

Certificate of Test

NCT CO., LTD.

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Republic of Korea
(Tel: +82-31-323-6070 / Fax: +82-31-323-6071)

Report No.:
NW2309-F005

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**1. Client**

- Name : NC& CO., LTD
- Address : Venture Forum Bldg 9F, 323, Pangyo-ro, Budang-gu, Seongnam-si, Gyeonggi-do, Republic of Korea
- Date of Receipt : 2023-07-03

2. Use of Report : FCC Certification**3. Test Sample**

- Description / Model : Vueroid BlackBox D21 ULTRA DUO / D21-UF
- FCC ID : 2BCO9-D214K-200S0

4. Place of Test : ■ Fixed test □ Field test

(Address: 211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Republic of Korea)

5. Date of Test : 2023-09-06 ~ 2023-09-16**6. Test method used : FCC Part 15 Subpart C 15.407****7. Testing Environment :**

- Temperature: (25 ± 5) °C, Humidity: Less than 75 % R.H.

* Unless specified otherwise in the individual methods, the tests were conducted on ambient conditions.

8. Test Results : Refer to the test results

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

This Test Report cannot be reproduced, except in full

This test report is not related to KOLAS recognition and RRA designation.

Affirmation

Tested by

Jun-gi Sin

(signature)

Technical Manager

Il-shin, Kim

(signature)

Sep 19, 2023

NCT CO., LTD.



Contact us at report@nct.re.kr to confirm the authenticity of this report

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1. General Information's

1.1 Test Performed

Laboratory : NCT Co., Ltd.
Address : 211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Korea
Telephone : +82-31-323-6070
Facsimile : +82-31-323-6071
FCC Designation No. : KR0166
FCC Registration Number : 409631

2. Information's about Test Item

2.1 Applicant Information

Company name : NC& CO., LTD
Address : Venture Forum Bldg 9F, 323, Pangyo-ro, Budang-gu, Seongnam-si,
Gyeonggi-do, Republic of Korea
Telephone / Facsimile : +82-10-3438-2772 / +82-2-3460-4799

2.2 Equipment Under Test (EUT) description

Test item particulars : VueroiD BlackBox D21 ULTRA DUO
Model and/or type reference : D21-UF
Additional model name : D21 ULTRA Solo
Serial number : Prototype
Antenna type and gain : Chip Antenna with Max gain: 2.79 dBi
Date (s) of performance of tests: : 2023-09-06 ~ 2023-09-16
Date of receipt of test item : 2023-07-03
EUT condition : Pre-production, not damaged
EUT Power Source : DC 12 V / 24 V
Type of Modulation : OFDM for 802.11ac_VHT20
Firmware version : 1.0
Hardware version : 1.0
Test software name(version) : Tera Term 4.58

2.3 Tested Frequency

5GHz Band	802.11ac_VHT20		Remark
	Channel	Frequency (MHz)	
U-NII 1	36	5 180	Single Channel
U-NII 3	149	5 745	Single Channel

2.4 Transmitting Configuration of EUT

Test Mode	Data rate
802.11ac_VHT20	MCS 0 ~ 8

3. Test Report

3.1 Test Summary

Applied	FCC Rule	Test Items	Test Condition	Result
☒	15.203	Antenna Requirement	Conducted	C
☒	15.407(a)	Emission Bandwidth (26 dB Bandwidth)		C
☒	15.407(e)	Minimum Emission Bandwidth (6 dB Bandwidth)		C
☒	15.407(a)	Maximum Conducted Output Power		C
☒	15.407(a)	Peak Power Spectral Density		C
☐	15.407(h)	Dynamic Frequency Selection		N/A ^{note2}
☒	15.407(b)	Undesirable Emissions	Radiated	C
☒	15.205 15.209 15.407(b)	General Field Strength Limits(Restricted Bands and Radiated Emission Limits)		C
☐	15.207	Conducted Emissions	AC Line Conducted	N/A ^{note3}

Note 1: C=Complies NC=Not Complies NT=Not Tested NA=Not Applicable

Note 2: This product was not used the U-NII 2A and U-NII 2C.

Note 3: This product is only using DC power. So, AC conducted emission test has not been performed.

The sample was tested according to the following specification: ANSI C63.10:2020, KDB789033 D02 V01, KDB644545 D03

Compliance was determined by specification limits of the applicable standard according to customer requirements.

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3.2 Test Report Version

Test Report No.	Date	Description
NW2309-F005	2023-09-19	Initial issue

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3.3 Transmitter Requirements

3.3.1 Antenna Requirement

According to §15.203 An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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 manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

3.3.1.1 Result

Complies

(The transmitter has a Chip Antenna. The directional peak gain of the antenna is 2.79 dBi)

3.3.2 26 dB Bandwidth

3.3.2.1 Test Setup

Refer to the APPENDIX I.

3.3.2.2 Limit

N/A

(The 26 dB bandwidth is used to determine the conducted output power limit.)

3.3.2.3 Test Procedure

The bandwidth at 26 dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the EUT's antenna terminal while the EUT is operating in transmission mode at the appropriate frequencies.

1. Set resolution bandwidth (RBW) = approximately 1 % of the EBW.
2. Set the video bandwidth (VBW) > RBW.
3. Detector = Peak.
4. Trace mode = Max Hold.
5. Sweep = Auto
6. Allow the trace to stabilize.
7. Measure the maximum width of the emission that is 26 dB down from the peak of the emission. Compare this with the RBW setting of the analyzer. Readjust RBW and repeat measurement as needed until the RBW/EBW ratio is approximately 1%.

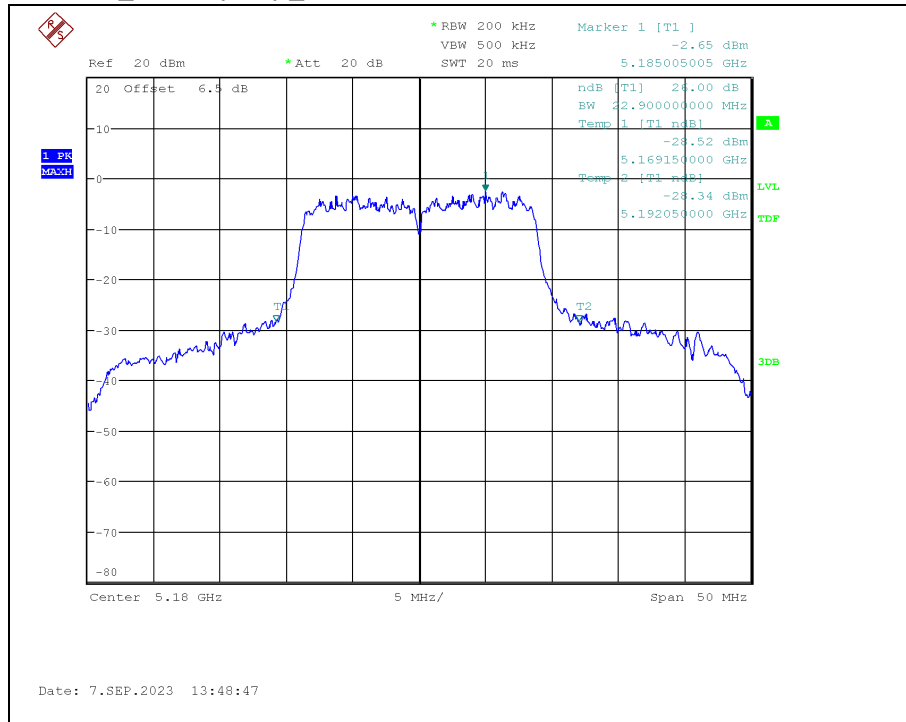
3.3.2.4 Test Result

Test Mode	Band	Test Frequency	26 dB Bandwidth (MHz)
802.11ac_VHT20 (12V)	U-NII 1	36	22.90
802.11ac_VHT20 (24V)			22.95

3.3.2.5 Test Plot

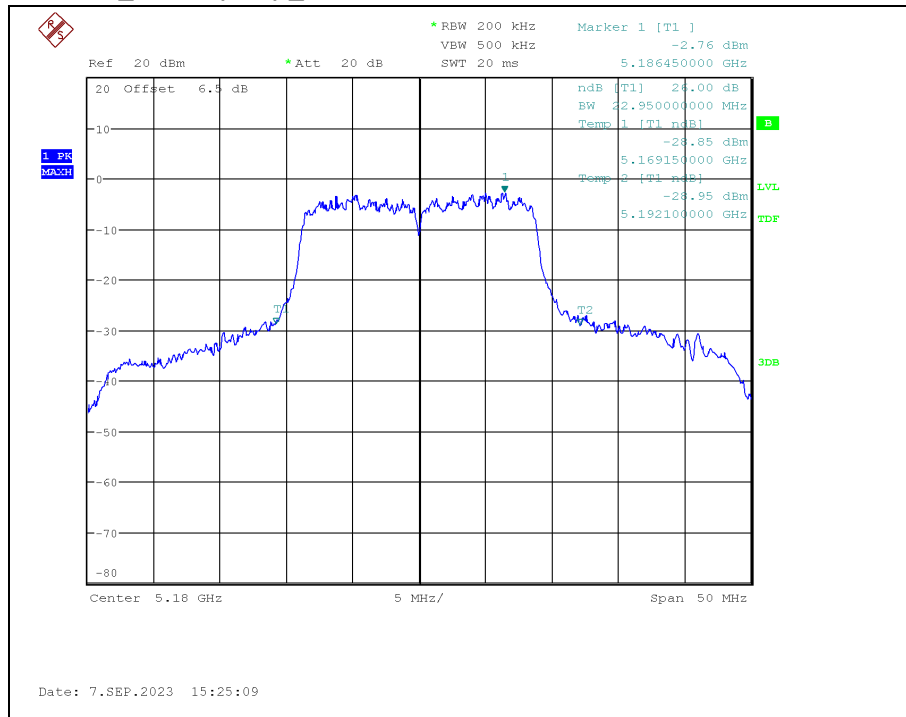
802.11ac_VHT20(12V)_ch.36

26 dB Bandwidth



802.11ac_VHT20(24V)_ch.36

26 dB Bandwidth



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3.3.3 6 dB Bandwidth & Occupied Bandwidth

3.3.3.1 Test Setup

Refer to the APPENDIX I.

3.3.3.2 Limit

Within the 5.725-5.85 GHz band, the minimum permissible 6 dB bandwidth is 500 kHz.

3.3.3.3 Test Procedure

The bandwidth at 6 dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the EUT's antenna terminal while the EUT is operating in transmission mode at the appropriate frequencies.

