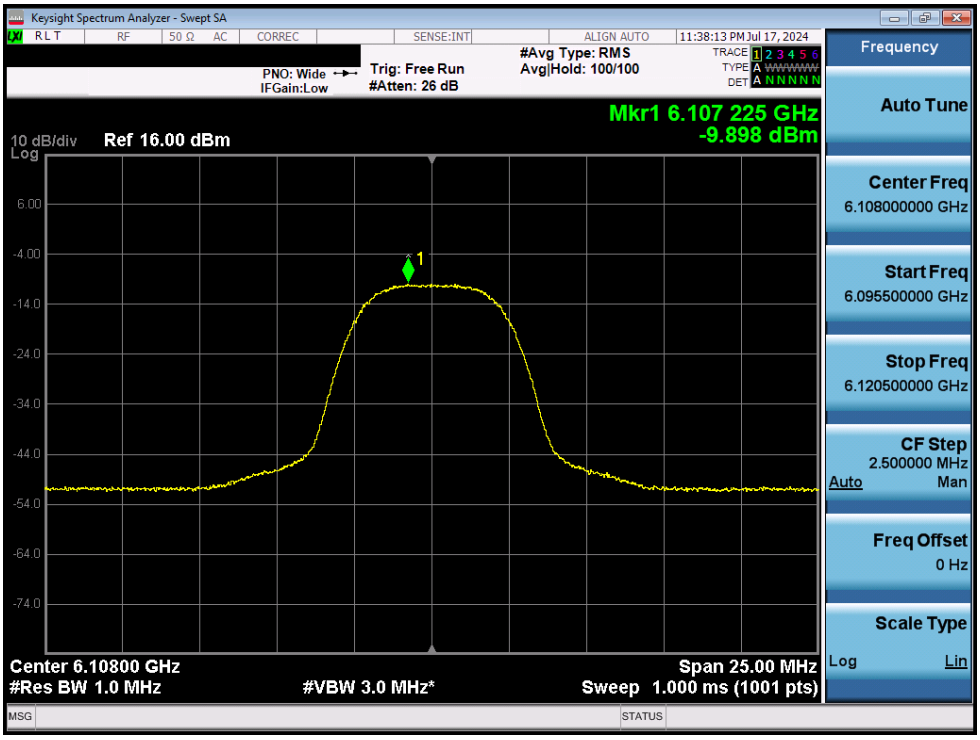
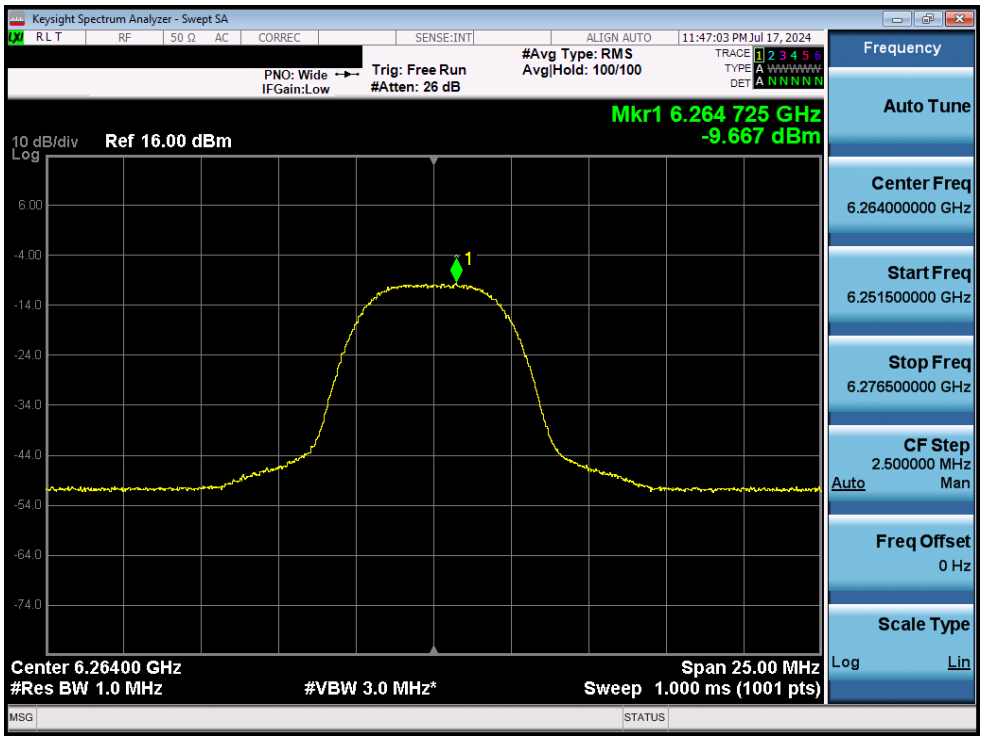
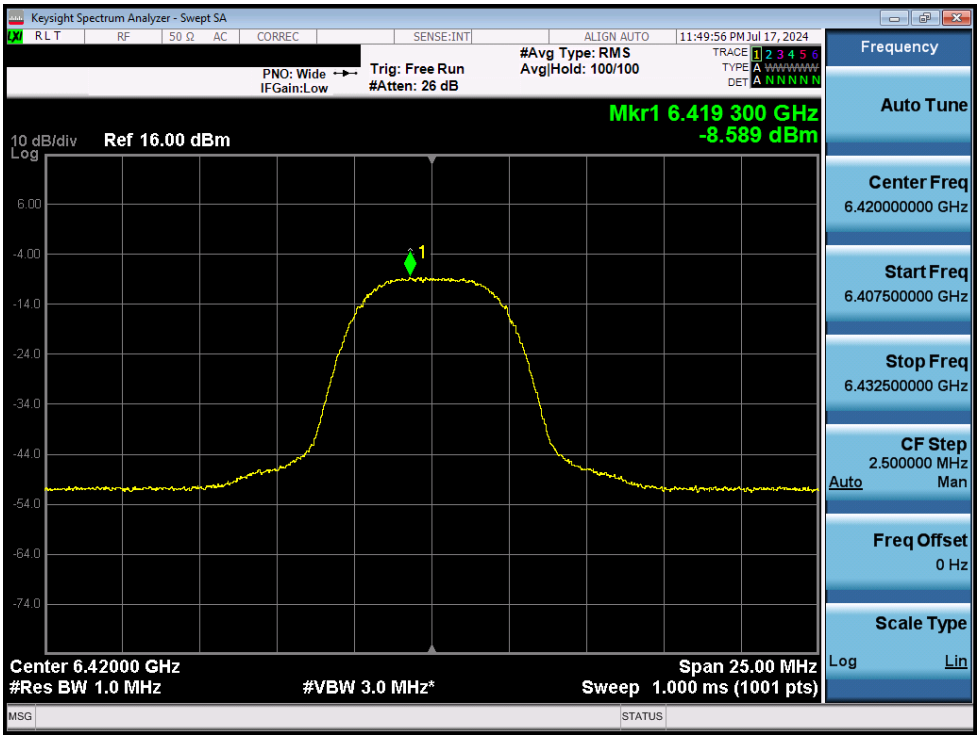


Plot 7-82. PSD (NB UNII_L HDRp8 – 6108MHz)



Plot 7-83. PSD (NB UNII_L HDRp8 – 6264MHz)



Plot 7-84. PSD (NB UNII_L HDRp8 – 6420MHz)

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.

Test Setup

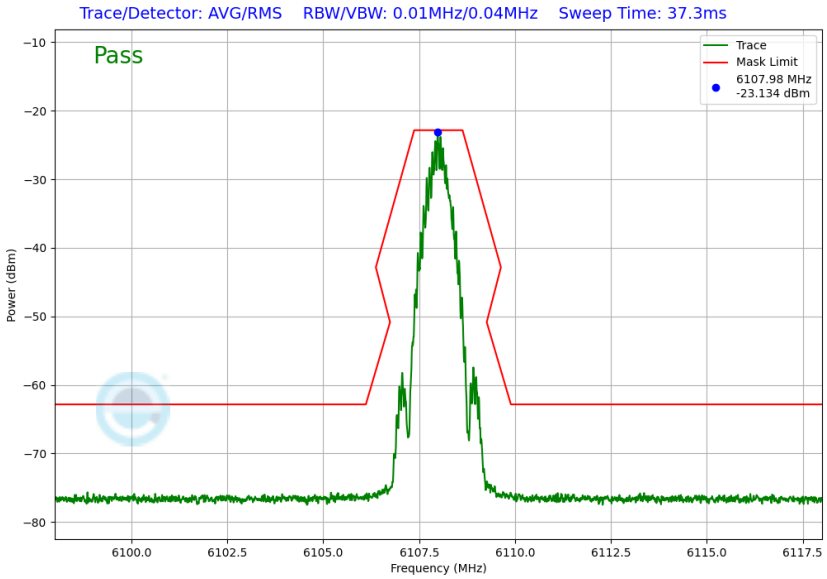
The EUT and measurement equipment were set up as shown in the diagram below.

Figure 7-4. Test Instrument & Measurement Setup

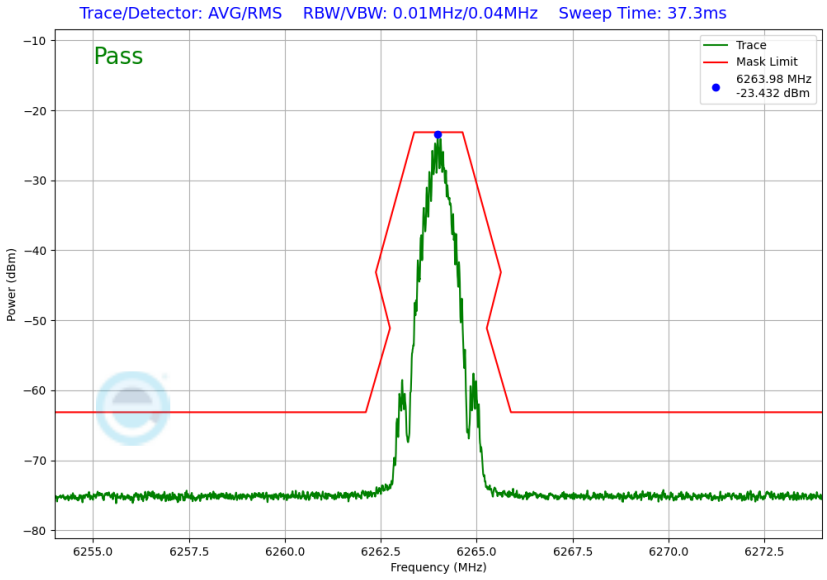
Test Notes

None.

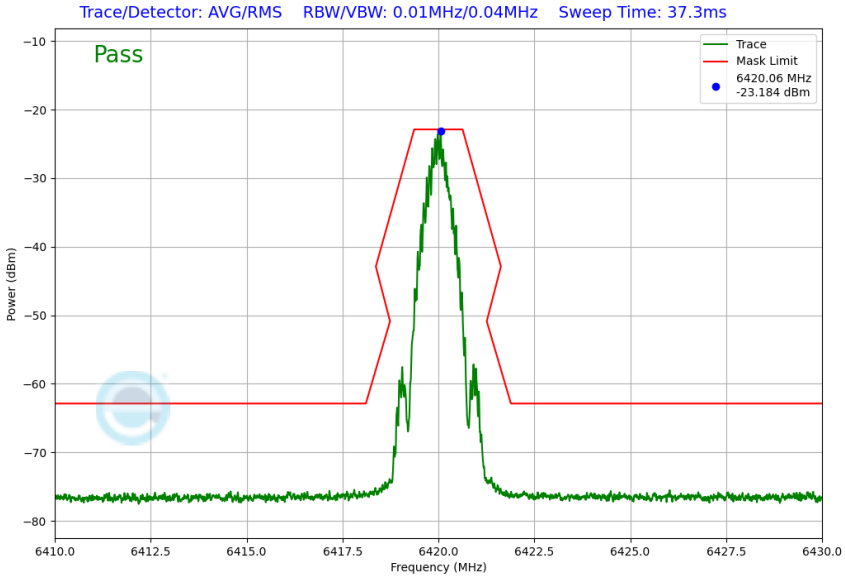
7.5.1 In-Band Emission Measurements



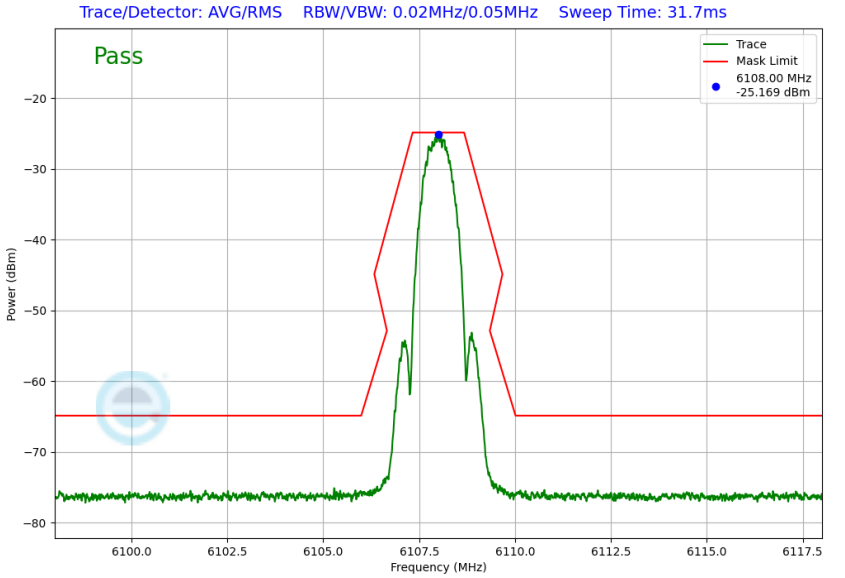
Plot 7-85. VLP In-Band Emission Plot (NB UNII_R BDR – 6108MHz)



