm/MHz.

The emission measurements are performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

To capture the band edge, the Spectrum Analyzer frequency span was set to 2.5 MHz to capture the peak level of the emission operating on the channel closest to the band edge as well as any modulation products falling outside of the authorized band of operation. Conducted measurements are performed with RBW = 100 kHz. In all cases, the VBW is set ≥ 3*RBW. The integration function on the spectrum analyzer was used to calculate the Band edge measurement over 1 MHz. See figure and calculations below for more detail.

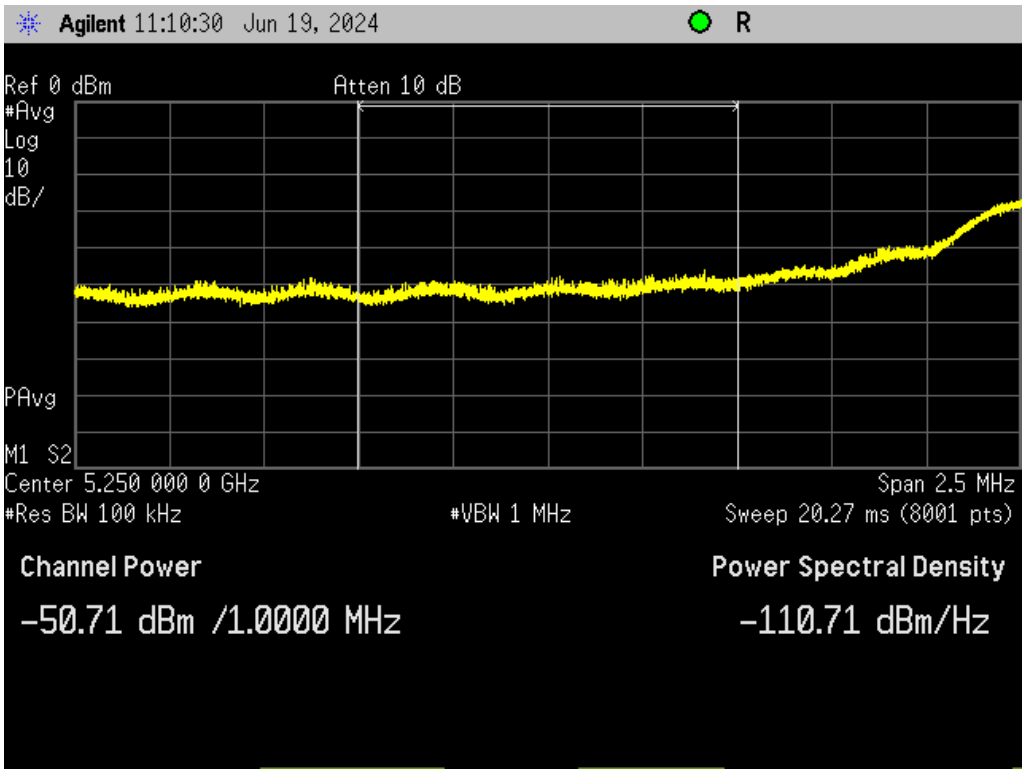


Figure 5. 5.25 GHZ Band Edge Compliance, 802.11a

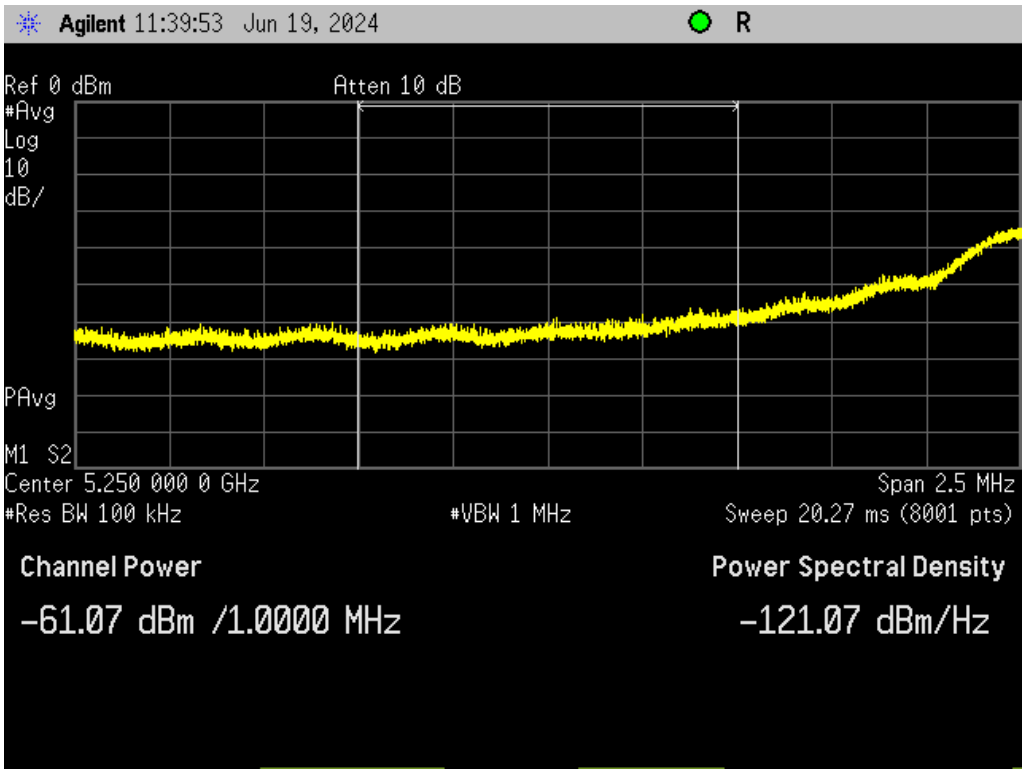


Figure 6. 5.25 GHZ Band Edge Compliance, 802.11n

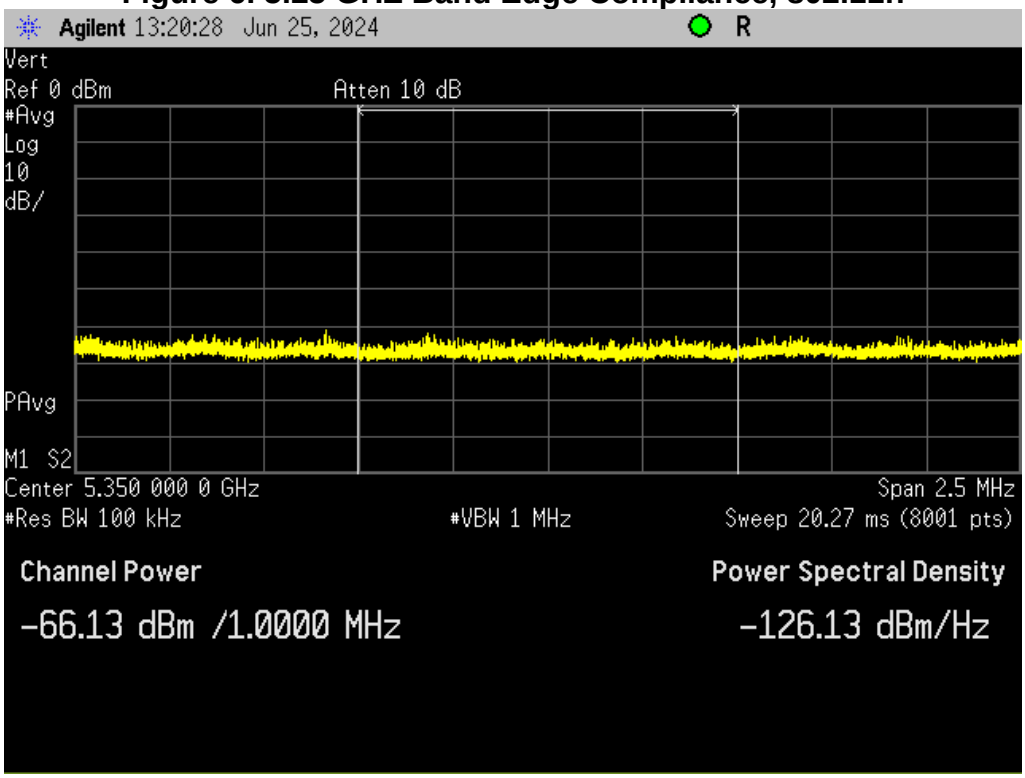


Figure 7. 5.35 GHZ Band Edge Compliance, 802.11a

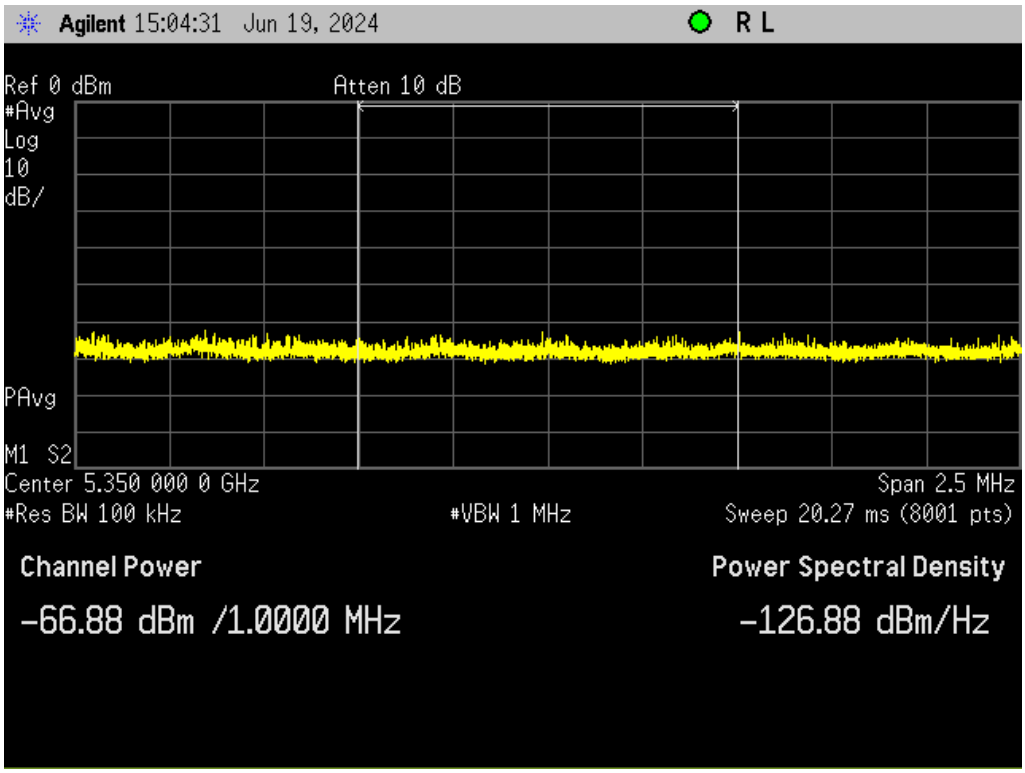


Figure 8. 5.35 GHZ Band Edge Compliance, 802.11n

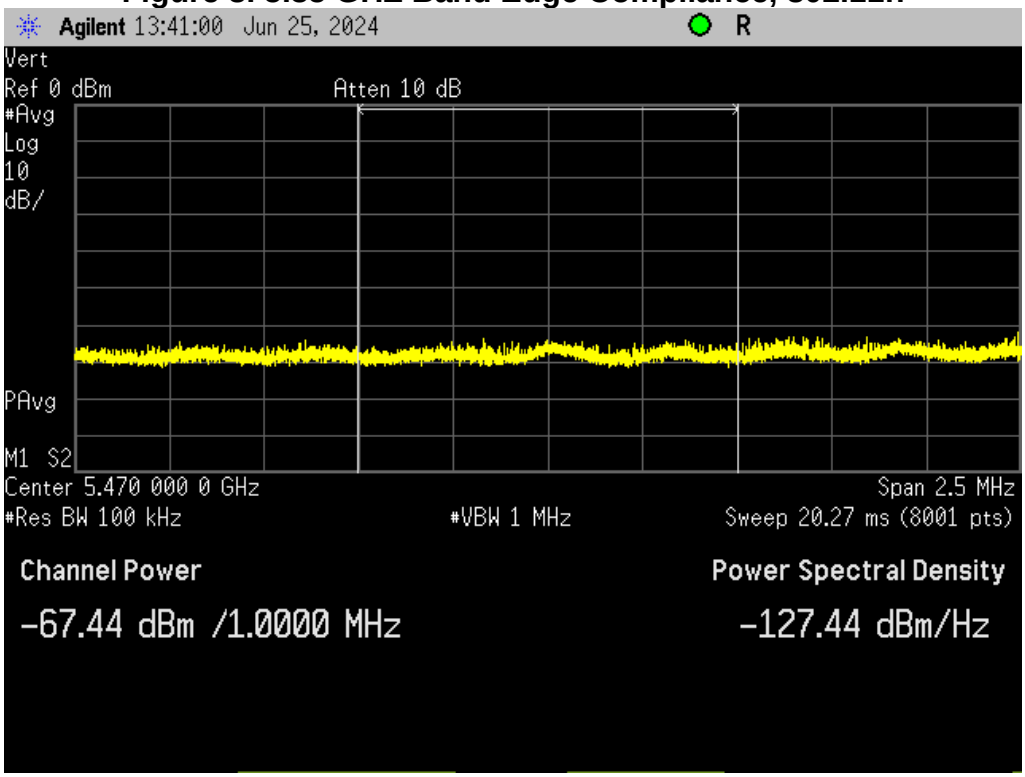


Figure 9. 5.47 GHZ Band Edge Compliance, 802.11a

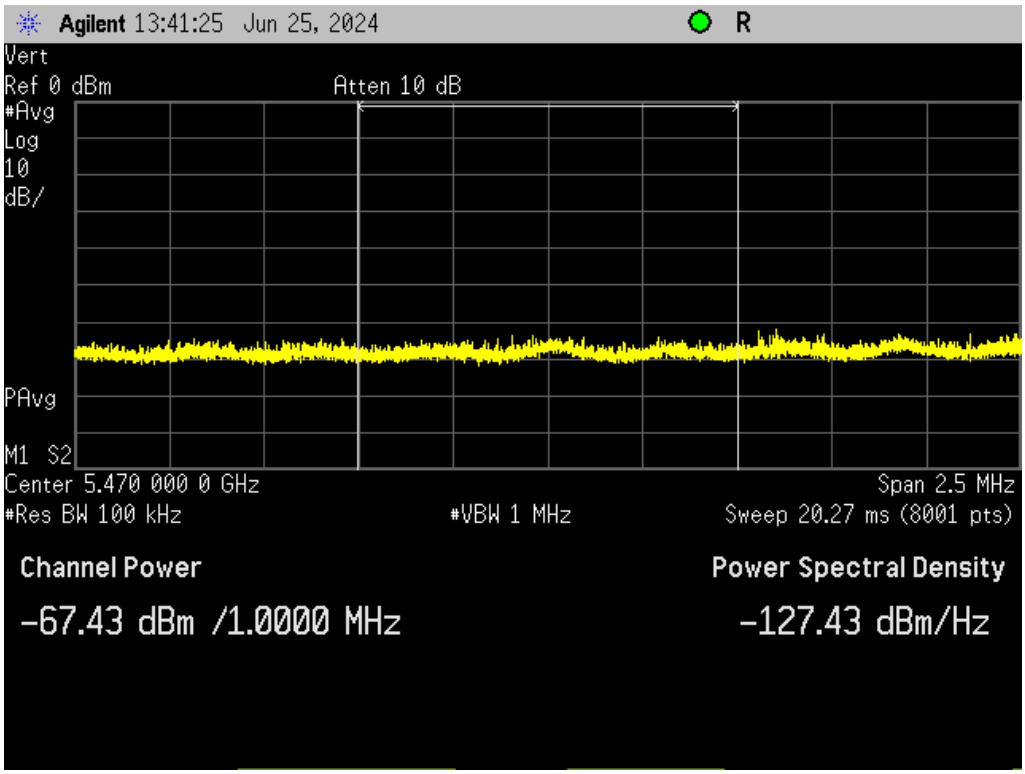


Figure 10. 5.47 GHZ Band Edge Compliance, 802.11n

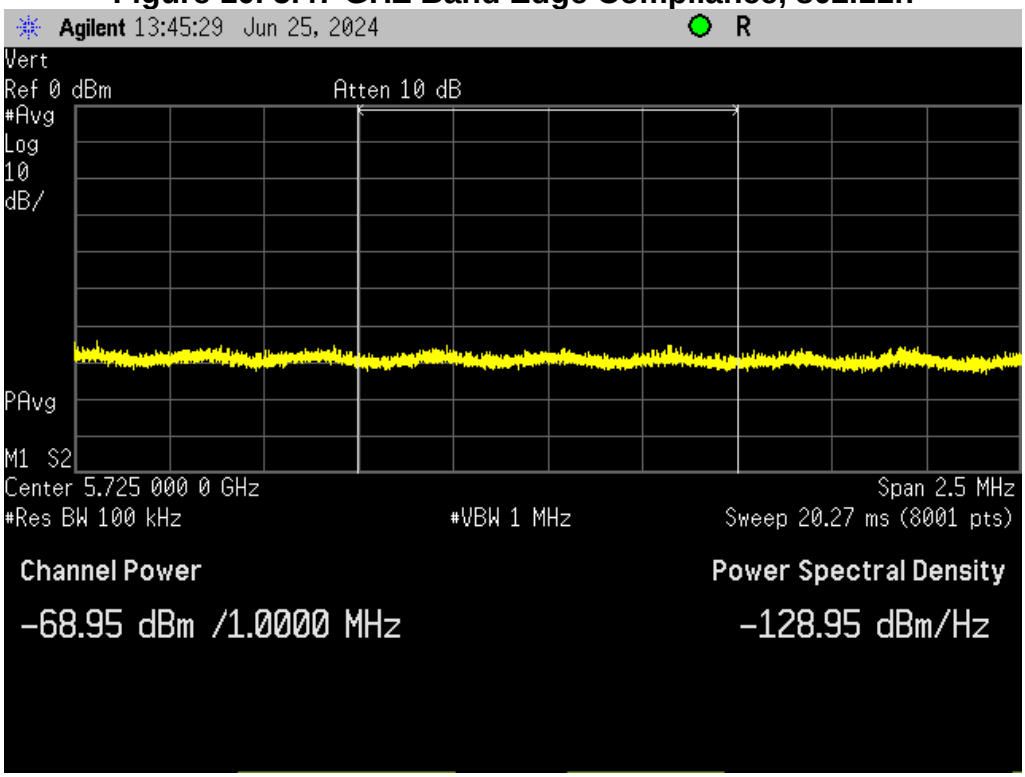


Figure 11. 5.725 GHZ Band Edge Compliance, 802.11a

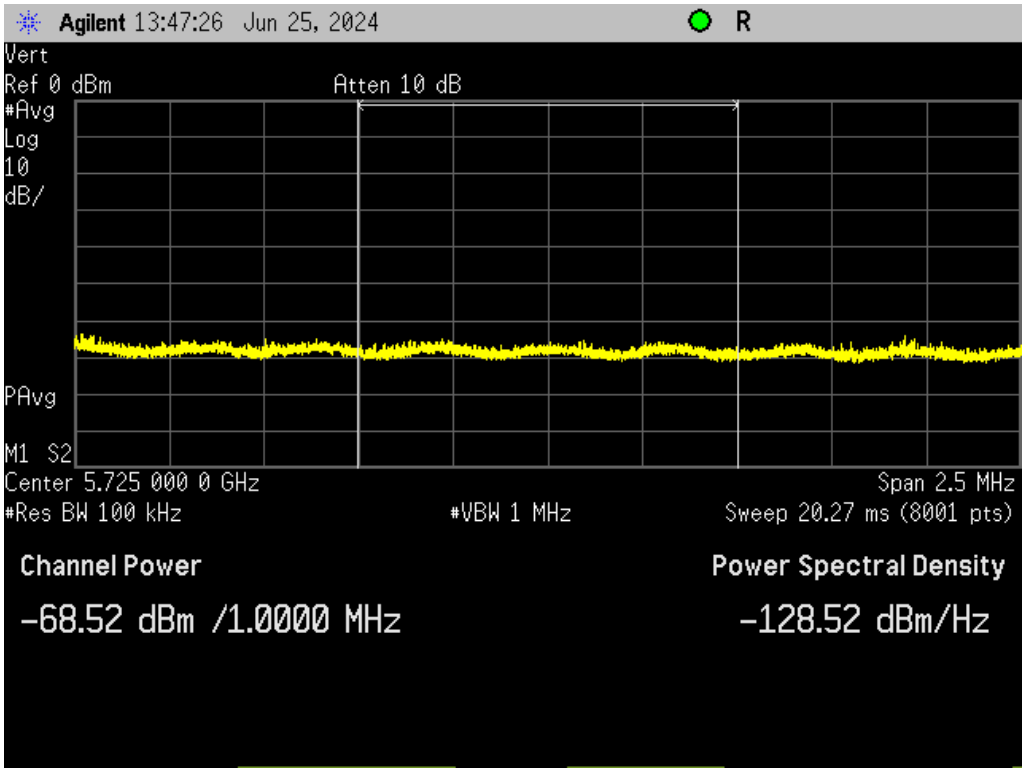


Figure 12. 5.725 GHz Band Edge Compliance, 802.11n

2.12 Unwanted Emissions in the Restricted Bands (CFR 15.407(b)(9,10) 15.205, 15.209)

