Test Report

1. Client
   - Name : Sena Technologies Co., Ltd.
   - Address : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea
2. Use of Report : FCC & IC Approval
3. Sample Description
   - Product Name : PHANTOM
   - Model Name : SP149
4. Date of Receipt : 2023-12-18
5. Date of Test : 2024-01-17 ~ 2024-01-26
6. Test Method : FCC Part 15 Subpart C 15.247
   RSS-247 Issue 3(2023-08), RSS-GEN Issue 5(2019-03)
7. Test Results : Refer to the test results

This test report must not be reproduced or reproduced in any way.
The results shown in this test report are the results of testing the samples provided.
This test report is prepared according to the requirements of ISO / IEC 17025.

Affirmation	Tested by Jong-Myoung, Shin (signature)	Technical Manager Kyung-Taek, Lee (signature)

Feb 08, 2024

EMC Labs Co., Ltd. (seal)

Contents

Version

TEST REPORT NO.	DATE	DESCRIPTION
KR0140-RF2402-004	Feb 08, 2024	Initial Issue

1. Applicant & Manufacturer & Test Laboratory Information

1.1 Applicant Information

Applicant	Sena Technologies Co., Ltd.
Applicant Address	19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea
Contact Person	Seunghyun Kim
Telephone No.	+82-2-573-7772
Fax No.	+82-2-573-7710
E-mail	shkim77@sena.com

1.2. Manufacturer Information

Manufacturer	Sena Technologies Co., Ltd.
Manufacturer Address	19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea

1.3 Test Laboratory Information

Laboratory	EMC Labs Co., Ltd.
Laboratory Address	100, Jangjateo-ro, Hobeop-myeon, Icheon-si, Gyeonggi-do, Republic of Korea
Contact Person	Jong-Myoung, Shin
Telephone No.	+82-31-637-8895
Fax No.	+82-505-116-8895
FCC Designation No.	KR0140
FCC Registration No.	580000
IC Site Registration No.	28751

2. Equipment under Test(EUT) Information

2.1 General Information

Product Name	PHANTOM
Model Name	SP149
FCC ID	S7A-SP149
IC	8154A-SP149
Rated Voltage	DC 3.7 V

2.2 Additional Information

Operating Frequency	2 412 MHz ~ 2 462 MHz
Number of Channel	11 for 802.11b/g/n_HT20 / 9 for 802.11n_HT40
Modulation Type	DSSS for 802.11b / OFDM for 802.11g/n_HT20/n_HT40
Antenna Type	PCB Pattern Antenna
Antenna Gain	0.65 dBi
Firmware Version	1.0
Hardware Version	1.0
Test Software	EspRFTestTool_v3.6

2.3 Test Frequency

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
802.11n_HT40	2 422	2 437	2 452

2.4 Used Test Software Setting Value

Test Mode	Setting Item
	Power
802.11b	35
802.11g	35
802.11n_HT20	35
802.11n_HT40	35

2.5 Transmitting Configuration of EUT

Test mode	Data Rate
802.11b	1 ~ 11 Mbps
802.11g	6 ~ 54 Mbps
802.11n_HT20	MCS 0 ~ 7
802.11n_HT40	MCS 0 ~ 7

2.6 Mode of operation during the test

- The EUT continuous transmission mode during the test with set at Low Channel, Middle Channel, and High Channel. To get a maximum radiated emission levels from the EUT, the EUT was moved throughout the XY, YZ, XZ planes.

2.7 Modifications of EUT

- None

3. 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 Peak 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.

4. Used equipment on test

	Description	Manufacturer	Model Name	Serial Name	Next Cal.
■	TEMP & HUMID CHAMBER	JFM	JFMA-001	20200929-01	2024.12.07
■	CONTROLLER	AMWON TECHNOLOGY	TEMI2500	S7800VK191 0707	2024.12.07
■	PSA SERIES SPECTRUM ANALYZER	AGILENT	E4440A	MY45304057	2024.12.08
■	MXG ANALOG SIGNAL GENERATOR	AGILENT	N5183A	MY50141890	2024.12.08
■	SYSTEM DC POWER SUPPLY	AGILENT	6674A	MY53000118	2024.12.11
□	VECTOR SIGNAL GENERATOR	ROHDE & SCHWARZ	SMBV100A	257524	2024.12.08
□	BLUETOOTH TESTER	TESCOM	TC-3000A	3000A480088	2024.12.08
□	DIRECTIONAL COUPLER	AGILENT	773D	2839A01855	2024.12.08
□	ATTENUATOR	AGILENT	8493C	73193	2024.12.08
□	TERMINATIOM	HEWLETT PACKARD	909D	07492	2024.12.08
□	POWER DIVIDER	HEWLETT PACKARD	11636A	06916	2024.12.08
□	SLIDE-AC	DAEKWANG TECH	SV-1023	NONE	2024.11.10
□	DIGITAL MULTIMETER	HUMANTECHSTORE	15B+	50561541WS	2024.12.08
■	ATTENUATOR	ACE RF COMM	ATT SMA 20W 20dB 8GHz	A-0820.SM20.2	2024.04.04
■	DC POWER SUPPLY	AGILENT	E3634A	MY40012120	2024.02.23
□	USB Peak Power Sensor	Anritsu	MA24408A	12321	2024.11.09
□	High Pass Filter	WT Microwave INC.	WT-A3314-HS	WT22111804-1	2024.12.08
■	High Pass Filter	WT Microwave INC.	WT-A1935-HS	WT22111804-2	2024.12.08
□	SPECTRUM ANALYZER	ROHDE & SCHWARZ	FSU26	200444	2024.02.22
■	ACTIVE LOOP ANTENNA	TESEQ	HLA 6121	55685	2024.12.22
■	Biconilog ANT	Schwarzbeck	VULB 9160	3260	2025.01.09
□	Biconilog ANT	Schwarzbeck	VULB9168	902	2024.11.30
■	Horn ANT	Schwarzbeck	BBHA9120D	974	2024.11.30
□	Horn ANT	Schwarzbeck	BBHA9120D	1497	2025.01.04
■	Amplifier	TESTEK	TK-PA18H	200104-L	2024.03.14
■	Horn ANT	Schwarzbeck	BBHA9170	01188	2024.03.16
□	Horn ANT	Schwarzbeck	BBHA9170	01189	2024.03.16
■	AMPLIFIER	TESTEK	TK-PA1840H	220105-L	2024.03.14
■	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	101952	2024.03.14
■	Test Receiver	ROHDE & SCHWARZ	ESR7	101616	2024.06.27
■	LISN	ROHDE & SCHWARZ	ENV216	100409	2025.01.04
■	PULSE LIMITER	lignex1	EPL-30	NONE	2025.01.04

5. Antenna Requirement

Accoding 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.

Accoding to §15.247(b)(4) e 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.

5.1 Result

Complies
(The transmitter has a PCB Pattern Antenna. The directional peak gain of the antenna is 0.65 dBi.)

6. 6 dB Bandwidth & Occupied Bandwidth (99%)

6.1 Test Setup

Refer to the APPENDIX I.

6.2 Limit

The minimum permissible 6 dB bandwidth is 500 kHz.

6.3 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) ≥ 3 x 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.

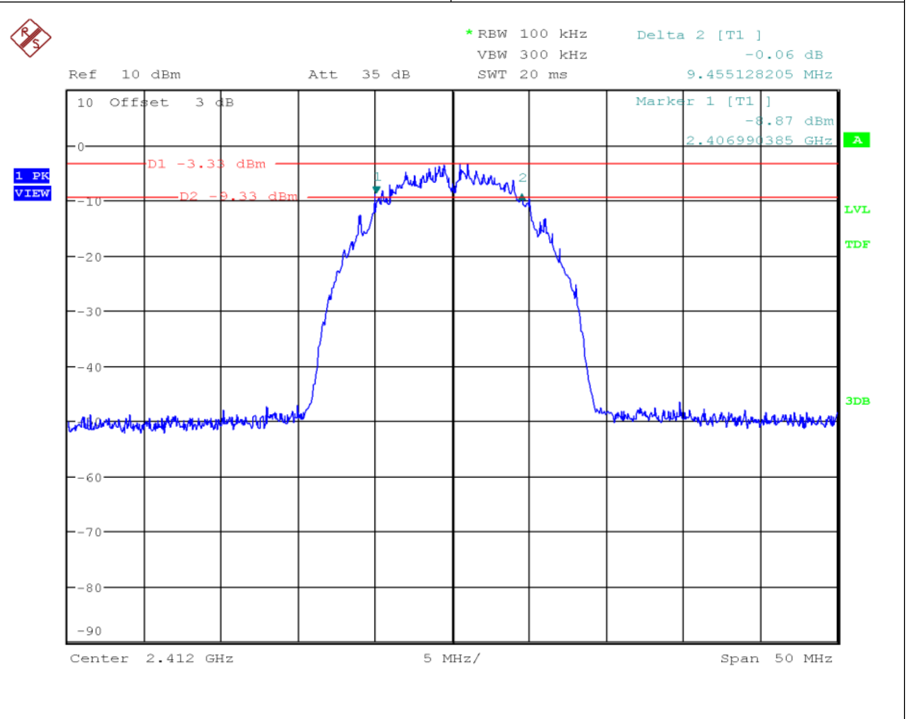
   Option 2 – The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 x RBW, peak detector with maximum hold) is implemented by the instrumentation function. When 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.

6.4 Test Result

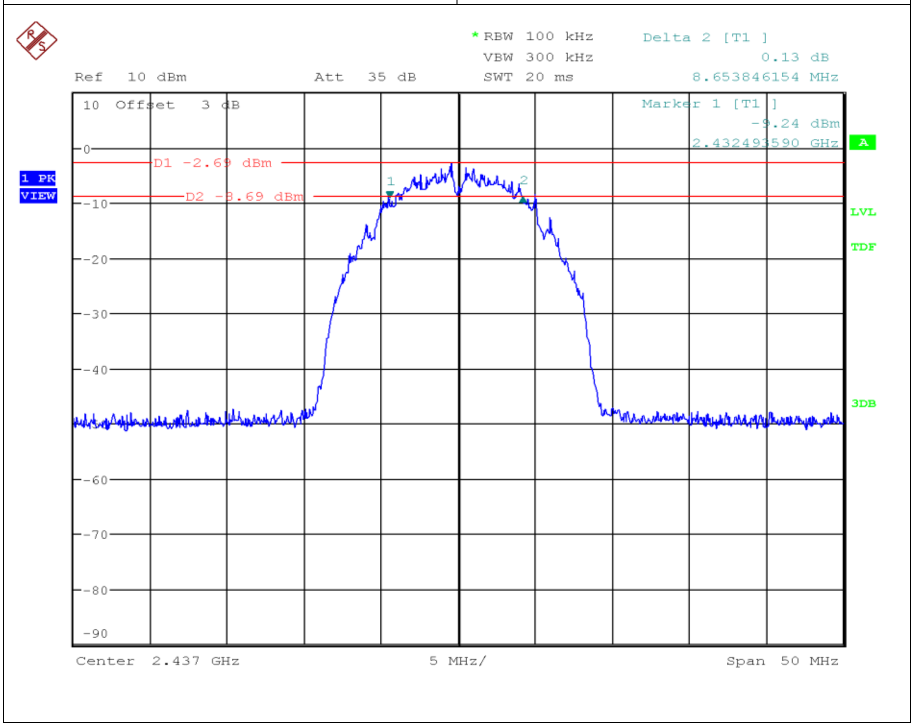
Test Mode	Test Frequency	6 dB Bandwidth (MHz)	Occupied Bandwidth (MHz)
802.11b	Low	9.455	13.000
	Middle	8.654	12.950
	High	9.776	13.000
802.11g	Low	16.346	16.500
	Middle	16.346	16.500
	High	16.346	16.500
802.11n_HT20	Low	16.971	17.350
	Middle	17.051	17.350
	High	16.987	17.350
802.11n_HT40	Low	34.936	35.700
	Middle	35.256	35.700
	High	35.096	35.800

6.5 Test Plot

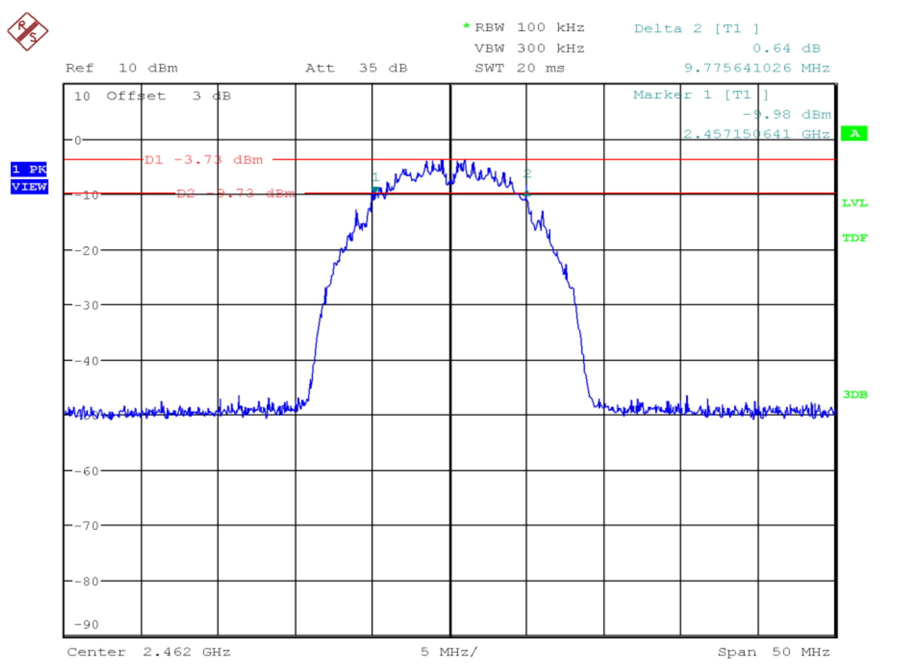
802.11b _ Low frequency	6 dB Bandwidth



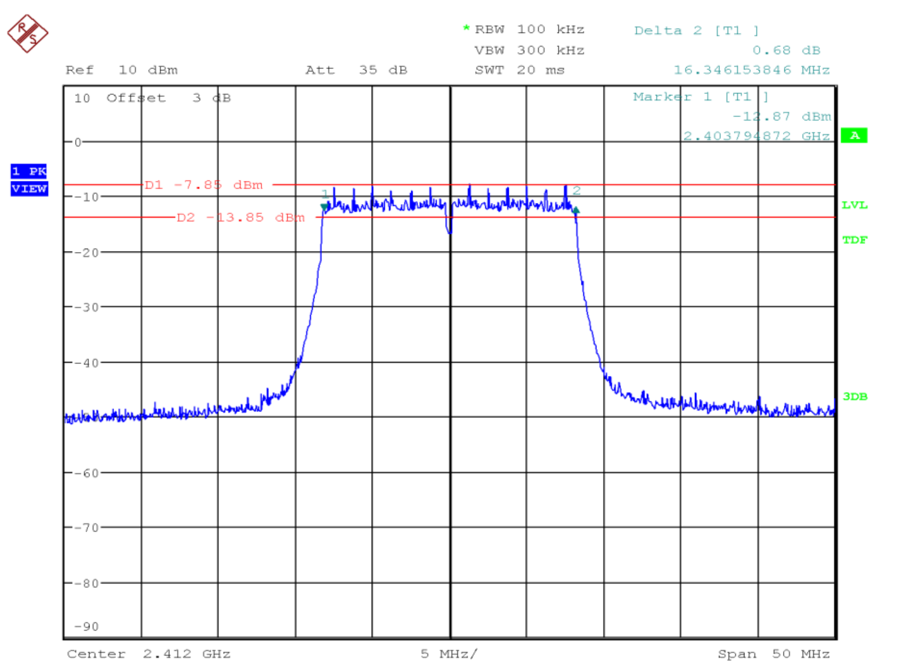
802.11b _ Mid frequency	6 dB Bandwidth



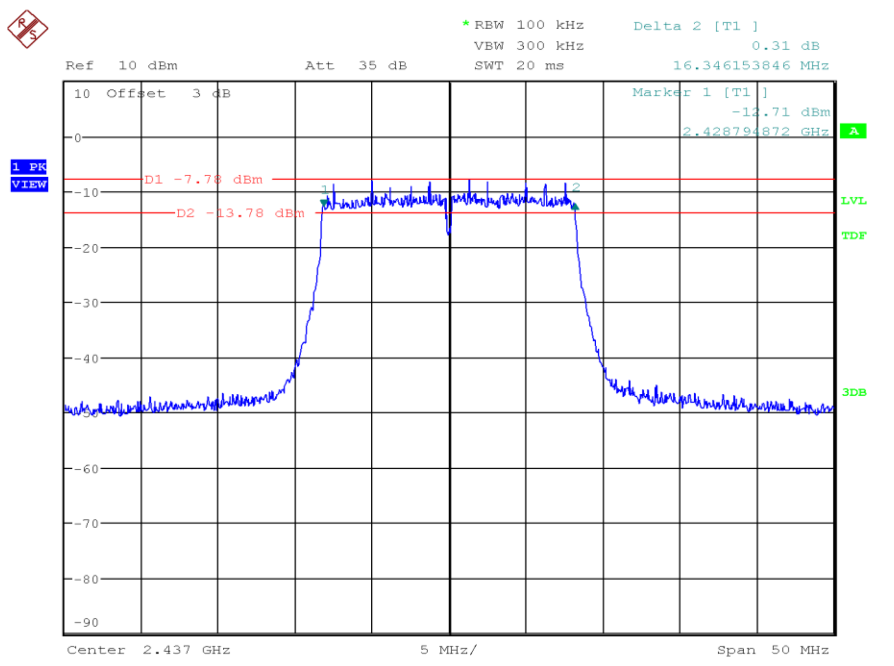
802.11b _ High frequency	6 dB Bandwidth



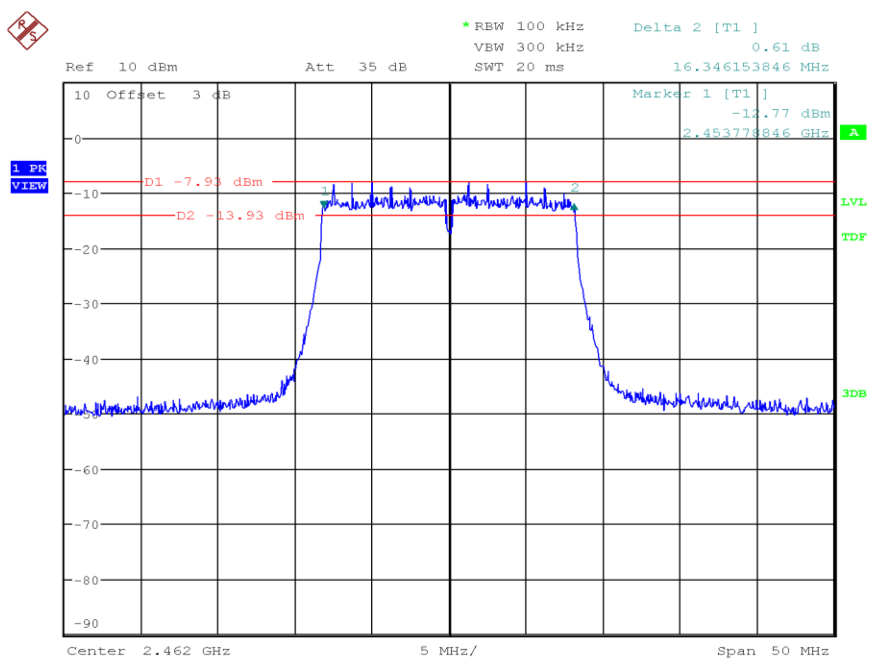
802.11g _ Low frequency	6 dB Bandwidth



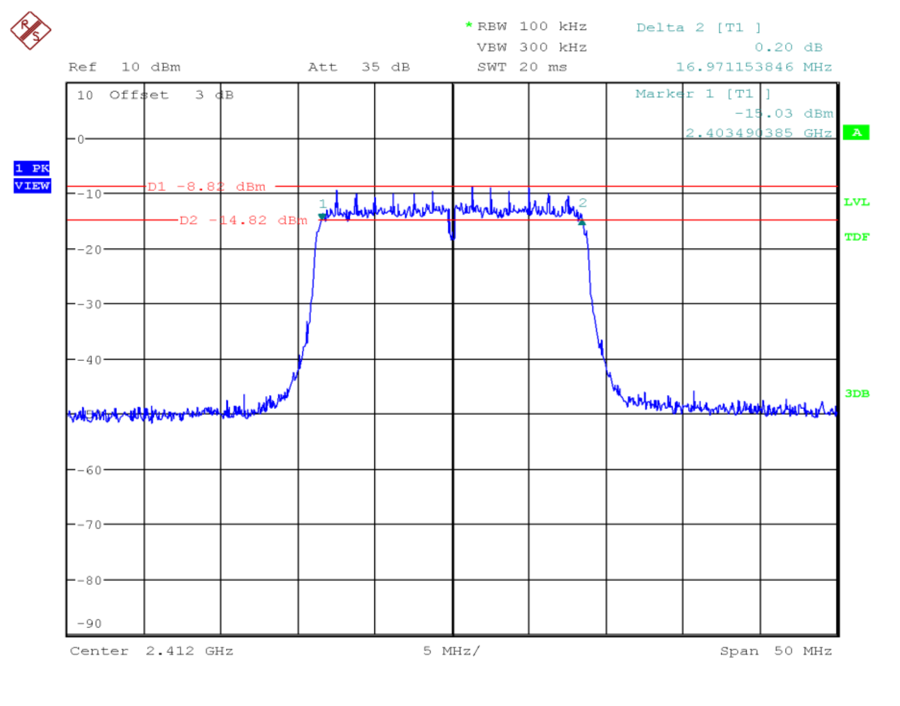
802.11g _ Mid frequency	6 dB Bandwidth



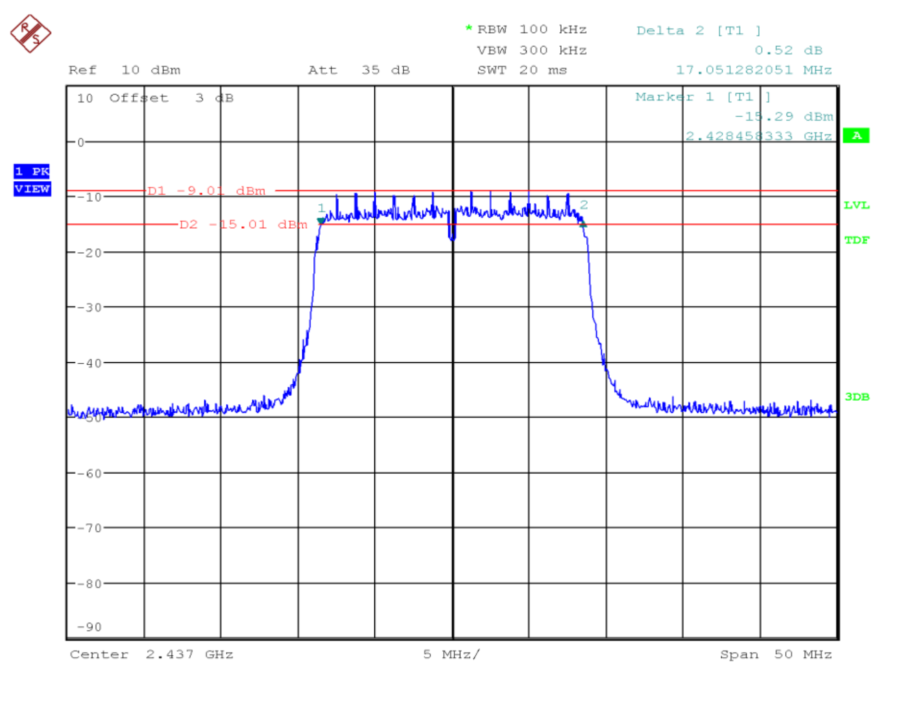
802.11g _ High frequency	6 dB Bandwidth



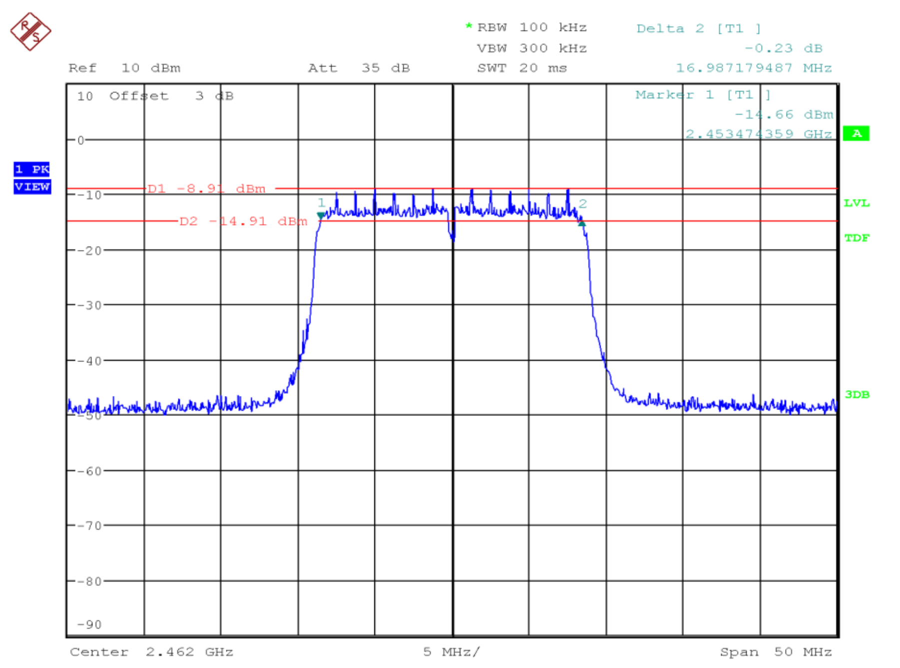
802.11n_HT20 _ Low frequency	6 dB Bandwidth



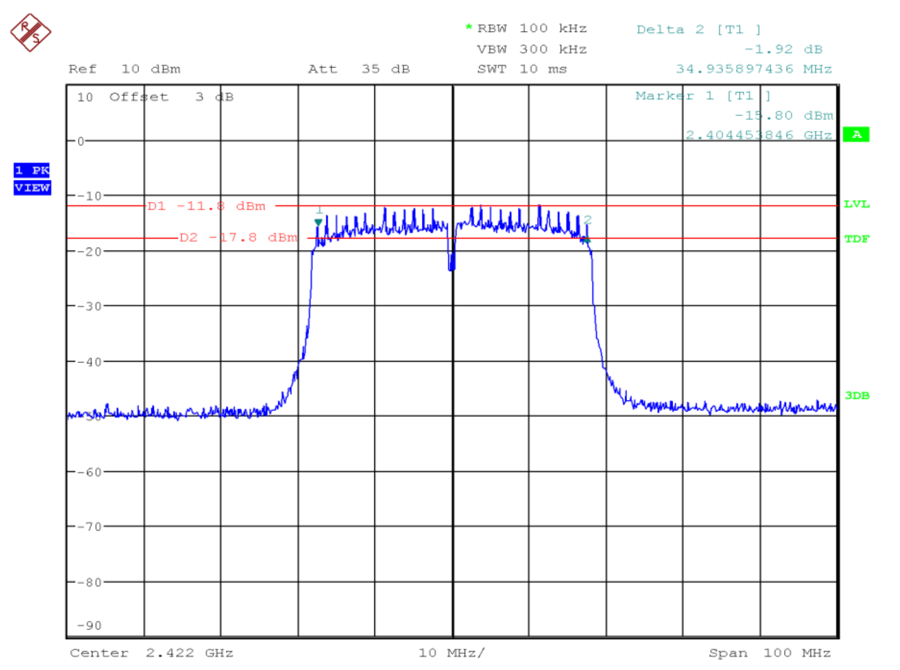
802.11n_HT20 _ Mid frequency	6 dB Bandwidth