1. Set resolution bandwidth (RBW) = 100 kHz
2. Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
3. Detector = Peak.
4. Trace mode = Max Hold.
5. Sweep = Auto
6. Allow the trace to stabilize.
7. Option 1 - Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.
 Option 2 - The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW $\geq 3 \times$ RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

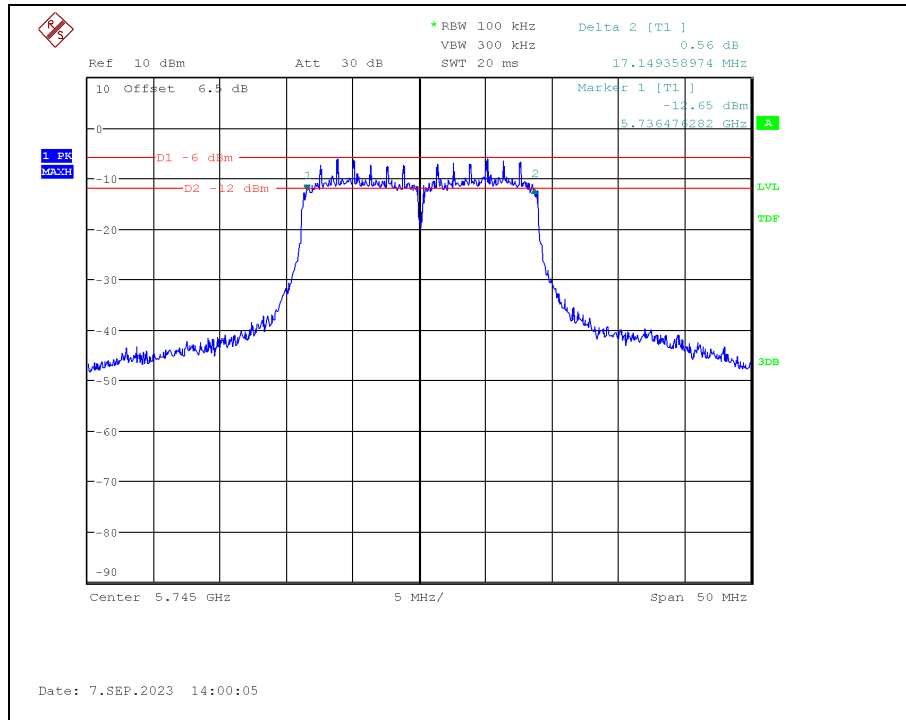
3.3.3.4 Test Result

Test Mode	Band	Test Frequency	6 dB Bandwidth (MHz)
802.11ac_VHT20 (12V)	U-NII 3	149	17.15
802.11ac_VHT20 (24V)			17.55

3.3.3.5 Test Plot

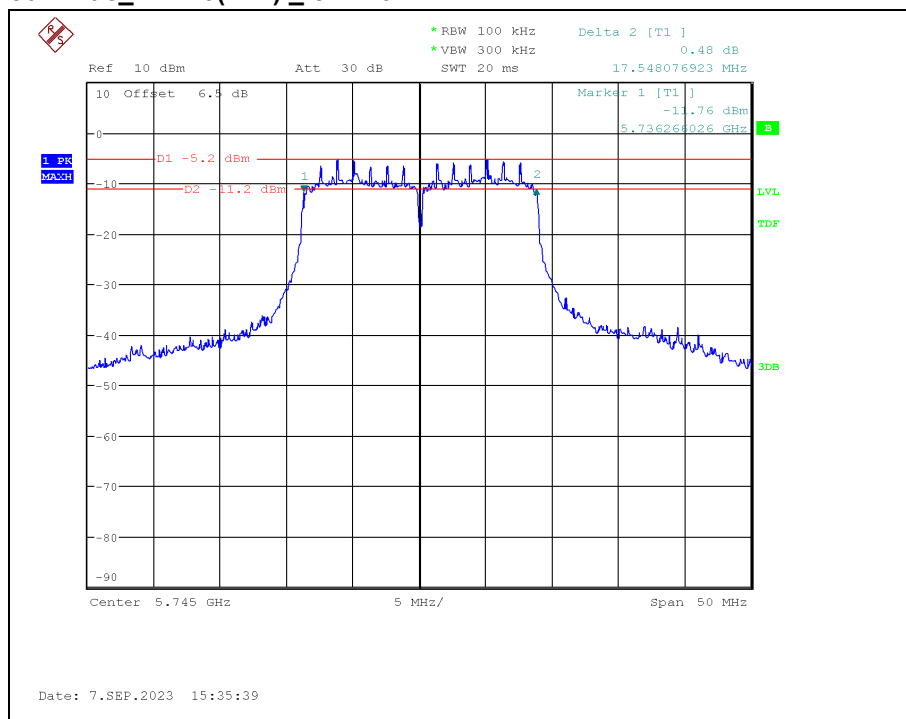
802.11ac_VHT20(12V)_ ch.149

6 dB Bandwidth



802.11ac_VHT20(24V)_ ch.149

6 dB Bandwidth



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3.3.4 Maximum Conducted Output Power

3.3.4.1 Test Setup

Refer to the APPENDIX I.

3.3.4.2 Limit

Part. 15.407(a)

(1) For the band 5.15 - 5.25 GHz.

- (i) For an outdoor access point operating in the band 5.15 - 5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. The maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm).
- (ii) For an indoor access point operating in the band 5.15 - 5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.
- (iii) For fixed point-to-point access points operating in the band 5.15 - 5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. Fixed point-to-point U-NII devices may employ antennas with directional gain up to 23 dBi without any corresponding reduction in the maximum conducted output power or maximum power spectral density. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum conducted output power and maximum power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.
- (iv) For mobile and portable client devices in the 5.15 - 5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(2) For the 5.25 - 5.35 GHz and 5.47 - 5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or $11 \text{ dBm} + 10 \log B$, where B is the 26 dB emission bandwidth in megahertz. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(3) For the band 5.725 - 5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the

equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

Band	Power Limit (mW)	Calculated Limit (dBm)	Antenna Gain (dBi)	Determined Limit (dBm)
U-NII 1	250	23.97	2.79	23.97

Band	Power Limit (mW) Least 26 dBc BW (MHz)	Calculated Limit (dBm)	Antenna Gain (Worst case) (dBi)	Determined Limit (dBm)
U-NII 2A	250	23.97	NA	NA
	NA	NA		
U-NII 2C	250	23.97	NA	NA
	NA	NA		

Band	Power Limit (mW)	Calculated Limit (dBm)	Antenna Gain (dBi)	Determined Limit (dBm)
U-NII 3	1000	30.00	2.79	30.00

3.3.4.3 Test Procedure

A transmitter antenna terminal of EUT is connected to the input of a spectrum analyzer. Measurement is made while the EUT is operating in transmission mode at the appropriate frequencies.

1. Measure the duty cycle D of the transmitter output signal
2. Set span to encompass the entire 26 dB EBW or 99% OBW of the signal
3. Set RBW = 1 MHz
4. Set VBW $\geq$ 3 MHz
5. Number of points in sweep $\geq [2 \times \text{span} / \text{RBW}]$. (This gives bin-to-bin spacing $\leq \text{RBW} / 2$, so that narrowband signals are not lost between frequency bins.)
6. Sweep time = auto.
7. Detector = RMS (power averaging)
8. Do not use sweep triggering. Allow the sweep to "free run."
9. Trace average at least 100 traces in power averaging (rms) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the ON and OFF periods of the transmitter.
10. Compute power by integrating the spectrum across the 26 dB EBW or 99% OBW of the signal using the instrument's band power measurement function with band limits set equal to the EBW or OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at 1 MHz intervals extending across the 26 dB EBW or 99% OBW of the spectrum.
11. Add $[10 \log (1 / D)]$, where D is the duty cycle, to the measured power to compute the average power during the actual transmission times (because the measurement represents an average over both the ON and OFF times of the transmission). For example, add $[10 \log (1 / 0.25)] = 6$ dB if the duty cycle is 25%.

3.3.4.4 Test Result

Test Mode	Band	Test Channel	Vol. (V)	Maximum Conducted Output Power			
				Reading	C.F	Test Result	
				(dBm)	(dB)	(dBm)	(mW)
802.11ac_VHT20	U-NII 1	36	12	6.58	0.12	6.70	4.68
			24	6.56	0.12	6.68	4.66
	U-NII 3	149	12	5.29	0.12	5.41	3.48
			24	5.46	0.12	5.58	3.62

Note 1: C.F(Correction Factor)

Correction Factor = DCCF

For DCCF(Duty Cycle Correction Factor) please refer to appendix III.

Note 2: Sample Calculation.