Unwanted Emissions in the Restricted Bands were made following the guidelines in FCC KDB Publication No. 789033 D02 v02 with the EUT operating on the channels closest to the restricted bands of operation. These measurements were performed with the EUT transmitting at >98% duty Cycle.

To capture the unwanted emissions, the Spectrum Analyzer frequency span was set to cover the full restricted band. Radiated measurements are performed with RBW = 1 MHz. In all cases, the VBW is set ≥ 3*RBW.

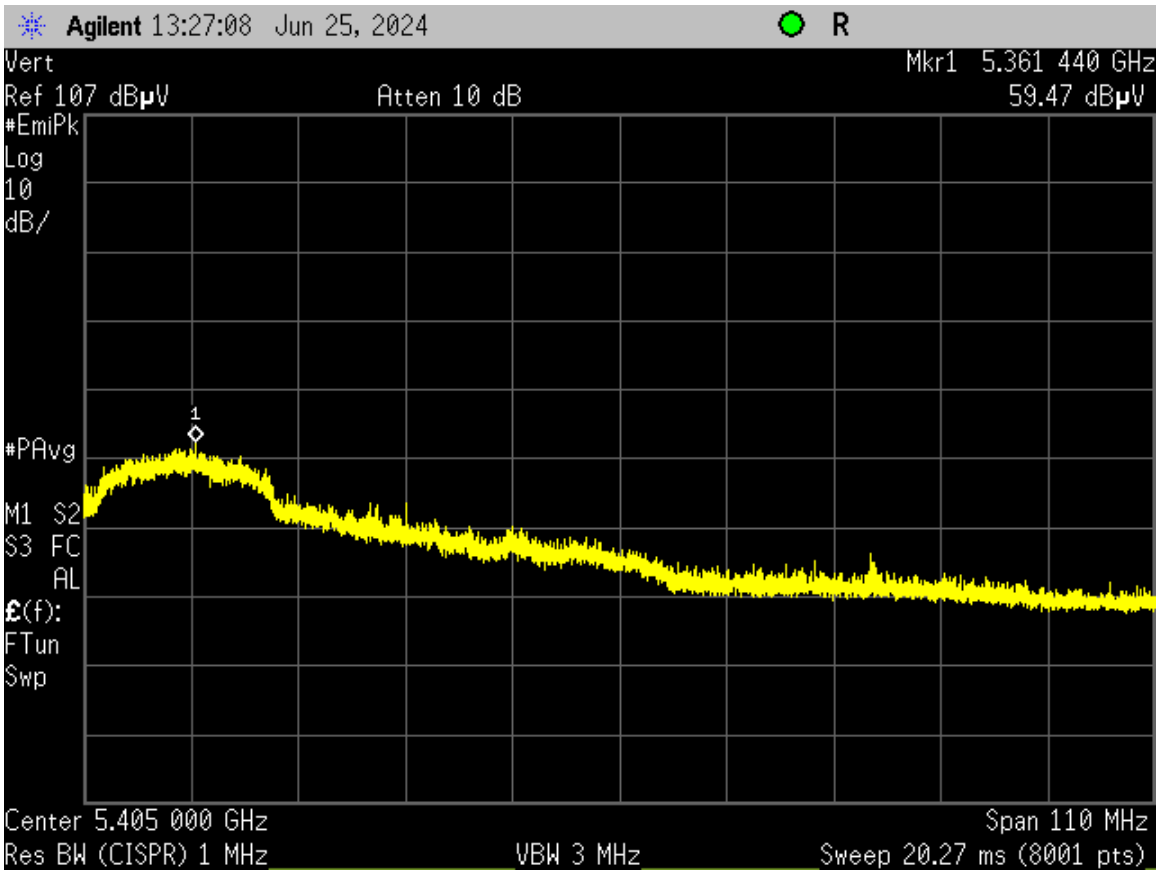


Figure 13. Restricted Band 5.35 – 5.46 GHz operating on Channel 64, 802.11a – on Chip Antenna

5.35 – 5.46 GHz Restricted Band Peak Measurements							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
5336.656	62.77	1.87	64.64	74.0	3.0m/Vert	9.4	**PK**
*5336.656	62.77	-14.10*	48.67	54.0	3.0m/Vert	5.3	**PK**

(*) Notes Duty cycle correction factor was used.

Sample calculation: at 5336.656 MHz, 62.77 dBuV + 1.87 (dB) = 64.64 dBuV/m

Test Date: June 25, 2024
Tested by
Signature: Name: Gabriel Medina

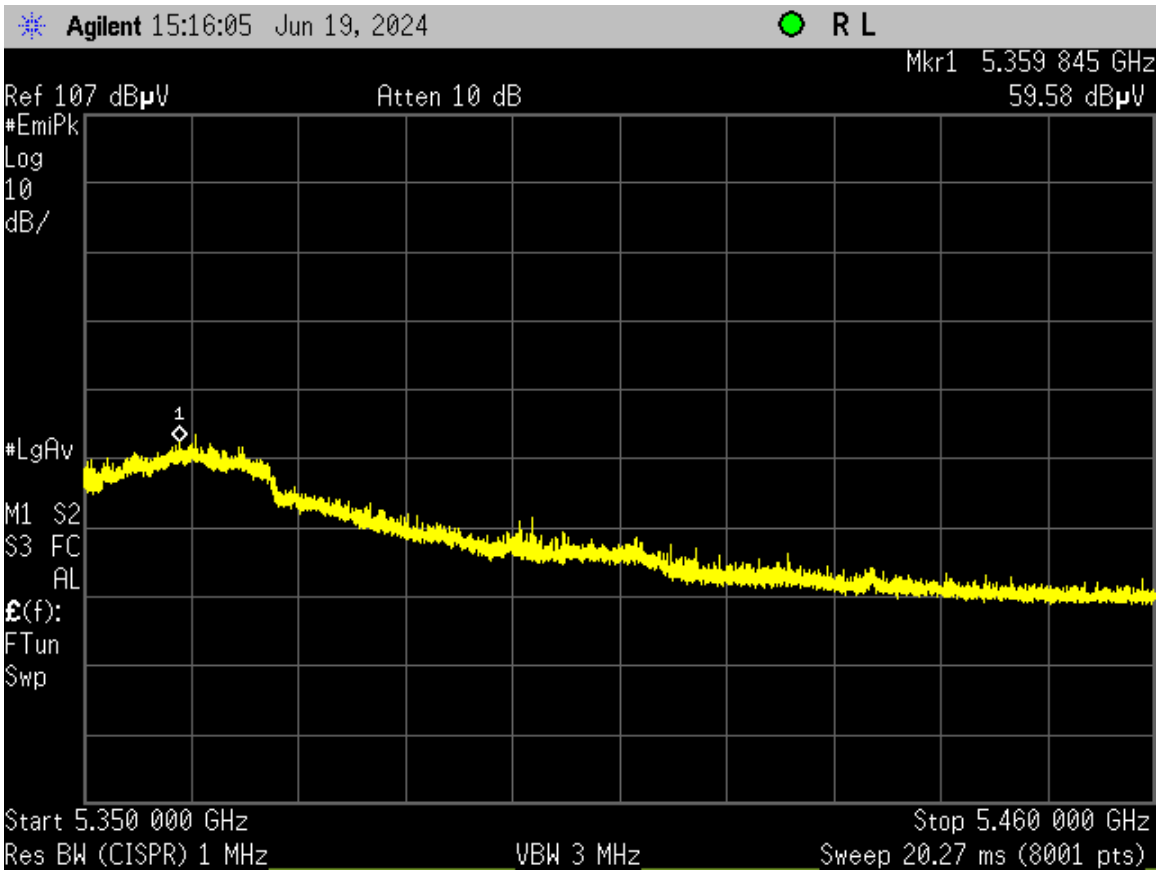


Figure 14. Restricted Band 5.35 – 5.46 GHz operating on Channel 64, 802.11n – on Chip Antenna

5.35 – 5.46 GHz Restricted Band Peak Measurements							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
5359.845	59.47	2.40	61.87	54.0	3.0m./VERT	12.1	**PK**
*5359.845	59.47	-13.57*	45.90	54.0	3.0m./VERT	8.1	PK

(*) Notes Duty cycle correction factor was used.

