

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.:
NW2109-F005

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**1. Client**

- o Name : SENA TECHNOLOGIES.Inc
- o Address : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea
- o Date of Receipt : 2021-04-14

2. Use of Report : FCC & IC Approval**3. Test Sample**

- o Description / Model : IMPULSE / SP87
- o FCC ID : S7A-SP87 / IC : 8154A-SP87

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 : 2021-05-11 ~ 2021-08-31**6. Test method used : FCC Part 15 Subpart C 15.247**

RSS-247 Issue 2(2017-02), RSS-GEN Issue 5(2019-03)

7. Testing Environment :

- o 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 Jong-Myoung, Shin	Technical Manager Changmin, Kim
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(signature)

Sep 13, 2021

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
 IC Site Registration No. : 25897

2. Information's about Test Item

2.1 Applicant Information

Company name : SENA TECHNOLOGIES.Inc
 Address : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea
 Telephone / Facsimile : +82-2-571-8283 / +82-2-573-7710

2.2 Equipment Under Test (EUT) description

Test item particulars : IMPULSE
 Model and/or type reference : SP87
 Additional model name : -
 Serial number : Prototype
 Antenna type and gain : PCB Pattern Antenna(M/N: GRSN21032WF31) with Max gain: -1.73 dBi
 Date (s) of performance of tests: : 2021-05-11 ~ 2021-08-31
 Date of receipt of test item : 2021-04-14
 EUT condition : Pre-production, not damaged
 Number of channel : 11 for 802.11b/g/n_HT20
 EUT Power Source : DC 3.7 V
 Type of Modulation : DSSS for 802.11b / OFDM for 802.11g/n_HT20
 Firmware version : 1.0
 Hardware version : 1.0
 Test software name(version) : XCOM V2.0

2.3 Tested Frequency

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Test Mode	Test frequency (MHz)		
	Low frequency	Middle frequency	High frequency
802.11b	2 412	2 437	2 462
802.11g	2 412	2 437	2 462
802.11n_HT20	2 412	2 437	2 462

2.4 Transmitting Configuration of EUT

Test Mode	Data rate
802.11b	1 ~ 11 Mbps
802.11g	6 ~ 54 Mbps
802.11n_HT20	MCS 0 ~ 7

3. Test Report

3.1 Test Summary

Applied	FCC Rule	IC Rule	Test Items	Test Condition	Result
☒	15.203	-	Antenna Requirement	Conducted	C
☒	15.247(a)	RSS-247 (5.2)	6 dB Bandwidth		C
☒	-	RSS GEN (6.7)	Occupied Bandwidth (99%)		C
☒	15.247(b)	RSS-247 (5.4)	Maximum Conducted Output Power		C
☒	15.247(e)	RSS-247 (5.2)	Peak Power Spectral Density		C
☒	15.247(d)	RSS-247 (5.5)	Conducted Spurious Emission		C
☒	15.247(d) 15.205 & 15.209	RSS-247 (5.5) RSS-GEN (8.9 & 8.10)	Radiated Spurious Emission	Radiated	C
☒	15.207	RSS-GEN (8.8)	Conducted Emissions	AC Line Conducted	C

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

The sample was tested according to the following specification: ANSI C63.10:2013.

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
NW2109-F005	2021-09-13	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.

According to §15.247(b)(4) the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

3.3.1.1 Result

Complies

(The transmitter has a PCB Pattern Antenna. The directional peak gain of the antenna is -1.73 dBi.)

3.3.2 6 dB Bandwidth & Occupied Bandwidth

3.3.2.1 Test Setup

Refer to the APPENDIX I.

3.3.2.2 Limit

The minimum permissible 6 dB bandwidth is 500 kHz.

3.3.2.3 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.

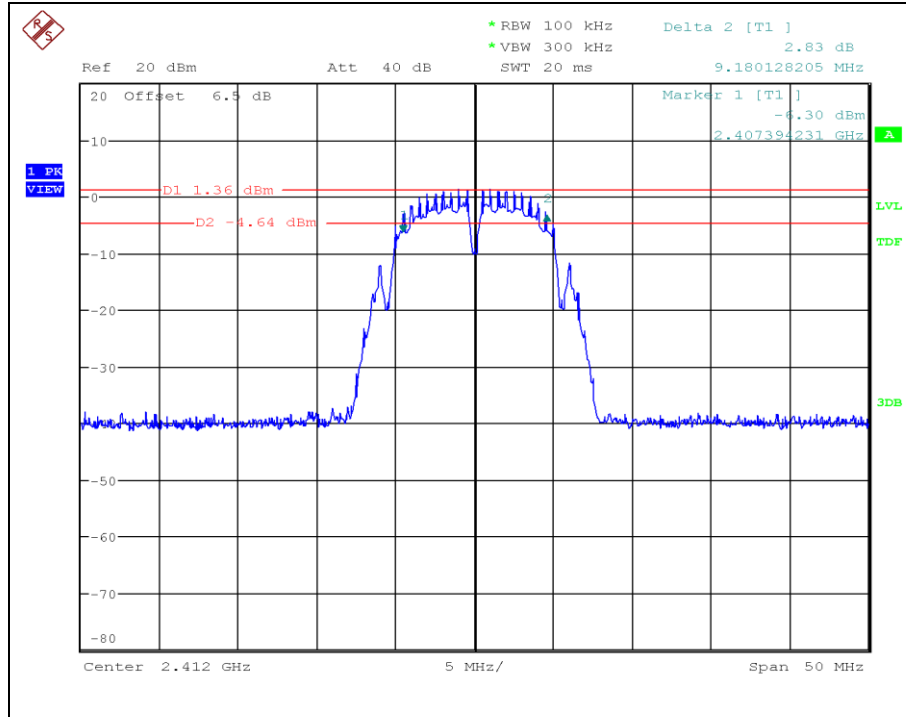
3.3.2.4 Test Result

Test Mode	Test Frequency	6 dB Bandwidth (MHz)	Occupied Bandwidth (MHz)
802.11b	Low	9.180	10.897
	Middle	9.186	10.897
	High	9.279	10.897
802.11g	Low	16.442	16.506
	Middle	16.474	16.506
	High	16.519	16.506
802.11n_HT20	Low	17.580	17.628
	Middle	17.610	17.628
	High	17.660	17.628

3.3.2.5 Test Plot

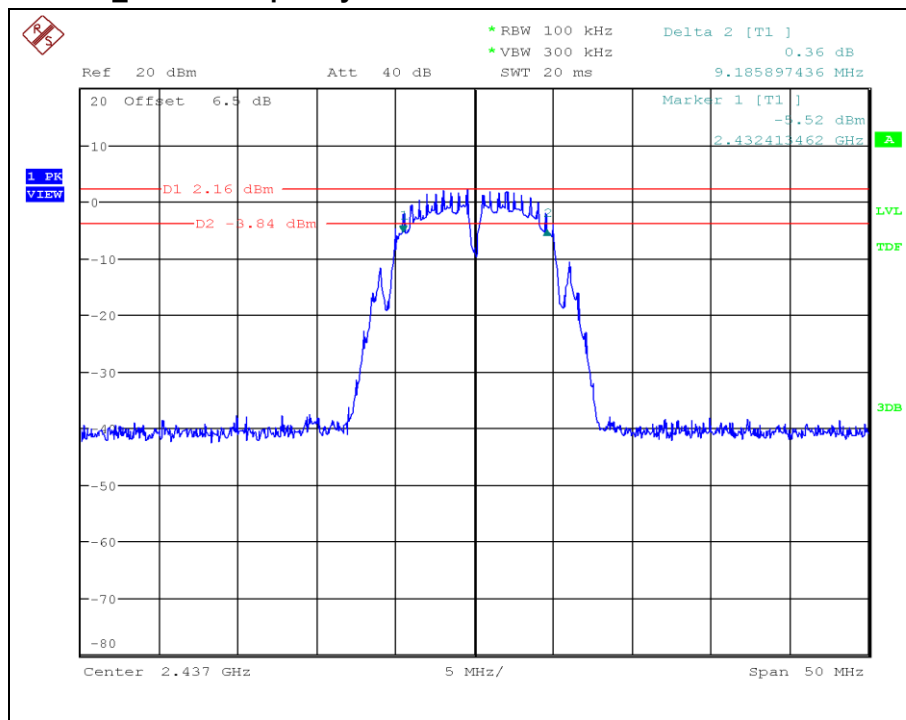
802.11b _ Low frequency

6 dB Bandwidth



802.11b _ Middle frequency

6 dB Bandwidth

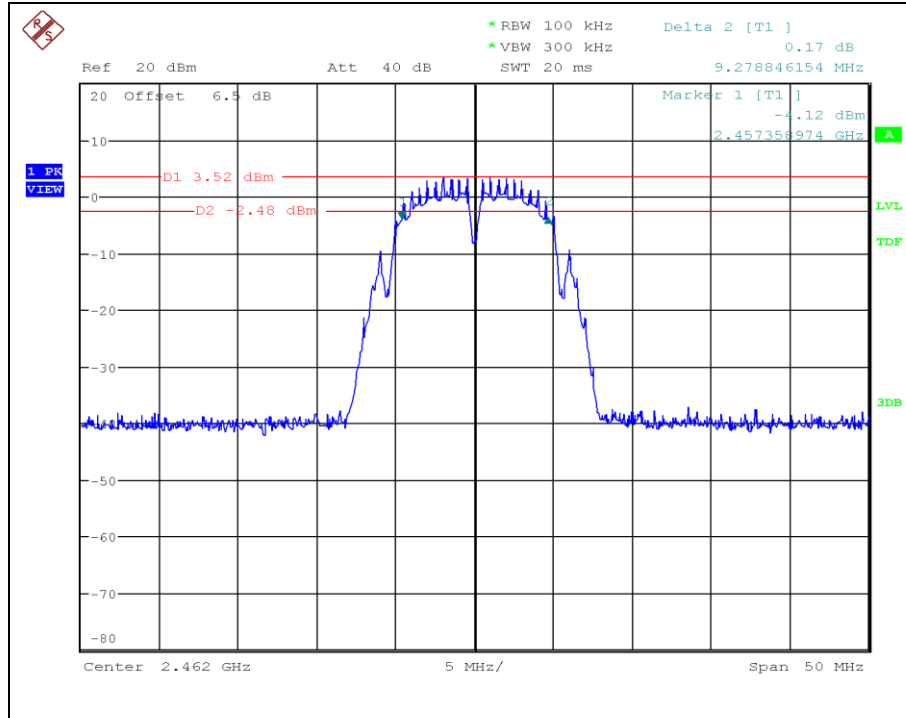


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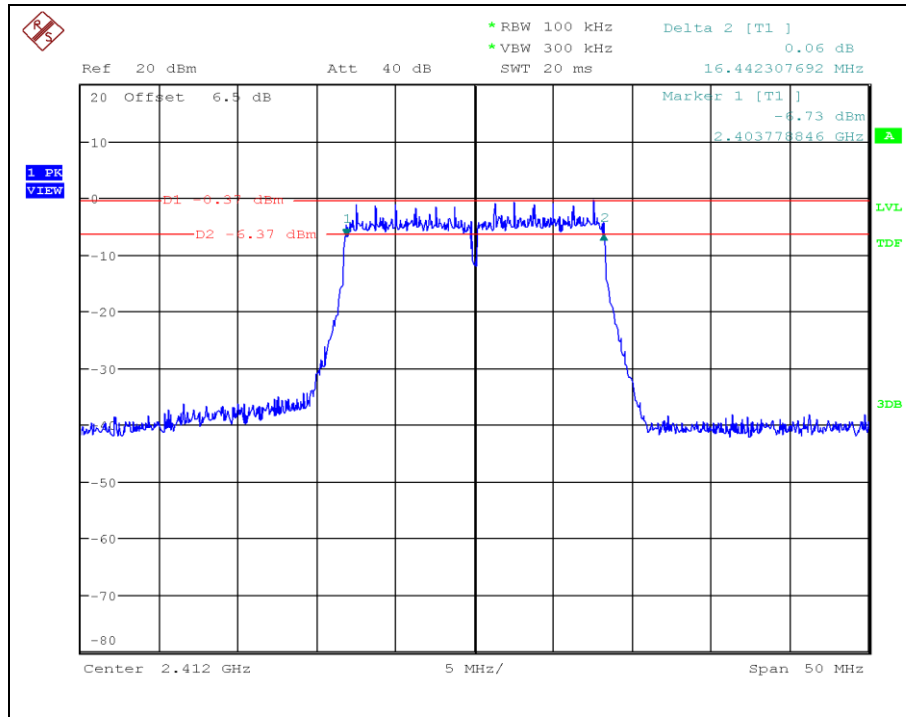
802.11b _ High frequency

6 dB Bandwidth



802.11g _ Low frequency

6 dB Bandwidth

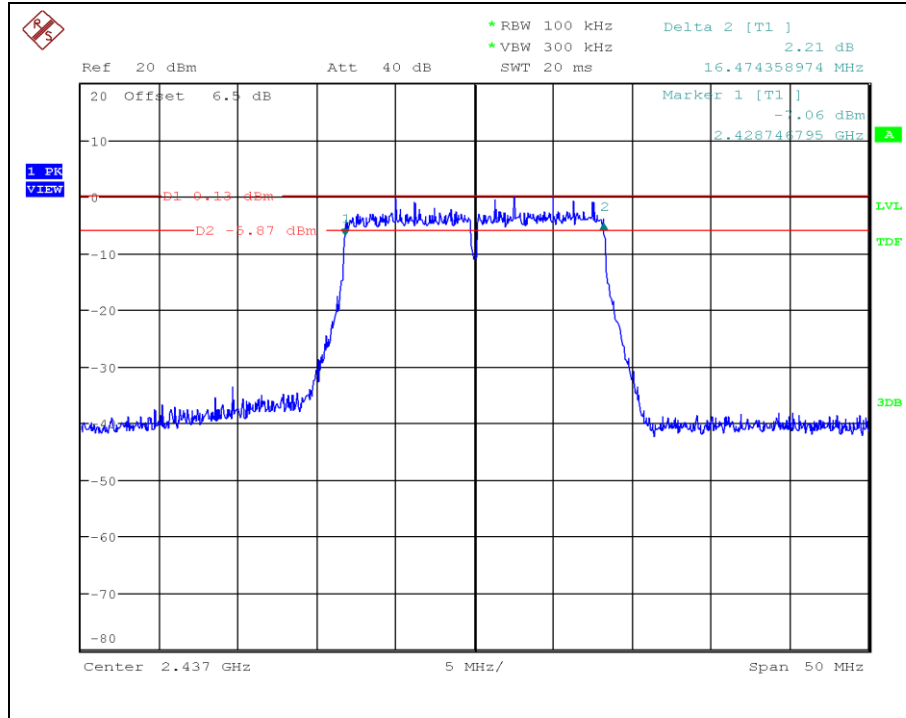


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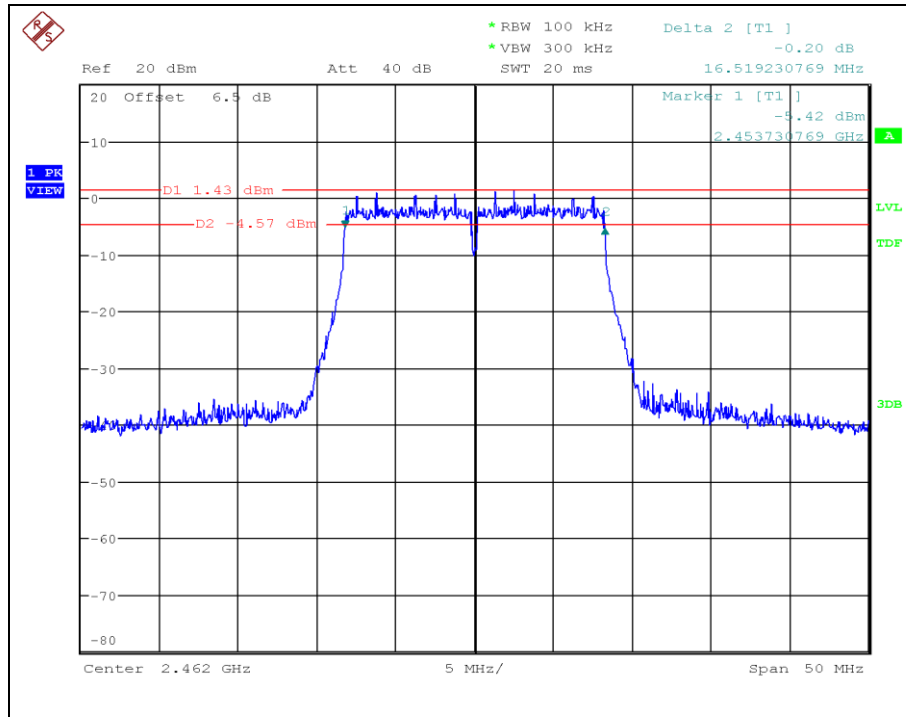
802.11g _ Middle frequency

6 dB Bandwidth



802.11g _ High frequency

6 dB Bandwidth

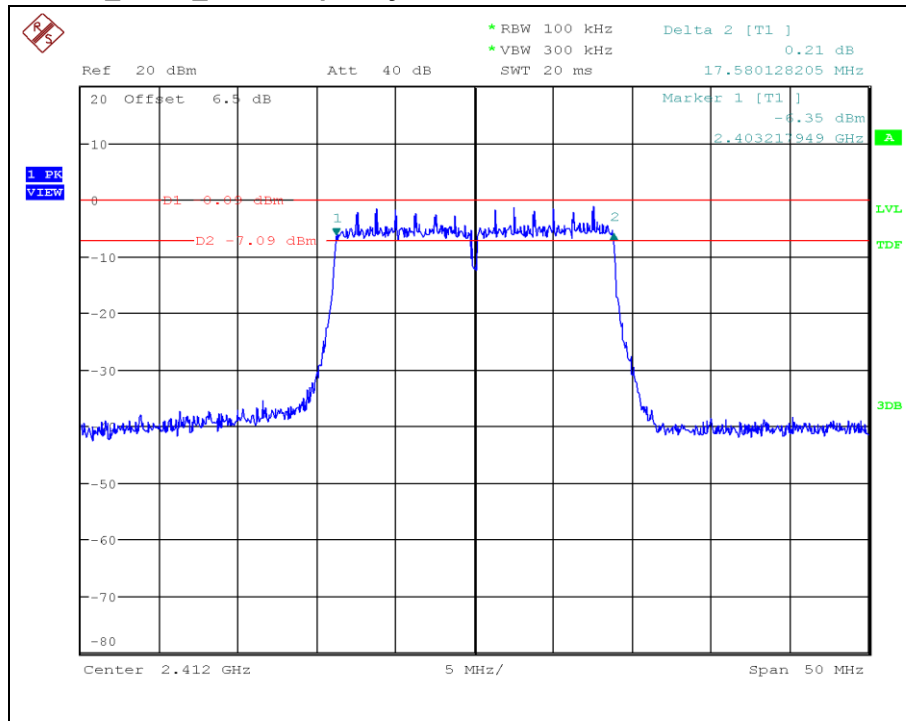


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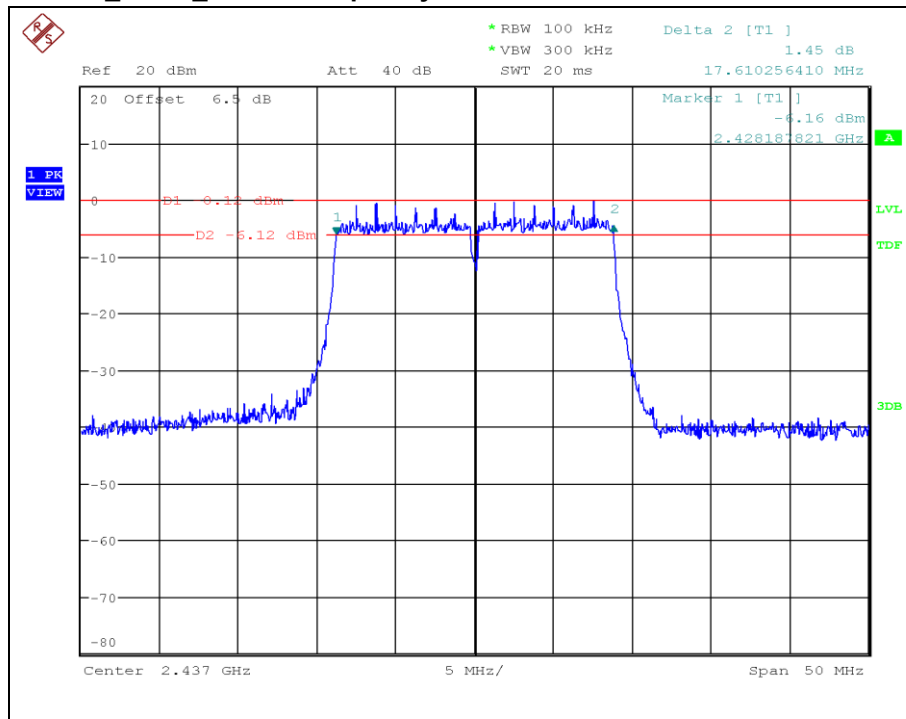
802.11n_HT20 _ Low frequency

6 dB Bandwidth



802.11n_HT20 _ Middle frequency

6 dB Bandwidth

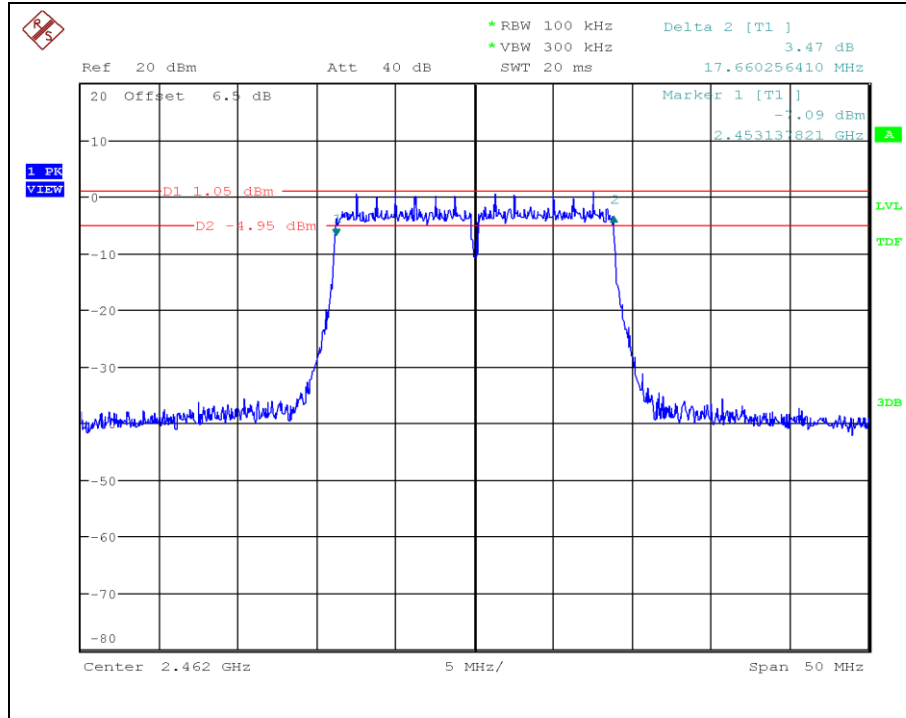


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802.11n_HT20 _ High frequency