Test Result = Reading + C.F

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3.3.4.5 Test Plot

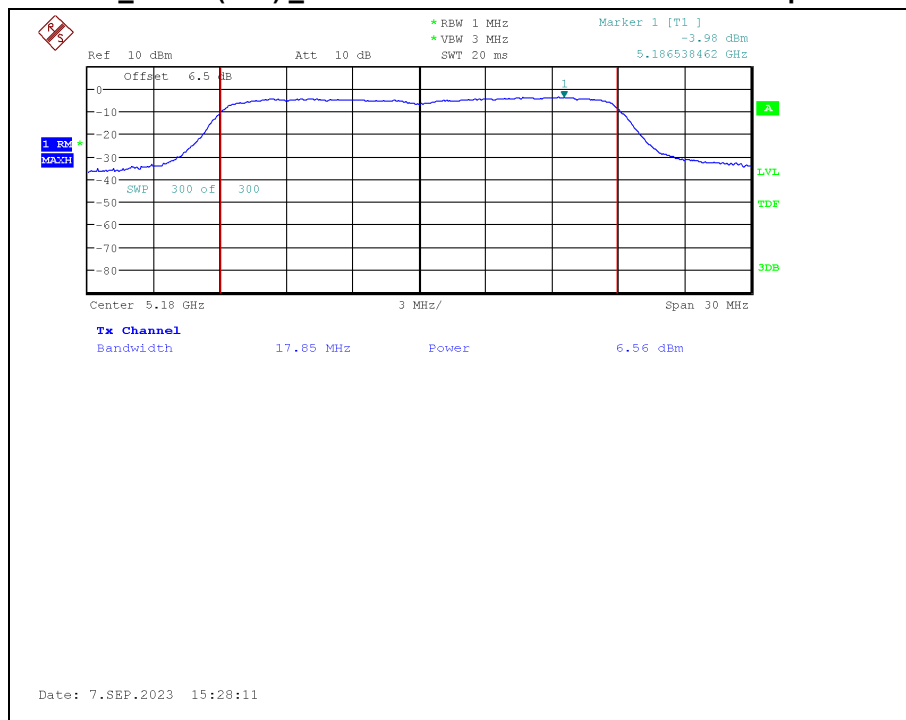
802.11ac_VHT20(12V)_ch.36

Maximum Conducted Output Power



802.11ac_VHT20(24V)_ch.36

Maximum Conducted Output Power

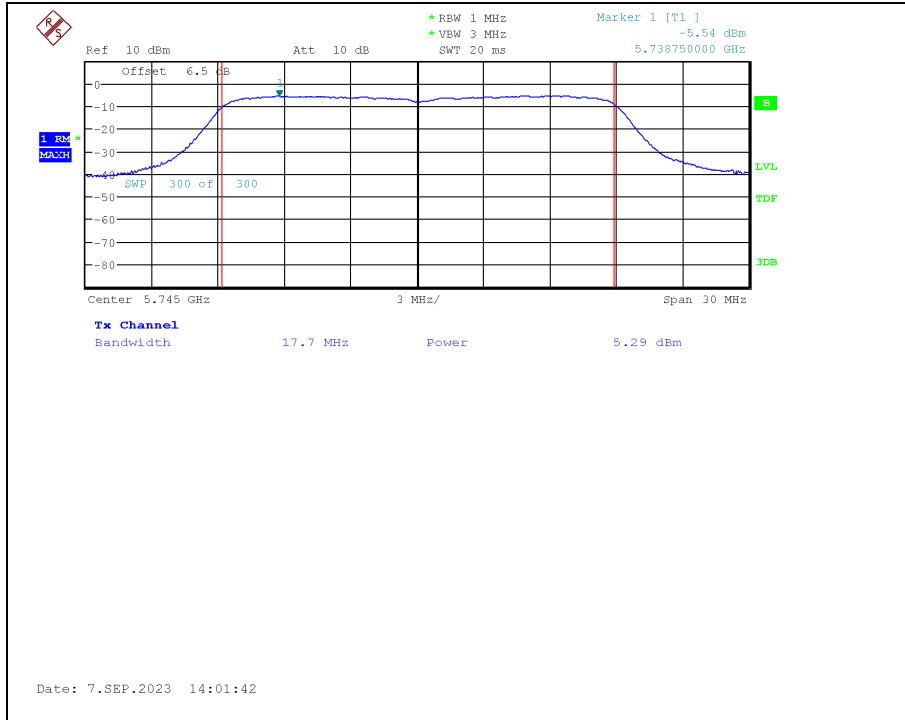


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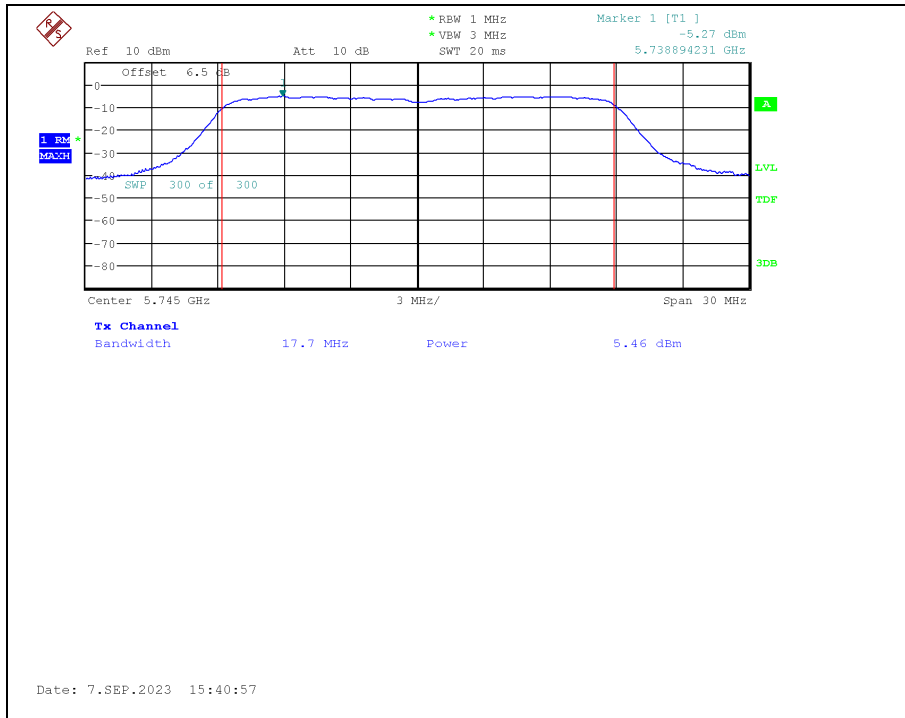
802.11ac_VHT20(12V)_ ch.149

Maximum Conducted Output Power



802.11ac_VHT20(24V)_ ch.149

Maximum Conducted Output Power



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3.3.5 Peak Power Spectral Density

3.3.5.1 Test Setup

Refer to the APPENDIX I.

3.3.5.2 Limit

Part. 15.407(a)

- (1) For the band 5.15 - 5.25 GHz.
- (i) For an outdoor access point operating in the band 5.15 - 5.25 GHz, the maximum power spectral density shall not exceed 17 dBm in any 1 MHz band. ^{note1}
 - (ii) For an indoor access point operating in the band 5.15 - 5.25 GHz, the maximum power spectral density shall not exceed 17 dBm in any 1 MHz band. ^{note1}
 - (iii) For fixed point-to-point access points operating in the band 5.15 - 5.25 GHz, transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi.
 - (iv) For mobile and portable client devices in the 5.15 - 5.25 GHz band, the maximum power spectral density shall not exceed 11 dBm in any 1 MHz band. ^{note1}
- (2) For the 5.25 - 5.35 GHz and 5.47 - 5.725 GHz bands, the peak power spectral density shall not exceed 11 dBm in any 1 MHz band. ^{note1}
- (3) For the band 5.725 - 5.85 GHz, the maximum power spectral density shall not exceed 30 dBm in any 500 kHz band. ^{note1,note2}

Note1: If transmitting antennas of directional gain greater than 6 dBi are used, the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Note2: Fixed point - to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-topoint operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information.

RSS-247

- (1) For the band 5.15 - 5.25 GHz.
- For OEM devices installed in vehicles, the maximum e.i.r.p. shall not exceed 30 mW or $1.76 + 10 \log_{10} B$, dBm, whichever is less. Devices shall implement transmitter power control (TPC) in order to have the capability to operate at least 3 dB below the maximum permitted e.i.r.p. of 30 mW.
- For other devices, the maximum e.i.r.p. shall not exceed 200 mW or $10 + 10 \log_{10} B$, dBm, whichever power is less. B is the 99% emission bandwidth in megahertz. The e.i.r.p. spectral density shall not exceed 10 dBm in any 1.0 MHz band.

(2) For the band 5.25 - 5.35 GHz.

For OEM devices installed in vehicles, the maximum e.i.r.p. shall not exceed 30 mW or $1.76 + 10 \log_{10} B$, dBm, whichever is less. Devices shall implement TPC in order to have the capability to operate at least 3 dB below the maximum permitted e.i.r.p. of 30 mW.

Devices, other than devices installed in vehicles, shall comply with the following:

- The maximum conducted output power shall not exceed 250 mW or $11 + 10 \log_{10} B$, dBm, whichever is less. The power spectral density shall not exceed 11 dBm in any 1.0 MHz band;
- The maximum e.i.r.p. shall not exceed 1.0 W or $17 + 10 \log_{10} B$, dBm, whichever is less. B is the 99% emission bandwidth in megahertz. Note that devices with a maximum e.i.r.p. greater than 500 mW shall implement TPC in order to have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W.

(3) For the band 5.47 - 5.60 GHz and 5.65 - 5.725 GHz.

The maximum conducted output power shall not exceed 250 mW or $11 + 10 \log_{10} B$, dBm, whichever is less. The power spectral density shall not exceed 11 dBm in any 1.0 MHz band.

The maximum e.i.r.p. shall not exceed 1.0 W or $17 + 10 \log_{10} B$, dBm, whichever is less. B is the 99% emission bandwidth in megahertz. Note that devices with a maximum e.i.r.p. greater than 500 mW shall implement TPC in order to have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W.

(4) For the band 5.725 - 5.85 GHz.

For equipment operating in the band 5725-5850 MHz, the minimum 6 dB bandwidth shall be at least 500 kHz.

The maximum conducted output power shall not exceed 1 W. The output power spectral density shall not exceed 30 dBm in any 500 kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the output power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed point-to-point operations exclude the use of point-to-multipointFootnote3 systems, omnidirectional applications and multiple collocated transmitters transmitting the same information.

3.3.5.3 Test Procedure

The peak power density is measured with a spectrum analyzer connected to the antenna terminal while the EUT is operating in transmission mode at the appropriate frequencies.

- 1) Create an average power spectrum for the EUT operating mode being tested by following the instructions in section II.E.2. for measuring maximum conducted output power using a spectrum analyzer or EMI receiver: select the appropriate test method (SA - 1, SA - 2, SA - 3, or alternatives to each) and apply it up to, but not including, the step labeled, "Compute power...". (This procedure is required even if the maximum conducted output power measurement was performed using a power meter, method PM.)
- 2) Use the peak search function on the instrument to find the peak of the spectrum and record its value.
- 3) Make the following adjustments to the peak value of the spectrum, if applicable:
 - a) If Method SA - 2 or SA - 2 Alternative was used, add $10 \log(1 / x)$, where x is the duty cycle, to the peak of the spectrum.
 - b) If Method SA - 3 Alternative was used and the linear mode was used in step II.E.2.g (viii), add 1 dB to the final result to compensate for the difference between linear averaging and power averaging.
- 4) The result is the Maximum PSD over 1 MHz reference bandwidth.
- 5) For devices operating in the bands 5.15 - 5.25 GHz, 5.25 - 5.35 GHz, and 5.47 - 5.725 GHz, the above procedures make use of 1 MHz RBW to satisfy directly the 1 MHz reference bandwidth specified in §15.407(a)(5). For devices operating in the band 5.725 - 5.85 GHz, the rules specify a measurement bandwidth of 500 kHz.