Sample calculation: at 5359.845 MHz: 59.58 dBuV + 2.39 (dB) = 61.97 dBuV/m

Test Date: June 19, 2024
Tested by
Signature: Name: Gabriel Medina

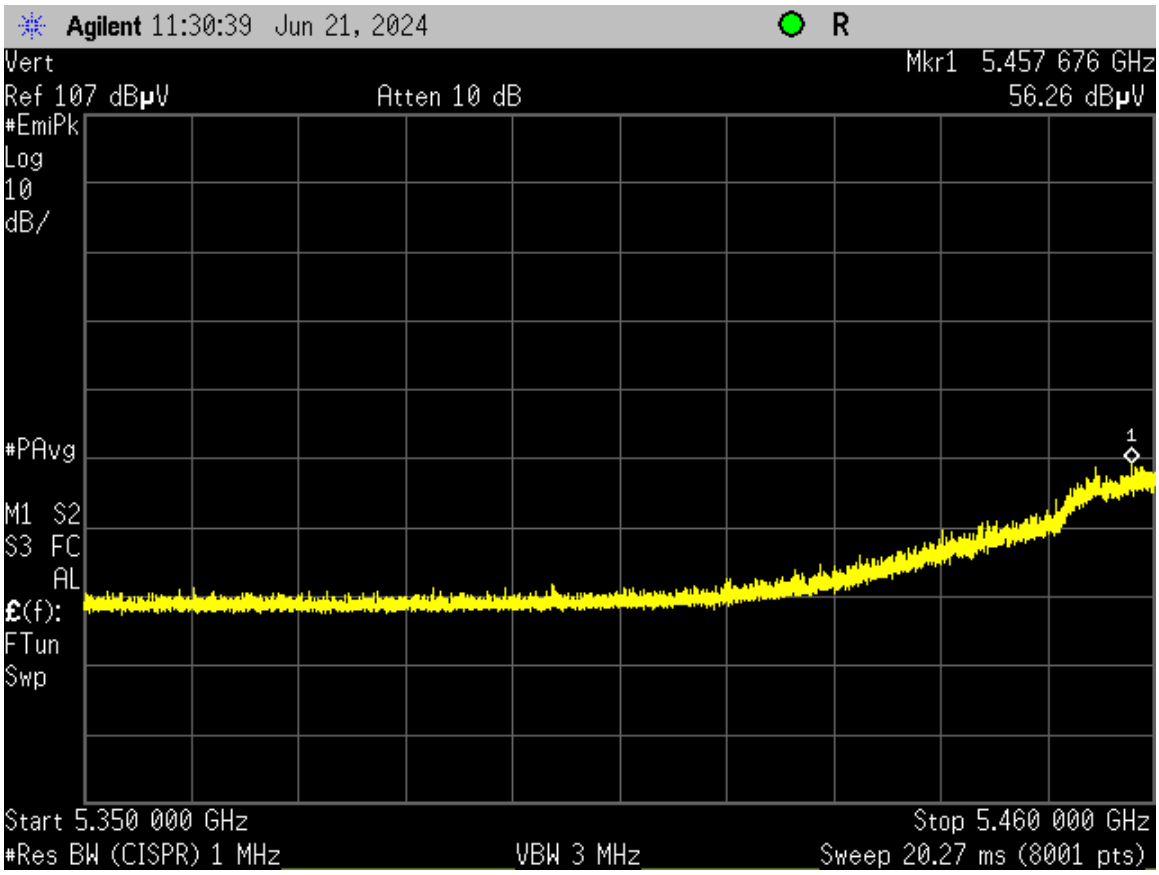


Figure 15. Radiated Restricted Band 5.35 – 5.46 GHz, 802.11a – on Chip Antenna

5.35 GHz to 5.46 GHz Restricted Band AVG Measurements							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
5457.676	56.26	2.38	58.64	74.0	3.0m./VERT	15.4	**PK**
*5457.676	56.26	-13.59*	42.67	54.0	3.0m./VERT	11.3	**PK**

(*) Notes Duty cycle correction factor was used.

Sample calculation: at 5457.676 MHz: 56.26 dBuV + 2.38 (dB) = 58.64 dBuV/m

Test Date: June 21, 2024
Tested by
Signature: Name: Gabriel Medina

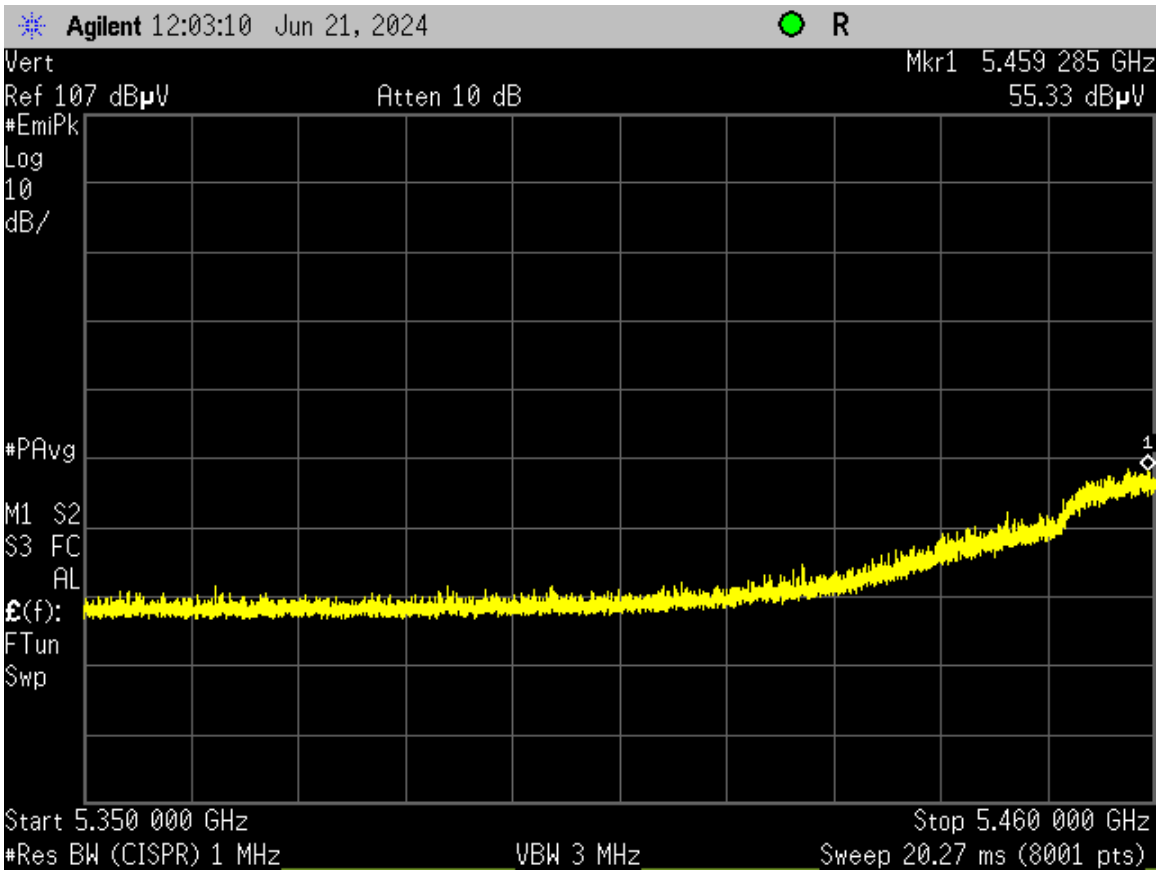


Figure 16. Restricted Band 5.35 – 5.46 GHz operating on Channel 36, 802.11a - Peak on Chip Antenna

4.5 GHz to 5.15 GHz Restricted Band Peak Measurements							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**PK Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
5459.285	55.33	2.38	57.71	74.0	3.0m./VERT	16.3	**PK**
*5459.285	55.33	-13.59*	41.74	54.0	3.0m./VERT	12.3	**PK**

(*) Notes Duty cycle correction factor was used.

Sample calculation: at 5459.285 MHz: 55.33 dBuV + 2.38 (dB) = 57.71 dBuV/m

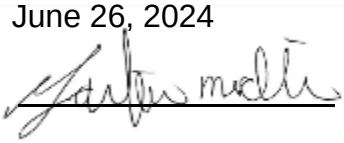
Test Date: June 21, 2024
Tested by
Signature: Name: Gabriel Medina

2.13 99% Occupied Bandwidth (15.407(a) (5), IC RSS 247, 6.4)

These measurements were performed while the EUT was in constant transmit mode. The spectrum analyzers bandwidth measurement was used to determine the 26 dB bandwidth and the 99% BW. The test procedures in the KDB document 789033 D02 v02 were followed. The RBW was set to approximately 1% to 5% times the OBW with the VBW ≥ RBW, and the span 1.5 to 5.0 times the OBW. The results of this test are given in Table 10 and 11 and Figures 86-99.

Table 9. 26 dB Bandwidth and 99% Occupied Bandwidth

Frequency (MHz)	26 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
802.11a		
5260	19.327	17.621
5320	19.335	17.625
5500	20.021	17.167
5580	20.024	17.686
5660	20.994	17.704
5700	21.822	17.728
802.11n		
5260	19.341	17.631
5320	19.334	17.654
5500	20.097	17.690
5580	20.005	17.699
5660	21.345	17.690
5700	20.853	17.713

