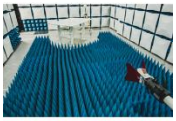
Element Materials Technology
(formerly PCTEST)
18855 Adams Court, Morgan Hill, CA 95037 USA
Tel. 408.538.5600
http://www.element.com



MEASUREMENT REPORT
FCC PART 15.407 Narrowband UNII-5

Applicant Name:
Apple Inc.
One Apple Park Way
Cupertino, CA 95014
United States

Date of Testing:
6/26/2024 - 8/14/2024
Test Report Issue Date:
8/23/2024
Test Site/Location:
Element Materials Technology Morgan Hill, CA, USA
Test Report Serial No.:
1C2405230025-07.BCG

FCC ID:	**BCG-A3055**
APPLICANT:	**Apple Inc.**

Application Type	Certification
Model:	A3055
EUT Type:	Wireless Earbud
Frequency Range:	6108 – 6420 MHz
Modulation Type:	GFSK, π/4 DQPSK
FCC Classification:	15E 6 GHZ Very Low Power Device (6VL)
FCC Rule Part(s):	Part 15 Subpart E (15.407)
Test Procedure(s):	ANSI C63.10-2020, KDB 789033 D02 v02r01, KDB 987594 D01 v02r02 KDB 987594 D02 v02r01 KDB 987594 D04 v02

This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10-2020, KDB 789033 D02 v02r01 and KDB 987593 D0 v02r01. Test results reported herein relate only to the item(s) tested.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

RJ Ortanez
Executive Vice President

Prepared by: WKR0000007200

Reviewed by: WKR0000006164

ACCREDITED
CERT #2041.02

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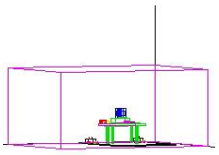
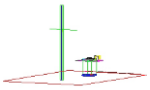


MEASUREMENT REPORT



UNII Band	Tx Frequency (MHz)	Mode	Max. e.i.r.p. [mW]	Max. e.i.r.p. [dBm]
5	6108-6420	NB UNII BDR	0.236	-6.28
		NB UNII LE-2M	0.230	-6.38
		NB UNII HDR4	0.435	-3.62
		NB UNII HDR8	0.748	-1.26
		NB UNII HDRp4	0.432	-3.65
		NB UNII HDRp8	0.750	-1.25

FCC EUT Overview

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1.0 INTRODUCTION

1.1 Scope

Measurement and determination of electromagnetic emissions (EMC) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission and the Innovation, Science and Economic Development Canada.

1.2 Element Materials Technology Test Location

These measurement tests were conducted at the Element Materials Technology facility located at 18855 Adams Court, Morgan Hill, CA 95037. The measurement facility is compliant with the test site requirements specified in ANSI C63.4-2014 and KDB 414788 D01 v01r01.

1.3 Test Facility / Accreditations

Measurements were performed at Element Materials Technology located in Morgan Hill, CA 95037, U.S.A.

- Element Materials Technology is an ISO 17025-2017 accredited test facility under the American Association for Laboratory Accreditation (A2LA) with Certificate number 2041.02 for Specific Absorption Rate (SAR), Hearing Aid Compatibility (HAC) testing, where applicable, and Electromagnetic Compatibility (EMC) testing for FCC and Innovation, Science, and Economic Development Canada rules.

- Element Washington DC LLC TCB is a Telecommunication Certification Body (TCB) accredited to ISO/IEC 17065-2012 by A2LA (Certificate number 2041.03) in all scopes of FCC Rules and ISED Standards (RSS).

- Element Materials Technology facility is a registered (22831) test laboratory with the site description on file with ISED.

- Element Washington DC LLC is a Recognized U.S. Certification Assessment Body (CAB# US0110) for ISED Canada as designed by NIST under the U.S. and Canada Mutual Recognition Agreements (MRAs)

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2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Apple Wireless Right Earbud FCC ID: BCG-A3055**. The test data contained in this report pertains only to the emissions due to the EUT's Narrowband UNII transmitter.

- This Narrowband UNII module has been tested by manufacturer and the following were confirmed:
  - A) The hopping sequence is pseudorandom
  - B) The receiver input bandwidth equals the transmit bandwidth
  - C) The receiver hops in sequence with the transmit signal
  - D) Narrowband UNII can only hop within the same UNII band and cannot hop between bands

Test Device Serial No.: H5RH72001JA0000B31, H5RH72001UC0000B31, H5RH72001Y00000B31, H5RH6W000TH0000B31

2.2 Device Capabilities

This device contains the following capabilities:

Bluetooth (1x, EDR, LE1M, LE2M, HDR4, HDR8, HDRp4, HDRp8), NB UNII (1x, LE2M, HDR4, HDR8, HDRp4, HDRp8).

Channels below 6108 MHz in the UNII-5 band are disabled in the US and its territories.

Band 5
Frequency (MHz)
6108
:
6264
:
6420

Table 2-1. NB UNII-5 Frequency / Channel Operations

Notes:

This device is capable of operating in hopping and non-hopping mode. The EUT can hop between different channels in the U-NII Band 1 & U-NII Band 3. The maximum achievable duty cycles for all modes were determined based on measurements performed on a spectrum analyzer in zero-span mode with RBW = 8MHz, VBW = 50MHz, and detector = peak per the guidance of Section B)2)b) of KDB 789033 D02 v02r01 and ANSI C63.10-2020. The RBW and VBW were both greater than 50/T, where T is the minimum transmission duration, and the number of sweep points across T was greater than 100. The duty cycles are as follows:

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Measured Duty Cycles		
Mode	**Frequency (MHz)**	**Duty Cycle [%[**
NB UNII BDR	6108-6420	76.6
NB UNII BLE-2M		80.1
NB UNII HDR4		77.9
NB UNII HDR8		77.9
NB UNII HDRp4		92.9
NB UNII HDRp8		88.1

Table 2-2. Measured Duty Cycles

1. Additionally, this device is sold together in the same package as a system with FCC ID: BDG-A3056 and FCC ID: BCG-A3059. Co-Tx configurations were tested, and the worst case has been included in the RF BTLE report.

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2.3 Antenna Description

The following antenna gains provided by the manufacturer were used for testing.

Frequency [MHz]	Antenna Gain (dBi)
6113	-3.1
6176	-3.2
6238	-3.1
6301	-3.3
6425	-2.7

Table 2-3. Antenna Gain

2.4 Test Support Equipment

1	Apple MacBook Pro	Model:	A2141	S/N:	C02H604EQ05D
	w/AC/DC Adapter	Model:	A2166	S/N:	C4H042705ZNPM0WA6
2	Apple Airpod Charging Case	Model:	A3059	S/N:	W1G9FWQMLX
	Apple Airpod (Left)	Model:	A3056	S/N:	H5RH73002770000B2Z
3	USB-C Cable	Model:	A246C	S/N:	N/A
	w/ AC Adapter	Model:	A2305	S/N:	N/A
4	Apple USB-C Cable	Model:	Spartan	S/N:	000MKTR02U
5	Netgear	Model:	RAXE500	S/N:	6JX215GA10A5
6	Head Mounted Device	Model:	A2117	S/N:	KQ4P243T74
	EUT Power Pack	Model:	N/A	S/N:	HTFGQW0009800001MV

Table 2-4. Test Support Equipment List

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2.5 Test Configuration

The EUT was tested per the guidance of ANSI C63.10-2020 and KDB 789033 D02 v02r01. ANSI C63.10-2020 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing. See Sections 3.2 for AC line conducted emissions test setups, 3.3 for radiated emissions test setups, and 7.2, 7.3, 7.4 and 7.5 for antenna port conducted emissions test setups.

For emissions from 1GHz – 18GHz, low, mid, and high channels were tested with highest power and worst case configuration. The emissions below 1GHz and above 18GHz were tested with the highest transmitting power and the worst case channel. The EUT was investigated with and without charging case.

The EUT was manipulated through three orthogonal planes of X-orientation (flatbed), Y-orientation (landscape), and Z-orientation (portrait) during the testing. Only the worst case emissions were reported in this test report.

For AC line conducted and radiated test below 1GHz, following configurations were investigated and EUT powered by AC/DC adaptor was the worst case.

- EUT charged by charging case and powered by AC/DC adaptor with USB-C cable.
- EUT charged by charging case and powered by host PC with USB-C cable.

2.6 Software and Firmware

The test was conducted with firmware version 7A343 installed on the EUT.

2.7 EMI Suppression Device(s)/Modifications

No EMI suppression device(s) were added and/or no modifications were made during testing.

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3.0 DESCRIPTION OF TESTS

3.1 Evaluation Procedure

The measurement procedures described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices (ANSI C63.10-2020) and the guidance provided in KDB 789033 D02 v02r01 were used in the measurement of the EUT**.**

Deviation from measurement procedure……..…….....None

3.2 AC Line Conducted Emissions

The line-conducted facility is located inside a 7m x 3.66m x 2.7m shielded enclosure. The shielded enclosure is manufactured by AP Americas. The shielding effectiveness of the shielded room is in accordance with MIL-Std-285 or NSA 65-6. A 1m x 1.5m wooden table 80cm high is placed 40cm away from the vertical wall and 80cm away from the sidewall of the shielded room. Two 10kHz-30MHz, 50Ω/50µH Line-Impedance Stabilization Networks (LISNs) are bonded to the shielded room floor. Power to the LISNs is filtered by external high-current high-insertion loss power line filters. The external power line filter is EPCOS 2X60A Power Line Filter (100dB Attenuation, 14kHz-18GHz) and the two EPCOs 2X48A filters (100dB Minimum Insertion Loss, 14kHz - 10GHz). These filters attenuate ambient signal noise from entering the measurement lines. These filters are also bonded to the shielded enclosure.

The EUT is powered from one LISN and the support equipment is powered from the second LISN. If the EUT is a DC-powered device, power will be derived from the source power supply it normally will be powered from and this supply line(s) will be connected to the second LISN. All interconnecting cables more than 1 meter were shortened to a 1 meter length by non-inductive bundling (serpentine fashion) and draped over the back edge of the test table. All cables were at least 40cm above the horizontal reference ground plane. Power cables for support equipment were routed down to the second LISN while ensuring that that cables were not draped over the second LISN.

Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer and exploratory measurements were made to determine the frequencies producing the maximum emission from the EUT. The spectrum was scanned from 150kHz to 30MHz with a spectrum analyzer. The detector function was set to peak mode for exploratory measurements while the bandwidth of the analyzer was set to 10kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Once the worst case emissions have been identified, the one EUT cable configuration/arrangement and mode of operation that produced these emissions is used for final measurements on the same test site. The analyzer is set to CISPR quasi-peak and average detectors with a 9kHz resolution bandwidth for final measurements.

Line conducted emissions test results are shown in Section 7.10. Automated test software was used to perform the AC line conducted emissions testing. Automated measurement software utilized is Rohde & Schwarz EMC32, Version 10.50.40.

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3.3 Radiated Emissions

The radiated test facilities consisted of an indoor 3 meter semi-anechoic chamber used for final measurements and exploratory measurements, when necessary. The measurement area is contained within the semi-anechoic chamber which is shielded from any ambient interference. The test site inside the chamber is a 6m x 5.2m elliptical, obstruction-free area in accordance with Figure 5.7 of Clause 5 in ANSI C63.4-2014. Absorbers are arranged on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections for measurements above 1GHz. An 80cm tall test table made of Styrodur is placed on top of the turn table. For measurements above 1GHz, an additional Styrodur pedestal is placed on top of the test table to bring the total table height to 1.5m.

Per KDB 414788 D01 v01r01, radiated emission test sites other than open-field test sites (e.g., shielded anechoic chambers), may be employed for emission measurements below 30MHz if characterized so that the measurements correspond to those obtained at an open-field test site. To determine test site equivalency, a reference sample transmitting at 149kHz was measured on an open field test site (asphalt with no ground plane) and then measured in the 3m semi-anechoic chamber. A calibrated 60cm loop antenna was used while the reference device was rotated through the X, Y and Z axis in order to capture the worst case level. A maximum deviation of 2.77dB at 149kHz was measured when comparing the 3 meter semi-anechoic chamber to the open field site.

For all measurements, the spectrum was scanned through all EUT azimuths and from 1 to 4 meter receive antenna height using a broadband antenna from 30MHz up to the upper frequency shown in 15.33 depending on the highest frequency generated or used in the device or on which the device operates or tunes. For frequencies above 1GHz, linearly polarized double ridge horn antennas were used. For frequencies below 30MHz, a calibrated loop antenna was used. When exploratory measurements were necessary, they were performed at 1 meter test distance inside the semi-anechoic chamber using broadband antennas, broadband amplifiers, and spectrum analyzers to determine the frequencies and modes producing the maximum emissions. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The test set-up was placed on top of the 1 x 1.5 meter table. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Appropriate precaution was taken to ensure that all emissions from the EUT were maximized and investigated. The system configuration, mode of operation, turntable azimuth, and receive antenna height was noted for each frequency found.

Final measurements were made in the semi-anechoic chamber using calibrated, linearly polarized broadband and horn antennas. The test setup was configured to the setup that produced the worst case emissions. The spectrum analyzer was set to investigate all frequencies required for testing to compare the highest radiated disturbances with respect to the specified limits. The turntable containing the EUT was rotated through 360 degrees and the height of the receive antenna was varied 1 to 4 meters and stopped at the azimuth and height producing the maximum emission. Each emission was maximized by changing the orientation of the EUT through three orthogonal planes and changing the polarity of the receive antenna, whichever produced the worst-case emissions.

3.4 Environmental Conditions

The temperature is controlled within range of 15ºC to 35ºC. The relative humidity is controlled within range of 10% to 75%. The atmospheric pressure is monitored within the range 86-106kPa (860-1060mbar).

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4.0 ANTENNA REQUIREMENTS

Excerpt from §15.203 of the FCC Rules/Regulations:
"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can 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 shall be considered sufficient to comply with the provisions of this section."

- The antennas of the EUT are **permanently attached.**
- There are no provisions for connection to an external antenna.

Conclusion:

The EUT complies with the requirement of §15.203.

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5.0 MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.23-2012. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Contribution	Expanded Uncertainty (±dB)
Conducted Bench Top Measurements	2.07
Line Conducted Disturbance	1.91
Radiated Disturbance (<30MHz)	4.12
Radiated Disturbance (30MHz - 1GHz)	4.85
Radiated Disturbance (1 - 18GHz)	5.08
Radiated Disturbance (>18GHz)	5.22

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6.0 TEST EQUIPMENT CALIBRATION DATA

Test Equipment Calibration is traceable to the National Institute of Standards and Technology (NIST). Measurements antennas used during testing were calibrated in accordance with the requirements of ANSI C63.5-2017.

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent Technologies	N9030A	3Hz-26.5GHz PXA Signal Analyzer	10/18/2023	Annual	10/18/2024	MY55330128
Anritsu	ML2495A	Power Meter	7/8/2024	Annual	7/8/2025	1039008
Anritsu	MA2411B	Pulse Power Sensor	7/1/2024	Annual	7/1/2025	1911105
Anritsu	MA2411B	Pulse Power Sensor	11/8/2023	Annual	11/8/2024	1027293
ATM	180-442A-KF	20dB Nominal Gain Horn Antenna	3/14/2024	Annual	3/14/2025	T058701-01
ETS-Lindgren	3117	Double Ridged Guide Antenna (1-18 GHz)	4/9/2024	Annual	4/9/2025	00218555
Keysight Technology	N9040B	UXA Signal Analyzer	5/28/2024	Annual	5/28/2025	MY57212015
Mini-Circuits	FLC-1.5FT-SMSM+	30MHz-27GHz Conducted Cable *	9/14/2023	Annual	9/14/2024	16113316
Rohde & Schwarz	TS-PR18	Pre-Amplifier (1GHz - 18GHz)	8/15/2023	Annual	8/15/2024	101639
Rohde & Schwarz	FSV40	Signal Analyzer (10Hz-40GHz)	5/29/2024	Annual	5/29/2025	101619
Rohde & Schwarz	ESW44	EMI Test Receiver	5/1/2024	Annual	5/1/2025	101867
Rohde & Schwarz	TS-PR8	Pre-Amplifier (30MHz - 8GHz)	7/3/2024	Annual	7/3/2025	102356
Rohde & Schwarz	TS-PR1840	Pre-Amplifier (18GHz - 40GHz)	6/10/2024	Annual	6/10/2025	100057
Rohde & Schwarz	HFH2-Z2	Loop Antenna	6/21/2024	Annual	6/21/2025	100519
Rohde & Schwarz	ENV216	Two-Line V-Network	7/12/2024	Annual	7/12/2025	101363
Schwarzbeck	VULB 9162	Bilog Antenna (30MHz - 6GHz)	4/29/2024	Annual	4/29/2025	00304

Table 6-1. Test Equipment List

Note:

1. For equipment listed above that has a calibration date or calibration due date that falls within the test date range, care was taken to ensure that this equipment was used after the calibration date and before the calibration due date.
2. * denotes passive equipment that has been internally verified/calibrated.

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7.0 TEST RESULTS

7.1 Summary

Company Name: Apple Inc.