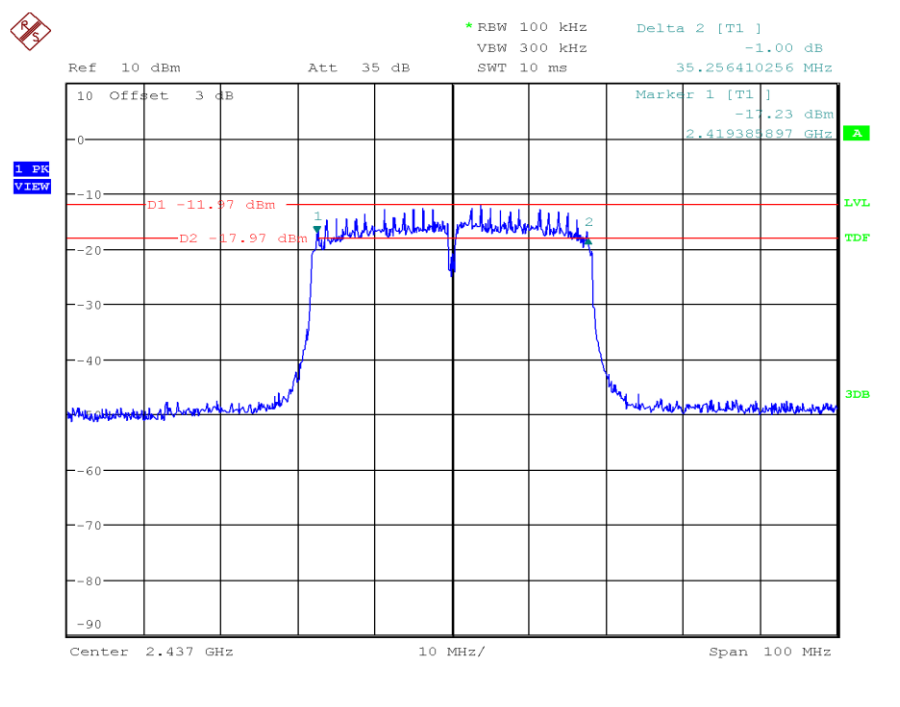
802.11n_HT20 _ High frequency	6 dB Bandwidth



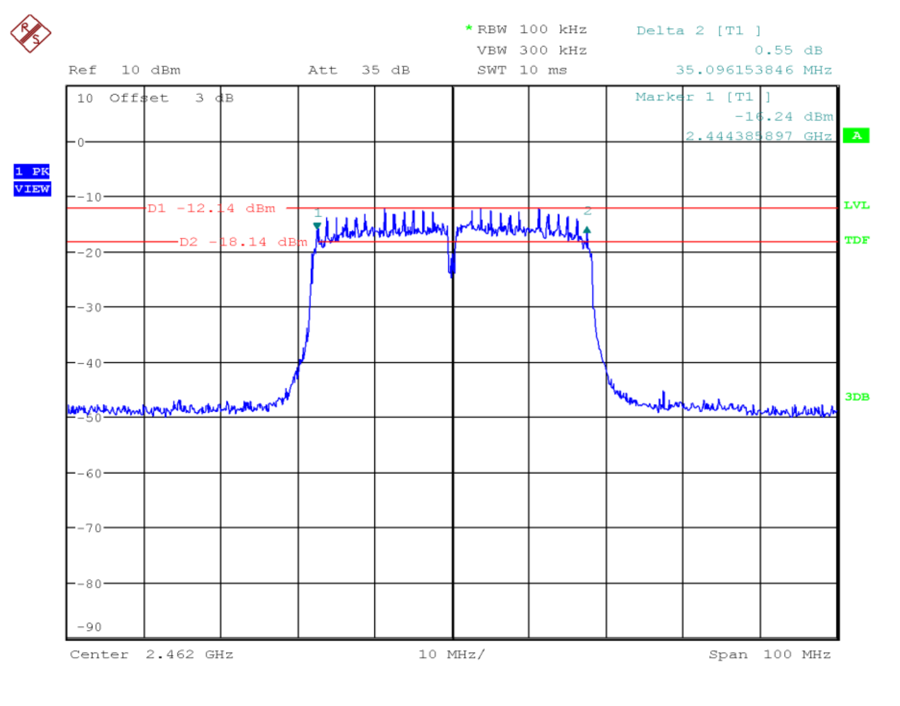
802.11n_HT40 _ Low frequency	6 dB Bandwidth



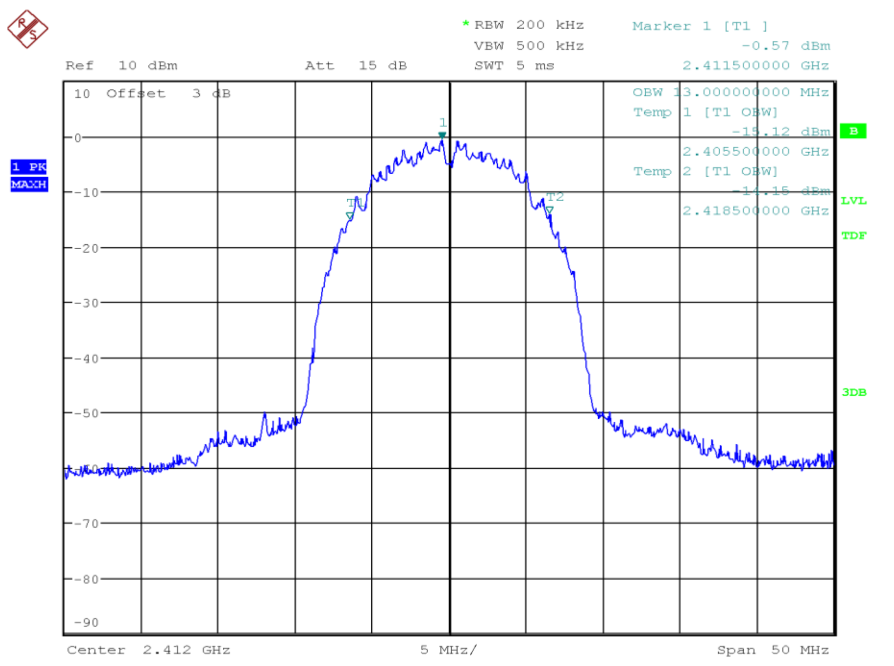
802.11n_HT40 _ Mid frequency	6 dB Bandwidth



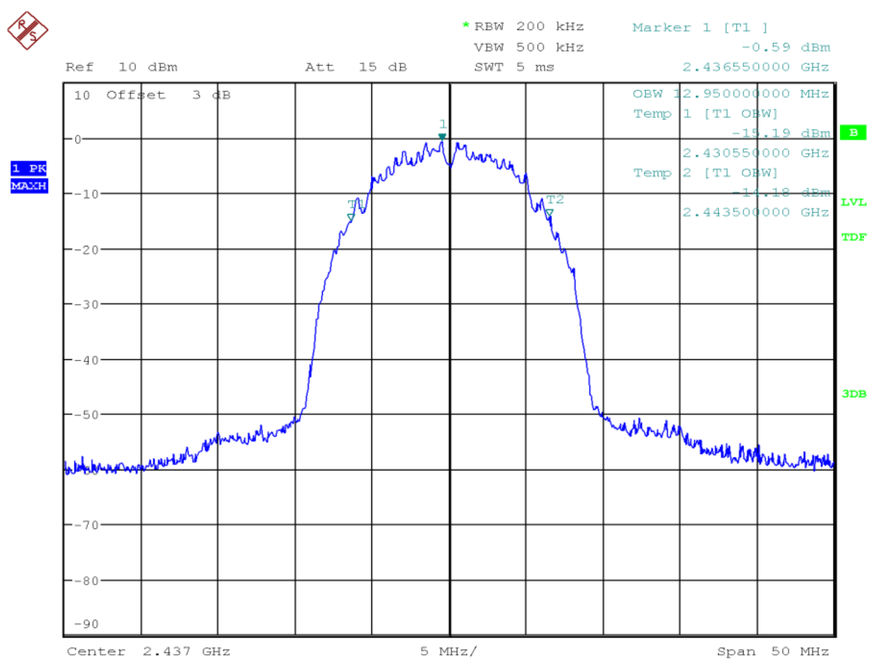
802.11n_HT40 _ High frequency	6 dB Bandwidth



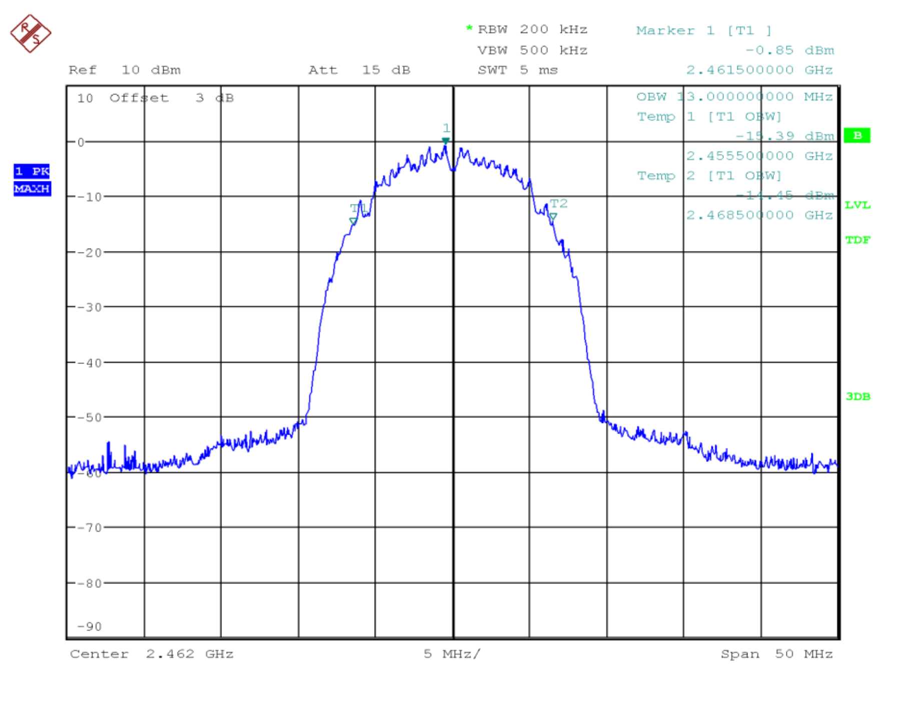
802.11b _ Low frequency	Occupied Bandwidth



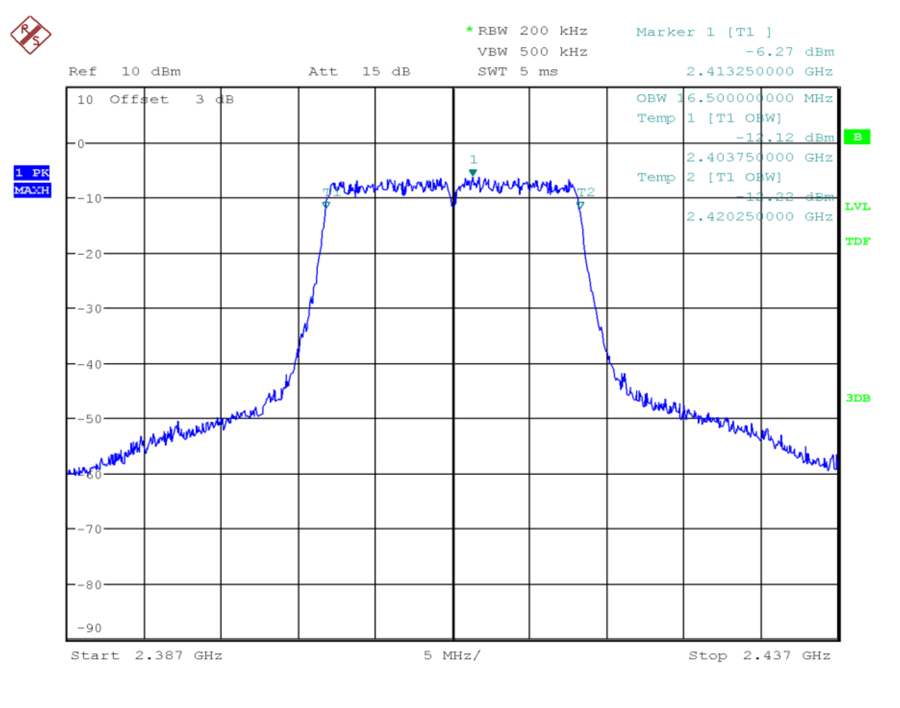
802.11b _ Mid frequency	Occupied Bandwidth



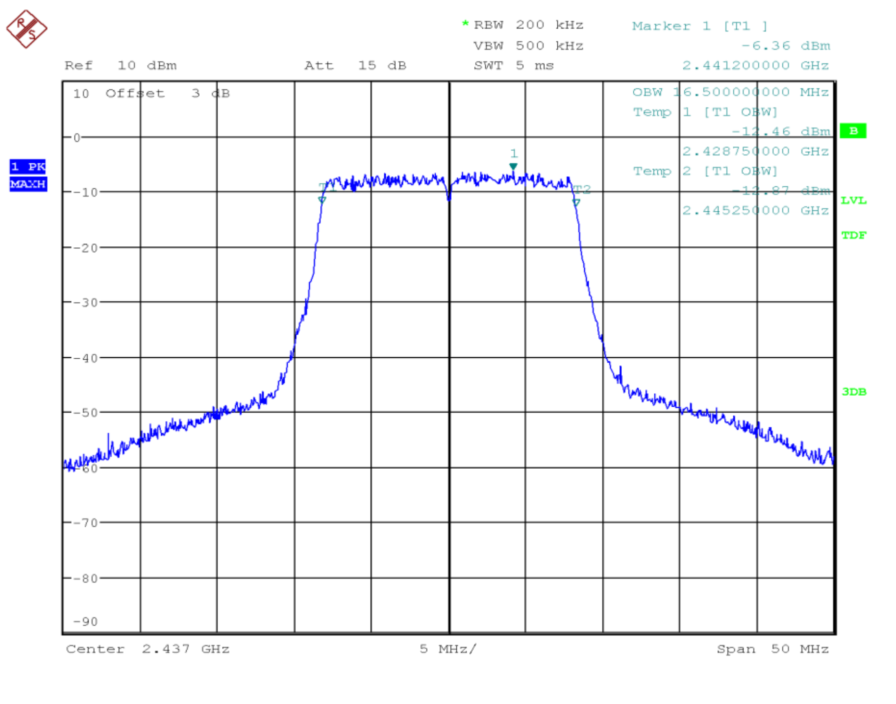
802.11b _ High frequency	Occupied Bandwidth



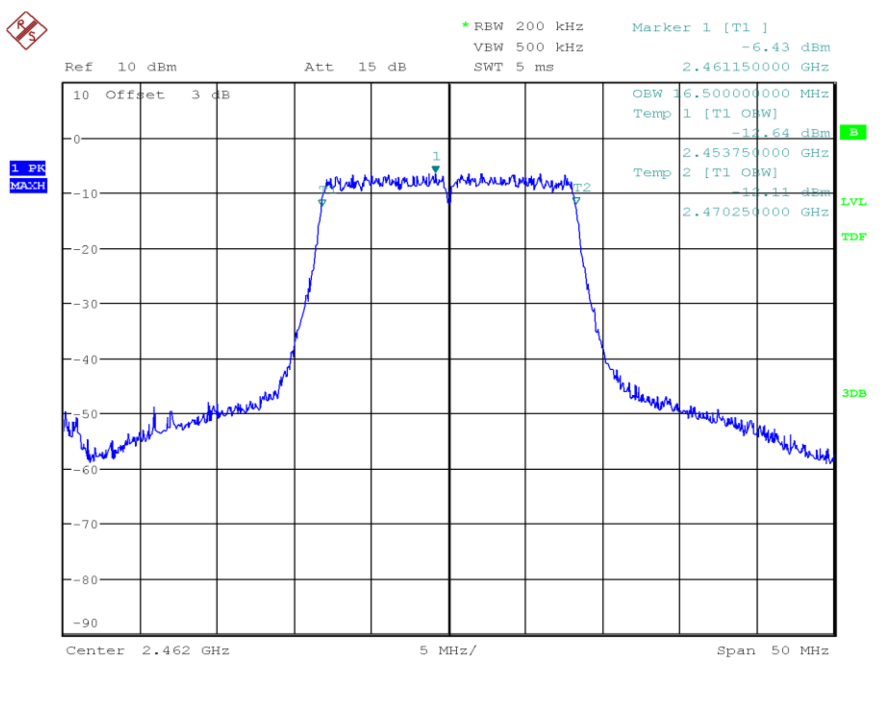
802.11g _ Low frequency	Occupied Bandwidth



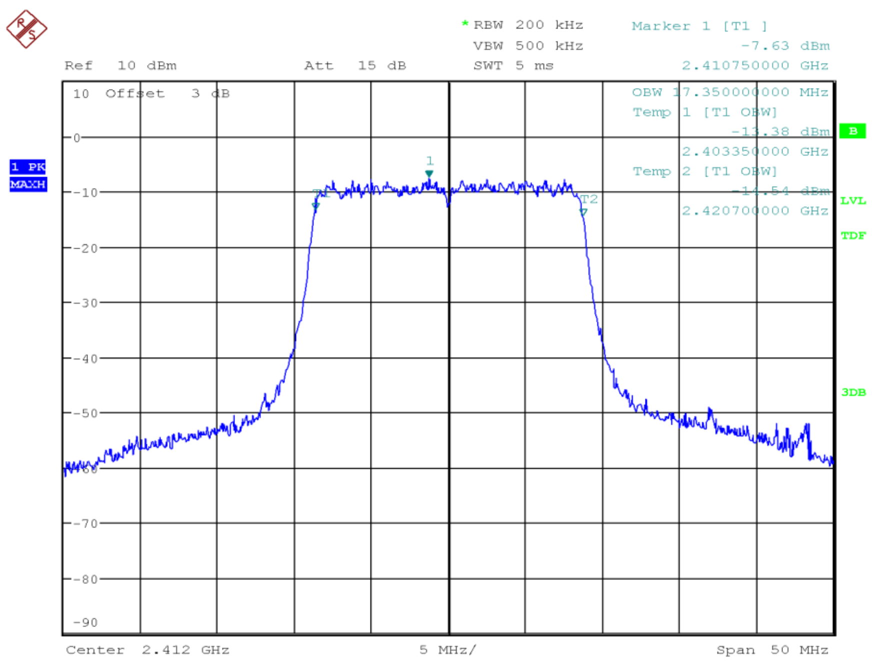
802.11g _ Mid frequency	Occupied Bandwidth



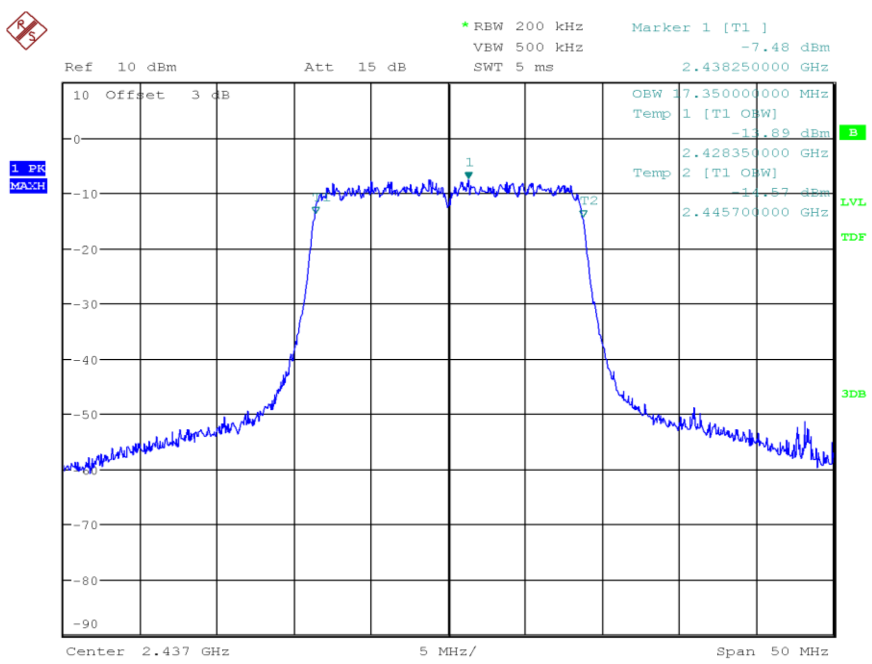
802.11g _ High frequency	Occupied Bandwidth



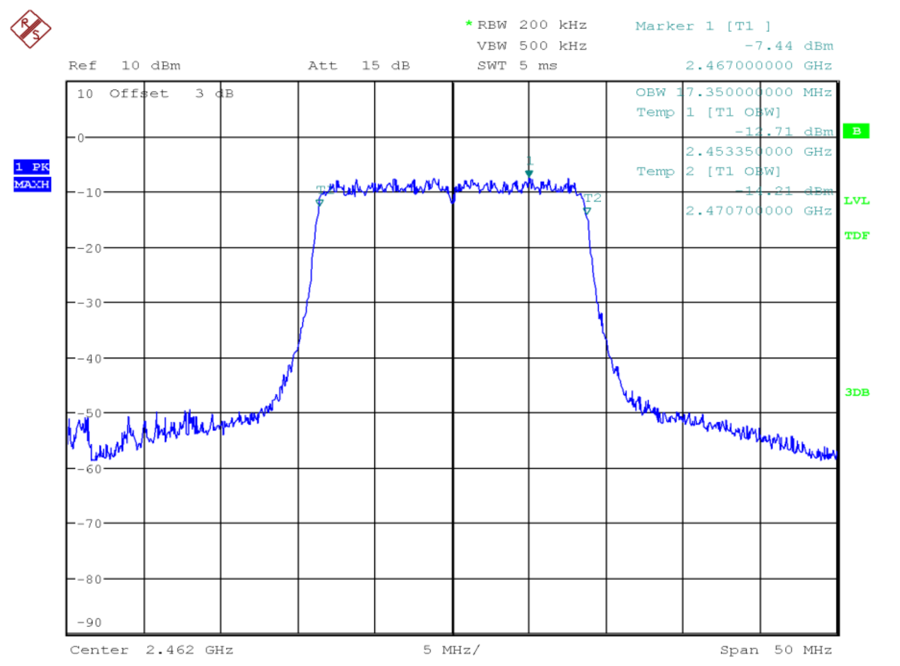
802.11n_HT20 _ Low frequency	Occupied Bandwidth



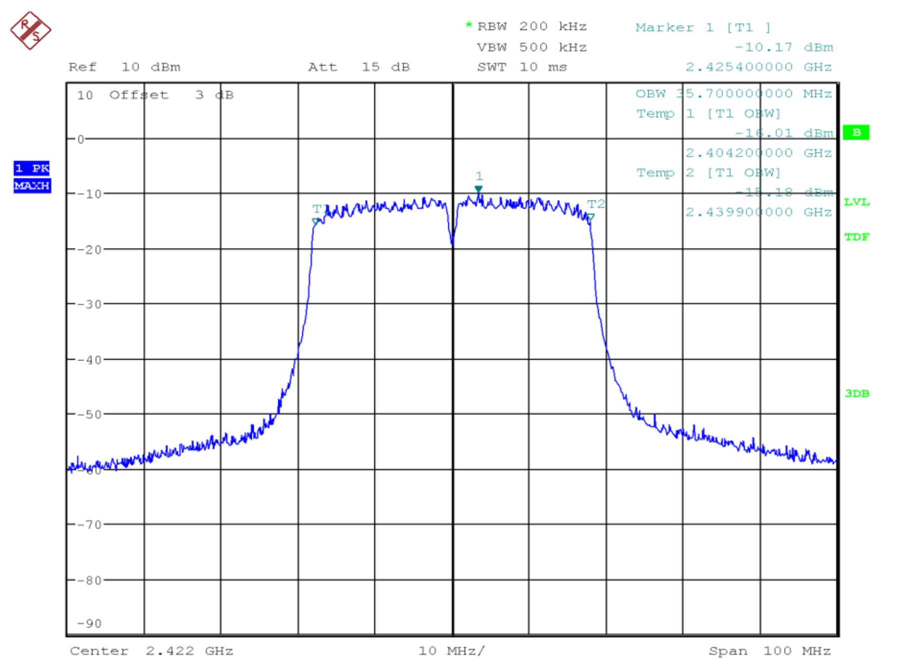
802.11n_HT20 _ Mid frequency	Occupied Bandwidth



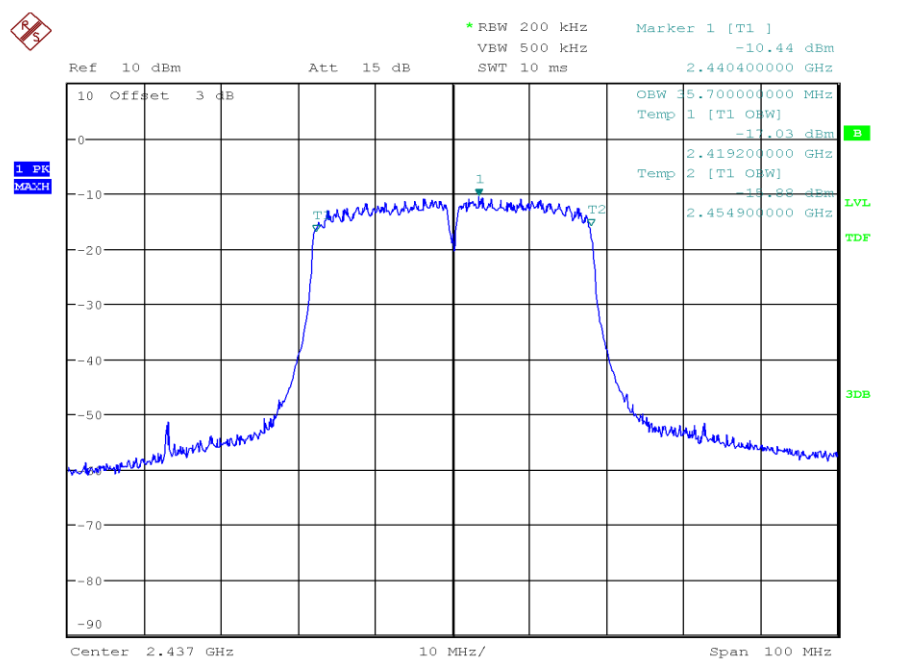
802.11n_HT20 _ High frequency	Occupied Bandwidth



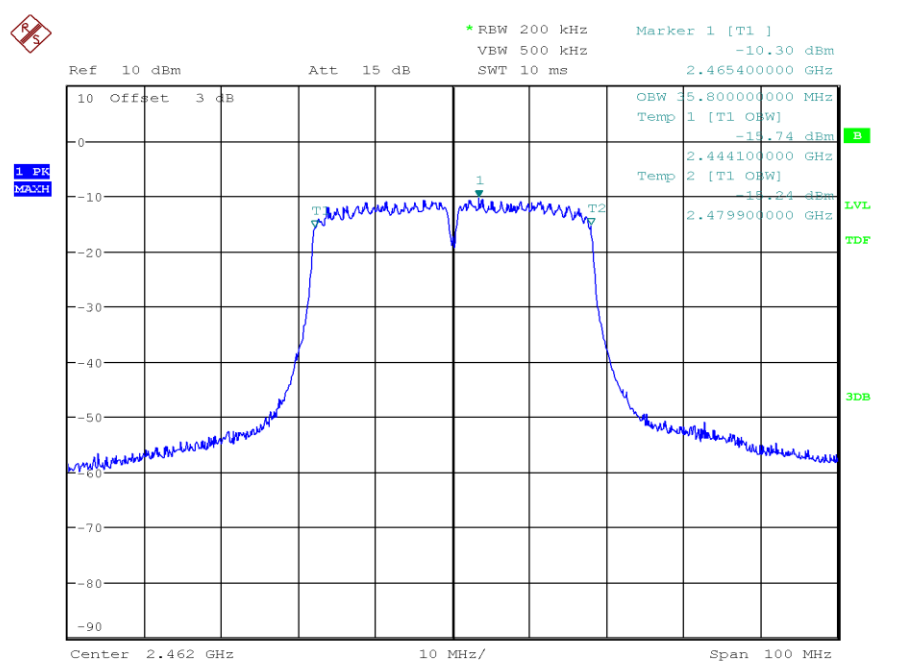
802.11n_HT40 _ Low frequency	Occupied Bandwidth



802.11n_HT40 _ Mid frequency	Occupied Bandwidth



802.11n_HT40 _ High frequency	Occupied Bandwidth



7. Maximum Conducted Output Power

7.1 Test Setup

Refer to the APPENDIX I.