Test Date: June 26, 2024
Tested by
Signature:  Name: Gabriel Medina

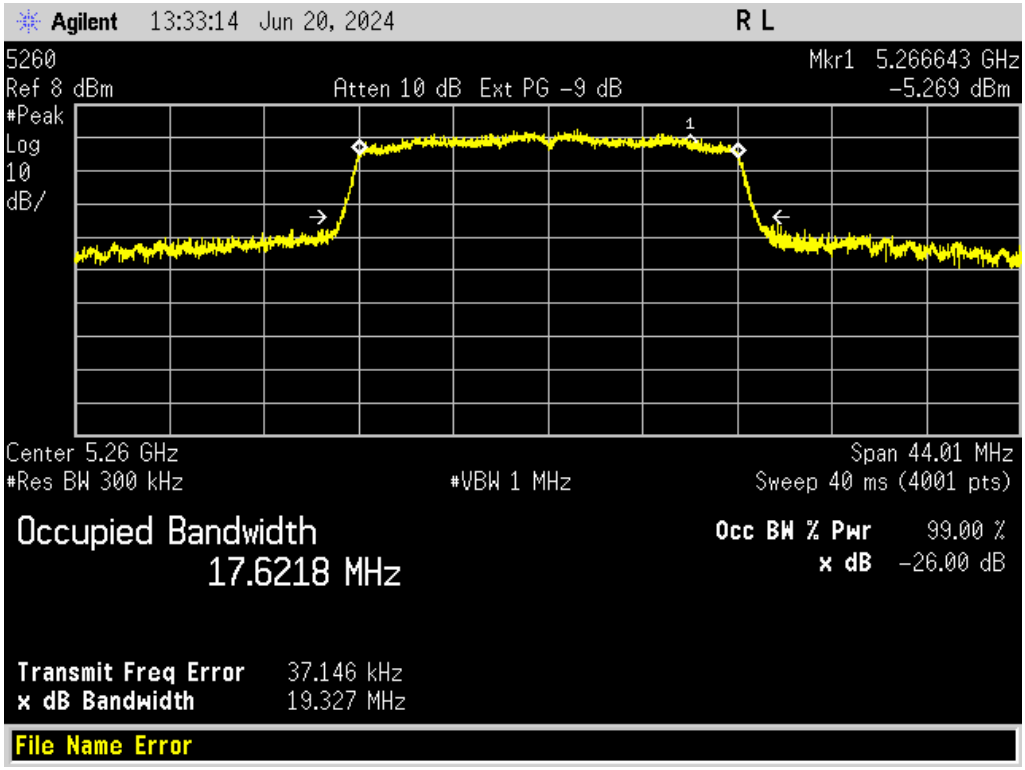


Figure 17. 26 dB BW and OBW -802.11a- Channel 52

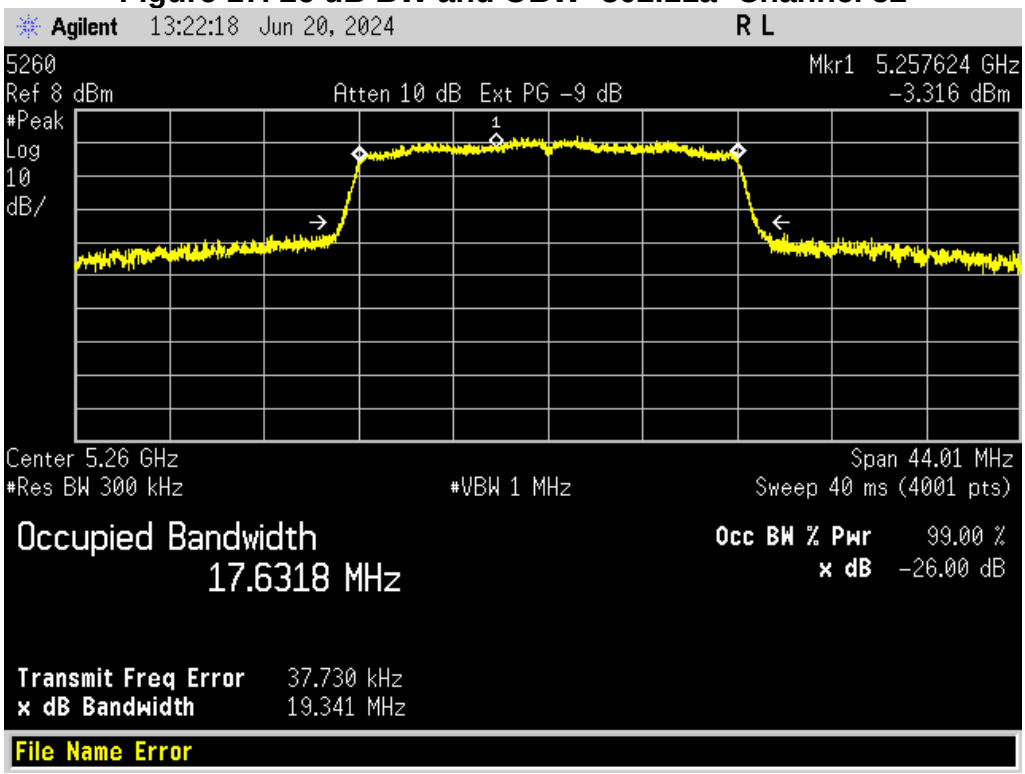


Figure 18. 26 dB BW and OBW -802.11n- Channel 52

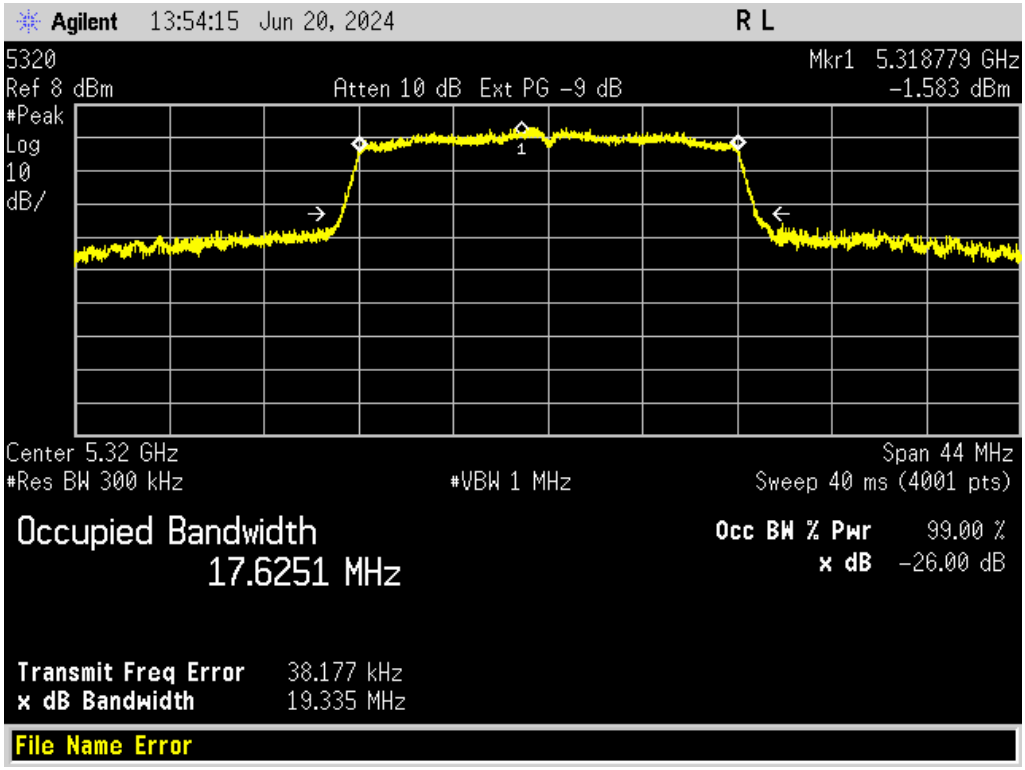


Figure 19. 26 dB BW and OBW -802.11a- Channel 64

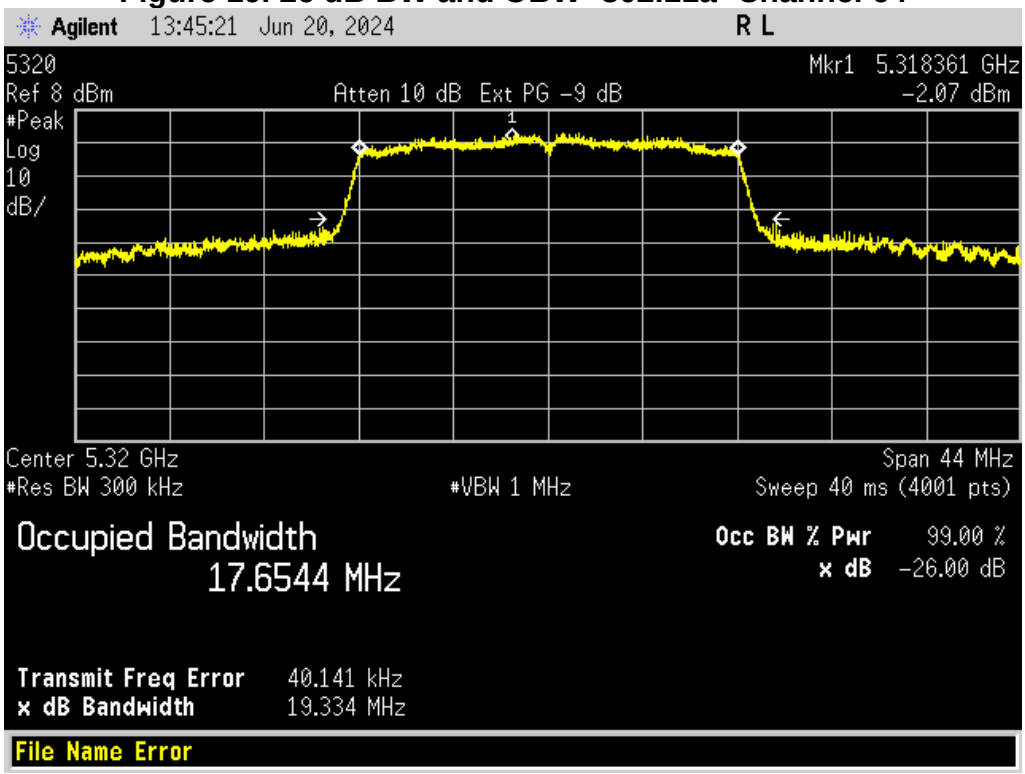


Figure 20. 26 dB BW and OBW -802.11n- Channel 165

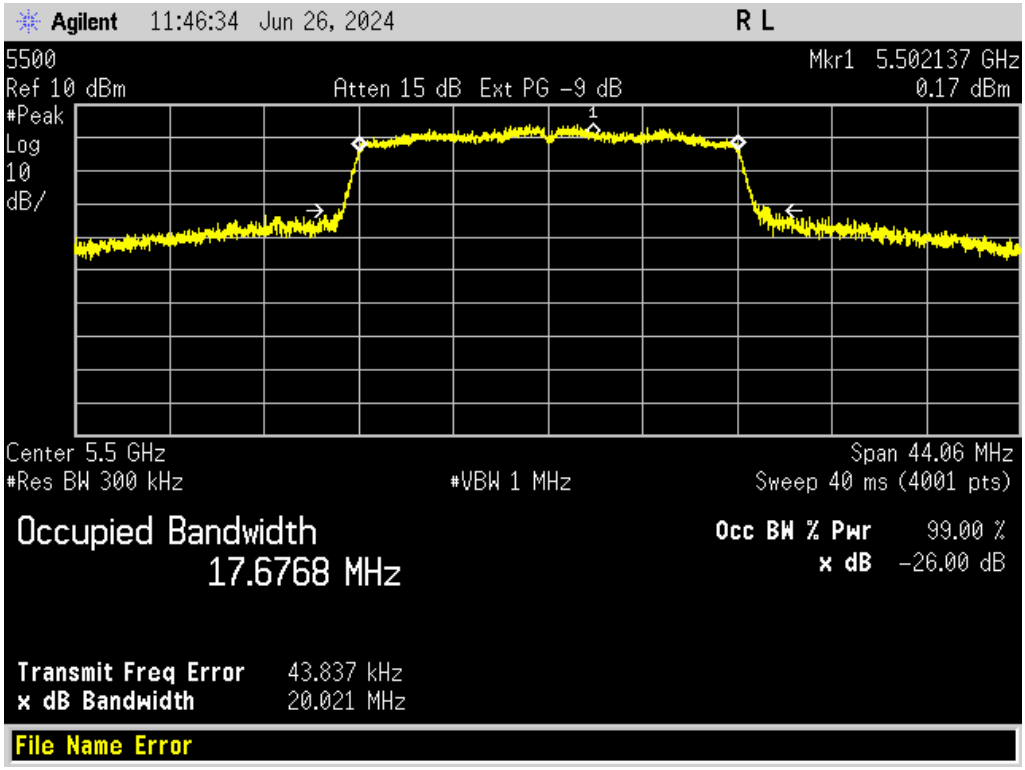


Figure 21. 26 dB BW and OBW -802.11a- Channel 100

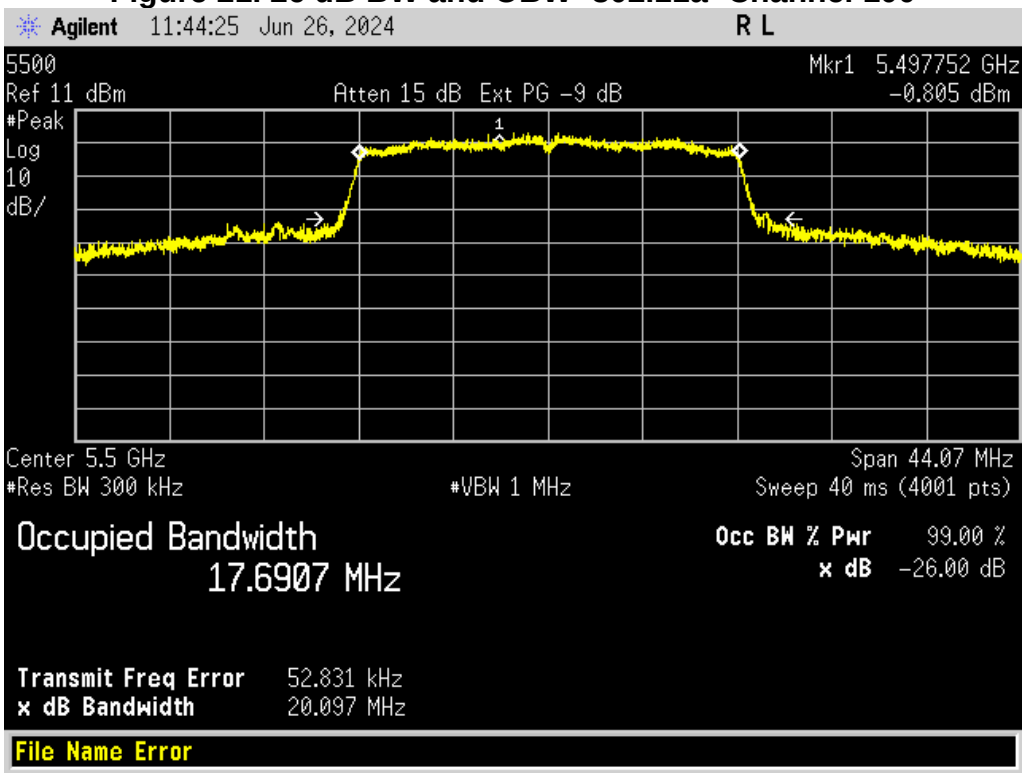


Figure 22. 26 dB BW and OBW -802.11n- Channel 100

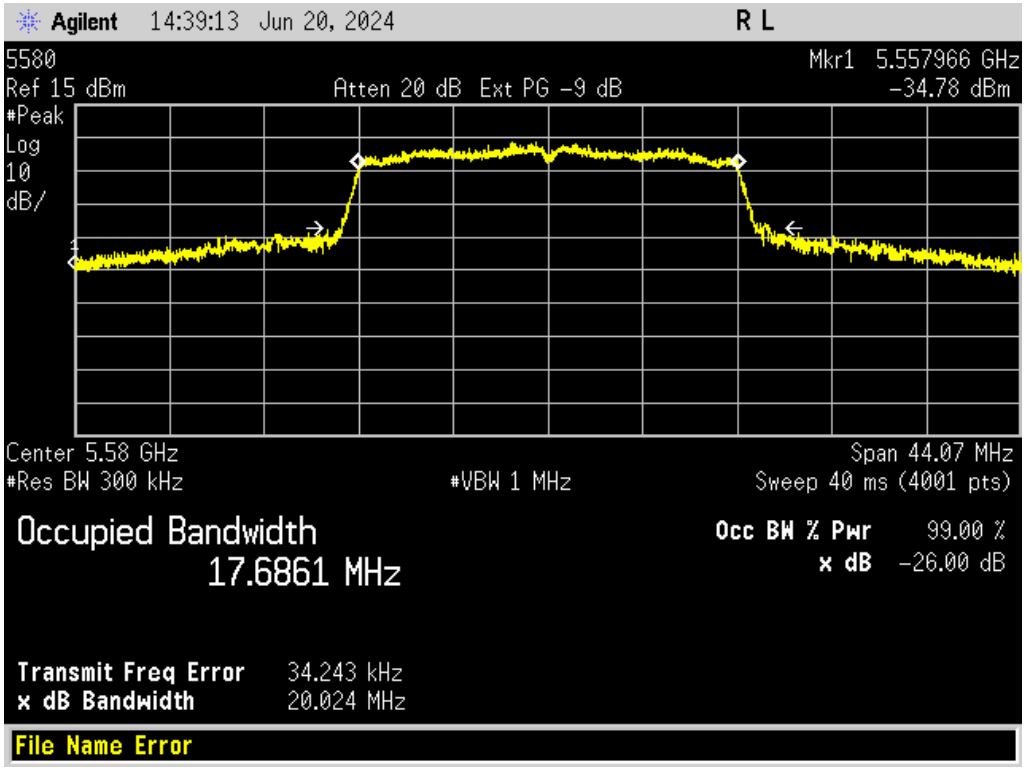


Figure 23. 26 dB BW and OBW -802.11a- Channel 116

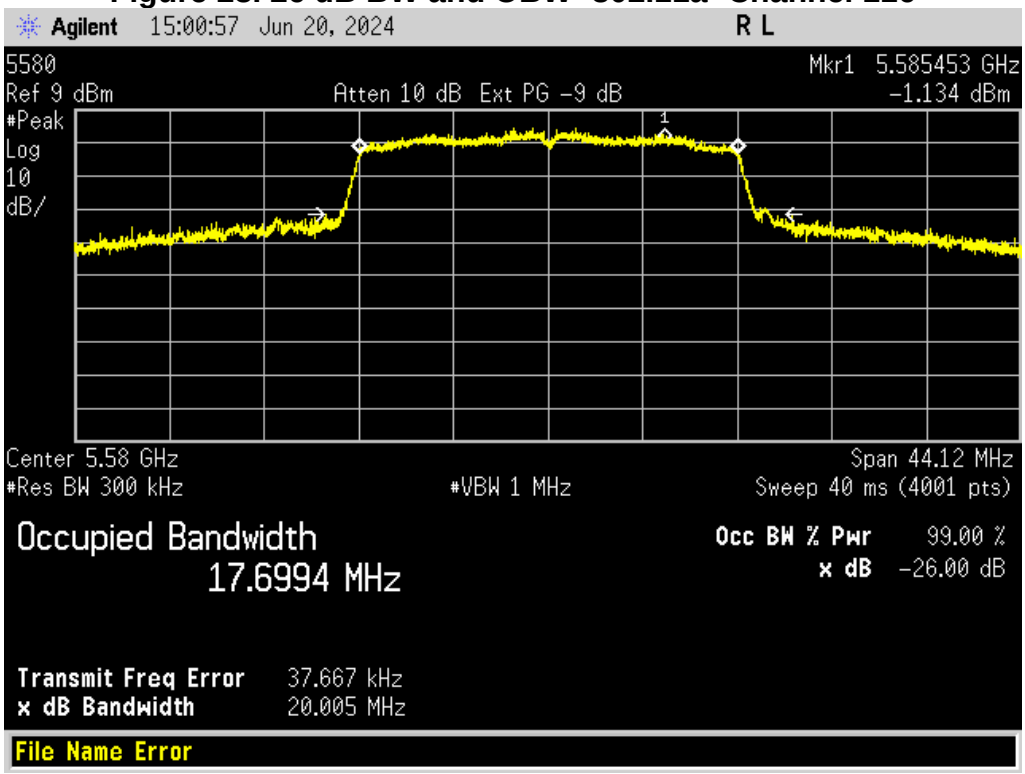


Figure 24. 26 dB BW and OBW -802.11n- Channel 116

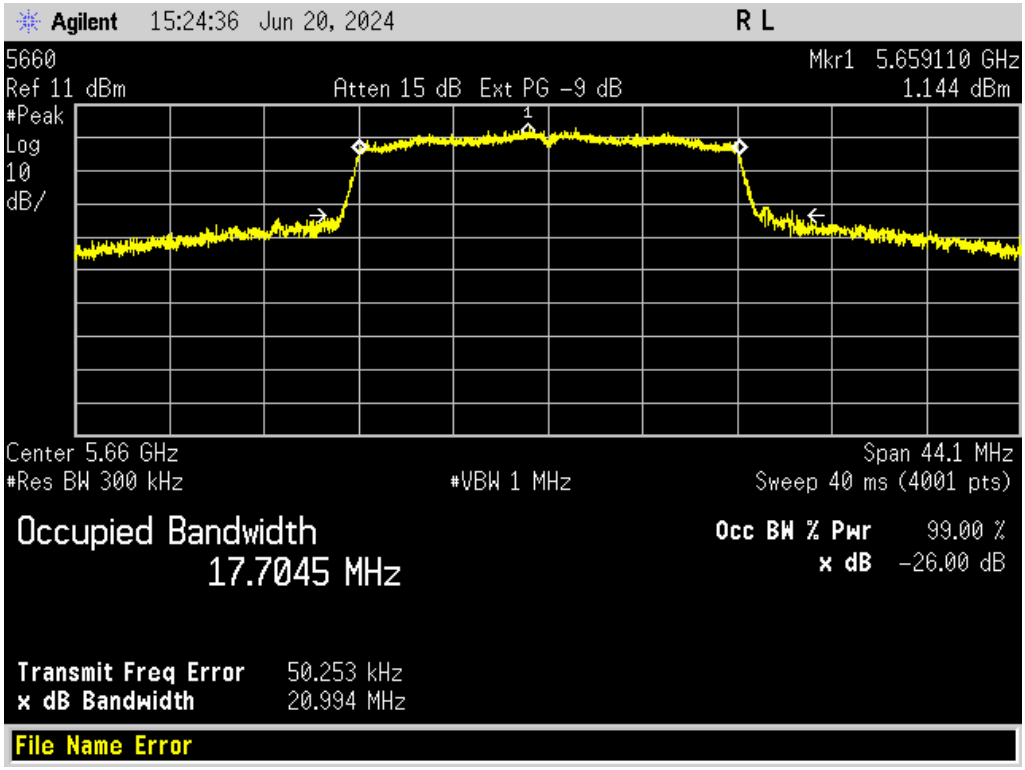


Figure 25. 26 dB BW and OBW -802.11a- Channel 132

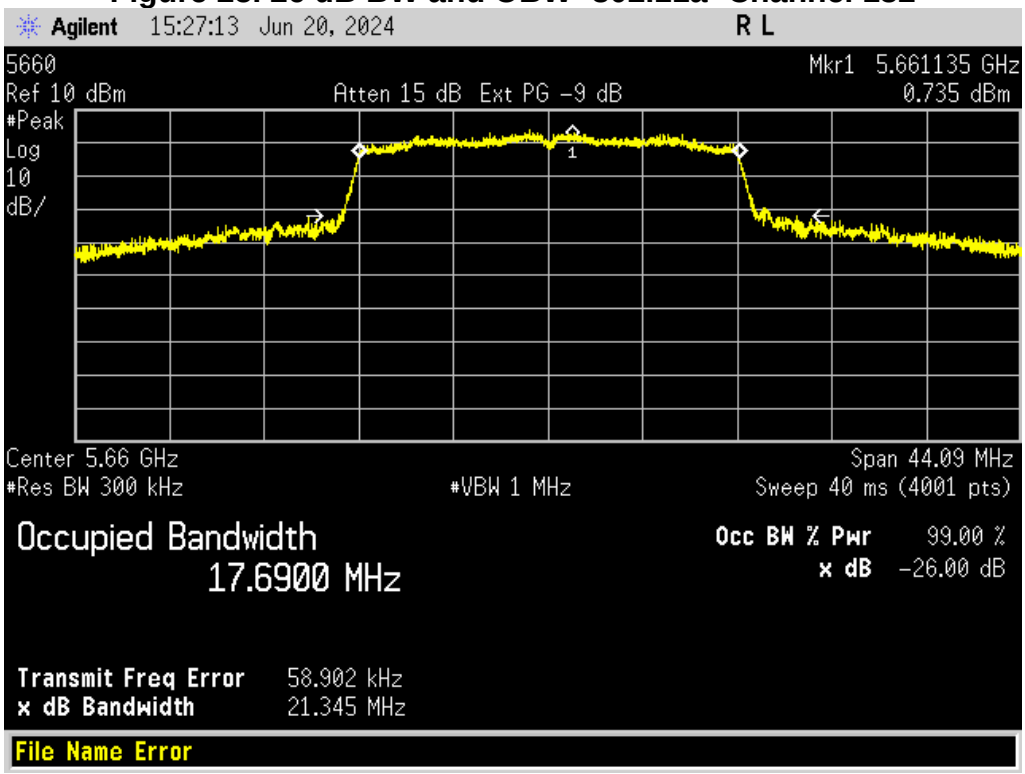


Figure 26. 26 dB BW and OBW -802.11n- Channel 132

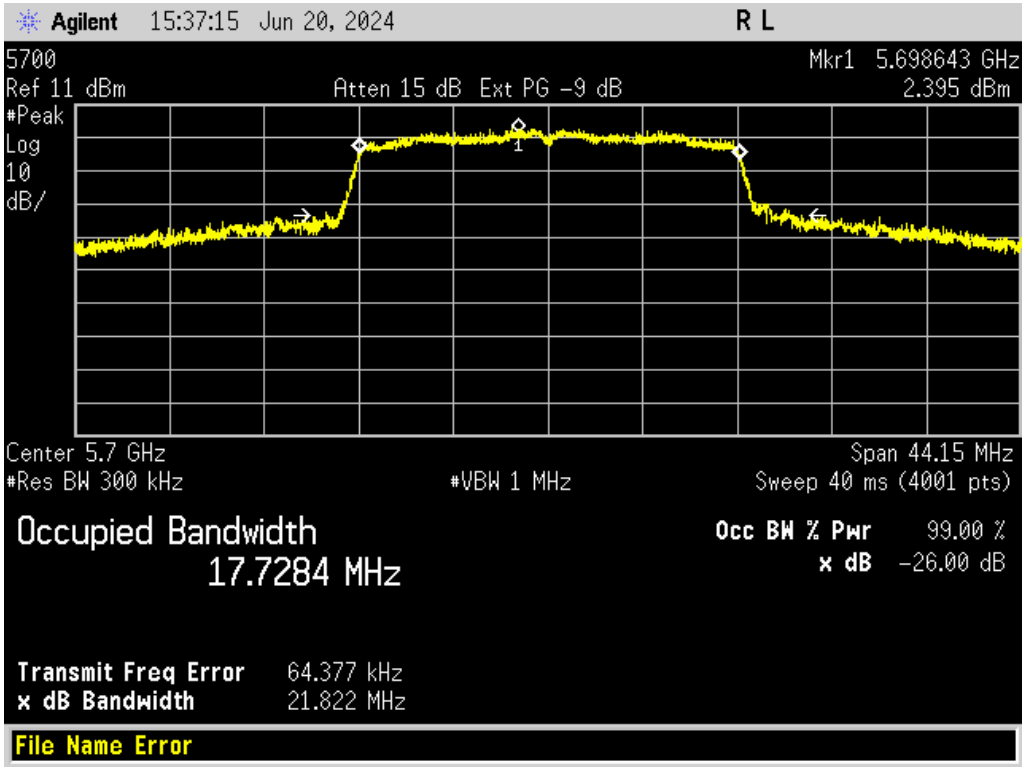


Figure 27. 26 dB BW and OBW -802.11a- Channel 140

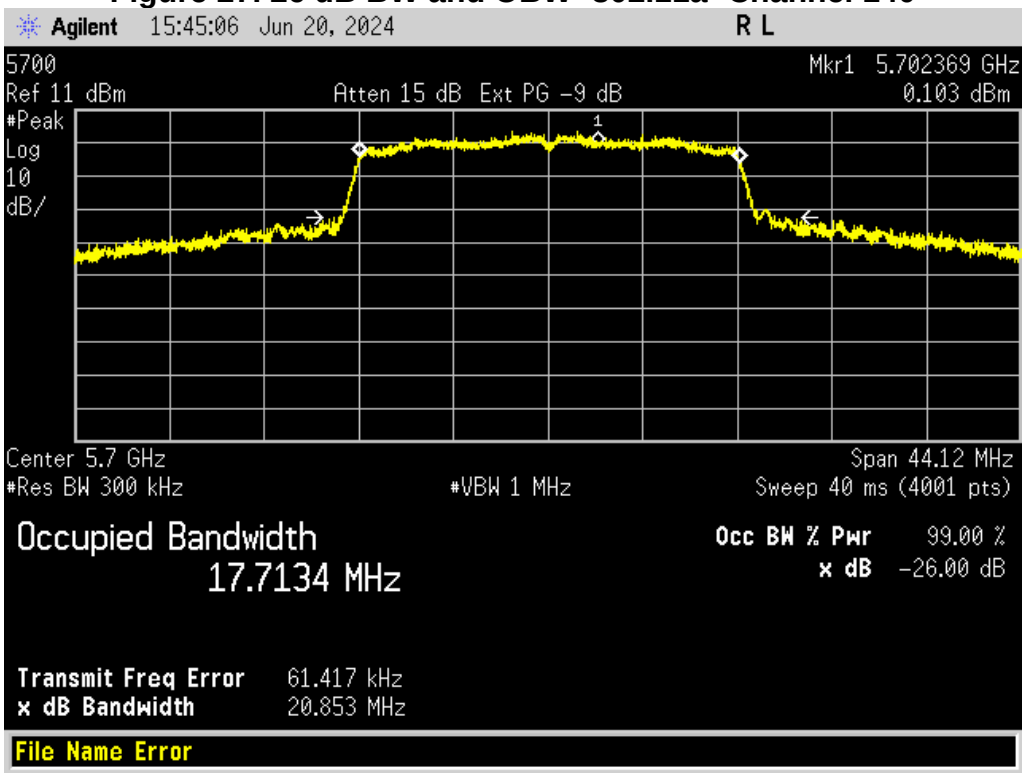


Figure 28. 26 dB BW and OBW -802.11n- Channel 100

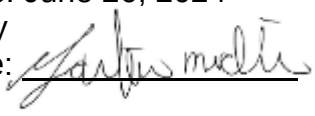