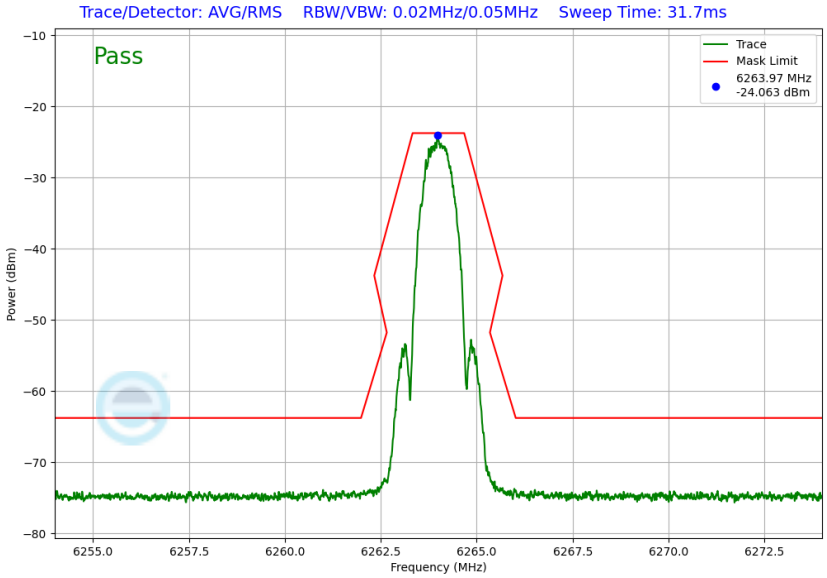
Plot 7-86. VLP In-Band Emission Plot (NB UNII_R BDR – 6264MHz)



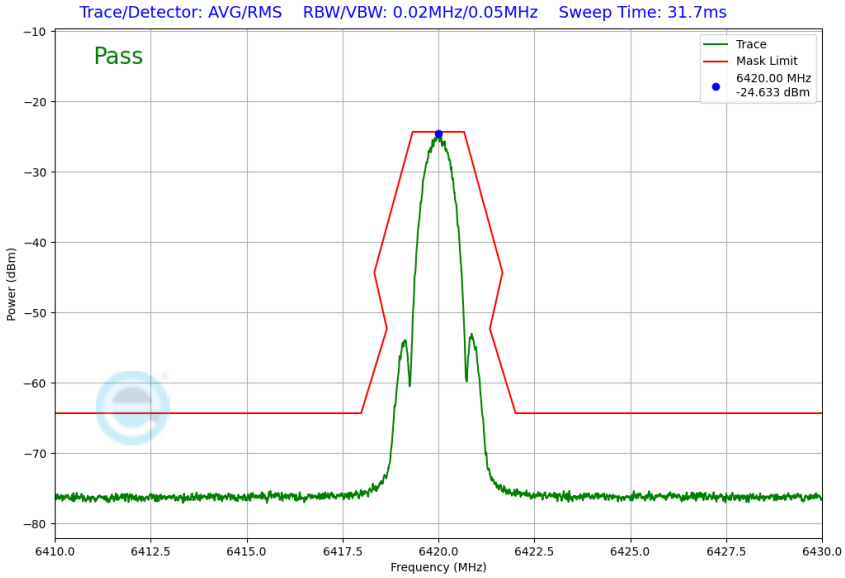
Plot 7-87. VLP In-Band Emission Plot (NB UNII_R BDR – 6420MHz)



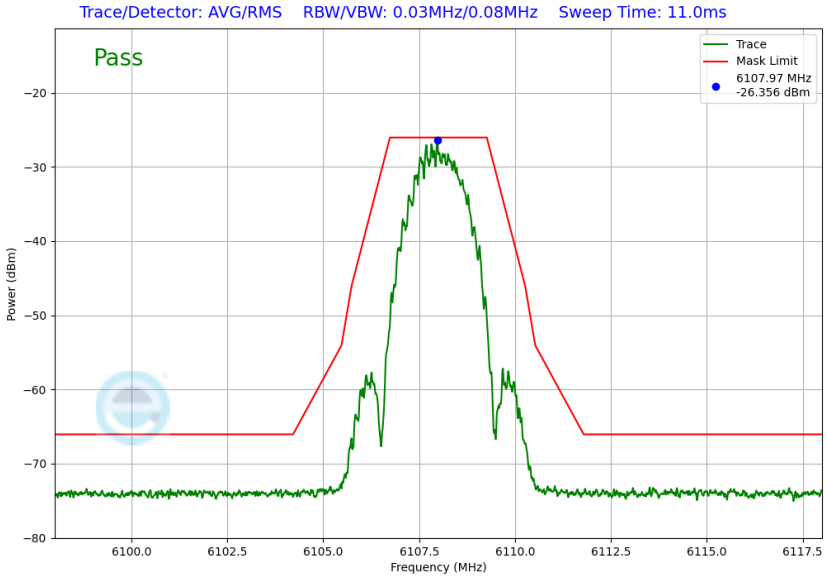
Plot 7-88. VLP In-Band Emission Plot (NB UNII_R LE, 1Mbps – 6108MHz)



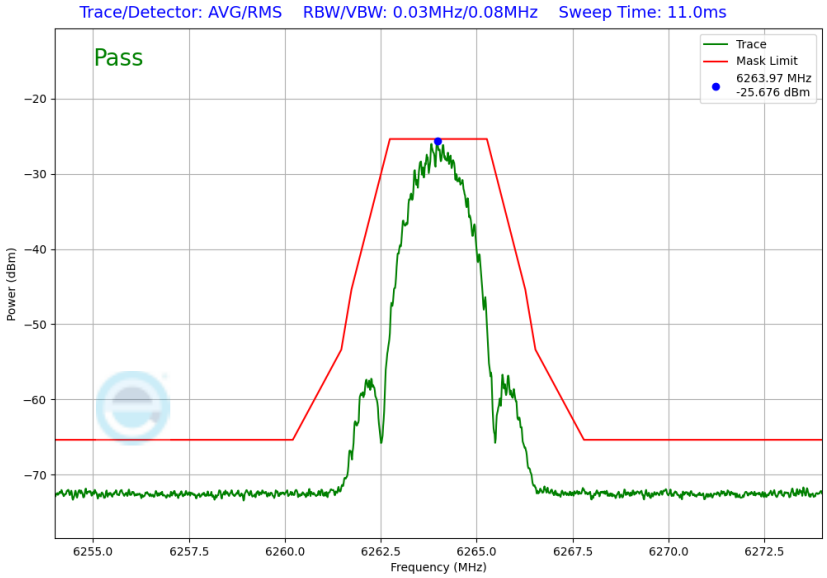
Plot 7-89. VLP In-Band Emission Plot (NB UNII_R LE, 1Mbps – 6264MHz)



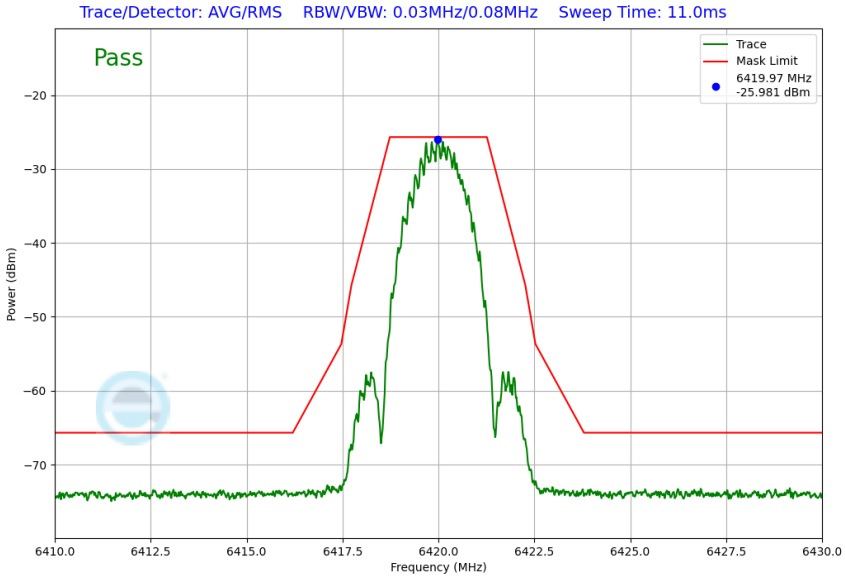
Plot 7-90. VLP In-Band Emission Plot (NB UNII_R LE, 1Mbps – 6420MHz)



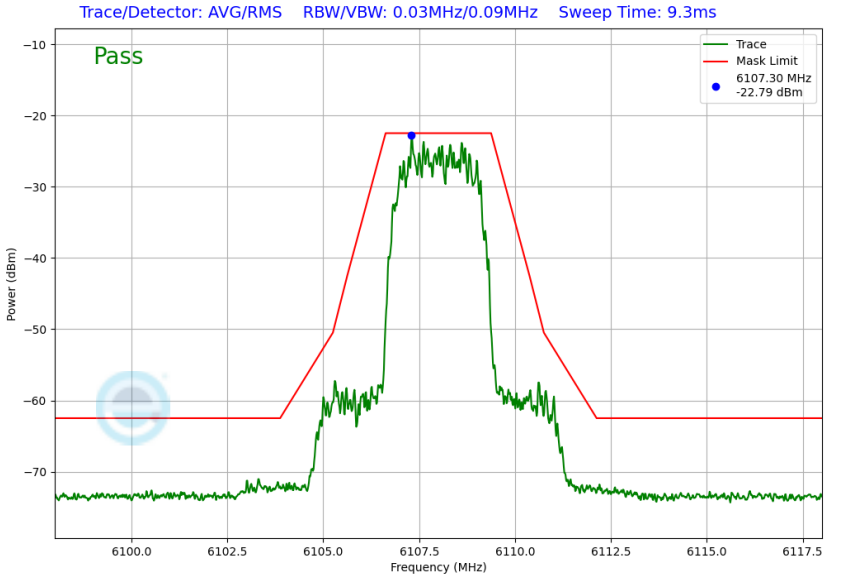
Plot 7-91. VLP In-Band Emission Plot (NB UNII_R LE, 2Mbps – 6108MHz)



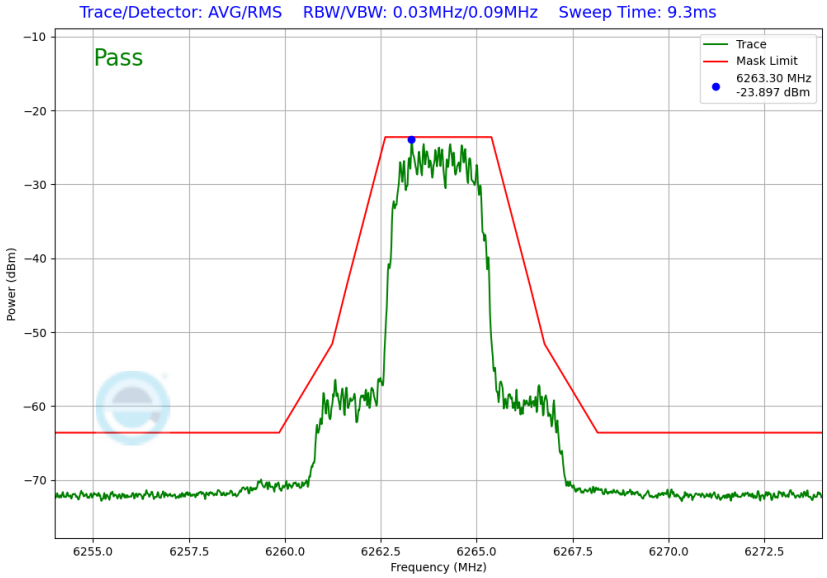
Plot 7-92. VLP In-Band Emission Plot (NB UNII_R LE, 2Mbps – 6264MHz)