6 dB Bandwidth

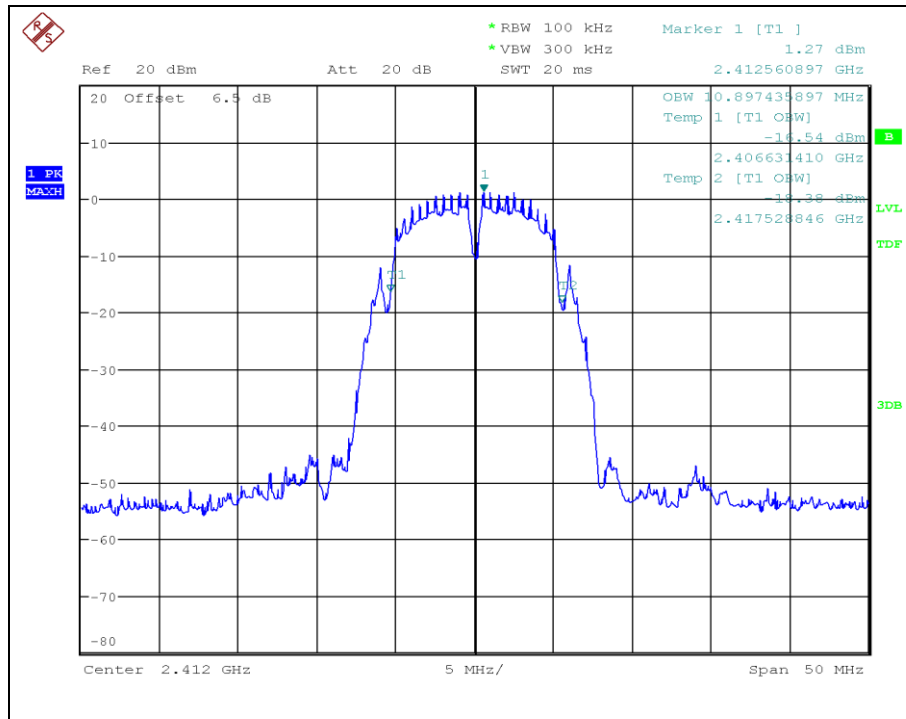


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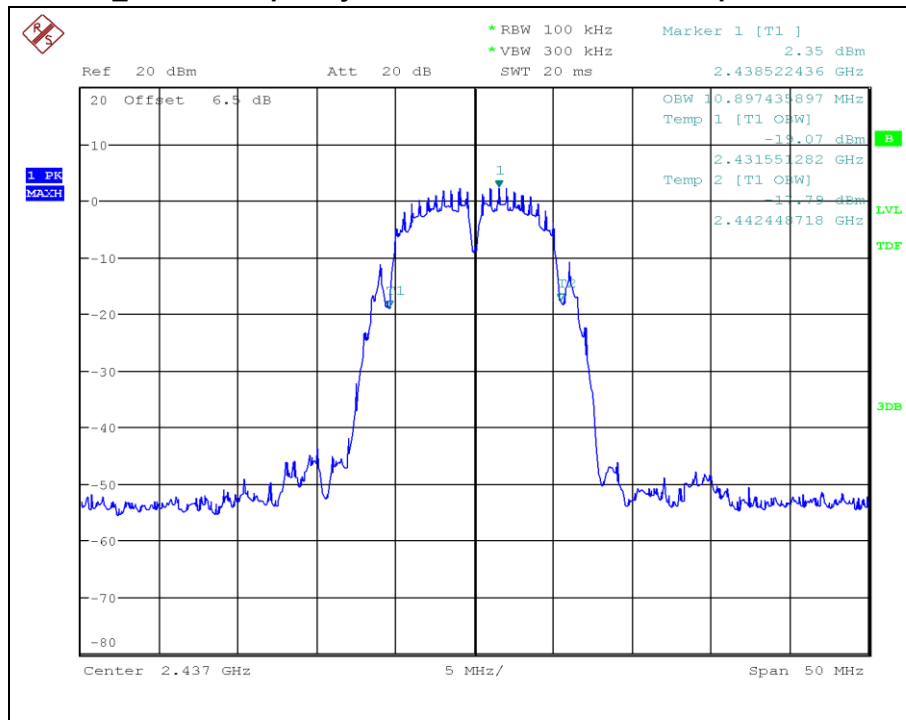
802.11b _ Low frequency

Occupied Bandwidth



802.11b _ Middle frequency

Occupied Bandwidth

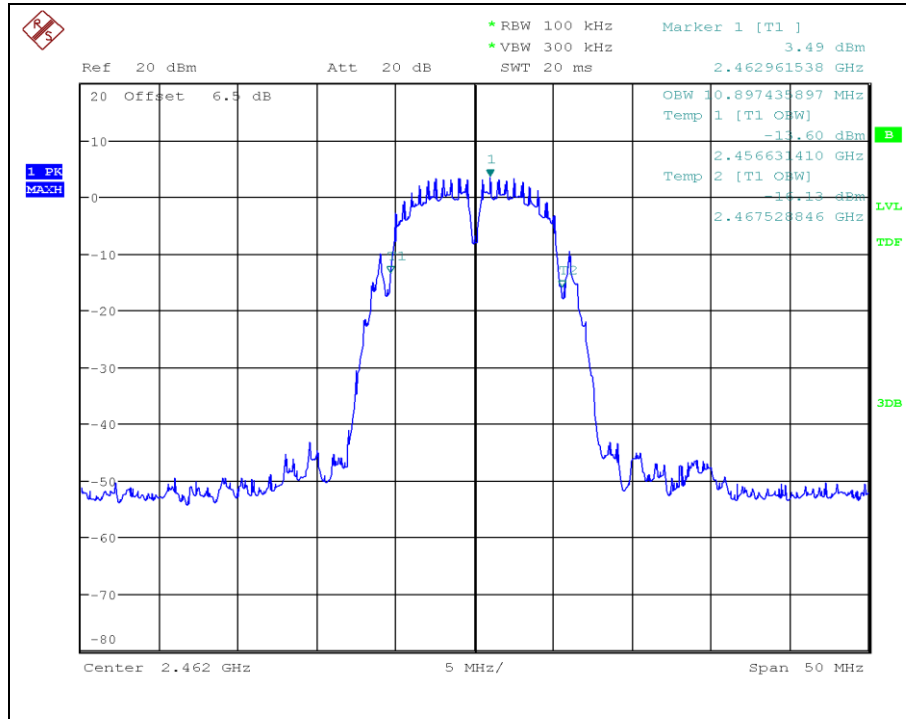


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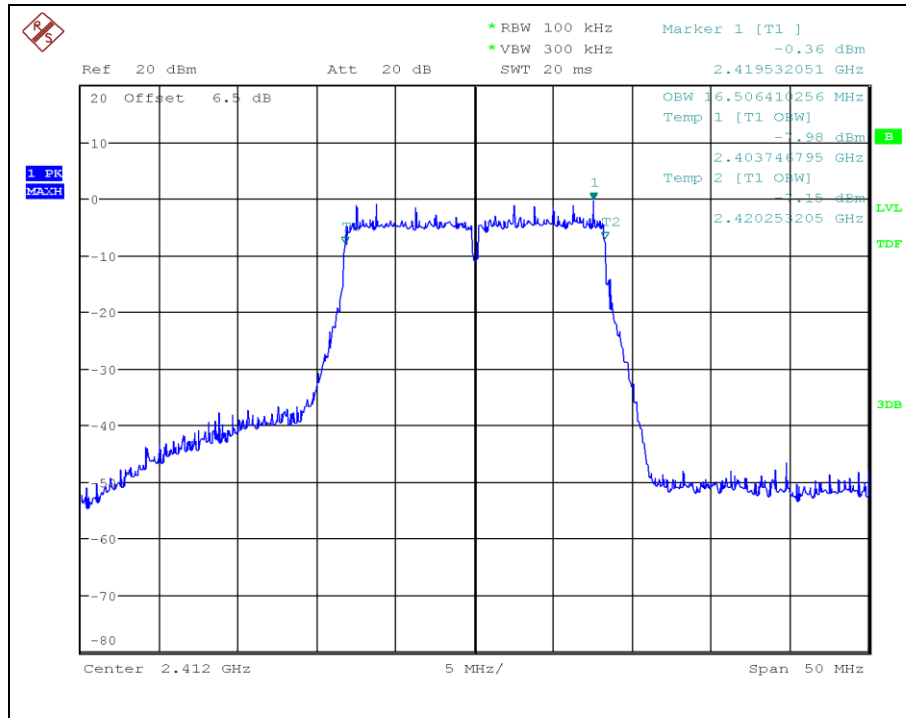
802.11b _ High frequency

Occupied Bandwidth



802.11g _ Low frequency

Occupied Bandwidth

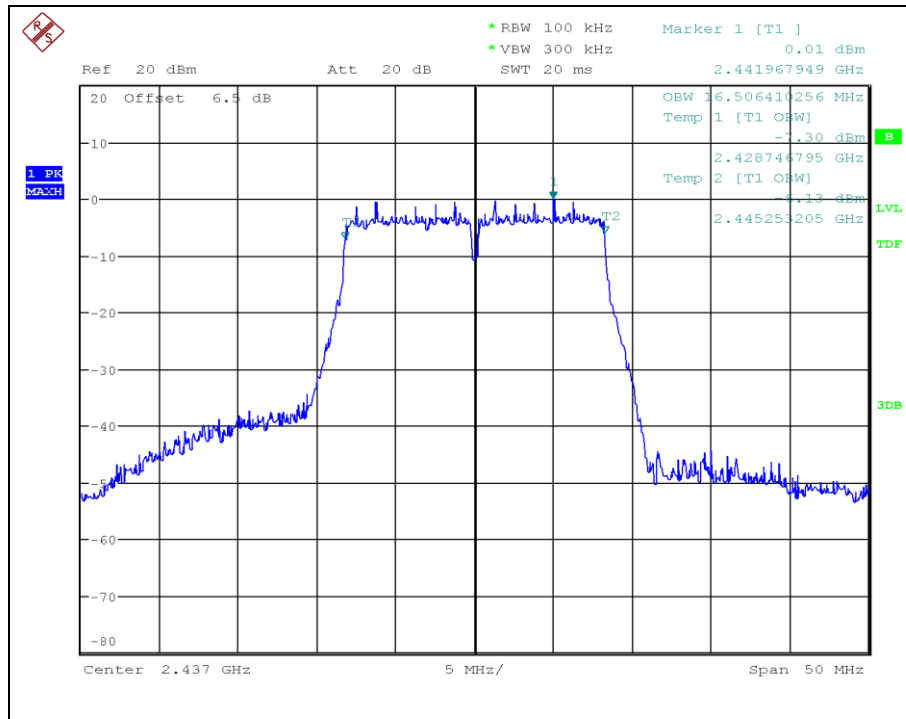


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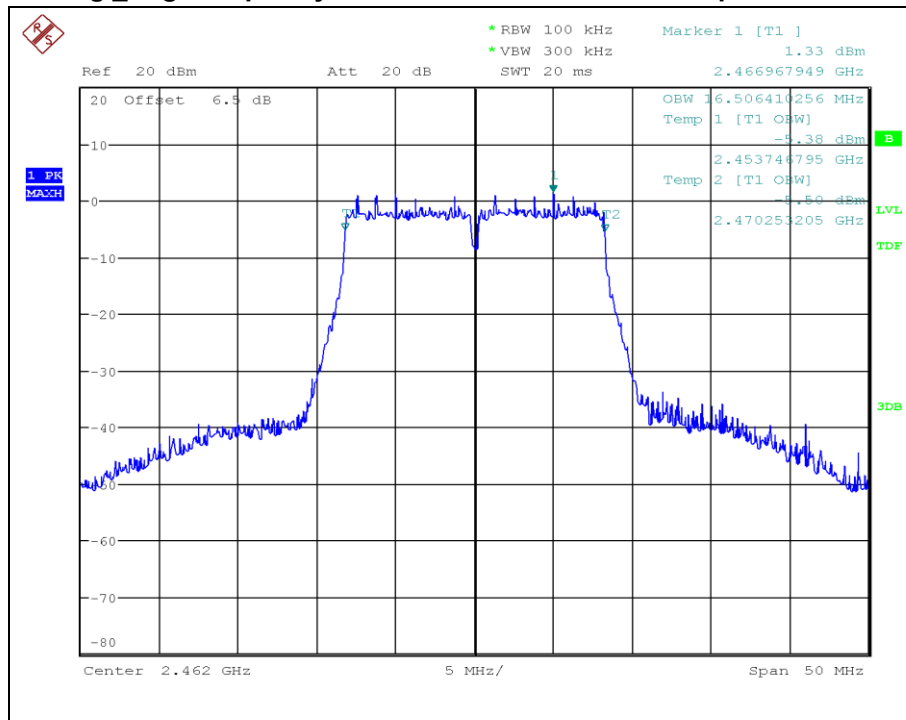
802.11g _ Middle frequency

Occupied Bandwidth



802.11g _ High frequency

Occupied Bandwidth

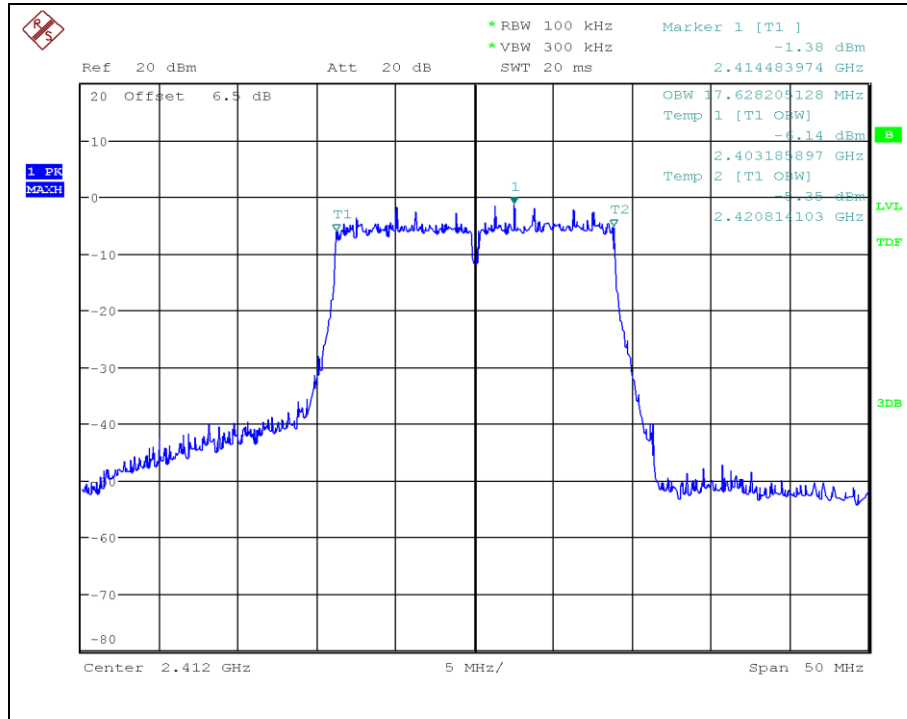


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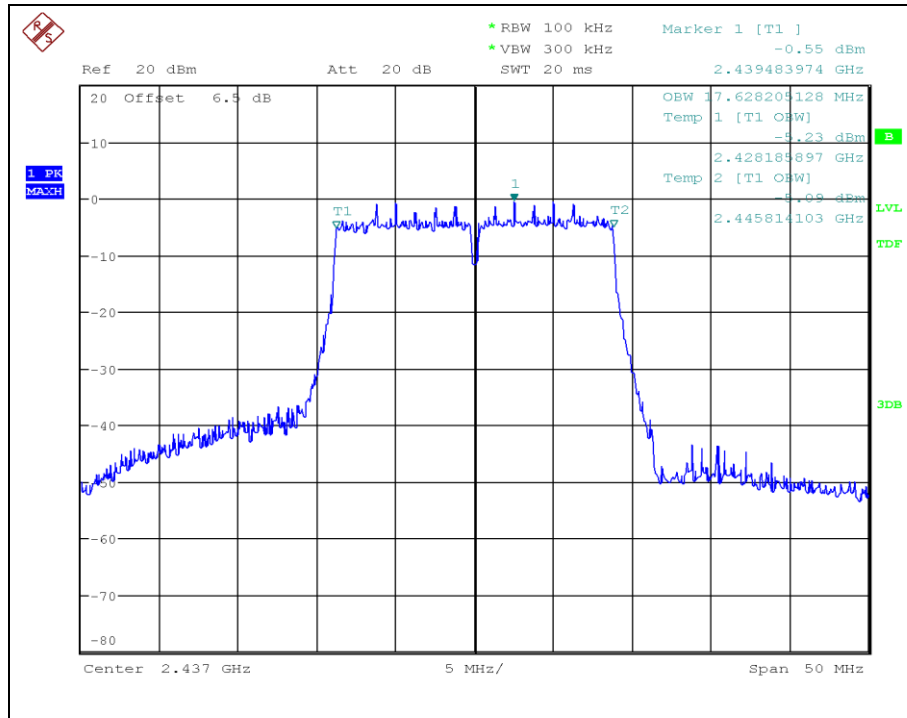
802.11n_HT20 _ Low frequency

Occupied Bandwidth



802.11n_HT20 _ Middle frequency

Occupied Bandwidth

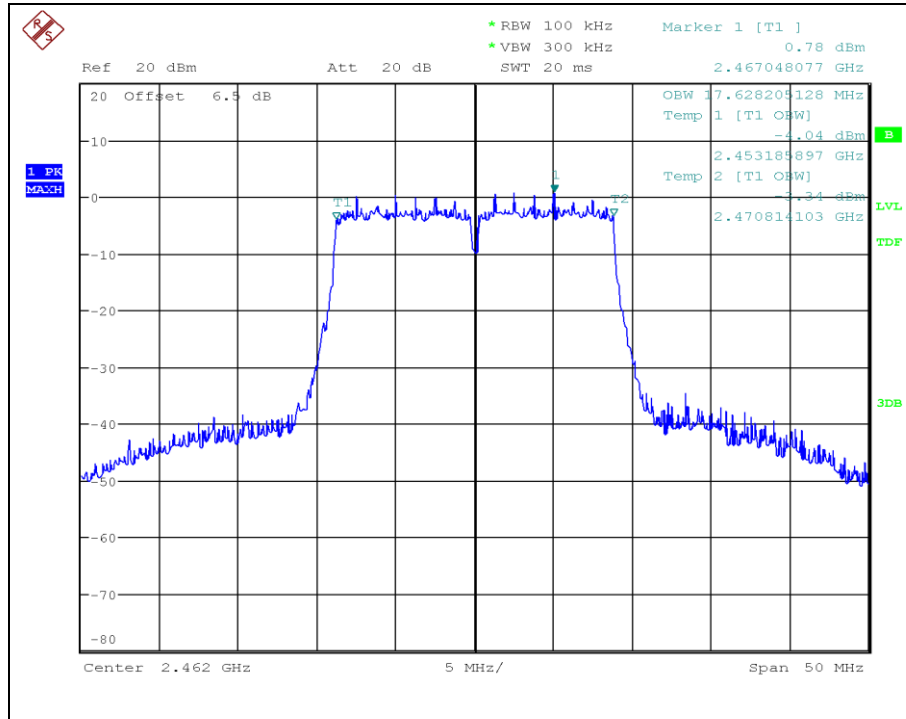


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802.11n_HT20 _ High frequency

Occupied Bandwidth



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3.3.3 Maximum Conducted Output Power

3.3.3.1 Test Setup

Refer to the APPENDIX I.

3.3.3.2 Limit

The maximum permissible conducted output power is 1 Watt.

3.3.3.3 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 at least 1.5 times the OBW.
3. Set RBW = 1 % to 5 % of the OBW, not to exceed 1 MHz.
4. Set VBW $\geq 3 \times$ RBW
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 OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire 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 $[10 \log (1/0.25)] = 6 \text{ dB}$ if the duty cycle is 25%.

3.3.3.4 Test Result

Test Mode	Test Frequency	Maximum Conducted Output Power			
		Reading	C.F	Test Result	
		(dBm)	(dB)	(dBm)	(mW)
802.11b	Low	10.33	0.00	10.33	10.79
	Middle	11.22	0.00	11.22	13.24
	High	12.54	0.00	12.54	17.95
802.11g	Low	10.86	0.00	10.86	12.19
	Middle	11.64	0.00	11.64	14.59
	High	12.94	0.00	12.94	19.68
802.11n_HT20	Low	10.17	0.00	10.17	10.40
	Middle	11.10	0.00	11.10	12.88
	High	12.40	0.00	12.40	17.38

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

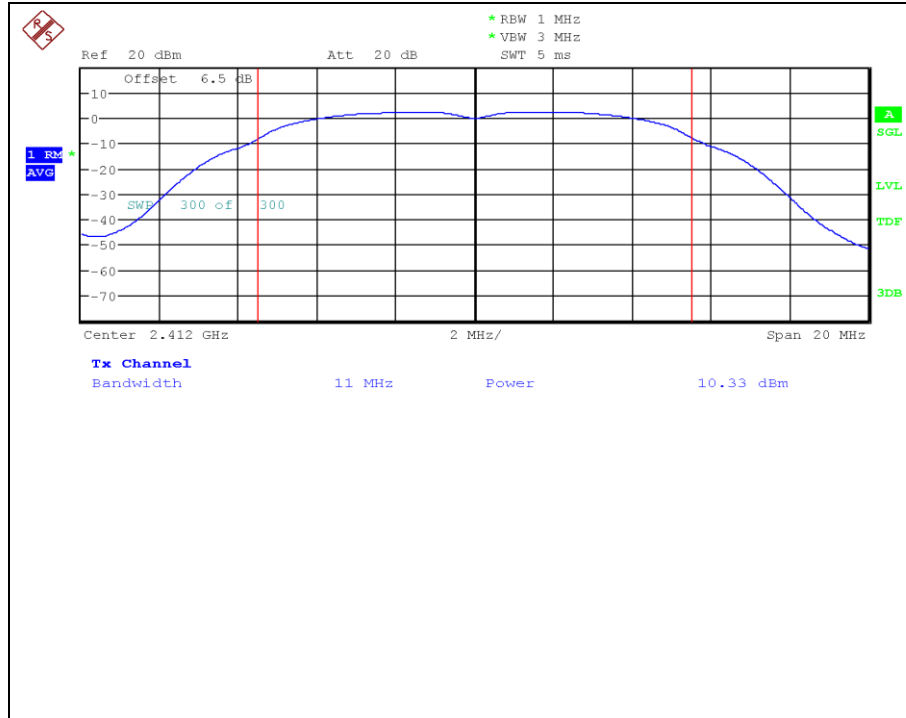
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3.3.3.5 Test Plot