7.2 Limit

The maximum permissible conducted output power is 1 Watt.

7.3 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 1MHz.
4. Set VBW ≥ 3 x RBW
5. Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ 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 dB if the duty cycle is 25%.

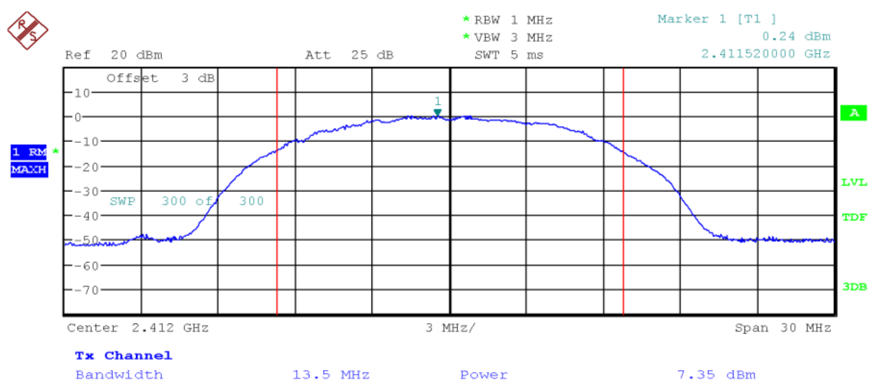
7.4 Test Result

Test Mode	Test Frequency	Maximum Conducted Output Power			
		Reading	C.F	Test Result	
		(dBm)	(dB)	(dBm)	(mW)
802.11b	Low	7.35	0.00	7.35	5.43
	Middle	7.44	0.00	7.44	5.55
	High	7.18	0.00	7.18	5.22
802.11g	Low	5.61	0.04	5.65	3.68
	Middle	5.65	0.04	5.69	3.71
	High	5.42	0.04	5.46	3.52
802.11n_HT20	Low	3.28	0.03	3.31	2.14
	Middle	3.35	0.03	3.38	2.18
	High	3.15	0.03	3.18	2.08
802.11n_HT40	Low	3.97	0.06	4.03	2.53
	Middle	3.68	0.06	3.74	2.36
	High	3.87	0.06	3.93	2.47

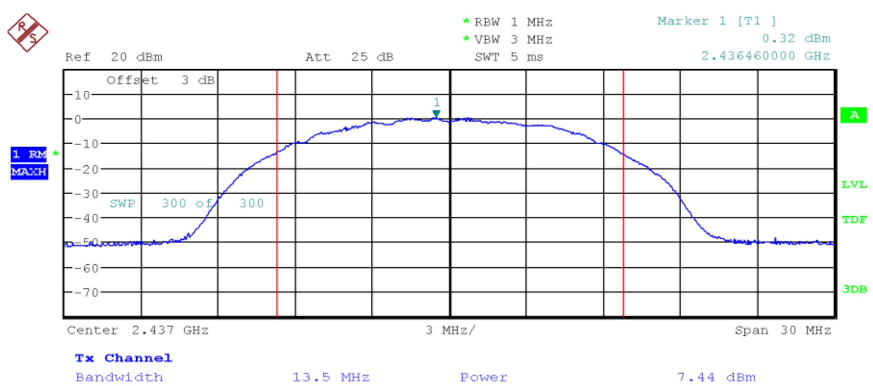
Note 1: C.F(Correction Factor)
Correction Factor = DCCF
For DCCF(Duty Cycle Correction Factor) please refer to appendix III.
Note 2: Sample Calculation.
Test Result = Reading + C.F

7.5 Test Plot

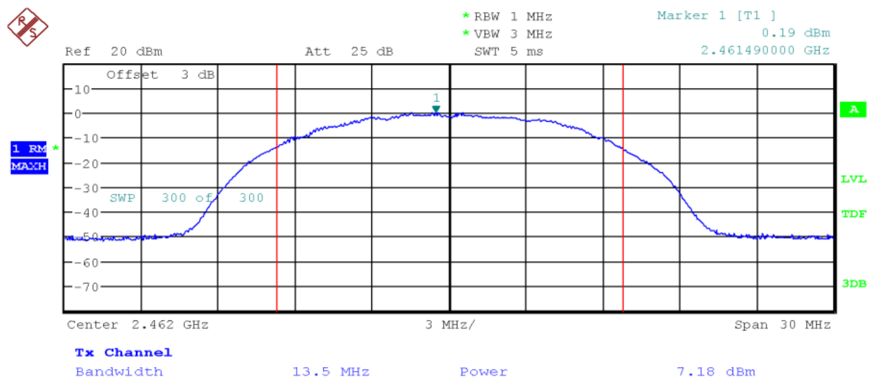
802.11b _ Low frequency	Maximum Conducted Output Power



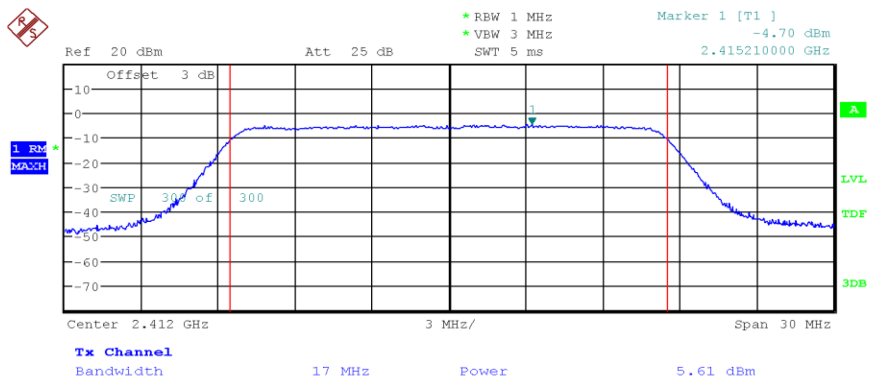
802.11b _ Middle frequency	Maximum Conducted Output Power



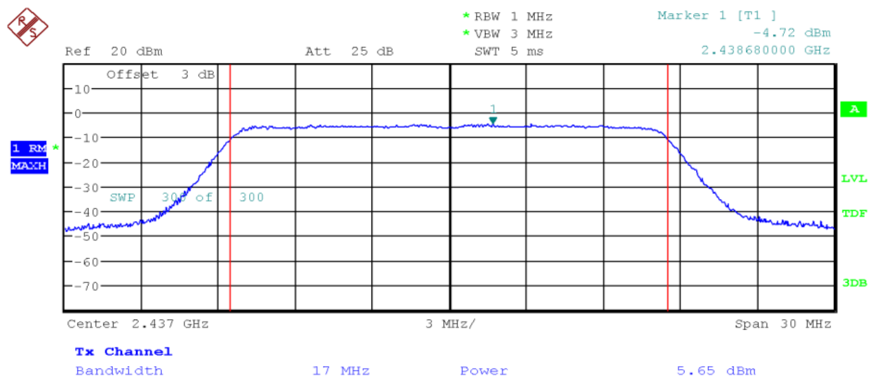
802.11b _ High frequency	Maximum Conducted Output Power



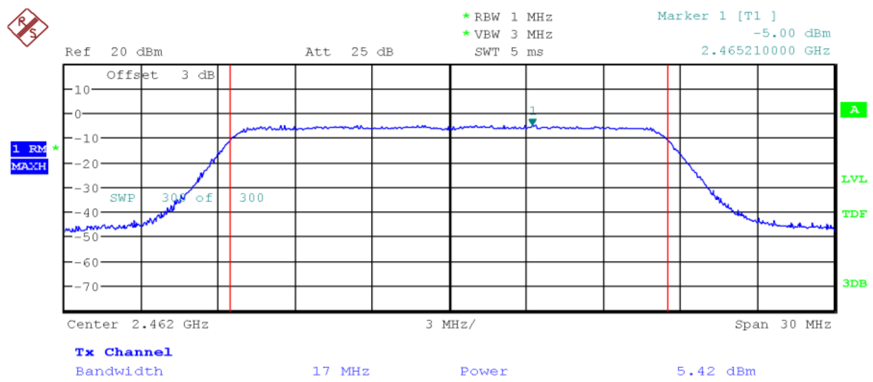
802.11g _ Low frequency	Maximum Conducted Output Power



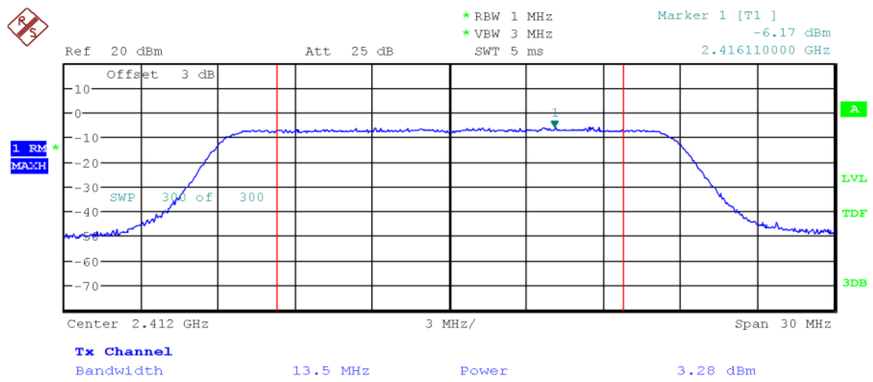
802.11g _ Mid frequency	Maximum Conducted Output Power



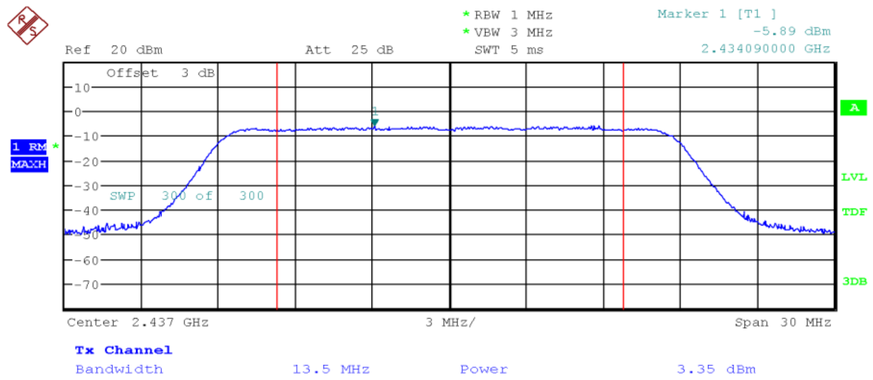
802.11g _ High frequency	Maximum Conducted Output Power



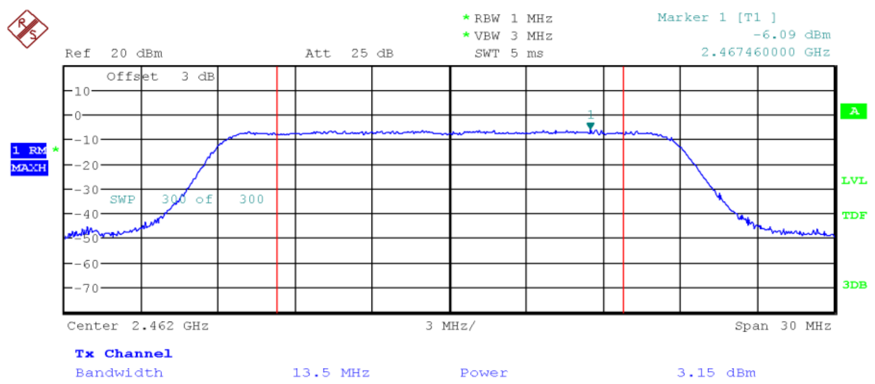
802.11n_HT20 _ Low frequency	Maximum Conducted Output Power



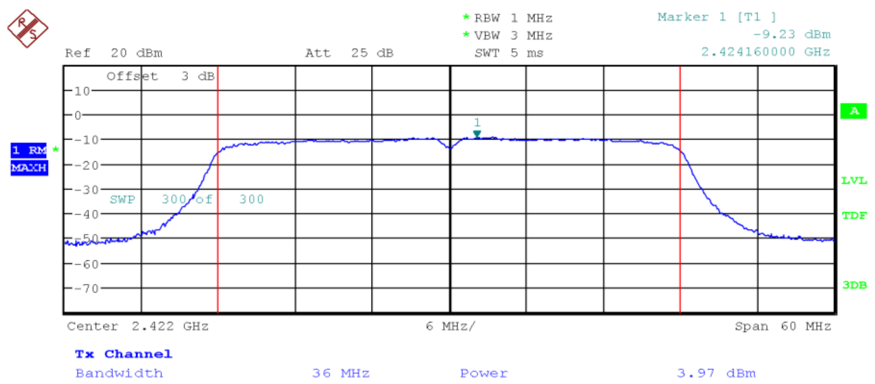
802.11n_HT20 _ Mid frequency	Maximum Conducted Output Power



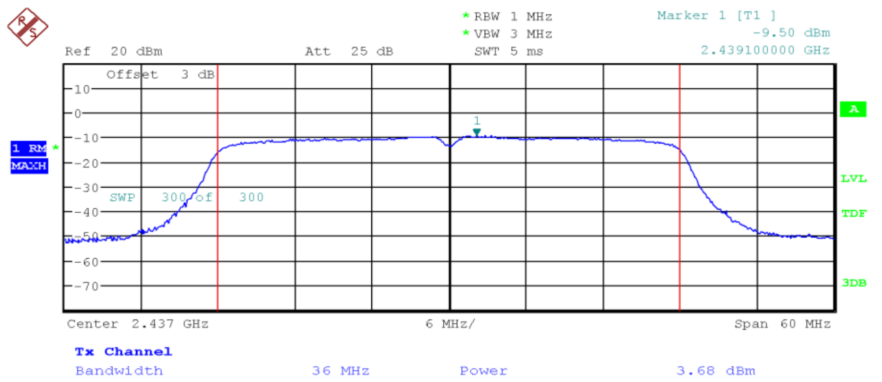
802.11n_HT20 _ High frequency	Maximum Conducted Output Power



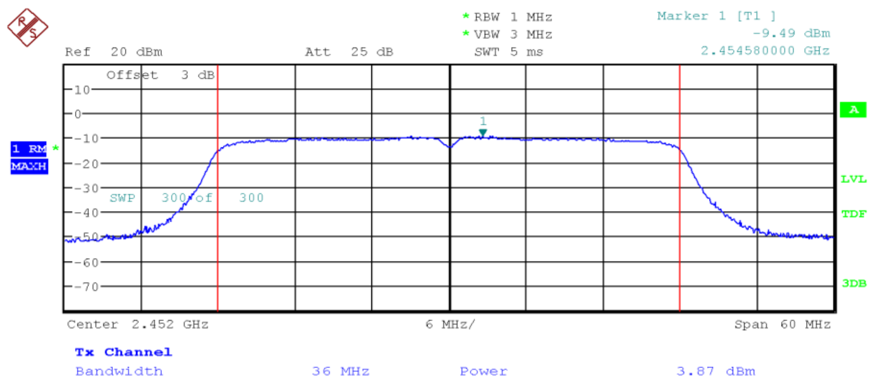
802.11n_HT40 _ Low frequency	Maximum Conducted Output Power



802.11n_HT40 _ Mid frequency	Maximum Conducted Output Power



802.11n_HT40 _ High frequency	Maximum Conducted Output Power



8. Peak Power Spectral Density

8.1 Test Setup

Refer to the APPENDIX I.

8.2 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

8.3 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.

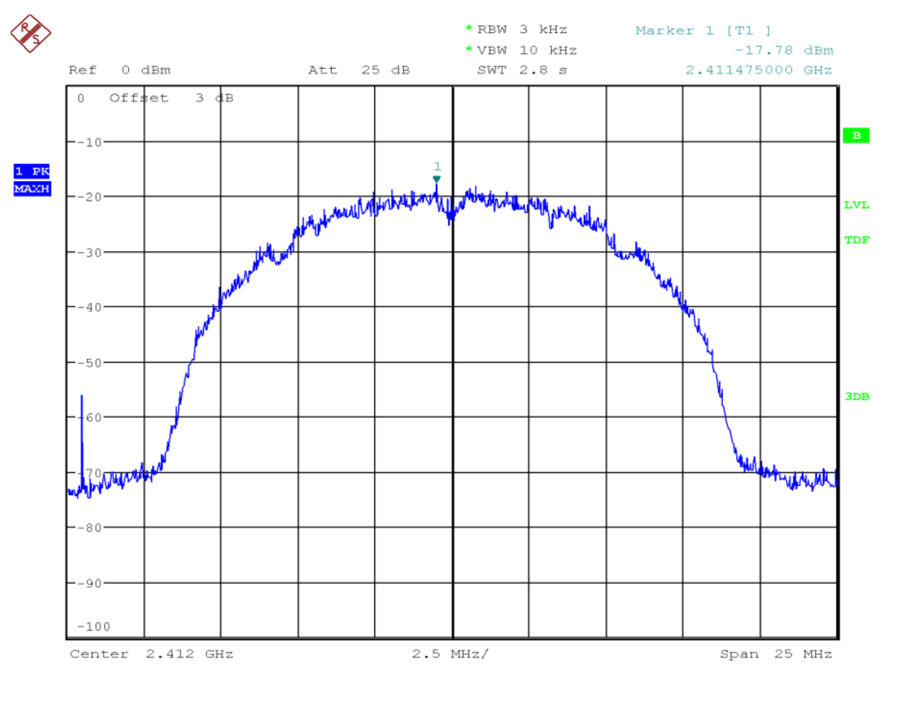
(ANSI C63.10-2013 _ Section 11.10.2 – Method PKPSD)
1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS bandwidth.
3. Set the RBW : 3 kHz ≤ RBW ≤ 100 kHz.
4. Set the VBW ≥ 3 x RBW.
5. Detector = Peak.
6. Sweep time = Auto
7. Trace mode = Max Hold.
8. 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.

8.4 Test Result

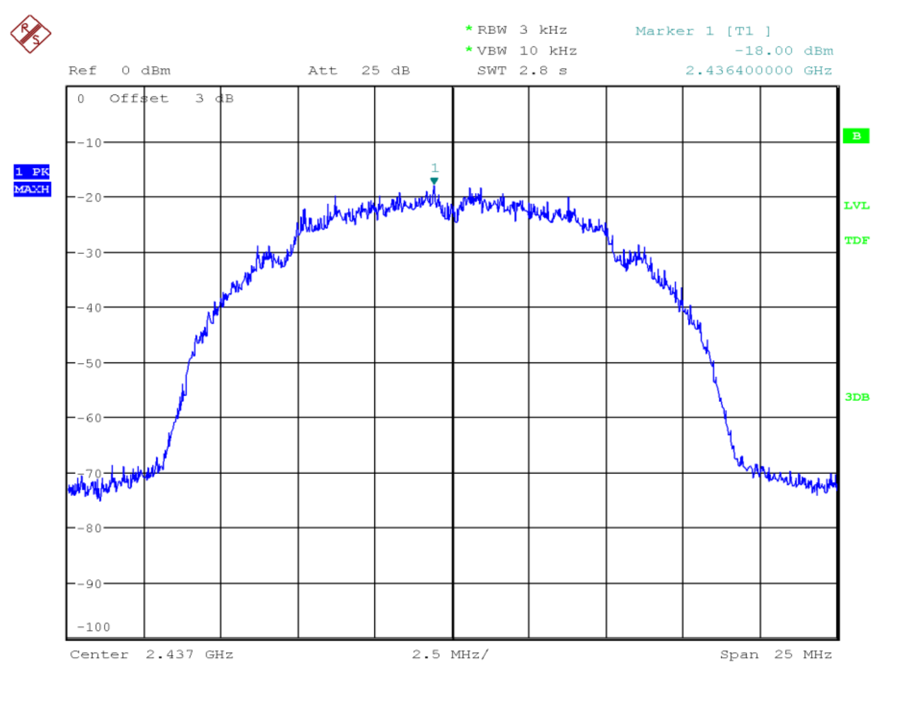
Test Mode	Test Frequency	Peak Power Spectral Density (dBm)
802.11b	Low	-17.78
	Middle	-18.00
	High	-18.45
802.11g	Low	-21.74
	Middle	-21.54
	High	-22.17
802.11n_HT20	Low	-22.74
	Middle	-22.33
	High	-22.25
802.11n_HT40	Low	-24.67
	Middle	-24.82
	High	-24.49

8.5 Test Plot

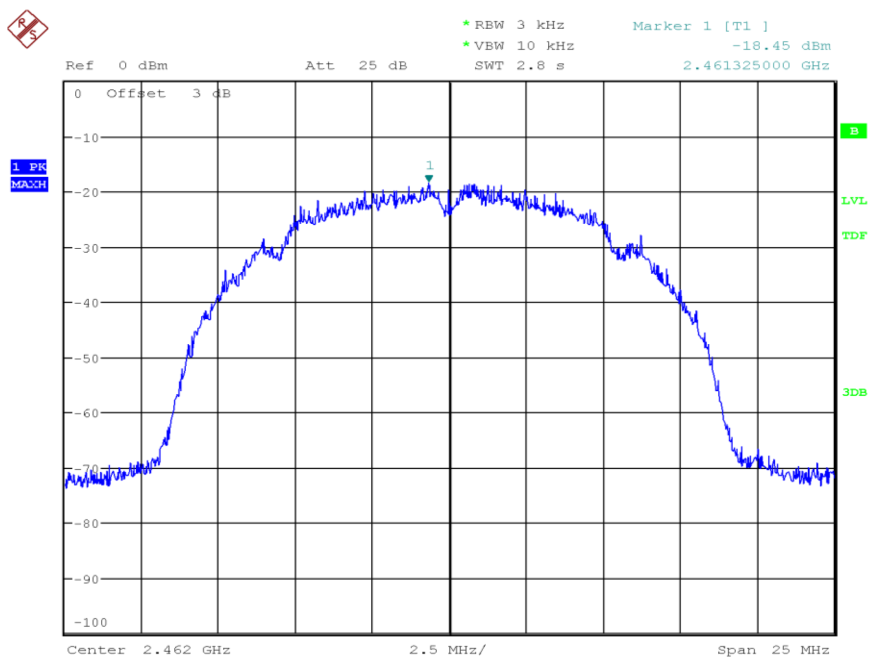
802.11b _ Low frequency	Peak Power Spectral Density



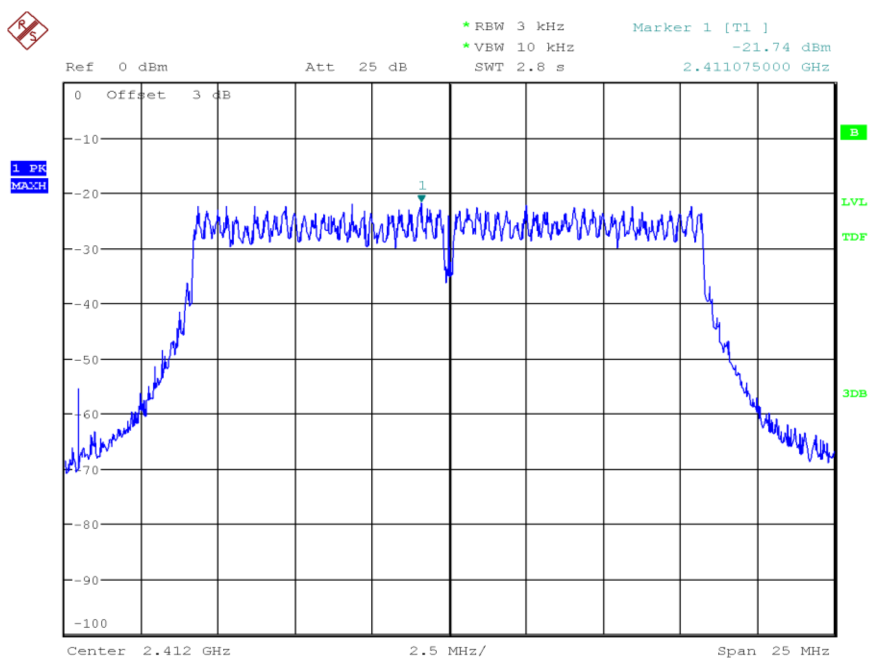
802.11b _ Middle frequency	Peak Power Spectral Density