FCC ID: BCG-A3055

FCC Classification: 15E 6 GHZ Very Low Power Device (6VL)

FCC Part Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
2.1049, 15.407	99% Occupied Bandwidth & 26dB Bandwidth	99% of the occupied bandwidth of any channel must be contained within each of its respective U-NII sub bands < 320MHz (5.925 - 7.125GHz)	CONDUCTED	PASS	Section 7.2
15.407 (a.9)	Maximum Conducted Output Power	Maximum conducted powers and Max EIRP must meet the limits detailed in 15.407 (a.9)		PASS	Section 7.3
15.407 (a.9)	Maximum Power Spectral Density	Maximum power spectral density must meet the limits detailed in 15.407 (a.9)		PASS	Section 7.4
15.407(b.7)	In-Band Emissions	EUT must meet the limits detailed in 15.407(b)(7)		PASS	Section 7.5
15.407(d.6)	Contention Based Protocol	EUT must detect AWGN signal with 90% (or better) certainty		PASS	Section 7.6
15.407(d.10)	Transmit Power Control	EUT must employ a TPC mechanism to operate 6dB below the maximum EIRP PSD detailed in 15.407 (a.9)		PASS	Section 7.7
15.407(b.6)	Undesirable Emissions	Undesirable emissions must meet the limits detailed in 15.407(b)	RADIATED	PASS	Section 7.8
15.205, 15.407(b.6)	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Emissions in restricted bands must meet the radiated limits detailed in 15.209		PASS	Section 7.8, 7.9
15.207	AC Conducted Emissions 150kHz – 30MHz	< FCC 15.207 limits	AC LINE CONDUCTED	PASS	Section 7.10

Table 7-1. Summary of Test Results

Notes:

1. All channels, modes, and modulations/data rates were investigated. The test results shown in the following sections represent the worst case emissions.
2. The analyzer plots shown in this section were all taken with a correction table loaded into the analyzer. The correction table was used to account for the losses of the cables and attenuators used as part of the system to connect the EUT to the analyzer at all frequencies of interest.
3. All antenna port conducted emissions testing was performed on a test bench with the antenna port of the EUT connected to the spectrum analyzer through calibrated cables and attenuators.
4. For conducted spurious emissions, automated test software was used to measure emissions and capture the corresponding plots necessary to show compliance. The measurement software utilized is Element "Conducted Automation Software," Version 1.1.0.
5. For radiated band edge, automated test software was used to measure emissions and capture the corresponding plots necessary to show compliance. The measurement software utilized is Element "Chamber Automation," Version 3.0.

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7.2 26dB & 99% Bandwidth Measurement

§2.1049; §15.407

Test Overview and Limit

The bandwidth at 26dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the antenna terminal while the EUT is operating at its maximum duty cycle, at its maximum power control level, as defined in ANSI C63.10-2020 and KDB 789033 D02 v02r01, and at the appropriate frequencies. The spectrum analyzer's bandwidth measurement function is configured to measure the 26dB bandwidth.

Test Procedure Used

ANSI C63.10-2020 – Subclause 12.5
KDB 789033 D02 v02r01 – Section C

Test Settings

1. The signal analyzers' automatic bandwidth measurement capability was used to perform the 26dB bandwidth measurement. The "X" dB bandwidth parameter was set to X = 26. The automatic bandwidth measurement function also has the capability of simultaneously measuring the 99% occupied bandwidth. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = approximately 1% of the emission bandwidth
3. VBW $\geq$ 3 x RBW
4. Detector = Peak
5. Trace mode = max hold

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

Figure 7-1. Test Instrument & Measurement Setup

Test Notes

None.

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7.2.1 26dB & 99% Bandwidth Measurements

	Frequency [MHz]	Data Rate [Mbps]	Mode	Measured 99% Occupied Bandwidth [MHz]	Measured 26dB Bandwidth [MHz]	Maximum Bandwidth Limit[MHz]	Pass / Fail
Band 5	6108	1.0	NB UNII BDR	0.95	1.26	320	Pass
	6264	1.0	NB UNII BDR	0.95	1.26	320	Pass
	6420	1.0	NB UNII BDR	0.96	1.26	320	Pass
	6108	2.0	NB UNII LE-2M	2.09	2.54	320	Pass
	6264	2.0	NB UNII LE-2M	2.09	2.54	320	Pass
	6420	2.0	NB UNII LE-2M	2.10	2.54	320	Pass
	6108	4.0	NB UNII HDR4	2.28	2.52	320	Pass
	6264	4.0	NB UNII HDR4	2.28	2.54	320	Pass
	6420	4.0	NB UNII HDR4	2.28	2.57	320	Pass
	6108	8.0	NB UNII HDR8	4.49	5.09	320	Pass
	6264	8.0	NB UNII HDR8	4.50	5.09	320	Pass
	6420	8.0	NB UNII HDR8	4.50	5.10	320	Pass
	6108	4.0	NB UNII HDRp4	2.43	2.72	320	Pass
	6264	4.0	NB UNII HDRp4	2.44	2.74	320	Pass
	6420	4.0	NB UNII HDRp4	2.44	2.73	320	Pass
	6108	8.0	NB UNII HDRp8	4.87	5.41	320	Pass
	6264	8.0	NB UNII HDRp8	4.89	5.42	320	Pass
	6420	8.0	NB UNII HDRp8	4.88	5.41	320	Pass

Table 7-2. Conducted BW Measurements

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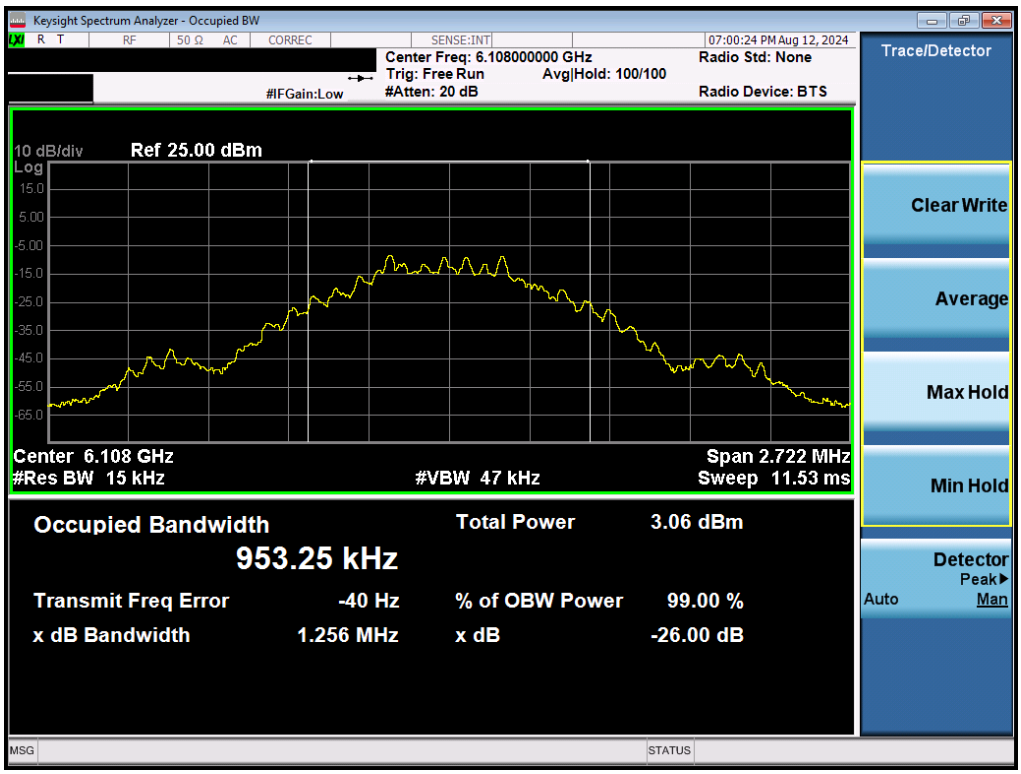

Plot 7-1. 26dB BW & 99% OBW (NB UNII BDR – 6108MHz)

Plot 7-2. 26dB BW & 99% OBW (NB UNII BDR – 6264MHz)

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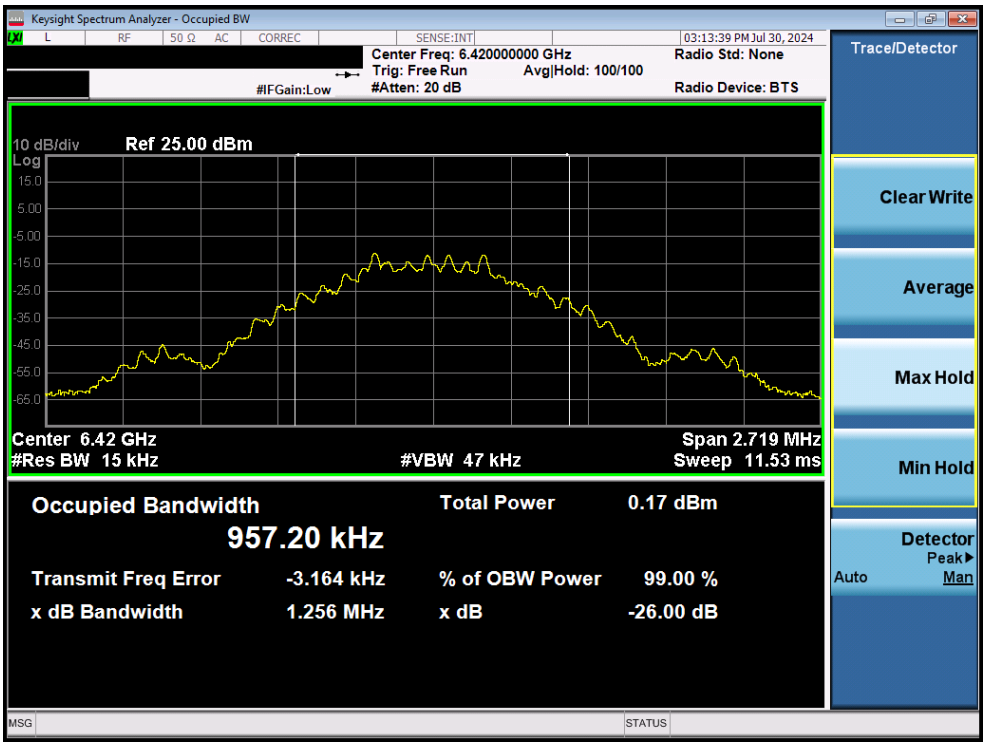

Plot 7-3. 26dB BW & 99% OBW (NB UNII BDR – 6420MHz)

Plot 7-4. 26dB BW & 99% OBW (NB UNII LE, 2Mbps – 6108MHz)

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Plot 7-5. 26dB BW & 99% OBW (NB UNII LE, 2Mbps – 6264MHz)

Plot 7-6. 26dB BW & 99% OBW (NB UNII LE, 2Mbps – 6420MHz)

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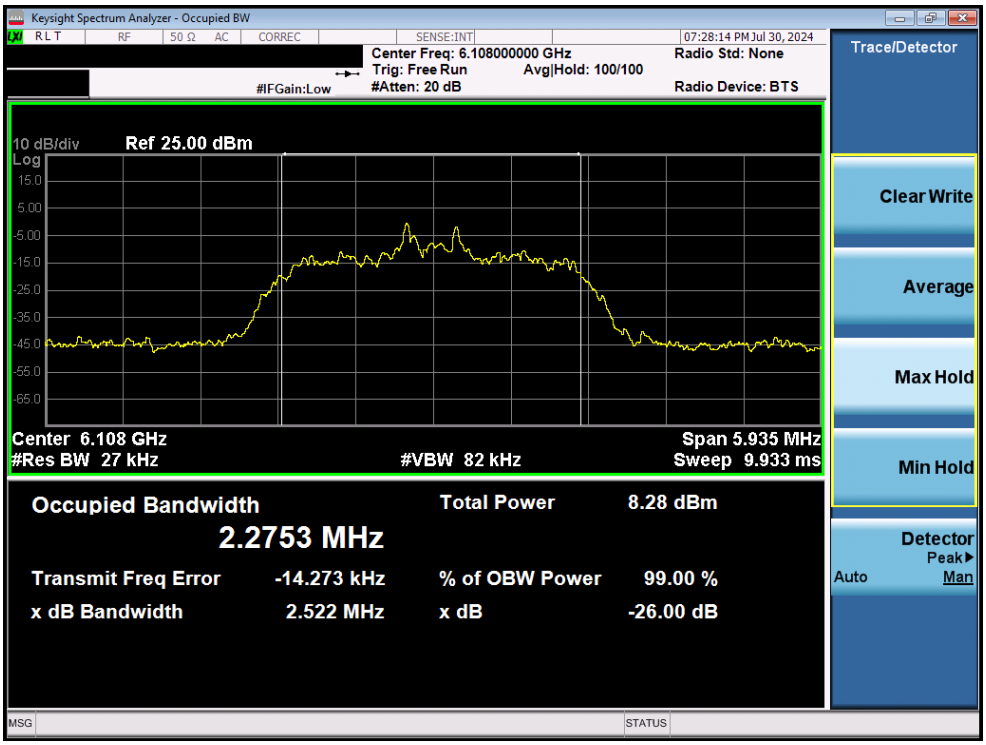
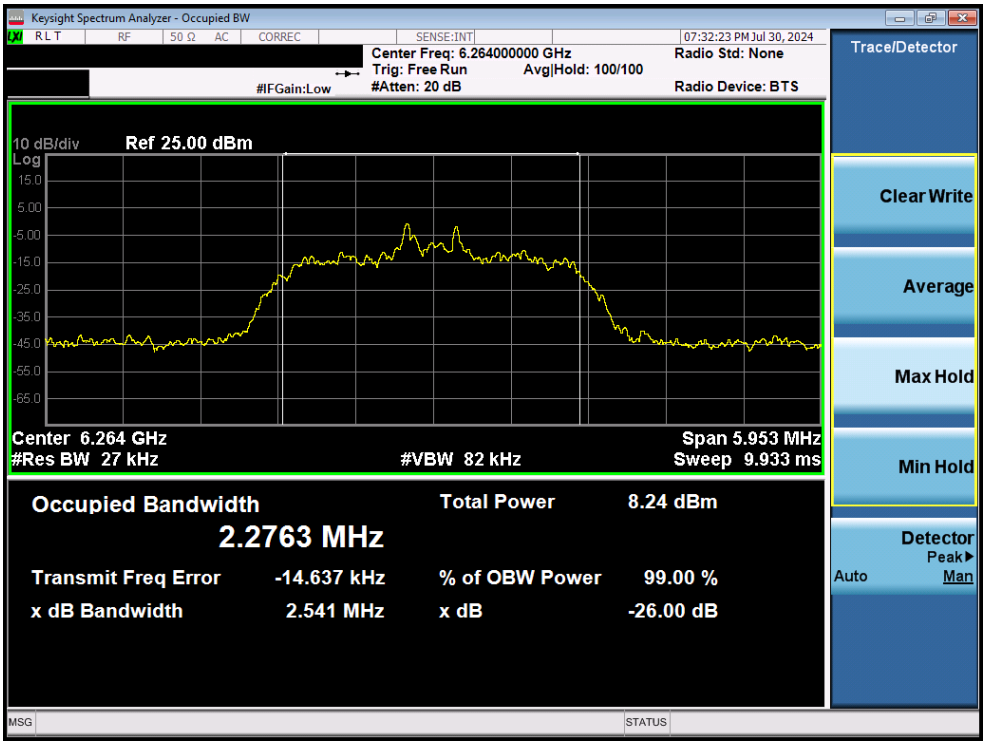


Plot 7-7. 26dB BW & 99% OBW (NB UNII HDR4 – 6108MHz)



Plot 7-8. 26dB BW & 99% OBW (NB UNII HDR4 – 6264MHz)

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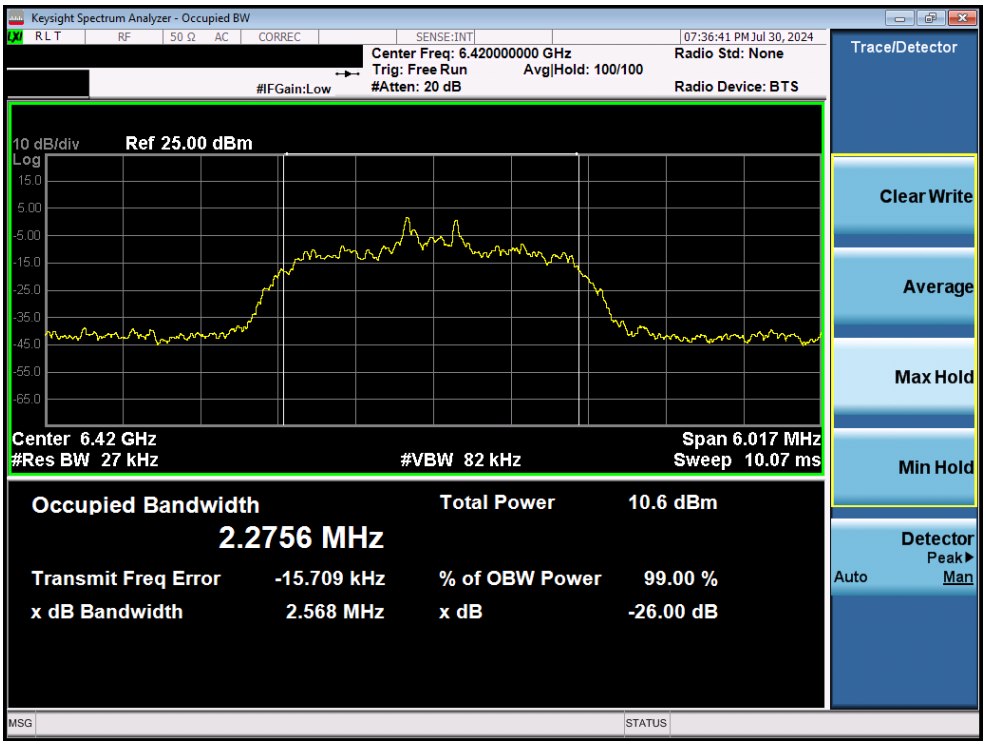
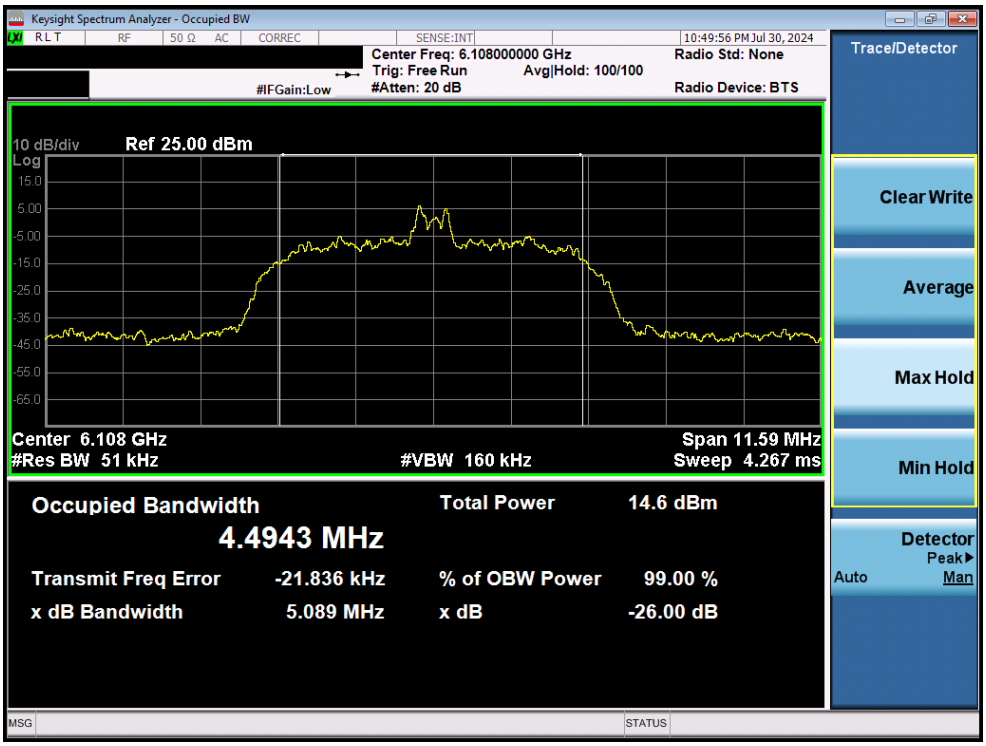