3.3.5.4 Test Result

Test Mode	Band	Test Channel	Vol. (V)	Peak Power Spectral Density			
				Reading	C.F	Test Result	Limit
				(dBm)	(dB)	(dBm)	(dBm)
802.11ac_VHT20	U-NII 1	36	12	-6.07	0.12	-5.95	11.00
			24	-5.89	0.12	-5.77	11.00
	U-NII 3	149	12	-6.80	0.12	-6.68	30.00
			24	-6.43	0.12	-6.31	30.00

Note 1: C.F(Correction Factor)

Correction Factor = DCCF

For DCCF(Duty Cycle Correction Factor) please refer to appendix III.

Note 2: Sample Calculation.

Test Result = Reading + C.F

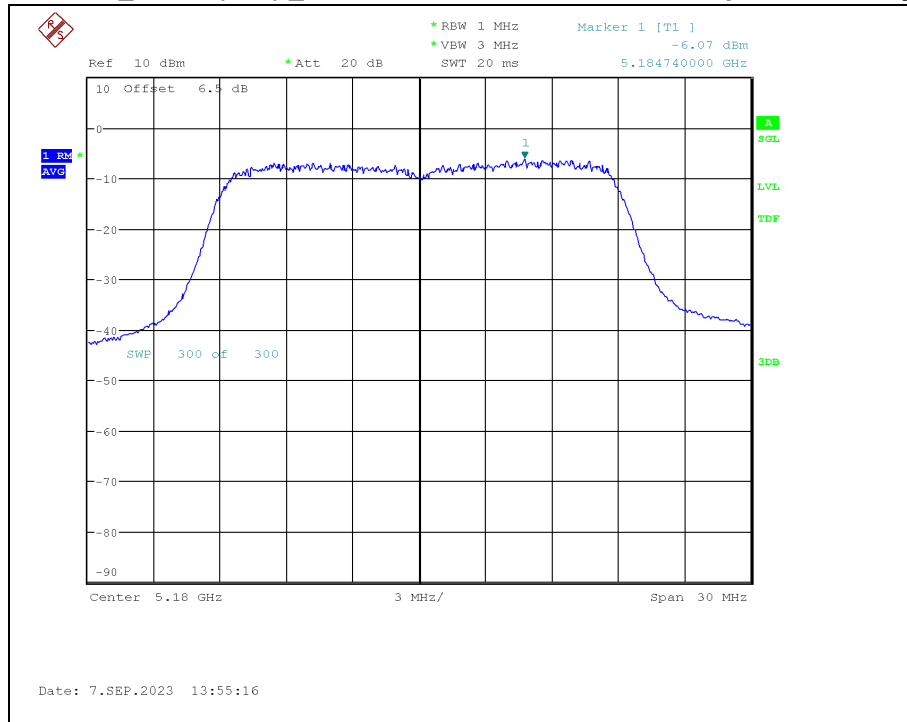
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3.3.5.5 Test Plot

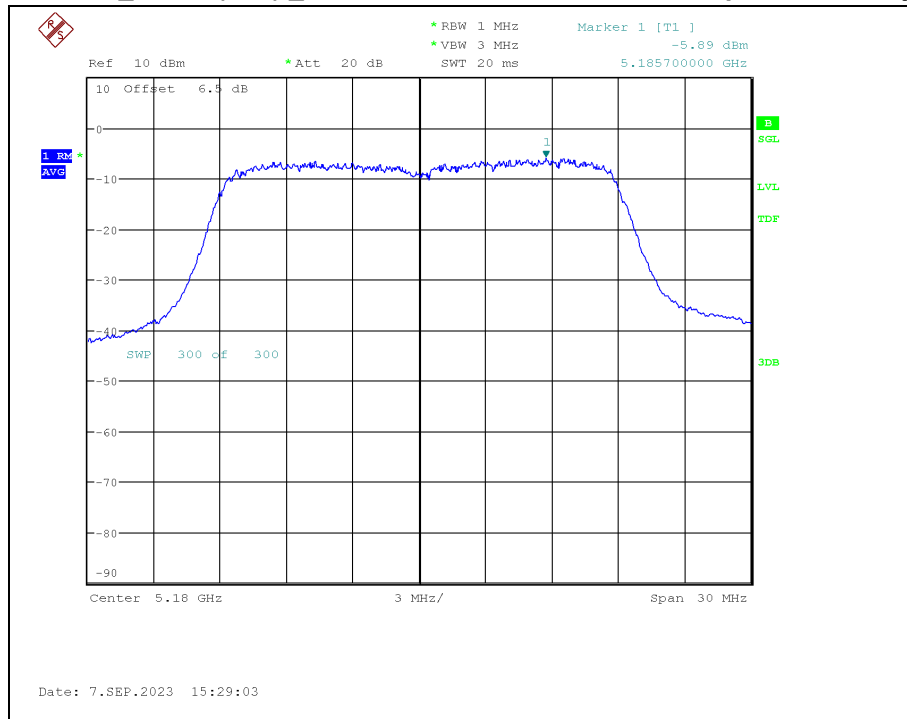
802.11ac_VHT20(12V)_ch.36

Peak Power Spectral Density



802.11ac_VHT20(24V)_ch.36

Peak Power Spectral Density

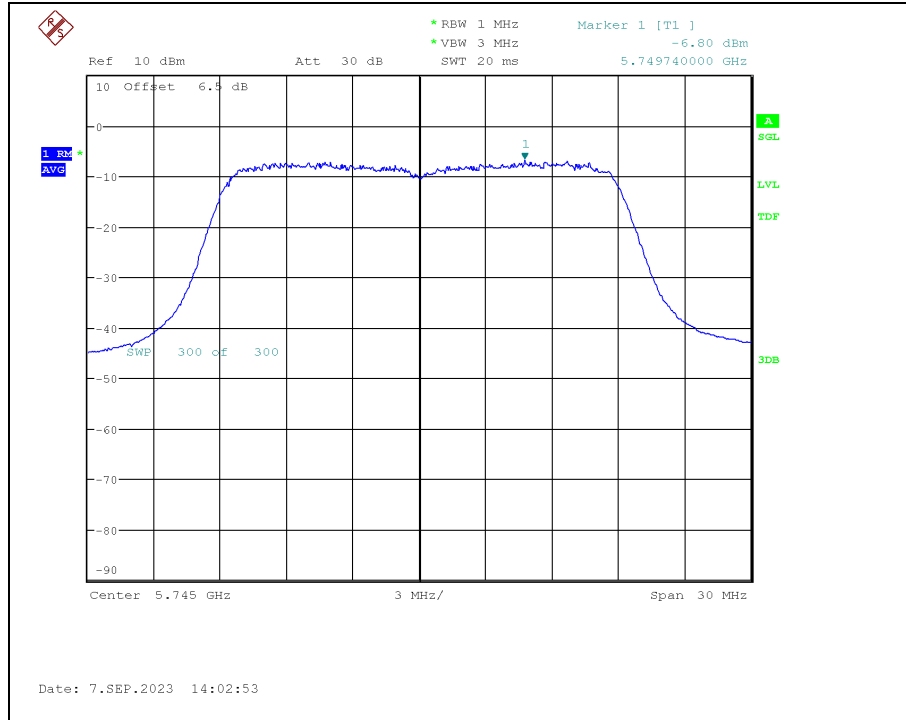


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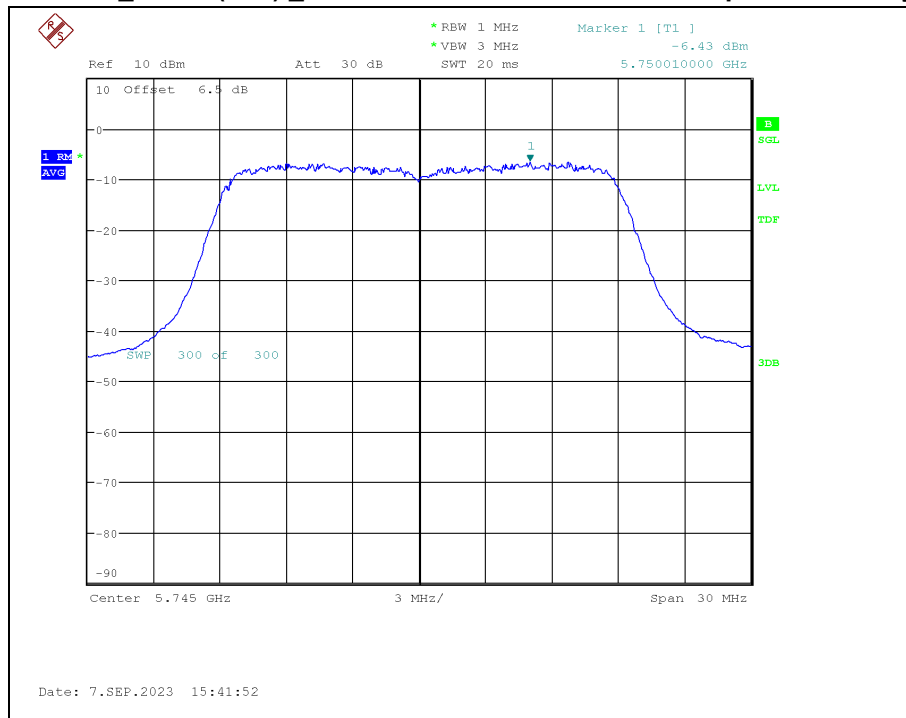
802.11ac_VHT20(12V) _ ch.149

Peak Power Spectral Density



802.11ac_VHT20(24V) _ ch.149

Peak Power Spectral Density



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3.3.6 TX Radiated Spurious Emission

3.3.6.1 Test Setup

Refer to the APPENDIX I.

3.3.6.2 Limit

FCC Part 15.407 (b): Undesirable emission limits. Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

- (1) For transmitters operating in the 5.15-5.25 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz.
- (2) For transmitters operating in the 5.25-5.35 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz.
- (3) For transmitters operating in the 5.47-5.725 GHz band: all emissions outside of the 5.47-5.725 GHz band shall not exceed an EIRP of -27 dBm/MHz.
- (4) For transmitters operating in the 5.725-5.85 GHz band: All emissions shall be limited to a level of -27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.
- (5) The emission measurements shall be 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.
- (6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in Section 15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in Section 15.207.
- (7) The provisions of §15.205 apply to intentional radiators operating under this section
- (8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

According to § 15.209(a), except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

Frequency (MHz)	Limit ($\mu\text{V/m}$)	Measurement Distance (meter)
0.009 ~ 0.490	2400/F (kHz)	300
0.490 ~ 1705	24000/F (kHz)	30
1705 ~ 30.0	30	30
30 ~ 88	100 **	3
88 ~ 216	150 **	3
216 ~ 960	200 **	3
Above 960	500	3

** Except as provided in 15.209(g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 - 72 MHz, 76 - 88 MHz, 174 - 216 MHz or 470 - 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g. 15.231 and 15.241.