2.14 Maximum Conducted Output Power (CFR 15.407 (a) (2))

The transmitter was programmed to operate at a maximum output power across the bandwidth. The maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW (24dBm) or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz.

Average detection was used to collect the measurements. Power within the transmitting bands was measured per FCC KDB Publication 789033 D02 v02 by connecting the spectrum analyzer directly via a short RF cable, and attenuators to the antenna output terminals on the EUT. The spectrum analyzer was set for an impedance of 50 Ω with the RBW set to 1 MHz, the VBW ≥ 3*RBW, and spans large enough to encompass the entire 99% bandwidth. The channel power was integrated over the whole band. Average antenna conducted output power is tabulated below.

Table 10. Average Antenna Conducted Output Power per 15.407 (a) (2) for 802.11a

Frequency of Fundamental (MHz)	Test Data (dBm)	FCC Limit (dBm)	Margin (dB)
802.11a			
5260	4.93	24	19.07
5320	5.73	24	18.27
5500	8.68	24	15.32
5580	8.23	24	15.77
5660	8.54	24	15.46
5700	8.82	24	15.18
802.11n			
5260	4.69	24	19.31
5320	5.74	24	18.26
5500	8.90	24	15.1
5580	7.99	24	16.01
5660	8.56	24	15.44
5700	8.88	24	15.12