Plot 7-9. 26dB BW & 99% OBW (NB UNII HDR4 – 6420MHz)



Plot 7-10. 26dB BW & 99% OBW (NB UNII HDR8 – 6108MHz)

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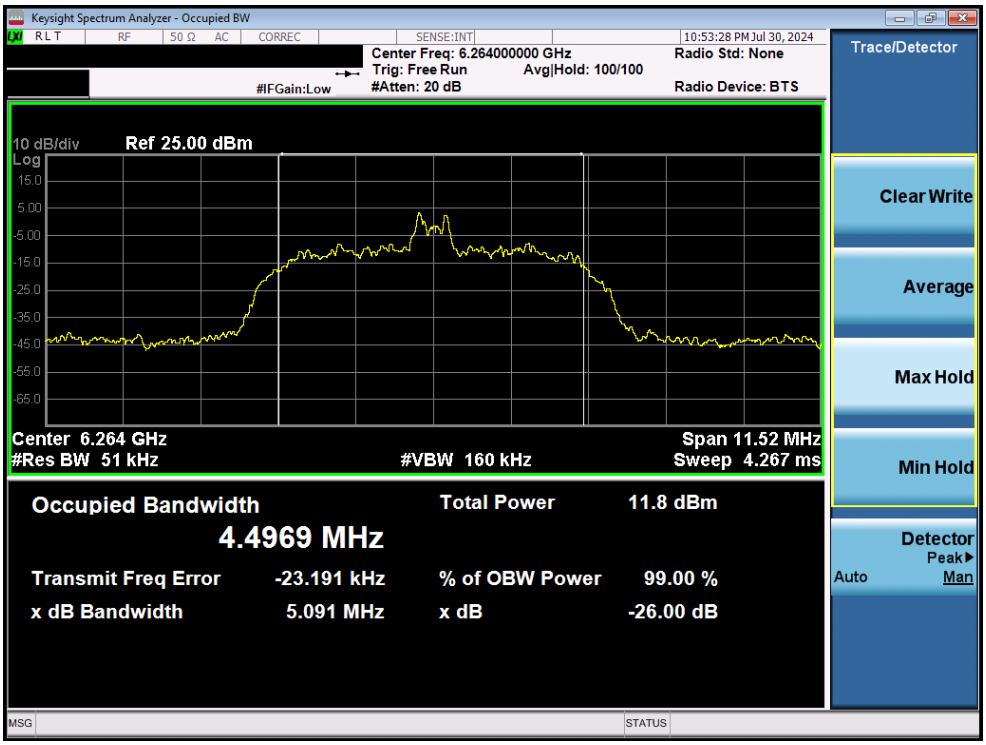
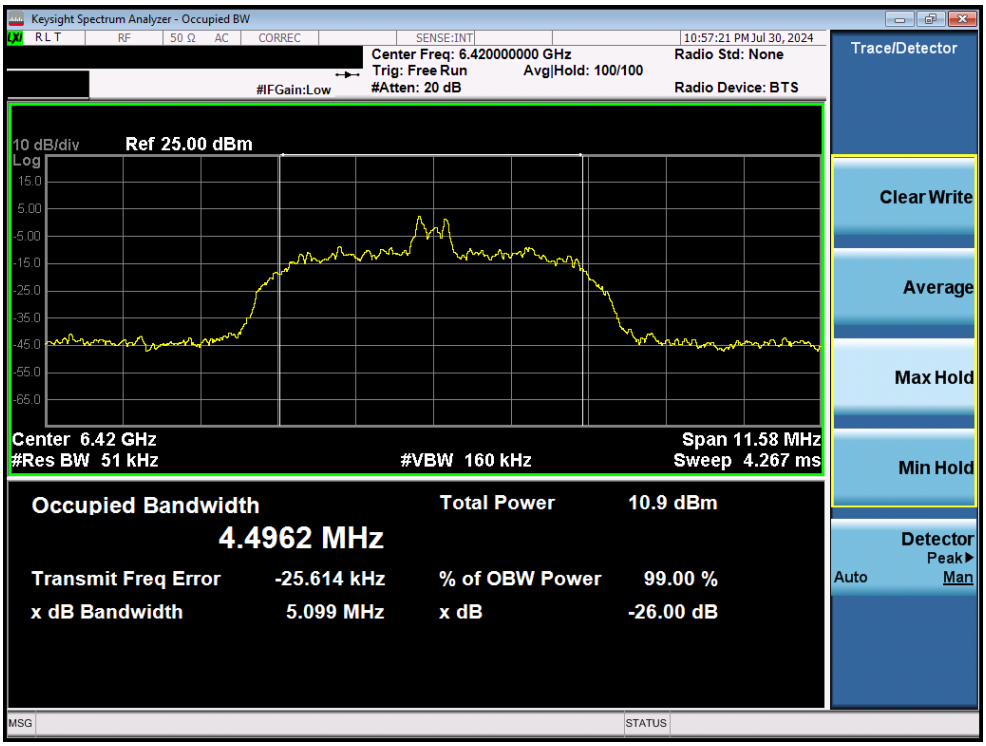


Plot 7-11. 26dB BW & 99% OBW (NB UNII HDR8 – 6264MHz)



Plot 7-12. 26dB BW & 99% OBW (NB UNII HDR8 – 6420MHz)

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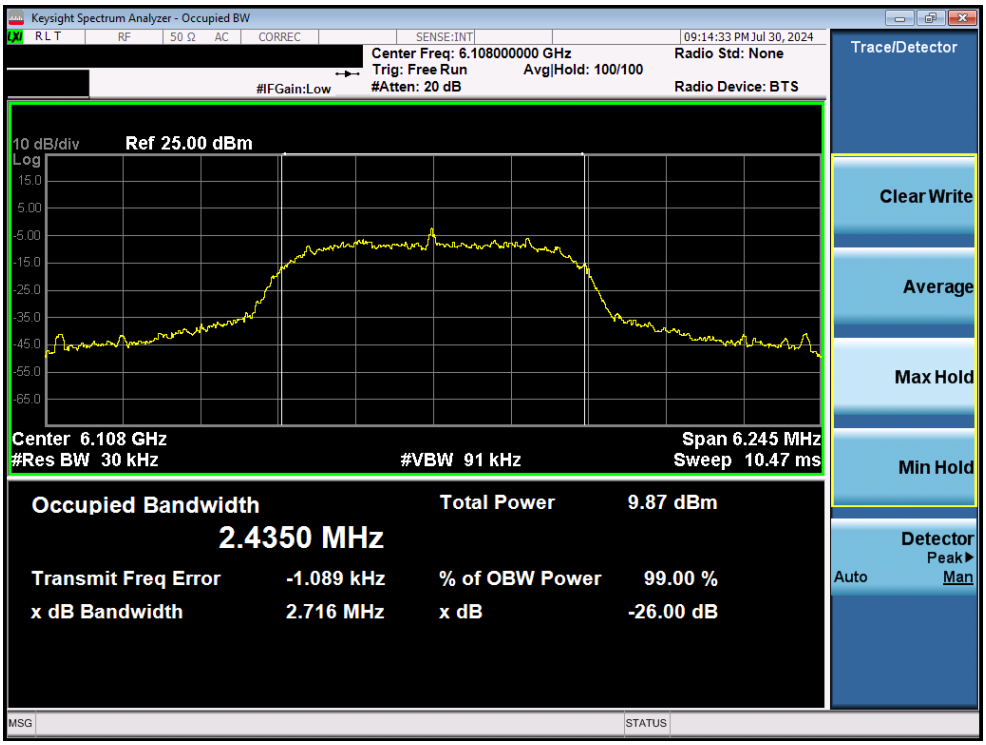
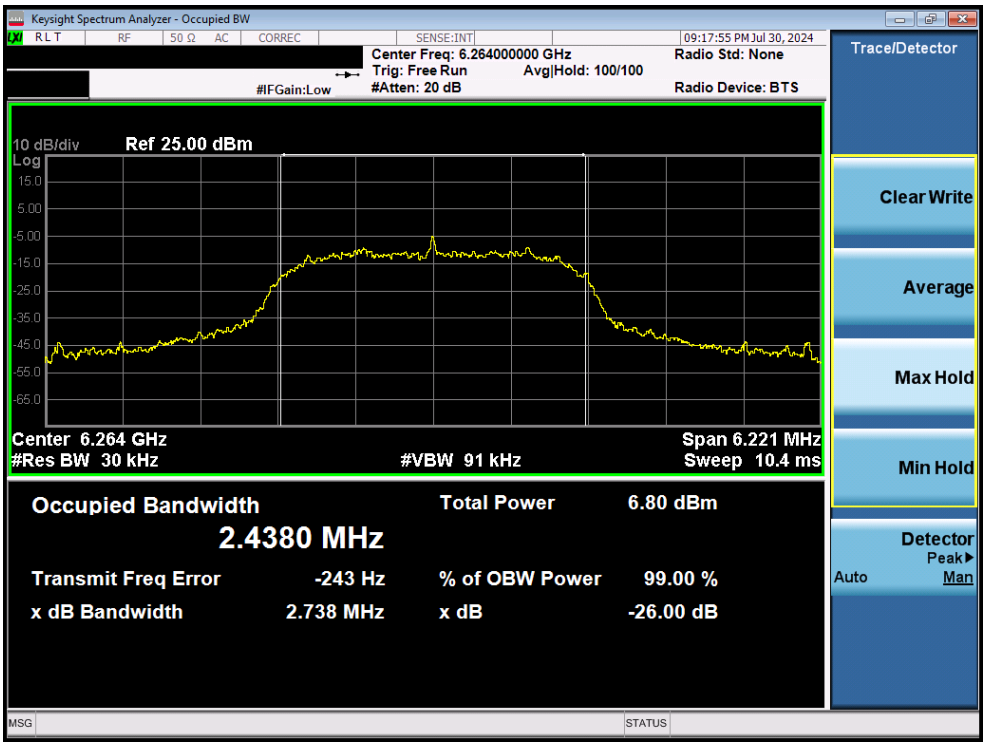


Plot 7-13. 26dB BW & 99% OBW (NB UNII HDRp4 – 6108MHz)



Plot 7-14. 26dB BW & 99% OBW (NB UNII HDRp4 – 6264MHz)

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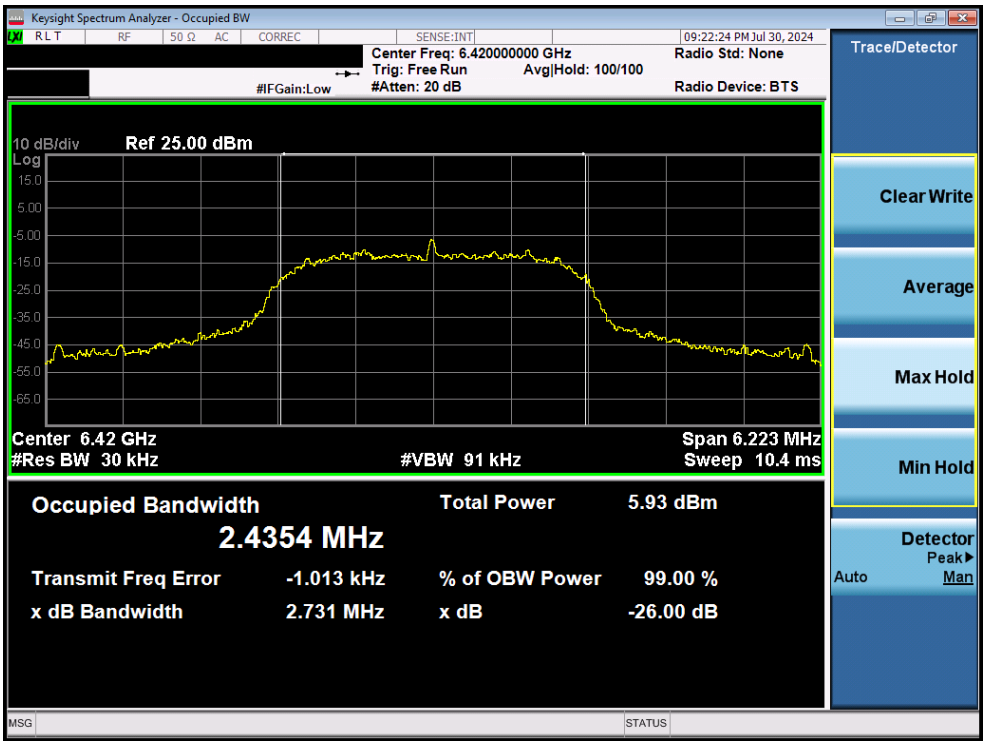

Plot 7-15. 26dB BW & 99% OBW (NB UNII HDRp4 – 6420MHz)

Plot 7-16. 26dB BW & 99% OBW (NB UNII HDRp8 – 6108MHz)

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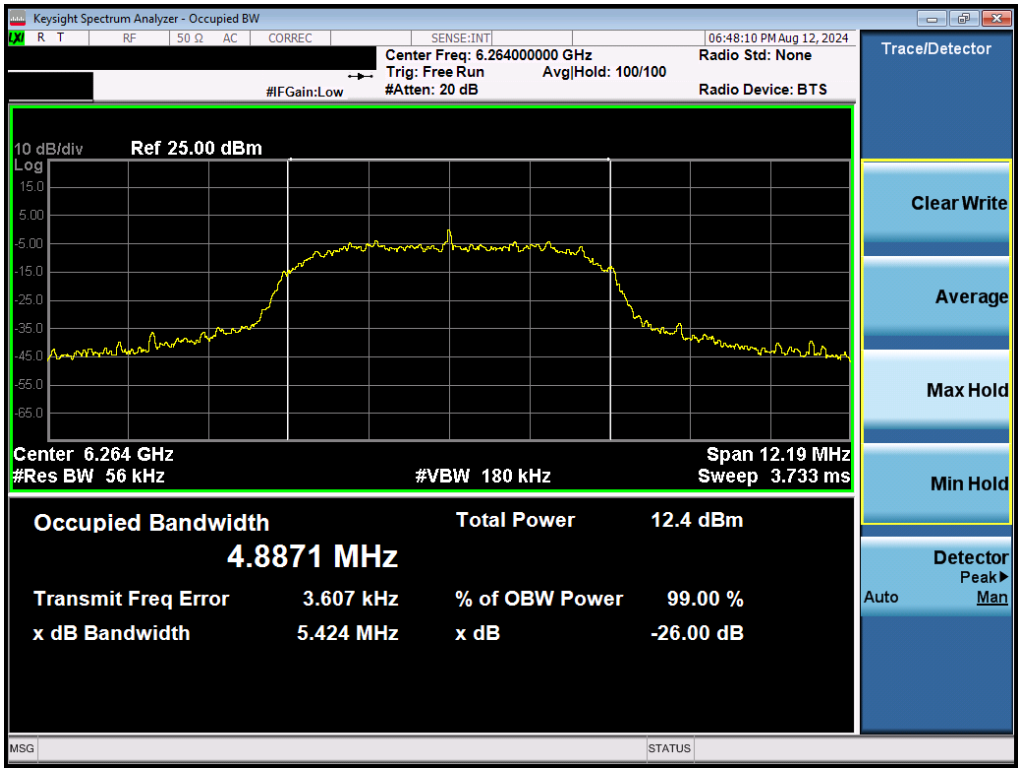
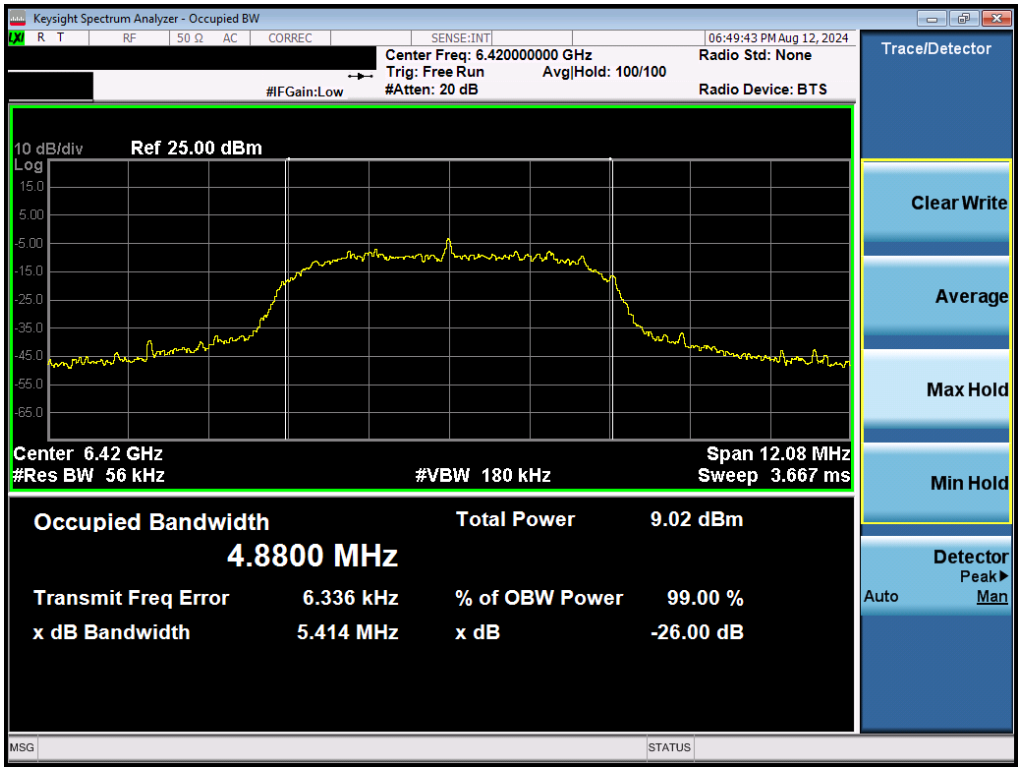


Plot 7-17. 26dB BW & 99% OBW (NB UNII HDRp8 – 6264MHz)



Plot 7-18. 26dB BW & 99% OBW (NB UNII HDRp8 – 6420MHz)

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7.3 Conducted Output Power and Max EIRP Measurement

§15.407(a.9)

Test Overview and Limits

A transmitter antenna terminal of the EUT is connected to the input of an RF pulse power sensor. Measurement is made using a broadband average power meter while the EUT is operating at its maximum duty cycle, at its maximum power control level, as defined in ANSI C63.10-2020 and KDB 789033 D02 v02r01, and at the appropriate frequencies.