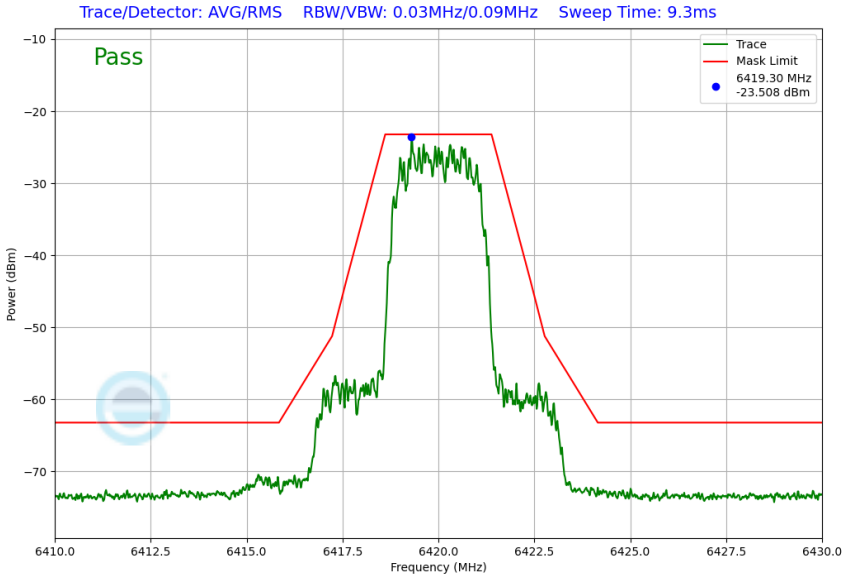
Plot 7-93. VLP In-Band Emission Plot (NB UNII_R LE, 2Mbps – 6420MHz)



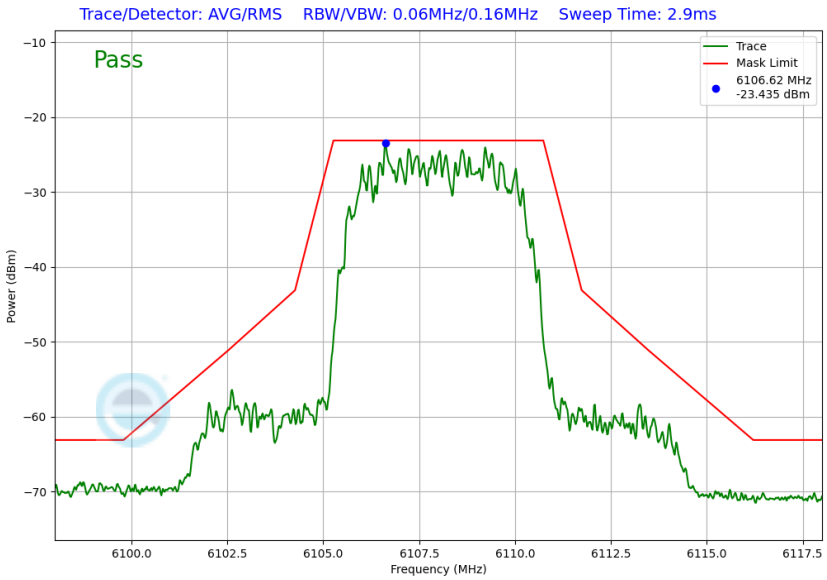
Plot 7-94. VLP In-Band Emission Plot (NB UNII_R HDR4 – 6108MHz)



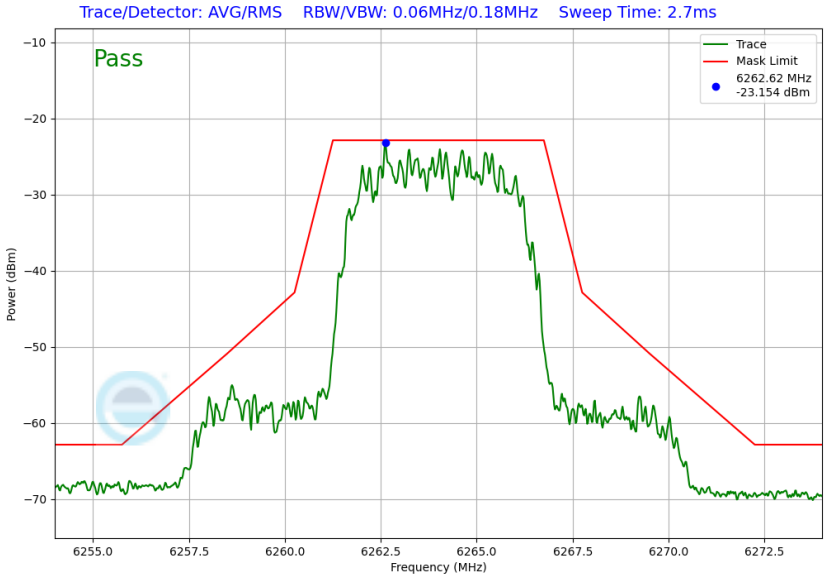
Plot 7-95. VLP In-Band Emission Plot (NB UNII_R HDR4 – 6264MHz)



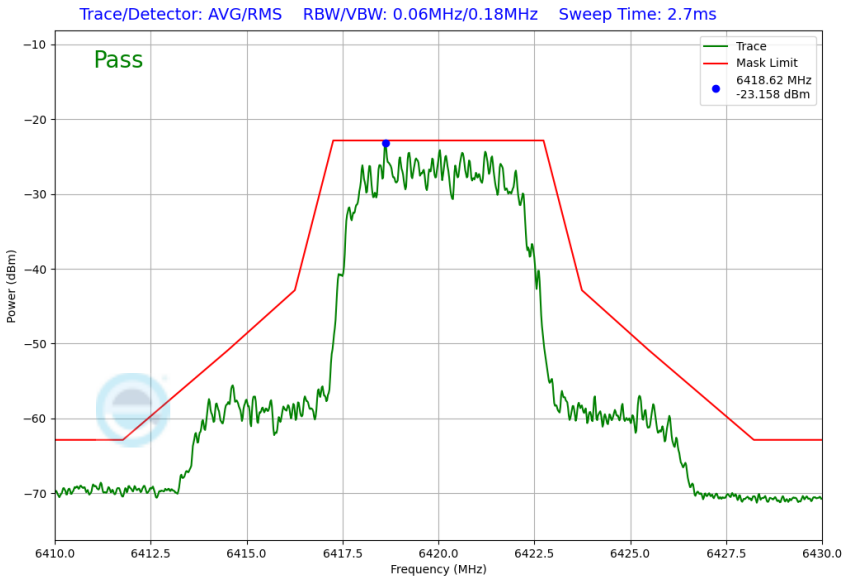
Plot 7-96. VLP In-Band Emission Plot (NB UNII_R HDR4 – 6420MHz)



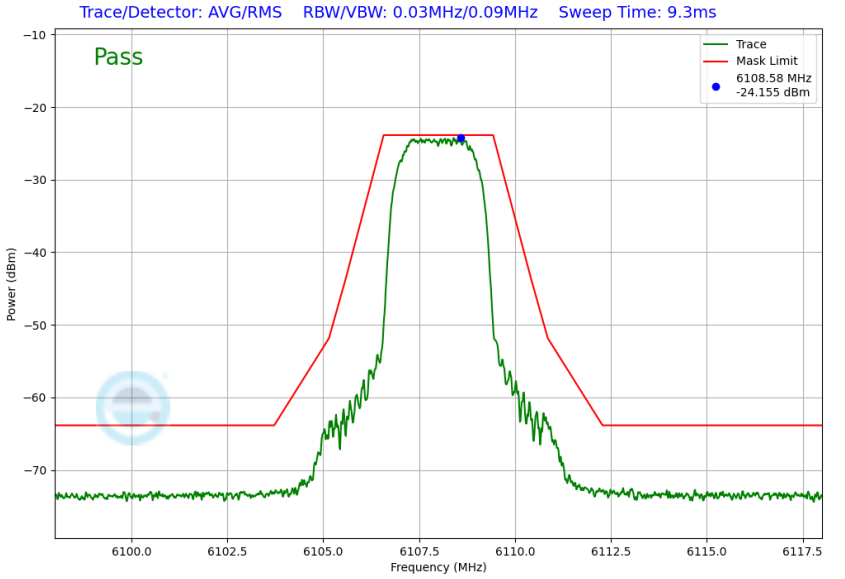
Plot 7-97. VLP In-Band Emission Plot (NB UNII_R HDR8 – 6108MHz)



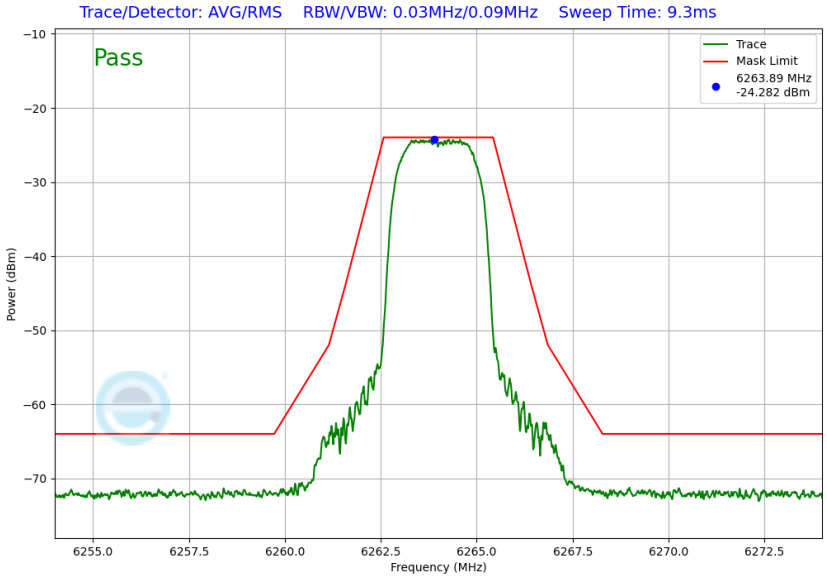
Plot 7-98. VLP In-Band Emission Plot (NB UNII_R HDR8 – 6264MHz)



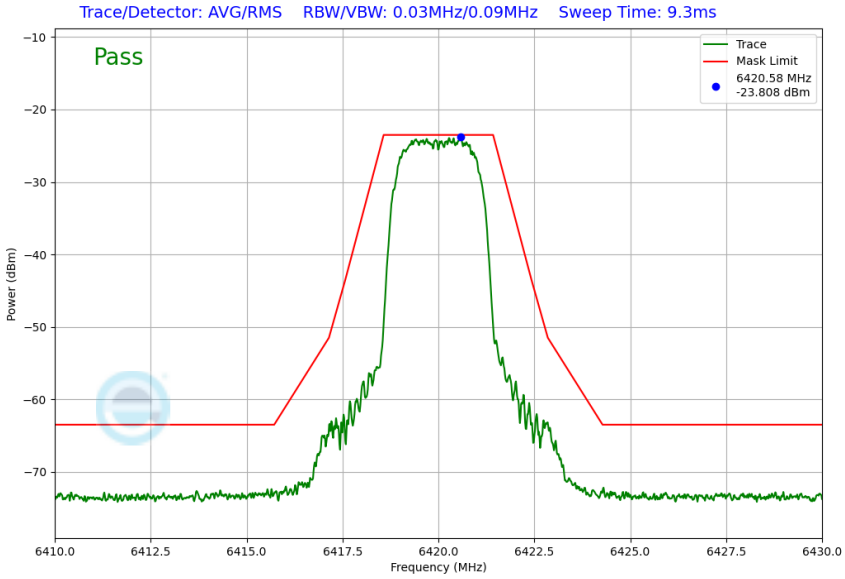
Plot 7-99. VLP In-Band Emission Plot (NB UNII_R HDR8 – 6420MHz)



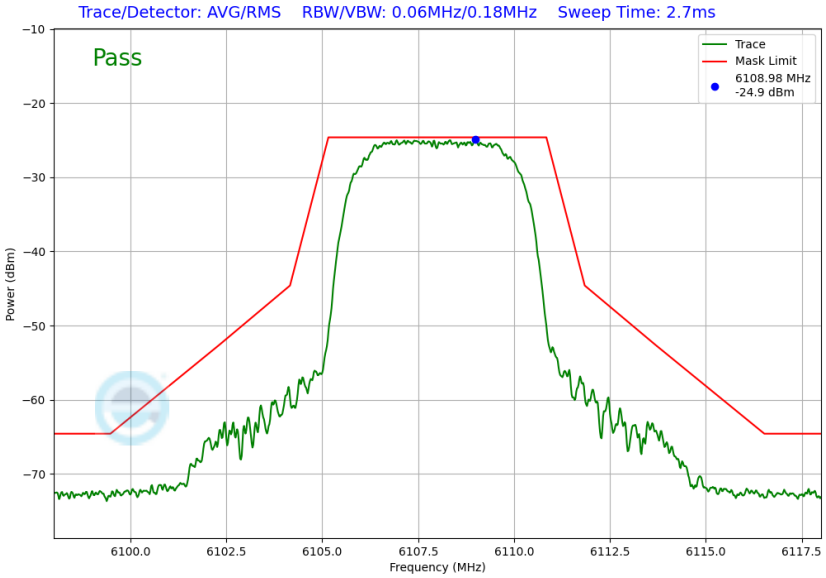
Plot 7-100. VLP In-Band Emission Plot (NB UNII_R HDRp4 – 6108MHz)



