DEKRA Testing and Certification, S.A.U.
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C.I.F. A29 507 456

DEKRA

ISED LISTED REGISTRATION NUMBER 4621A-4

Test report No:
NIE: 59573RRF.001

Test report

USA FCC Part 15.247, 15.209
CANADA RSS-210, RSS-Gen

Radio Frequency Devices. Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz.
Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices.
General Requirements and Information for the Certification of Radio Apparatus.

Identification of item tested	Wi-Fi bgn wireless radio module with embedded full stack.
Trademark	Silicon Labs
Model and /or type reference	WGM160P22N (ordering code WGM160PX22KGN2)
Other identification of the product	FCC ID: QOQWGM160P IC: 5123A-WGM160P
Features	802.11bgn @ 2.4GHz, single spatial stream.
Applicant	SILICON LABORATORIES FINLAND OY Alberga Business Park, Bertel Jungin aukio 3, 02600 Espoo, Finland
Test method requested, standard	USA FCC Part 15.247 10-1-17 Edition: Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.209 10-1-17 Edition: Radiated emission limits; general requirements. CANADA RSS-247 Issue 2 (February 2017). CANADA RSS-Gen Issue 5 (April 2018). Guidance for Performing Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid Systems Devices Operating Under Section 15.247 of the FCC Rules. 558074 D01 Meas Guidance v05 dated August 24, 2018. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	A. Llamas RF Lab. Manager Firmado digitalmente por ALEJANDRO LLAMAS RODRIGUEZ Fecha: 2019.03.12 15:37:26 +01'00'

Date of issue	2019-03-12
Report template No	FDT08_21

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Competences and guarantees

DEKRA Testing and Certification S.A.U. is a testing laboratory accredited by the National Accreditation Body (ENAC -Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 147.

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In order to assure the traceability to other national and international laboratories, DEKRA Testing and Certification S.A.U. has a calibration and maintenance program for its measurement equipment.

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The results presented in this Test Report apply only to the particular item under test established in this document.

General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of DEKRA Testing and Certification S.A.U.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification S.A.U. and the Accreditation Bodies.

Uncertainty

Uncertainty (factor k=2) was calculated according to the DEKRA Testing and Certification S.A.U. internal document PODT000.

Data provided by the client

The test sample consists of a Wi-Fi bgn wireless radio module with embedded full stack.

DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by: The client.

- Sample S/01 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Reception
59573/003	Wi-Fi bgn wireless radio module with embedded full stack	WGM160P22N (ordering code WGM160PX22KGN2)	--	2018/12/27
59573/014	SMA cable	--	--	2018/12/27

Sample S/01 has undergone the following test(s): All CONDUCTED tests indicated in Appendixes A, B.

- Sample S/02 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Reception
59573/004	Wi-Fi bgn wireless radio module with embedded full stack	WGM160P22N (ordering code WGM160PX22KGN2)	--	2018/12/27
59573/010	External Antenna	--	--	2018/12/27
59573/011	External Antenna	--	--	2018/12/27

Sample S/02 has undergone the following test(s): All RADIATED tests indicated in Appendixes A, B.

Test sample description

<table>
<tr><td rowspan="2">Ports……. :</td><td rowspan="2">Port name and description</td><td colspan="4">Cable</td></tr>
<tr><td>Specified max length [m]</td><td>Attached during test</td><td>Shielded</td><td>Coupled to patient(3)</td></tr>
<tr><td></td><td>Module has UART host interface (@115200 with no flow control), which is routed to USB-UART converter of certification board.</td><td></td><td>Yes, to launch the test modes - Can be detached during testing when module is supplied by lab power supply</td><td>☐</td><td>☐</td></tr>
<tr><td rowspan="3">Rated power supply ……:</td><td rowspan="2">Voltage and Frequency</td><td colspan="5">Reference poles</td></tr>
<tr><td>L1</td><td>L2</td><td>L3</td><td>N</td><td>PE</td></tr>
<tr><td>☒</td><td colspan="5">DC: Nominal 3.3V, min 3.0V, max 3.6V</td></tr>
</table>