In the 5.925 – 7.125GHz band, the maximum e.i.r.p. over the frequency band of operation must not exceed 14dBm for very low power devices.

Test Procedure Used

ANSI C63.10-2020 – Subclause 12.4.3.2 Method PM-G
KDB 789033 D02 v02r01 – Section E)3)b) Method PM-G

Test Settings

Average power measurements were performed only when the EUT was transmitting at its maximum power control level using a broadband power meter with a pulse sensor. The power meter implemented triggering and gating capabilities which were set up such that power measurements were recorded only during the ON time of the transmitter. The trace was averaged over 100 traces to obtain the final measured average power.

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

Figure 7-2. Test Instrument & Measurement Setup

Test Notes

None

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7.3.1 Conducted Output Power Measurements

Frequency [MHz]	Detector	Mode	Conducted Powers [dBm]	Ant. Gain [dBi]	Max e.i.r.p. [dBm]	Max e.i.r.p. Limit [dBm]	e.i.r.p. Margin [dB]
6108	AVG	NB UNII BDR	-3.19	-3.10	-6.29	14.00	-20.29
6264	AVG	NB UNII BDR	-3.38	-3.10	-6.48	14.00	-20.48
6420	AVG	NB UNII BDR	-3.58	-2.70	-6.28	14.00	-20.28
6108	AVG	NB UNII LE-2M	-3.34	-3.10	-6.44	14.00	-20.44
6264	AVG	NB UNII LE-2M	-3.39	-3.10	-6.49	14.00	-20.49
6420	AVG	NB UNII LE-2M	-3.68	-2.70	-6.38	14.00	-20.38
6108	AVG	NB UNII HDR4	-0.52	-3.10	-3.62	14.00	-17.62
6264	AVG	NB UNII HDR4	-0.87	-3.10	-3.97	14.00	-17.97
6420	AVG	NB UNII HDR4	-1.08	-2.70	-3.78	14.00	-17.78
6108	AVG	NB UNII HDR8	1.76	-3.10	-1.34	14.00	-15.34
6264	AVG	NB UNII HDR8	1.67	-3.10	-1.43	14.00	-15.43
6420	AVG	NB UNII HDR8	1.44	-2.70	-1.26	14.00	-15.26
6108	AVG	NB UNII HDRp4	-0.55	-3.10	-3.65	14.00	-17.65
6264	AVG	NB UNII HDRp4	-0.82	-3.10	-3.92	14.00	-17.92
6420	AVG	NB UNII HDRp4	-1.18	-2.70	-3.88	14.00	-17.88
6108	AVG	NB UNII HDRp8	1.75	-3.10	-1.35	14.00	-15.35
6264	AVG	NB UNII HDRp8	1.68	-3.10	-1.42	14.00	-15.42
6420	AVG	NB UNII HDRp8	1.45	-2.70	-1.25	14.00	-15.25

Table 7-3. FCC Maximum E.I.R.P.

Sample e.i.r.p. Calculation:

At 6108 MHz for NB UNII BDR, the average conducted output power was measured to be -3.19 dBm with a gain of -3.10 dBi.

e.i.r.p. (dBm) = Conducted Power (dBm) + Ant gain (dBi)

-3.19 dBm + -3.10 dBi = -6.29 dBm

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7.4 Maximum Power Spectral Density

§15.407(a.9)

Test Overview and Limit

The spectrum analyzer was connected to the antenna terminal while the EUT was operating at its maximum duty cycle, at its maximum power control level, as defined in ANSI C63.10-2020 and KDB 789033 D02 v02r01, and at the appropriate frequencies. Method SA-1, as defined in ANSI C63.10-2020 and KDB 789033 D02 v02r01, was used to measure the power spectral density.

In the 5.925 – 7.125GHz band, the maximum permissible power spectral density must not exceed -5 dBm e.i.r.p in any 1-megahertz band for Very Low Power (VLP) devices.

Test Procedure Used

ANSI C63.10-2020 – Section 12.4.2.2
KDB 789033 D02 v02r01 – Section F

Test Settings

1. Analyzer was set to the center frequency of the UNII channel under investigation
2. Span was set to encompass the entire emission bandwidth of the signal
3. RBW = 1MHz
4. VBW ≥ 3MHz
5. Number of sweep points ≥ 2 x (span/RBW)
6. Sweep time = auto
7. Detector = power averaging (RMS)
8. Trigger was set to free run for all modes
9. Trace was averaged over 100 sweeps
10. The peak search function of the spectrum analyzer was used to find the peak of the spectrum.

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

Figure 7-3. Test Instrument & Measurement Setup

Test Notes

None.

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7.4.1 Power Spectral Density Measurements

	Frequency [MHz]	Data Rate [Mbps]	Mode	Measured Power Density [dBm/MHz]	Antenna Gain [dBi]	e.i.r.p Density [dBm/MHz]	Max Permissible Power Density [dBm/MHz]	Margin [dB]
Band 5	6108	1.0	NB UNII BDR	-3.43	-3.10	-6.53	-5	-1.53
	6264	1.0	NB UNII BDR	-3.18	-3.10	-6.28	-5	-1.28
	6420	1.0	NB UNII BDR	-3.22	-2.70	-5.92	-5	-0.92
	6108	2.0	NB UNII LE-2M	-5.10	-3.10	-8.20	-5	-3.20
	6264	2.0	NB UNII LE-2M	-4.64	-3.10	-7.74	-5	-2.74
	6420	2.0	NB UNII LE-2M	-4.91	-2.70	-7.61	-5	-2.61
	6108	4.0	NB UNII HDR4	-3.44	-3.10	-6.54	-5	-1.54
	6264	4.0	NB UNII HDR4	-3.07	-3.10	-6.17	-5	-1.17
	6420	4.0	NB UNII HDR4	-2.86	-2.70	-5.56	-5	-0.56
	6108	8.0	NB UNII HDR8	-2.83	-3.10	-5.93	-5	-0.93
	6264	8.0	NB UNII HDR8	-2.48	-3.10	-5.58	-5	-0.58
	6420	8.0	NB UNII HDR8	-3.24	-2.70	-5.94	-5	-0.94
	6108	4.0	NB UNII HDRp4	-4.29	-3.10	-7.39	-5	-2.39
	6264	4.0	NB UNII HDRp4	-4.23	-3.10	-7.33	-5	-2.33
	6420	4.0	NB UNII HDRp4	-4.05	-2.70	-6.75	-5	-1.75
	6108	8.0	NB UNII HDRp8	-4.15	-3.10	-7.25	-5	-2.25
	6264	8.0	NB UNII HDRp8	-4.11	-3.10	-7.21	-5	-2.21
	6420	8.0	NB UNII HDRp8	-4.25	-2.70	-6.95	-5	-1.95

Table 7-4. Power Spectral Density Measurements

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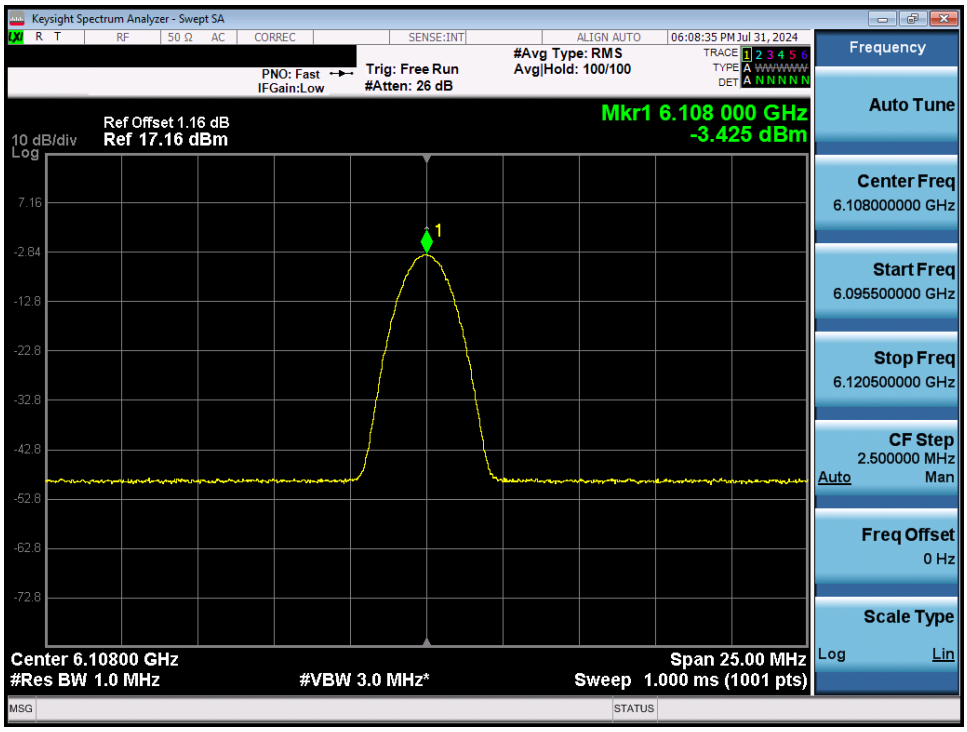
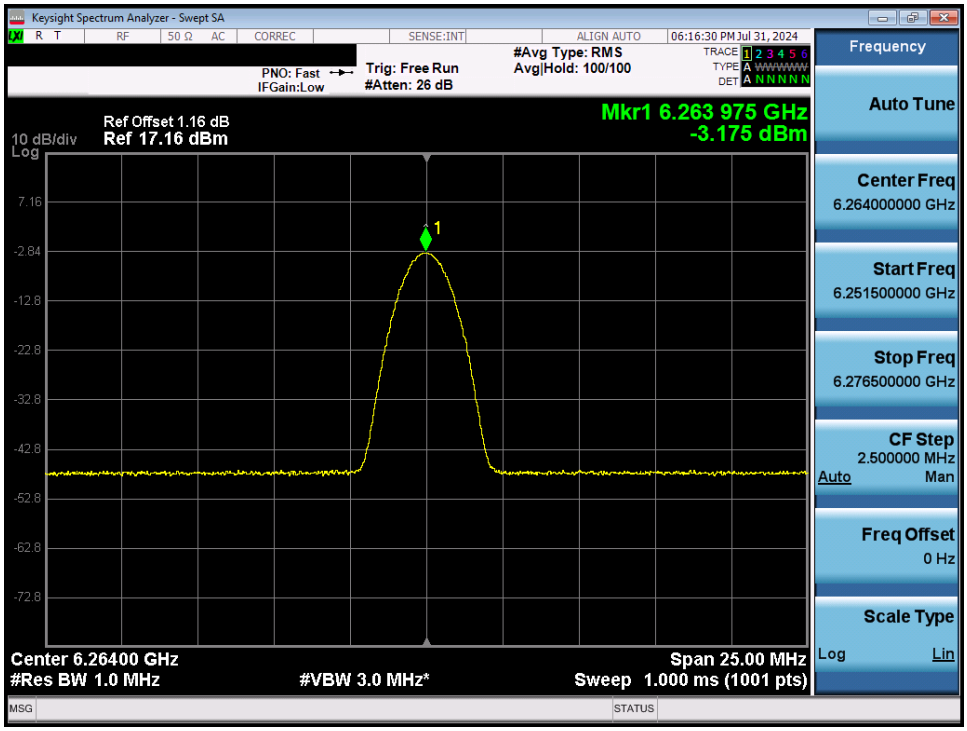


Plot 7-19. PSD (NB UNII BDR – 6108MHz)



Plot 7-20. PSD (NB UNII BDR – 6264MHz)

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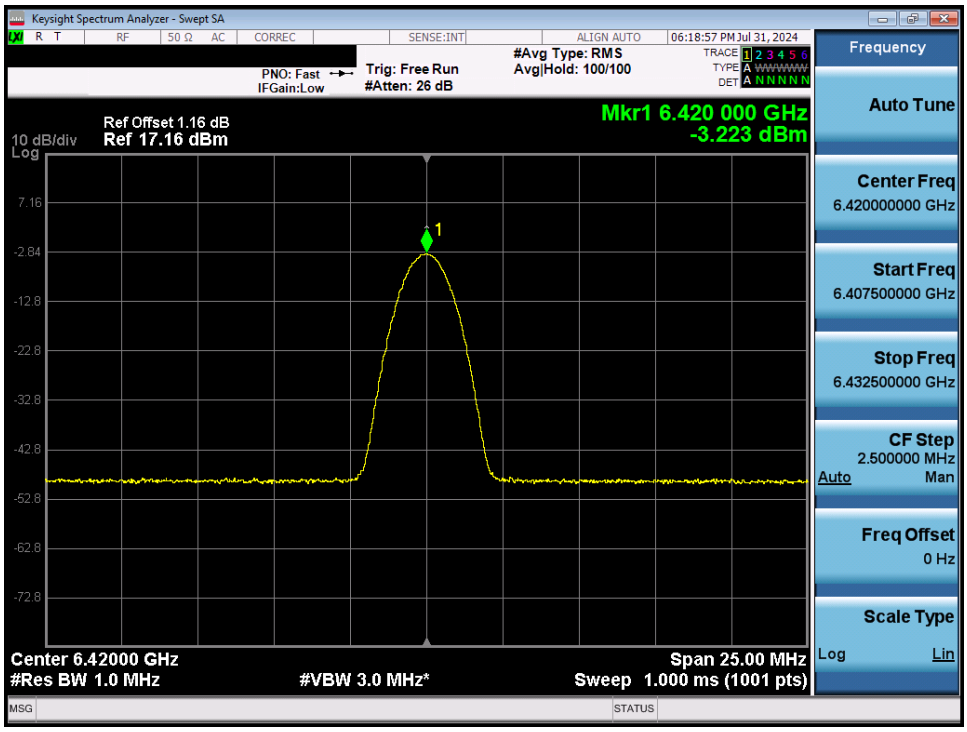
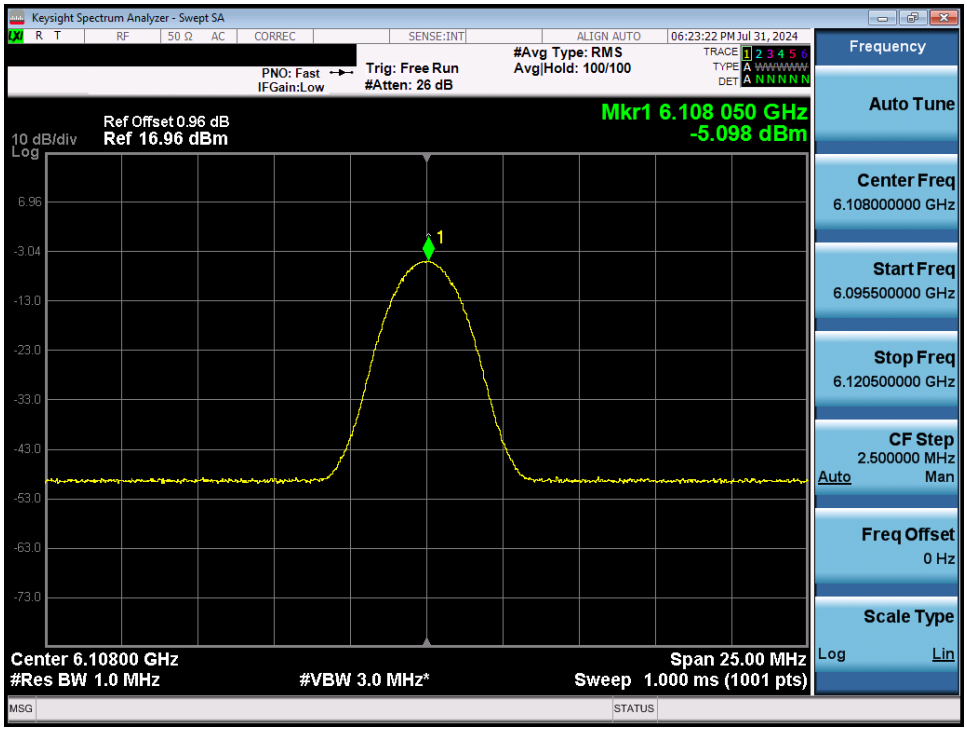