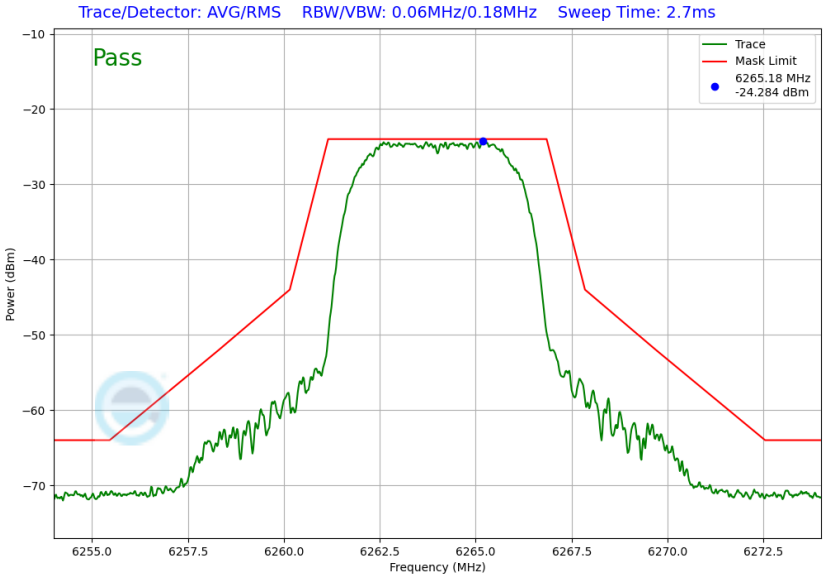
Plot 7-101. VLP In-Band Emission Plot (NB UNII_R HDRp4 – 6264MHz)



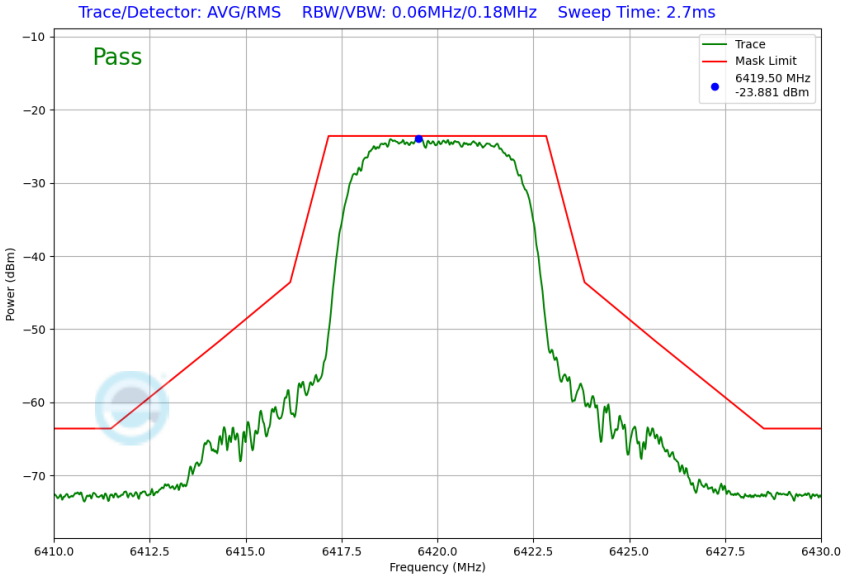
Plot 7-102. VLP In-Band Emission Plot (NB UNII_R HDRp4 – 6420MHz)



Plot 7-103. VLP In-Band Emission Plot (NB UNII_R HDRp8 – 6108MHz)

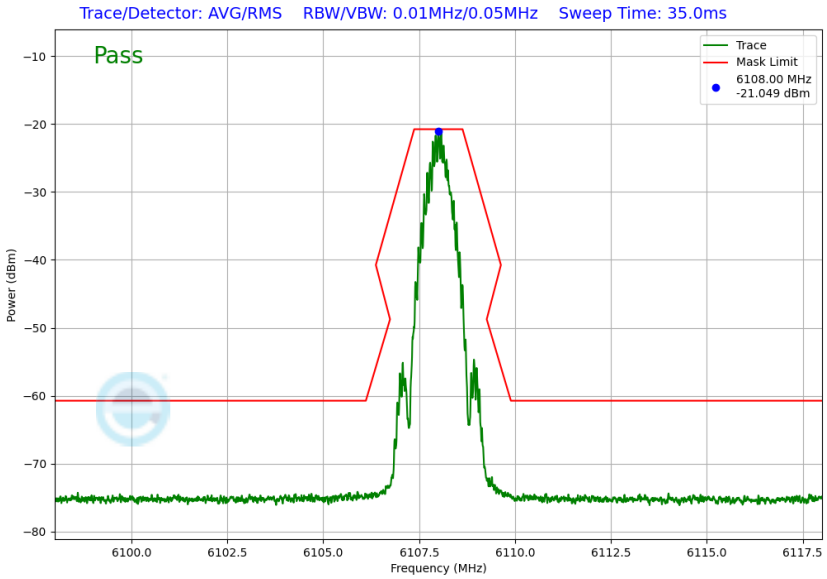


Plot 7-104. VLP In-Band Emission Plot (NB UNII_R HDRp8 – 6264MHz)

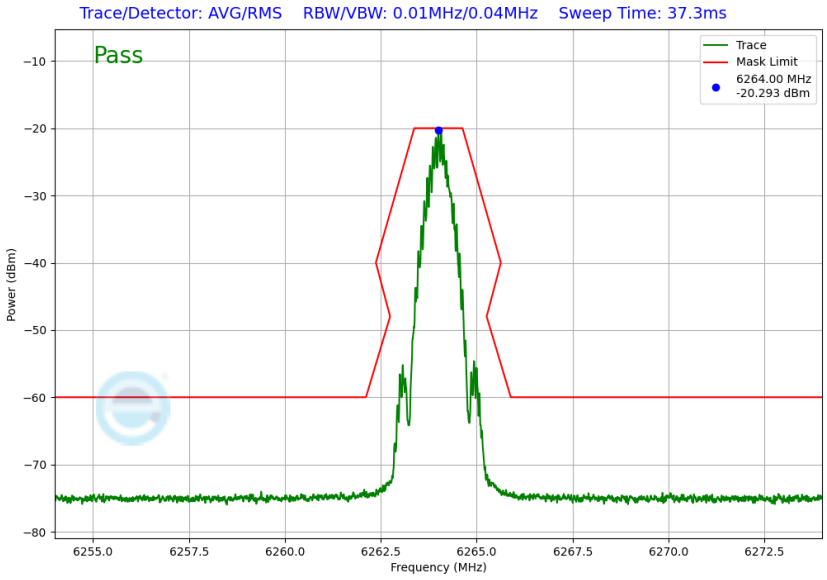


Plot 7-105. VLP In-Band Emission Plot (NB UNII_R HDRp8 – 6420MHz)

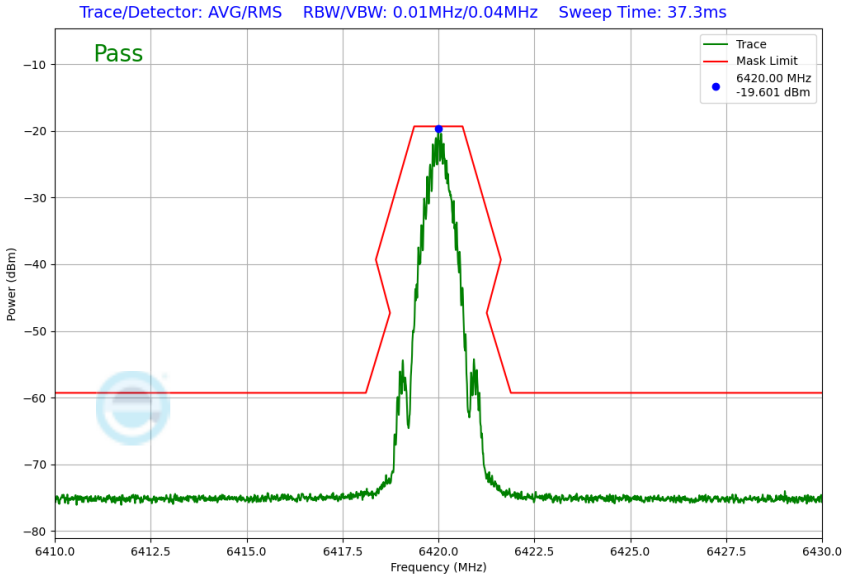
7.5.2 In-Band Emission Measurements



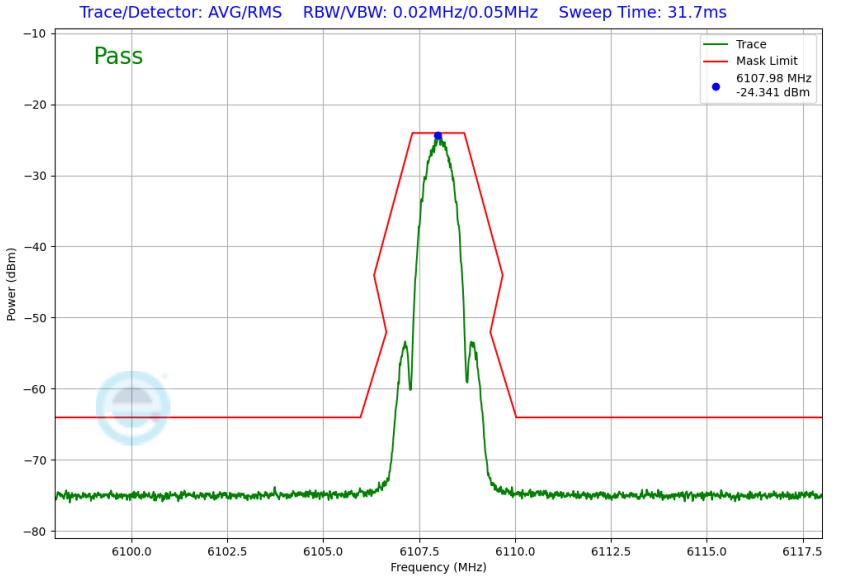
Plot 7-106. VLP In-Band Emission Plot (NB UNII_R BDR – 6108MHz)



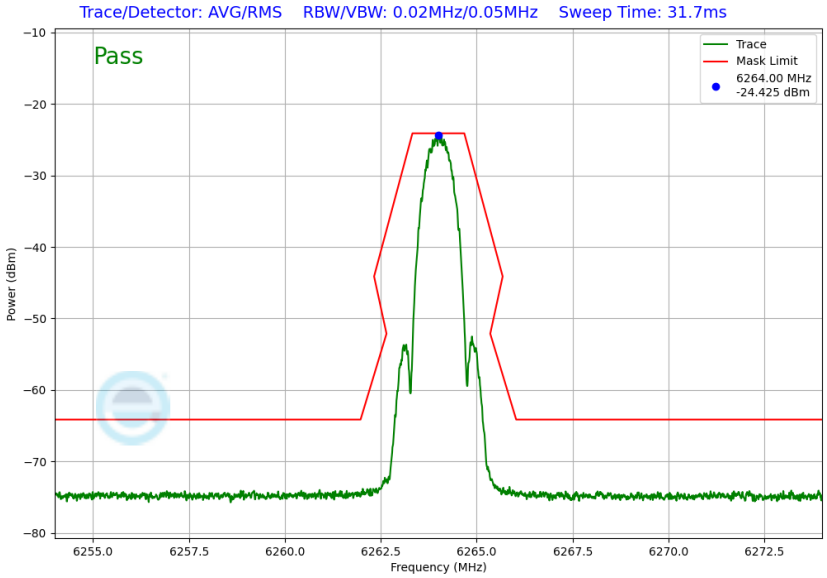
Plot 7-107. VLP In-Band Emission Plot (NB UNII_R BDR – 6264MHz)



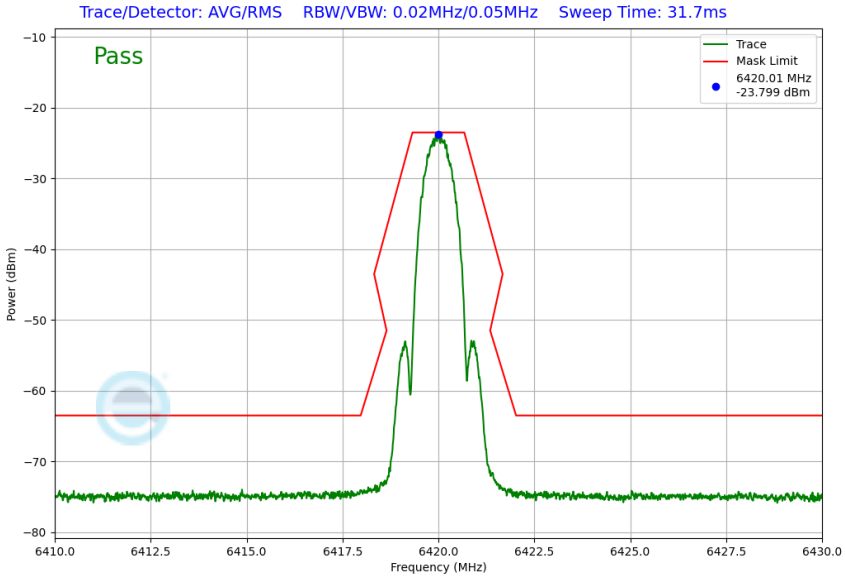
Plot 7-108. VLP In-Band Emission Plot (NB UNII_R BDR – 6420MHz)