According to § 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below:

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MHz	MHz	MHz	GHz
0.009 ~ 0.110	16.42 ~ 16.423	399.90 ~ 410	4.5 ~ 5.15
0.495 ~ 0.505	16.69475 ~ 16.69525	608 ~ 614	5.35 ~ 5.46
2.1735 ~ 2.1905	16.80425 ~ 16.80475	960 ~ 1240	7.25 ~ 7.75
4.125 ~ 4.128	25.5 ~ 25.67	1300 ~ 1427	8.025 ~ 8.5
4.17725 ~ 4.17775	37.5 ~ 38.	1435 ~ 1626.5	9.0 ~ 9.2
4.20725 ~ 4.20775	25 73 ~ 74.6	1645.5 ~ 1646.5	9.3 ~ 9.5
4.17725 ~ 4.17775	74.8 ~ 75.2	1660 ~ 1710	10.6 ~ 12.7
6.215 ~ 6.218	108 ~ 121.94	1718.8 ~ 1722.2	13.25 ~ 13.4
6.26775 ~ 6.26825	149.9 ~ 150.05	2200 ~ 2300	14.47 ~ 14.5
6.31175 ~ 6.31225	156.52475 ~ 156.52525	2310 ~ 2390	15.35 ~ 16.2
8.291 ~ 8.294	156.7 ~ 156.9	2483.5 ~ 2500	17.7 ~ 21.4
8.362 ~ 8.366	162.0125 ~ 167.17	2690 ~ 2900	22.01 ~ 23.12
8.37625 ~ 8.38675	3345.8 ~ 3358	3260 ~ 3267	23.6 ~ 24.0
8.41425 ~ 8.41475	3600 ~ 4400	3332 ~ 3339	31.2 ~ 31.8
12.51975 ~ 12.52025	3345.8 ~ 3358	240 ~ 285	36.43 ~ 36.5
12.57675 ~ 12.57725	3600 ~ 4400	322 ~ 335.4	Above 38.6
13.36 ~ 13.41			

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

3.3.6.3 Test Procedure

1. The EUT is placed on a non-conductive table. For emission measurements at or below 1 GHz, the table height is 80 cm. For emission measurements above 1 GHz, the table height is 1.5 m. The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 1 or 3 meter away from the interference-receiving antenna.
3. For measurements above 1 GHz absorbers are placed 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 below 1 GHz, the absorbers are removed.
4. The antenna is a Broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
5. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
(The EUT was pre-tested with three axes (X, Y, Z) and the final test was performed at the worst case.)
6. Repeat above procedures until the measurements for all frequencies are complete.

Radiated spurious emission measured using following Measurement Procedure of **KDB789033 D02v02r01**

General Requirements for Unwanted Emissions Measurements

The following requirements apply to all unwanted emissions measurements, both in and outside of the restricted bands:

▪ EUT Duty Cycle

- (1) The EUT shall be configured or modified to transmit continuously except as stated in (ii), below. The intent is to test at 100 percent duty cycle; however a small reduction in duty cycle (to no lower than 98 percent) is permitted if required by the EUT for amplitude control purposes. Manufacturers are expected to provide software to the test lab to permit such continuous operation.
- (2) If continuous transmission (or at least 98 percent duty cycle) cannot be achieved due to hardware limitations of the EUT (e.g., overheating), the following additions to the measurement and reporting procedures are required:
 - The EUT shall be configured to operate at the maximum achievable duty cycle.
 - Measure the duty cycle, x, of the transmitter output signal.
 - Adjustments to measurement procedures (e.g., increasing test time and number of traces averaged) shall be performed as described in the procedures below.
 - The test report shall include the following additional information:
 - The reason for the duty cycle limitation.
 - The duty cycle achieved for testing and the associated transmit duration and interval between transmissions.
 - The sweep time and the amount of time used for trace stabilization during max-hold measurements for peak emission measurements.
- (3) Reduction of the measured emission amplitude levels to account for operational duty factor is not permitted. Compliance is based on emission levels occurring during transmission - not on an average across on and off times of the transmitter.

Measurements below 1 GHz

- a) Follow the requirements in section II.G.3, “General Requirements for Unwanted Emissions Measurements”.
- b) Compliance shall be demonstrated using CISPR quasi-peak detection; however, peak detection is permitted as an alternative to quasi-peak detection.

Measurements above 1 GHz (Peak)

- a) Follow the requirements in section II.G.3, “General Requirements for Unwanted Emissions Measurements”.
- b) Peak emission levels are measured by setting the analyzer as follows:
 - (i) RBW = 1 MHz.
 - (ii) VBW $\geq$ 3 MHz.
 - (iii) Detector = Peak.
 - (iv) Sweep time = Auto.
 - (v) Trace mode = Max hold.
 - (vi) Allow sweeps to continue until the trace stabilizes. Note that if the transmission is not continuous, the time required for the trace to stabilize will increase by a factor of approximately $1/x$, where x is the duty cycle.

For example, at 50 percent duty cycle, the measurement time will increase by a factor of two relative to measurement time for continuous transmission.

Measurements above 1 GHz (Method AD)

- (i) RBW = 1 MHz.
- (ii) VBW $\geq$ 3 MHz.
- (iii) Detector = RMS, if $\text{span} / (\# \text{ of points in sweep}) \leq \text{RBW} / 2$. Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If the condition is not satisfied, the detector mode shall be set to peak.
- (iv) Averaging type = power (i.e., RMS)
 - As an alternative, the detector and averaging type may be set for linear voltage averaging. Some analyzers require linear display mode in order to use linear voltage averaging. Log or dB averaging shall not be used.
- (v) Sweep time = Auto.
- (vi) Perform a trace average of at least 100 traces if the transmission is continuous. If the transmission is not continuous, the number of traces shall be increased by a factor of $1/x$, where x is the duty cycle. For example, with 50 percent duty cycle, at least 200 traces shall be averaged.
- (vii) If tests are performed with the EUT transmitting at a duty cycle less than 98 percent, a correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle. The correction factor is computed as follows:
 - If power averaging (RMS) mode was used in step (iv) above, the correction factor is $10 \log(1/x)$, where x is the duty cycle. For example, if the transmit duty cycle was 50 percent, then 3 dB must be added to the measured emission levels.
 - If linear voltage averaging mode was used in step (iv) above, the correction factor is $20 \log(1/x)$, where x is the duty cycle. For example, if the transmit duty cycle was 50 percent, then 6 dB must be added to the measured emission levels.
 - If a specific emission is demonstrated to be continuous (100 percent duty cycle) rather than turning on and off with the transmit cycle, no duty cycle correction is required for that emission.

Please refer to Appendix III for the duty cycle correction factor

3.3.6.4 Test Result

9 kHz ~ 40 GHz Data for 802.11ac_VHT20

Band	Tested Channel	Vol. (V)	Freq.	Reading		Pol.	T.F (dB)	DCCF (dB)	Limits		Result		Margin	
				(dBμV/m)					(dBμV/m)		(dB)			
			(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
U-NII 1	36	12	2 880.28	45.15	54.65	V	-10.39	0.12	54.0	74.0	34.9	44.4	19.1	29.6
		24	2 879.67	45.14	54.43	V	-10.39	0.12	54.0	74.0	34.9	44.2	19.1	29.8
U-NII 3	149	12	2 879.93	43.68	53.83	V	-10.39	0.12	54.0	74.0	33.4	43.6	20.6	30.4
		24	2 880.37	44.43	54.41	V	-10.39	0.12	54.0	74.0	34.2	44.1	19.8	29.9

Note 1: No other spurious and harmonic emissions were found greater than listed emissions on above table.

Note 2: DCCF(Duty Cycle Correction Factor)

For DCCF(Duty Cycle Correction Factor) please refer to appendix III.

Note 3: Sample Calculation.

Margin = Limit – Result / Peak Result = Peak Reading + TF / Average Result = Average Reading + TF + DCCF

TF = Ant factor + Cable Loss + Filter Loss – Amp Gain

Note 4: The limit is converted to field strength

$E[\text{dB}\mu\text{V/m}] = \text{EIRP}[\text{dBm}] + 95.2 \text{ dB} = -27 \text{ dBm} + 95.2 \text{ dB} = 68.2 \text{ dB}\mu\text{V/m}$

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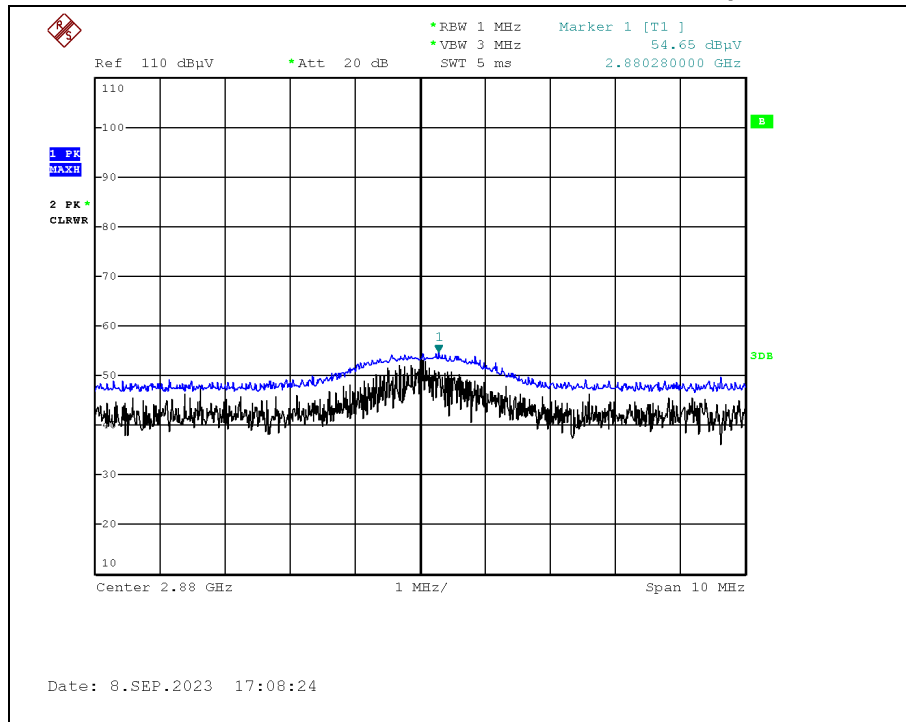
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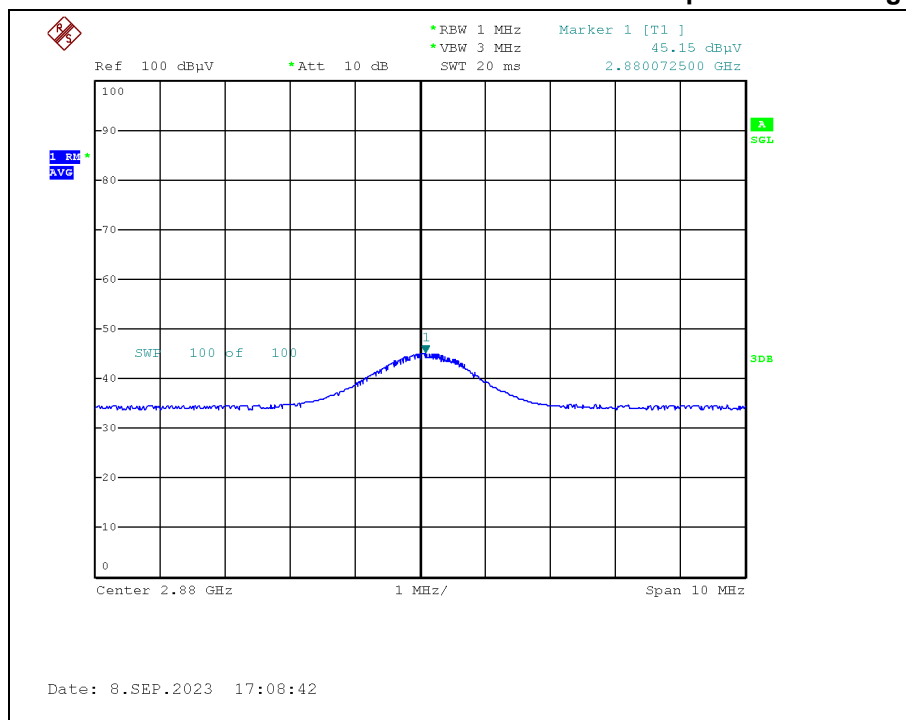
3.3.6.5 Test Plot