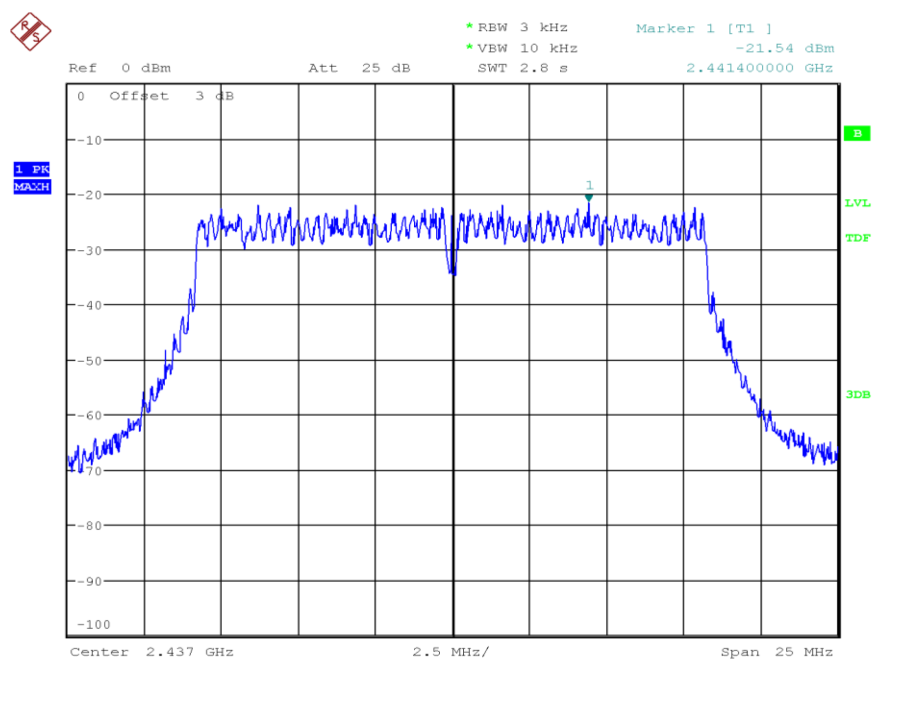
802.11b _ High frequency	Peak Power Spectral Density



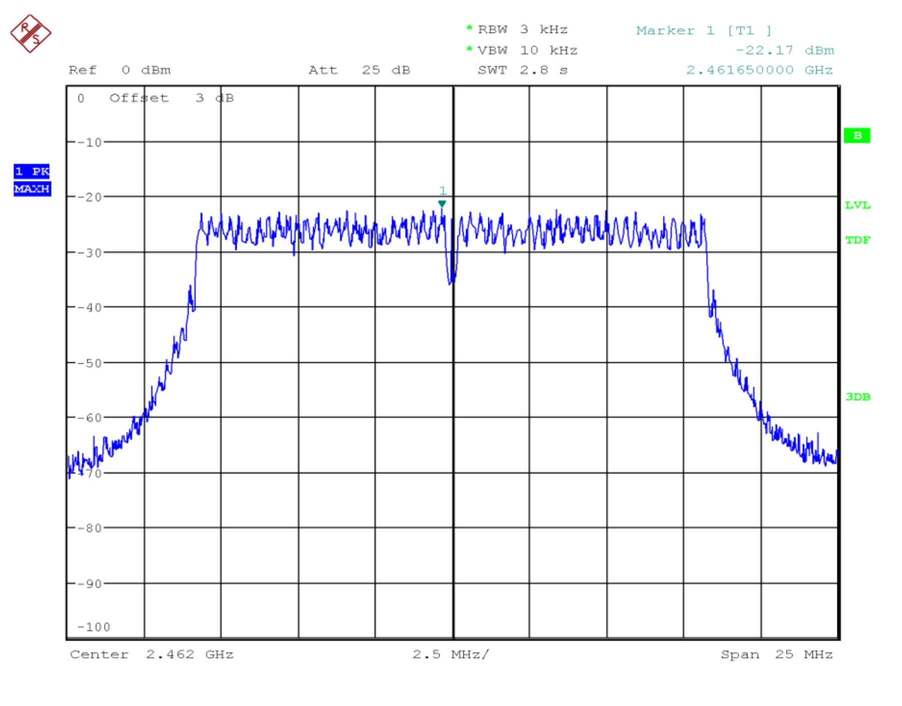
802.11g _ Low frequency	Peak Power Spectral Density



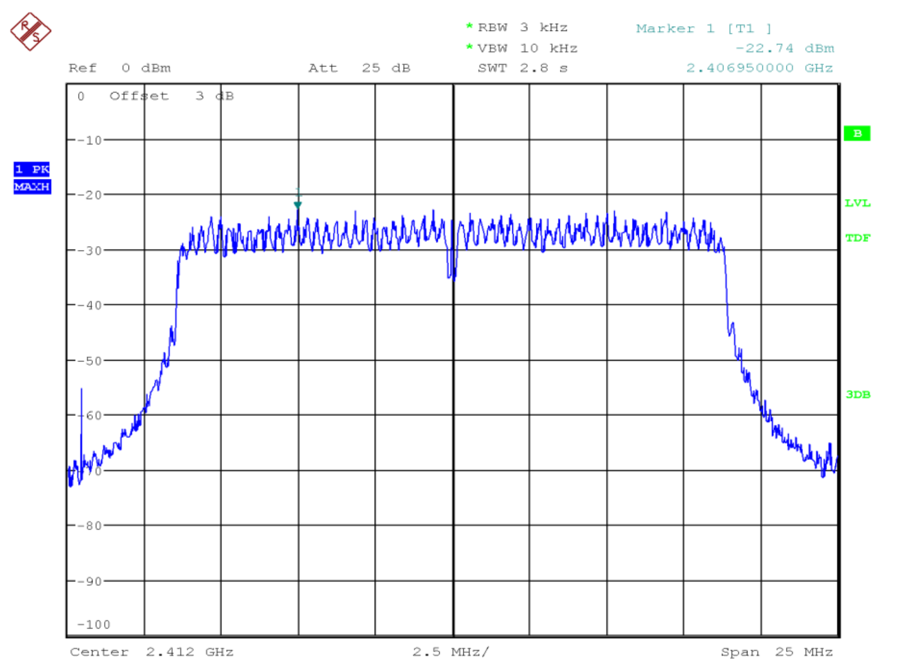
802.11g _ Mid frequency	Peak Power Spectral Density



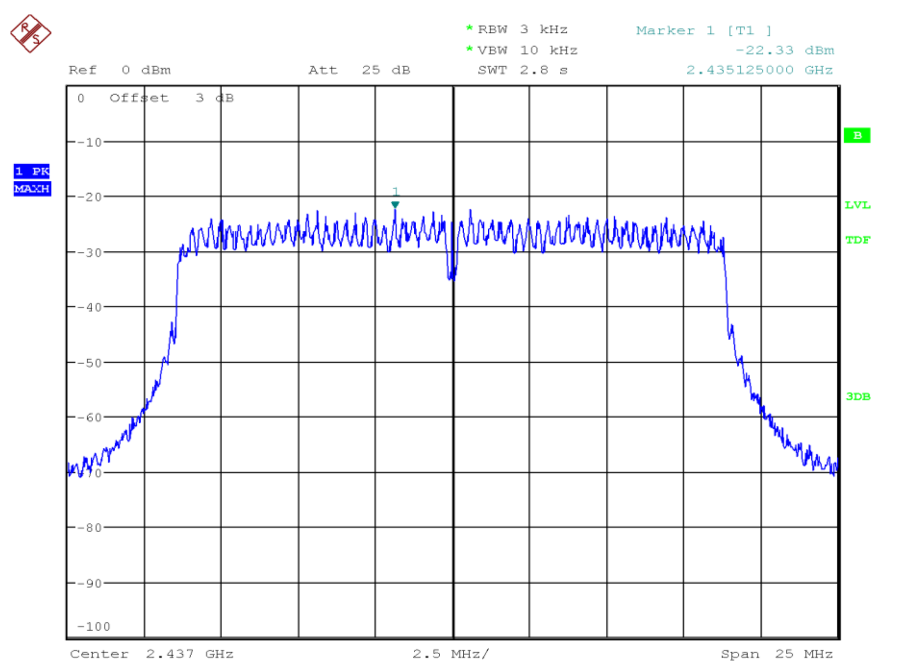
802.11g _ High frequency	Peak Power Spectral Density



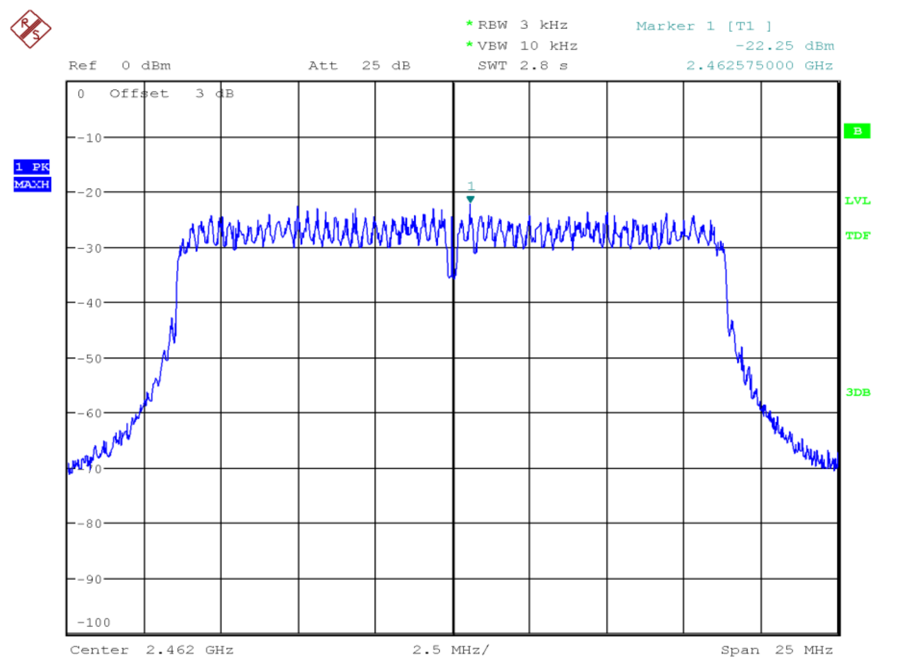
802.11n_HT20 _ Low frequency	Peak Power Spectral Density



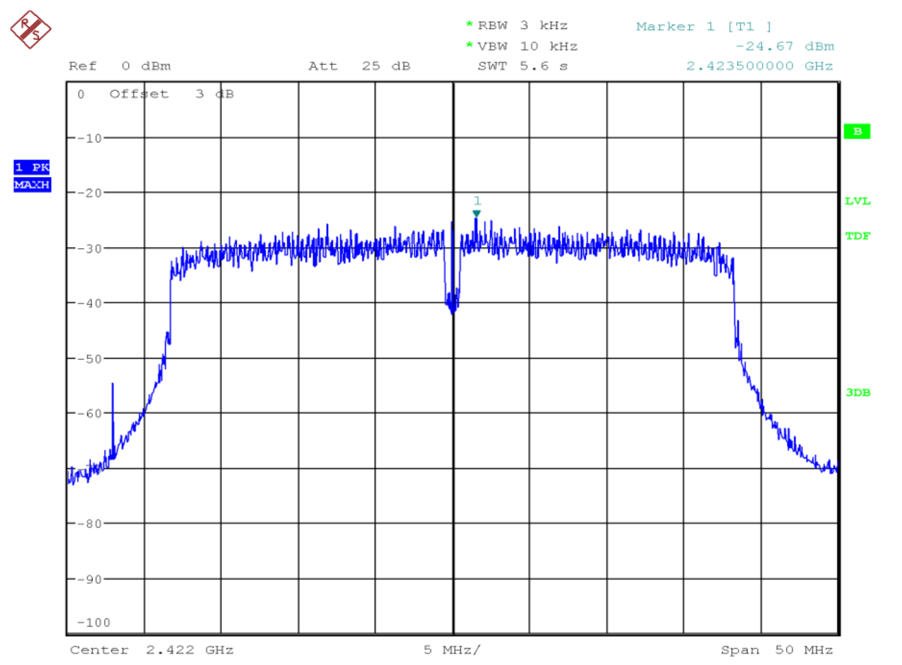
802.11n_HT20 _ Mid frequency	Peak Power Spectral Density



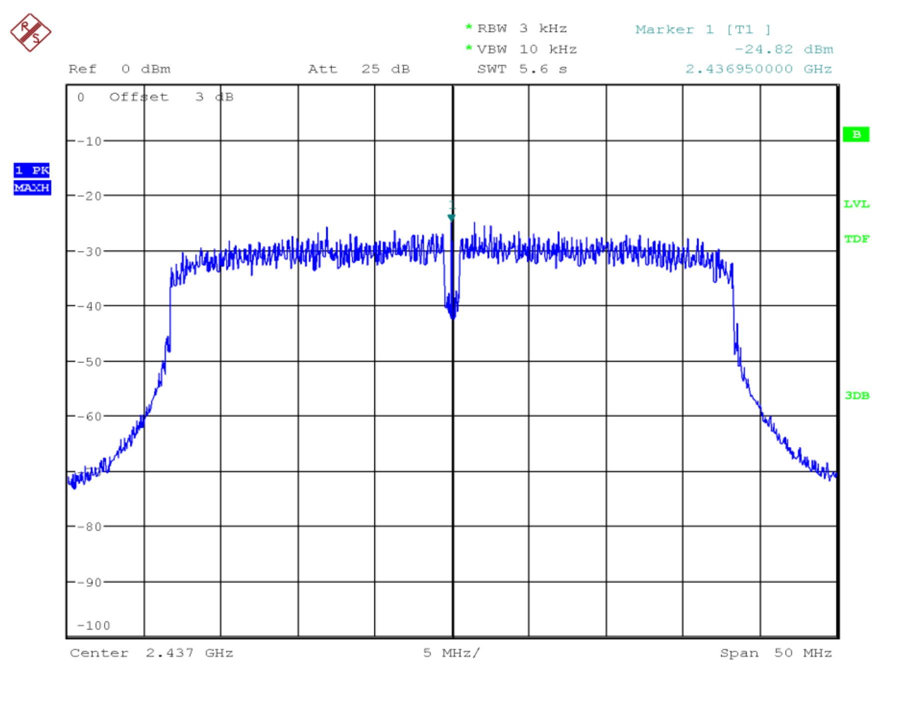
802.11n_HT20 _ High frequency	Peak Power Spectral Density



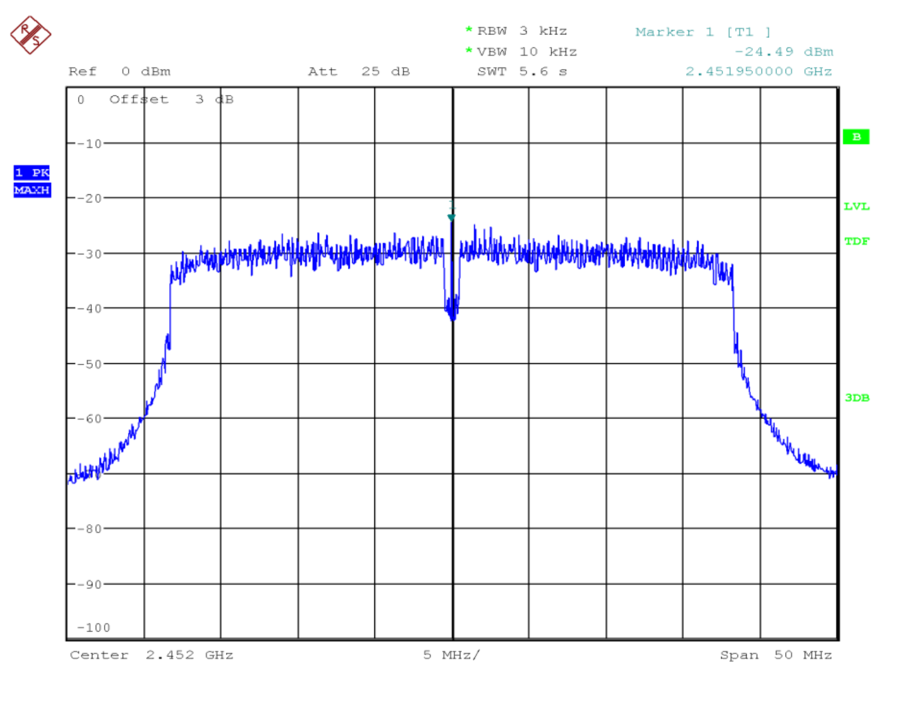
802.11n_HT40 _ Low frequency	Peak Power Spectral Density



802.11n_HT40 _ Mid frequency	Peak Power Spectral Density



802.11n_HT40 _ High frequency	Peak Power Spectral Density



9. TX Radiated Spurious Emission and Conducted Spurious Emission

9.1 Test Setup

Refer to the APPENDIX I.

9.2 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.

9.3 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 3.75 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 ≥ 2 x Span / 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 tuning on and off with the transmit cycle, then no duty cycle correction is required for that emission.

9.4 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)

9.5 Test Result

9 kHz ~ 25 GHz Data for 802.11b

- Low frequency

Frequency	Reading		Pol.	T.F	DCCF	Limits		Result		Margin	
	(dBuV/m)			(dB)	(dB)	(dBuV/m)		(dBuV/m)		(dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 374.46	15.83	27.44	H	9.78	0.00	54.0	74.0	25.6	37.2	28.4	36.8

- Middle frequency

Frequency	Reading		Pol.	T.F	DCCF	Limits		Result		Margin	
	(dBuV/m)			(dB)	(dB)	(dBuV/m)		(dBuV/m)		(dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	

- High frequency

Frequency	Reading		Pol.	T.F	DCCF	Limits		Result		Margin	
	(dBuV/m)			(dB)	(dB)	(dBuV/m)		(dBuV/m)		(dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 488.19	17.69	28.91	H	10.61	0.00	54.0	74.0	28.3	39.5	25.7	34.5

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 + DCF
TF = Ant factor + Cable Loss + Filter Loss – Amp Gain + Distance Factor
Distance Factor = 20log(applied distance/required distance) = 20log(3.75m/3m) = 1.94

9 kHz ~ 25 GHz Data for 802.11g

- Low frequency

Frequency	Reading (dBuV/m)		Pol.	T.F (dB)	DCCF (dB)	Limits (dBuV/m)		Result (dBuV/m)		Margin (dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 360.55	15.94	27.22	H	9.78	0.04	54.0	74.0	25.8	37.0	28.2	37.0

- Middle frequency

Frequency	Reading (dBuV/m)		Pol.	T.F (dB)	DCCF (dB)	Limits (dBuV/m)		Result (dBuV/m)		Margin (dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	

- High frequency

Frequency	Reading (dBuV/m)		Pol.	T.F (dB)	DCCF (dB)	Limits (dBuV/m)		Result (dBuV/m)		Margin (dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 493.32	17.72	30.72	H	10.61	0.04	54.0	74.0	28.4	41.3	25.6	32.7

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 + DCF
TF = Ant factor + Cable Loss + Filter Loss – Amp Gain + Distance Factor
Distance Factor = 20log(applied distance/required distance) = 20log(3.75m/3m) = 1.94

9 kHz ~ 25 GHz Data for 802.11n_HT20

- Low frequency

Frequency	Reading (dBuV/m)		Pol.	T.F (dB)	DCCF (dB)	Limits (dBuV/m)		Result (dBuV/m)		Margin (dB)	
(MHz)	AV	Peak				AV	Peak	AV	Peak	AV	Peak
2 349.36	15.91	27.55	H	10.38	0.03	54.0	74.0	26.3	37.9	27.7	36.1

- Middle frequency

Frequency	Reading (dBuV/m)		Pol.	T.F (dB)	DCCF (dB)	Limits (dBuV/m)		Result (dBuV/m)		Margin (dB)	
(MHz)	AV	Peak				AV	Peak	AV	Peak	AV	Peak

- High frequency

Frequency	Reading (dBuV/m)		Pol.	T.F (dB)	DCCF (dB)	Limits (dBuV/m)		Result (dBuV/m)		Margin (dB)	
(MHz)	AV	Peak				AV	Peak	AV	Peak	AV	Peak
2 496.98	17.50	29.78	H	10.61	0.03	54.0	74.0	28.1	40.4	25.9	33.6

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 + DCF
TF = Ant factor + Cable Loss + Filter Loss – Amp Gain + Distance Factor
Distance Factor = 20log(applied distance/required distance) = 20log(3.75m/3m) = 1.94

9 kHz ~ 25 GHz Data for 802.11n_HT40

- Low frequency

Frequency	Reading		Pol.	T.F (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 371.02	16.04	27.04	H	9.78	0.06	54.0	74.0	25.9	36.8	28.1	37.2

- Middle frequency

Frequency	Reading		Pol.	T.F (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	

- High frequency

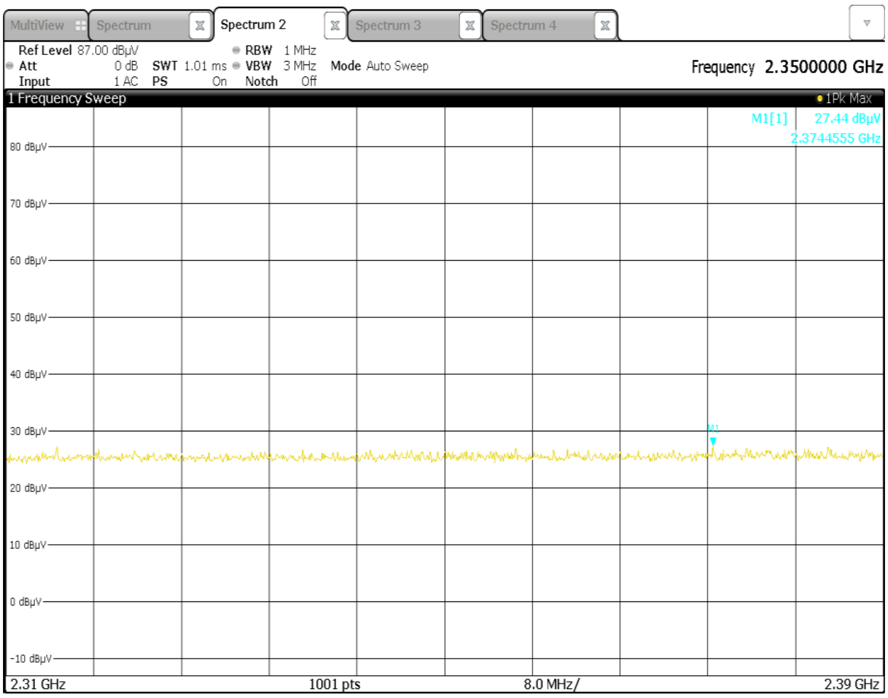
Frequency	Reading		Pol.	T.F (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
(MHz)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 486.48	17.44	29.15	H	10.61	0.06	54.0	74.0	28.1	39.8	25.9	34.2

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 + DCF
TF = Ant factor + Cable Loss + Filter Loss – Amp Gain + Distance Factor
Distance Factor = 20log(applied distance/required distance) = 20log(3.75m/3m) = 1.94

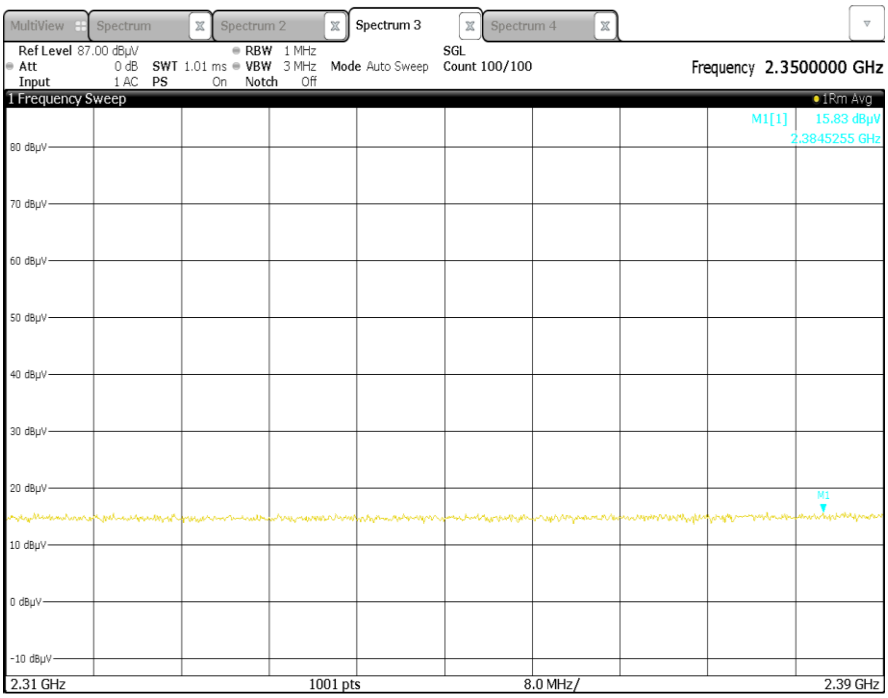
9.6 Test Plot for Radiated Spurious Emission