Plot 7-21. PSD (NB UNII BDR – 6420MHz)



Plot 7-22. PSD (NB UNII LE, 2Mbps – 6108MHz)

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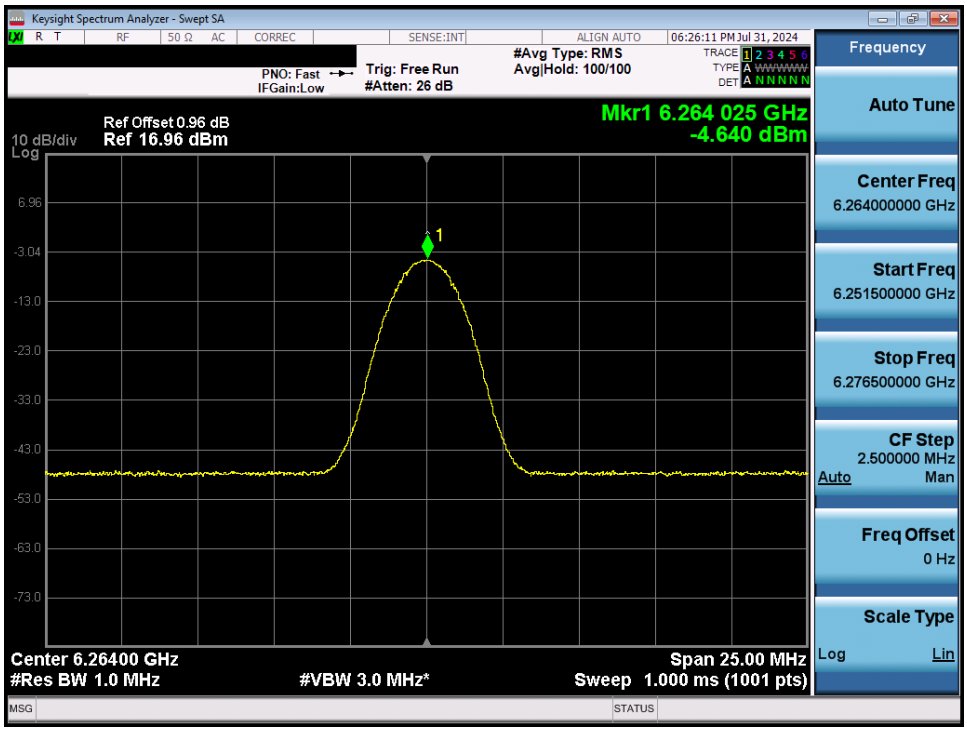
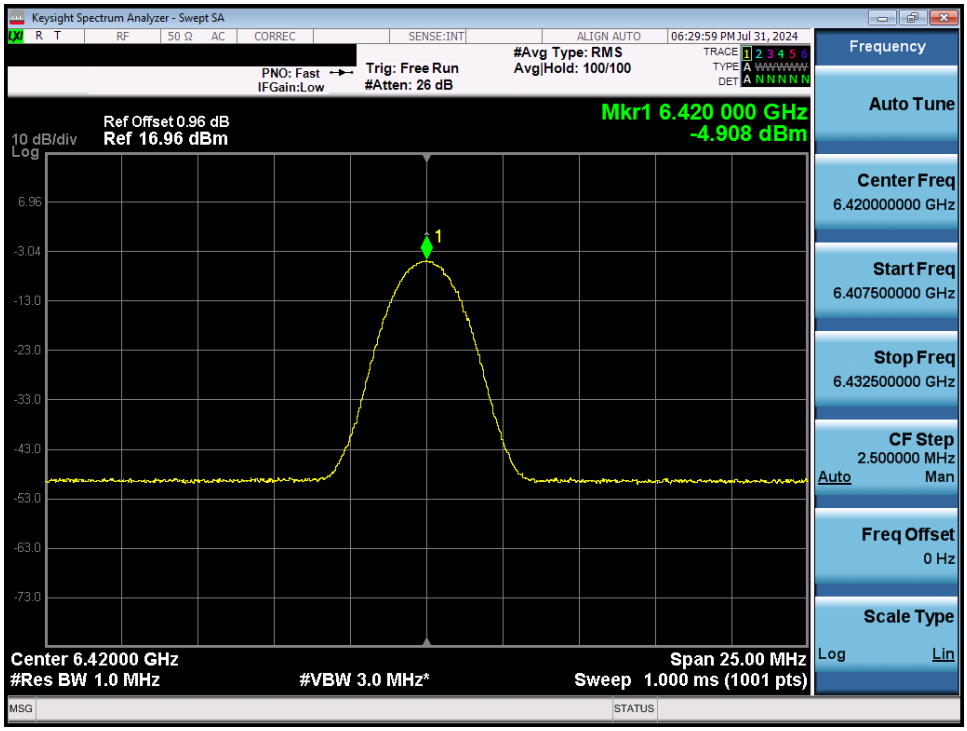


Plot 7-23. PSD (NB UNII LE, 2Mbps – 6264MHz)



Plot 7-24. PSD (NB UNII LE, 2Mbps – 6420MHz)

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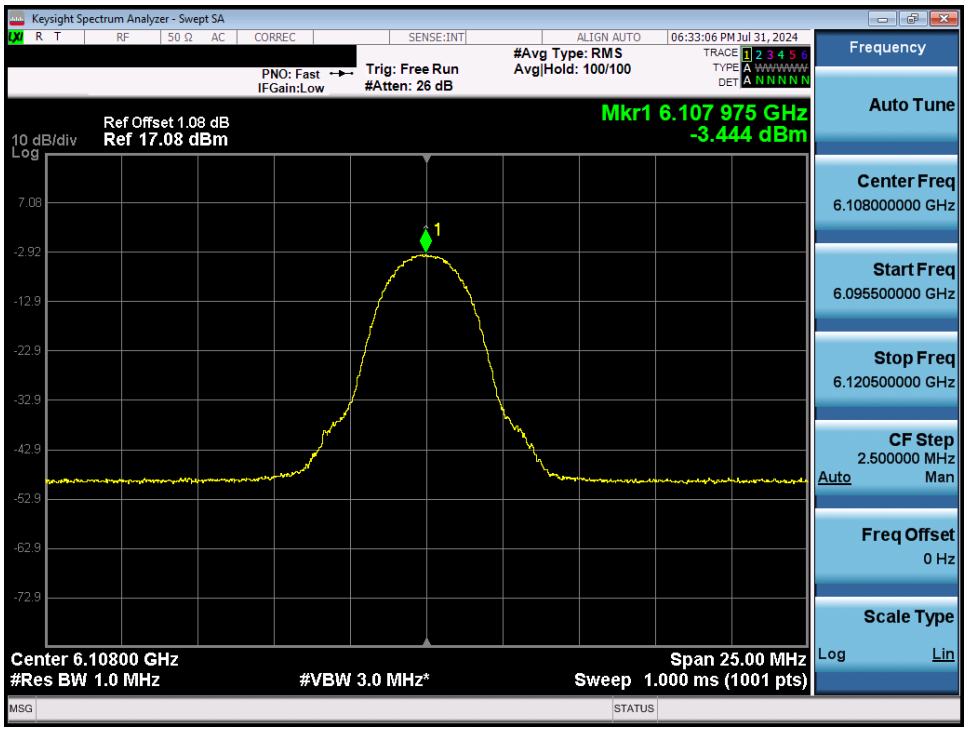
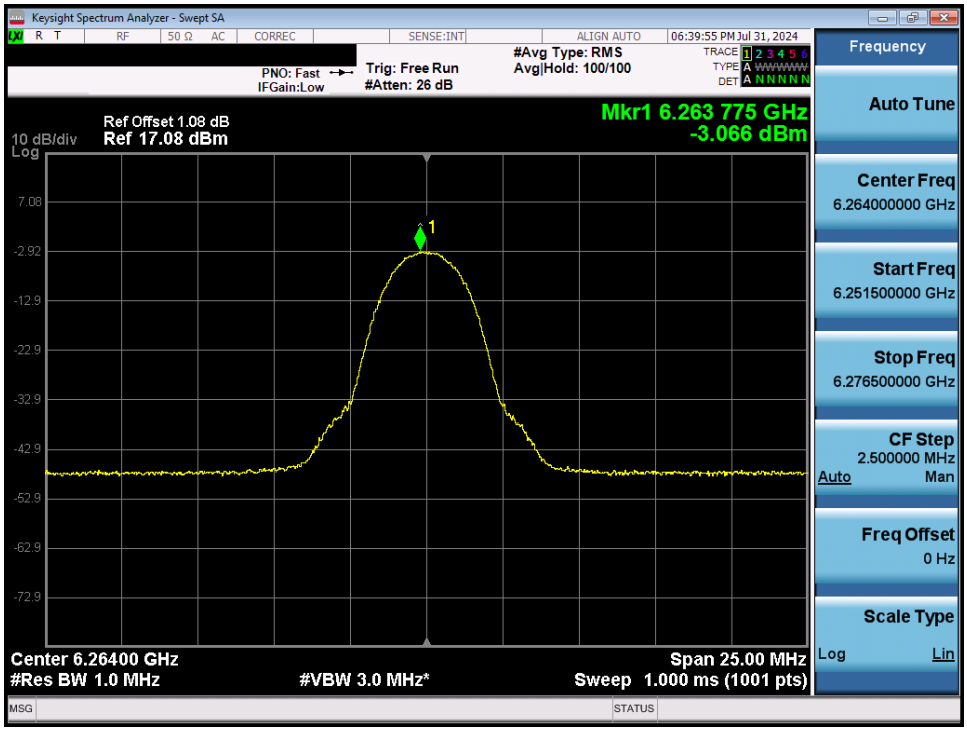


Plot 7-25. PSD (NB UNII HDR4 – 6108MHz)



Plot 7-26. PSD (NB UNII HDR4 – 6264MHz)

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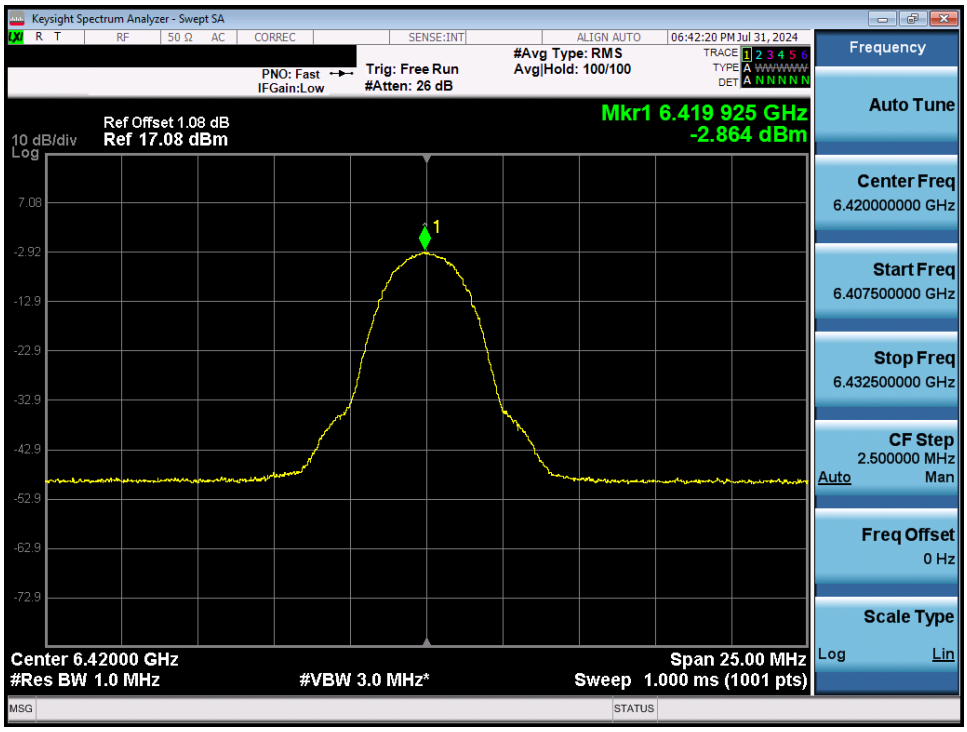
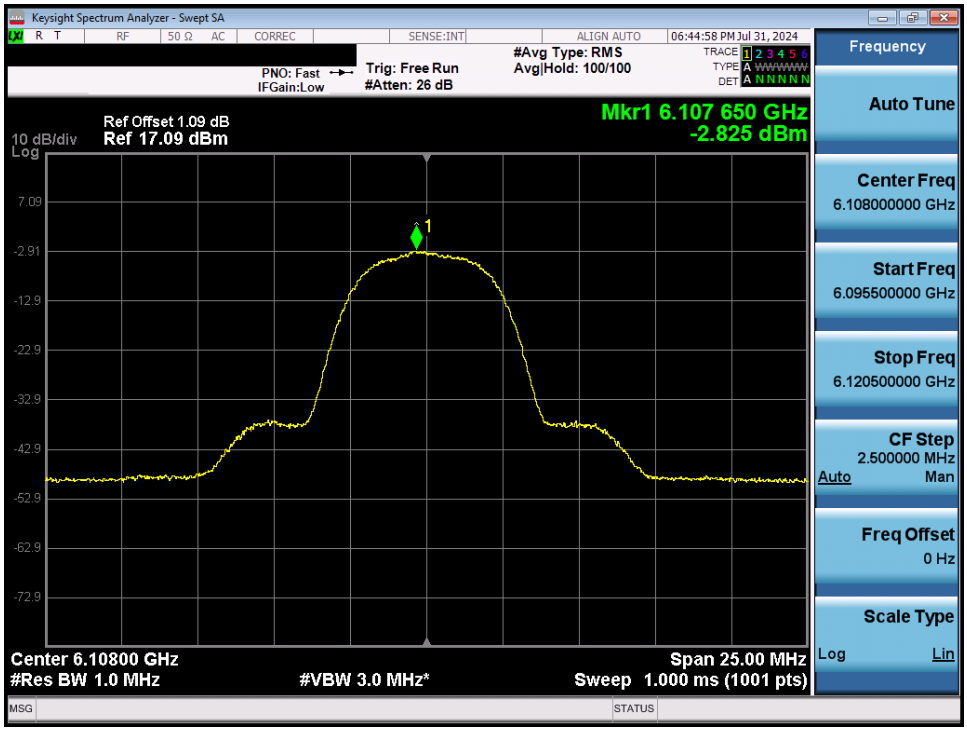


Plot 7-27. PSD (NB UNII HDR4 – 6420MHz)



Plot 7-28. PSD (NB UNII HDR8 – 6108MHz)

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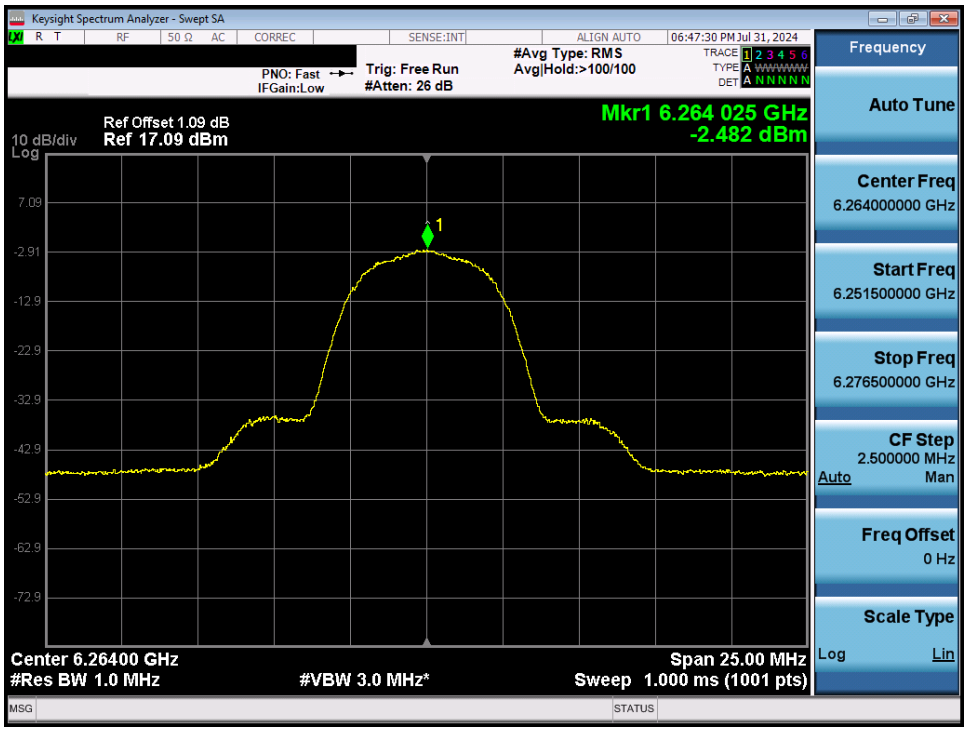
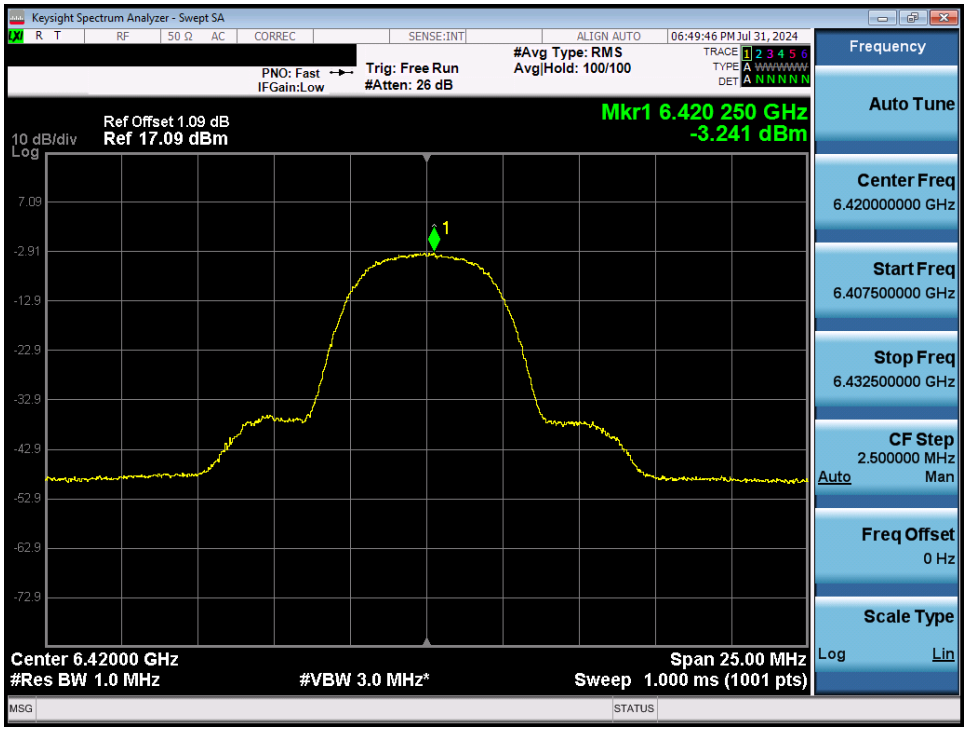