- 802.11ac_VHT20(12V) _ ch.36

Spurious – Peak



Spurious – Average

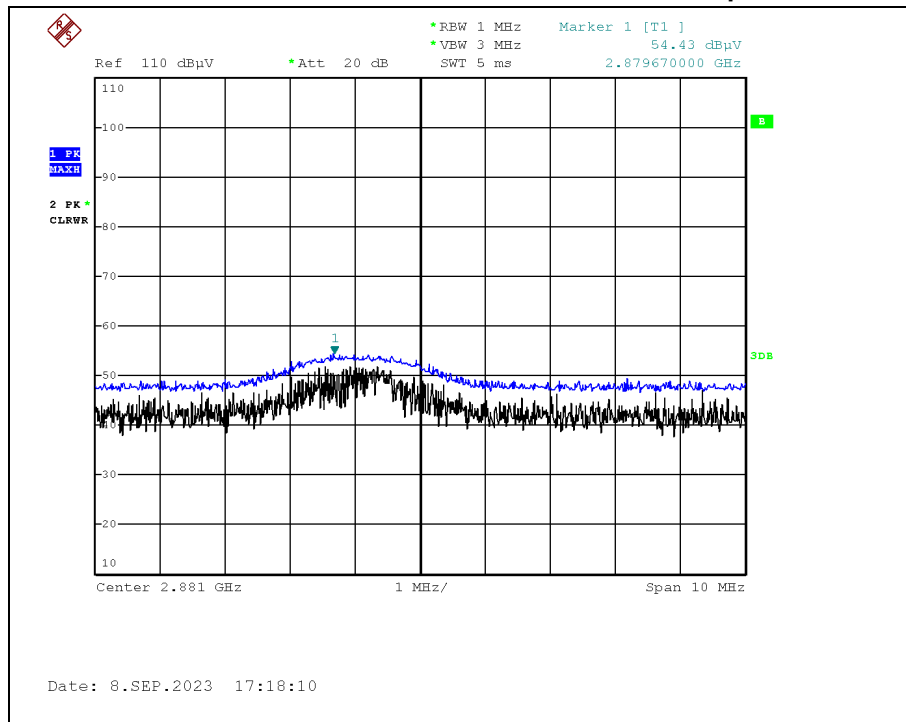


Test Report No.: NW2309-F005

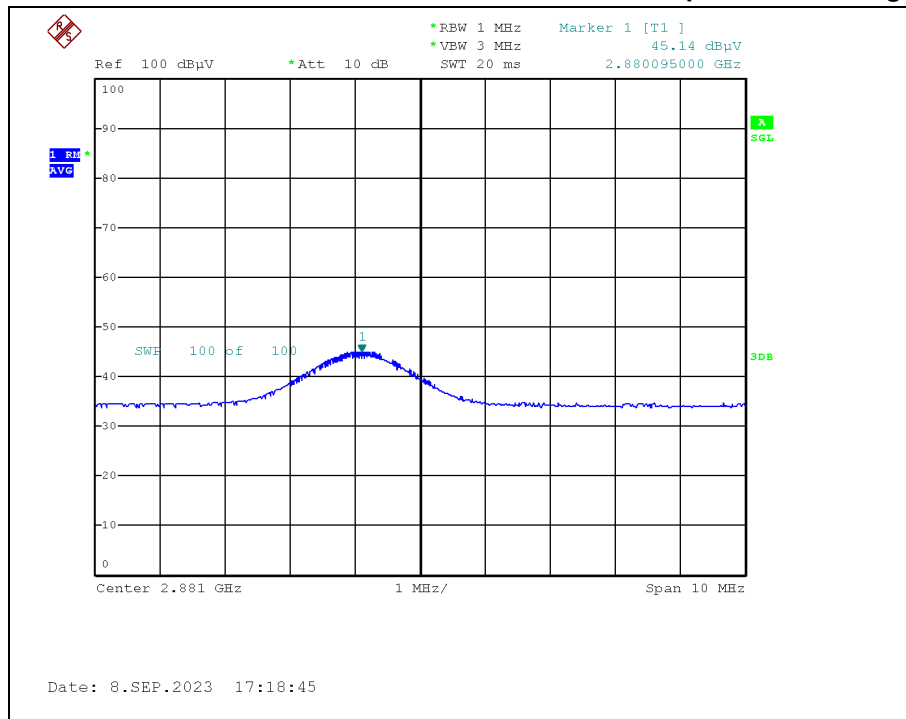
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- 802.11ac_VHT20(24V) _ ch.36

Spurious – Peak



Spurious – Average

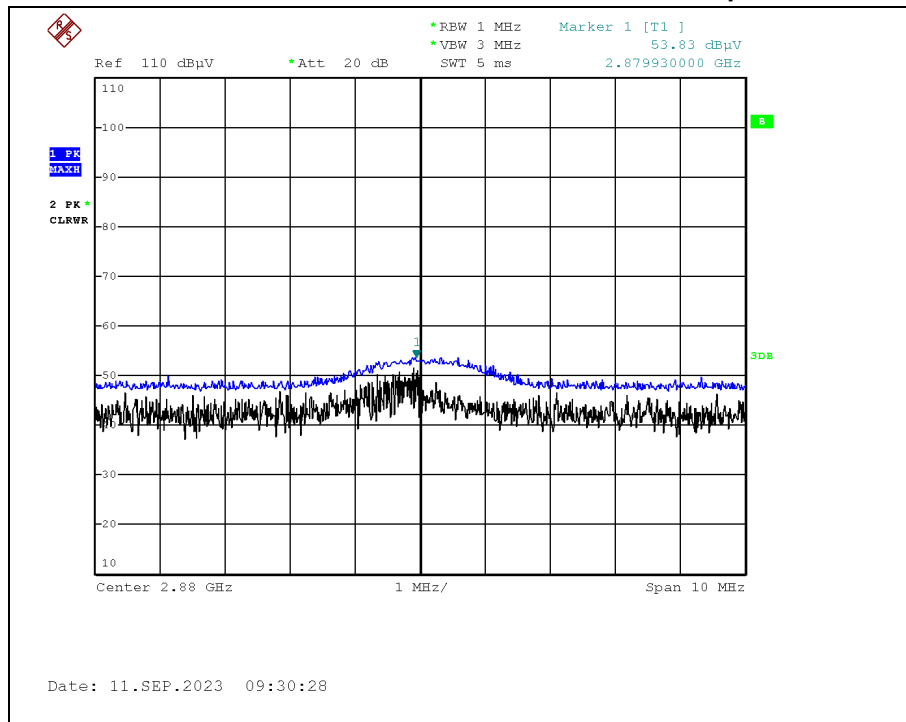


Test Report No.: NW2309-F005

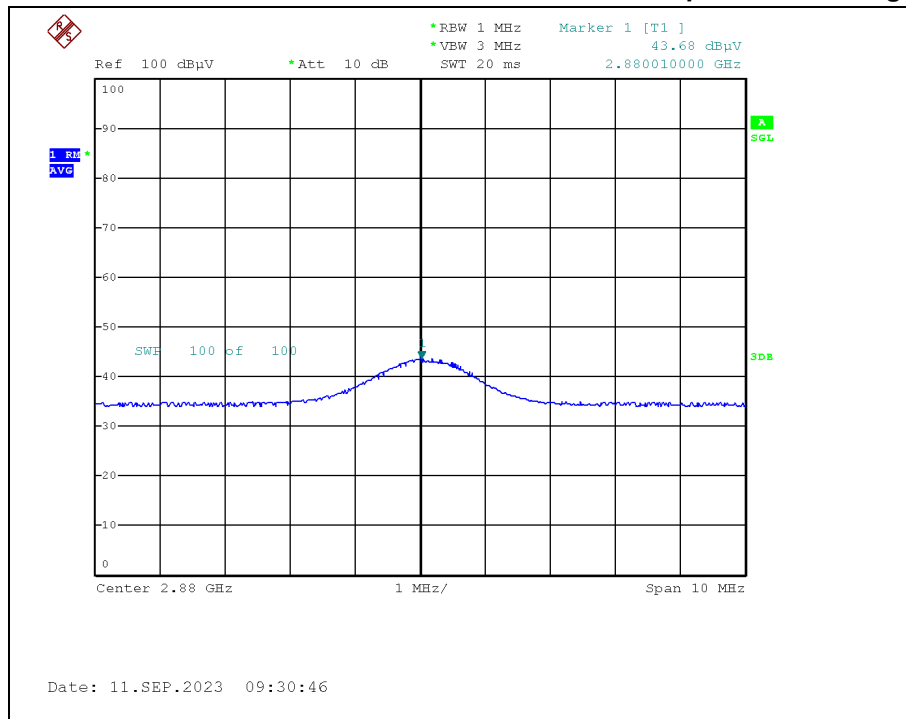
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- 802.11ac_VHT20(12V) _ ch.149