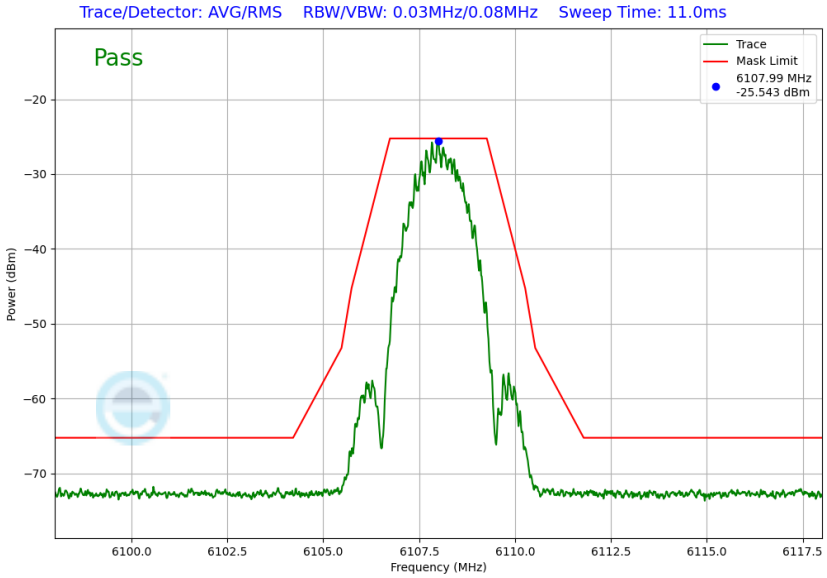
Plot 7-109. VLP In-Band Emission Plot (NB UNII_R LE, 1Mbps – 6108MHz)



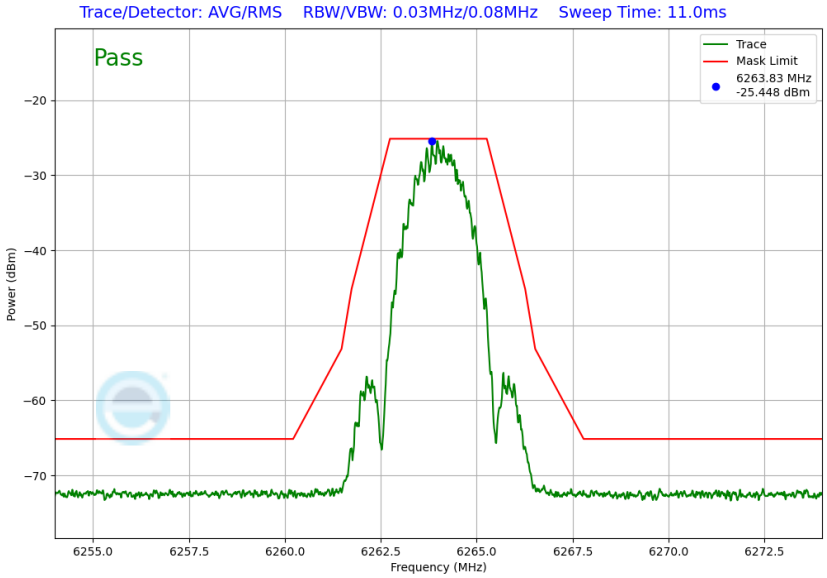
Plot 7-110. VLP In-Band Emission Plot (NB UNII_R LE, 1Mbps – 6264MHz)



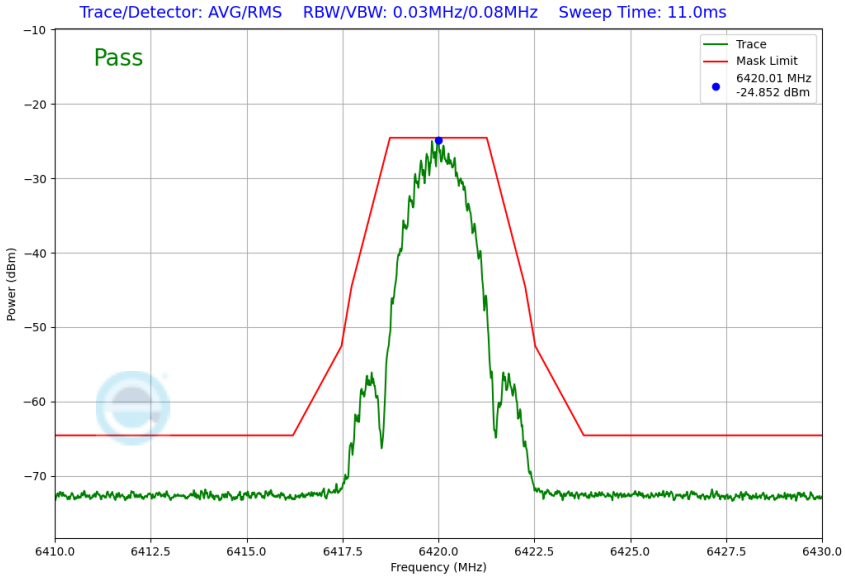
Plot 7-111. VLP In-Band Emission Plot (NB UNII_R LE, 1Mbps – 6420MHz)



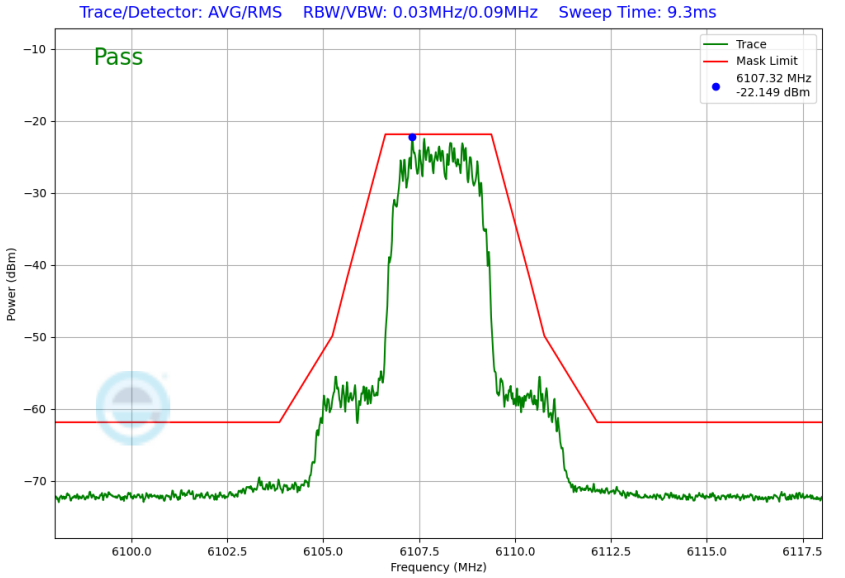
Plot 7-112. VLP In-Band Emission Plot (NB UNII_R LE, 2Mbps – 6108MHz)



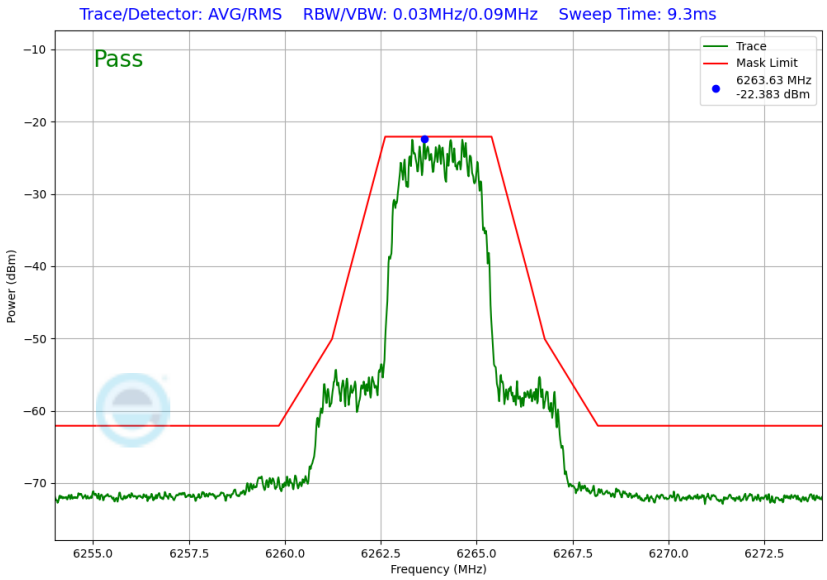
Plot 7-113. VLP In-Band Emission Plot (NB UNII_R LE, 2Mbps – 6264MHz)



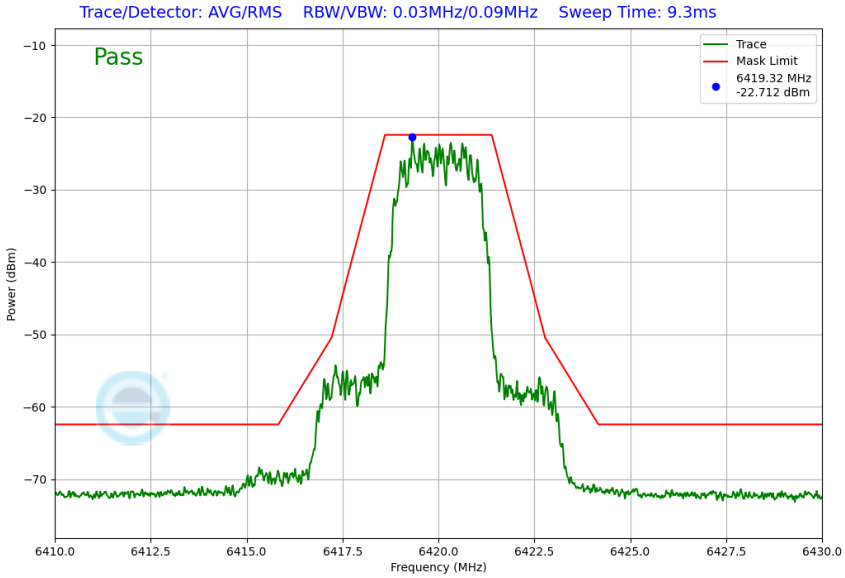
Plot 7-114. VLP In-Band Emission Plot (NB UNII_R LE, 2Mbps – 6420MHz)



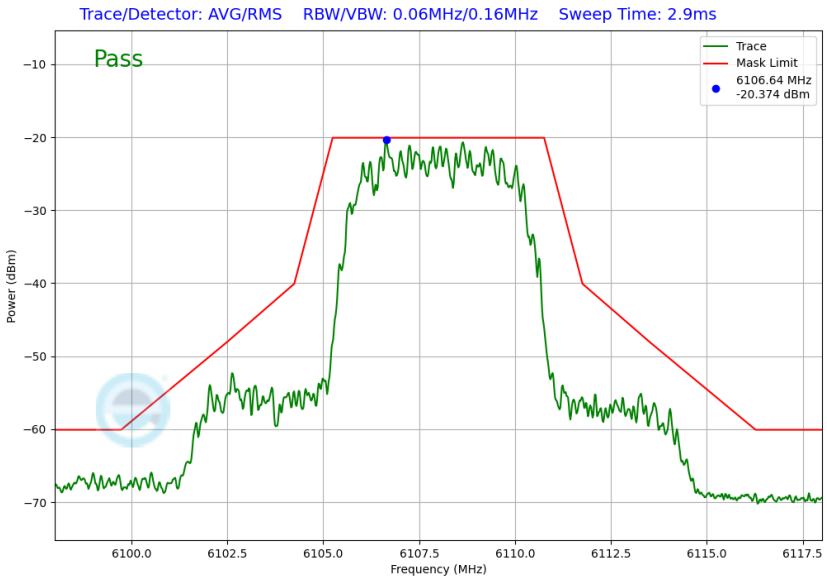
Plot 7-115. VLP In-Band Emission Plot (NB UNII_R HDR4 – 6108MHz)