Test Date: June 26, 2024
Tested by
Signature:  Name: Gabriel Medina

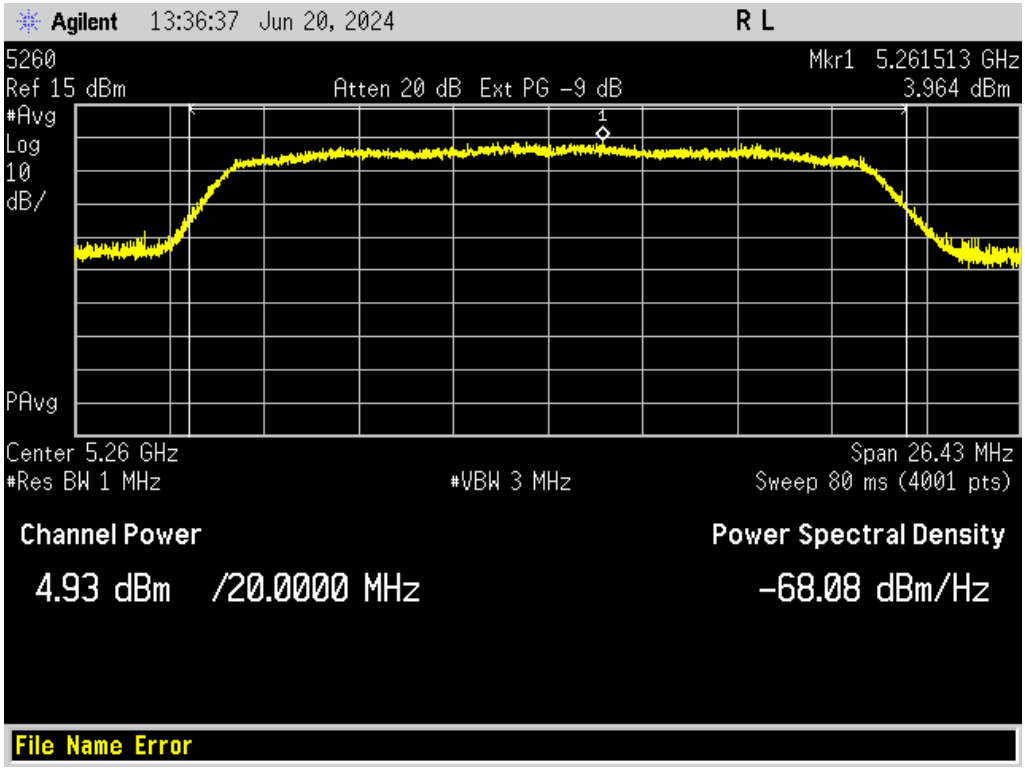


Figure 29. Antenna Conducted Output Power, 802.11a Channel 52

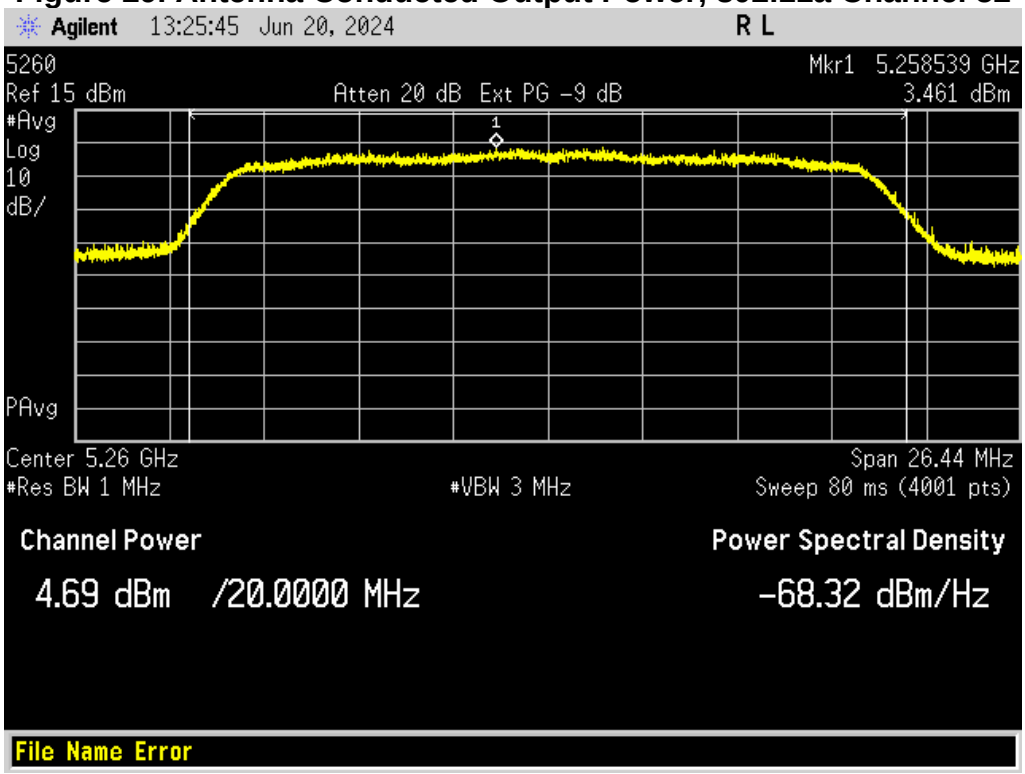


Figure 30. Antenna Conducted Output Power, 802.11n Channel 52

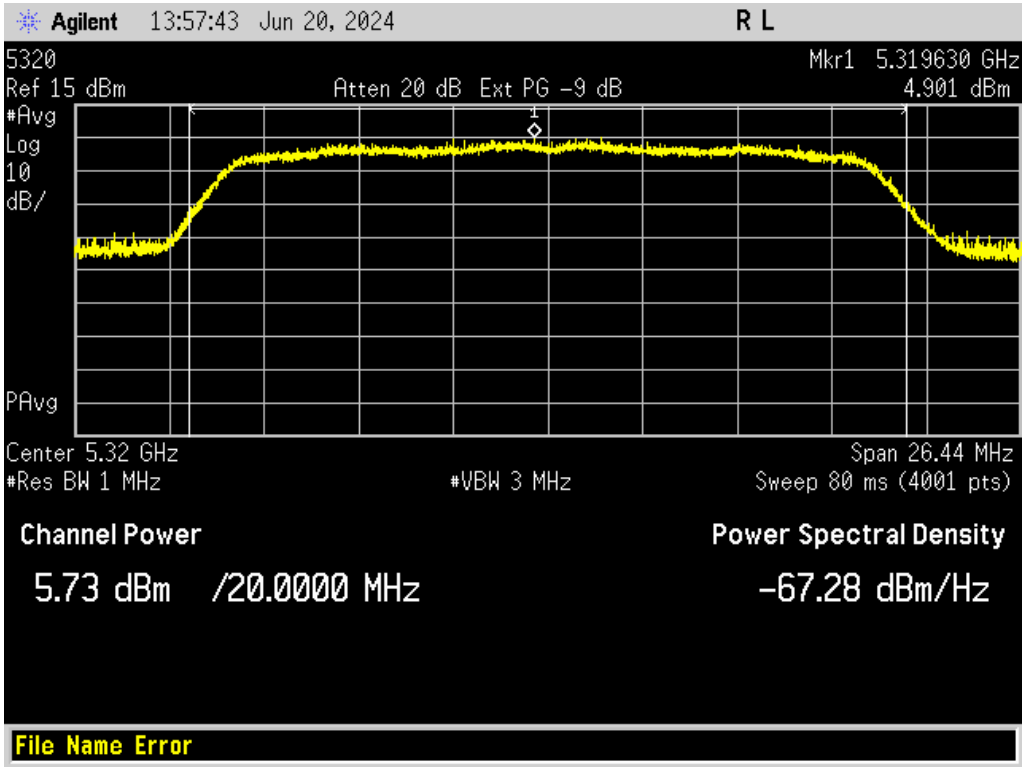


Figure 31. Antenna Conducted Output Power, 802.11a Channel 64

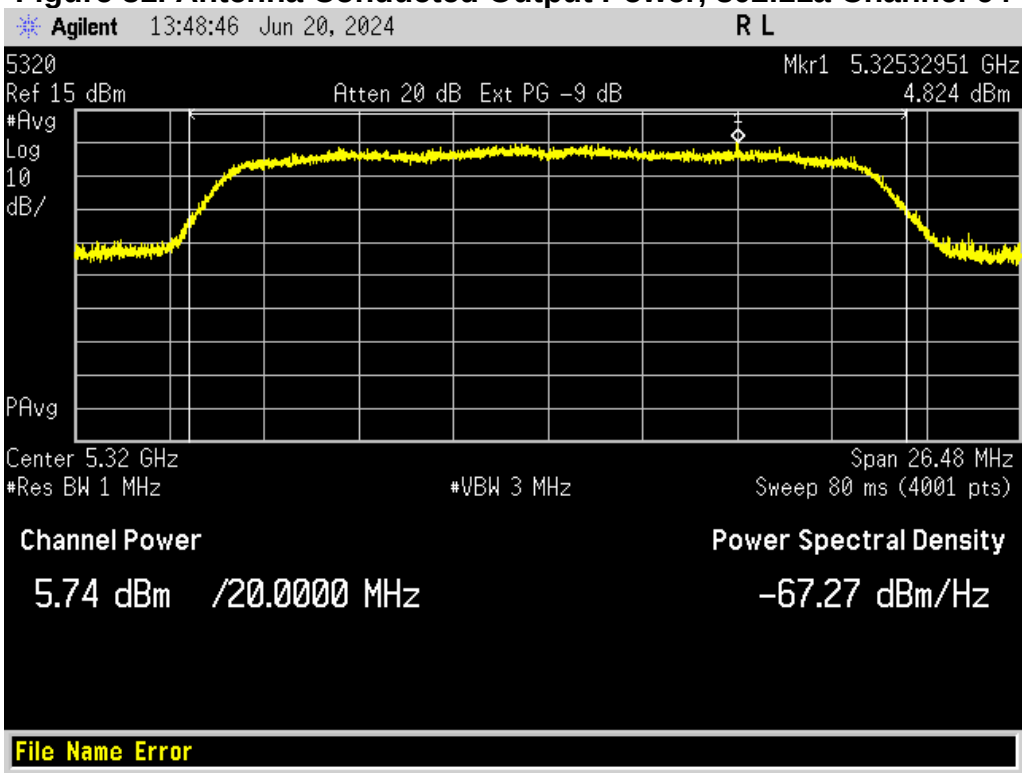


Figure 32. Peak Antenna Conducted Output Power, 802.11n Channel 64

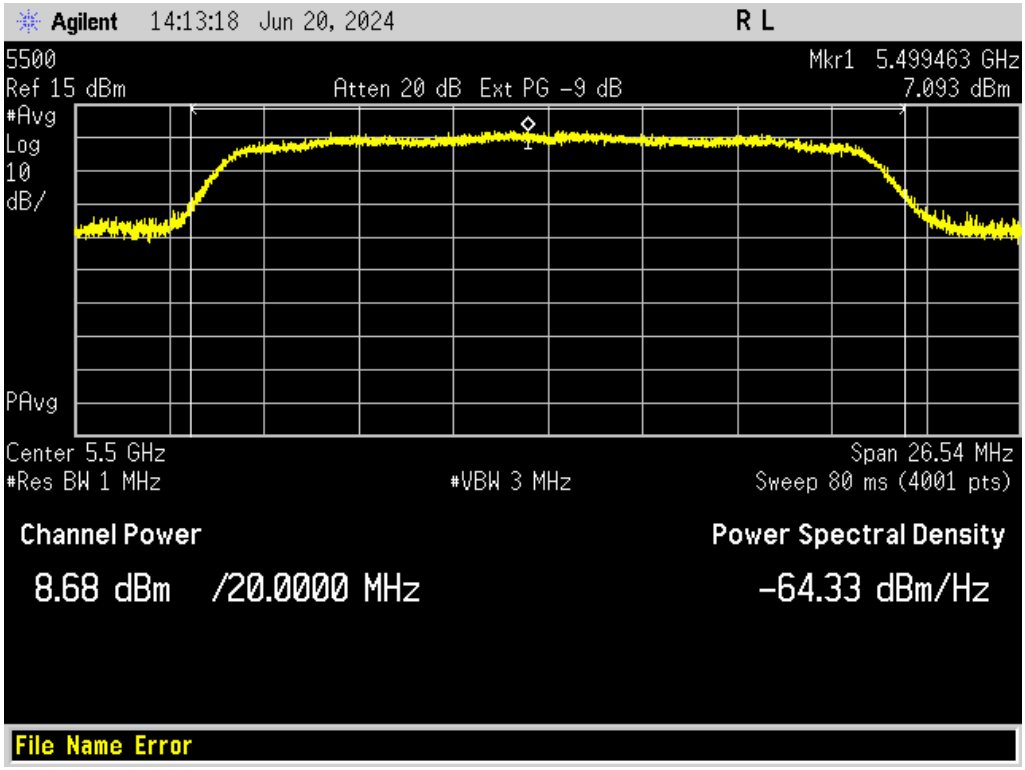


Figure 33. Peak Antenna Conducted Output Power, 802.11a Channel 100

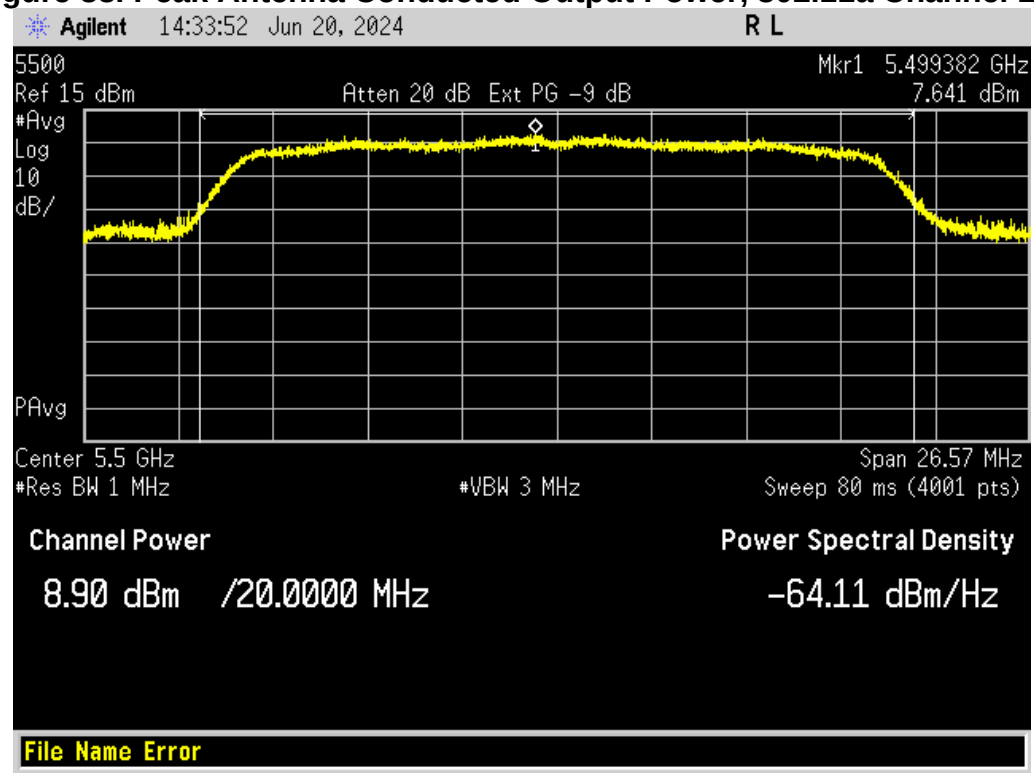


Figure 34. Peak Antenna Conducted Output Power, 802.11n Channel 100

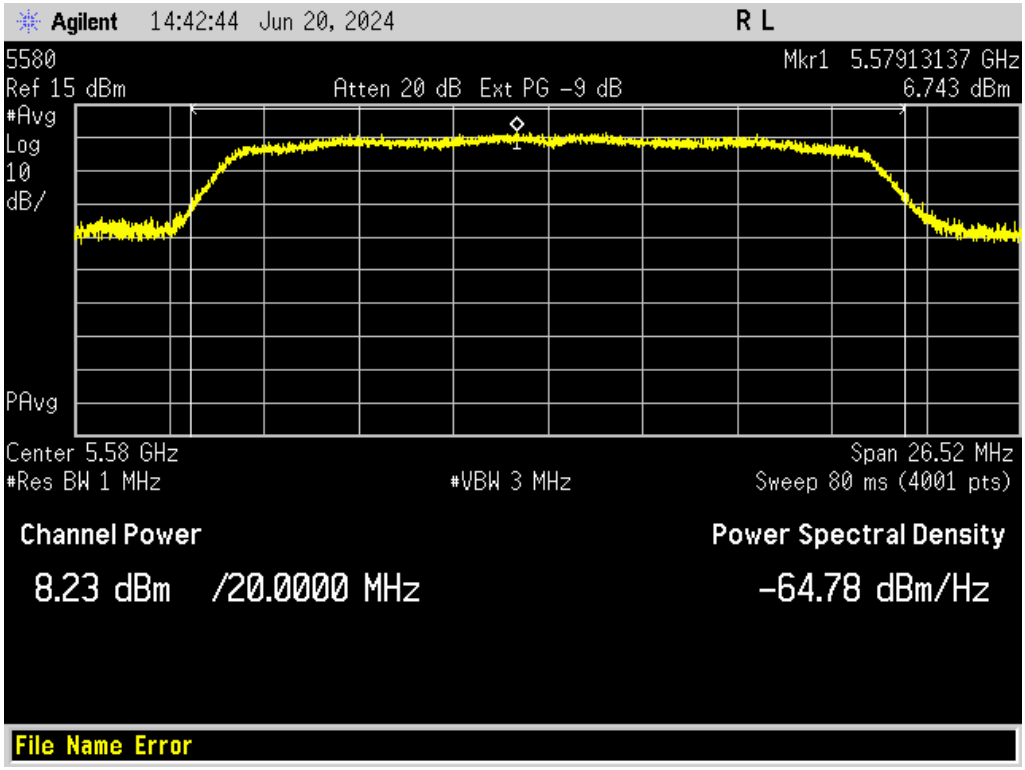


Figure 35. Peak Antenna Conducted Output Power, 802.11a Channel 116

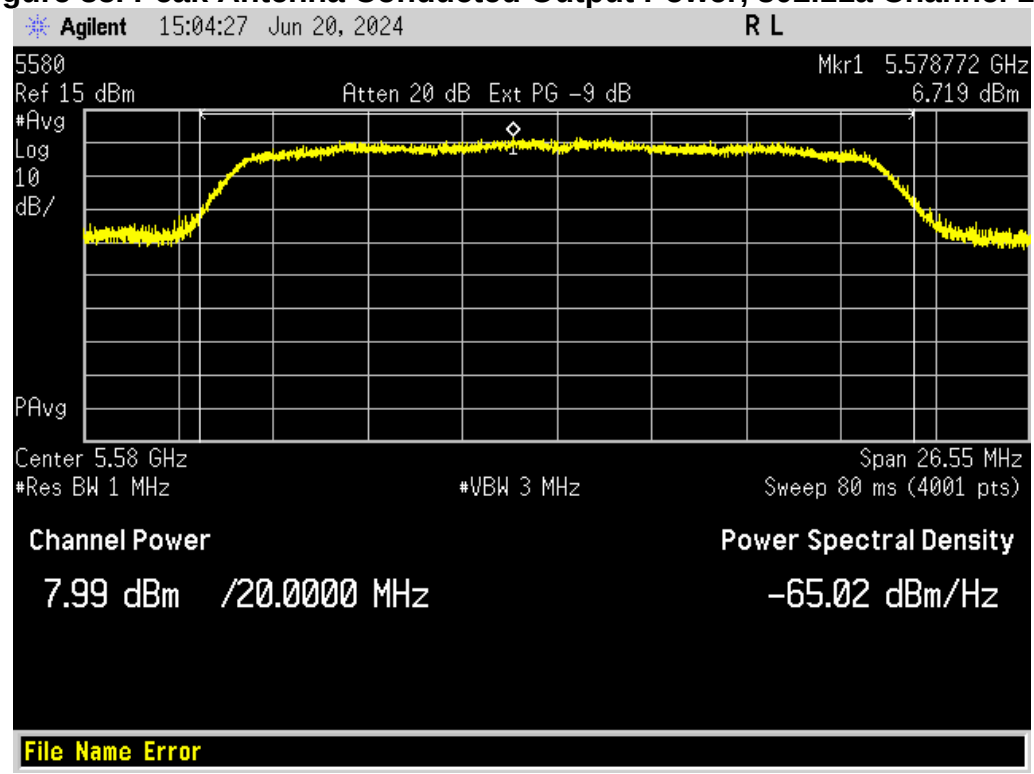


Figure 36. Peak Antenna Conducted Output Power, 802.11n Channel 116

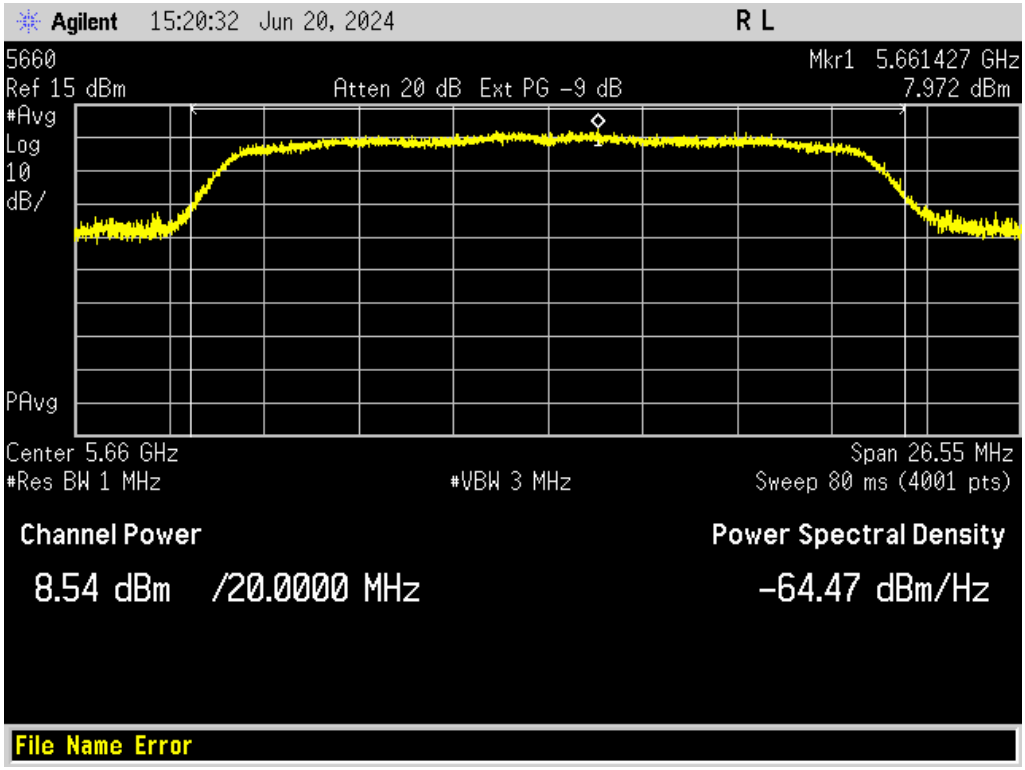


Figure 37. Peak Antenna Conducted Output Power, 802.11a Channel 132

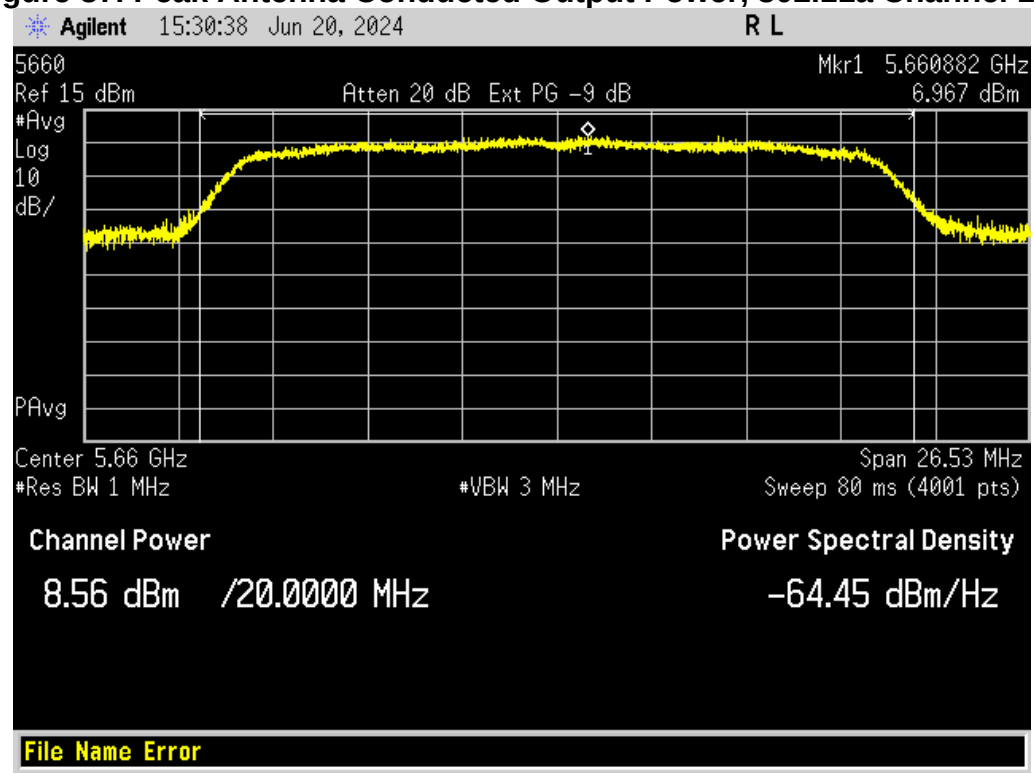


Figure 38. Peak Antenna Conducted Output Power, 802.11n Channel 132

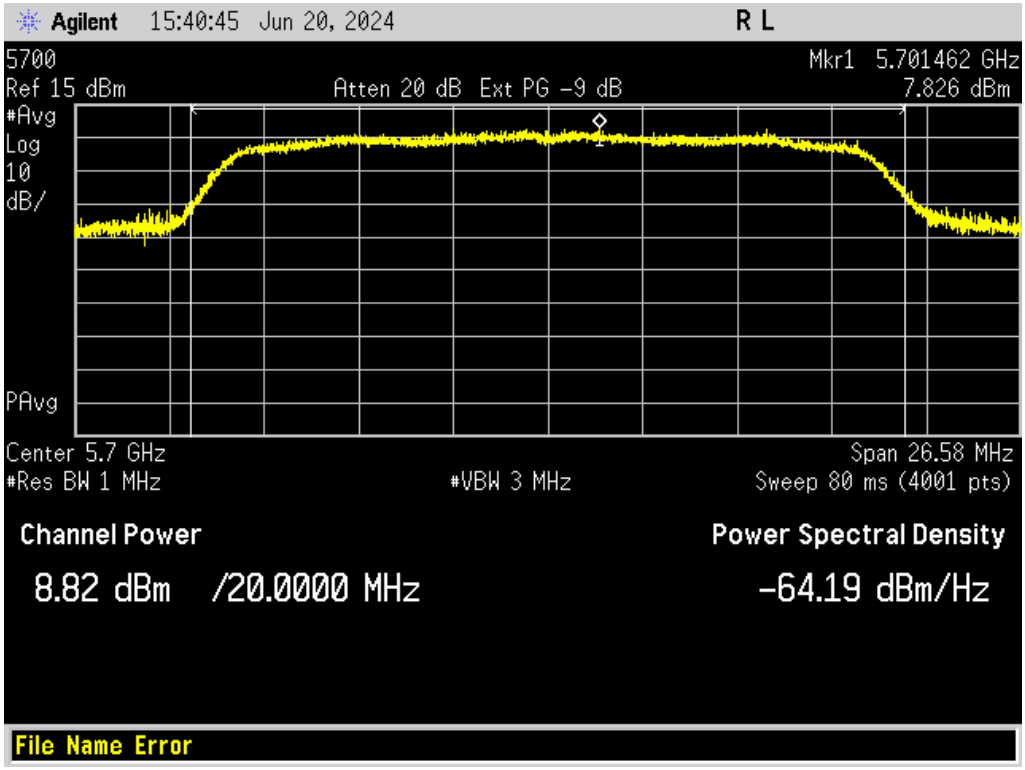