Spurious – Peak



Spurious – Average

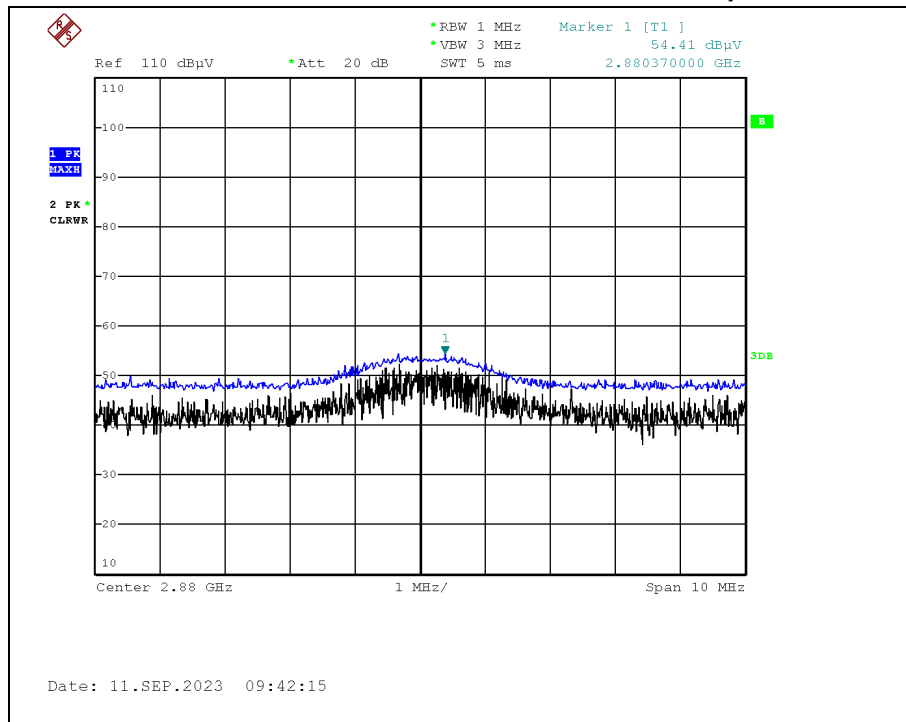


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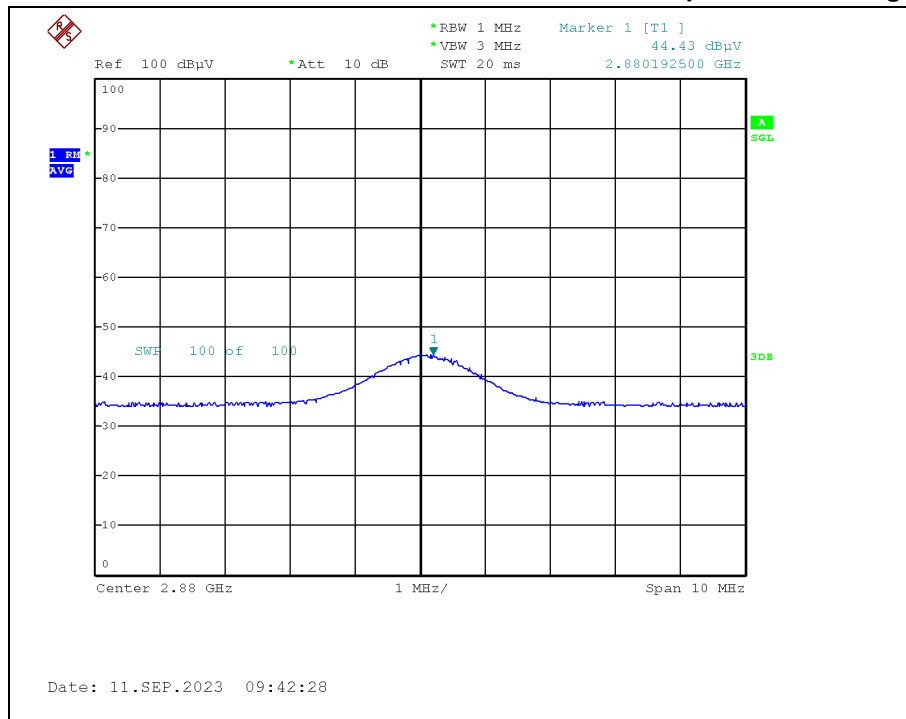
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- 802.11ac_VHT20(24V) _ ch.149

Spurious – Peak



Spurious – Average



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3.3.7 Conducted Emission

3.3.7.1 Test Setup

See test photographs for the actual connections between EUT and support equipment.

3.3.7.2 Limit

According to §15.207(a) for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 uH/50 ohm line impedance stabilization network (LISN).

Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequency ranges.

Frequency Range (MHz)	Conducted Limit (dBμV)	
	Quasi-Peak	Average
0.15 ~ 0.5	66 to 56 *	56 to 46 *
0.5 ~ 5	56	46
5 ~ 30	60	50

* Decreases with the logarithm of the frequency

3.3.7.3 Test Procedure

Conducted emissions from the EUT were measured according to the ANSI C63.10.

1. The test procedure is performed in a 6.5 m × 3.5 m × 3.5 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
3. All peripherals were connected to the second LISN and the chassis ground also bounded to the horizontal ground plane of shielded room.
4. The excess power cable between the EUT and the LISN was bundled. The power cables of peripherals were unbundled. All connecting cables of EUT and peripherals were moved to find the maximum emission.

3.3.7.4 Test Result

Not Applicable

(This product is only using DC power. So, AC conducted emission test has not been performed.)

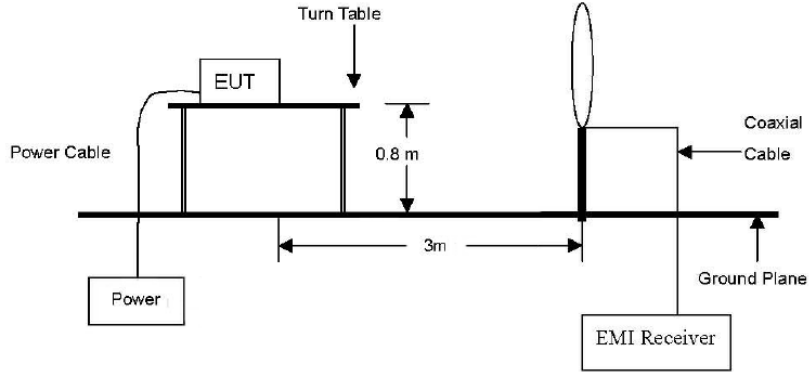
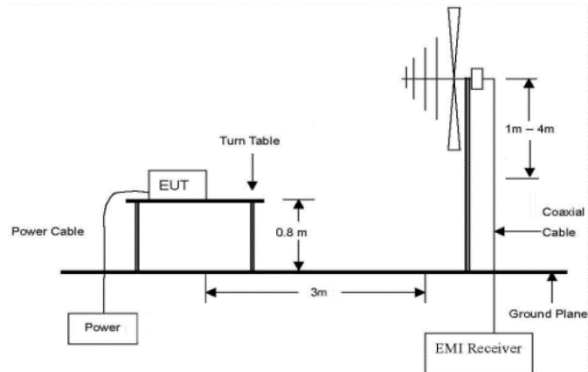
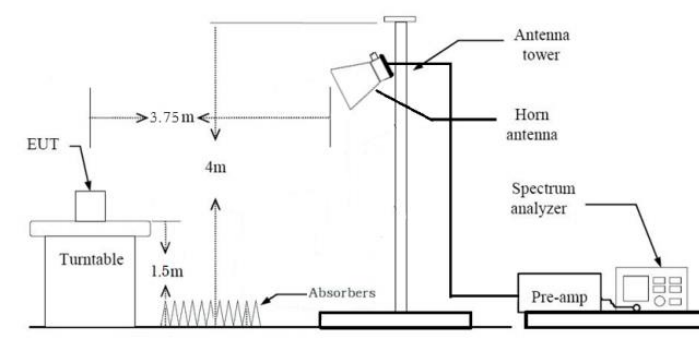
APPENDIX I

TEST SETUP

Test Repot No.: NW2309-F005

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- Radiated Measurement

below 30 MHz	
below 1 GHz	
above 1 GHz	Above 1 GHz 

- Conducted Measurement

Conducted	
-------------------------	--

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APPENDIX III

TEST EQUIPMENT USED FOR TESTS

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	Description	Manufacturer	Serial No.	Model No.	Cal. Date	Next Cal. Date
1	SPECTRUM ANALYZER	R&S	100617	FSP40	2023-03-28	2024-03-28
2	Signal Analyzer	Anritsu	6261831920	MS2850A	2023-08-31	2024-08-31
3	Triple Output DC Power Supply	Agilent	MY40038816	E3631A	2023-03-07	2024-03-07
4	Vector SG	R&S	255563	SMBV100A	2023-03-09	2024-03-09
5	8360B SERIES SWEPT SIGNAL GENERATOR	HP	3614A00312	83640B	2023-08-30	2024-08-30
6	Humi./Baro/Temp. data recorder	Lutron	89503	MHB-382SD	2023-07-21	2024-07-21
7	ATTENUATOR	Agilent	08259	8493C	2023-03-10	2024-03-10
8	High Pass Filter	WT Microwave INC	WT210907-1-1	WT-A1944-HS	2023-08-31	2024-08-31
9	Low Noise Amplifier	LTC MICROWAVE	143	LLA01185025Q	2023-08-30	2024-08-30
10	Amplifier	TESTEK	190008-L	TK-PA1840H	2023-05-24	2024-05-24
11	LOOP-ANTENNA	Schwarzbeck	00124	FMZB1519 B	2023-05-25	2025-05-25
12	TRILOG Broadband Antenna	01027	VULB 9168	VULB 9168	2023-05-23	2025-05-23
13	Double Ridged Broadband Horn Antenna	02087	BBHA 9120 D	BBHA 9120 D	2023-05-04	2024-05-04
14	Broadband Horn Antenna	00938	BBHA 9170	BBHA 9170	2023-05-25	2024-05-25

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APPENDIX III

DUTY CYCLE CORRECTION FACTOR

Test Repot No.: NW2309-F005

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Test Procedure

Duty Cycle $[X = \text{On Time} / (\text{On} + \text{Off time})]$ is measured using Measurement Procedure of KDB558074 D01v05r02

1. Set the center frequency of the spectrum analyzer to the center frequency of the transmission.
2. Set RBW $\geq$ OBW if possible; otherwise, set RBW to the largest available value.
3. Set VBW $\geq$ RBW. Set detector = peak.
4. Note : The zero-span measurement method shall not be used unless both RBW and VBW are $> 50/T$, where T is defined in section II.B.1.a), and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if $T \leq 16.7$ microseconds.)