Plot 7-29. PSD (NB UNII HDR8 – 6264MHz)



Plot 7-30. PSD (NB UNII HDR8 – 6420MHz)

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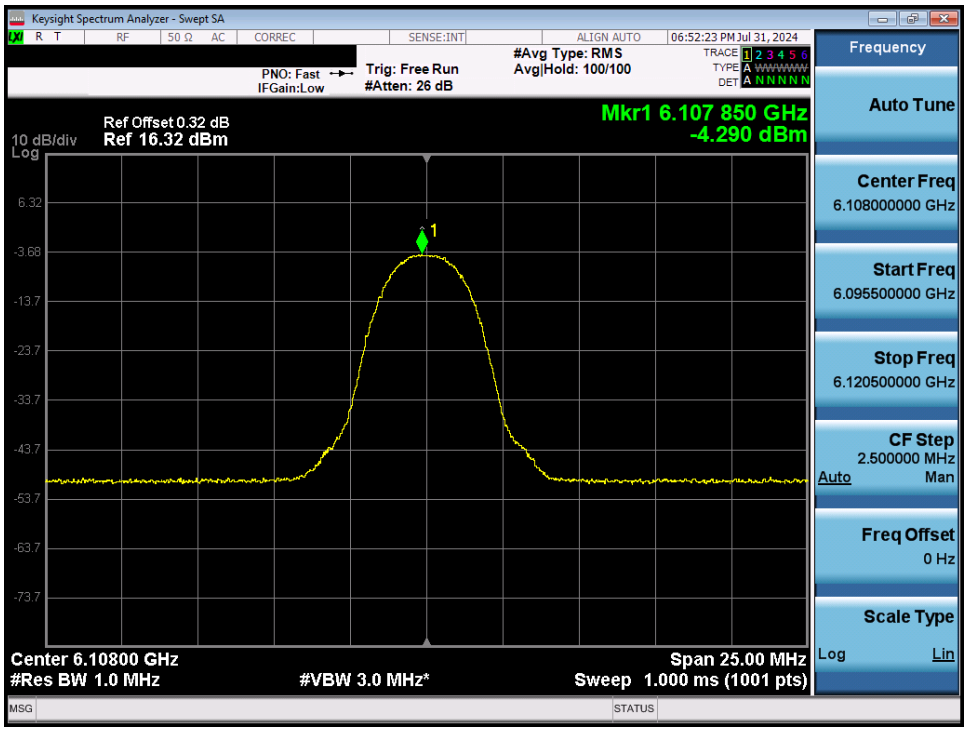
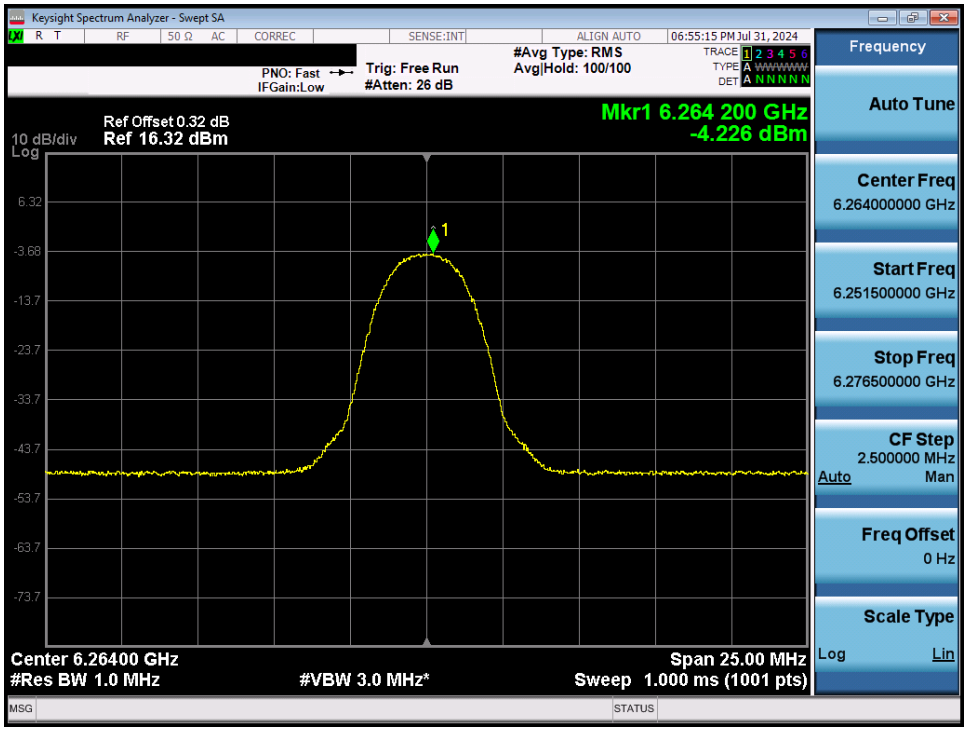


Plot 7-31. PSD (NB UNII HDRp4 – 6108MHz)



Plot 7-32. PSD (NB UNII HDRp4 – 6264MHz)

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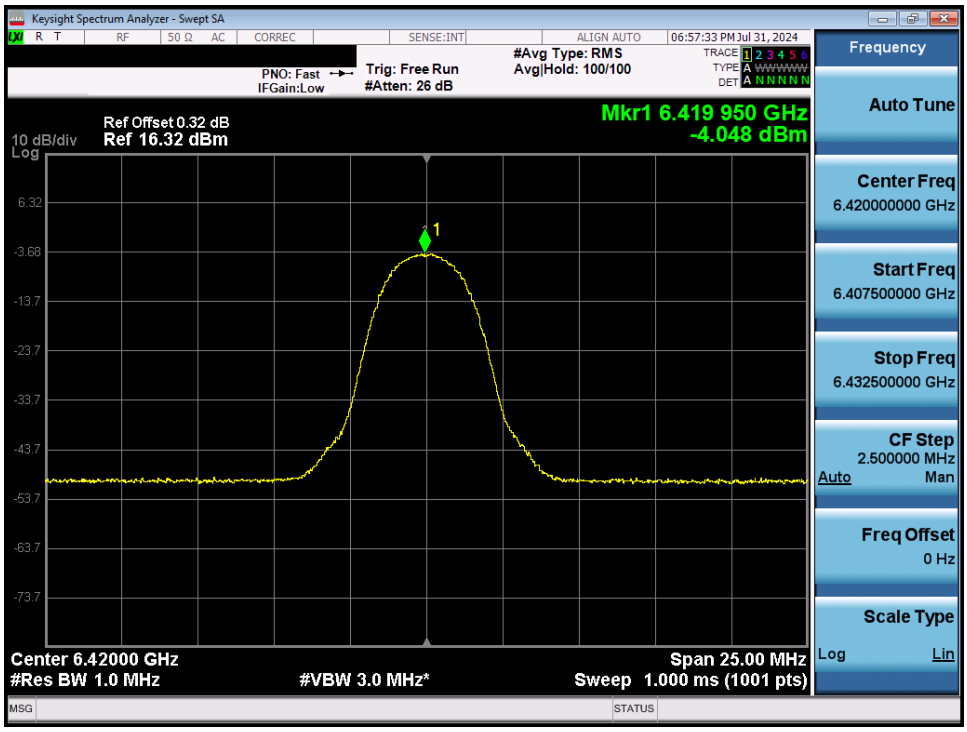
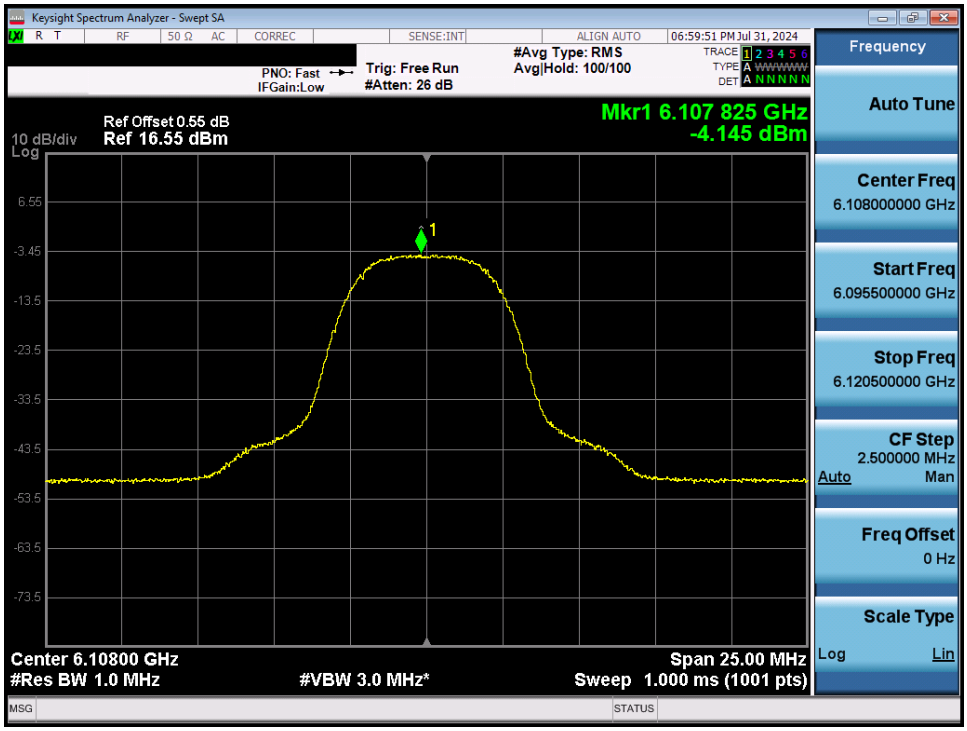


Plot 7-33. PSD (NB UNII HDRp4 – 6420MHz)



Plot 7-34. PSD (NB UNII HDRp8 – 6108MHz)

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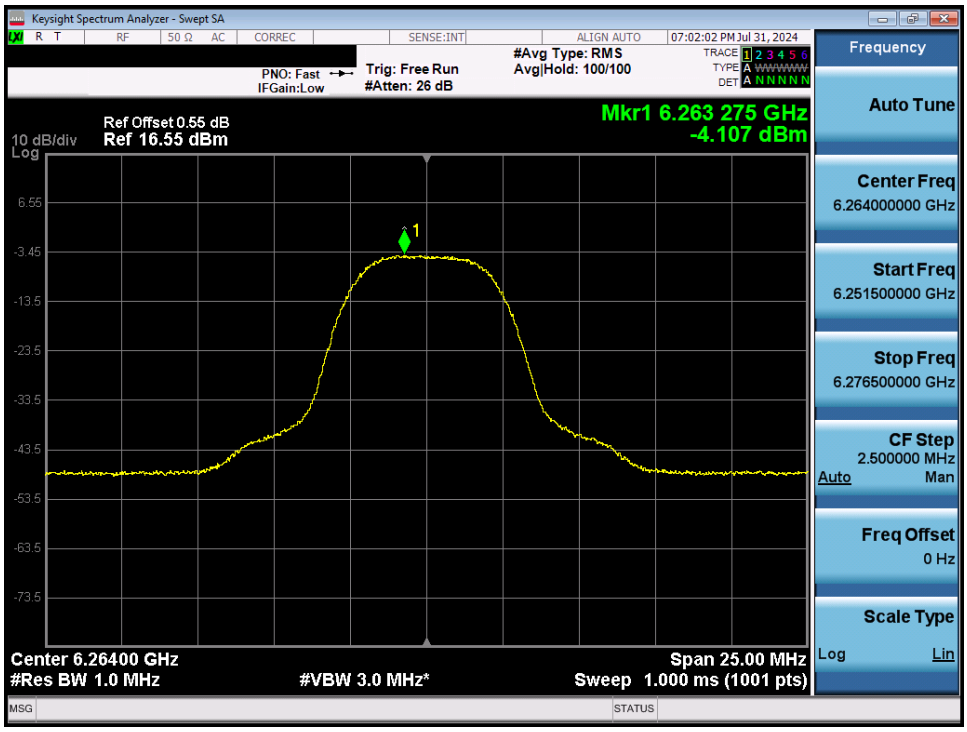
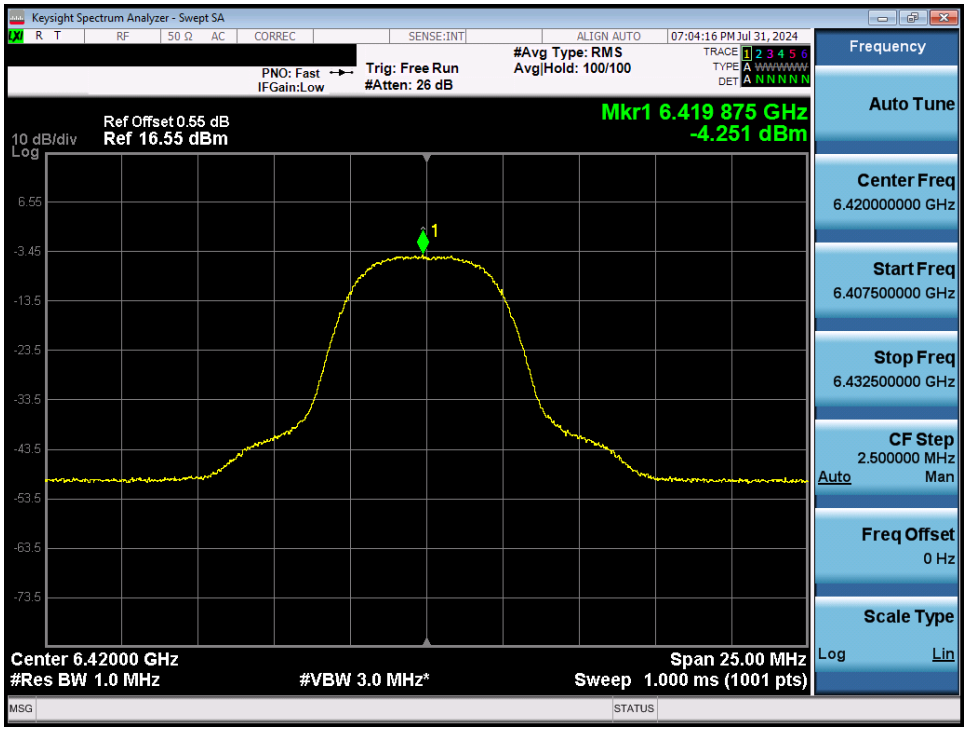


Plot 7-35. PSD (NB UNII HDRp8 – 6264MHz)



Plot 7-36. PSD (NB UNII HDRp8 – 6420MHz)

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7.5 In-Band Emissions

§15.407(b.7)

Test Overview and Limit

The spectrum analyzer was connected to the antenna terminal while the EUT was operating at its maximum duty cycle, at its maximum power control level, as defined in ANSI C63.10-2020 and KDB 789033 D02 v02r01, and at the appropriate frequencies.

For transmitters operating within the 5.925-7.125 GHz bands: Power spectral density must be suppressed by 20 dB at 1 MHz outside of channel edge, by 28 dB at one channel bandwidth from the channel center, and by 40 dB at one- and one-half times the channel bandwidth away from channel center. At frequencies between one megahertz outside an unlicensed device's channel edge and one channel bandwidth from the center of the channel, the limits must be linearly interpolated between 20 dB and 28 dB suppression, and at frequencies between one and one- and one-half times an unlicensed device's channel bandwidth, the limits must be linearly interpolated between 28 dB and 40 dB suppression. Emissions removed from the channel center by more than one- and one-half times the channel bandwidth must be suppressed by at least 40 dB.