- 802.11b _ Low frequency

Restricted Band – Peak

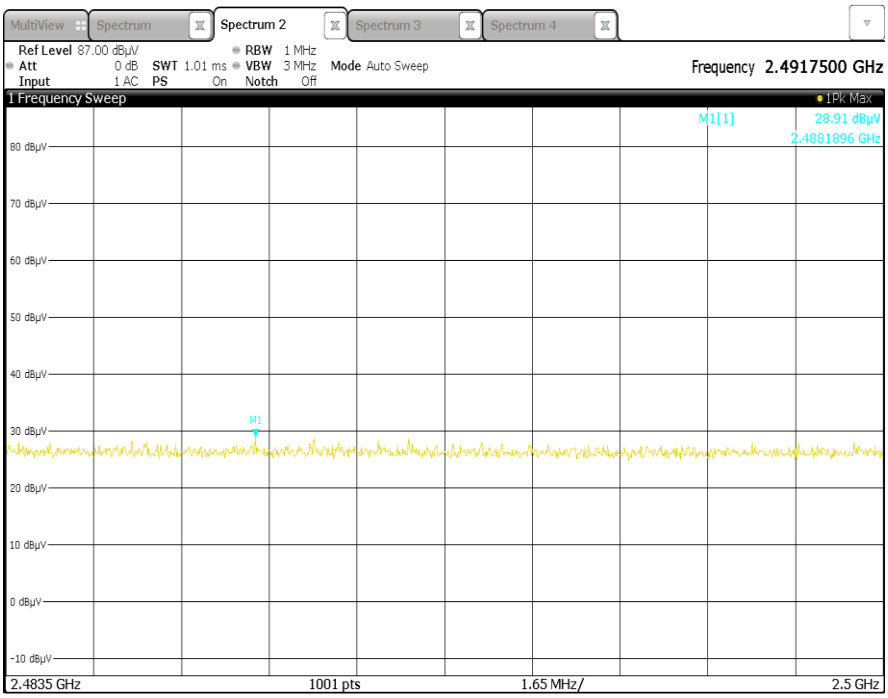


Restricted Band – Average

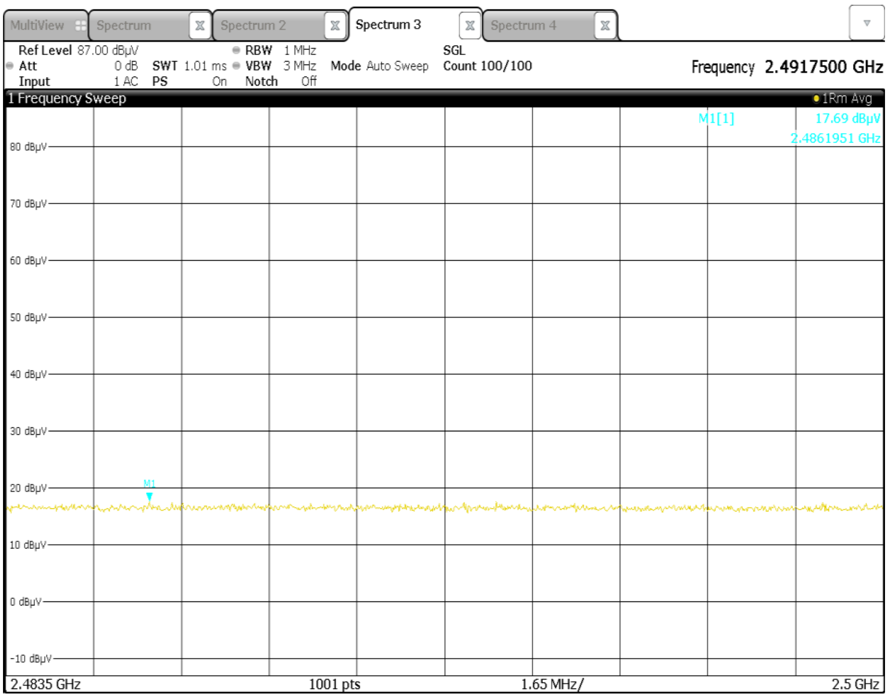


- 802.11b _ High frequency

	Restricted Band – Peak

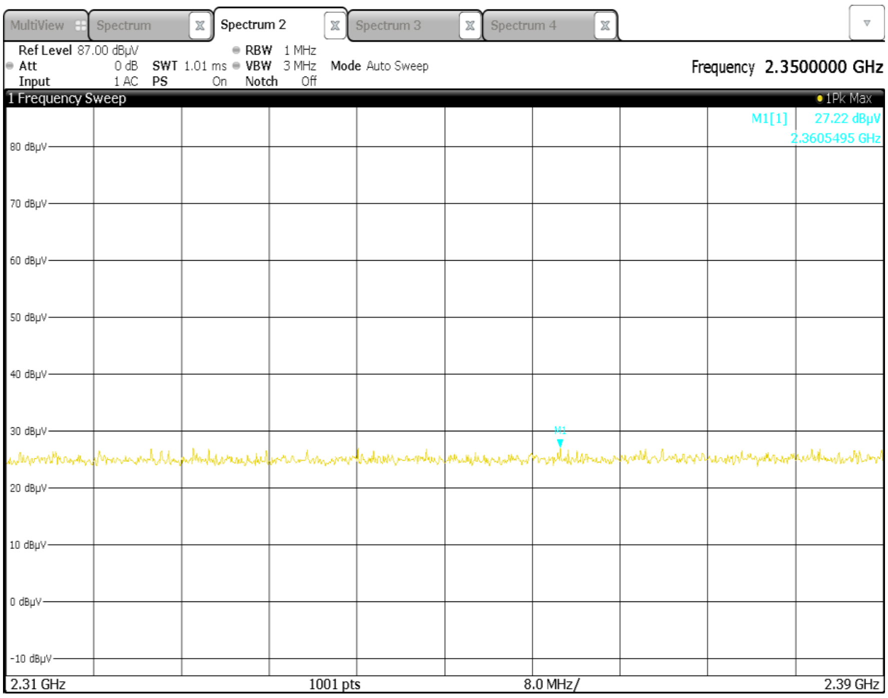


	Restricted Band – Average

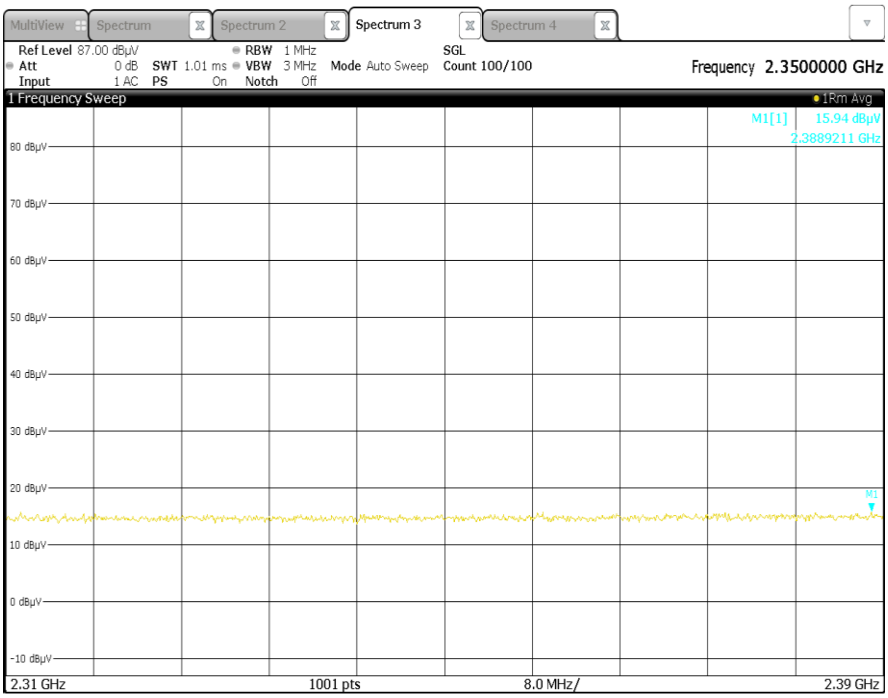


- 802.11g _ Low frequency

	Restricted Band – Peak

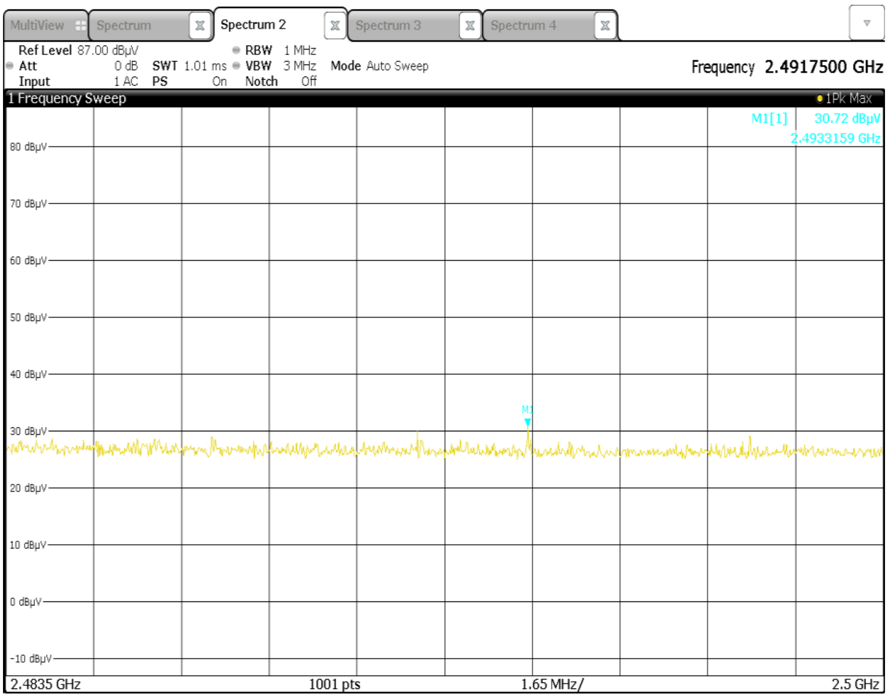


	Restricted Band – Average

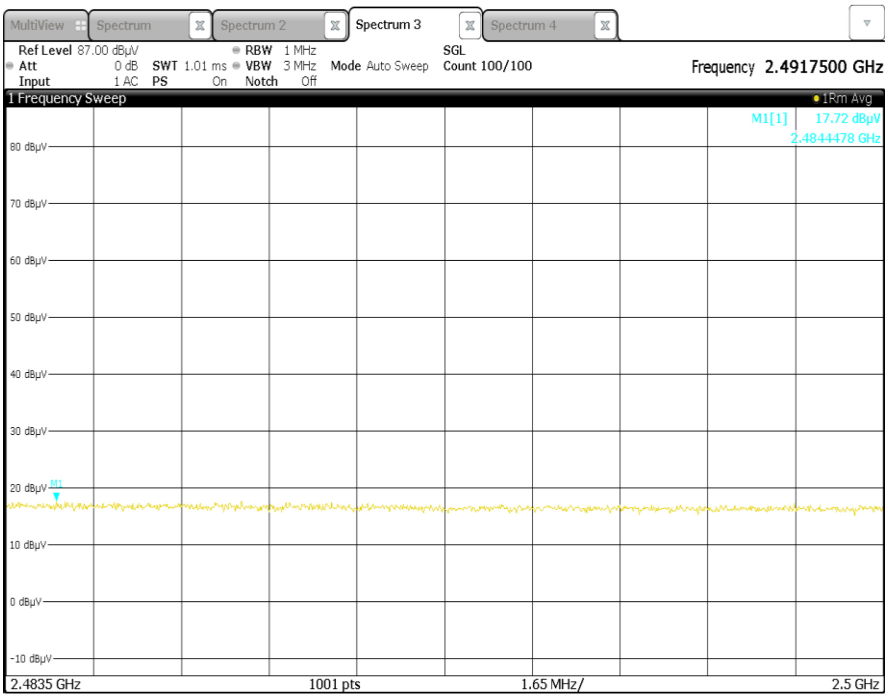


- 802.11g _ High frequency

Restricted Band – Peak

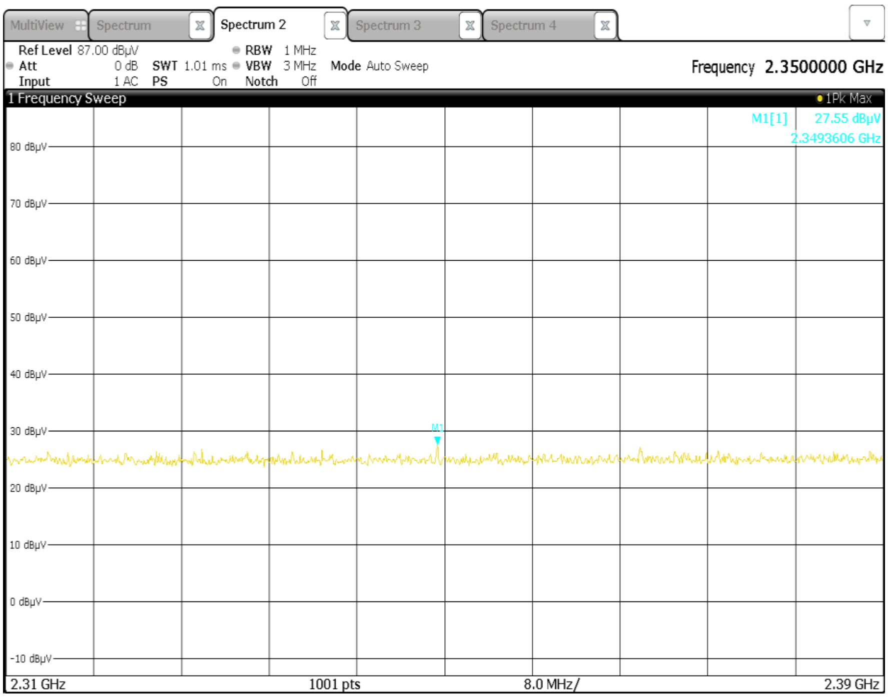


Restricted Band – Average

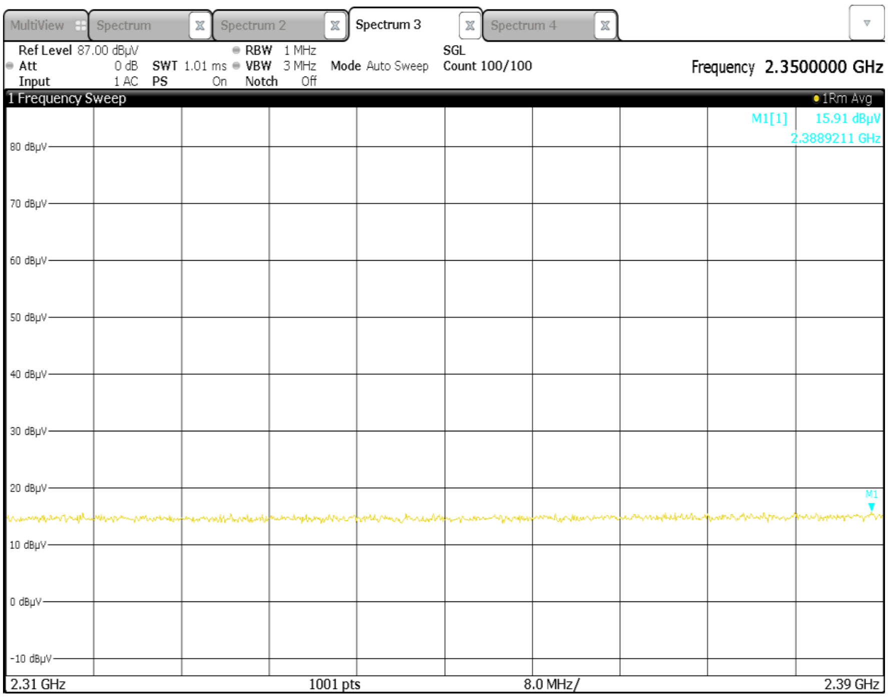


- 802.11n_HT20 _ Low frequency

Restricted Band – Peak

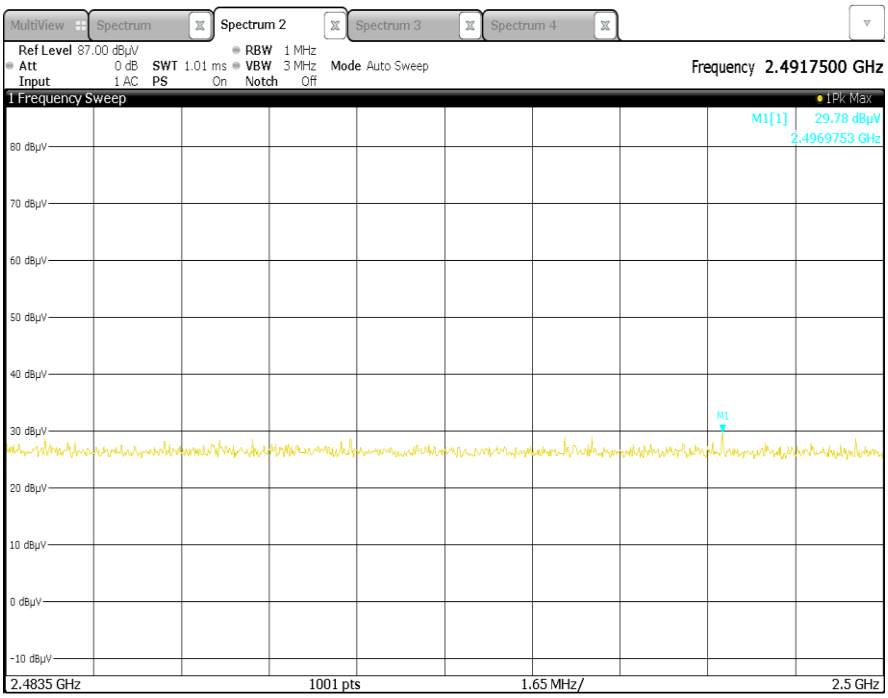


Restricted Band – Average

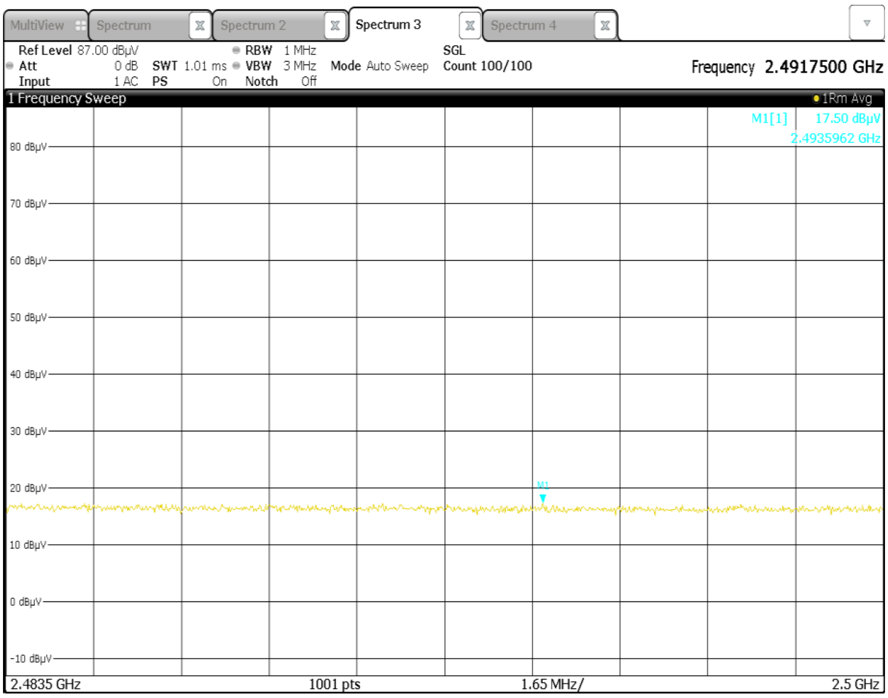


- 802.11n_HT20 _ High frequency

Restricted Band – Peak

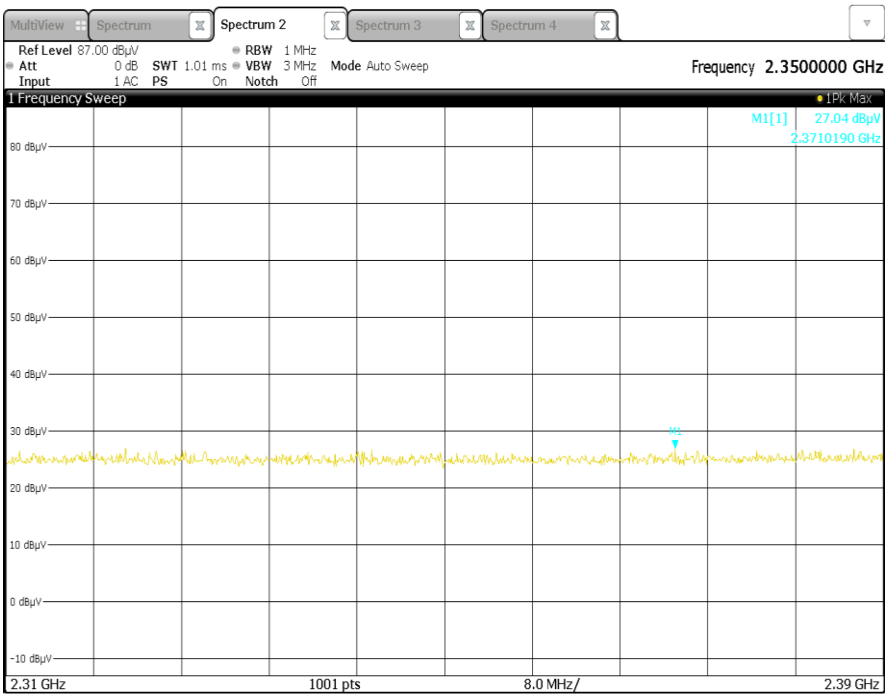


Restricted Band – Average

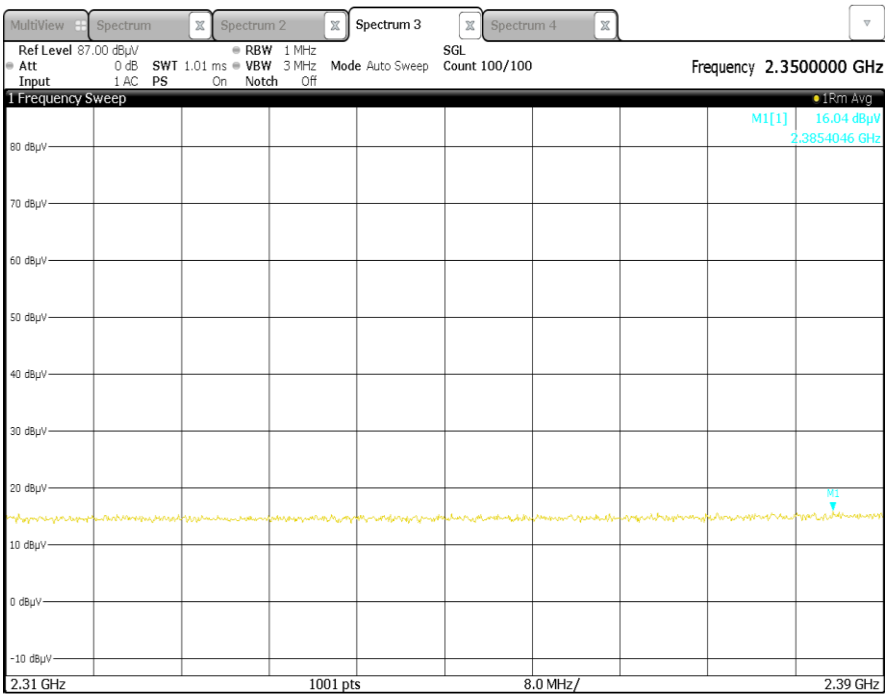


- 802.11n_HT40 _ Low frequency

Restricted Band – Peak

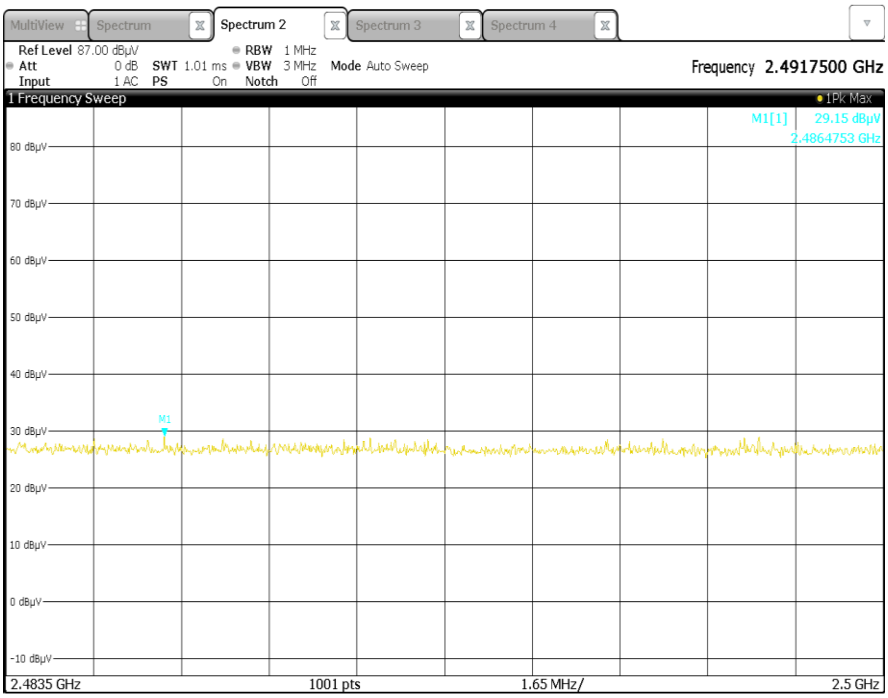


Restricted Band – Average

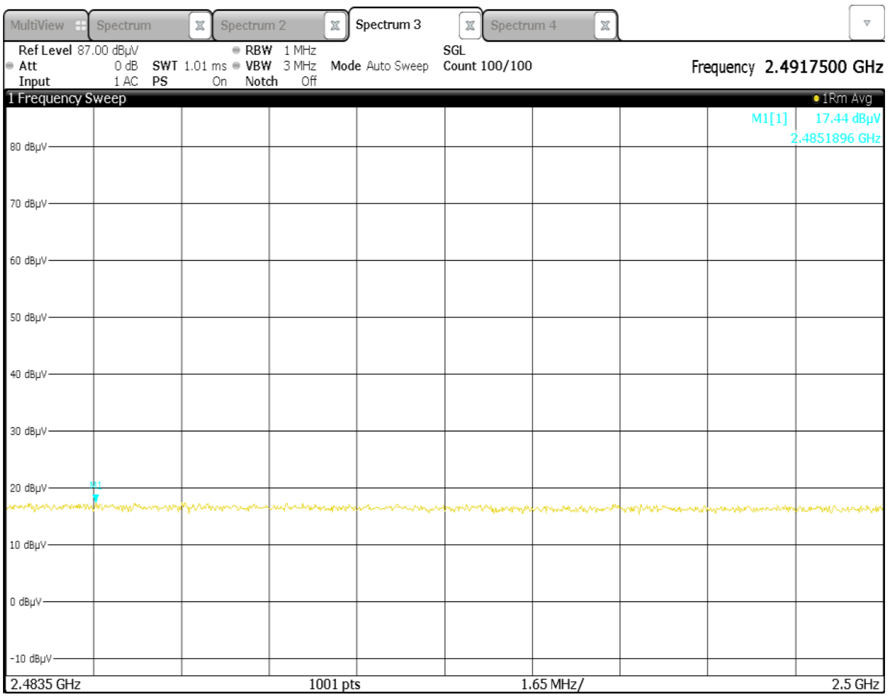


- 802.11n_HT40 _ High frequency

Restricted Band – Peak



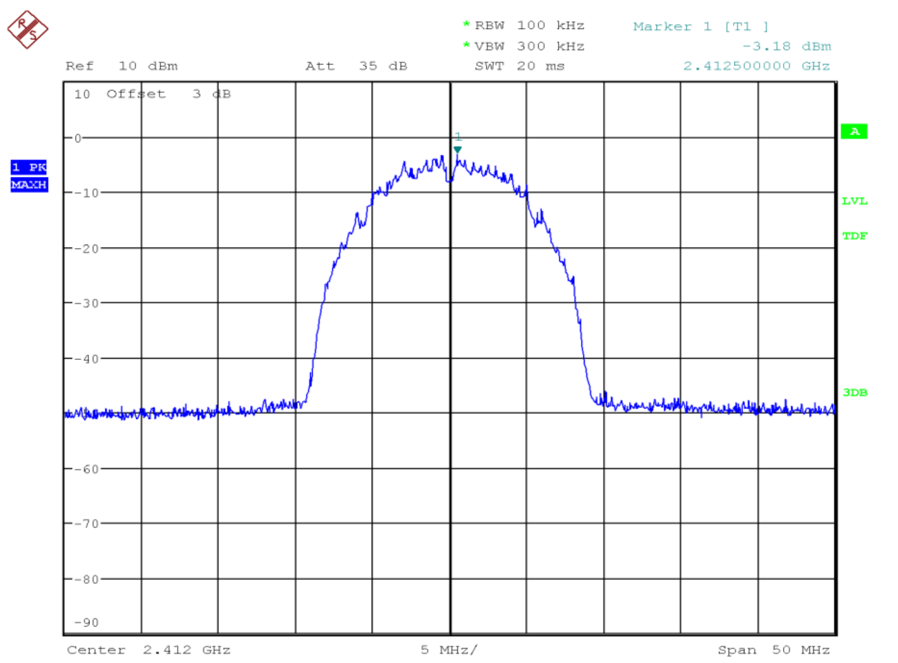
Restricted Band – Average



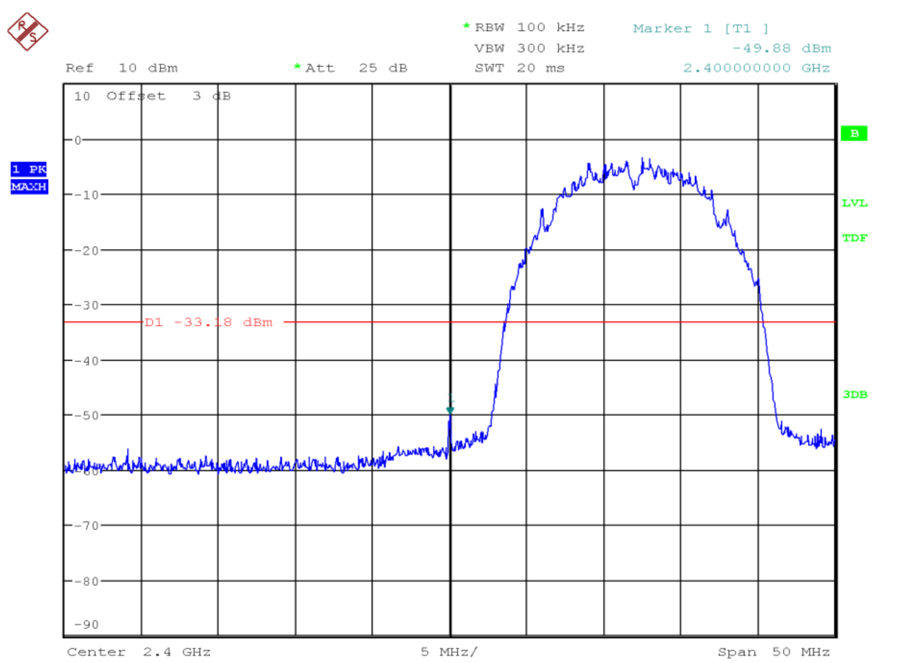
9.7 Test Plot for Conducted Spurious Emission