T : The minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

(T = On time of the above table since the EUT operates with above fixed Duty Cycle and it is the minimum On time)

Test Result

Test Mode		Data Rate	Test Channel	Maximum Achievable Duty Cycle (x) = On / (On+Off)			Duty Cycle Correction Factor (dB)	50/T (kHz)
				On Time (ms)	(On+Off) Time (ms)	Duty Cycle (x)		
U-NII 1	802.11ac_VHT20 (12V)	MCS 0	36	1.897	1.952	0.972	0.12	26.35
	802.11ac_VHT20 (24V)	MCS 0	36	1.897	1.952	0.972	0.12	26.35
U-NII 3	802.11ac_VHT20 (12V)	MCS 0	149	1.897	1.952	0.972	0.12	26.35
	802.11ac_VHT20 (24V)	MCS 0	149	1.897	1.952	0.972	0.12	26.35

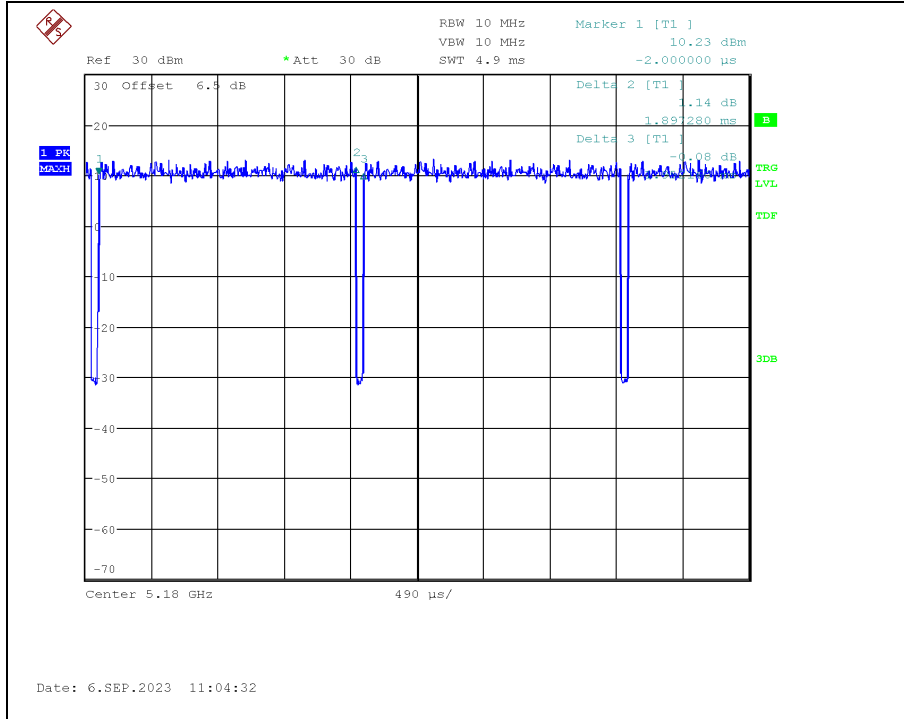
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Test Plot

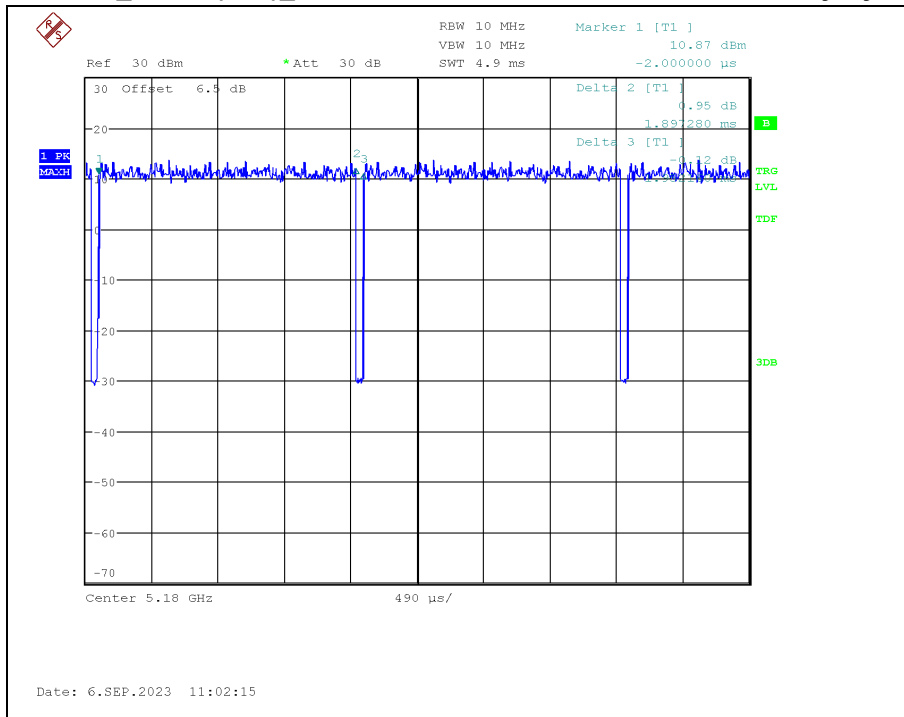
802.11ac_VHT20(12V)_ch.36

Duty Cycle



802.11ac_VHT20(24V)_ch.36

Duty Cycle

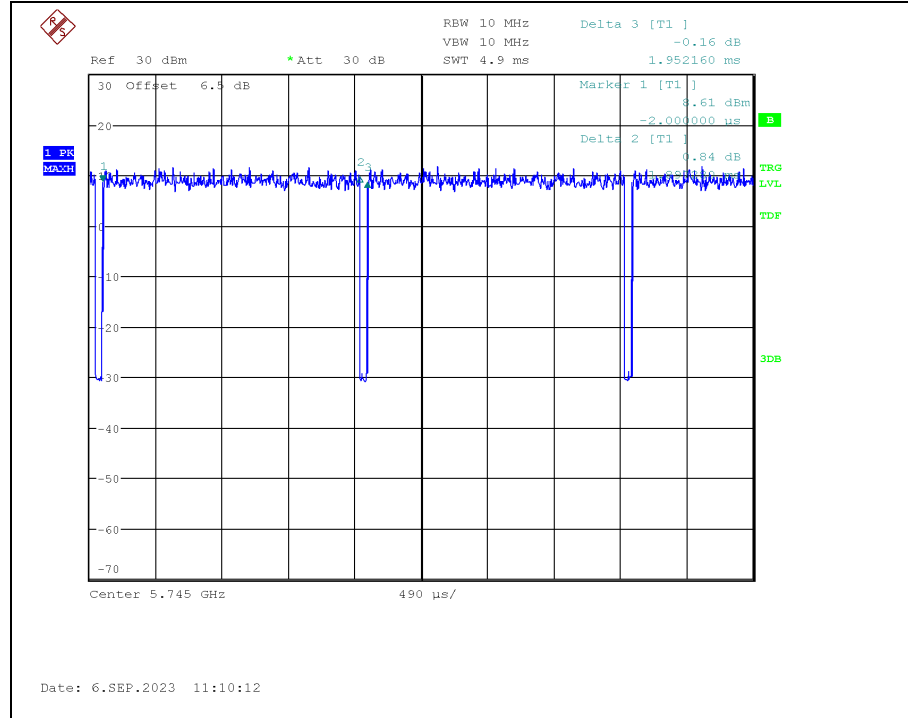


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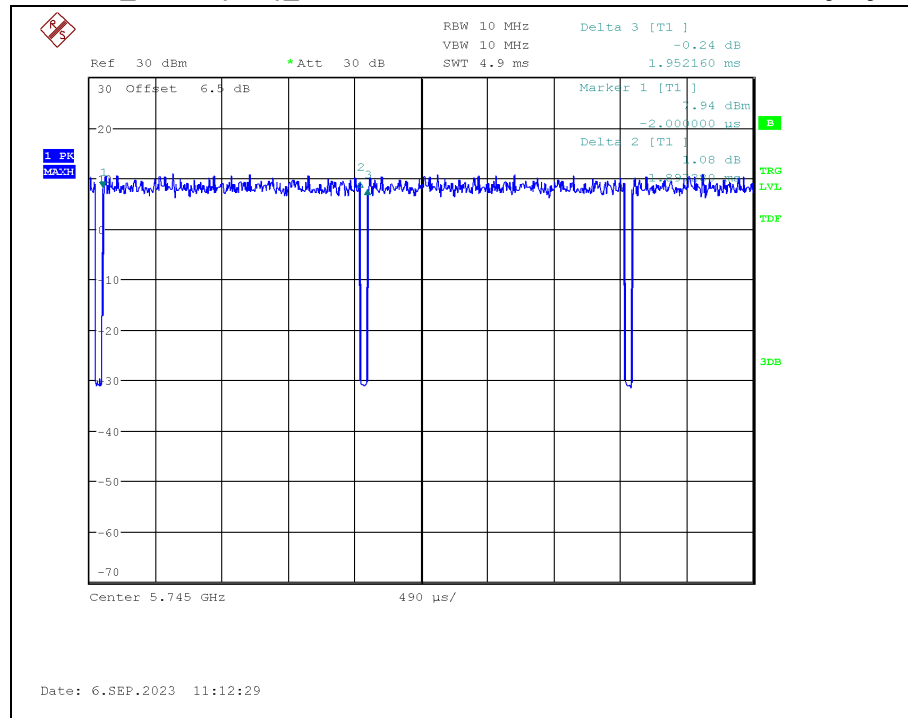
802.11ac_VHT20(24V)_ch.149

Duty Cycle



802.11ac_VHT20(24V)_ch.149

Duty Cycle



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APPENDIX IV

UNCERTAINTY

Measurement Item	Expanded Uncertainty $U = kU_c (k=2)$
Conducted RF power	0.40 dB
Conducted Spurious Emissions	0.40 dB
Radiated Spurious Emissions	5.16 dB
Conducted Emissions	3.68 dB

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