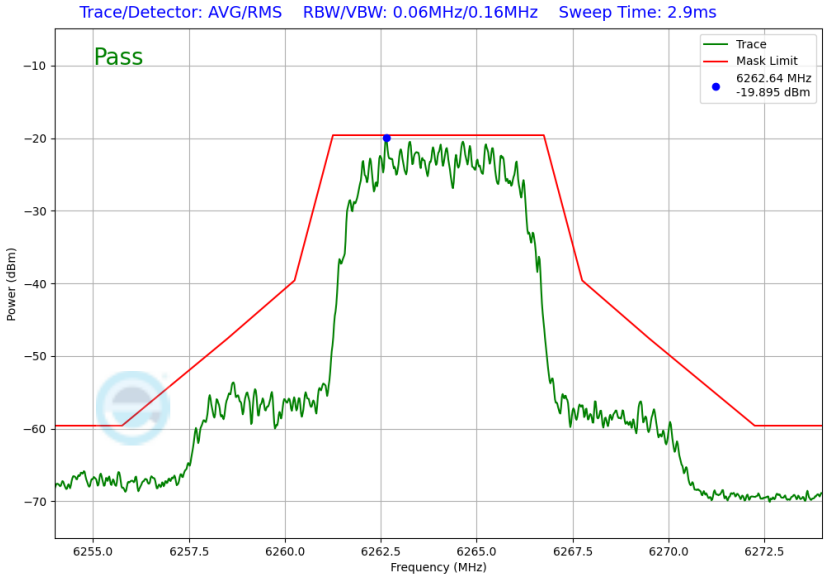
Plot 7-116. VLP In-Band Emission Plot (NB UNII_R HDR4 – 6264MHz)



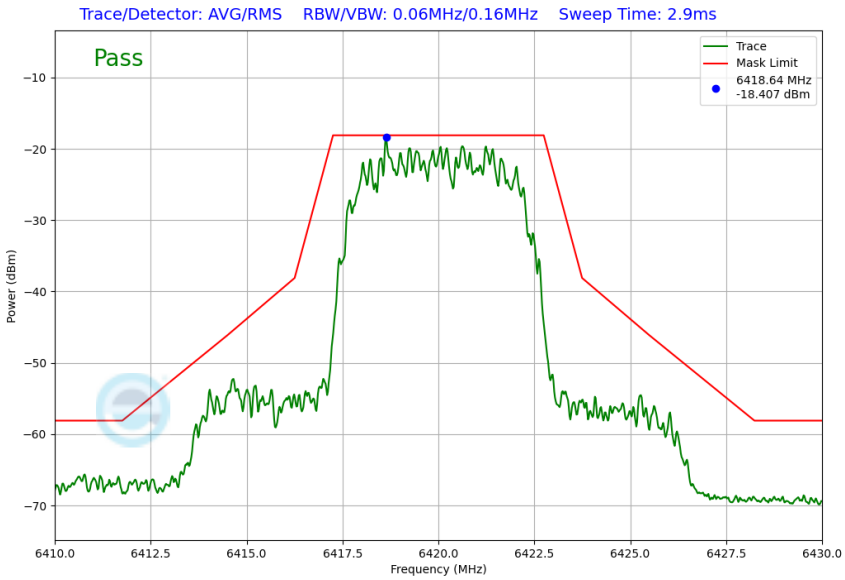
Plot 7-117. VLP In-Band Emission Plot (NB UNII_R HDR4 – 6420MHz)



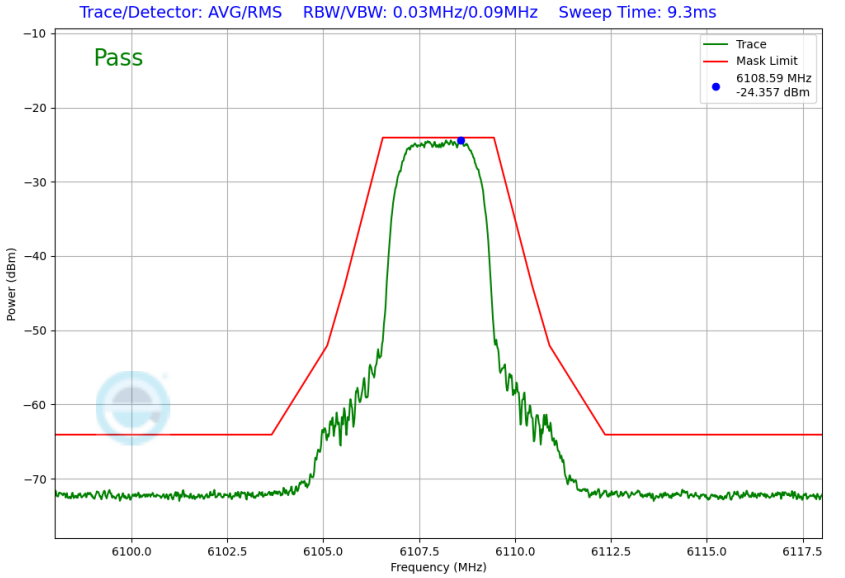
Plot 7-118. VLP In-Band Emission Plot (NB UNII_R HDR8 – 6108MHz)



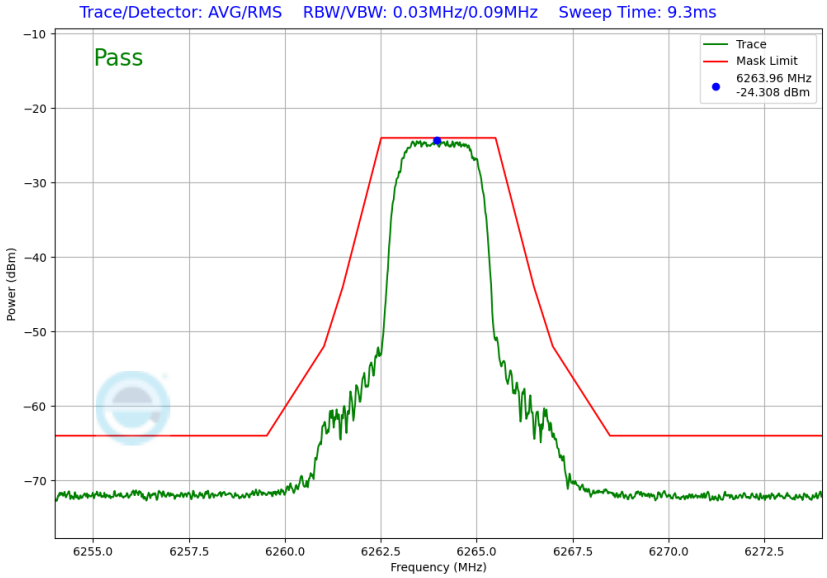
Plot 7-119. VLP In-Band Emission Plot (NB UNII_R HDR8 – 6264MHz)



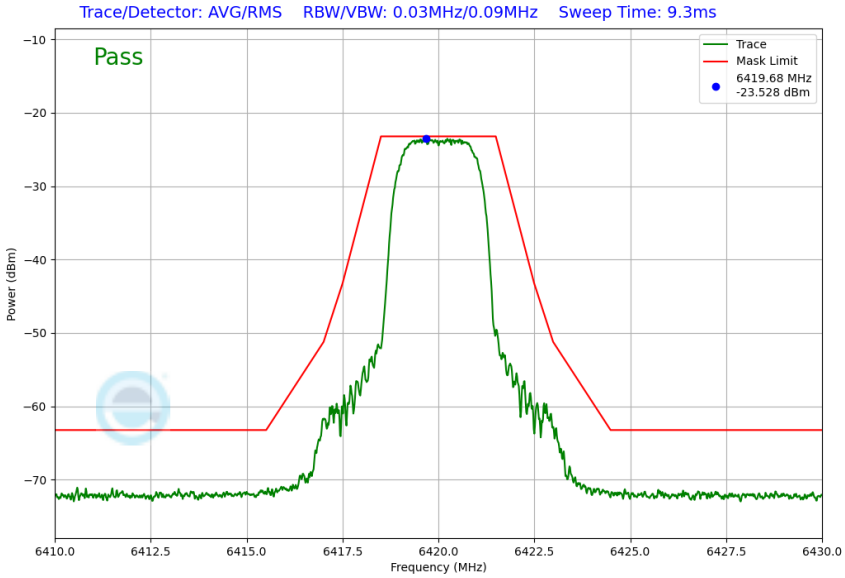
Plot 7-120. VLP In-Band Emission Plot (NB UNII_R HDR8 – 6420MHz)



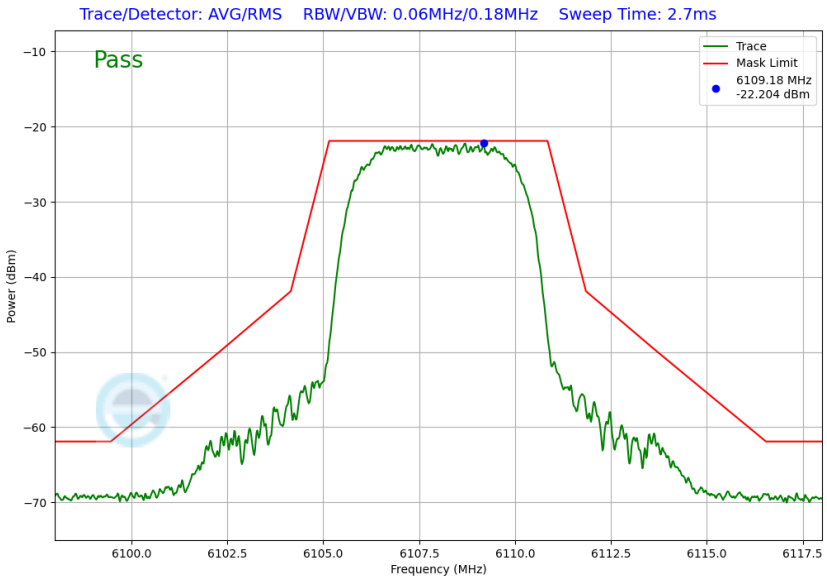
Plot 7-121. VLP In-Band Emission Plot (NB UNII_R HDRp4 – 6108MHz)



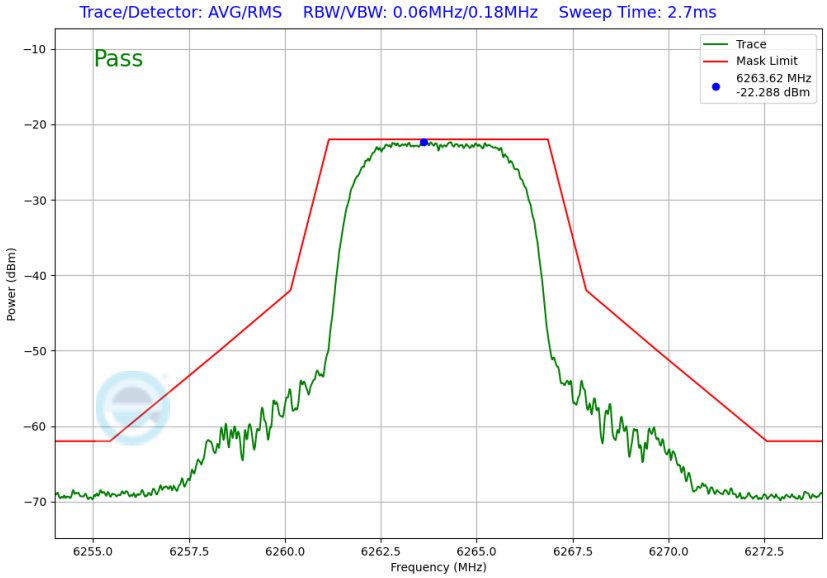
Plot 7-122. VLP In-Band Emission Plot (NB UNII_R HDRp4 – 6264MHz)



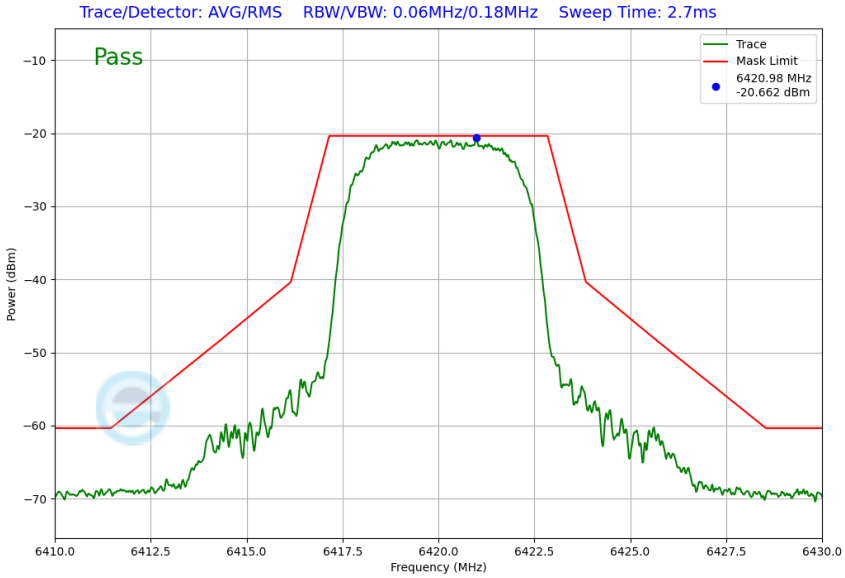
Plot 7-123. VLP In-Band Emission Plot (NB UNII_R HDRp4 – 6420MHz)



Plot 7-124. VLP In-Band Emission Plot (NB UNII_R HDRp8 – 6108MHz)



Plot 7-125. VLP In-Band Emission Plot (NB UNII_R HDRp8 – 6264MHz)



Plot 7-126. VLP In-Band Emission Plot (NB UNII_R HDRp8 – 6420MHz)

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.