- 802.11b _ Low frequency

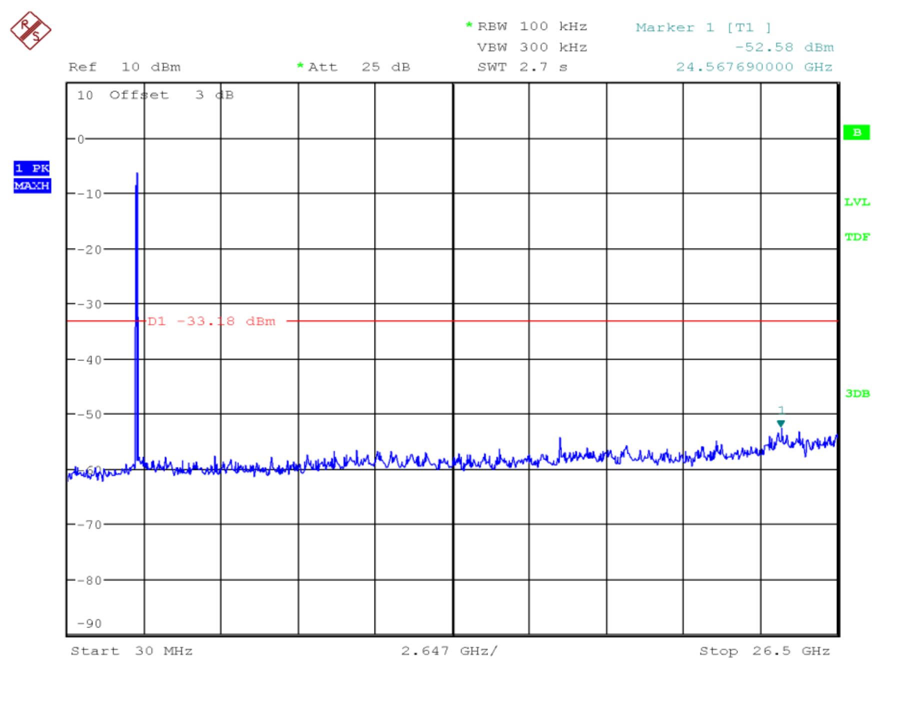
	Reference



	Bandedge



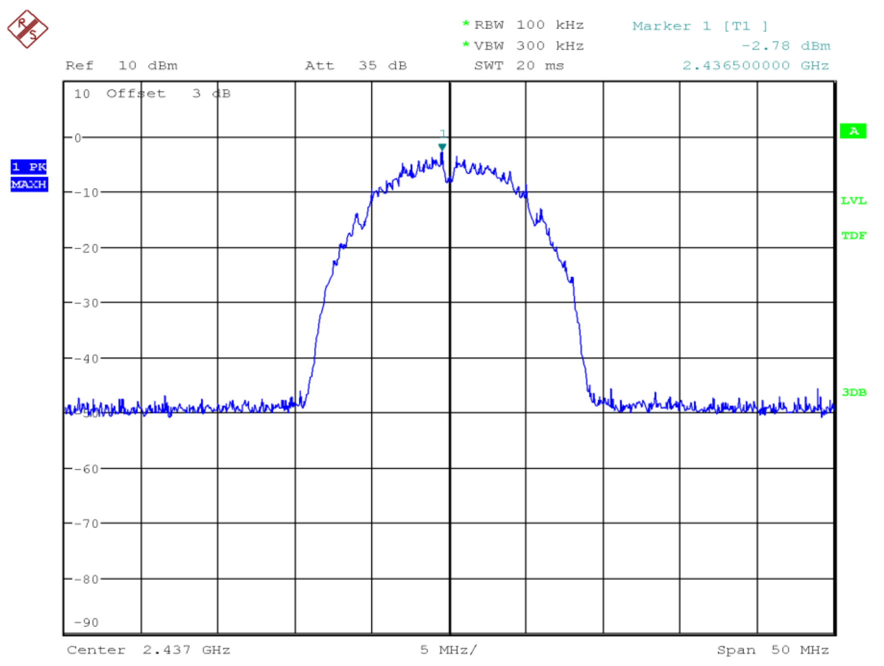
	Spurious



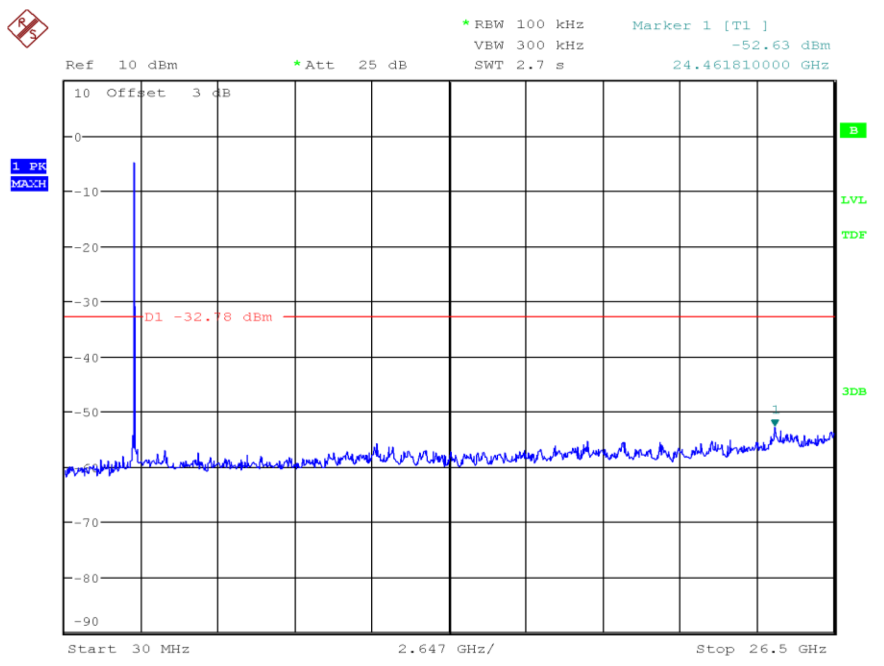
RBW 100 kHz
VBW 300 kHz
SWT 2.7 s
Marker 1 [T1]
-52.58 dBm
24.567690000 GHz
Ref 10 dBm
Att 25 dB
10 Offset 3 dB
1 PK
MAXH
D1 -33.18 dBm
LVL
TDF
3DB
Start 30 MHz
2.647 GHz/
Stop 26.5 GHz

- 802.11b _ Middle frequency

	Reference

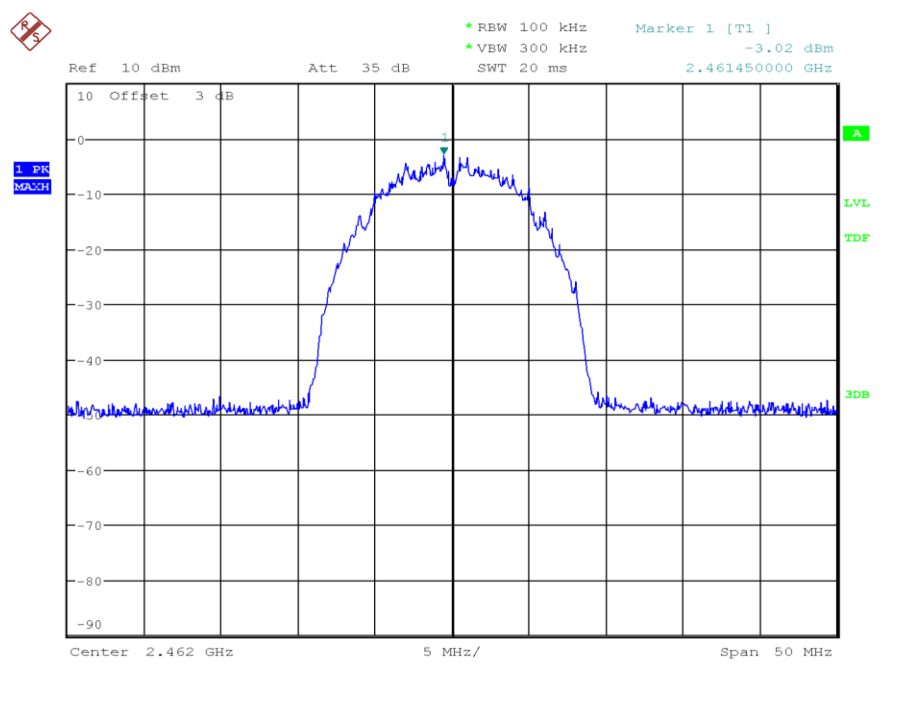


	Spurious

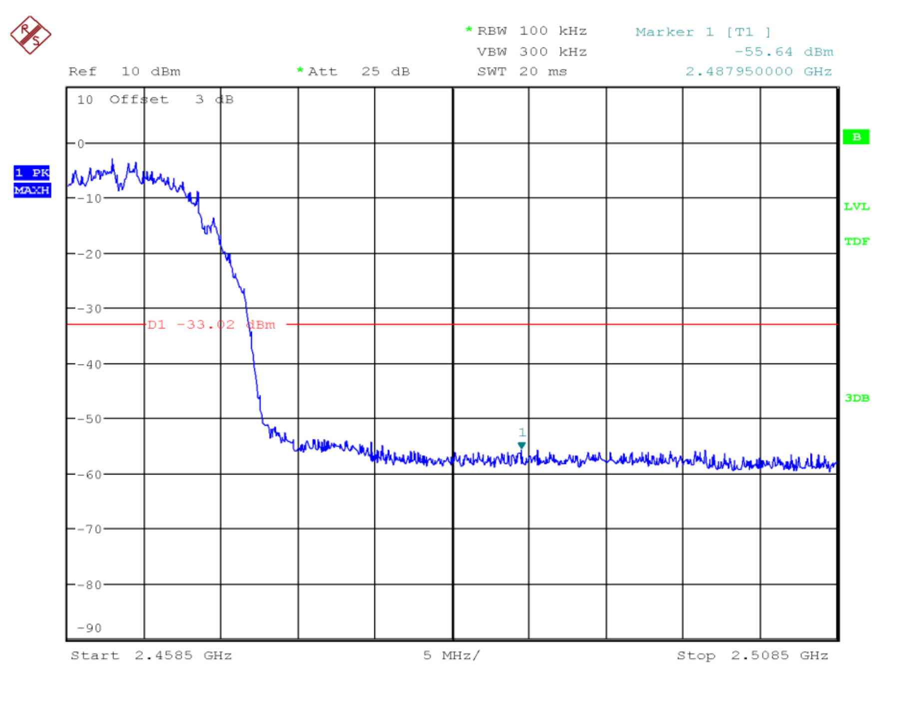


- 802.11b _ High frequency

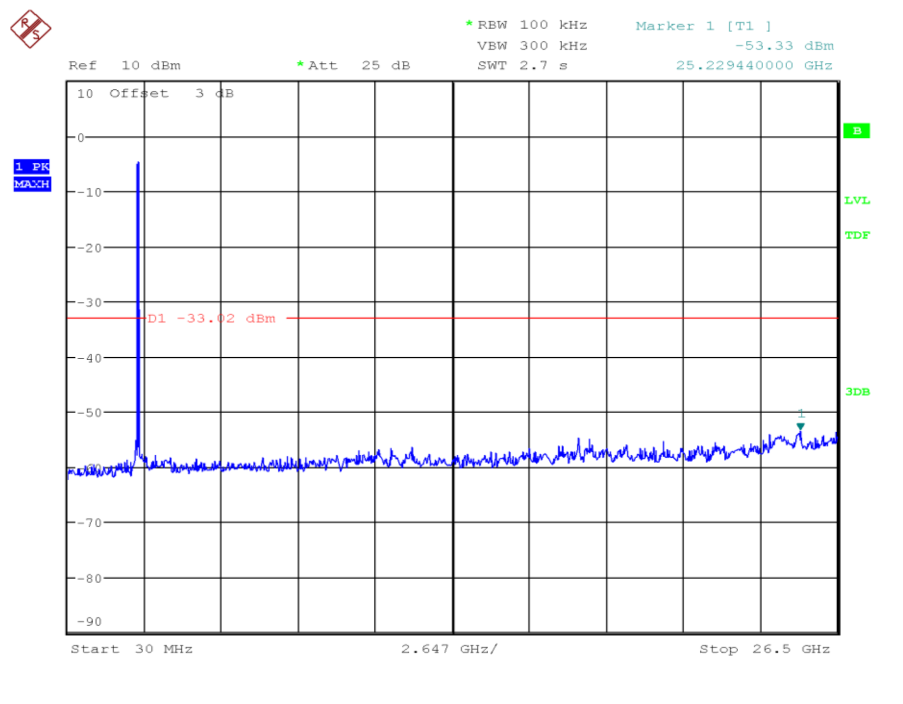
	Reference



	Bandedge



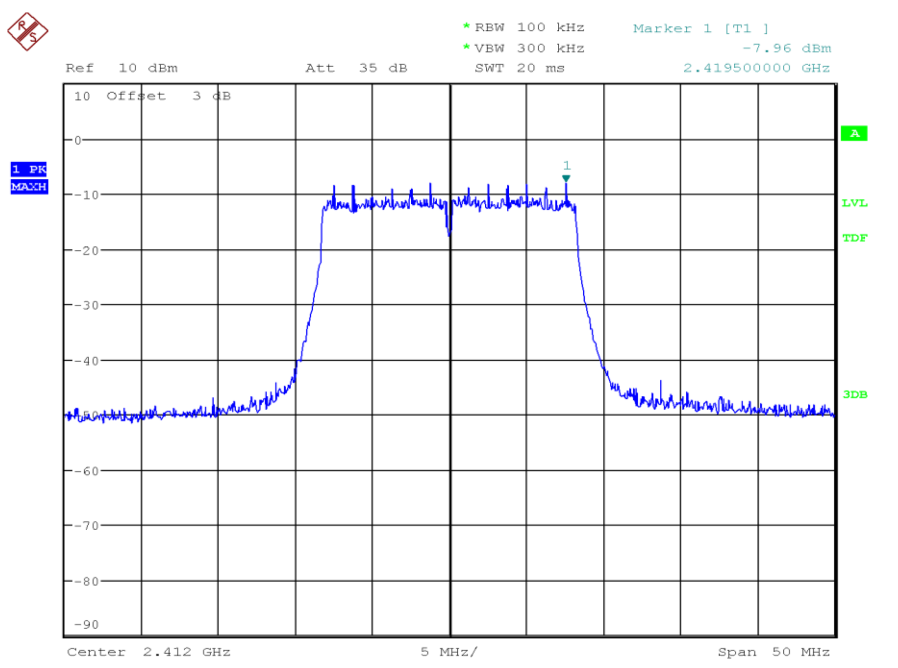
	Spurious



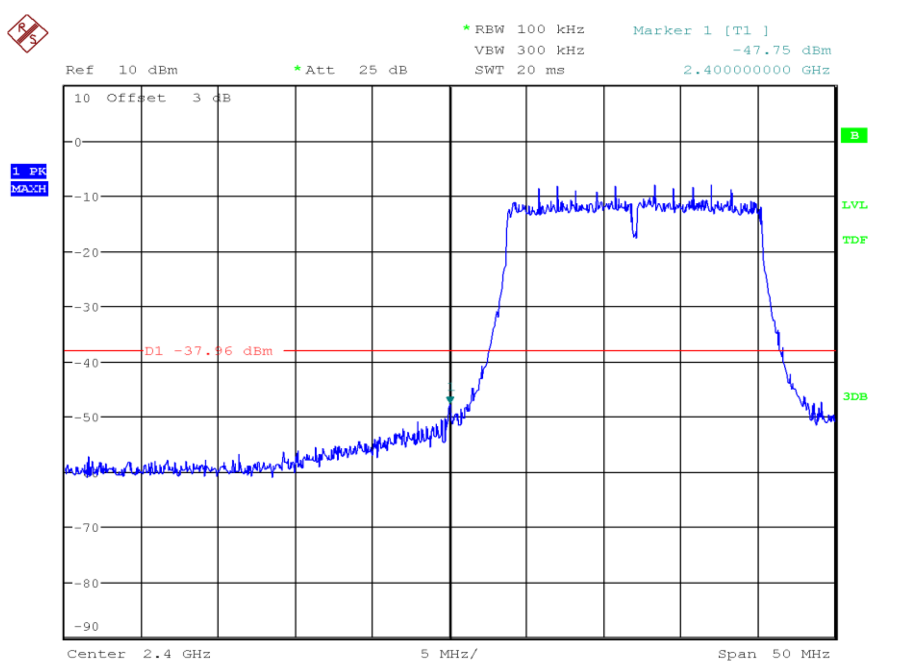
*RBW 100 kHz
Marker 1 [T1]
VBW 300 kHz
-53.33 dBm
Ref 10 dBm
*Att 25 dB
SWT 2.7 s
25.229440000 GHz
10 Offset 3 dB
1 PK MAXH
D1 -33.02 dBm
B
LVL
TDF
3DB
Start 30 MHz
2.647 GHz/
Stop 26.5 GHz

- 802.11g _ Low frequency

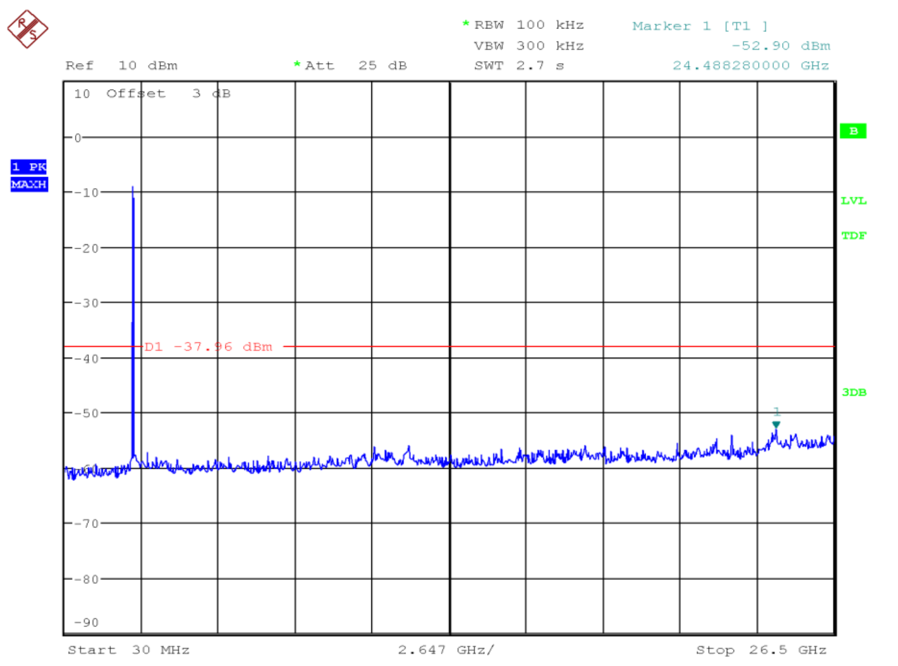
	Reference



	Bandedge

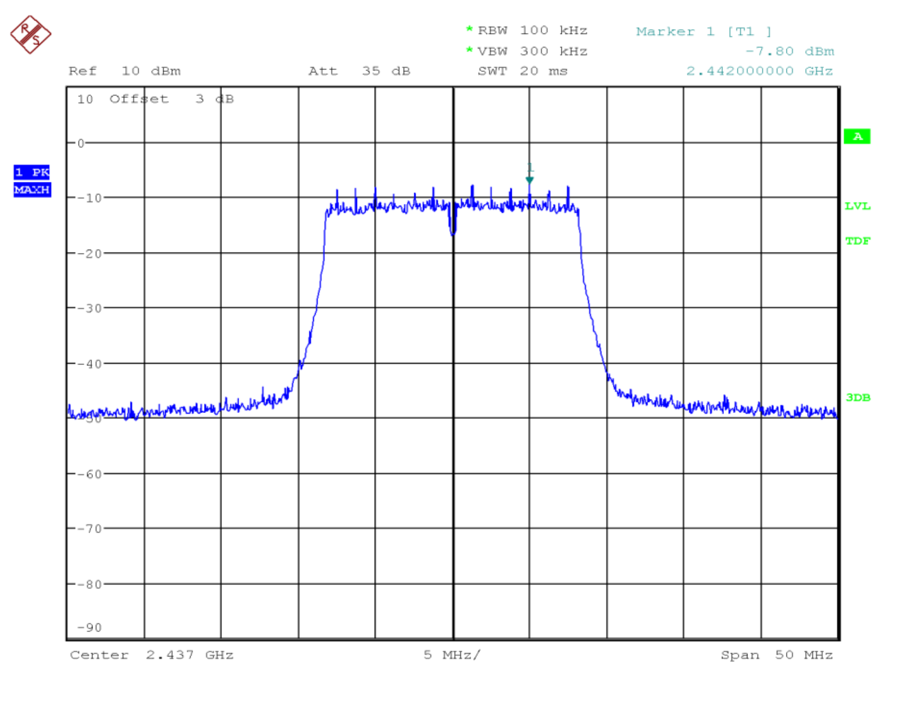


	Spurious

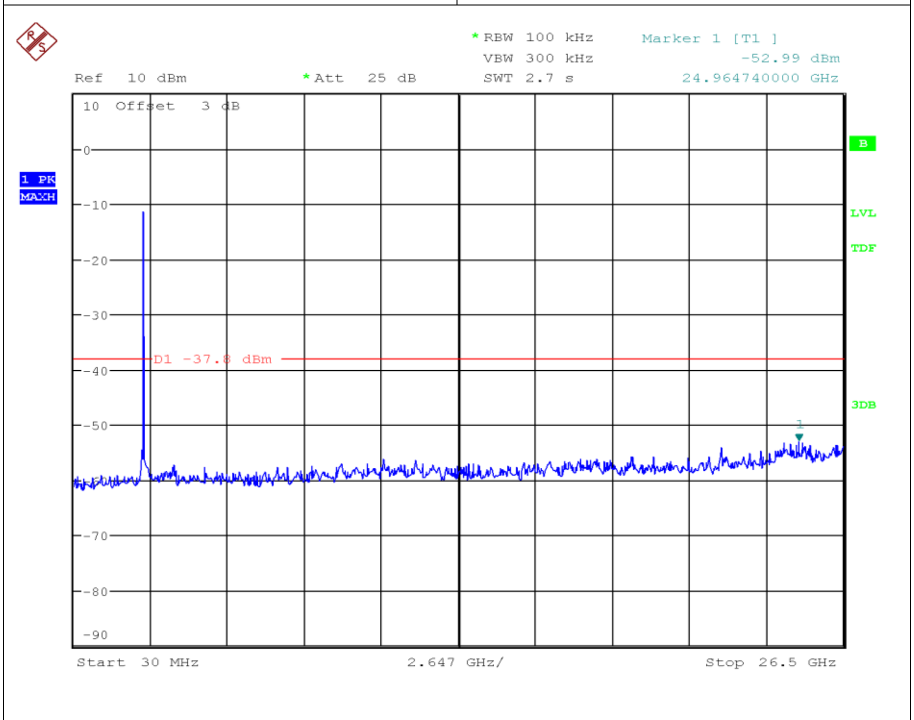

RBW 100 kHz
Marker 1 [T1]
VBW 300 kHz
-52.90 dBm
Ref 10 dBm
Att 25 dB
SWT 2.7 s
24.488280000 GHz
10 Offset 3 dB
1 PK
MAXH
D1 -37.96 dBm
B
LVL
TDF
3DB
Start 30 MHz
2.647 GHz/
Stop 26.5 GHz