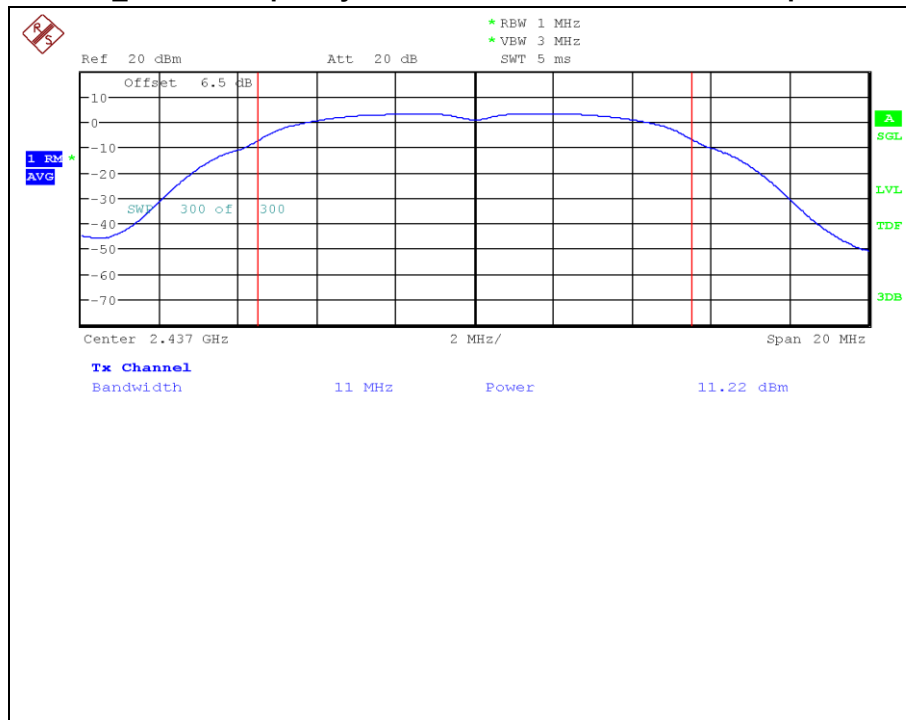
802.11b _ Low frequency

Maximum Conducted Output Power



802.11b _ Middle frequency

Maximum Conducted Output Power

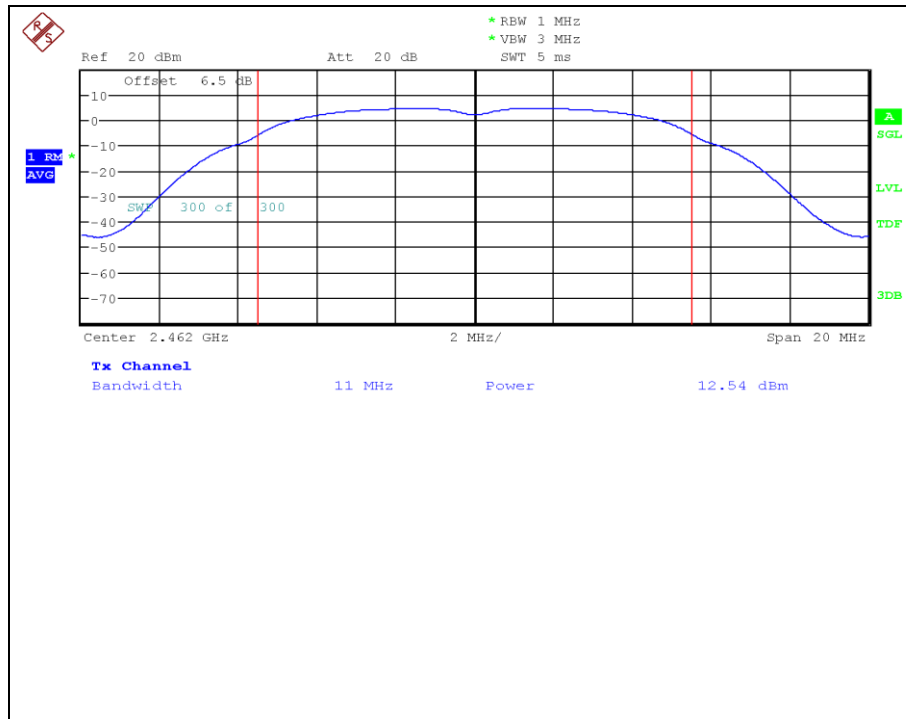


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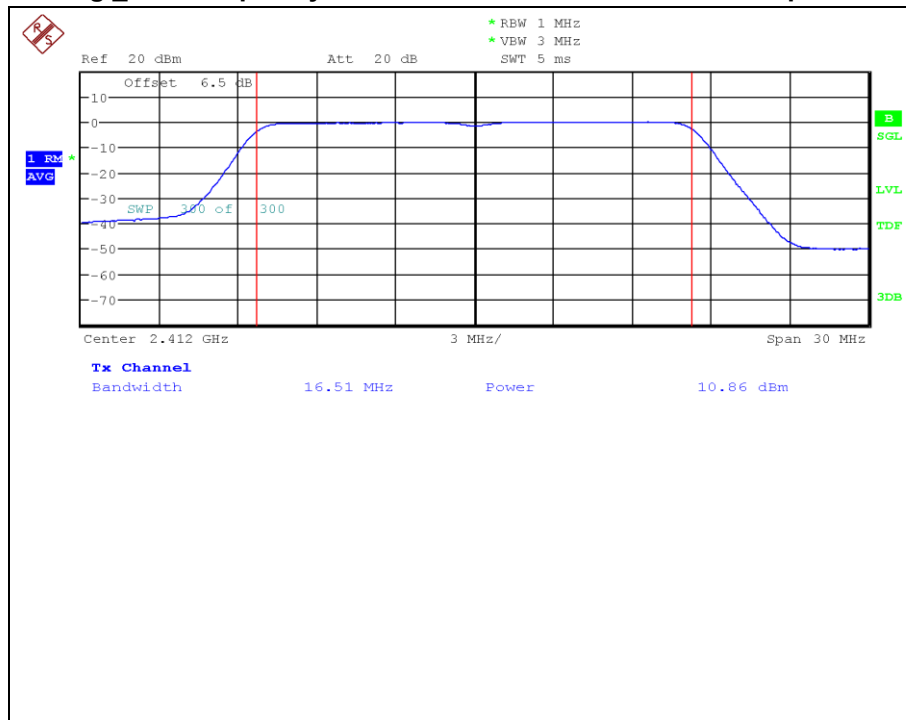
802.11b _ High frequency

Maximum Conducted Output Power



802.11g _ Low frequency

Maximum Conducted Output Power

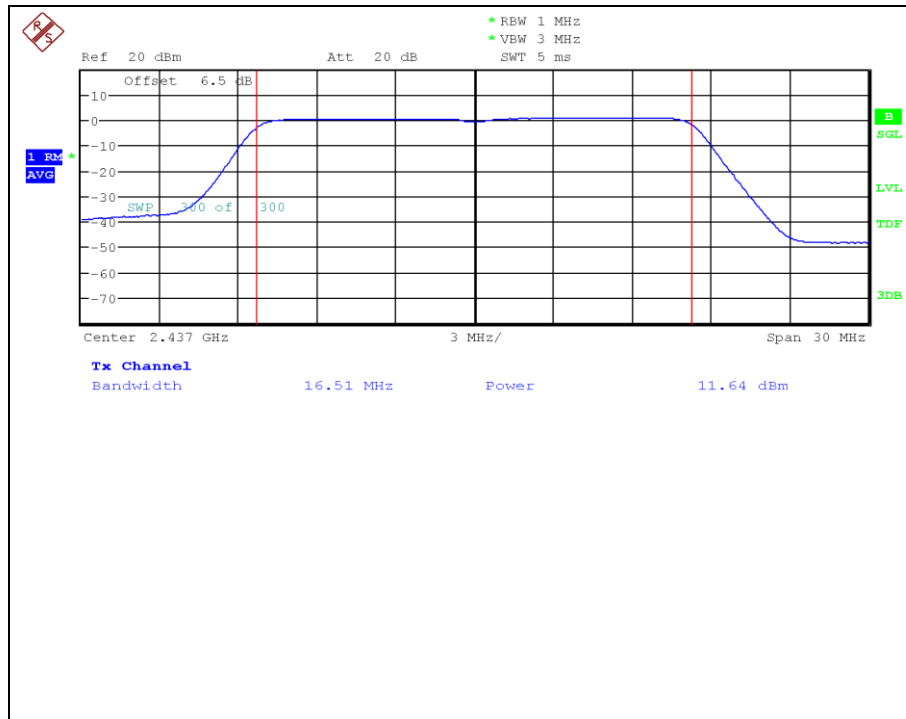


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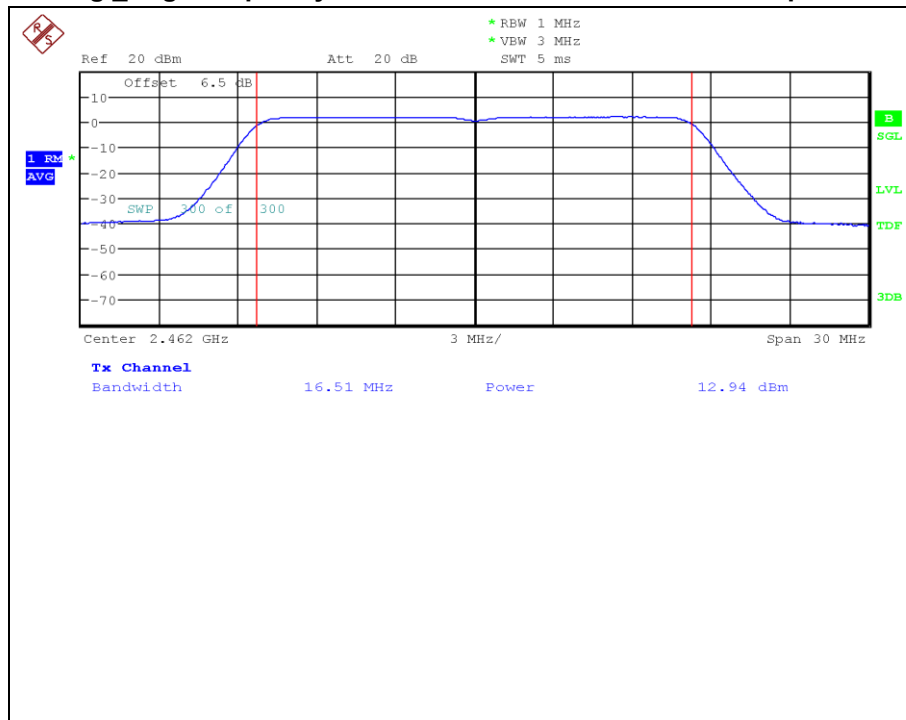
802.11g _ Middle frequency

Maximum Conducted Output Power



802.11g _ High frequency

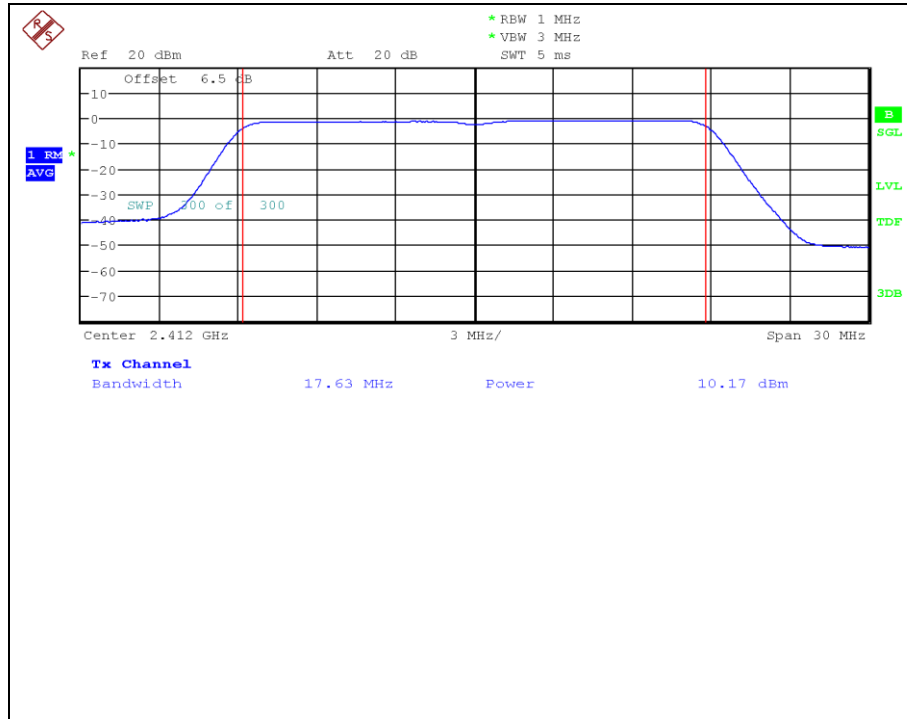
Maximum Conducted Output Power



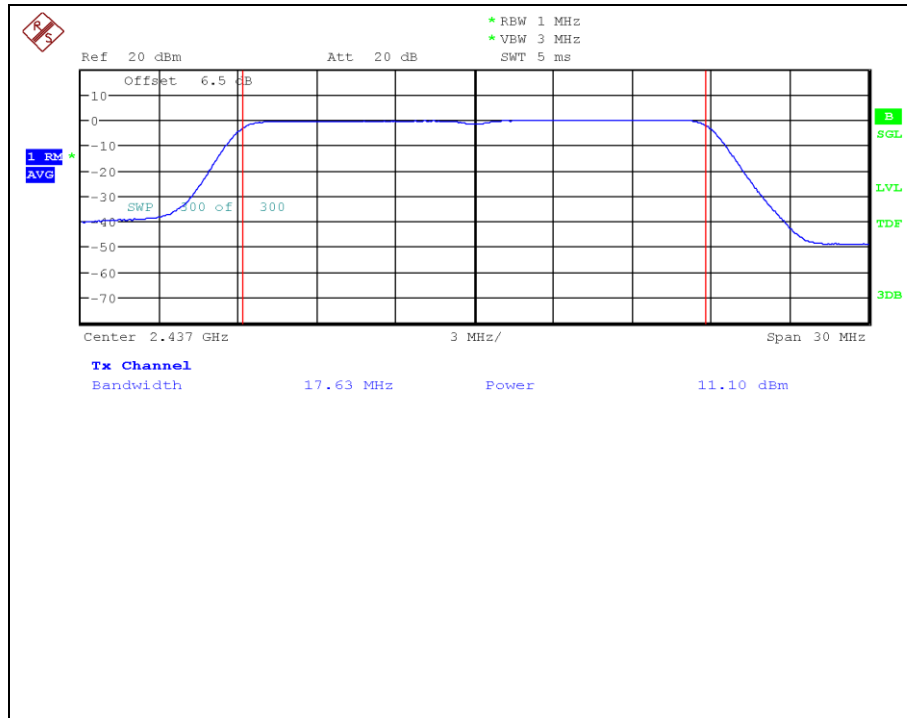
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802.11n_HT20 _ Low frequency Maximum Conducted Output Power



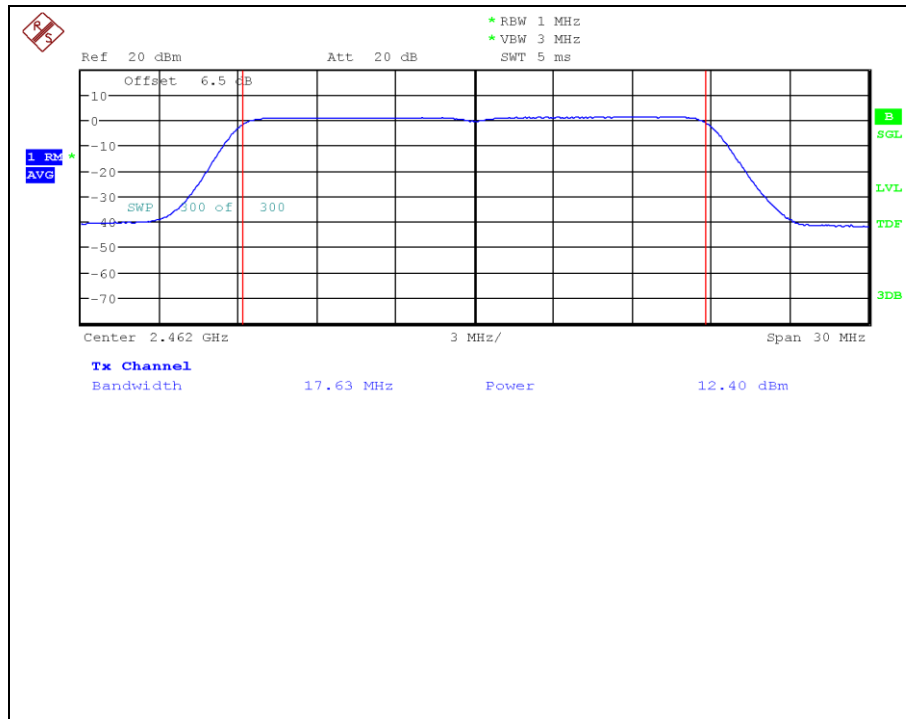
802.11n_HT20 _ Middle frequency Maximum Conducted Output Power



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802.11n_HT20 _ High frequency Maximum Conducted Output Power



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3.3.4 Peak Power Spectral Density

3.3.4.1 Test Setup

Refer to the APPENDIX I.

3.3.4.2 Limit

The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission

3.3.4.3 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.

(ANSI C63.10-2013 _ Section 11.10.2 - Method PKPSD)

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS bandwidth.
3. Set the RBW : $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
4. Set the VBW $\geq 3 \times \text{RBW}$.
5. Detector = Peak.
6. Sweep time = Auto
7. Trace mode = Max Hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

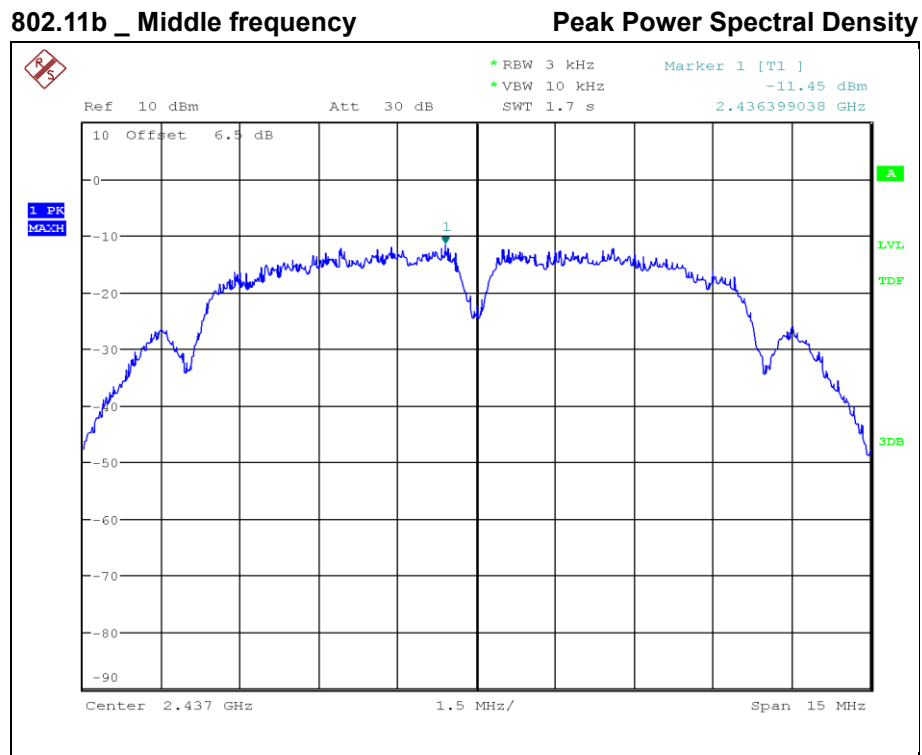
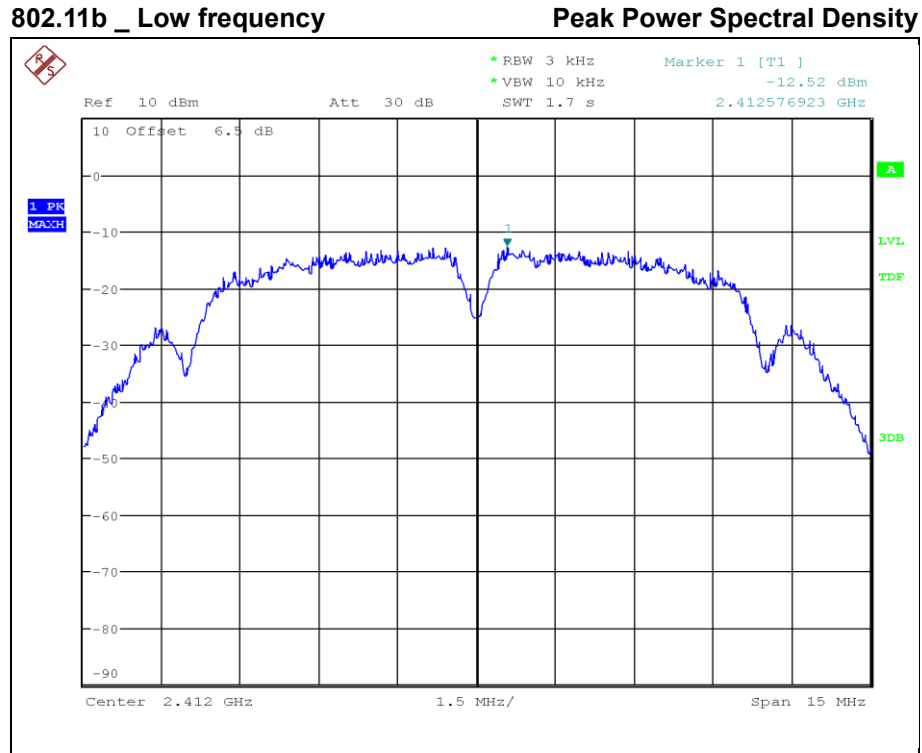
3.3.4.4 Test Result

Test Mode	Test Frequency	Peak Power Spectral Density (dBm)
802.11b	Low	-12.52
	Middle	-11.45
	High	-10.49
802.11g	Low	-12.99
	Middle	-13.57
	High	-11.02
802.11n_HT20	Low	-15.22
	Middle	-14.70
	High	-12.88

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3.3.4.5 Test Plot

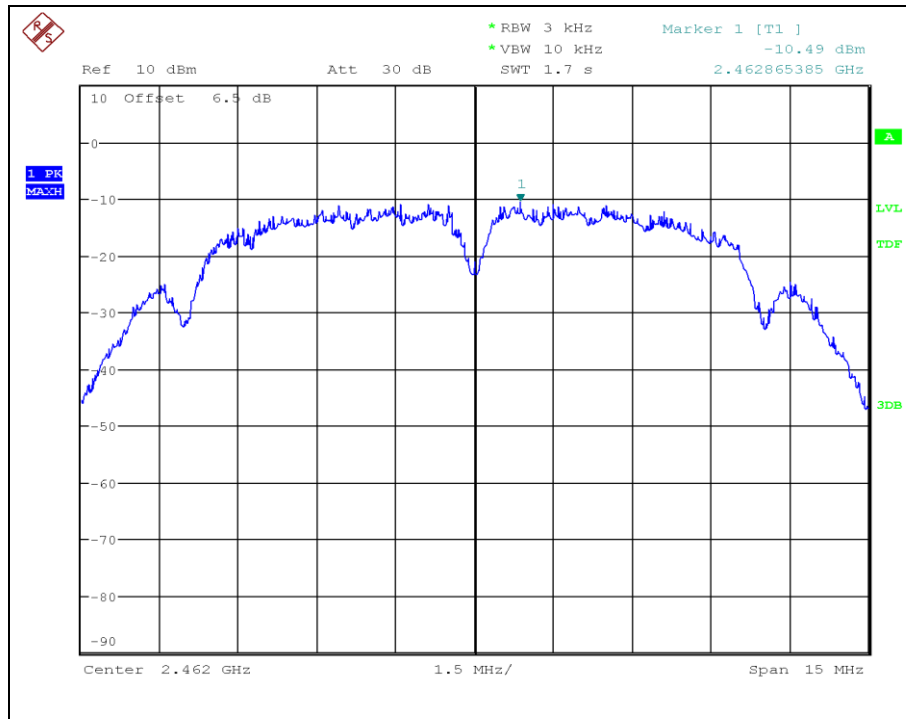


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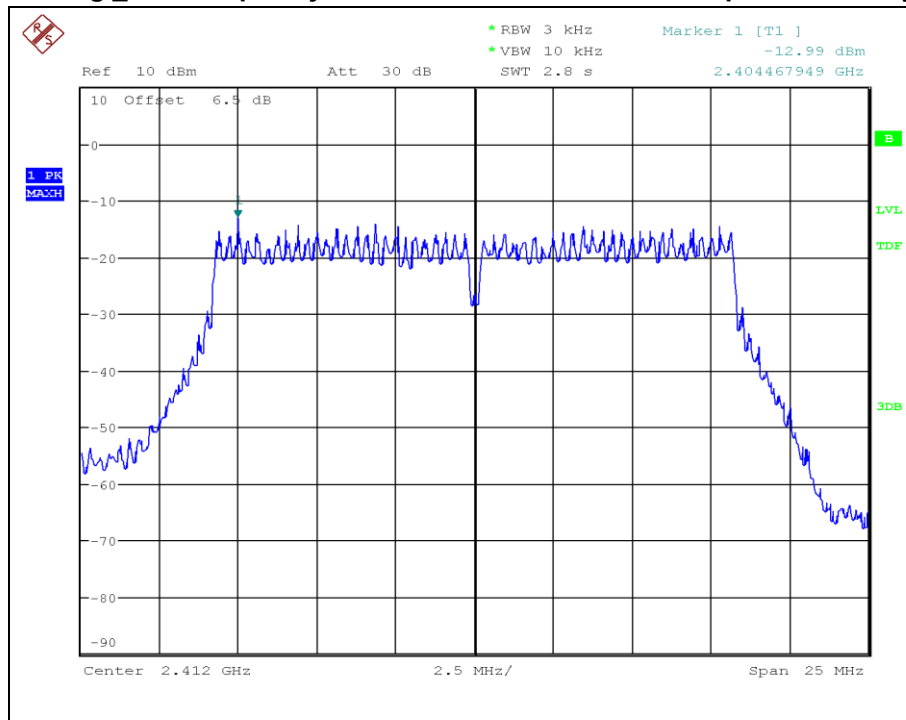
802.11b _ High frequency