Test Procedure Used

ANSI C63.10-2020 – Section 12.4.2.2
KDB 987594 D02 v02r01 – Section J

Test Settings

1. Connect output of the antenna port to a spectrum analyzer or EMI receiver, with appropriate attenuation, as to not damage the instrumentation.
2. Set the reference level of the measuring equipment in accordance with procedure 4.1.6.2 of ANSI C63.10-2020.
3. Measure the 26 dB EBW using the test procedure 12.5.2 of ANSI C63.10-2020. (This will be used to determine the channel edge.)
4. Measure the power spectral density (which will be used for emissions mask reference) using the following procedure:
    a) Set the span to encompass the entire 26 dB EBW of the signal.
    b) Set RBW = same RBW used for 26 dB EBW measurement.
    c) Set VBW ≥ 3 X RBW
    d) Number of points in sweep ≥ [2 X span / RBW].
    e) Sweep time = auto.
    f) Detector = RMS (i.e., power averaging)
    g) Trace average at least 100 traces in power averaging (rms) mode.
    h) Use the peak search function on the instrument to find the peak of the spectrum.
5. For the purposes of developing the emission mask, the channel bandwidth is defined as the 26 dB EBW.
6. Using the measuring equipment limit line function, develop the emissions mask based on the following requirements. The emissions power spectral density must be reduced below the peak power spectral density (in dB) as follows:
    i) Suppressed by 20 dB at 1 MHz outside of the channel edge. (The channel edge is defined as the 26-dB point on either side of the carrier center frequency.)
    j) Suppressed by 28 dB at one channel bandwidth from the channel center.
    k) Suppressed by 40 dB at one- and one-half times the channel bandwidth from the channel center.
7. Adjust the span to encompass the entire mask as necessary.
8. Clear trace.
9. Trace average at least 100 traces in power averaging (rms) mode.
10. Adjust the reference level as necessary so that the crest of the channel touches the top of the emission mask.

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Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

Figure 7-4. Test Instrument & Measurement Setup

Test Notes

None.

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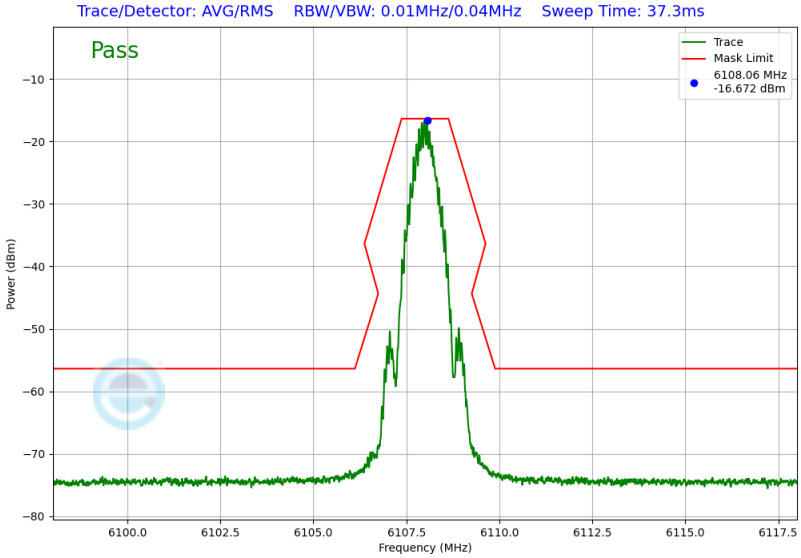
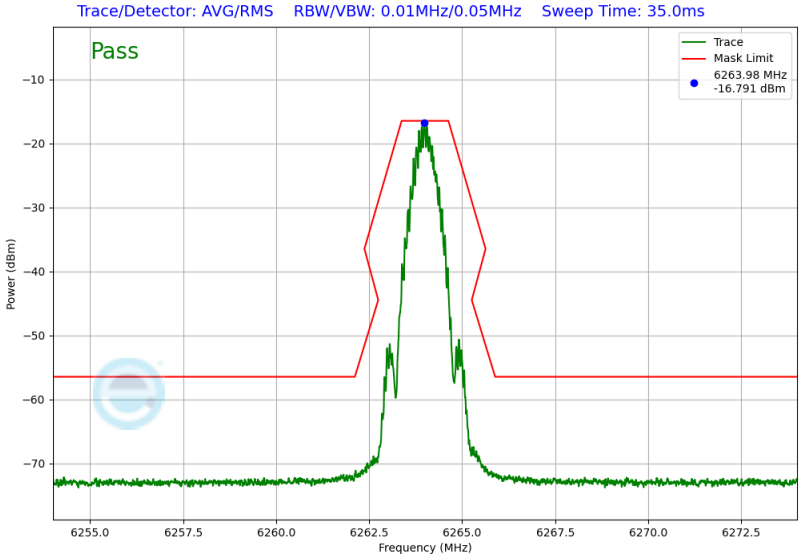
7.5.1 In-Band Emission Measurements



Plot 7-37. VLP In-Band Emission Plot (NB UNII BDR – 6108MHz)



Plot 7-38. VLP In-Band Emission Plot (NB UNII BDR – 6264MHz)

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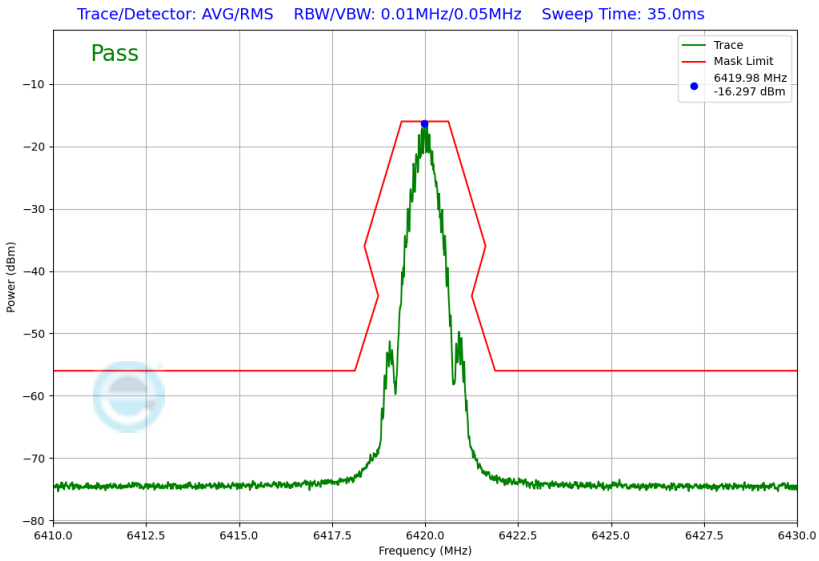
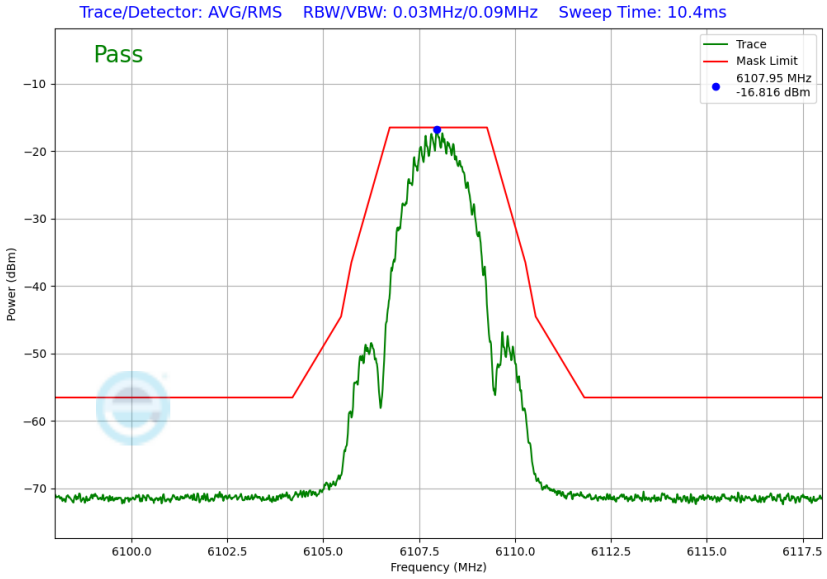


Plot 7-39. VLP In-Band Emission Plot (NB UNII BDR – 6420MHz)



Plot 7-40. VLP In-Band Emission Plot (NB UNII LE, 2Mbps – 6108MHz)

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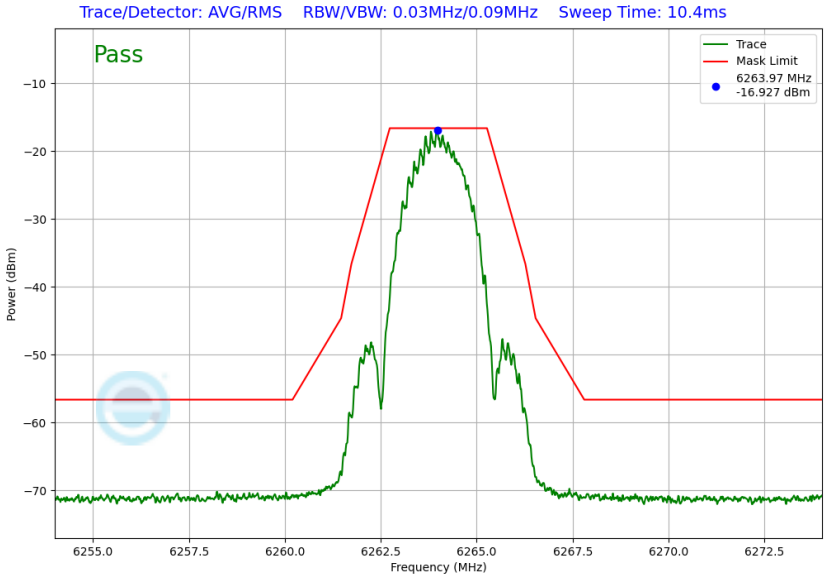
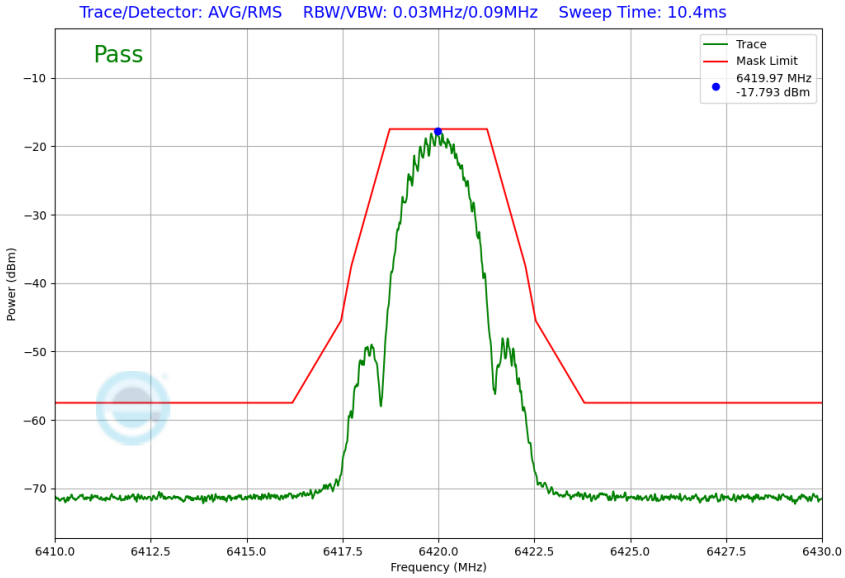


Plot 7-41. VLP In-Band Emission Plot (NB UNII LE, 2Mbps – 6264MHz)



Plot 7-42. VLP In-Band Emission Plot (NB UNII LE, 2Mbps – 6420MHz)

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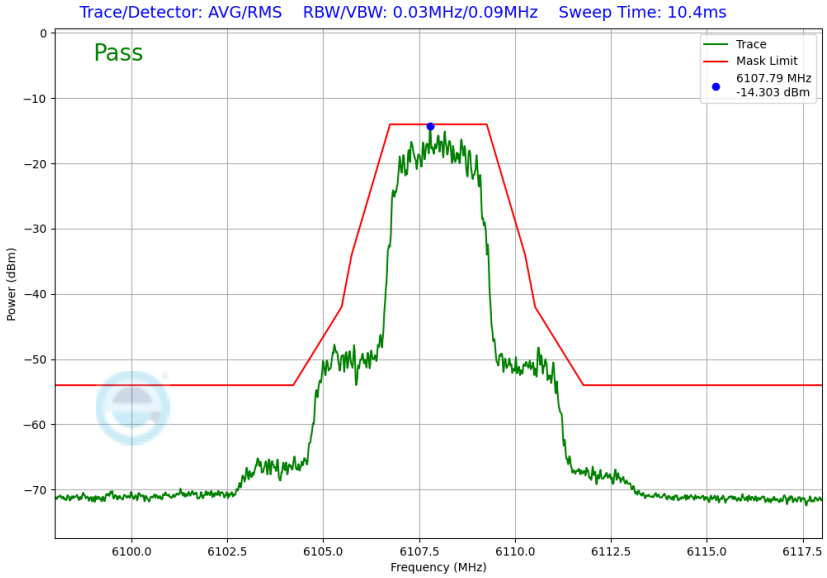
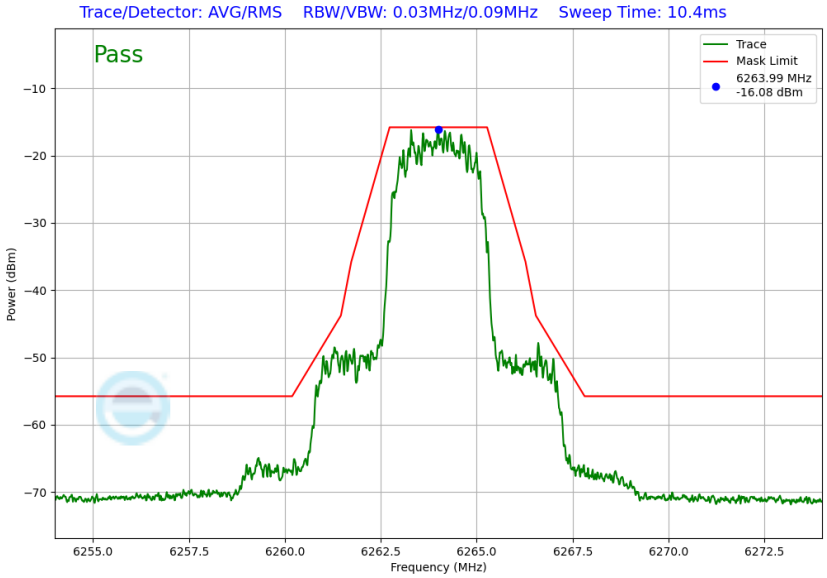


Plot 7-43. VLP In-Band Emission Plot (NB UNII HDR4 – 6108MHz)



Plot 7-44. VLP In-Band Emission Plot (NB UNII HDR4 – 6264MHz)

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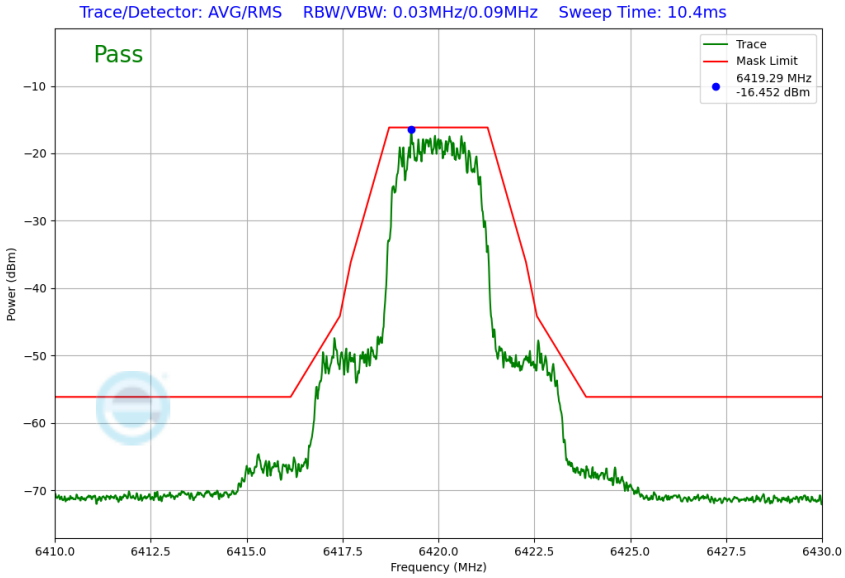
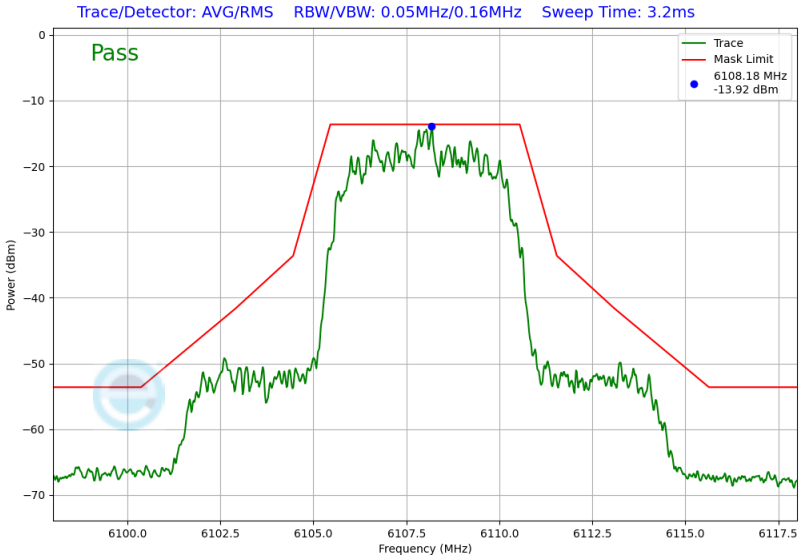


Plot 7-45. VLP In-Band Emission Plot (NB UNII HDR4 – 6420MHz)



Plot 7-46. VLP In-Band Emission Plot (NB UNII HDR8 – 6108MHz)