- 802.11g _ Middle frequency

Reference

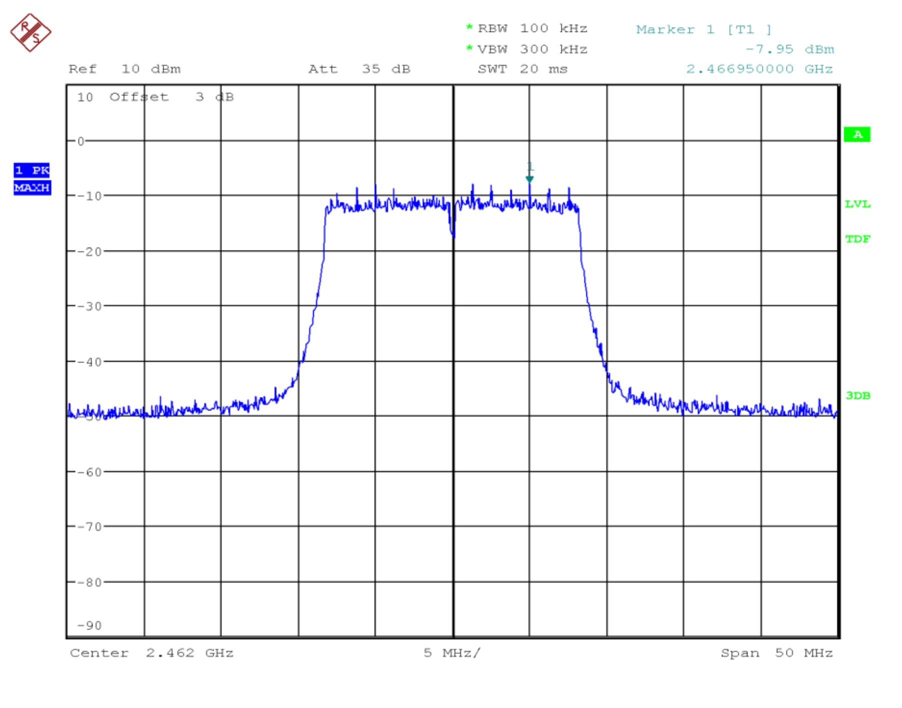


Spurious

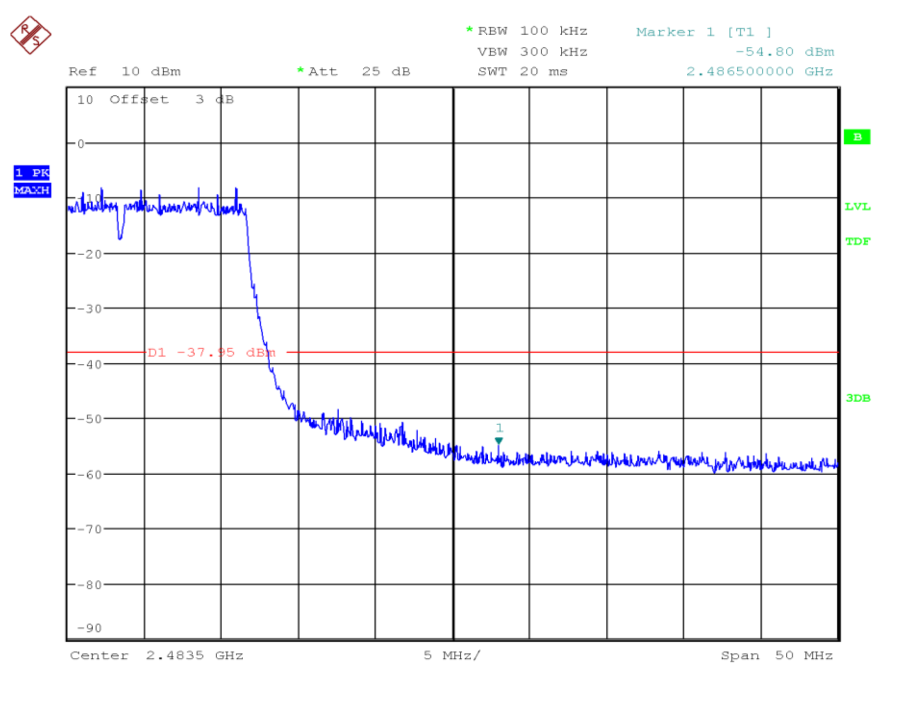


- 802.11g _ High frequency

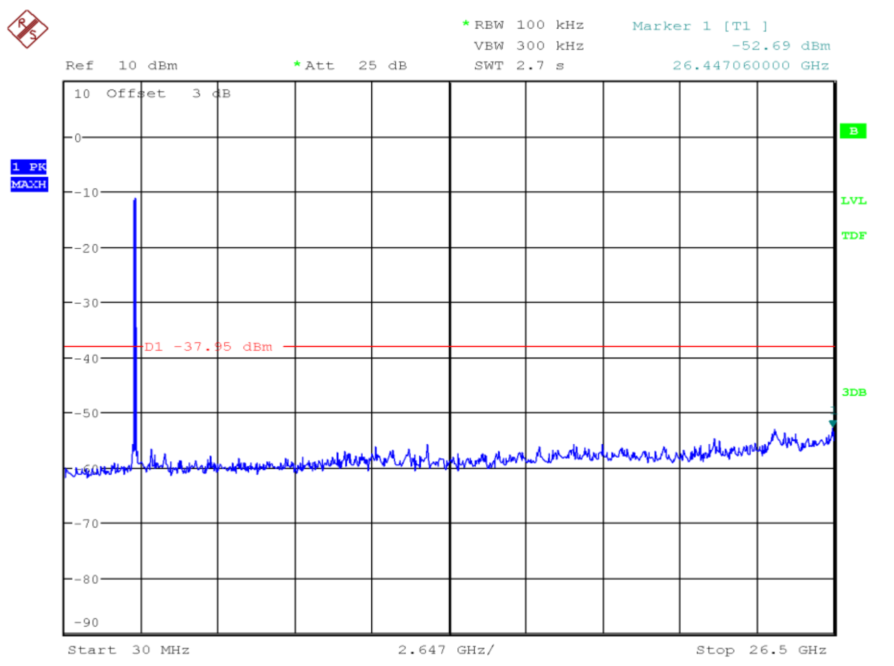
	Reference



	Bandedge



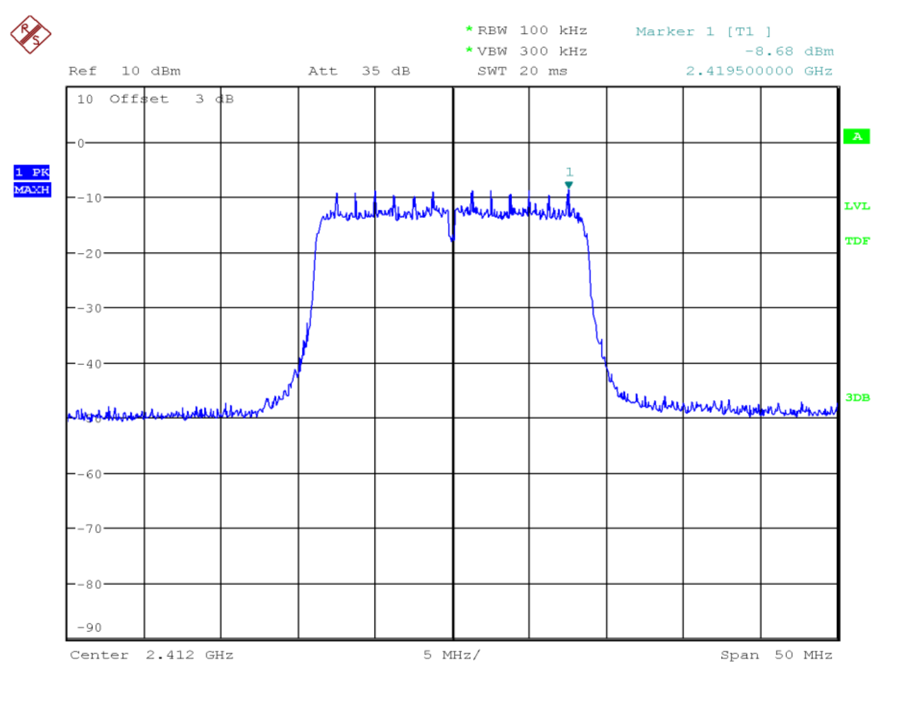
	Spurious



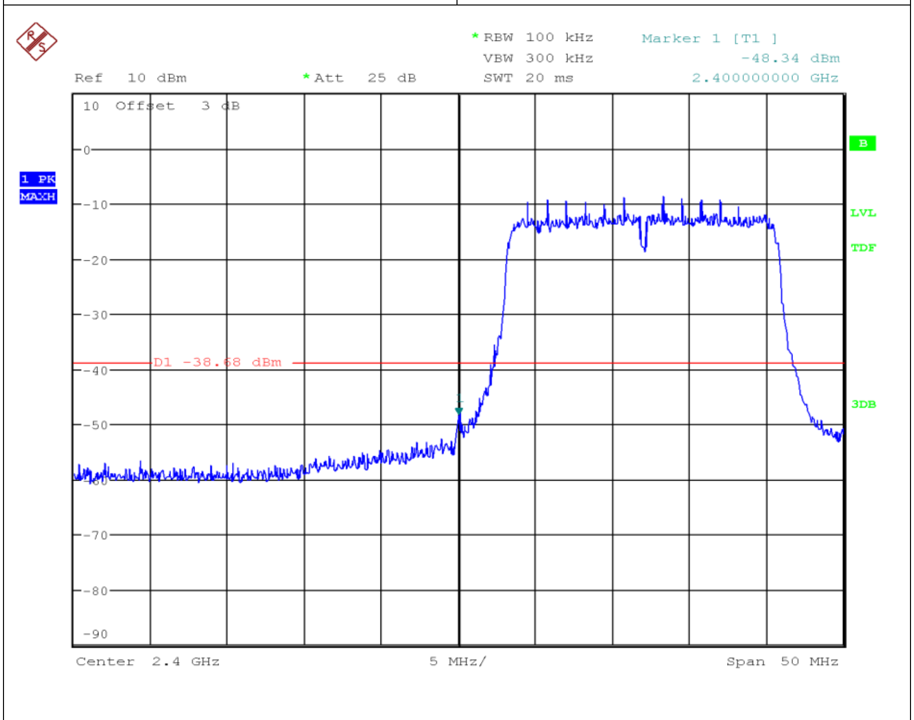
RBW 100 kHz
VBW 300 kHz
SWT 2.7 s
Marker 1 [T1]
-52.69 dBm
26.447060000 GHz
Ref 10 dBm
Att 25 dB
10 Offset 3 dB
1 PK
MAXH
D1 -37.95 dBm
LVL
TDF
3DB
Start 30 MHz
2.647 GHz/
Stop 26.5 GHz

- 802.11n_HT20 _ Low frequency

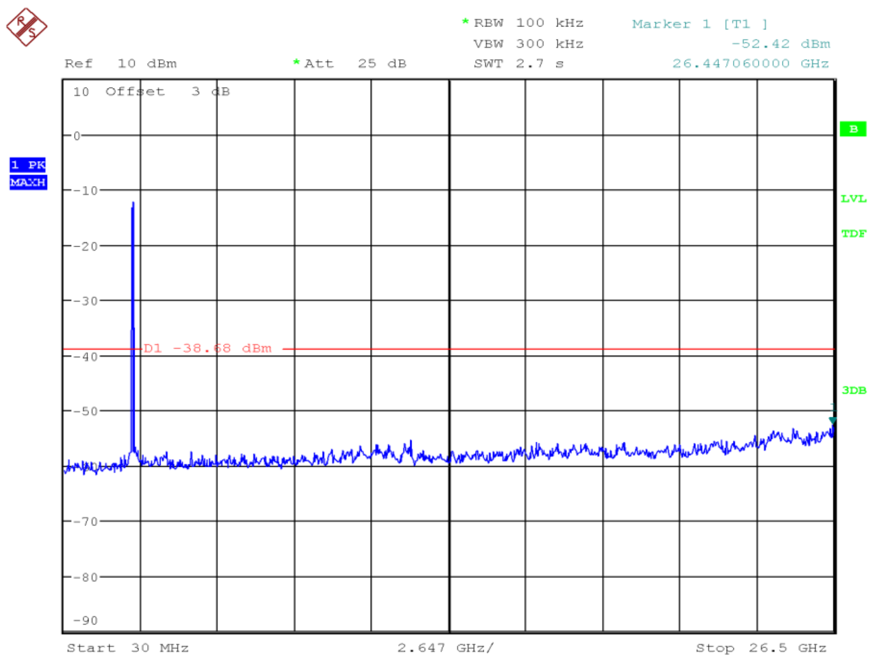
	Reference



	Bandedge



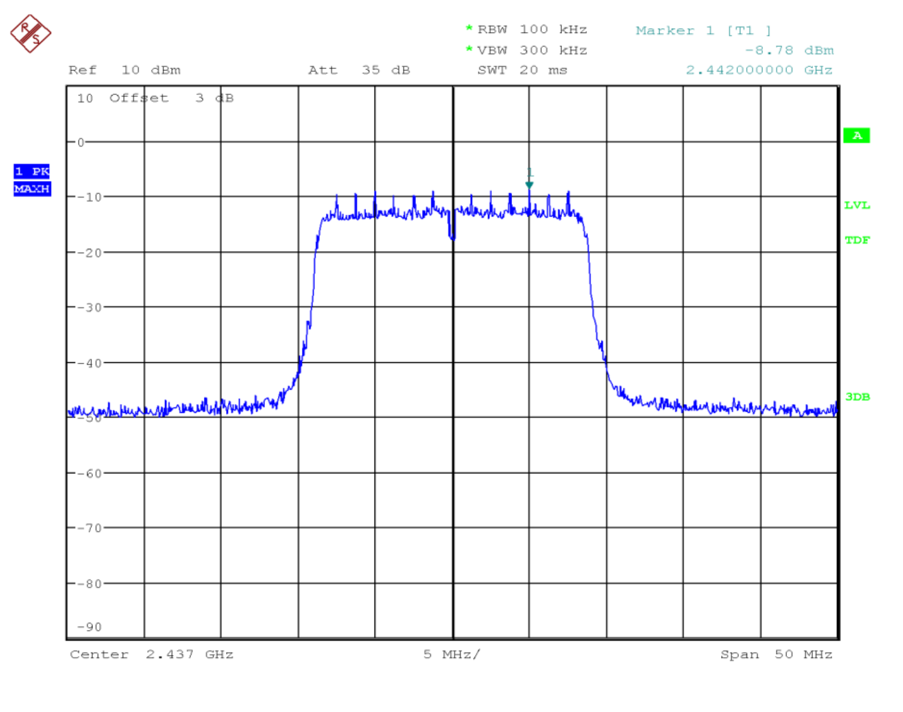
	Spurious



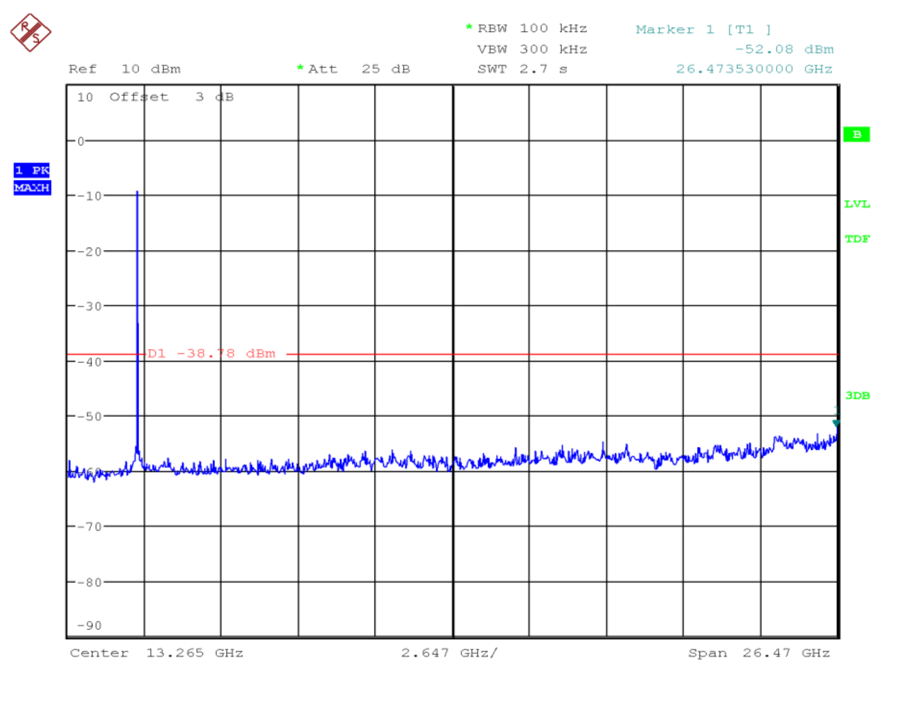
RBW 100 kHz
VBW 300 kHz
SWT 2.7 s
Marker 1 [T1]
-52.42 dBm
26.447060000 GHz
Ref 10 dBm
Att 25 dB
10 Offset 3 dB
1 PK
MAXH
D1 -38.68 dBm
LVL
TDF
3DB
Start 30 MHz
2.647 GHz/
Stop 26.5 GHz

- 802.11n_HT20 _ Middle frequency

	Reference

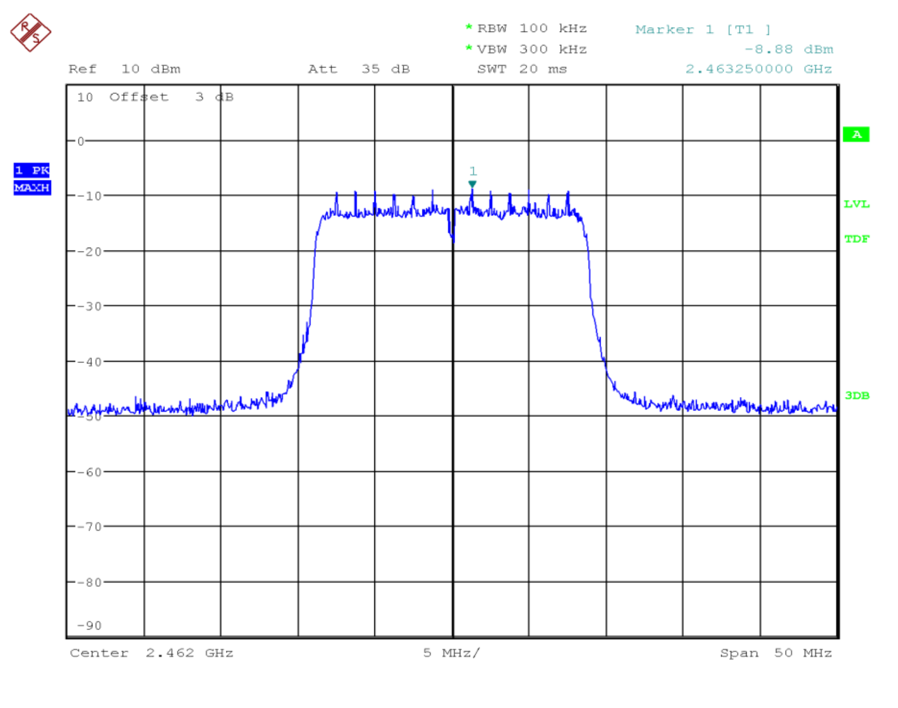


	Spurious

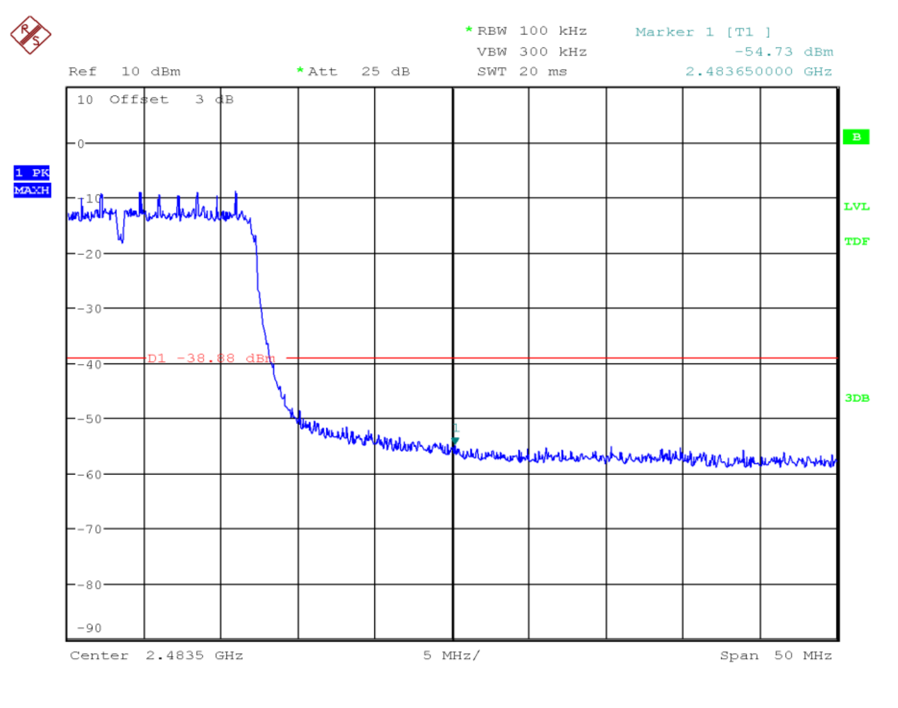


- 802.11n_HT20 _ High frequency

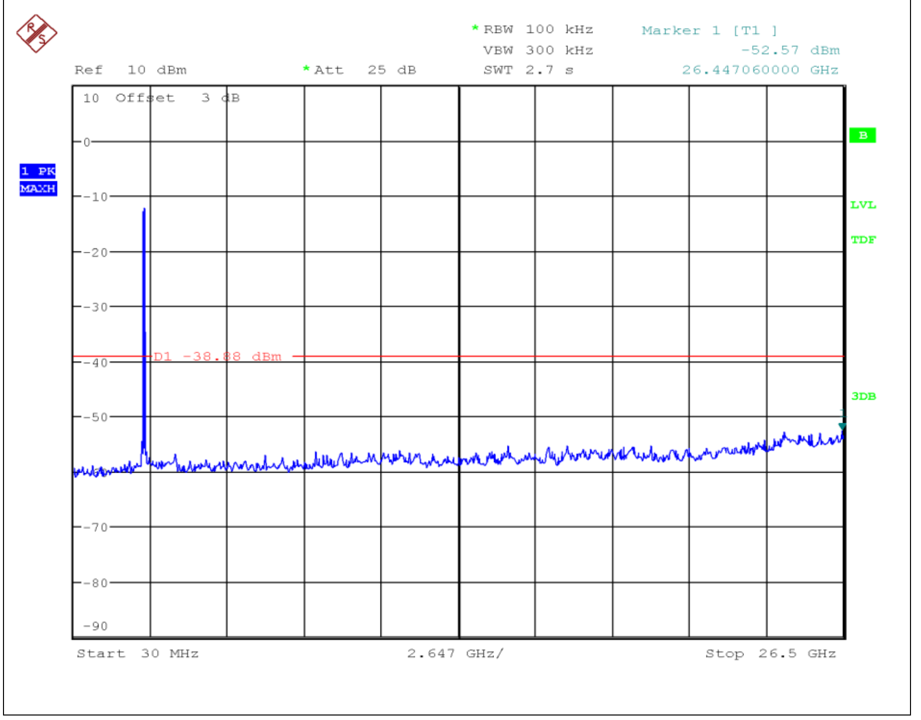
	Reference



	Bandedge



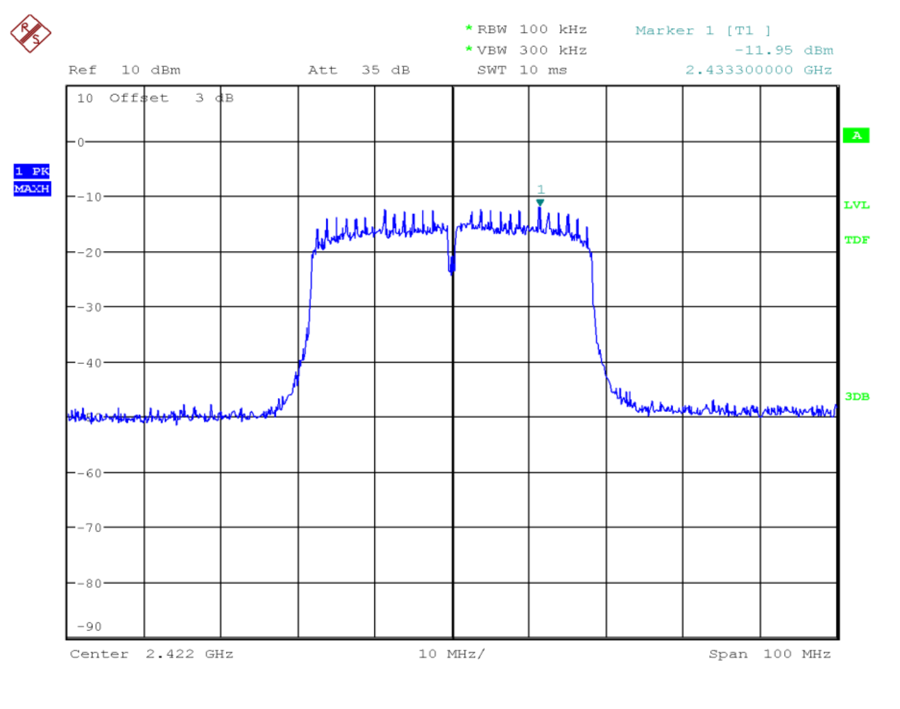
	Spurious



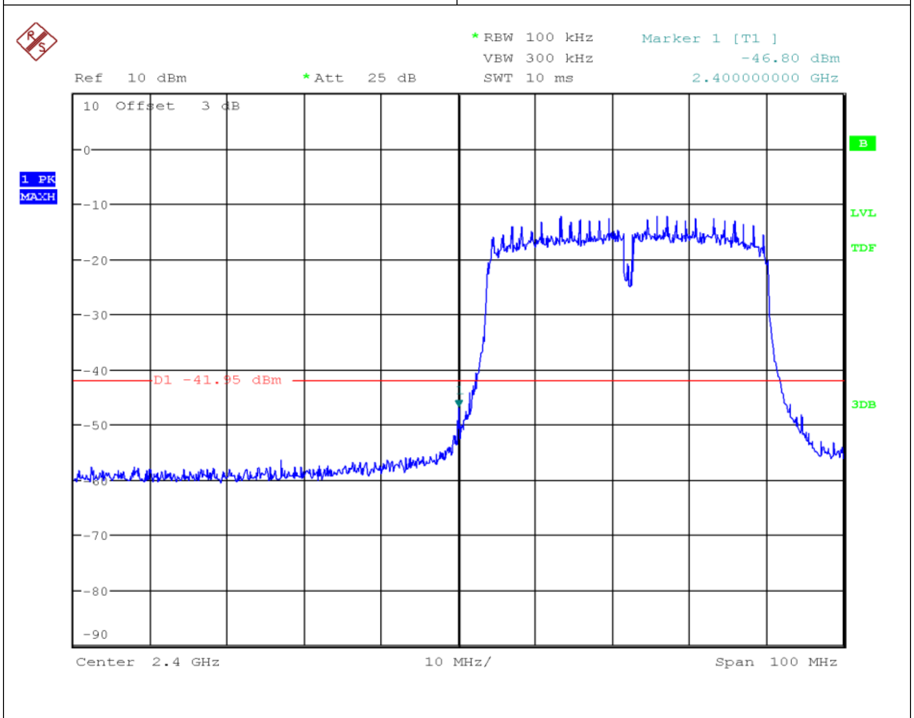
*RBW 100 kHz
VBW 300 kHz
SWT 2.7 s
Marker 1 [T1]
-52.57 dBm
26.447060000 GHz
Ref 10 dBm
*Att 25 dB
10 Offset 3 dB
1 PK
MAXH
D1 -38.88 dBm
B
LVL
TDF
3DB
0
-10
-20
-30
-40
-50
-70
-80
-90
Start 30 MHz
2.647 GHz/
Stop 26.5 GHz