Peak Power Spectral Density



802.11g _ Low frequency

Peak Power Spectral Density

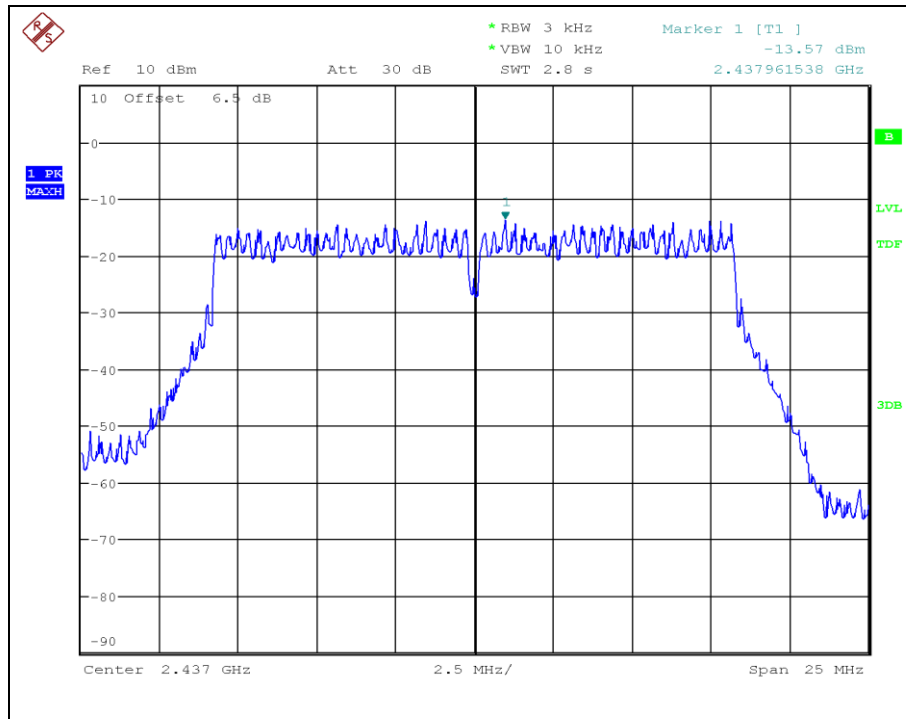


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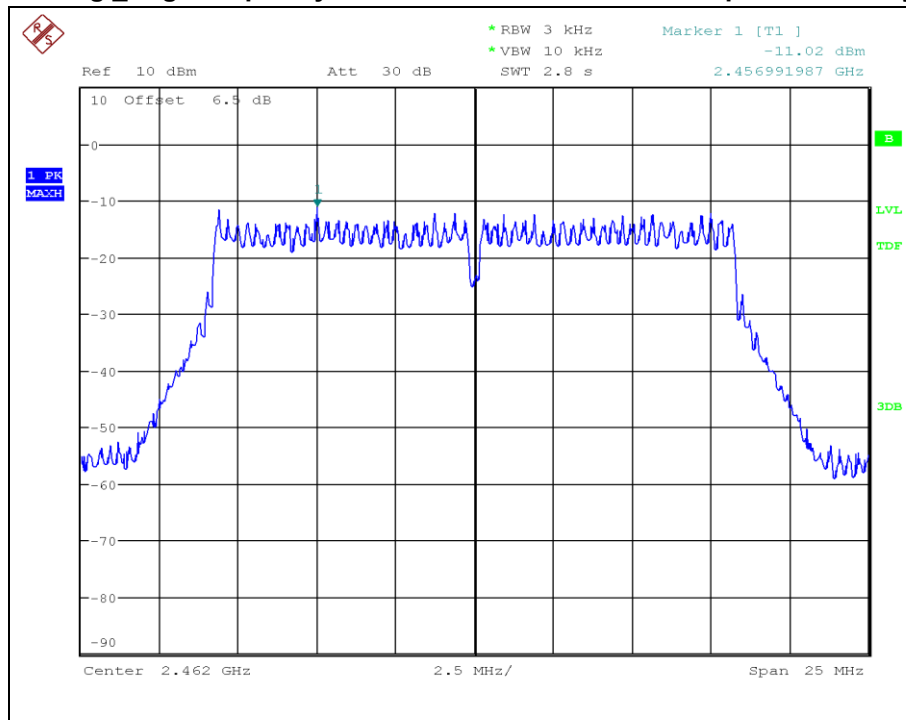
802.11g _ Middle frequency

Peak Power Spectral Density



802.11g _ High frequency

Peak Power Spectral Density

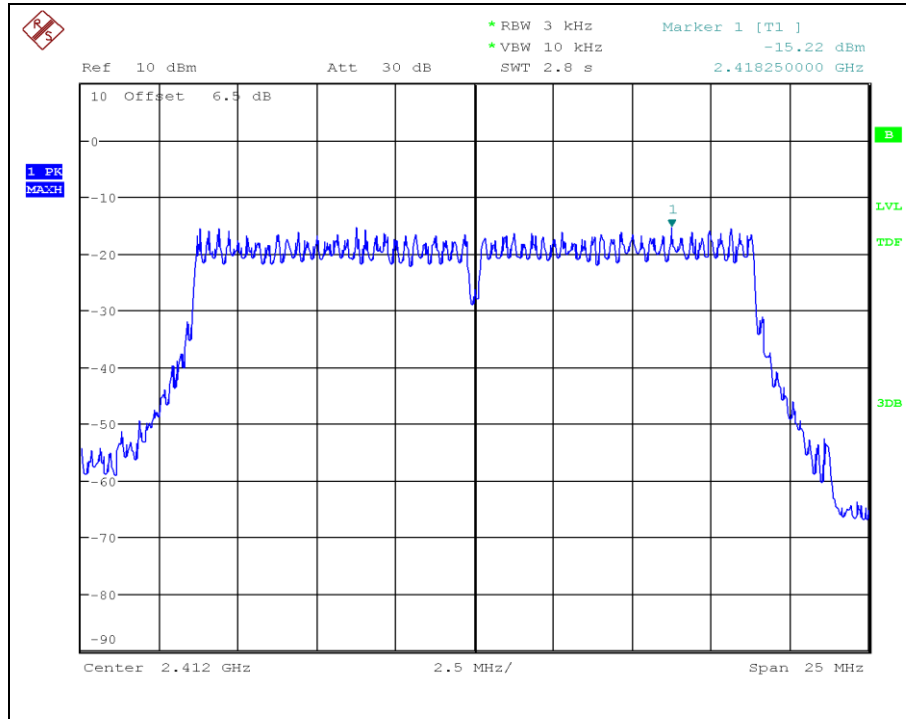


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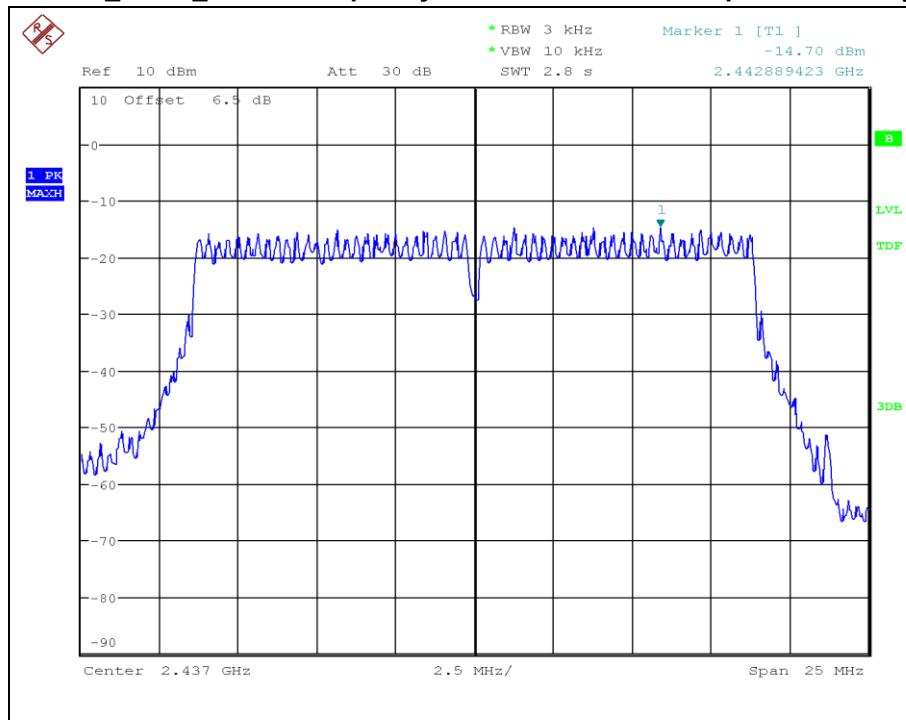
802.11n_HT20 _ Low frequency

Peak Power Spectral Density



802.11n_HT20 _ Middle frequency

Peak Power Spectral Density

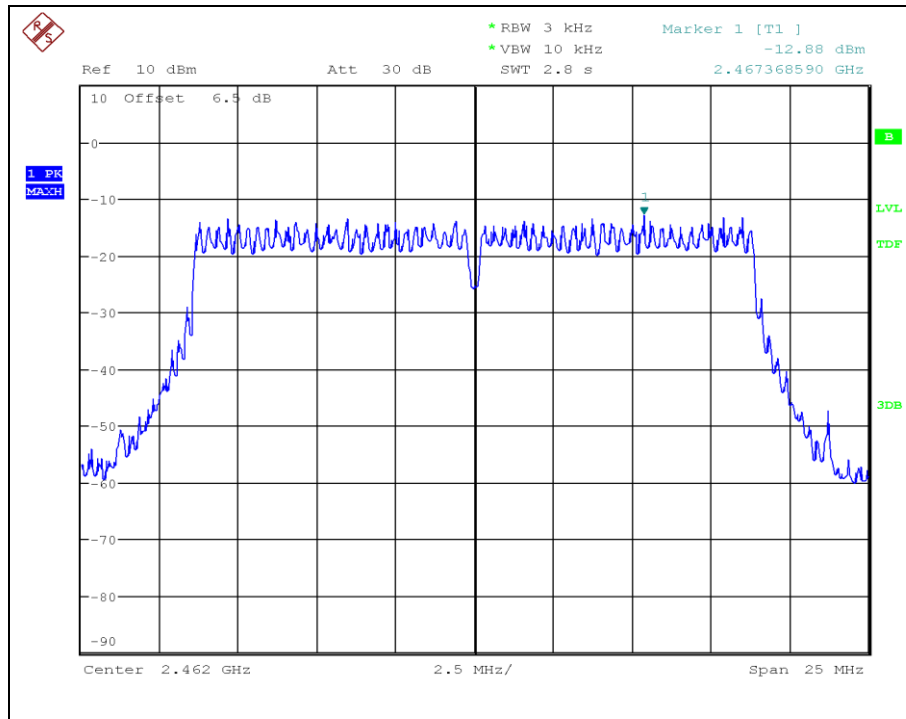


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802.11n_HT20 _ High frequency

Peak Power Spectral Density



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3.3.5 TX Radiated Spurious Emission and Conducted Spurious Emission

3.3.5.1 Test Setup

Refer to the APPENDIX I.

3.3.5.2 Limit

According to §15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph(b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in section §15.209(a) is not required. In addition, radiated emission which in the restricted band, as define in section §15.205(a), must also comply the radiated emission limits specified in section §15.209(a) (see section §15.205(c))

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 (uV/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:

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.

3.3.5.3 Test Procedure for Radiated Spurious Emission

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.

Measurement Instrument Setting

1. Frequency Range: Below 1 GHz
RBW = 100 or 120 kHz, VBW = 3 x RBW, Detector = Peak or Quasi Peak
2. Frequency Range: Above 1 GHz

Peak Measurement

RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Sweep time = Auto,
Trace mode = Max Hold until the trace stabilizes

Average Measurement

RBW = 1 MHz, VBW = 3 MHz, Detector = RMS (Number of points $\geq 2 \times \text{Span} / \text{RBW}$),
Trace Mode = Average (Averaging type = power(i.e. RMS)), Sweep Time = Auto,
Sweep Count = at least 100 traces

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:

- 1) If power averaging (RMS) mode was used in step 4, then the applicable correction factor is $10 \log(1/x)$, where x is the duty cycle.
- 2) If linear voltage averaging mode was used in step 4, then the applicable correction factor is $20 \log(1/x)$, where x is the duty cycle.
- 3) If a specific emission is demonstrated to be continuous (≥ 98 percent duty cycle) rather than turning on and off with the transmit cycle, then no duty cycle correction is required for that emission.

3.3.5.4 Test Procedure for Conducted Spurious Emission

1. The transmitter output was connected to the spectrum analyzer.
2. The reference level of the fundamental frequency was measured with the spectrum analyzer using
RBW = 100 kHz, VBW = 300 kHz.
3. The conducted spurious emission was tested each ranges were set as below.
Frequency range: 30 MHz ~ 26.5 GHz
RBW = 100 kHz, VBW = 300 kHz, Sweep Time = Auto, Detector = Peak,
Trace = Max Hold

LIMIT LINE = 20 dB below of the reference level of above measurement procedure Step 2. (RBW = 100 kHz, VBW = 300 kHz)

3.3.5.5 Test Result

9 kHz ~ 25 GHz Data for 802.11b

● Low frequency

Frequency	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)	(dB uV/m)	(dB)			
	AV / Peak					AV / Peak		AV / Peak			
2 381.46	16.33	35.74	H	17.65	0.00	54.0	74.0	34.0	53.4	20.0	20.6
4 823.77	33.65	45.57	V	-3.98	0.00	54.0	74.0	29.7	41.6	24.3	32.4

● Middle frequency

Frequency	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)	(dB uV/m)	(dB)			
	AV / Peak					AV / Peak	AV / Peak	AV / Peak			
4 873.47	31.43	45.98	V	-3.95	0.00	54.0	74.0	27.5	42.0	26.5	32.0

● High frequency

Frequency	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)		(dB uV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 497.33	16.00	35.64	H	17.5	0.00	54.0	74.0	33.5	53.1	20.5	20.9
4 923.57	33.12	45.66	V	-4.04	0.00	54.0	74.0	29.1	41.6	24.9	32.4

Note 1: The radiated emissions were investigated 9 kHz to 25 GHz. And no other spurious and harmonic emissions were found above listed frequencies.

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

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9 kHz ~ 25 GHz Data for 802.11g

● Low frequency

Frequency	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)	(dB uV/m)	(dB)			
	AV / Peak					AV / Peak	AV / Peak	AV / Peak			
2 390.00	22.89	42.85	H	17.65	0.00	54.0	74.0	40.5	60.5	13.5	13.5

● Middle frequency

Frequency	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)		(dB uV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
No emissions were detected at a level greater than 10dB below limit.											

● High frequency

Frequency (MHz)	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)		(dB uV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 484.11	15.42	35.03	H	17.5	0.00	54.0	74.0	32.9	52.5	21.1	21.5

Note 1: The radiated emissions were investigated 9 kHz to 25 GHz. And no other spurious and harmonic emissions were found above listed frequencies.

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

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9 kHz ~ 25 GHz Data for 802.11n_HT20

● Low frequency

Frequency	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)	(dB uV/m)	(dB)			
	AV / Peak					AV / Peak	AV / Peak	AV / Peak			
2 390.00	23.94	44.46	H	17.65	0.00	54.0	74.0	41.6	62.1	12.4	11.9

● Middle frequency

Frequency (MHz)	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)		(dB uV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
No emissions were detected at a level greater than 10dB below limit.											

● High frequency

Frequency	Reading		Pol.	TF (dB)	DCCF (dB)	Limits		Result		Margin	
	(dB uV/m)					(dB uV/m)		(dB uV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 483.72	21.39	43.41	H	17.5	0.00	54.0	74.0	38.9	60.9	15.1	13.1

Note 1: The radiated emissions were investigated 9 kHz to 25 GHz. And no other spurious and harmonic emissions were found above listed frequencies.

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

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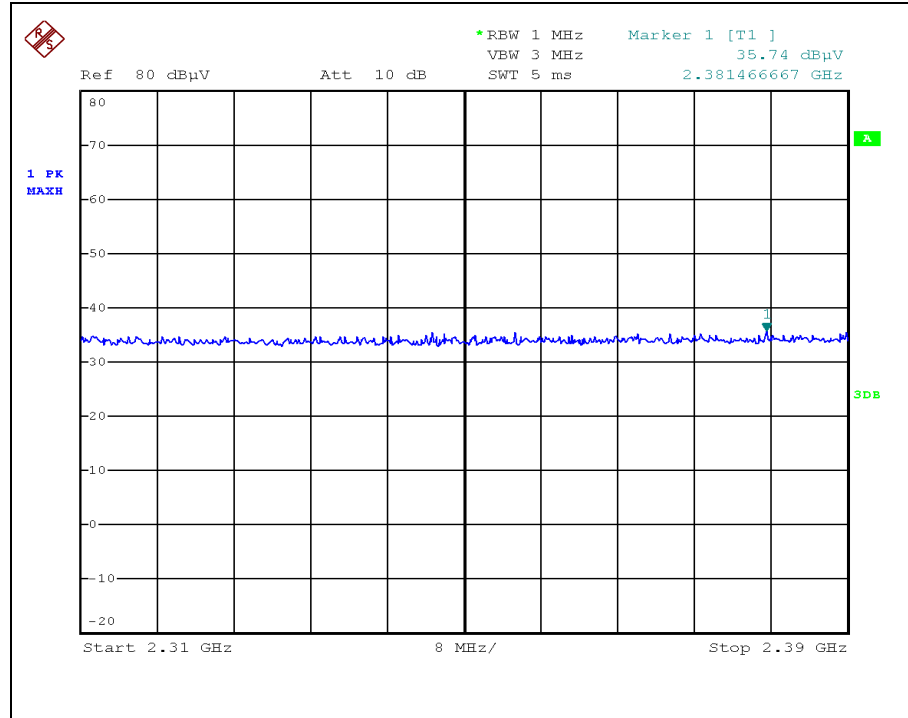
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3.3.5.6 Test Plot for Radiated Spurious Emission

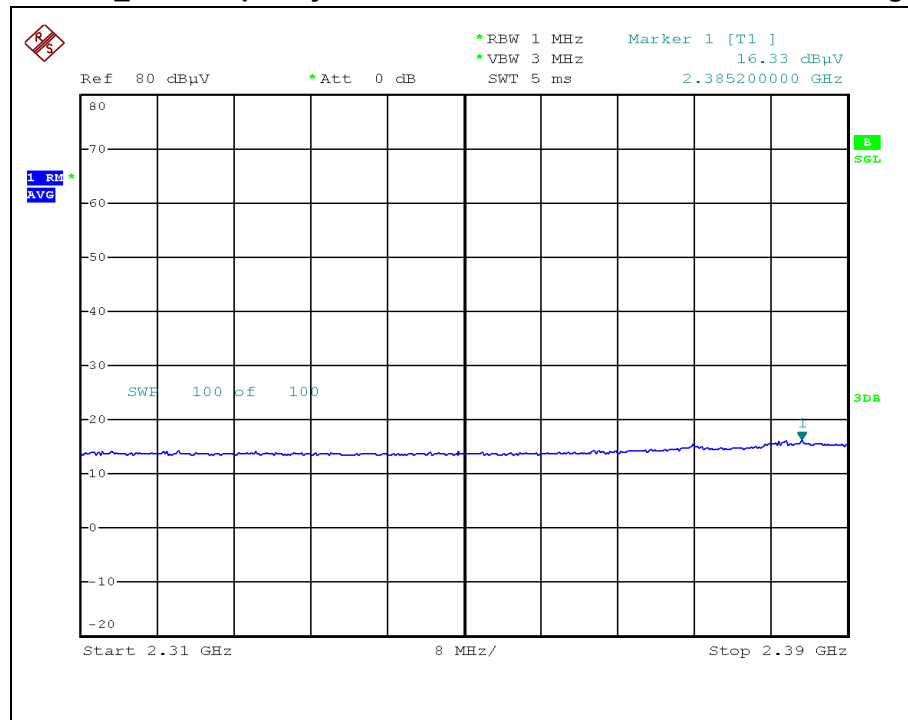
802.11b _ Low frequency

Restricted Band - Peak



802.11b _ Low frequency

Restricted Band - Average

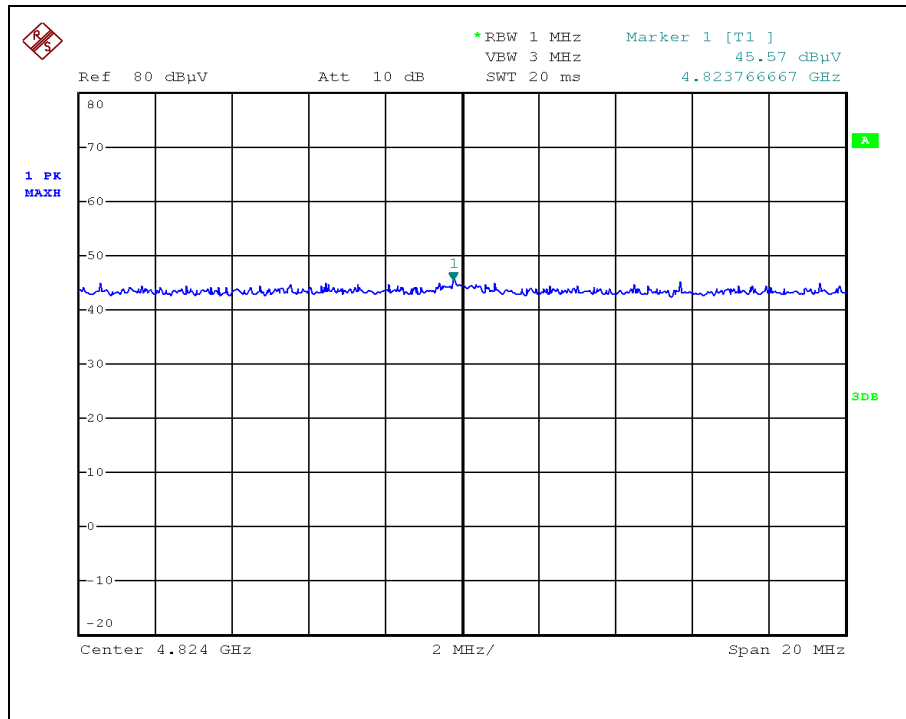


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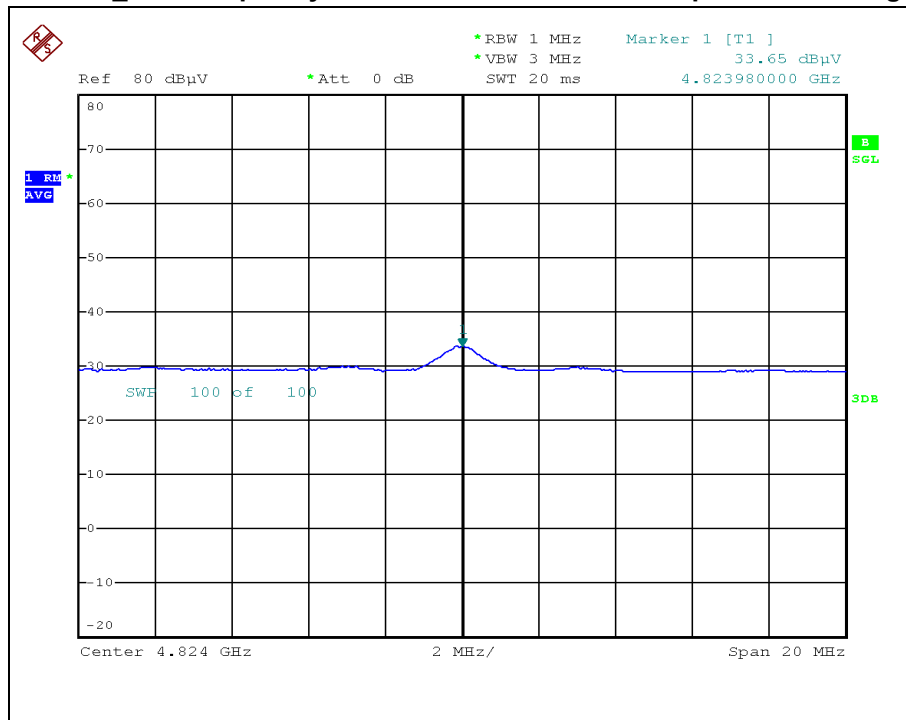
802.11b _ Low frequency