Rated Power .....:	~0.7W		
Clock frequencies .....:	38.4MHz (RE XTAL), 72MHz (internal processor), 32.768KHz (low freq XTAL) — None of the clocks is exposed to a module's pin.		
Other parameters.....:			
Software version .....:			
Hardware version.....:			
Dimensions in cm (W x H x D)....:	23.8mm x 14.2mm x 2.3mm		
Mounting position.....:	☒	Other: This is an embedded module, meant to be surface-mounted in the PCB of an end-product by OEMs, etc.	
Modules/parts .....:	Module/parts of test item	Type	Manufacturer
Accessories (not part of the test item).....:	Description	Type	Manufacturer
	2 x External dipole antenna		
	2 x 50-Ohm Termination		
	SMA to U.FL terminated coax cables		
	WSTK evaluation board to be used as flash programmer if needed		
Documents as provided by the applicant.....:	Description	File name	Issue date
	Descriptions of test items and accessories and tools, plus instructions for testing.		

(3) Only for Medical Equipment

Identification of the client

SILICON LABORATORIES FINLAND OY

Alberga Business Park, Bertel Jungin aukio 3, 02600 Espoo, Finland.

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2019-01-08
Date (finish)	2019-02-01

Document history

Report number	Date	Description
59573RRF.001	2019-03-12	First release

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %
Shielding effectiveness	> 100 dB
Electric insulation	> 10 kΩ
Reference resistance to earth	< 1 Ω

In the semianechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Electric insulation	> 10 kΩ
Reference resistance to earth	< 1 Ω
Normal site attenuation (NSA)	< ±4 dB at 10 m distance between item under test and receiver antenna, (30 MHz to 1000 MHz)
Field homogeneity	More than 75% of illuminated surface is between 0 and 6 dB (26 MHz to 1000 MHz).

In the chamber for conducted measurements, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 35 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Electric insulation	> 10 kΩ
Reference resistance to earth	< 1 Ω

Remarks and comments

-The tests have been performed by the technical personnel: Miguel Ángel Torres, José Manuel Jiménez González, Verónica García Capilla, José Gabriel Pendón.

-Used instrumentation:

Conducted Measurements:

		Last Calibration	Due Calibration
1.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV40	2017/07	2019/07
2.	DC Power Supply 40V/40A Rohde & Schwarz NGPE40	2018/02	2021/02
3.	Wideband Power sensor Rohde & Schwarz NRP-Z81	2017/04	2019/04

Radiated Measurements:

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP	N.A.	N.A.
2.	EMI Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2018/10	2020/10
3.	RF Pre-amplifier, 38 dB, 30 MHz-6 GHz BONN ELEKTRONIK BLNA 0360-01N	2018/07	2019/07
4.	Biconical/Log Antenna 30 MHz - 6 GHz ETS LINDGREN 3142E	2018/07	2021/07
5.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV 40	2018/02	2020/02
6.	Pre-amplifier G>30dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-3A	2018/03	2019/03
7.	RF Pre-amplifier, G>48dB, 18-40GHz NARDA JS44-18004000-33-8P	2018/02	2020/02
8.	Broadband Horn antenna 1-18GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2018/01	2021/01
9.	Broadband Horn antenna 18 - 40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2018/07	2021/07

-Manufacturer's statement:

Description of WGM160P Variants and of Low Freq Crystal Oscillator Functionality

In the WGM160P family of Wi-Fi modules, four variants exist, and the manufacturing differences are described in the following table:

- Integral chip antenna assembled and connected to primary RF port - 32kHz crystal assembled - Orderable part number: WGM160PX22KGA2 - Known as "A" variant with generic model name: WGM160P22A	- Integral chip antenna not assembled: external antenna(s) required for normal operations - 32kHz crystal assembled - Orderable part number: WGM160PX22KGN2 - Known as "N" variant with generic model name: WGM160P22N
- Integral chip antenna assembled and connected to primary RF port - 32kHz crystal not assembled - Orderable part number: WGM160P022KGA2 - Known as "A" variant with generic model name: WGM160P22A	- Integral chip antenna not assembled: external antenna(s) required for normal operations - 32kHz crystal not assembled - Orderable part number: WGM160P022KGN2 - Known as "N" variant with generic model name: WGM160P22N

A 32.768kHz crystal is connected to the microcontroller inside the module, which contains a low-frequency crystal oscillator being used as the sleep clock for the power saving modes of the module. The microcontroller feeds the buffered 32kHz clock signal to the radio chip which uses it to schedule its sleep periods between RF operation periods.

A variant with the 32.768kHz crystal not assembled in production is provided to reduce the module cost, for customers for whom the power consumption is not as important as the cost. In the variants where the crystal has not been assembled, the software will detect its absence and will configure the microcontroller first, and consequently the radio chipset, to use internal RC clocks for sleep timing. The radio listen periods will be widened too, due to the lower timing precision, with the only side effect of increasing the average current consumption.

All RF operation is correlated to a separate, high precision, thermally compensated, crystal which is connected to the radio chipset, and which is used among others for all precision timings required by the radio communication. Nothing that affects radio operation depends on the low frequency crystal.

The printed circuit board with all the variants is identical, as is the software and all settings.

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Phone: +358 9 435 5060
www.silabs.com

Testing verdicts

Not applicable:	N/A
Pass:	P
Fail:	F
Not measured:	N/M

Summary

WiFi 2.4 GHz (802.11b/g/n).

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		**Verdict**	**Remark**
Section 15.247 Subclause (a) (2) / RSS-247 5.2. (a)	6 dB Bandwidth	P	
Section 15.247 Subclause (b) / RSS-247 5.4. (d)	Maximum output power and antenna gain	P	
Section 15.247 Subclause (d) / RSS-247 5.5	Emission limitations conducted (Transmitter)	P	
Section 15.247 Subclause (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)	P	
Section 15.247 Subclause (e) / RSS-247 5.2. (b)	Power spectral density	P	
Section 15.247 Subclause (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)	P	
Supplementary information and remarks: None.			

Appendix A: Test results. RF interface 1.

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TEST CONDITIONS

POWER SUPPLY (V):

V nonimal:	3.3 Vdc
Type of power supply:	DC voltage.
Type of Antenna:	External dipole.
Declared Antenna Gain:	2.14 dBi

TEST FREQUENCIES:

Low Channel:	2412 MHz
Middle Channel:	2437 MHz
High Channel:	2462 MHz

CONDUCTED MEASUREMENTS

The equipment under test was set up in a shielded room and it is connected to the spectrum analyser using a low loss RF cable. The reading of the spectrum analyser is corrected taking into account the cable loss.