Figure 39. Peak Antenna Conducted Output Power, 802.11a Channel 140

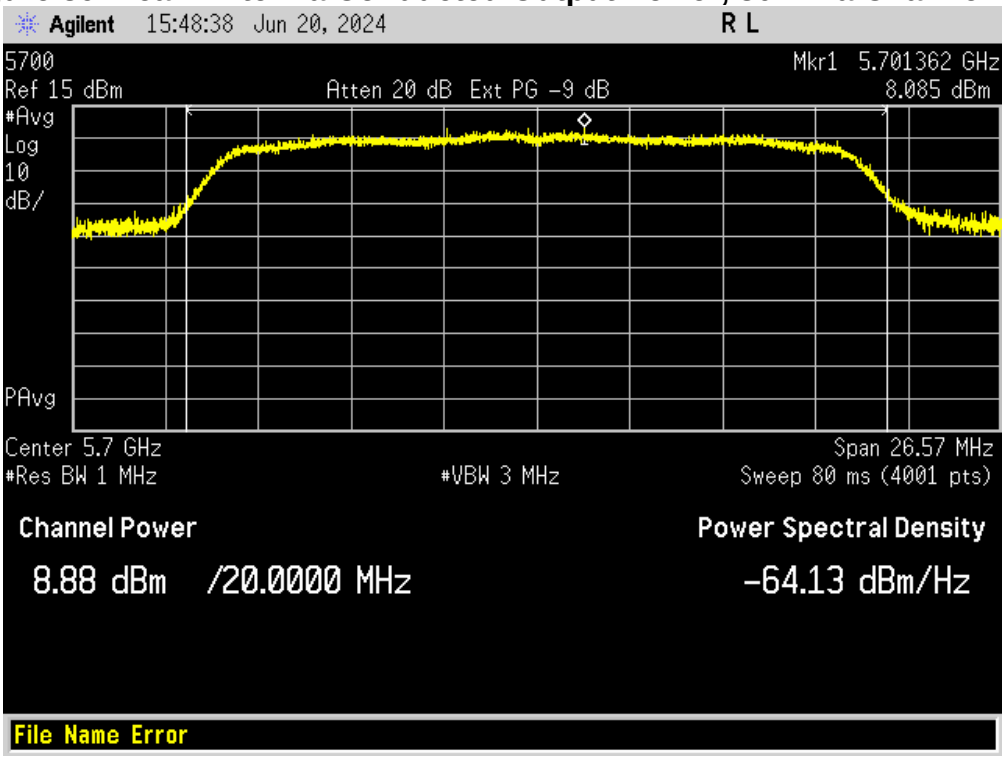


Figure 40. Peak Antenna Conducted Output Power, 802.11n Channel 140

2.15 Power Spectral Density (CFR 15.407(a) (2)) (IC RSS 247 6.2)

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The measurements were performed per the procedures of FCC KDB Procedure 789033 D02 v02. The RBW was set to 1 MHz and the Video Bandwidth was set to ≥ 3*RBW. The span was set to encompass the OBW. The averaging detector was used on the spectrum analyzer to determine the maximum PSD over the corresponding bandwidth.

In the operating bands 5.15 – 5.25 GHz, 5.25 - 5.35 GHz, and 5.47 - 5.725 GHz, the maximum power spectral density shall not exceed 11 dBm in any 1 MHz band.

Table 11. Power Spectral Density for 802.11a in the Lower Frequency Bands

Frequency (MHz)	Test Data (dBm/1 MHz)	FCC Limit (dBm/1 MHz)	Margin (dB)
802.11a			
5260	3.96	11.00	7.01
5320	4.90	11.00	6.21
5500	7.09	11.00	3.64
5580	6.74	11.00	4.31
5660	7.97	11.00	3.66
5700	7.83	11.00	3.28
802.11n			
5260	3.46	11.00	7.1
5320	4.82	11.00	6.82
5500	7.64	11.00	3.43
5580	6.72	11.00	3.98
5660	6.97	11.00	3.22
5700	8.09	11.00	3.31

See above figures.