Spurious - Peak



802.11b _ Low frequency

Spurious - Average

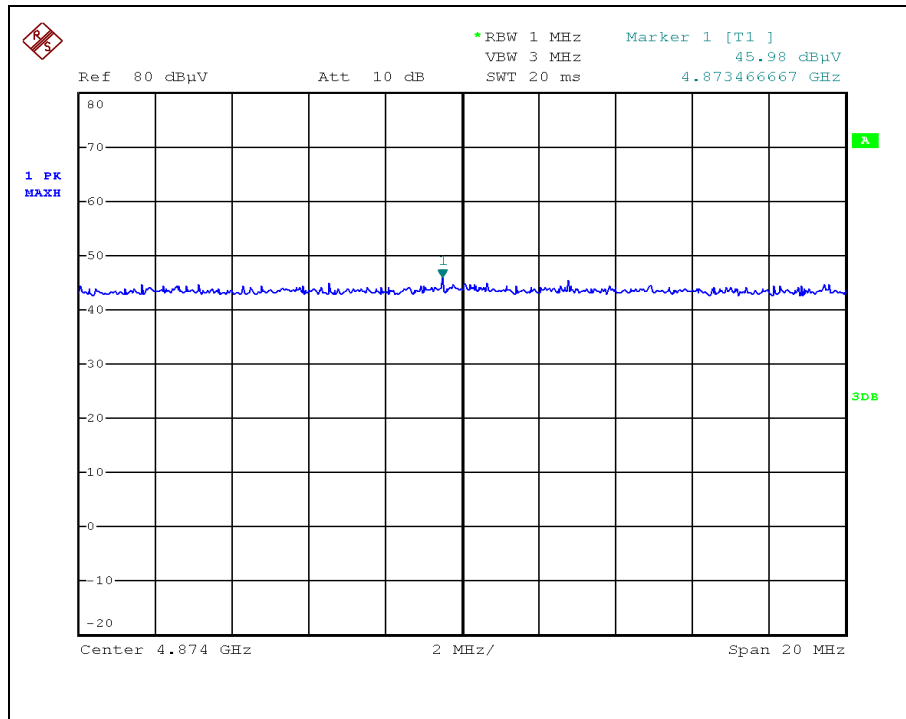


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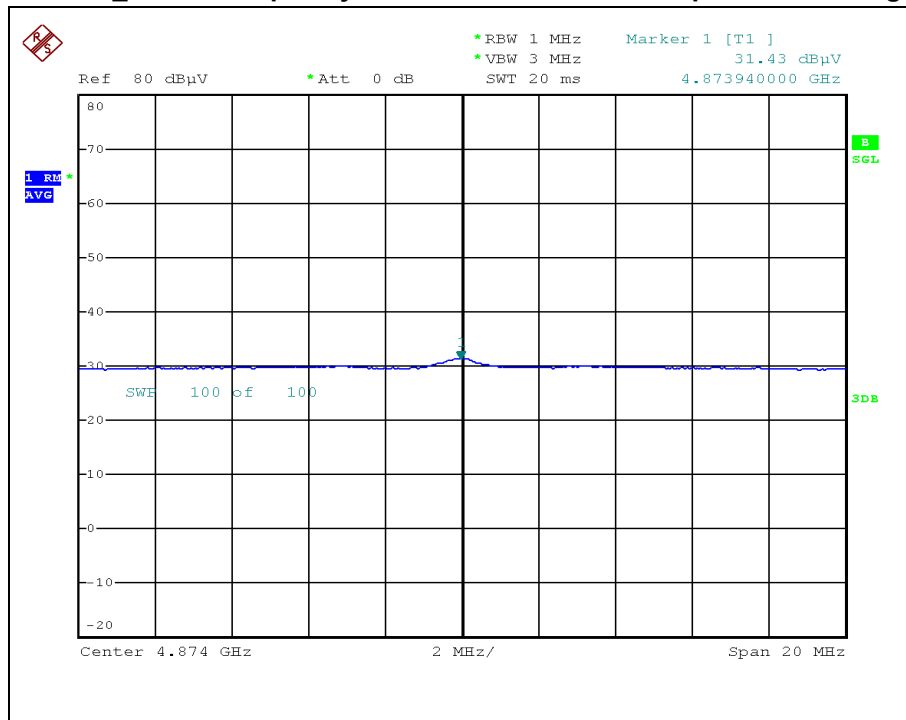
802.11b _ Middle frequency

Spurious - Peak



802.11b _ Middle frequency

Spurious - Average

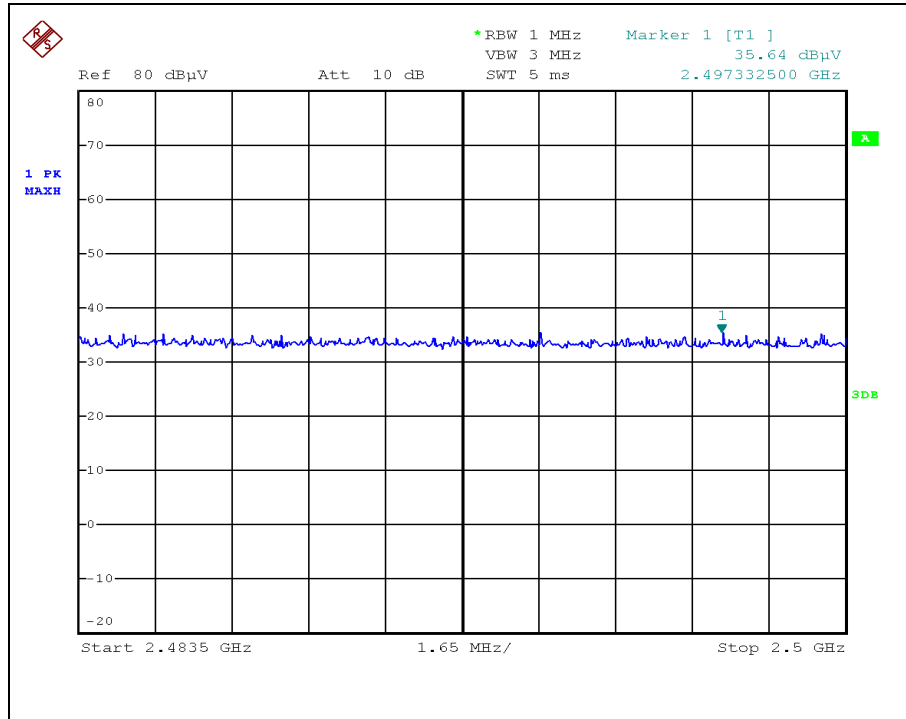


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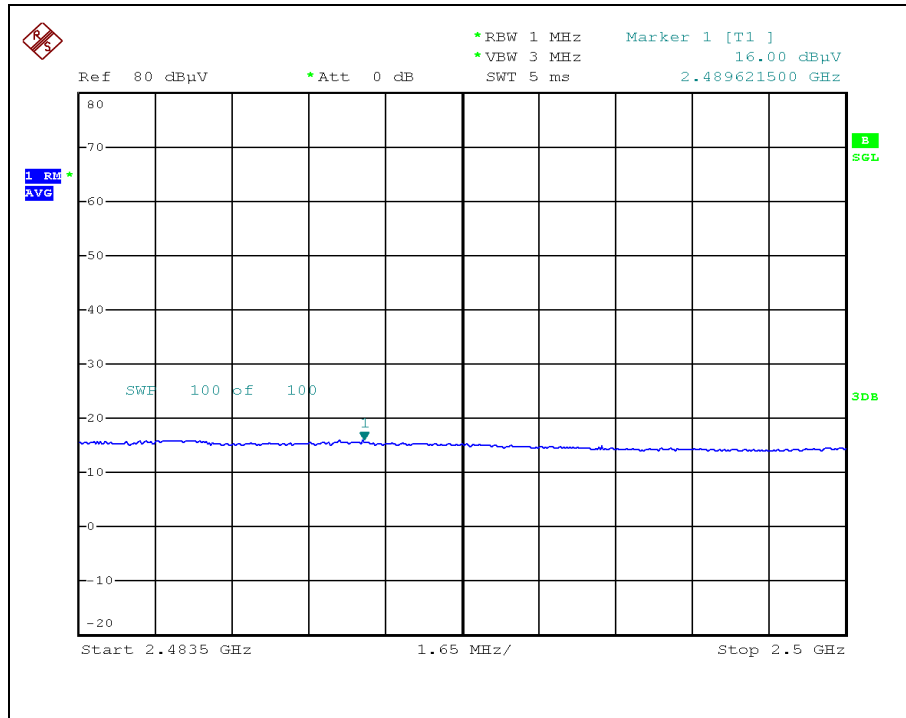
802.11b _ High frequency

Restricted Band - Peak



802.11b _ High frequency

Restricted Band - Average

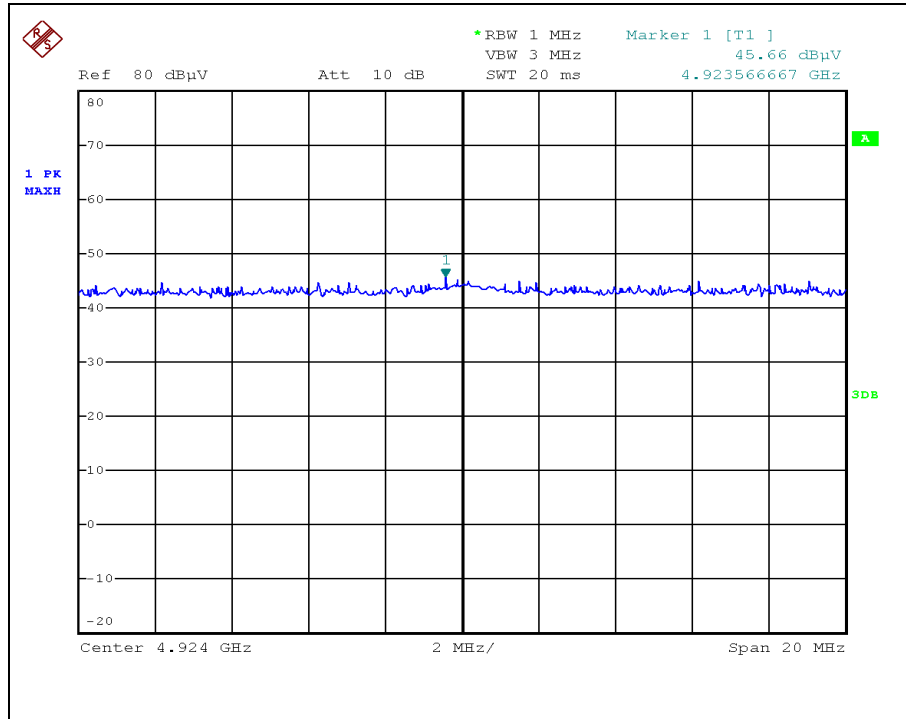


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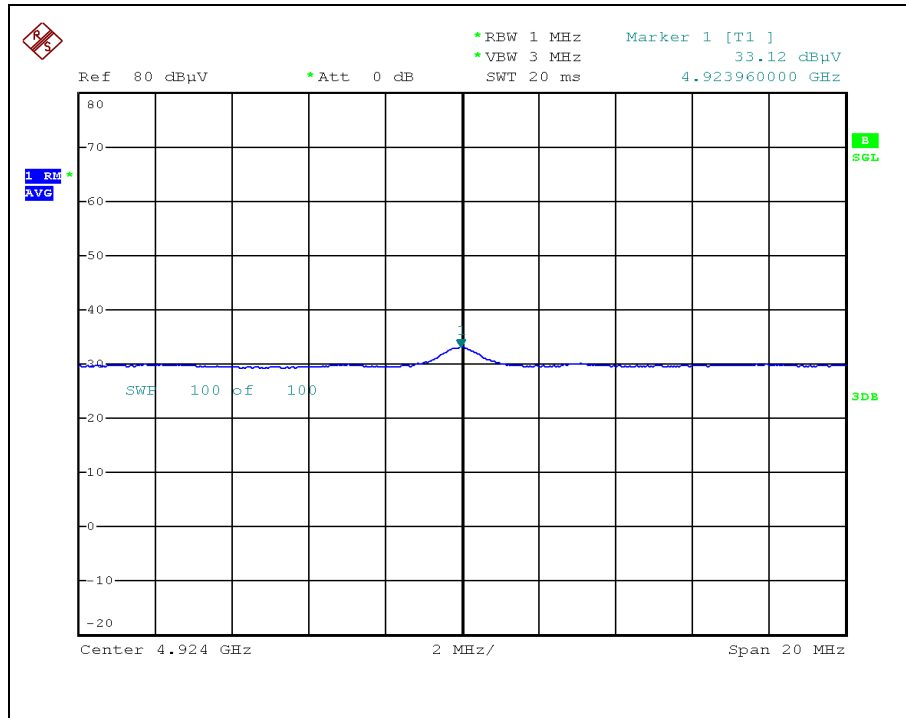
802.11b _ Low frequency

Spurious - Peak



802.11b _ Low frequency

Spurious - Average

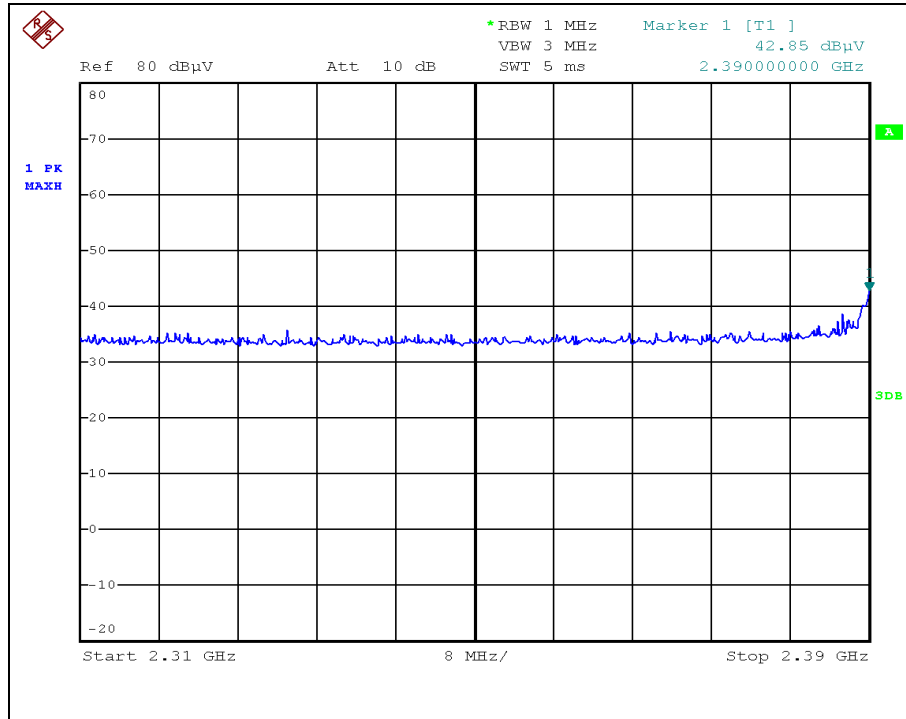


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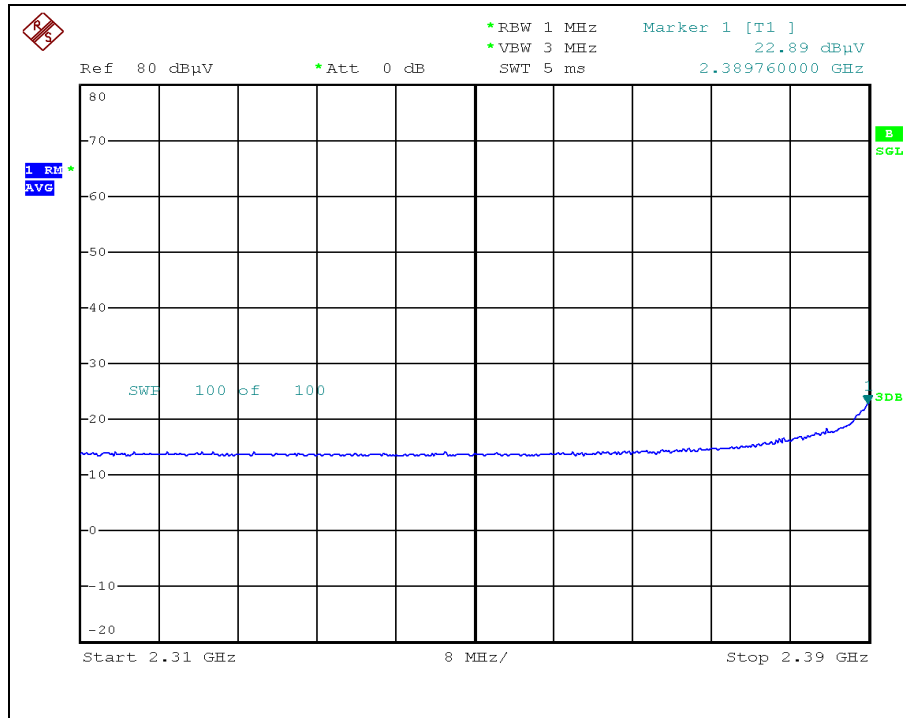
802.11g _ Low frequency

Restricted Band - Peak



802.11g _ Low frequency

Restricted Band - Average

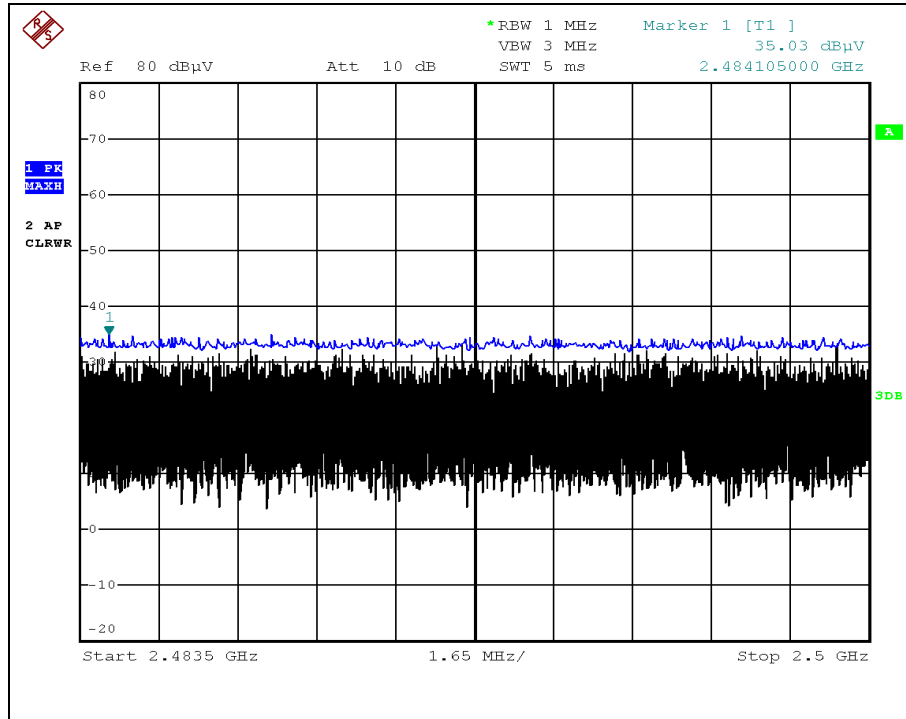


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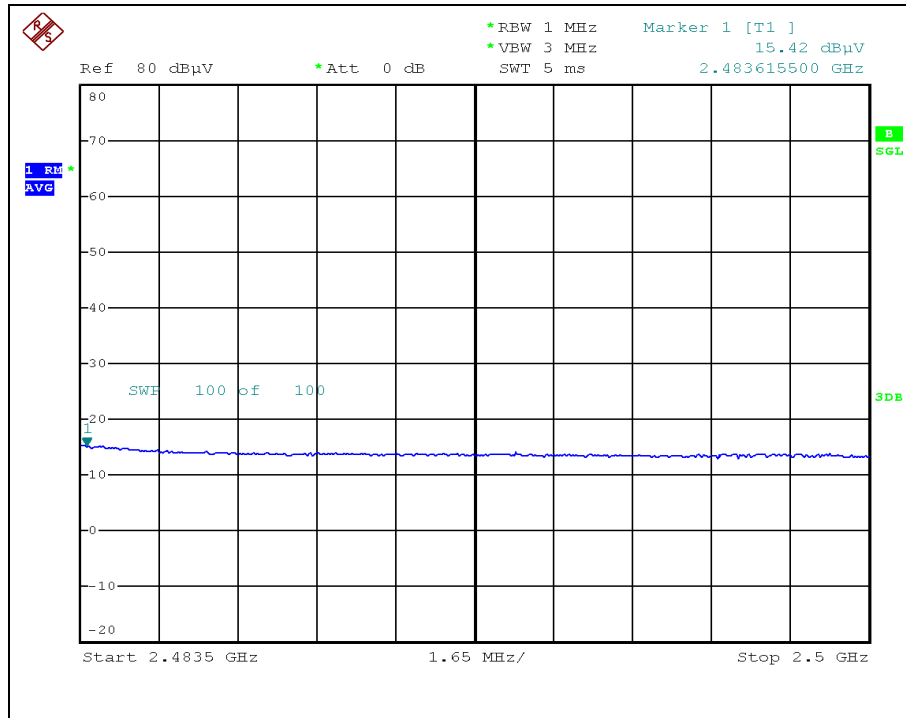
802.11g _ High frequency