- 802.11n_HT40 _ Low frequency

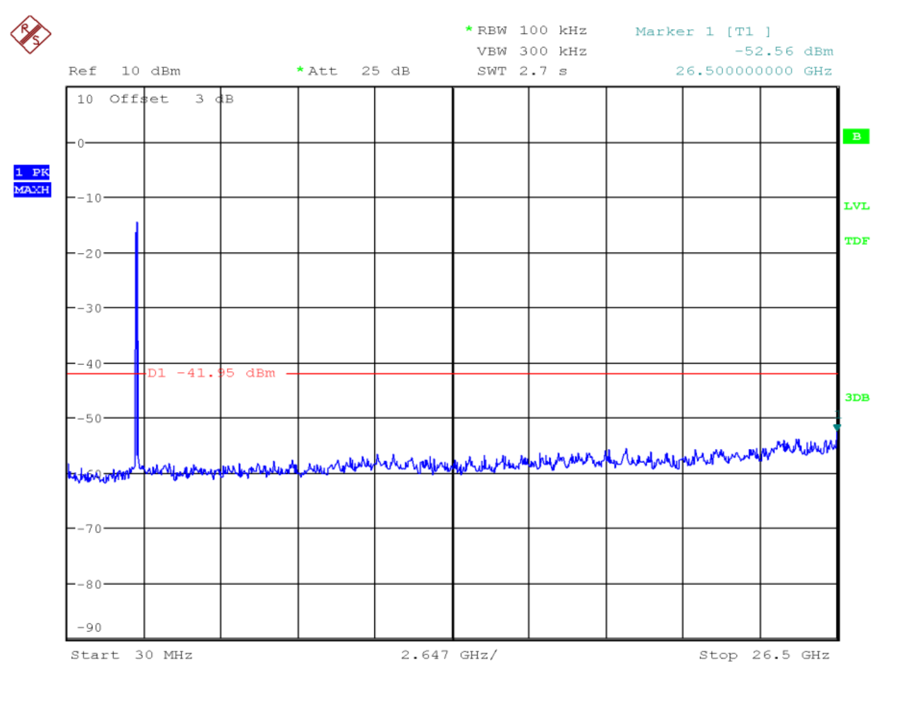
Reference



Bandedge

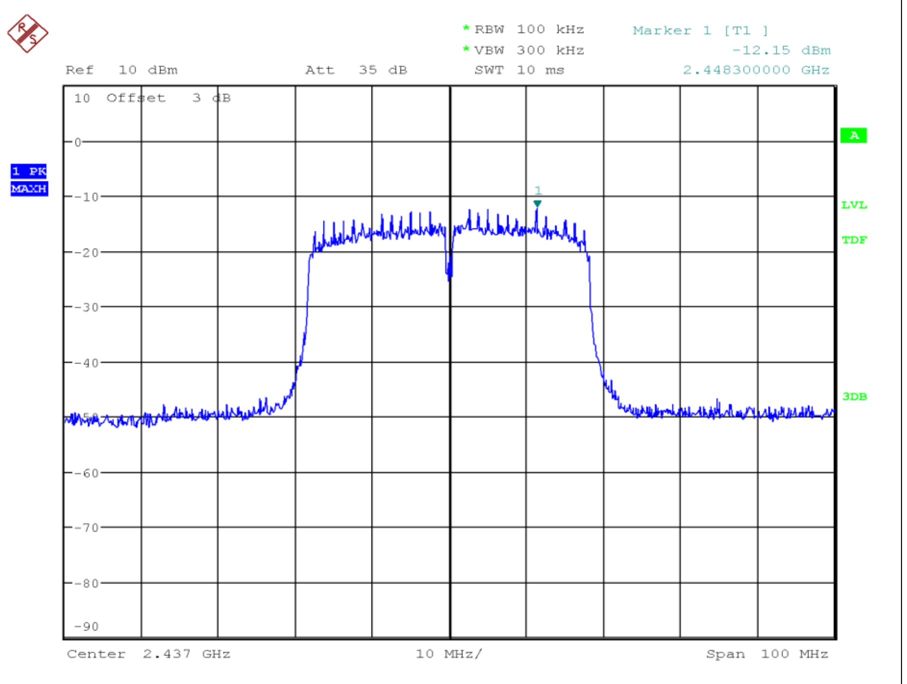


	Spurious

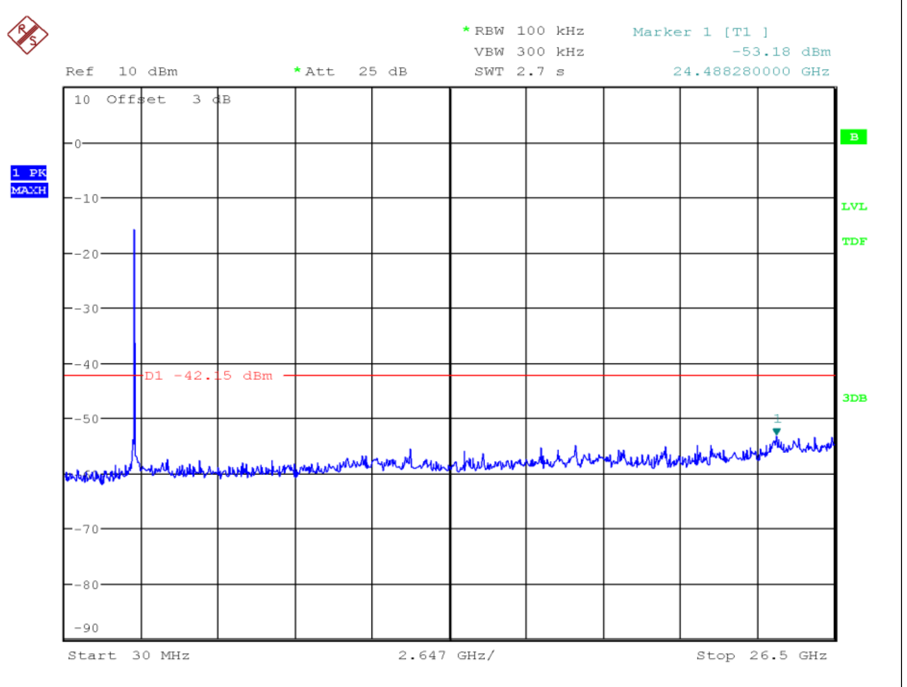

RBW 100 kHz
Marker 1 [T1]
VBW 300 kHz
-52.56 dBm
Ref 10 dBm
Att 25 dB
SWT 2.7 s
26.500000000 GHz
10 Offset 3 dB
1 PK
MAXH
D1 -41.95 dBm
LVL
TDF
3DB
Start 30 MHz
2.647 GHz/
Stop 26.5 GHz

- 802.11n_HT40 _ Middle frequency

Reference

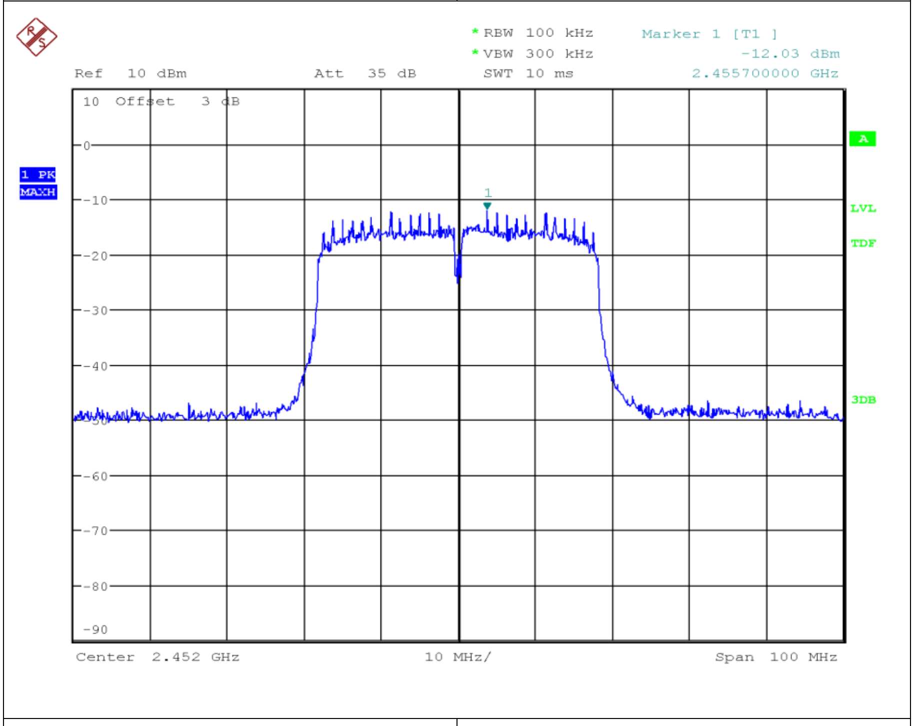


Spurious

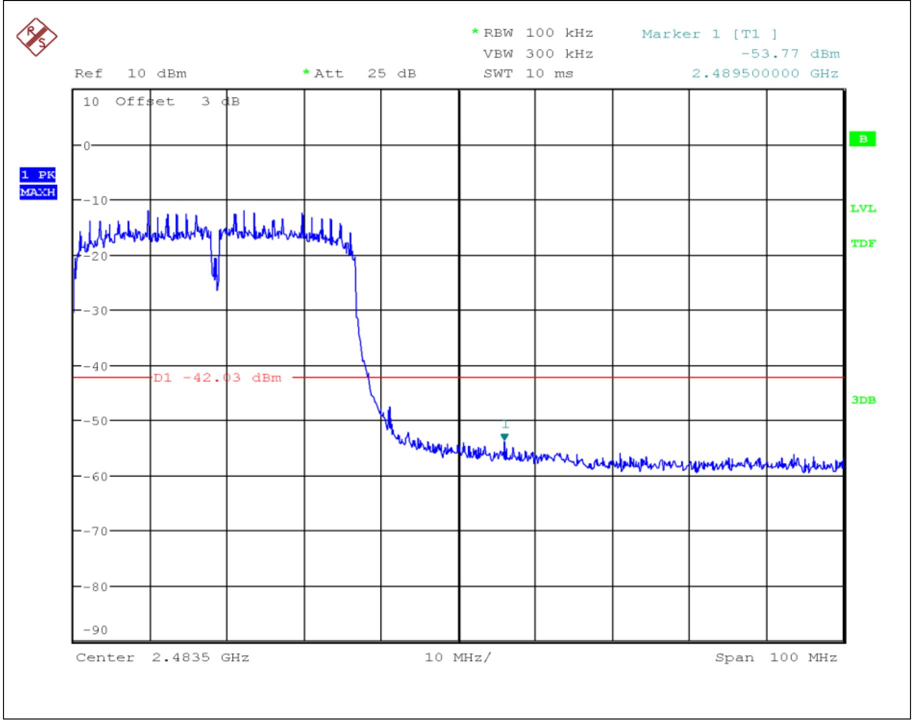


- 802.11n_HT40 _ High frequency

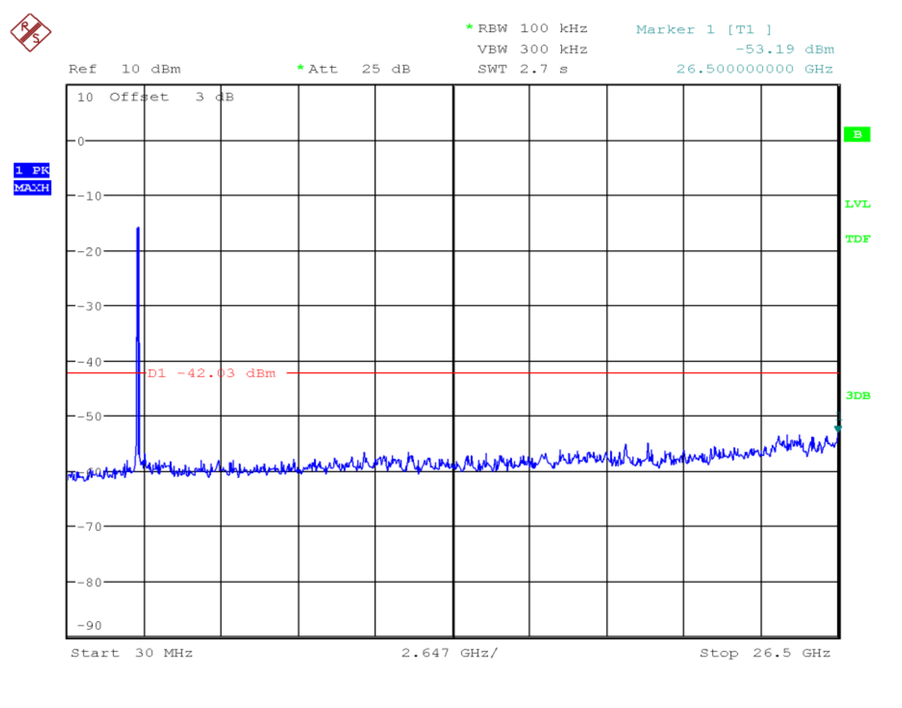
	Reference



	Bandedge



	Spurious


RBW 100 kHz
Marker 1 [T1]
VBW 300 kHz
-53.19 dBm
Ref 10 dBm
Att 25 dB
SWT 2.7 s
26.500000000 GHz
Offset 3 dB
1 PK
MAXH
D1 -42.03 dBm
LVL
TDF
3DB
Start 30 MHz
2.647 GHz/
Stop 26.5 GHz

10. Conducted Emission

10.1 Test Setup

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

10.2 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

10.3 Test Procedure

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

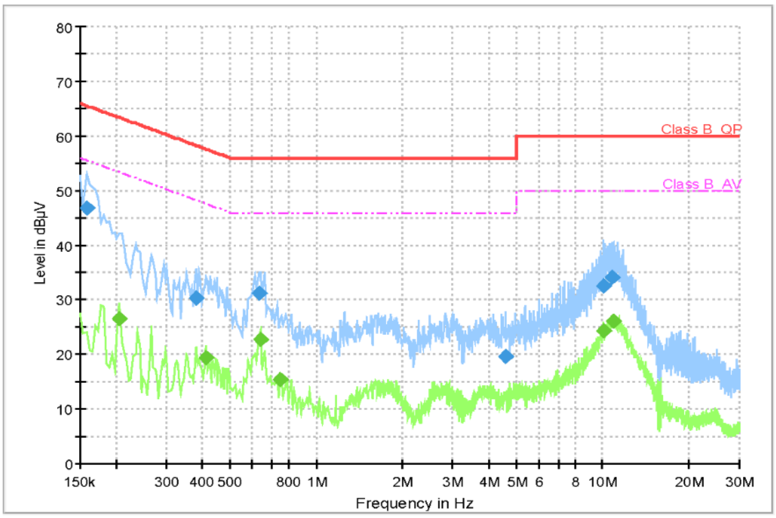
1. The test procedure is performed in a 6.5 m × 3.5 m × 3.5 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected 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.

10.4 Test Result

- AC Line Conducted Emission (Graph)

SP149_WLAN_L1

Conducted Emission

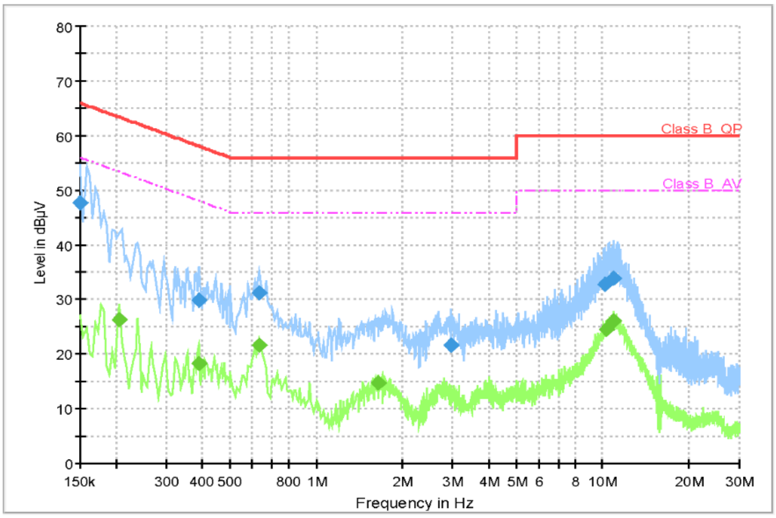


Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Bandwidth (kHz)	Line	Corr. (dB)
0.158	46.84	---	65.57	18.73	9	L1	10.7
0.206	---	26.56	53.37	26.80	9	L1	10.6
0.382	30.39	---	58.24	27.84	9	L1	10.7
0.414	---	19.28	47.57	28.29	9	L1	10.7
0.630	31.13	---	56.00	24.87	9	L1	10.5
0.640	---	22.67	46.00	23.33	9	L1	10.4
0.750	---	15.36	46.00	30.64	9	L1	10.0
4.580	19.71	---	56.00	36.29	9	L1	9.9
10.110	32.56	---	60.00	27.44	9	L1	9.9
10.110	---	24.18	50.00	25.82	9	L1	9.9
10.800	34.13	---	60.00	25.87	9	L1	9.9
10.860	---	25.99	50.00	24.01	9	L1	9.9

SP149_WLAN_N

Conducted Emission



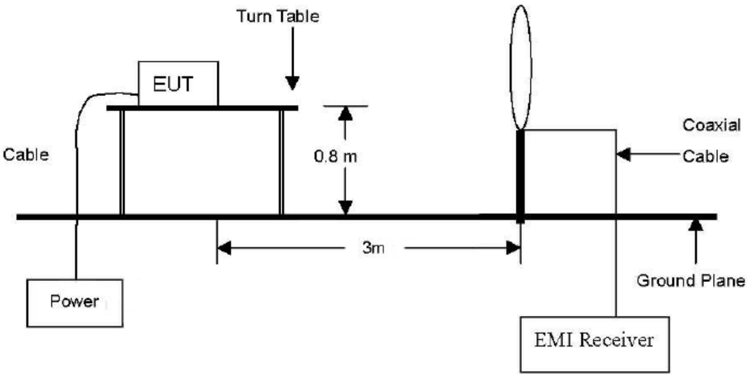
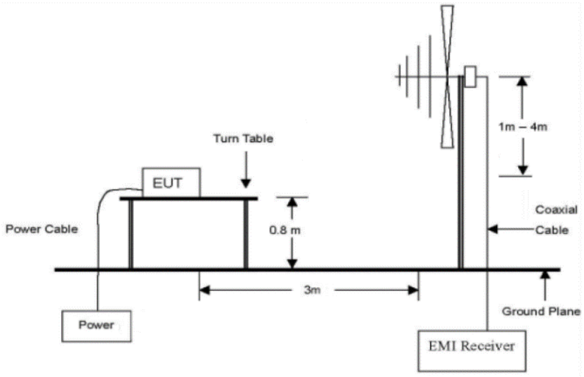
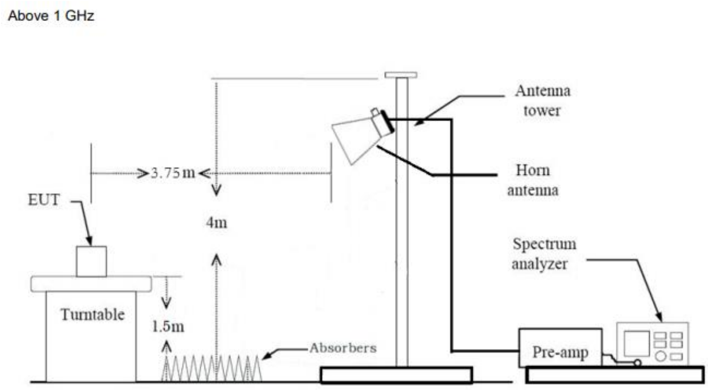
Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Bandwidth (kHz)	Line	Corr. (dB)
0.150	47.67	---	66.00	18.33	9	N	10.6
0.206	---	26.33	53.37	27.03	9	N	10.6
0.390	---	18.22	48.06	29.85	9	N	10.7
0.390	29.88	---	58.06	28.18	9	N	10.7
0.630	---	21.64	46.00	24.36	9	N	10.5
0.630	31.13	---	56.00	24.87	9	N	10.5
1.640	---	14.66	46.00	31.34	9	N	9.9
2.960	21.71	---	56.00	34.29	9	N	9.9
10.140	32.69	---	60.00	27.31	9	N	9.9
10.280	---	24.55	50.00	25.45	9	N	9.9
10.900	---	26.02	50.00	23.98	9	N	9.9
10.900	33.95	---	60.00	26.05	9	N	9.9

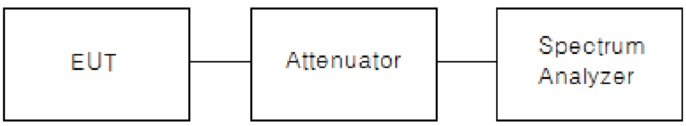
APPENDIX I

TEST SETUP

- Radiated Measurement

below 30 MHz	
below 1 GHz	
above 1 GHz	

- Conducted Measurement

Conducted	

APPENDIX II

UNCERTAINTY

Measurement Item	Expanded Uncertainty U = kUc (k=2)
Conducted RF power	0.32 dB
Conducted Spurious Emissions	0.32 dB
Radiated Spurious Emissions	6.34 dB
Conducted Emissions	1.74 dB

APPENDIX III

DUTY CYCLE CORRECTION FACTOR

Test Procedure

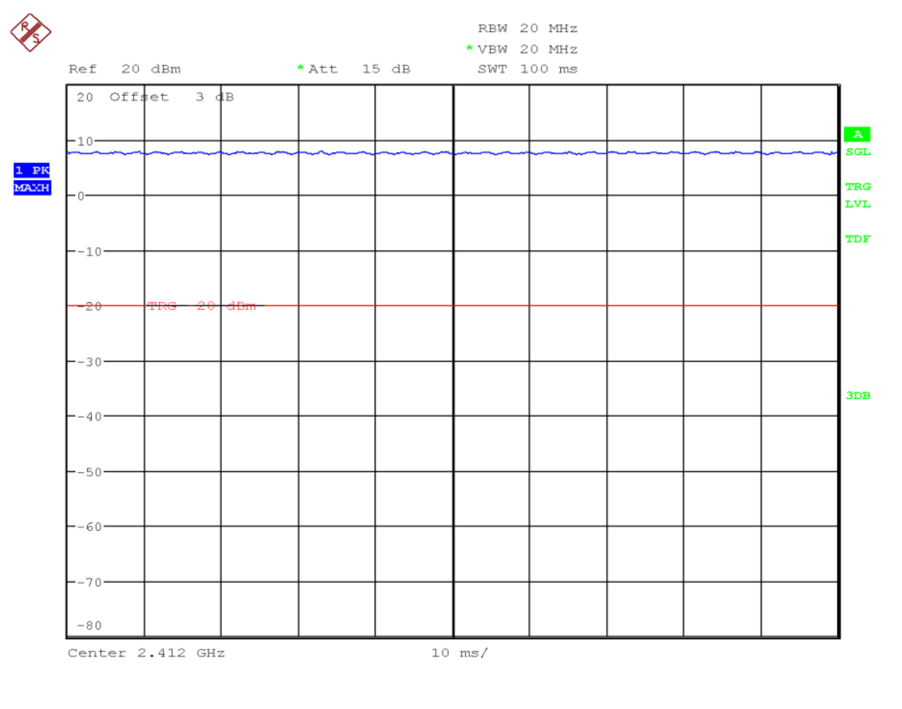
Duty Cycle [X = On Time / (On + Off time)] is measured using Measurement Procedure of KDB558074 D01v05r02

1. Set the center frequency of the spectrum analyzer to the center frequency of the transmission.
2. Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.
3. Set VBW ≥ 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 ㎒, then the zero-span method of measuring duty cycle shall not be used if T ≤ 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)

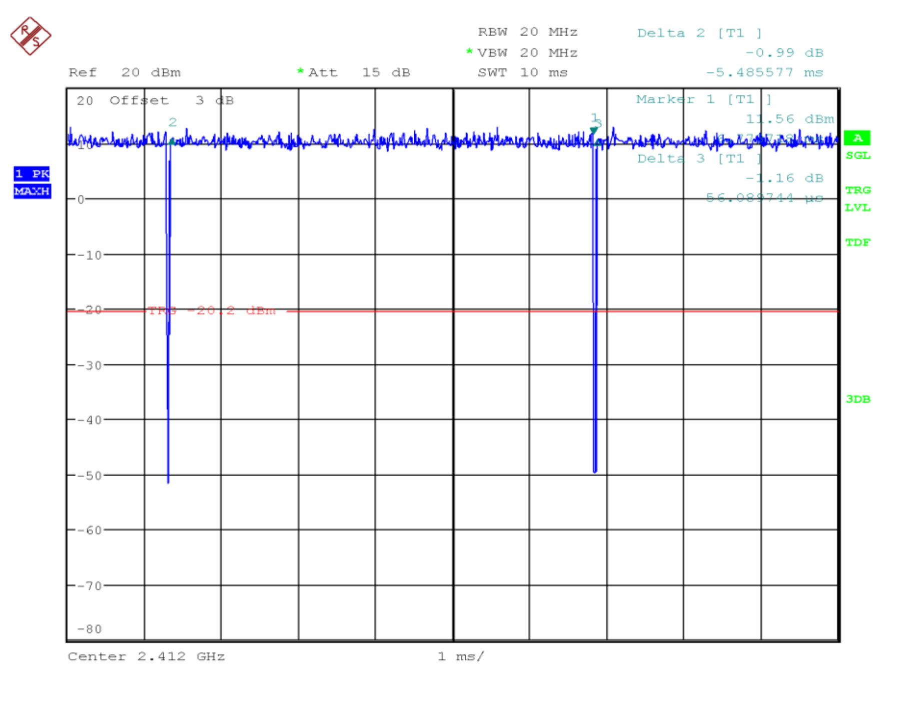
Test Result

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)		
802.11b	11 Mbps	6	100.000	100.000	1.000	0.00	0.50
802.11g	6 Mbps	6	5.486	5.542	0.990	0.04	9.11
802.11n _HT20	MCS 0	6	5.088	5.125	0.993	0.03	9.83
802.11n _HT40	MCS 0	6	2.470	2.502	0.987	0.06	20.25

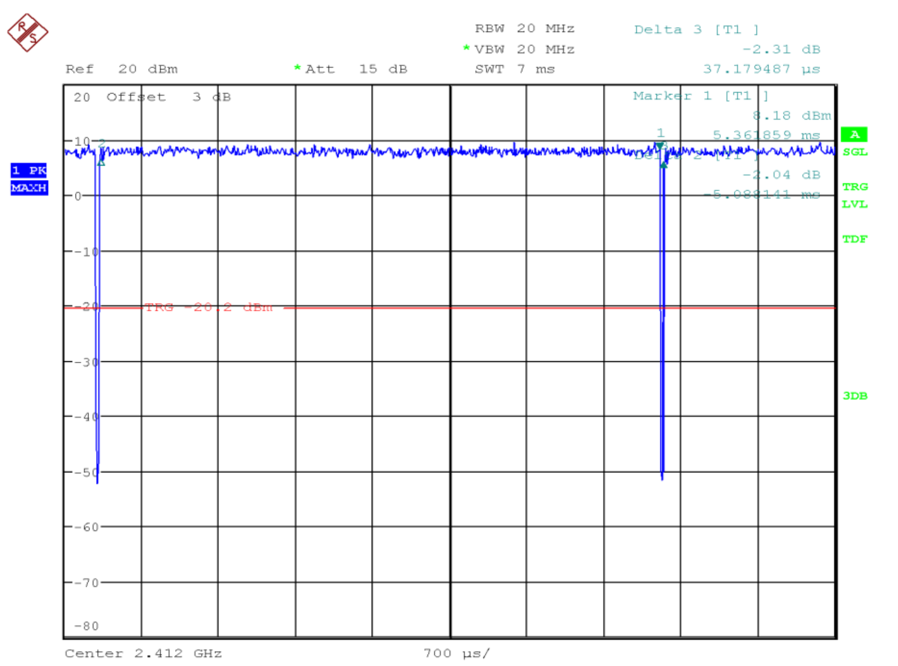
802.11b	Duty Cycle



802.11g	Duty Cycle



802.11n_HT20	Duty Cycle



802.11n_HT40	Duty Cycle