2.16 Frequency Stability (CFR 15.407 (g))

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The RBW was set to 1 MHz and the Video Bandwidth was set to ≥ 3*RBW. The span was adjusted during testing to ensure measurement accuracy. The carrier frequency was measured from 50˚C to -30˚C at 10˚C increments and at 85% Nominal voltage to 115% Nominal voltage to ensure that it stayed within the band of operation.

Table 12. Frequency Stability 50˚C to -30˚C for 802.11a Channel 52

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)
-30	5258.8650	5258.8150	9.5
-20	5258.8500	5258.8150	6.7
-10	5258.8475	5258.8150	6.2
0	5258.8525	5258.8150	7.1
10	5258.8100	5258.8150	1.0
20 (low voltage)	5258.7750	5258.8150	7.6
20 (Nominal voltage)	5258.8150	5258.8150	0.0
20 (High voltage)	5258.7750	5258.8150	7.6
30	5258.7850	5258.8150	5.7
40	5258.7800	5258.8150	6.7
50	5258.7900	5258.8150	4.8

Actual TX Frequency was: 5258.8150 MHz

Test Date: June 6-14, 2024
Tested by

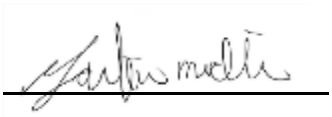
Signature:  Name: Gabriel Medina

Table 13. Frequency Stability 50˚C to -30˚C for 802.11n Channel 52

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)
-30	5258.8650	5258.8400	4.8
-20	5258.8675	5258.8400	5.2
-10	5258.8425	5258.8400	0.5
0	5258.8675	5258.8400	5.2
10	5258.8450	5258.8400	1.0
20 (low voltage)	5258.7925	5258.8400	9.0
20 (Nominal voltage)	5258.8400	5258.8400	0.0
20 (High voltage)	5258.7925	5258.8400	9.0
30	5258.7950	5258.8400	8.6
40	5258.7950	5258.8400	8.6
50	5258.7950	5258.8400	8.6

Actual TX Frequency was: 5258.8400 MHz

Table 14. Frequency Stability 50˚C to -30˚C for 802.11a Channel64

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)
-30	5318.8700	5318.8200	9.4
-20	5318.8725	5318.8200	9.9
-10	5318.8450	5318.8200	4.7
0	5318.8550	5318.8200	6.6
10	5318.8350	5318.8200	2.8
20 (low voltage)	5318.8050	5318.8200	2.8
20 (Nominal voltage)	5318.8200	5318.8200	0.0
20 (High voltage)	5318.7800	5318.8200	7.5
30	5318.7750	5318.8200	8.5
40	5318.7700	5318.8200	9.4
50	5318.7950	5318.8200	4.7

Actual TX Frequency was: 5318.8200 MHz

Test Date: June 6-14, 2024
Tested by

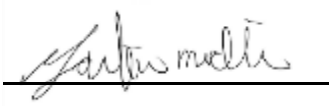
Signature:  Name: Gabriel Medina

Table 15. Frequency Stability 50˚C to -30˚C for 802.11n Channel 64

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)
-30	5318.8650	5318.8200	8.5
-20	5318.8725	5318.8200	9.9
-10	5318.8550	5318.8200	6.6
0	5318.8400	5318.8200	3.8
10	5318.8400	5318.8200	3.8
20 (low voltage)	5318.7900	5318.8200	5.6
20 (Nominal voltage)	5318.8200	5318.8200	0.0
20 (High voltage)	5318.7725	5318.8200	8.9
30	5318.7850	5318.8200	6.6
40	5318.7750	5318.8200	8.5
50	5318.7800	5318.8200	7.5

Actual TX Frequency was: 5318.8200 MHz

Table 16. Frequency Stability 50˚C to -30˚C for 802.11a Channel 100

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)
-30	5498.8625	5498.8200	7.7
-20	5498.8675	5498.8200	8.6
-10	5498.8425	5498.8200	4.1
0	5498.8725	5498.8200	9.5
10	5498.8450	5498.8200	4.5
20 (low voltage)	5498.7820	5498.8200	6.9
20 (Nominal voltage)	5498.8200	5498.8200	0.0
20 (High voltage)	5498.7800	5498.8200	7.3
30	5498.8200	5498.8200	0.0
40	5498.7700	5498.8200	9.1
50	5498.7750	5498.8200	8.2

Actual TX Frequency was: 5498.8200 MHz

Test Date: June 6-14, 2024
Tested by

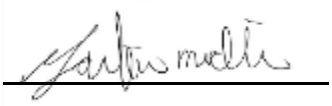
Signature:  Name: Gabriel Medina

Table 17. Frequency Stability 50˚C to -30˚C for 802.11n Channel 100

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)
-30	5498.8700	5498.8200	9.1
-20	5498.8750	5498.8200	10.0
-10	5498.8700	5498.8200	9.1
0	5498.8400	5498.8200	3.6
10	5498.8400	5498.8200	3.6
20 (low voltage)	5498.8050	5498.8200	2.7
20 (Nominal voltage)	5498.8200	5498.8200	0.0
20 (High voltage)	5498.7950	5498.8200	4.5
30	5498.7850	5498.8200	6.4
40	5498.7750	5498.8200	8.2
50	5498.7900	5498.8200	5.5

Actual TX Frequency was: 5498.8200MHz

Table 18. Frequency Stability 50˚C to -30˚C for 802.11n Channel 140

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)
-30	5698.8725	5698.8200	9.2
-20	5698.8725	5698.8200	9.2
-10	5698.8375	5698.8200	3.1
0	5698.8525	5698.8200	5.7
10	5698.8400	5698.8200	3.5
20 (low voltage)	5698.7925	5698.8200	4.8
20 (Nominal voltage)	5698.8200	5698.8200	0.0
20 (High voltage)	5698.7900	5698.8200	5.3
30	5698.8000	5698.8200	3.5
40	5698.7800	5698.8200	7.0
50	5698.7700	5698.8200	8.8

Actual TX Frequency was: 5698.8200 MHz

Test Date: June 6-14, 2024
Tested by

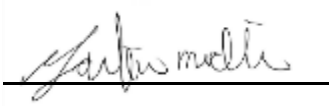
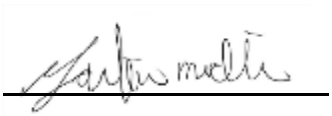
Signature:  Name: Gabriel Medina

Table 19. Frequency Stability 50˚C to -30˚C for 802.11n Channel 165

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)
-30	5698.8625	5698.8100	9.2
-20	5698.8650	5698.8100	9.7
-10	5698.8450	5698.8100	6.1
0	5698.8525	5698.8100	7.5
10	5698.8375	5698.8100	4.8
20 (low voltage)	5698.7975	5698.8100	2.2
20 (Nominal voltage)	5698.8100	5698.8100	0.0
20 (High voltage)	5698.7975	5698.8100	2.2
30	5698.8100	5698.8100	0.0
40	5698.7650	5698.8100	7.9
50	5698.7600	5698.8100	8.8

Actual TX Frequency was: 5698.8200 MHz

Test Date: June 6-14, 2024
Tested by

Signature:  Name: Gabriel Medina

2.17 Radiated Digital Emissions (15.407(b) (2,3,9,10), IC RSS 247 6.2)

The test data provided herein is to support the verification requirement for radiated emissions coming from the EUT in a transmitting state per 15.407. Emissions were investigated from 30 MHz to 25 GHz and tested as detailed in KDB Publication 789033 DO2 v02r0.

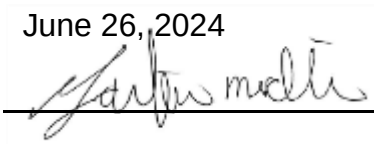
Measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth; 1 MHz RBW and 3 MHz VBW. The test data were maximized for magnitude by rotating the turntable through 360 degrees and raising and lowering the receiving antenna between 1 to 4 meters in height as a part of the measurement procedure.

Table 20. Spurious Radiated Emissions (30 MHz – 1 GHz)

Test: FCC Part 15.209							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector PK / QP/AVG**
53.35	49.52	-13.07	36.45	40.0	3m./HORZ	3.6	**PK**
240.00	45.51	-10.93	34.58	46.0	3m./HORZ	11.4	**PK**
648.05	31.01	-1.14	29.87	46.0	3m./HORZ	16.1	**PK**
53.35	49.53	-13.77	35.76	40.0	3m./VERT	4.2	**PK**
240.00	43.51	-10.83	32.68	46.0	3m./VERT	13.3	**PK**
960.05	31.22	1.54	32.76	54.0	3m./VERT	21.2	**PK**

Sample Calculation at 53.35 MHz:

Magnitude of Measured Frequency	49.52	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	-13.07	dB/m
Corrected Result	36.45	dBuV/m

Test Date: June 26, 2024
Tested by
Signature: 

Name: Gabriel Medina

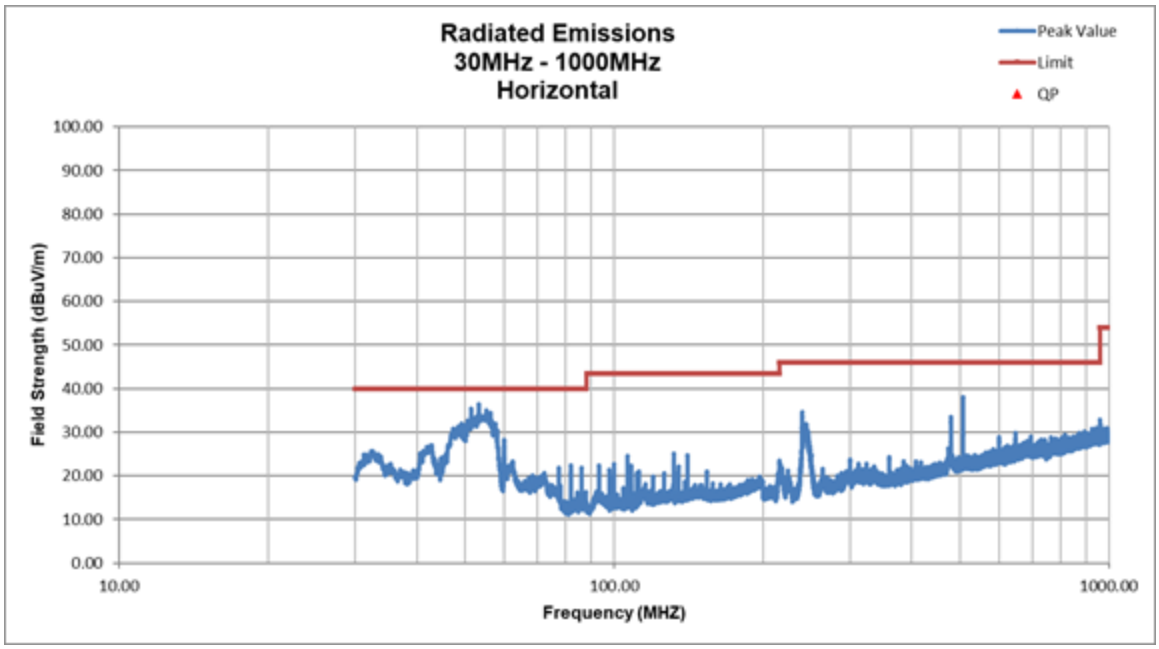


Figure 41. Radiated Emissions, Horizontal 30 – 1000 MHz

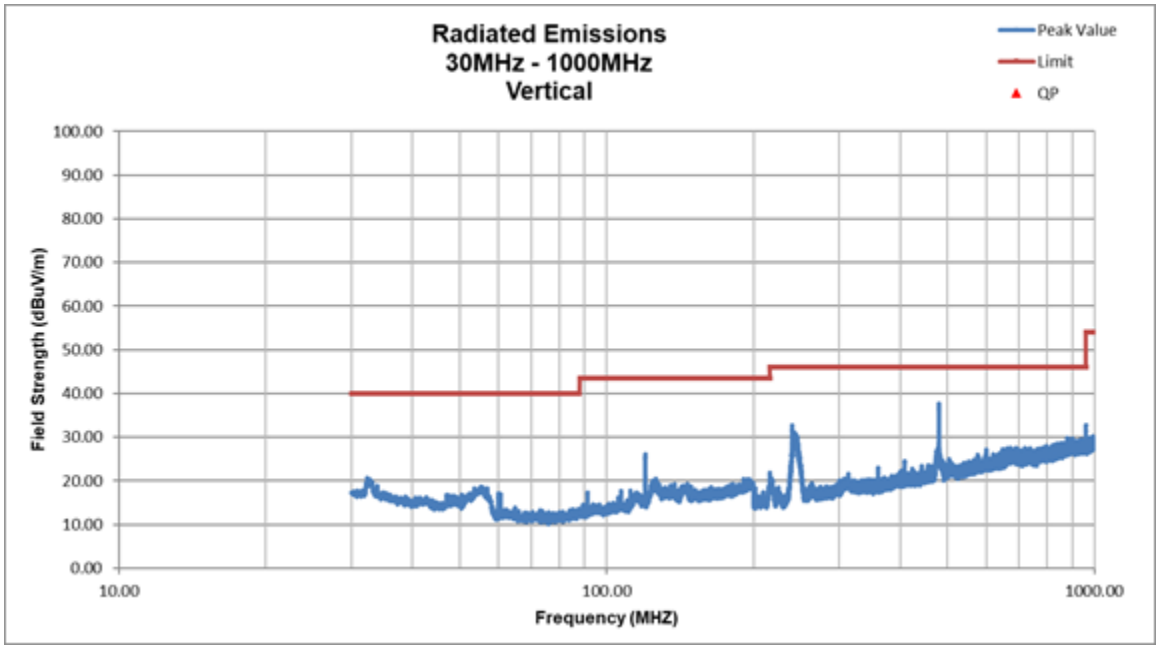


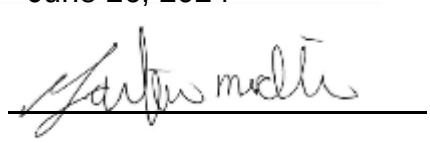
Figure 42. Radiated Emissions, Vertical 30 – 1000 MHz

Table 21. Spurious Radiated Emissions (1 GHz – 25 GHz)

Test: FCC Part 15.407							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
All emissions were more than 20 dB below the applicable limit.							

SAMPLE CALCULATION: N/A

Test Date: June 26, 2024

Tested by
Signature:  Name: Gabriel Medina

2.18 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4-2. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

2.18.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.78 dB.

2.18.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m, the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ± 5.39 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ± 5.18 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.21dB.

END TEST REPORT