Restricted Band - Peak



802.11g _ High frequency

Restricted Band - Average

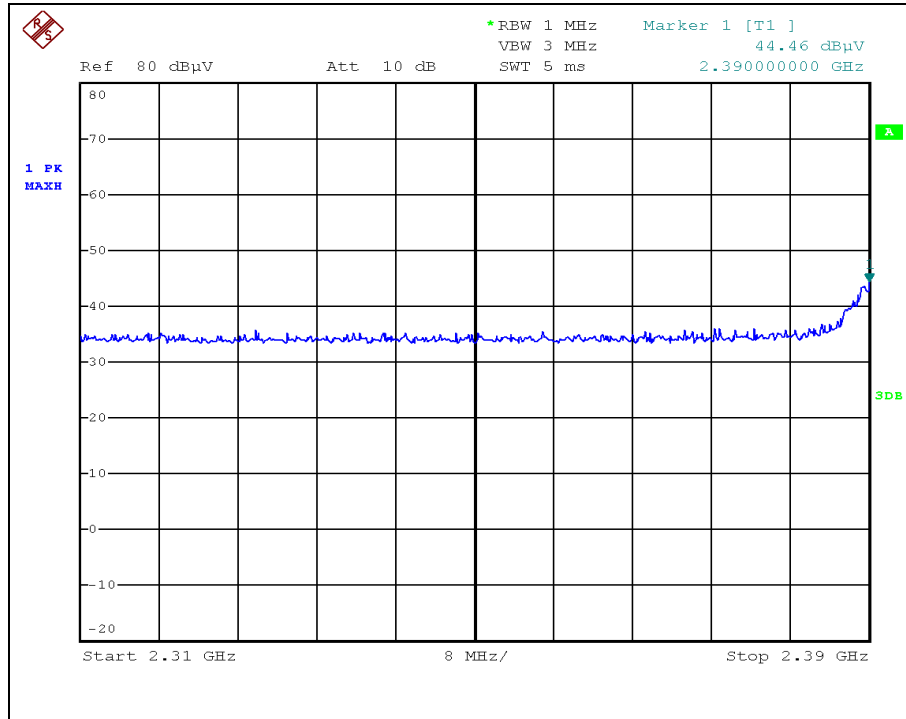


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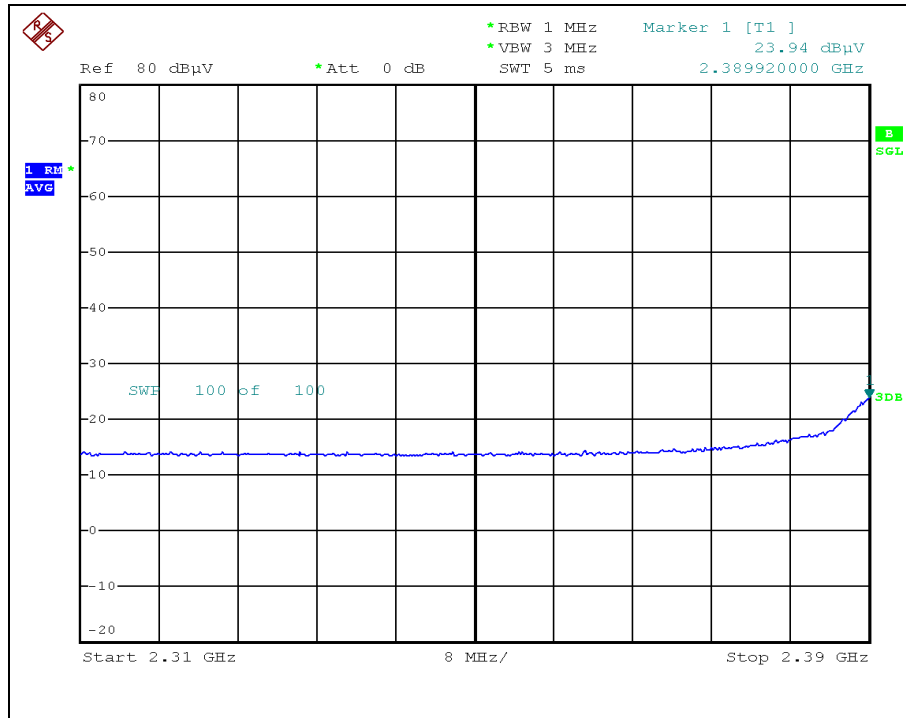
802.11n_HT20 _ Low frequency

Restricted Band - Peak



802.11n_HT20 _ Low frequency

Restricted Band - Average

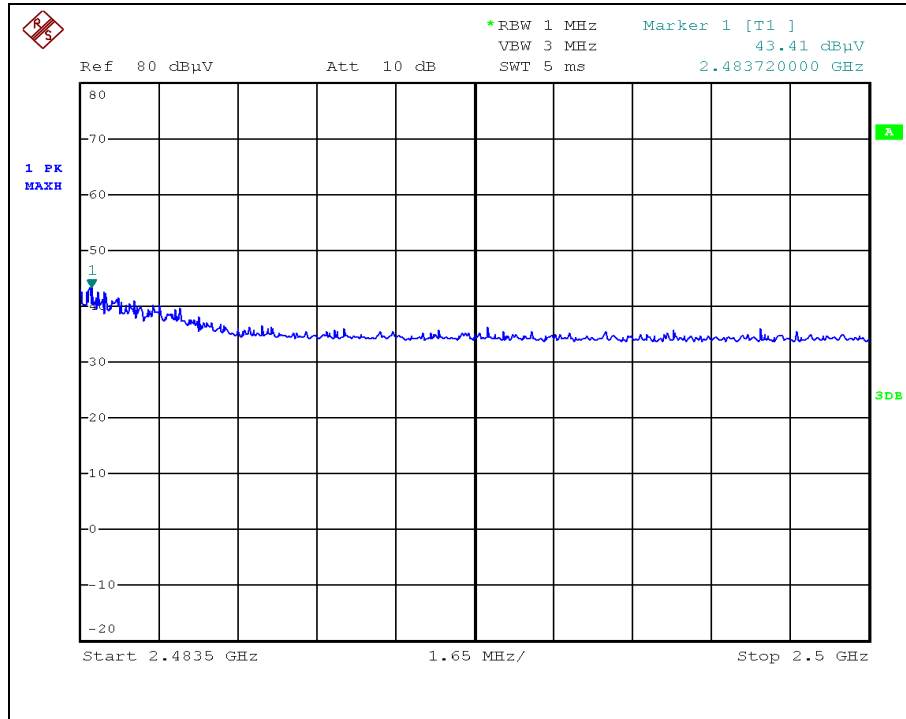


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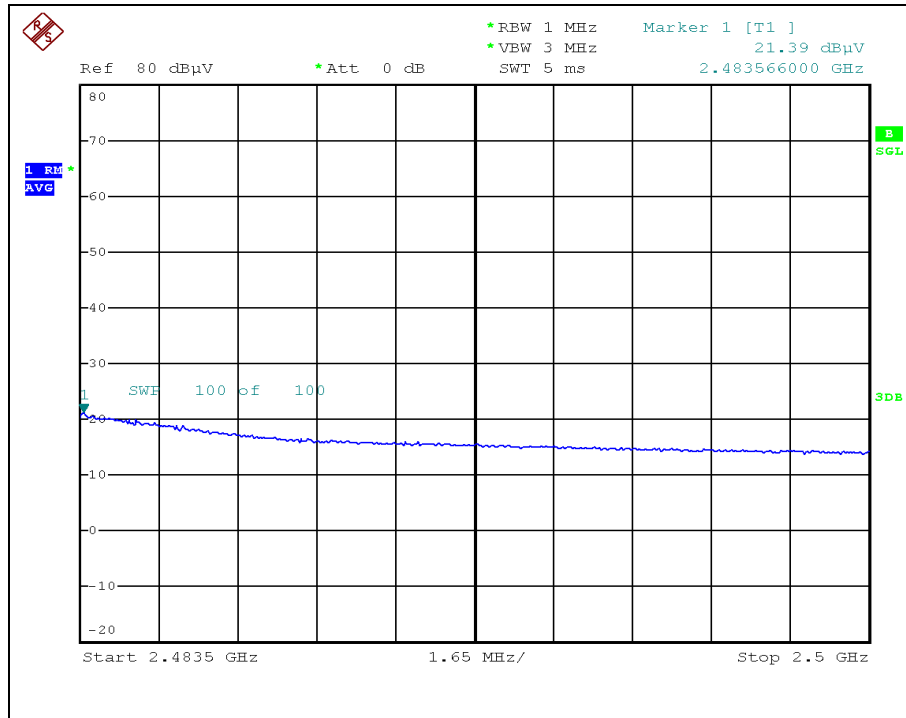
802.11n_HT20 _ High frequency

Restricted Band - Peak



802.11n_HT20 _ High frequency

Spurious - Average



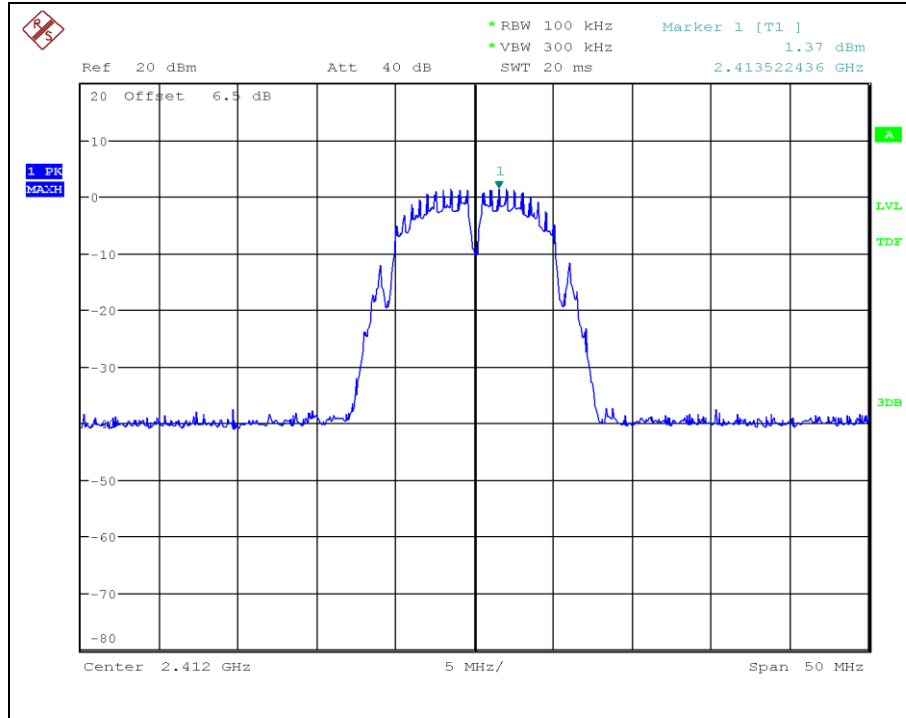
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3.3.5.7 Test Plot for Conducted Spurious Emission

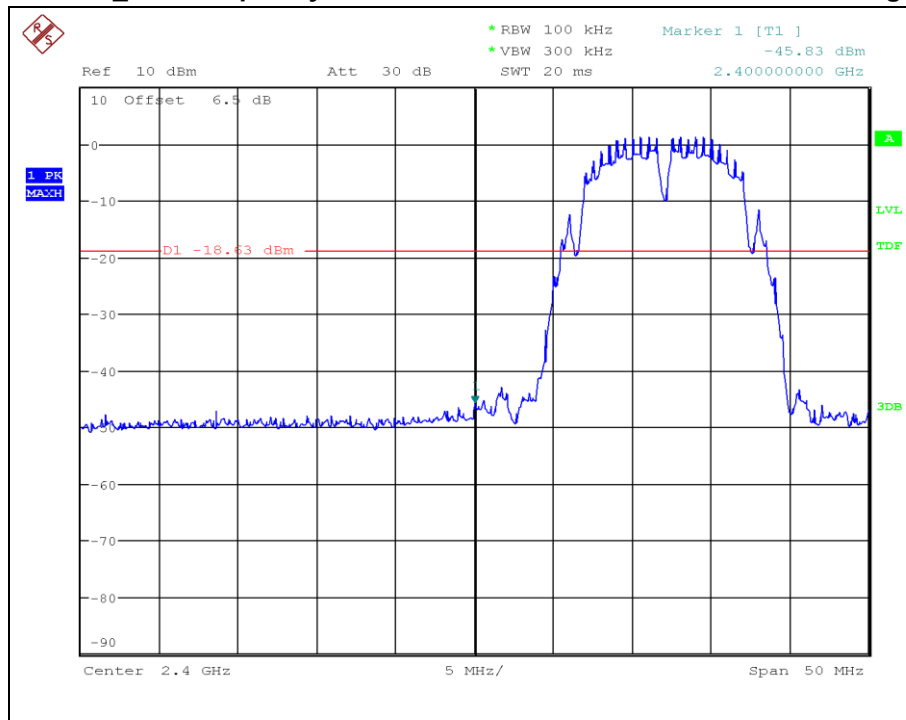
802.11b _ Low frequency

Reference



802.11b _ Low frequency

Bandedge

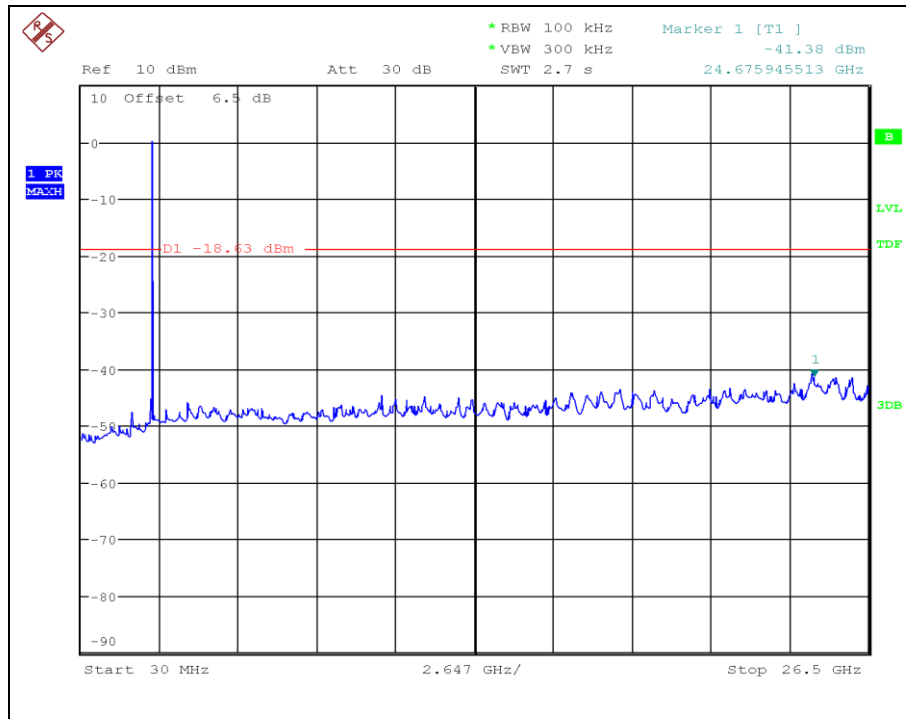


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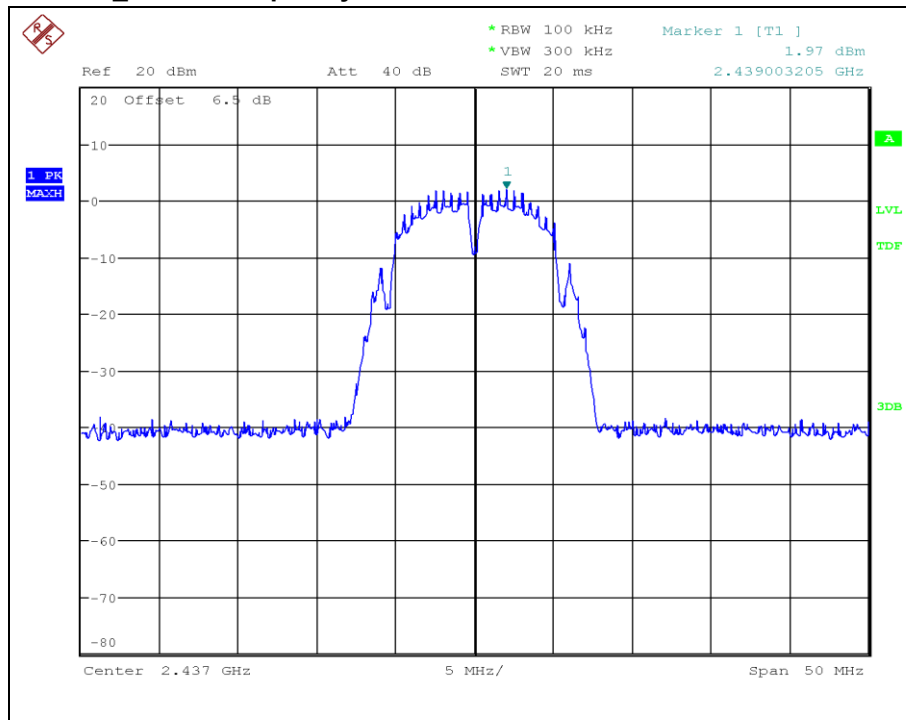
802.11b _ Low frequency

Spurious



802.11b _ Middle frequency

Reference

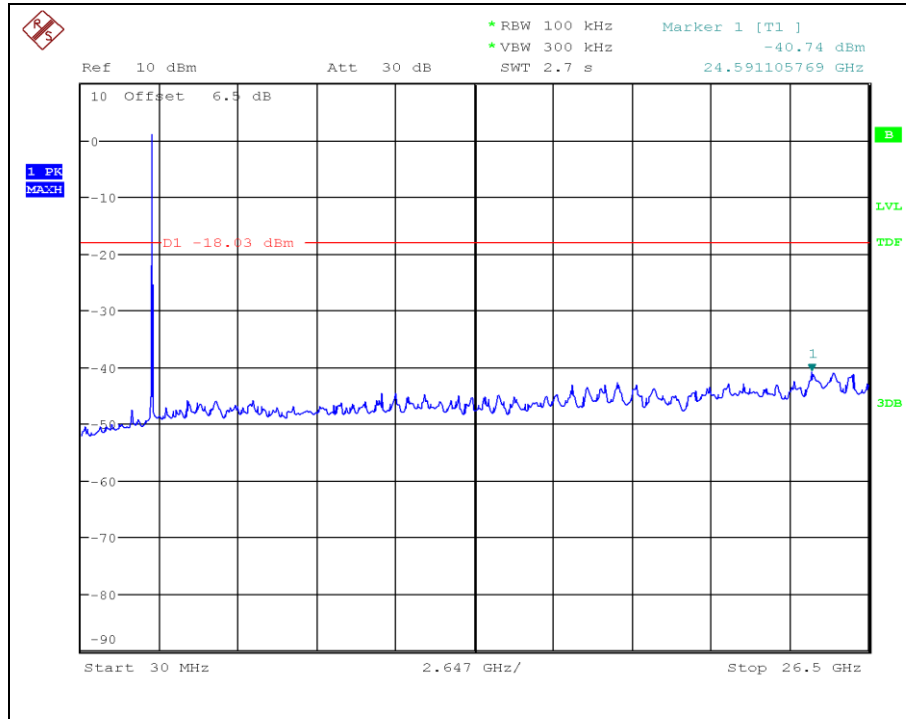


Test Report No.: NW2109-F005

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www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

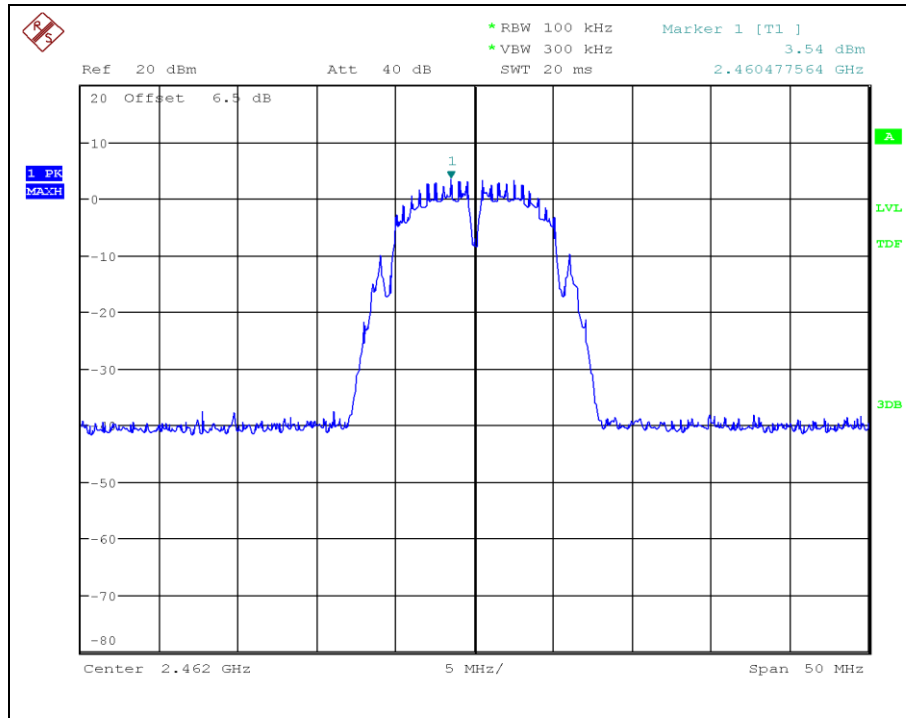
802.11b _ Middle frequency

Spurious



802.11b _ High frequency

Reference

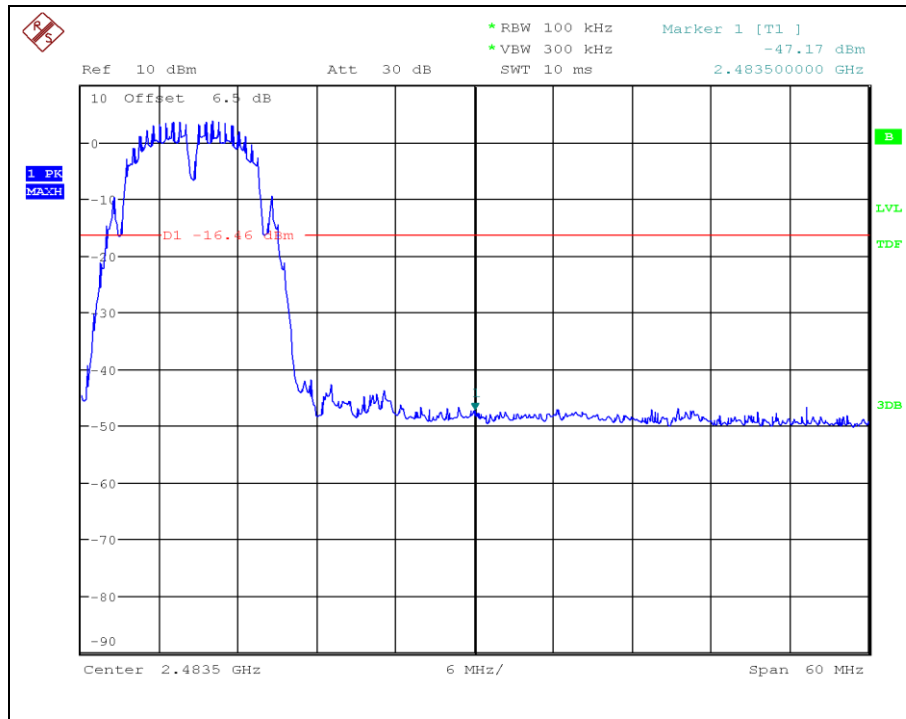


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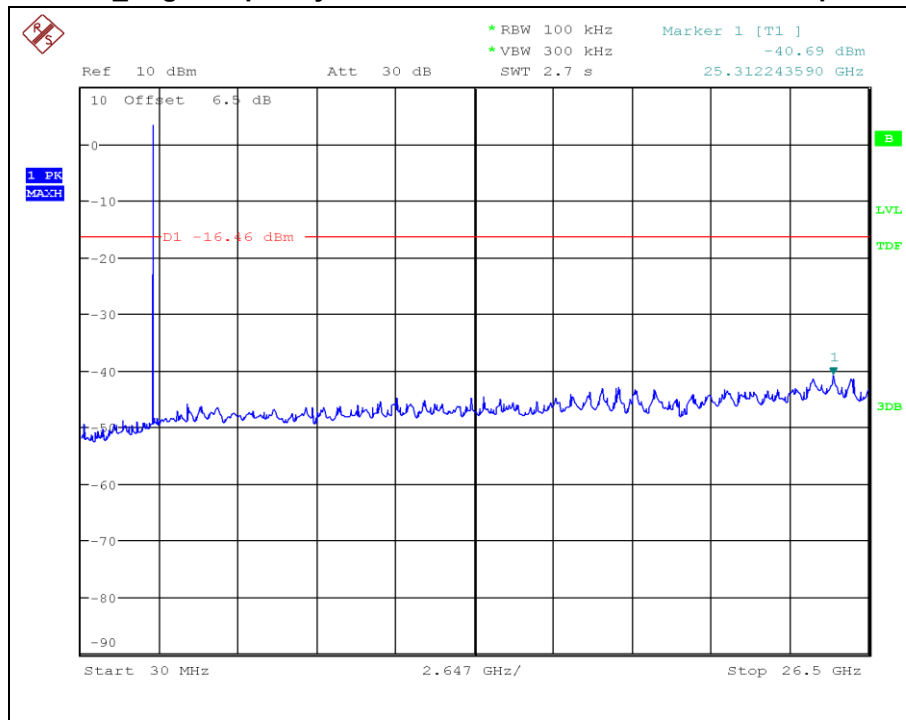
802.11b _ High frequency