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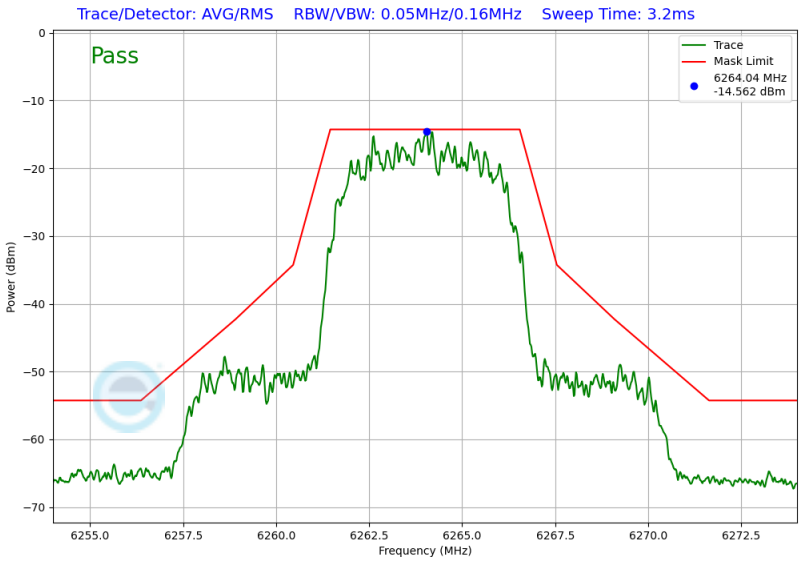
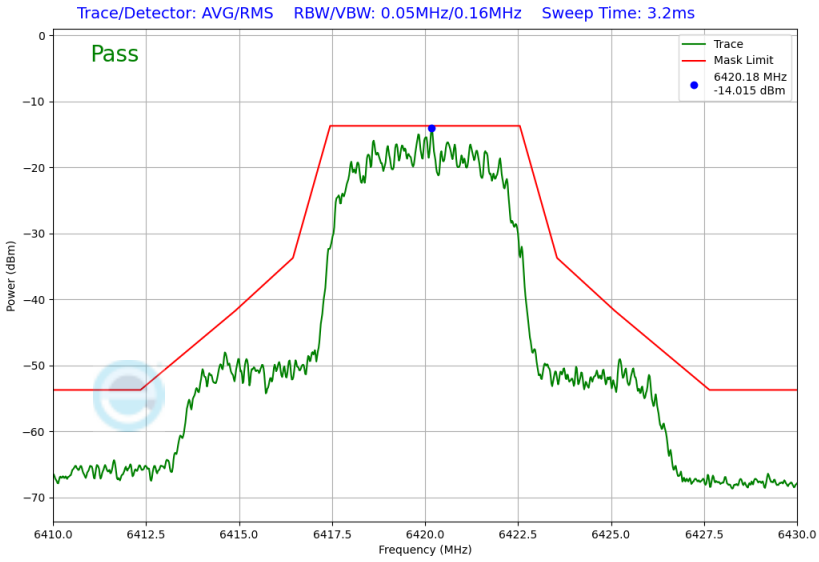


Plot 7-47. VLP In-Band Emission Plot (NB UNII HDR8 – 6264MHz)



Plot 7-48. VLP In-Band Emission Plot (NB UNII HDR8 – 6420MHz)

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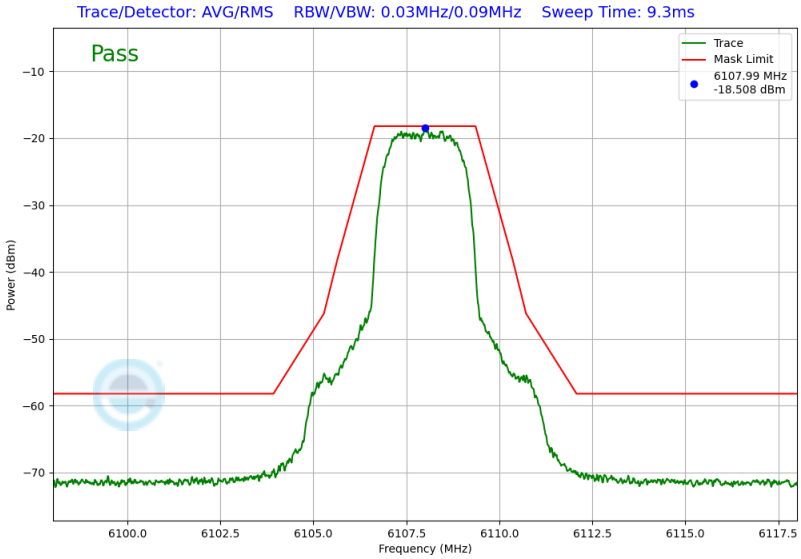
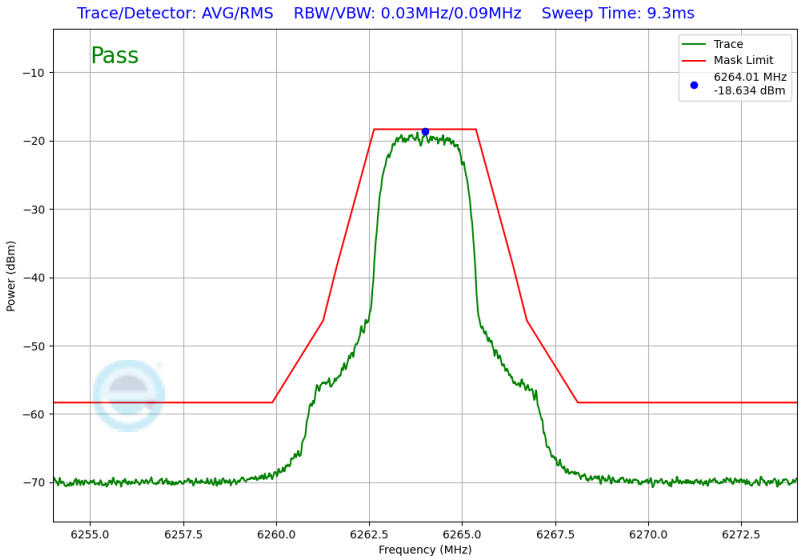


Plot 7-49. VLP In-Band Emission Plot (NB UNII HDRp4 – 6108MHz)



Plot 7-50. VLP In-Band Emission Plot (NB UNII HDRp4 – 6264MHz)

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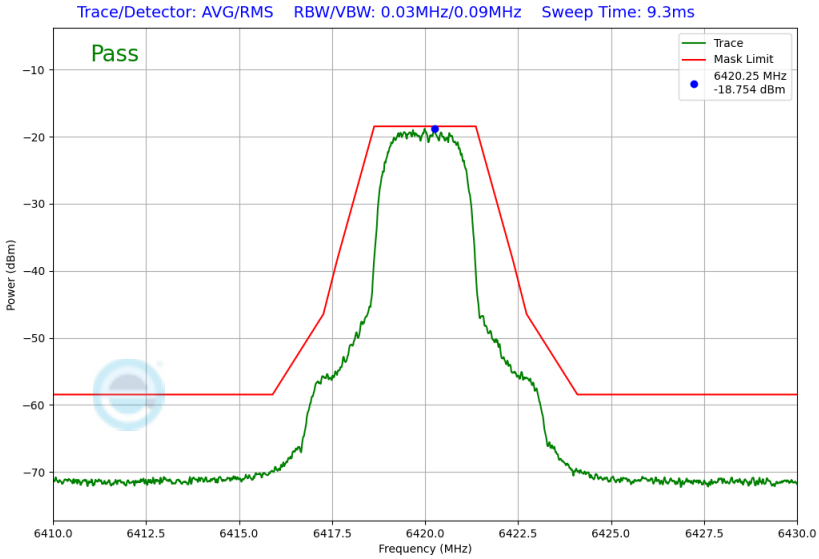
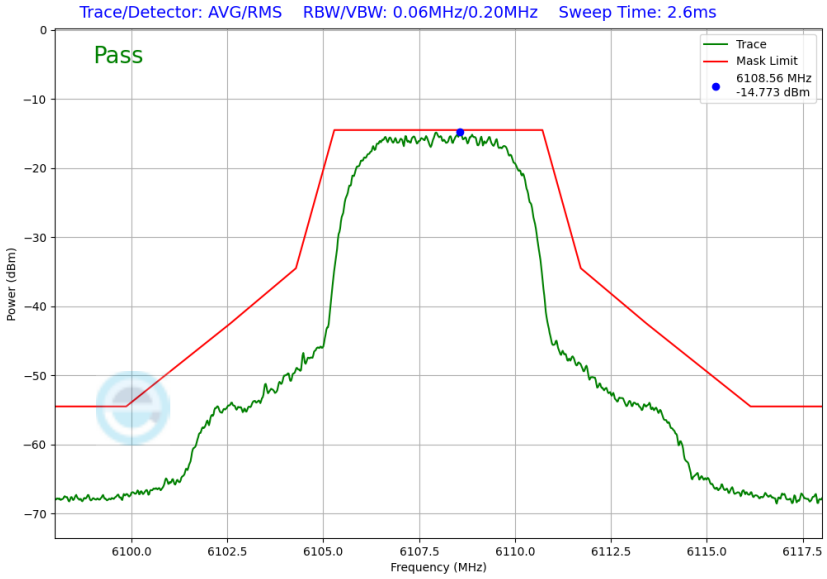


Plot 7-51. VLP In-Band Emission Plot (NB UNII HDRp4 – 6420MHz)



Plot 7-52. VLP In-Band Emission Plot (NB UNII HDRp8 – 6108MHz)

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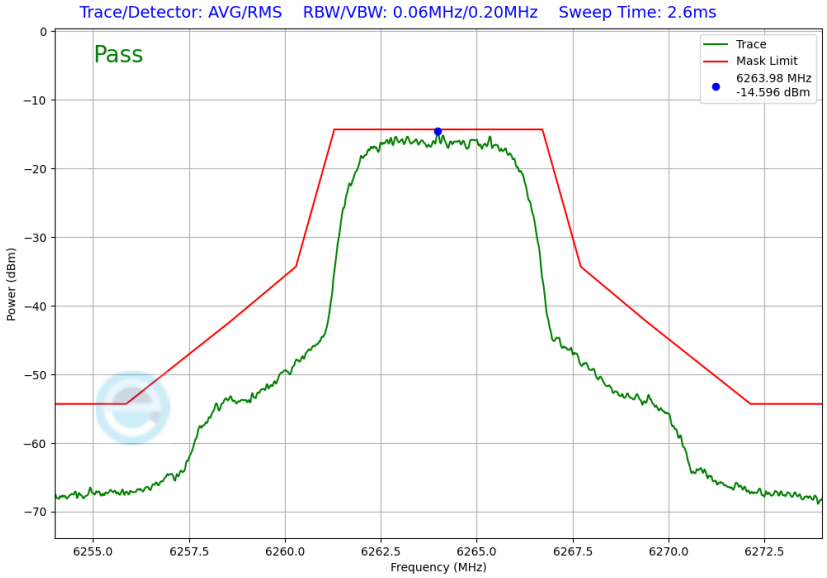
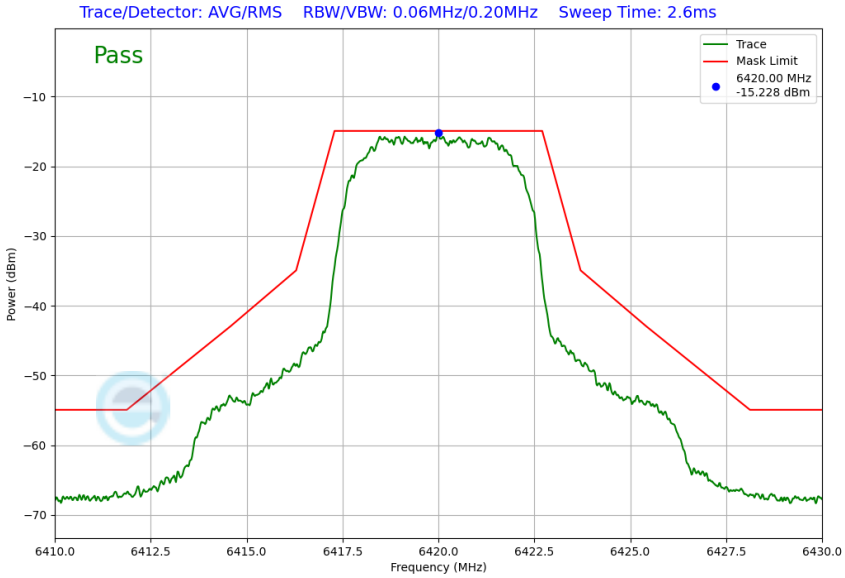


Plot 7-53. VLP In-Band Emission Plot (NB UNII HDRp8 – 6264MHz)



Plot 7-54. VLP In-Band Emission Plot (NB UNII HDRp8 – 6420MHz)

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7.6 Contention Based Protocol

§15.407(d.6)

Test Overview and Limit

Indoor access points, subordinate devices and client devices operating in the 5.925-7.125 GHz band (herein referred to as unlicensed devices) are required to use technologies that include a contention-based protocol to avoid co-channel interference with incumbent devices sharing the band. To ensure incumbent co-channel operations are detected in a technology-agnostic manner, unlicensed devices are required to detect co-channel radio frequency energy (energy detect) and avoid simultaneous transmission.

Unlicensed indoor low-power devices must detect co-channel radio frequency power that is at least -62 dBm or lower. Upon detection of energy in the band, unlicensed low power indoor devices must vacate the channel and stay off the channel as long as detected radio frequency power is equal to or greater than the threshold (-62 dBm). The -62 dBm (or lower) threshold is referenced to a 0 dBi antenna gain.

To ensure incumbent operations are reliably detected in the band, low power indoor devices must detect RF energy throughout their intended operating channel.

Test Procedure Used

ANSI C63.10-2020 – Section 12.4.2.2
KDB 987594 D02 v02r01 – Section I

Test Settings

1. Configure the EUT to transmit with a constant duty cycle.
2. Set the operating parameters of the EUT including power level, operating frequency, modulation and bandwidth
3. Set the signal analyzer center frequency to the nominal EUT channel center frequency. The span range of the signal analyzer shall be between two times and five times the OBW of the EUT.
4. Connect the output port of the EUT to the signal analyzer 2, as shown in Figure 2. Ensure that the attenuator 2 provides enough attenuation to not overload the signal analyzer 2 receiver.
5. Monitoring the signal analyzer 2, verify the EUT is operating and transmitting with the parameters set at step two.
6. Using an AWGN signal source, generate (but do not transmit, i.e., RF OFF) a 10 MHz-wide AWGN signal. Use Table 1 to determine the center frequency of the 10 MHz AWGN signal relative to the EUT's channel bandwidth and center frequency.
7. Set the AWGN signal power to an extremely low level (more than 20 dB below the -62 dBm threshold). Connect the AWGN signal source, via a 3-dB splitter, to the signal analyzer 1 and the EUT as shown in Figure 2.
8. Transmit the AWGN signal (RF ON) and verify its characteristics on the signal analyzer 1.
9. Monitor the signal analyzer 2 to verify if the AWGN signal has been detected and the EUT has ceased transmission. If the EUT continues to transmit, then incrementally increase the AWGN signal power level until the EUT stops transmitting.
10. Including all losses in the RF paths) Determine and record the AWGN signal power level (at the EUT's antenna port) at which the EUT ceased transmission. Repeat the procedure at least 10 times to verify the EUT can detect an AWGN signal with 90% (or better) level of certainty.
11. Refer to Table 1 to determine number of times the detection threshold testing needs to be repeated. If testing is required more than once, then go back to step 5, choose a different center frequency for the AWGN signal and repeat the process.

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Test Setup

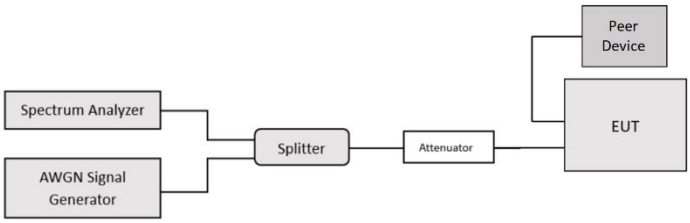

Figure 7-5. Contention-based protocol test setup, conducted method

Test Notes

1. Peer devices used was model: A2117 (refer to Table 2-4).
2. Per guidance from KDB 987594 D02 v02r01, contention-based protocol was tested using an AWGN signal with a bandwidth of 10MHz. The amplitude of the signal was increased until detected by the EUT, signaled by the ceasing of transmission, marker indicates the point at which the AWGN signal is introduced.
3. Per KDB 987594 D04 v01, contention-based protocol was tested with receiver with the lowest antenna gain.
4. 15 trials were ran in order to assure that at least 90% of certainty was met.
5. Per manufacturer's declaration, after establishing communication between the EUT and the peer device, NB UNII HDR is used to maintain communication and traffic. NB UNII BDR and NB UNII LE are used for establishing the initial connection with the peer device.
6. EUT does not support channel puncturing

Detection Level = Injected AWGN Power (dBm) – Antenna Gain (dBi) + Path Loss (dB)

Equation 7-1. Incumbent Detection Level Calculation

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Band	Incumbent Frequency [MHz]	Injected (AWGN) [dBm]	Antenna Gain [dBi]	Adjusted Power Level [dBm]	Detection Limit [dBm]	Margin [dB]
UNII Band 5	6350	-81.57	-3.30	-78.27	-62.0	-16.27

Table 7-5. Contention Based Protocol – Incumbent Detection Results

Band	EUT Transmission Status		
	Adjusted AWGN Power (dBm)		
	Normal	Minimal	Ceased
UNII Band 5	-86.65	-77.42	-78.27

Table 7-6. Contention Based Protocol – Detection Results

CBP Detection (1 = Detection, Blank = No Detection)																		
Band	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 6	Trail 7	Trail 8	Trail 9	Trail 10	Trail 11	Trail 12	Trail 13	Trail 14	Trail 15	Detection Rate [%]	Limit [%]	Pass/Fail
UNII Band 5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100.0	90	Pass

Table 7-7. Contention Based Protocol – Incumbent Detection Trials

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