Test Setup

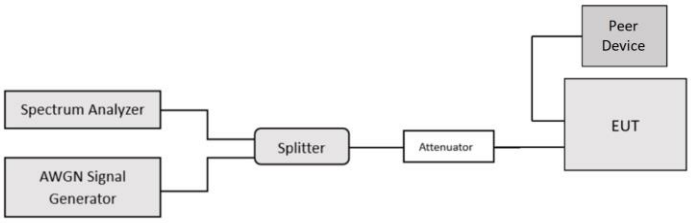


Figure 7-5. Contention-based protocol test setup, conducted method

Test Notes

1. 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.
2. Per KDB 987594 D04 v01, contention-based protocol was tested with receiver with the lowest antenna gain.
3. 15 trials were ran in order to assure that at least 90% of certainty was met.
4. 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.
5. Peer device used was model: A3048 (refer to Table 2-5)
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

Band	Incumbent Frequency [MHz]	Injected (AWGN) [dBm]	Antenna Gain [dBi]	Adjusted Power Level [dBm]	Detection Limit [dBm]	Margin [dB]
UNII Band 5	6350	-75.62	0.10	-75.72	-62.0	-13.72

Table 7-8. Contention Based Protocol – Incumbent Detection Results

Band	EUT Transmission Status		
	Adjusted AWGN Power		
	Normal	Minimal	Ceased
UNII Band 5	-86.92	-77.08	-75.72

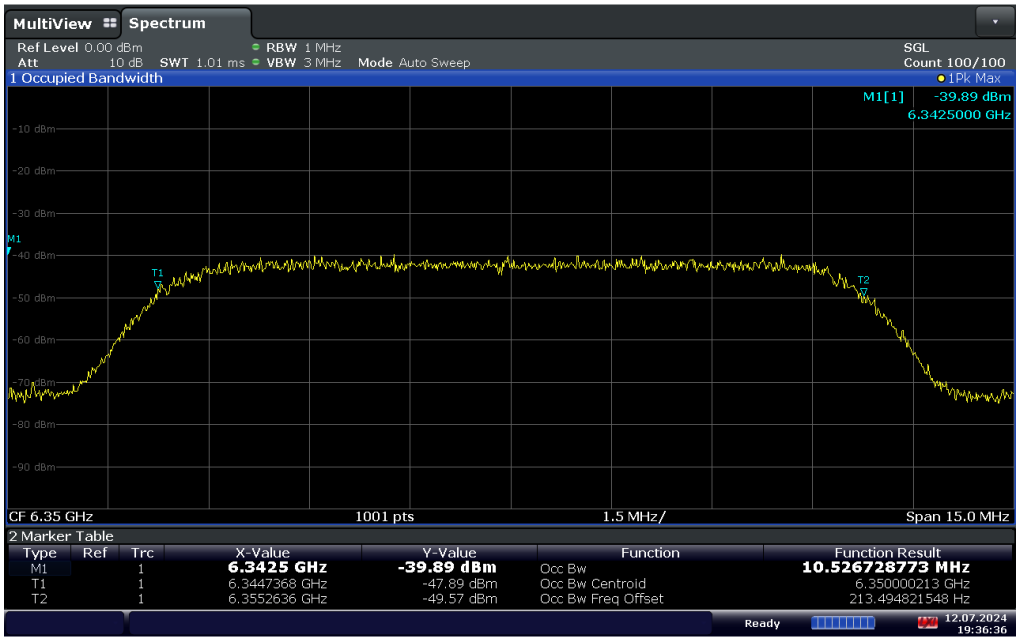
Table 7-9. Contention Based Protocol – Detection Results

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 7-10. Contention Based Protocol – Incumbent Detection Trials

AWGN Plots

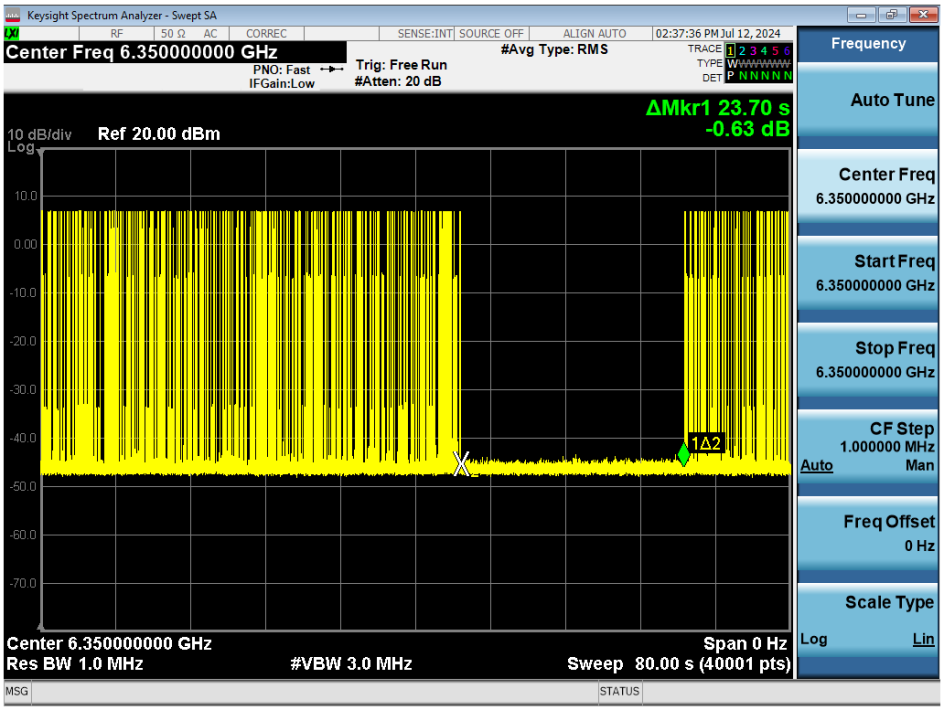
Element



19:36:36 12.07.2024

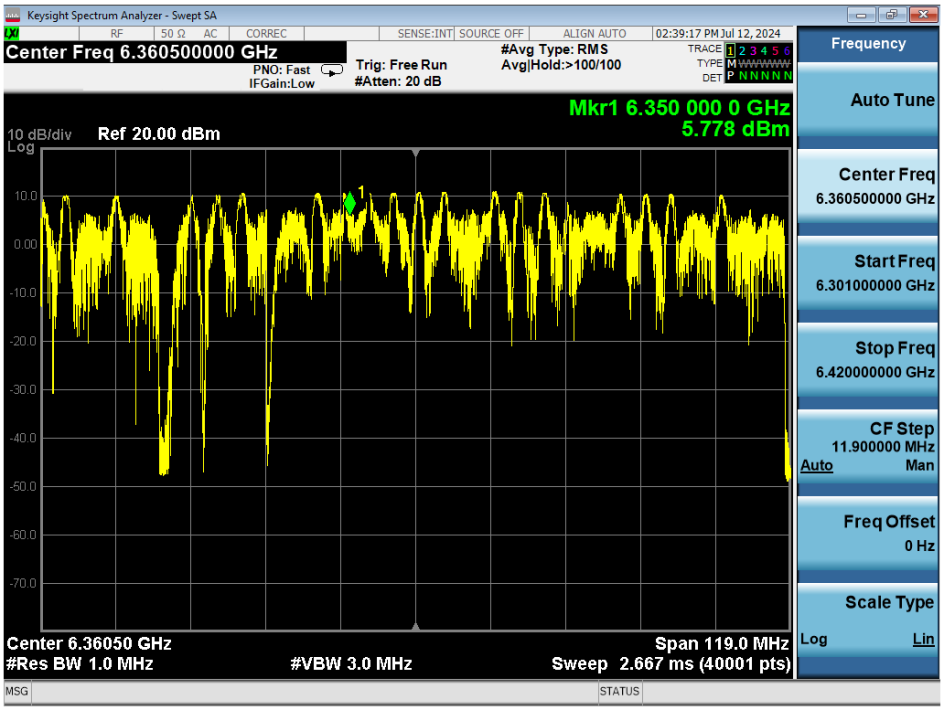
Plot 7-127. AWGN Signal

Contention-Based Protocol Timing Plots

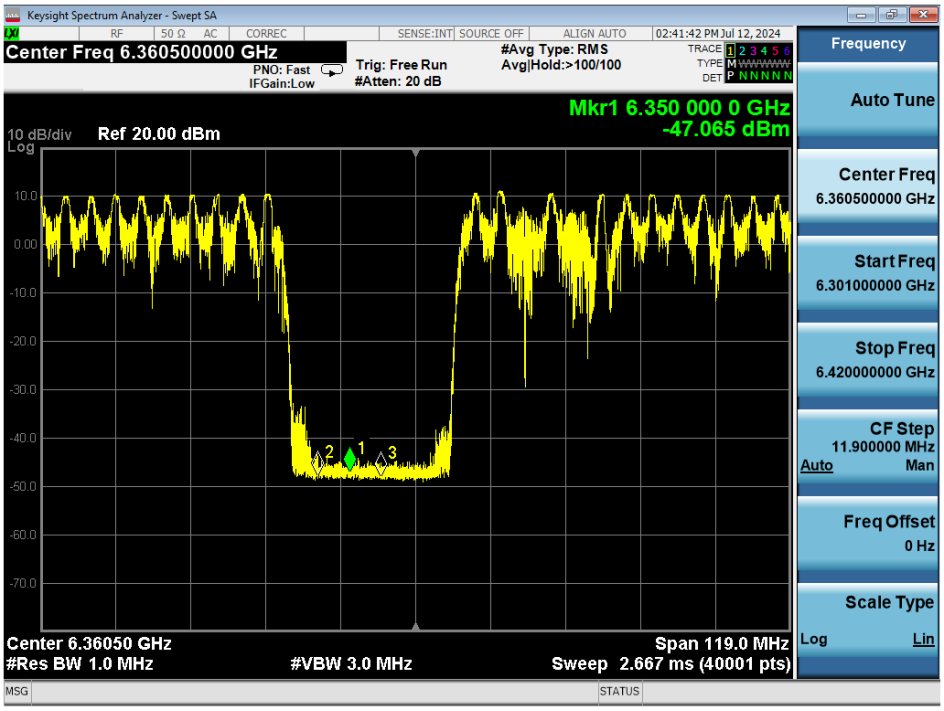


Plot 7-128. CBP Timing Plot

Bandwidth Reduction Plots



Plot 7-129. Before AWGN Signal Injected



Plot 7-130. After AWGN Signal Injected at 6350MHz

7.7 Transmit Power Control (TPC)

§15.407(d.10)

Test Overview and Limit

Very low power devices operating in the 5.925-6.425 and 6.525-6.875 GHz bands shall employ a transmit power control (TPC) mechanism. A very low power device is required to have the capability to operate at least 6 dB below the maximum EIRP power spectral density (PSD) value of −5 dBm/MHz.

Test Procedure Used

ANSI C63.10-2020 – Section 12.4.2.7
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 99% OBW of the signal
3. RBW = 1MHz
4. VBW ≥ 1 / *T*, (*T* refers to the minimum transmissions duration over which the transmitter is on)
5. Number of sweep points > 2 x (span/RBW)
6. Sweep time = No faster than couples (auto) time
7. Detector = peak
8. Trace mode = max hold
9. Trigger was set to free run for all modes
10. Compute power by integrating the spectrum across the 99 %OBW of the signal using the instrument's band-power measurement function with band limits set equal to the OBW band-edges.

Test Setup

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

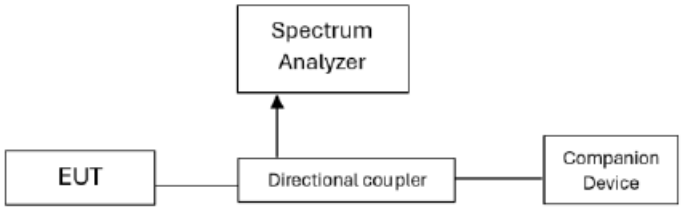


Figure 7-6. Test Instrument & Measurement Setup (No Attenuation)

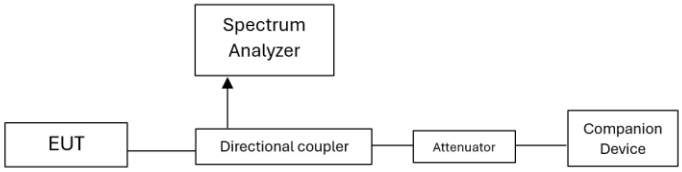


Figure 7-7. Test Instrument & Measurement Setup (With Attenuation)

This test demonstrates the ability of the device to increase and decrease power by the required 6dB as the RSSI is decreased and increased.