Bandedge



802.11b _ High frequency

Spurious

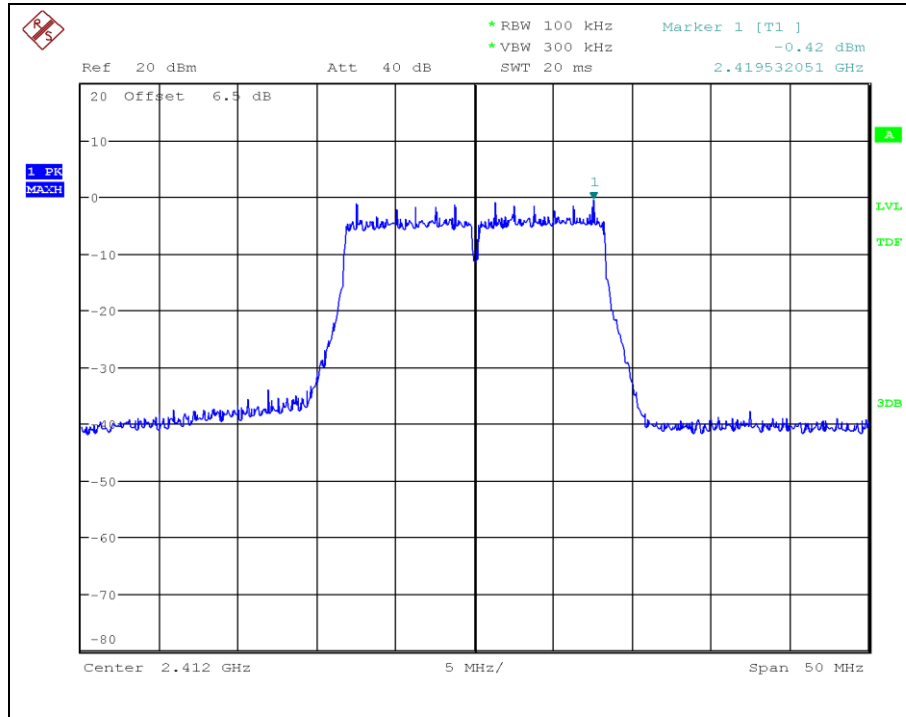


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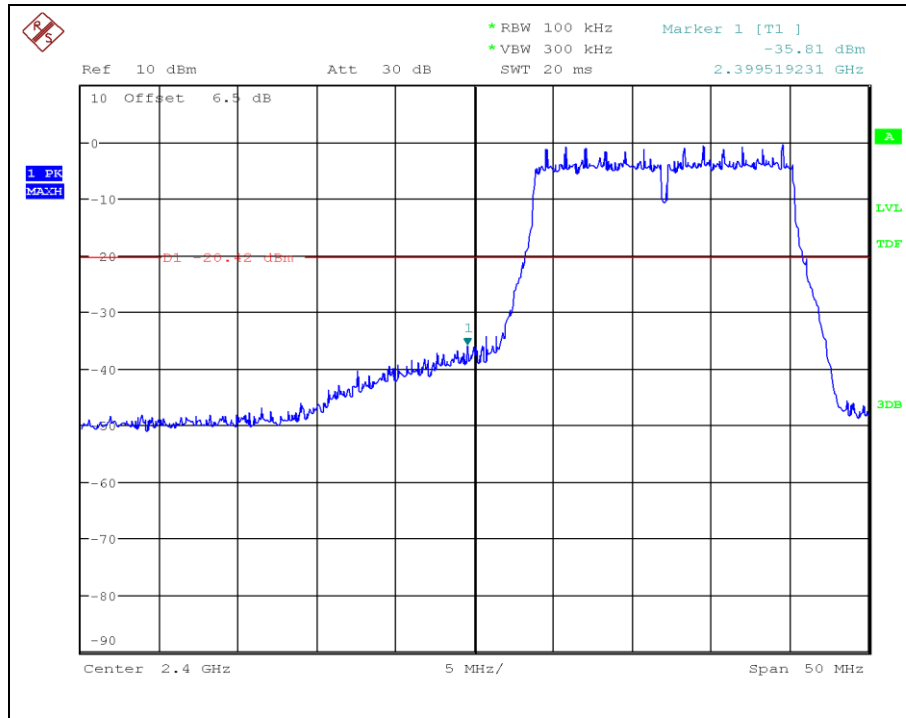
802.11g _ Low frequency

Reference



802.11g _ Low frequency

Bandedge

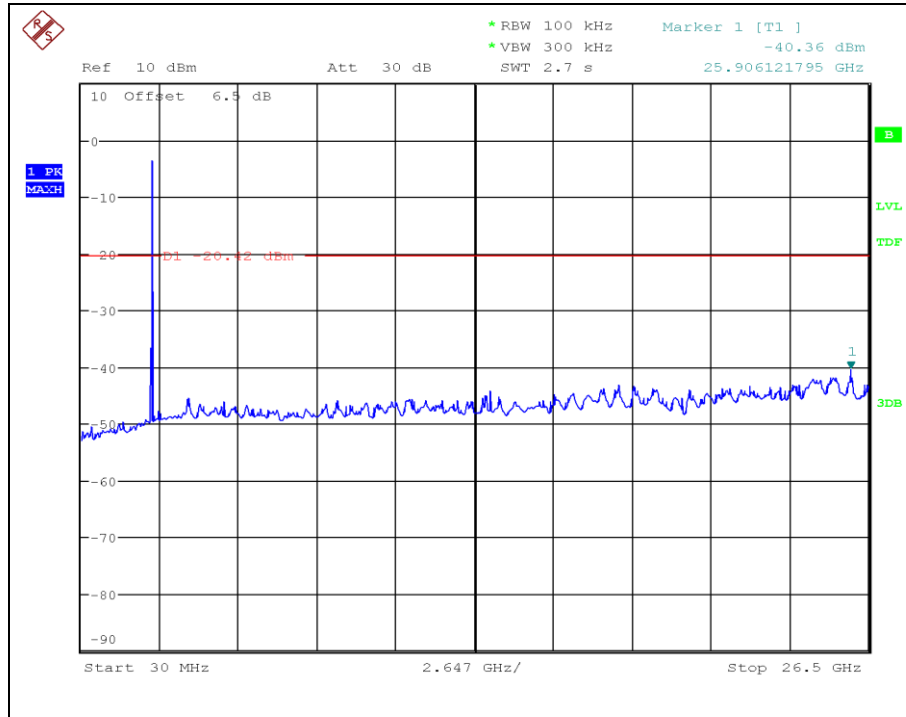


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www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

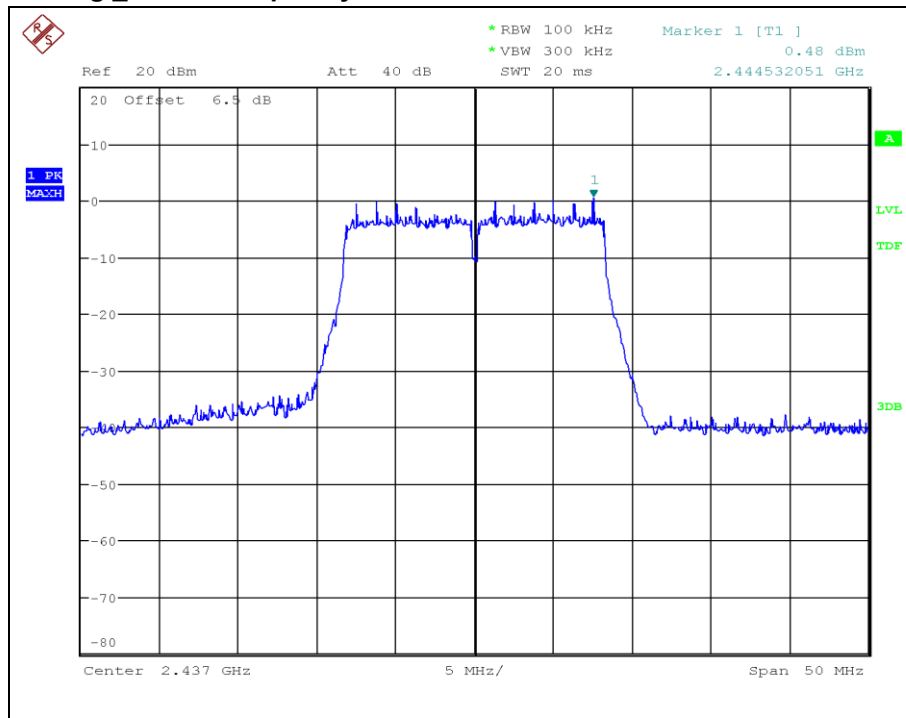
802.11g _ Low frequency

Spurious



802.11g _ Middle frequency

Reference

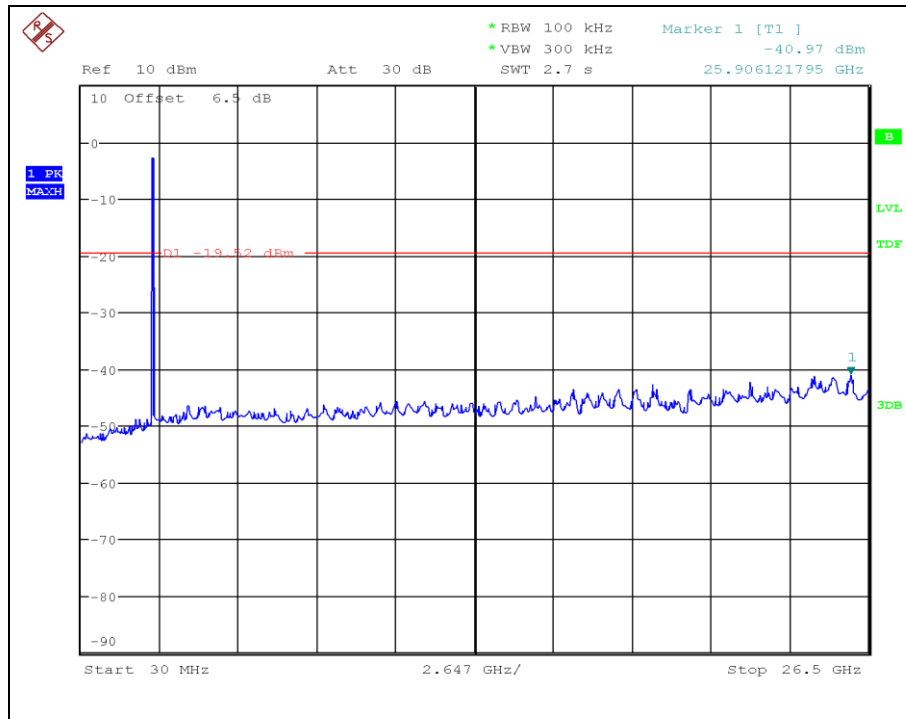


Test Report No.: NW2109-F005

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www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

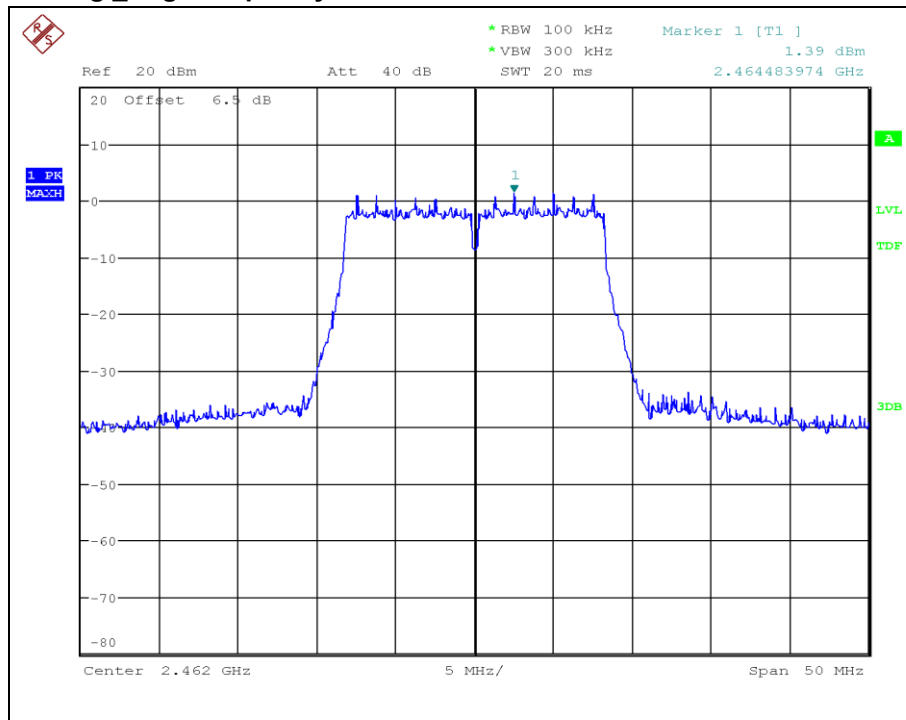
802.11g _ Middle frequency

Spurious



802.11g _ High frequency

Reference

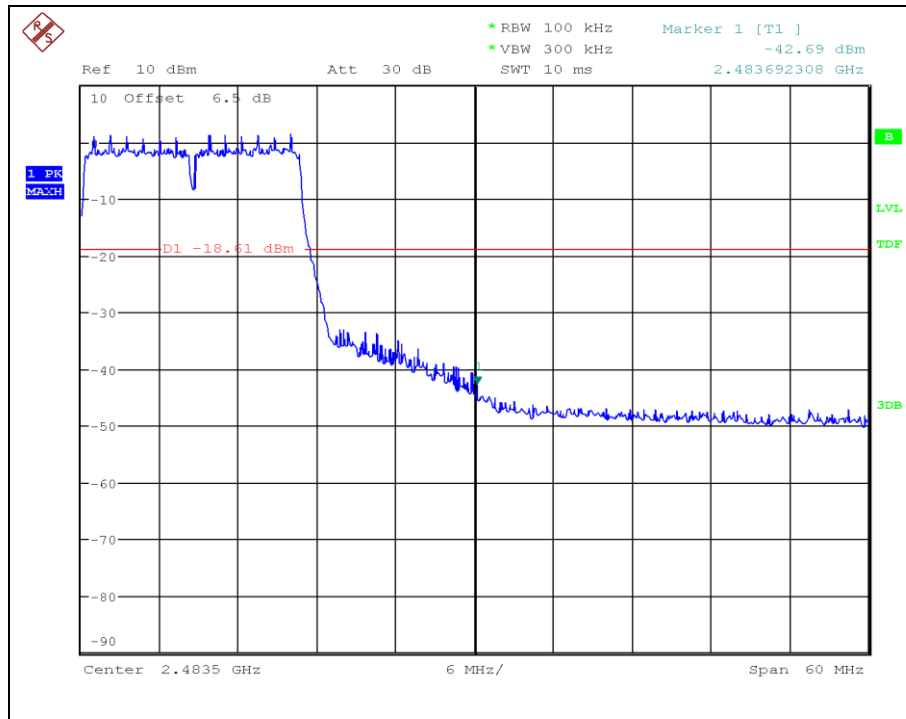


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www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

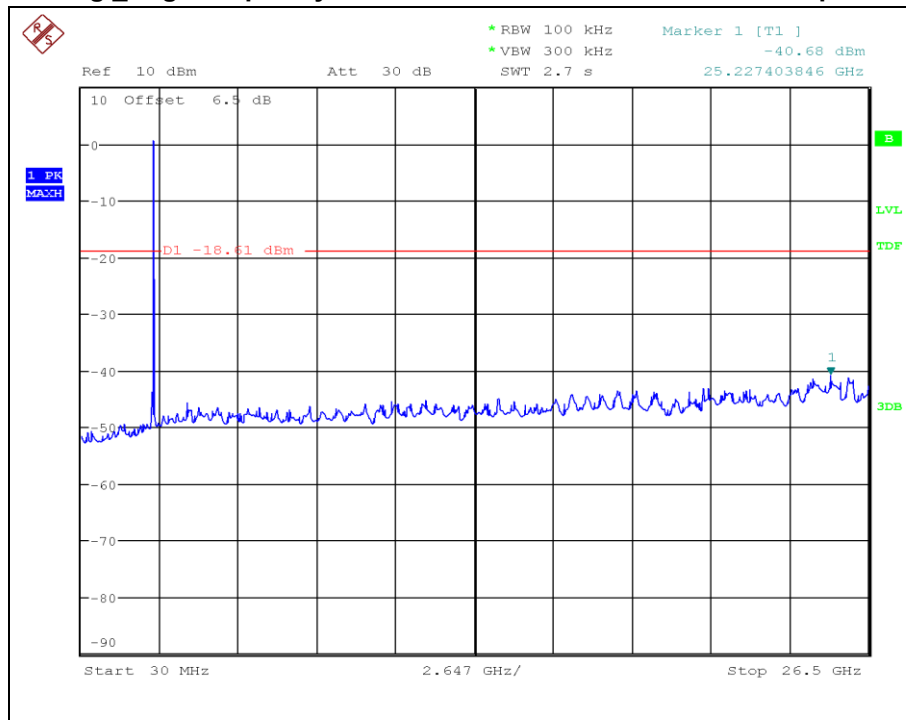
802.11g _ High frequency

Bandedge



802.11g _ High frequency

Spurious

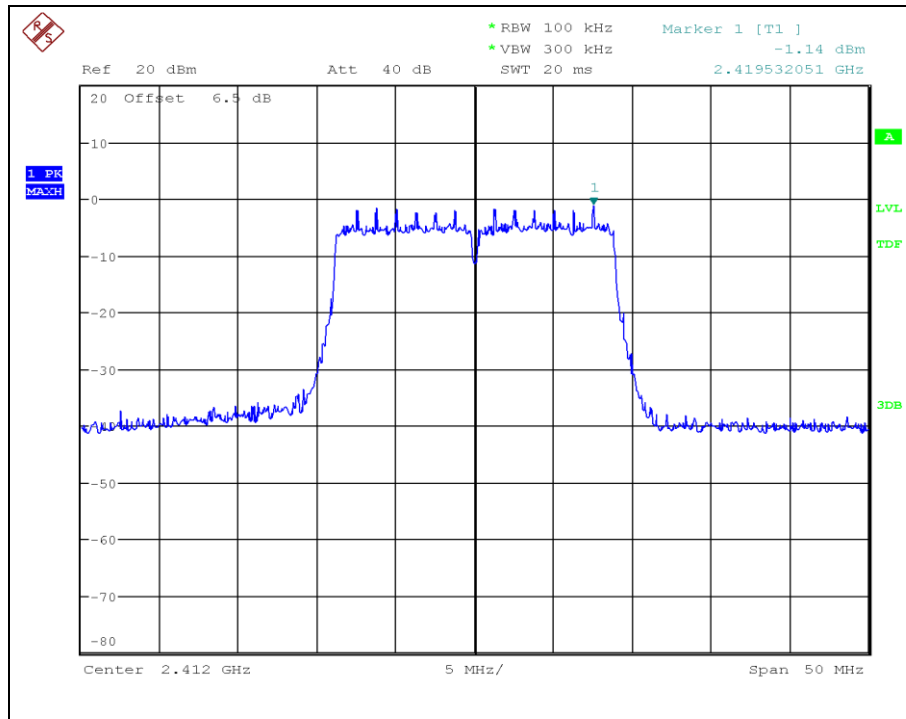


Test Report No.: NW2109-F005

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www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

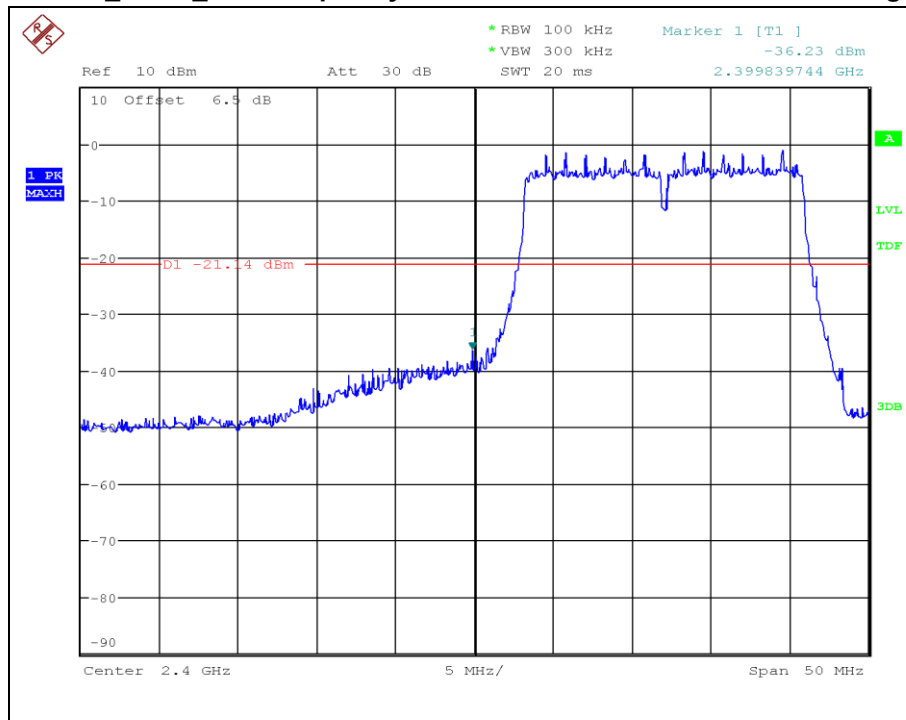
802.11n_HT20 _ Low frequency

Reference



802.11n_HT20 _ Low frequency

Bandedge

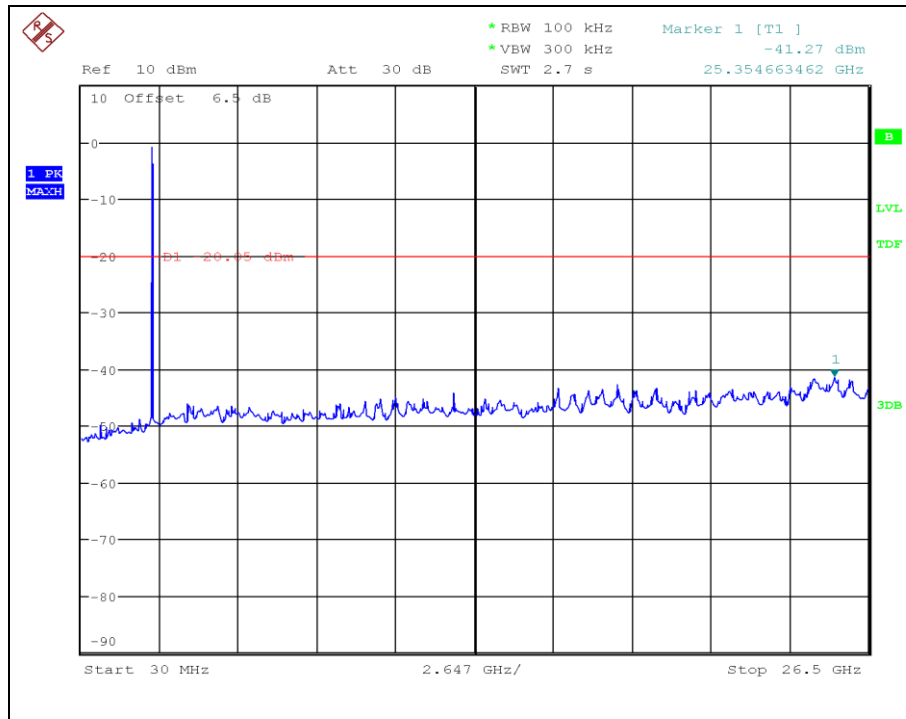


Test Report No.: NW2109-F005

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www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

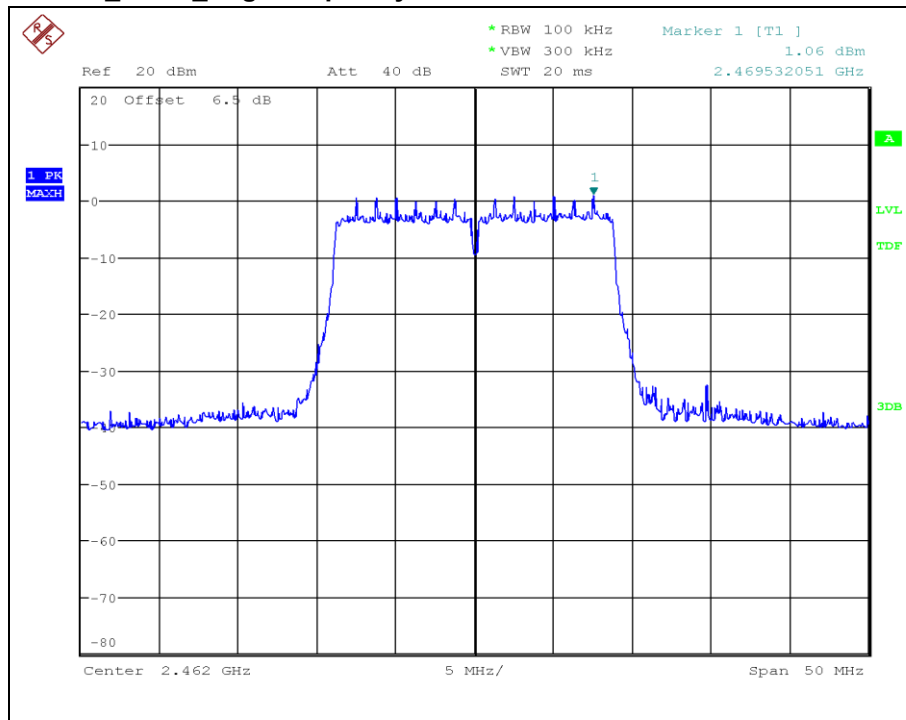
802.11n_HT20 _ Middle frequency

Spurious



802.11n_HT20 _ High frequency

Reference

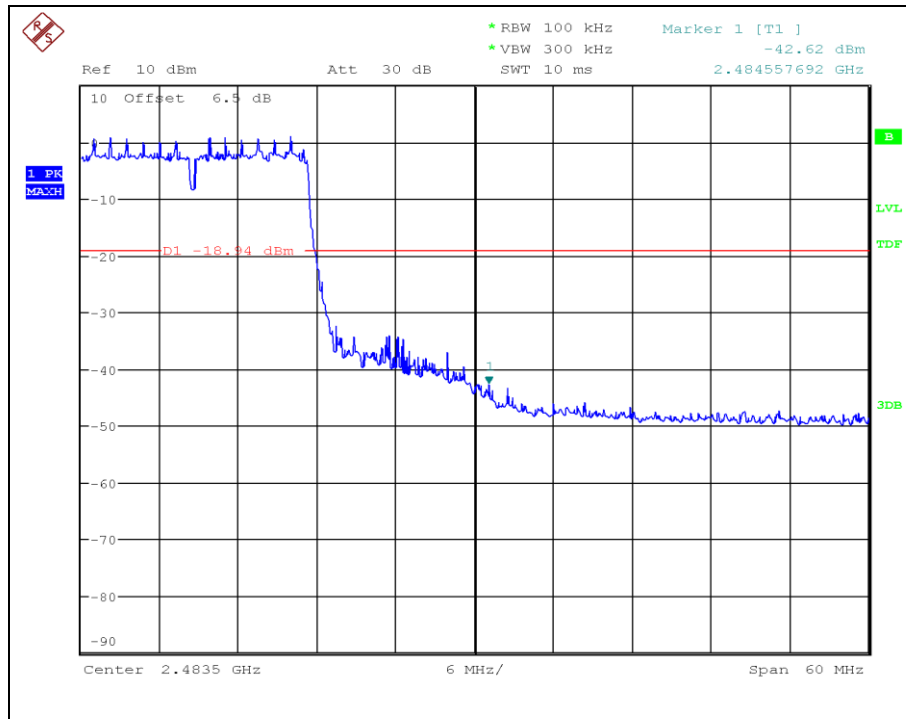


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www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

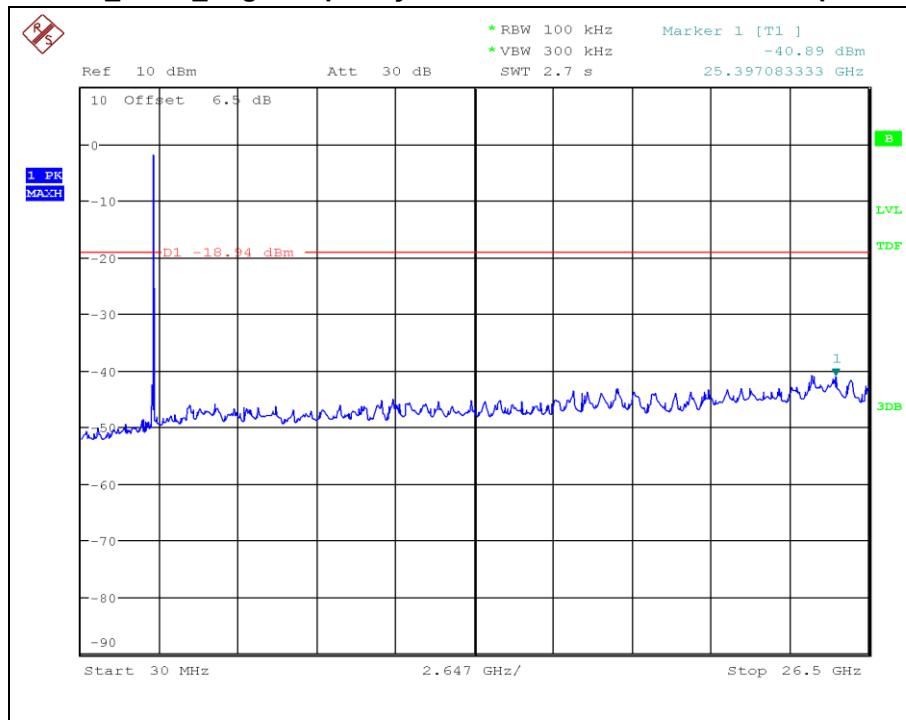
802.11n_HT20 _ High frequency

Bandedge



802.11n_HT20 _ High frequency

Spurious



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3.3.6 Conducted Emission

3.3.6.1 Test Setup

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

3.3.6.2 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 (dBuV)	
	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

3.3.6.3 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.

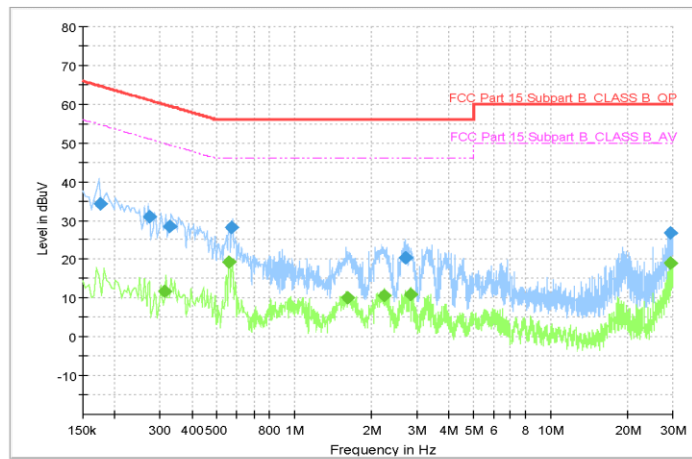
3.3.6.4 Test Result

- AC Line Conducted Emission (Graph)

Test Report

Common Information

Test Model: SP87
Test Standard: FCC Part 15 Subpart B
Test Mode: WLAN+Charging
Test Conditions: AC 120 V, 60 Hz / 25.1 °C, 48.2 % R. H.
Operator Name: JongMyoung, Shin
Comment: LINE
Order Number: -



Final Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.175000	34.45	—	64.67	30.22	1000.0	9.000	L1	10.4
0.272000	31.03	—	61.06	30.03	1000.0	9.000	L1	10.5
0.312000	—	11.62	49.92	38.29	1000.0	9.000	L1	10.5
0.328000	28.53	—	59.50	30.97	1000.0	9.000	L1	10.5
0.560000	—	19.30	46.00	26.70	1000.0	9.000	L1	10.4
0.572000	28.10	—	56.00	27.90	1000.0	9.000	L1	10.4
1.614000	—	10.14	46.00	35.86	1000.0	9.000	L1	10.6
2.256000	—	10.64	46.00	35.36	1000.0	9.000	L1	10.6
2.722000	20.38	—	56.00	35.62	1000.0	9.000	L1	10.6
2.848000	—	10.95	46.00	35.05	1000.0	9.000	L1	10.6
29.236000	—	19.01	50.00	30.99	1000.0	9.000	L1	12.0
29.236000	26.90	—	60.00	33.10	1000.0	9.000	L1	12.0

2021-06-24

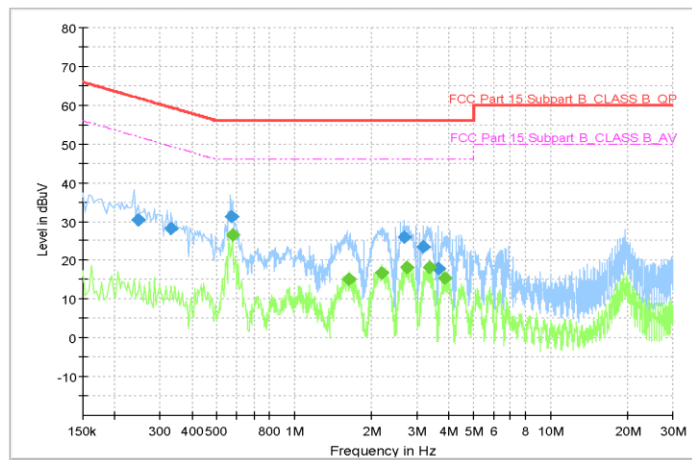
Test Report No.: NW2109-F005

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Test Report

Common Information

Test Model: SP87
Test Standard: FCC Part 15 Subpart B
Test Mode: WLAN+Charging
Test Conditions: AC 120 V, 60 Hz / 25.1 °C, 48.2 % R. H.
Operator Name: JongMyoung, Shin
Comment: NEUTRAL
Order Number: -



Final Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.248000	30.39	---	61.92	31.43	1000.0	9.000	N	10.4
0.330000	28.19	---	59.45	31.26	1000.0	9.000	N	10.5
0.570000	31.30	---	56.00	24.70	1000.0	9.000	N	10.4
0.578000	---	28.42	46.00	19.58	1000.0	9.000	N	10.4
1.844000	---	15.10	46.00	30.90	1000.0	9.000	N	10.6
2.192000	---	16.86	46.00	29.14	1000.0	9.000	N	10.6
2.692000	25.89	---	56.00	30.11	1000.0	9.000	N	10.6
2.752000	---	18.26	46.00	27.74	1000.0	9.000	N	10.6
3.196000	23.41	---	56.00	32.59	1000.0	9.000	N	10.6
3.392000	---	18.07	46.00	27.93	1000.0	9.000	N	10.6
3.652000	17.84	---	56.00	38.16	1000.0	9.000	N	10.6
3.856000	---	15.31	46.00	30.69	1000.0	9.000	N	10.7

2021-06-24

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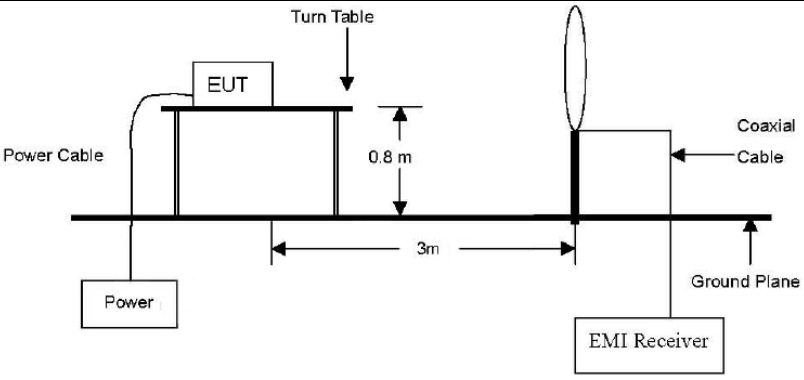
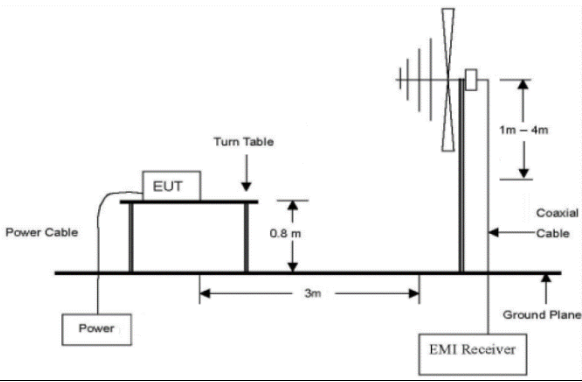
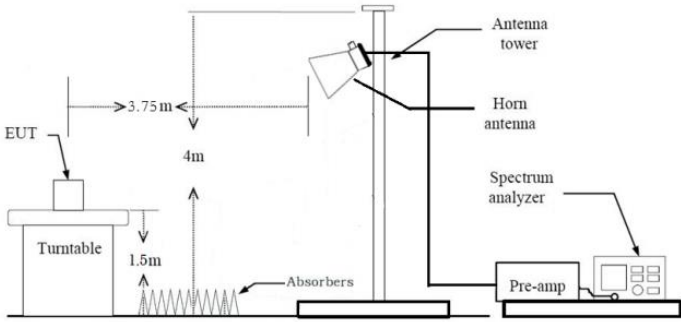
APPENDIX I

TEST SETUP

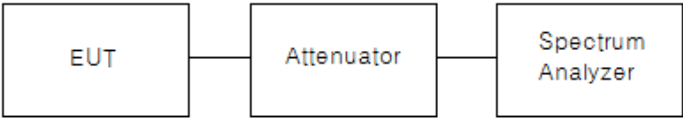
Test Repot No.: NW2109-F005

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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 II

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	2021-03-09	2022-03-09
2	SPECTRUM ANALYZER	R&S	100250	FSU26	2020-09-22	2021-09-22
3	Triple Output DC Power Supply	Agilent	MY40038816	E3631A	2021-03-09	2022-03-09
4	Power supply	GWInstek	EH120798	PST-3202	2021-03-09	2022-03-09
5	Humi./Baro/Temp. data recorder	Lutron	38420	MHB-382SD	2020-11-13	2021-11-13
6	USB Peak & Average Power Sensor	KEYSIGHT	MY58140003	U2044XA	2021-09-03	2022-09-03
7	8360B SERIES SWEPT SIGNAL GENERATOR	HP	3614A00312	83640B	2020-12-30	2021-12-30
8	LOOP-ANTENNA	Schwarzbeck	00124	FMZB1519 B	2021-06-01	2023-06-01
9	TRILOG Broadband Antenna	Schwarzbeck	01027	VULB 9168	2021-06-08	2023-06-08
10	Double Ridged Broadband Horn Antenna	Schwarzbeck	02087	BBHA 9120D	2021-06-02	2022-06-02
11	Broadband Horn Antenna	Schwarzbeck	00938	BBHA 9170	2021-06-01	2022-06-01
12	AMPLIFIER	TESTEK	160011-L	TK-PA18M	2021-05-24	2022-05-24
13	Amplifier	TESTEK	190008-L	TK-PA1840H	2021-05-28	2022-05-28
14	ATTENUATOR	INMET	279465	40AH2W	2021-07-27	2022-07-27
15	ATTENUATOR	Weinschel	none	WA41/12-30-12	2021-03-09	2022-03-09
16	High Pass Filter	Mini-Circuits	1741	VHF-3100+	2021-03-09	2022-03-09
17	High Pass Filter	Mini-Circuits	1732	VHF-8400+	2021-03-09	2022-03-09
18	LISN	Schwarzbeck	00984	NSLK 8127	2020-09-24	2021-09-24
19	EMI Test Receiver	R&S	102116	ESRP3	2021-05-27	2022-05-27

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APPENDIX III

DUTY CYCLE CORRECTION FACTOR

Test Repot No.: NW2109-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)	x		
802.11b	1 Mbps	6	100.000	100.000	1.000	0.00	0.50
802.11g	6 Mbps	6	100.000	100.000	1.000	0.00	0.50
802.11ac_VHT40	MCS 0	6	100.000	100.000	1.000	0.00	0.50

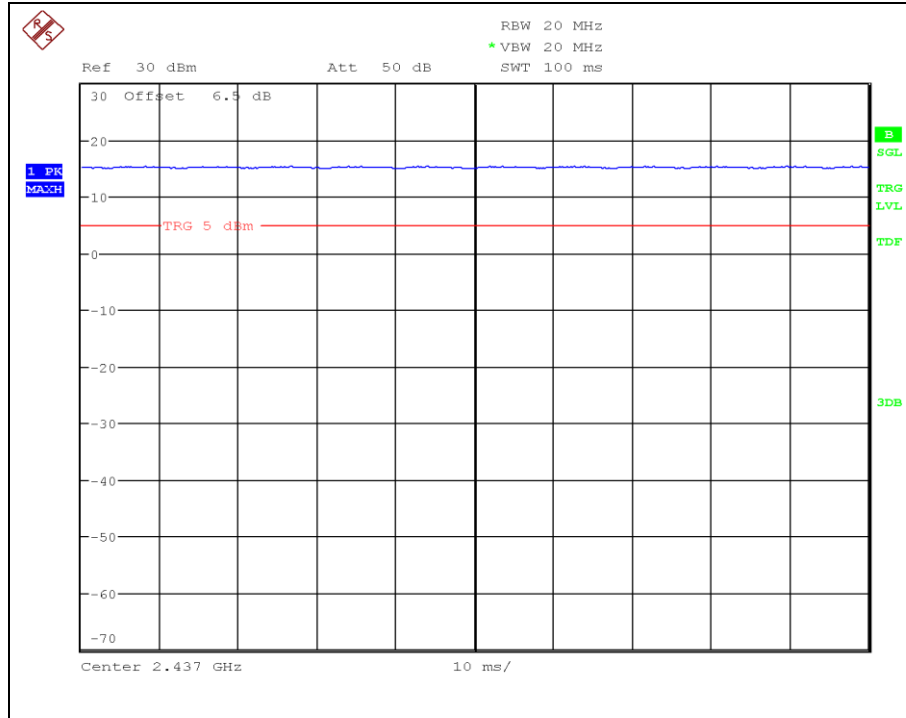
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Test Plot

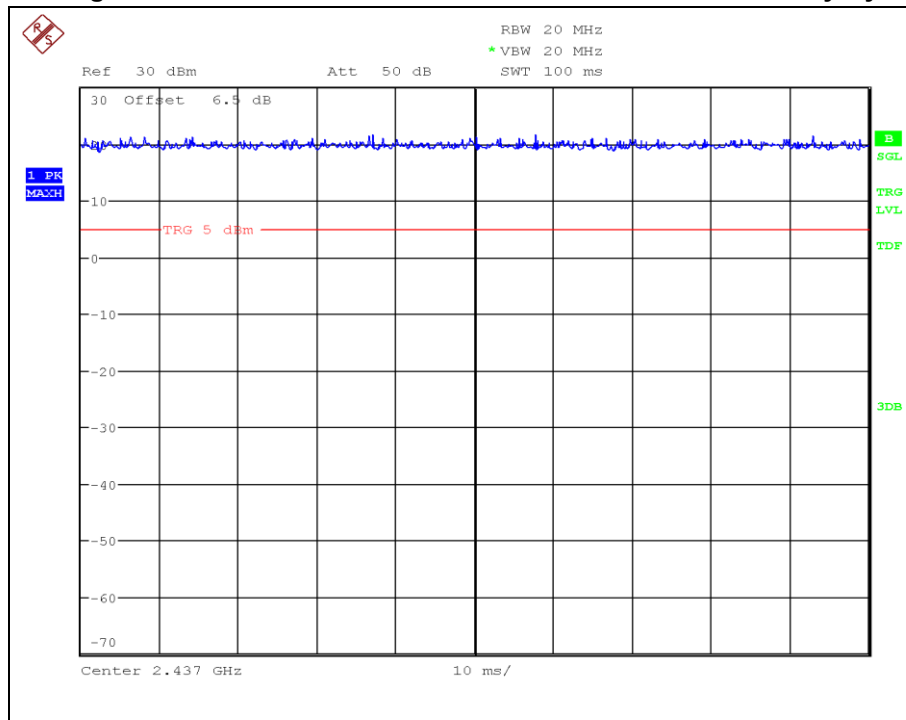
802.11b

Duty Cycle



802.11g

Duty Cycle

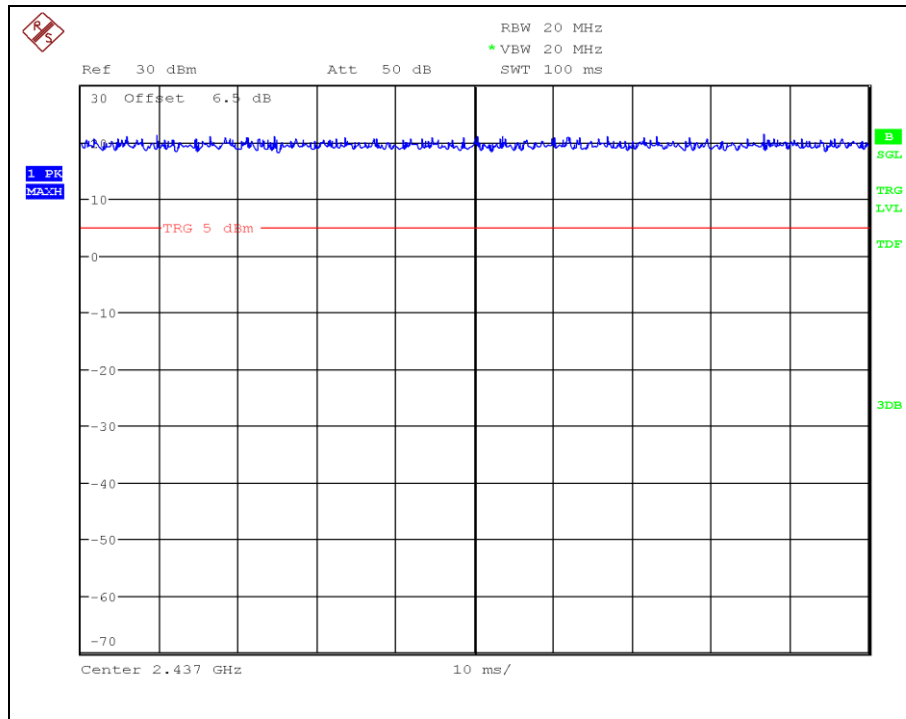


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802.11n_HT20

Duty Cycle



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