1. Configure EUT and companion device for peer-to-peer communication as shown in Figure 7-6. (no attenuation for noise free spectral environment, high RSSI simulation)
2. Establish a link and start communication between EUT and companion device
3. Capture PSD spectrum analyzer trace
4. Add a 20dB attenuator to the setup as shown in Figure 7-7 (noisy spectral environment, low RSSI simulation)
5. Capture PSD spectrum analyzer
6. Compare the highest PSD captured in step 3 to the highest PSD on step 5 and determine the delta.

Implementation Expectation: Tx power Backoff enabled at -20dBm or stronger RSSI, backoff disabled at -40dBm or weaker RSSI (RSSI updated every second)

Test Notes

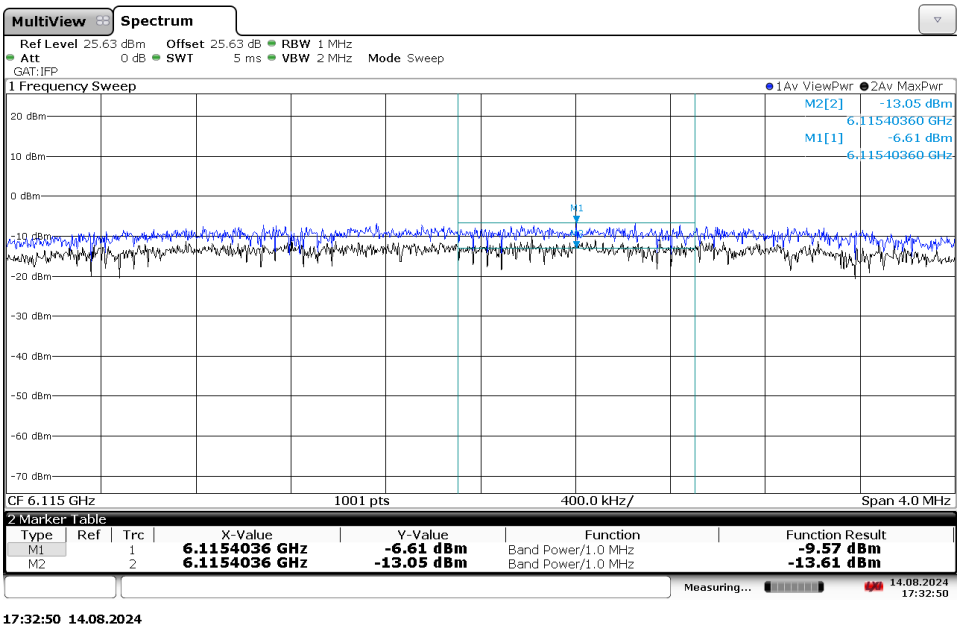
1. Companion device used was model A3048 (refer to Table 2-5)
2. Per manufacturer's declaration, after establishing communication between the EUT and the companion device, NB UNII HDR is used to maintain communication and traffic. NB UNII BDR and NB UNII LE are used for establishing the initial connection with the companion device.
3. TPC is triggered when a high RSSI is detected. As RSSI detected signal decreases, the transmitters output power will increase back to maximum allowed power.

Frequency [MHz]	Data Rate [Mbps]	Measured Power Density [dBm/MHz]	Antenna Gain [dBi]	e.i.r.p Power Density [dBm/MHz]	TPC e.i.r.p Power Density Limit [dBm/MHz]	Verdict
6115	1.0	-9.57	2.4	-7.17	-5.00	PASS
6236	1.0	-8.61	2.4	-6.21	-5.00	PASS
6377	1.0	-9.83	2.4	-7.43	-5.00	PASS

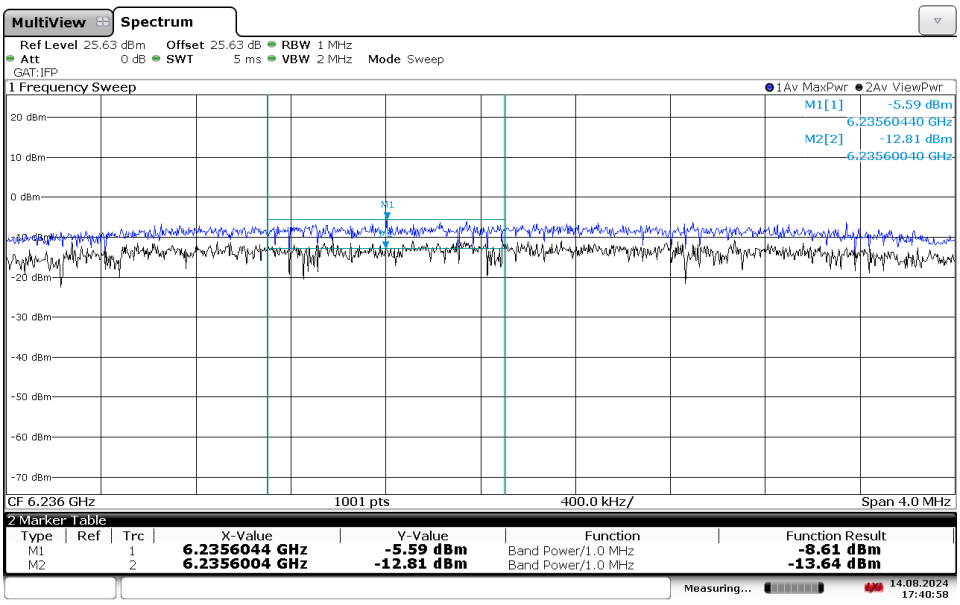
Table 7-11. PSD Measurements (no TPC)

Frequency [MHz]	Data Rate [Mbps]	Measured Power Density [dBm/MHz]	Antenna Gain [dBi]	e.i.r.p Power Density [dBm/MHz]	TPC e.i.r.p Power Density Limit [dBm/MHz]	Verdict
6115	1.0	-13.61	2.4	-11.21	-11.00	PASS
6236	1.0	-13.64	2.4	-11.24	-11.00	PASS
6377	1.0	-14.05	2.4	-11.65	-11.00	PASS

Table 7-12. PSD Measurements (with TPC)



Plot 7-131. Power Density Plot (NB UNII, 6115MHz)



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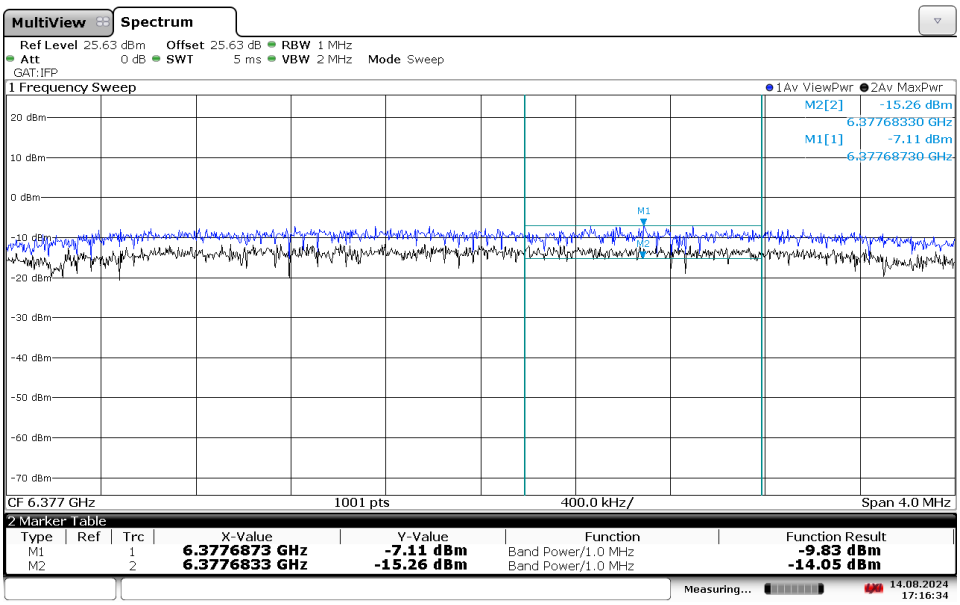
Plot 7-132. Power Density Plot (NB UNII, 6236MHz)



17:16:34 14.08.2024

Plot 7-133. Power Density Plot (NB UNII, 6377MHz)

7.8 Radiated Spurious Emission – Above 1GHz

§15.407(b) §15.205 §15.209

Test Overview and Limit

All out of band radiated spurious emissions are measured with a spectrum analyzer connected to a receive antenna 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. Only the radiated emissions of the configuration that produced the worst case emissions are reported in this section.

All out of band emissions appearing in a restricted band as specified in Section 15.205 of the Title 47 CFR must not exceed the limits shown in Table 7-13 per Section 15.209.

Frequency	Field Strength [µV/m]	Measured Distance [Meters]
Above 960.0 MHz	500	3

Table 7-13. Radiated Limits

Test Procedures Used

ANSI C63.10-2020 – Sections 12.7.7.2, 12.7.6, 12.7.5
KDB 789033 D02 v02r01 – Section G

Test Settings

Average Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 3MHz
4. Detector = power average (RMS)
5. Number of measurement points = 1001 (Number of points must be ≥ 2 x span/RBW)
6. Averaging type = power (RMS)
7. Sweep time = auto couple
8. Trace was averaged over 100 sweeps

Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 3MHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

Test Setup

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

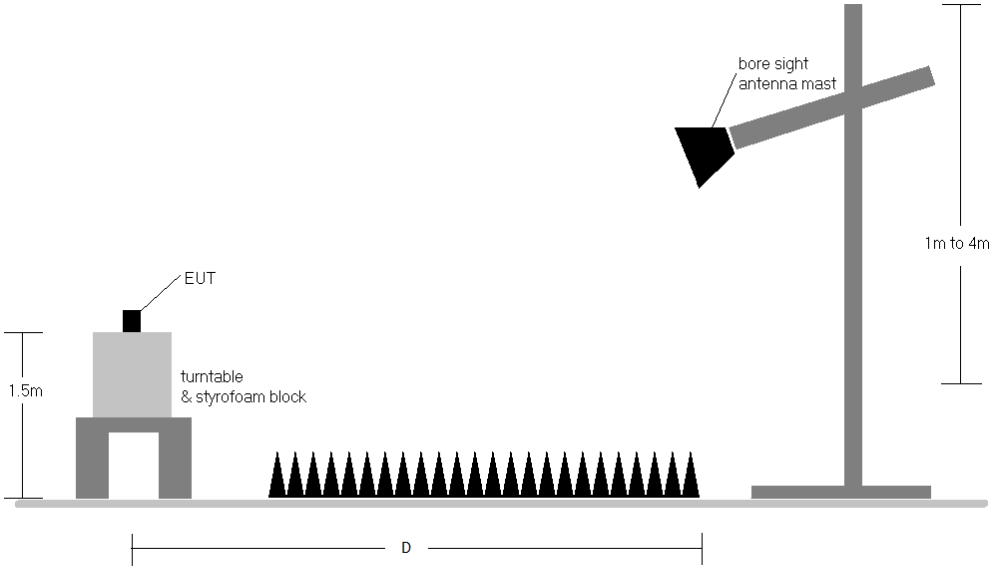


Figure 7-8. Test Instrument & Measurement Setup

Test Notes

1. All emissions that lie in the restricted bands (denoted by a * next to the frequency) specified in §15.205 are below the limit shown in Table 7-13.
2. All spurious emissions lying in restricted bands specified in §15.205 are below the limit shown in Table 7-13. All spurious emissions that do not lie in a restricted band are subject to a limit of -27dBm/MHz. At a distance of 3 meters, the field strength limit in dBμV/m can be determined by adding a “conversion” factor of 95.2dB to the EIRP limit of -27dBm/MHz to obtain the limit for out of band spurious emissions of 68.2dBμV/m.
3. The antenna is manipulated through typical positions, polarity and length during the tests. The EUT is manipulated through three orthogonal planes.
4. This unit was tested with its standard battery.
5. The spectrum is measured from 9kHz to the 10th harmonic of the fundamental frequency of the transmitter using CISPR quasi peak detector below 1GHz. Above 1 GHz, average and peak measurements were taken using linearly polarized horn antennas.
6. D is the measurement test distance and emissions 1-18GHz were measured at a 3 meters test distance while emissions above 18GHz were measured at a 1 meter test distance with the application of a distance correction factor.
7. The "-" shown in the following RSE tables are used to denote a noise floor measurement.

Sample Calculations

Determining Spurious Emissions Levels

- Field Strength Level $_{[dB\mu V/m]}$ = Analyzer Level $_{[dBm]}$ + 107 + AFCL $_{[dB/m]}$
- AFCL $_{[dB/m]}$ = Antenna Factor $_{[dB/m]}$ + Cable Loss $_{[dB]}$ – Preamplifier Gain $_{[dB]}$
- Margin $_{[dB]}$ = Field Strength Level $_{[dB\mu V/m]}$ – Limit $_{[dB\mu V/m]}$

Radiated Band Edge Measurement Offset

- The amplitude offset shown in the radiated restricted band edge plots in Section 7.8.2 was calculated using the formula:
  Offset (dB) = (Antenna Factor + Cable Loss + Attenuator) – Preamplifier Gain