RADIATED MEASUREMENTS

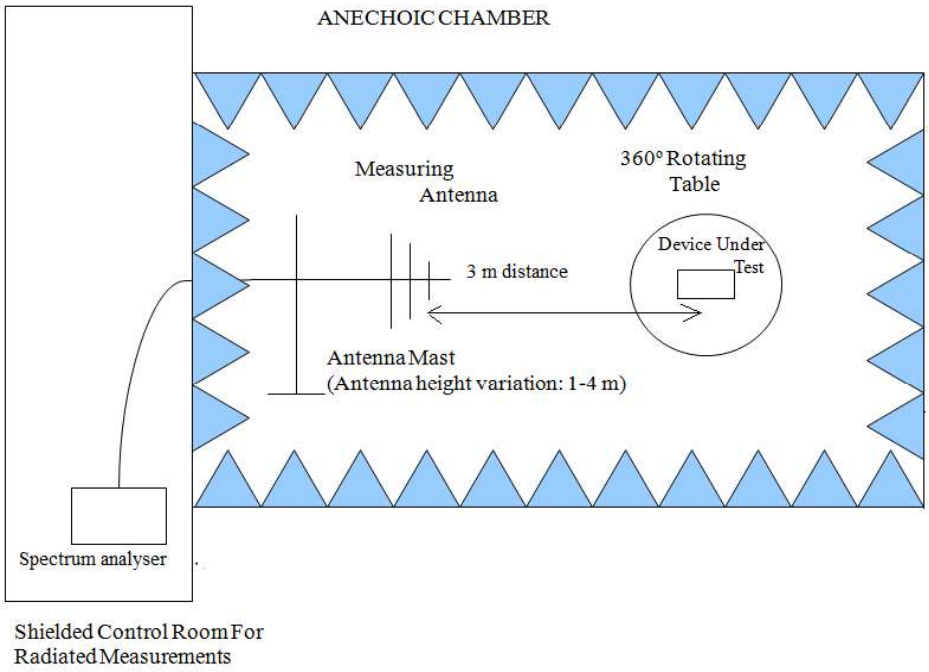
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz) is situated at a distance of 3 m and at a distance of 1m for the frequency range 1 GHz-26 GHz (1 GHz-18 GHz Double ridge horn antenna and 18 GHz-40 GHz horn antenna).

For radiated emissions in the range 1 GHz-26 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

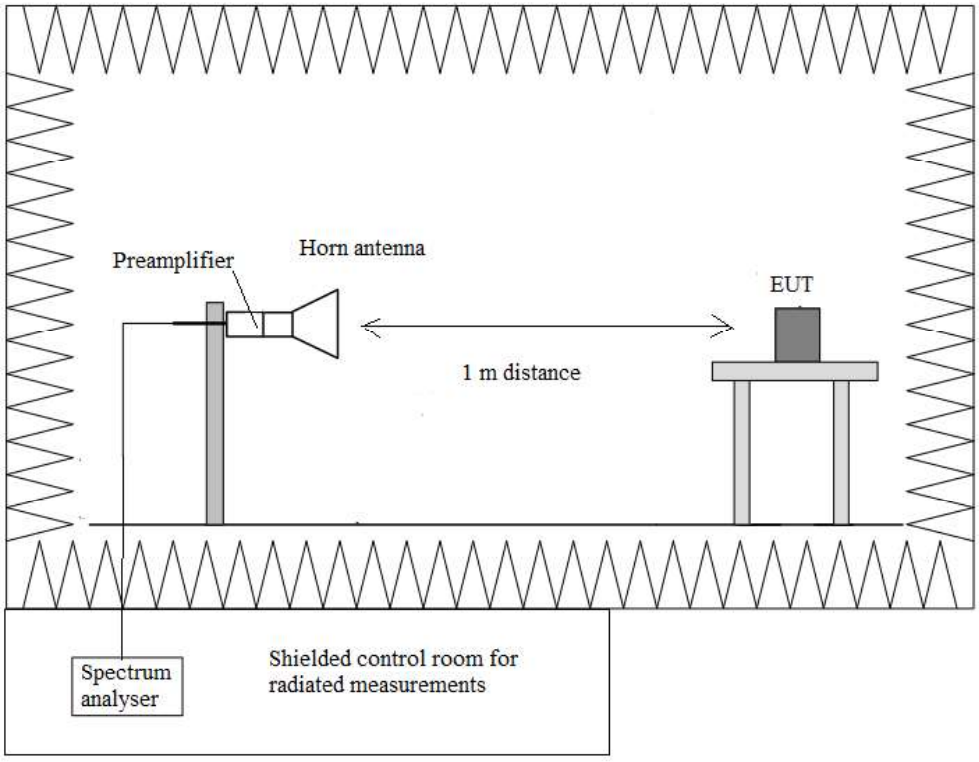
The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find the maximum radiated emission.

Measurements were made in both horizontal and vertical planes of polarization.

Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup f > 1 GHz:



Occupied Bandwidth

RESULTS:

- **Mode 802.11 b**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% bandwidth (MHz)	13.05	13.45	13.10
Measurement uncertainty (kHz)	<± 28.03		

- **Mode 802.11 g**

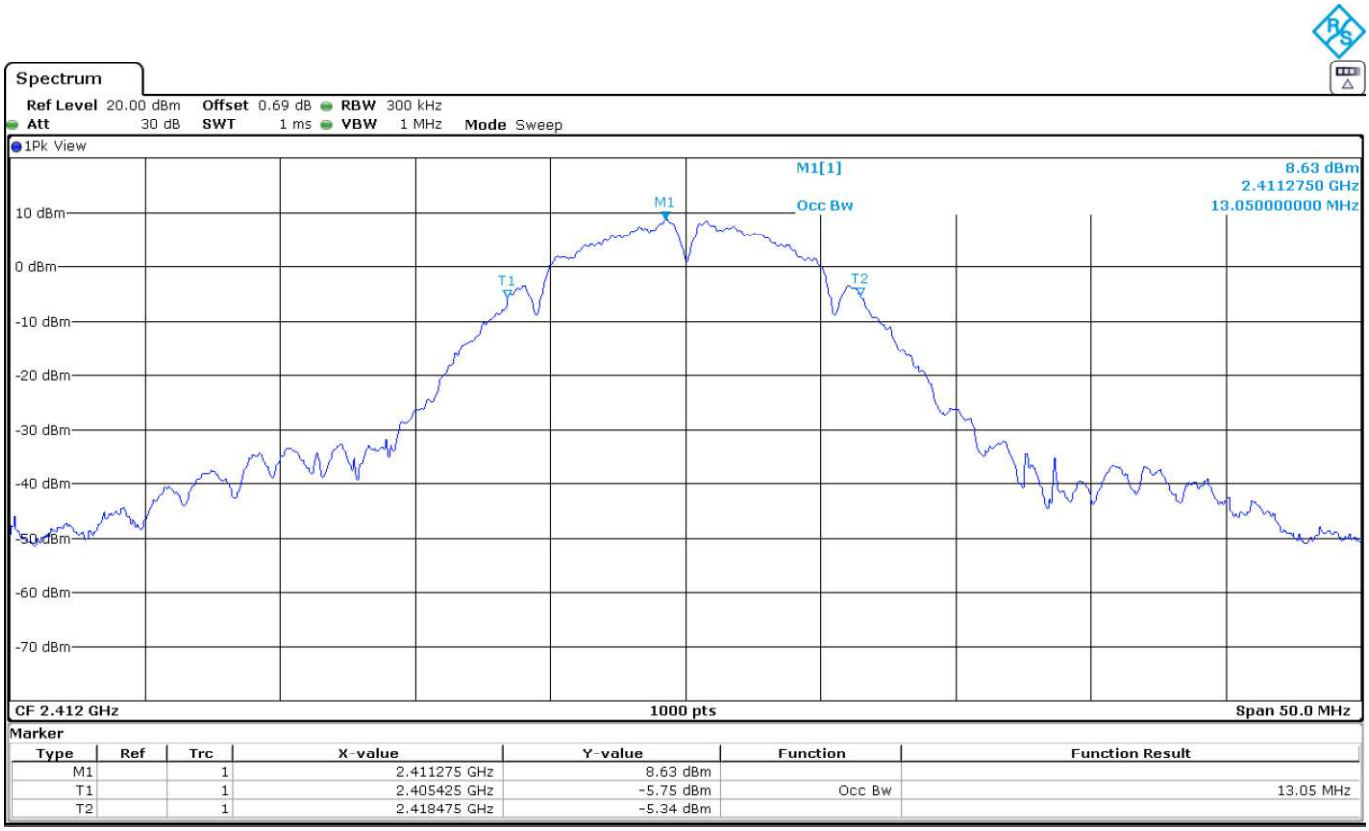
	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% bandwidth (MHz)	16.75	24.25	16.75
Measurement uncertainty (kHz)	<± 28.03		

- **Mode 802.11 n20**

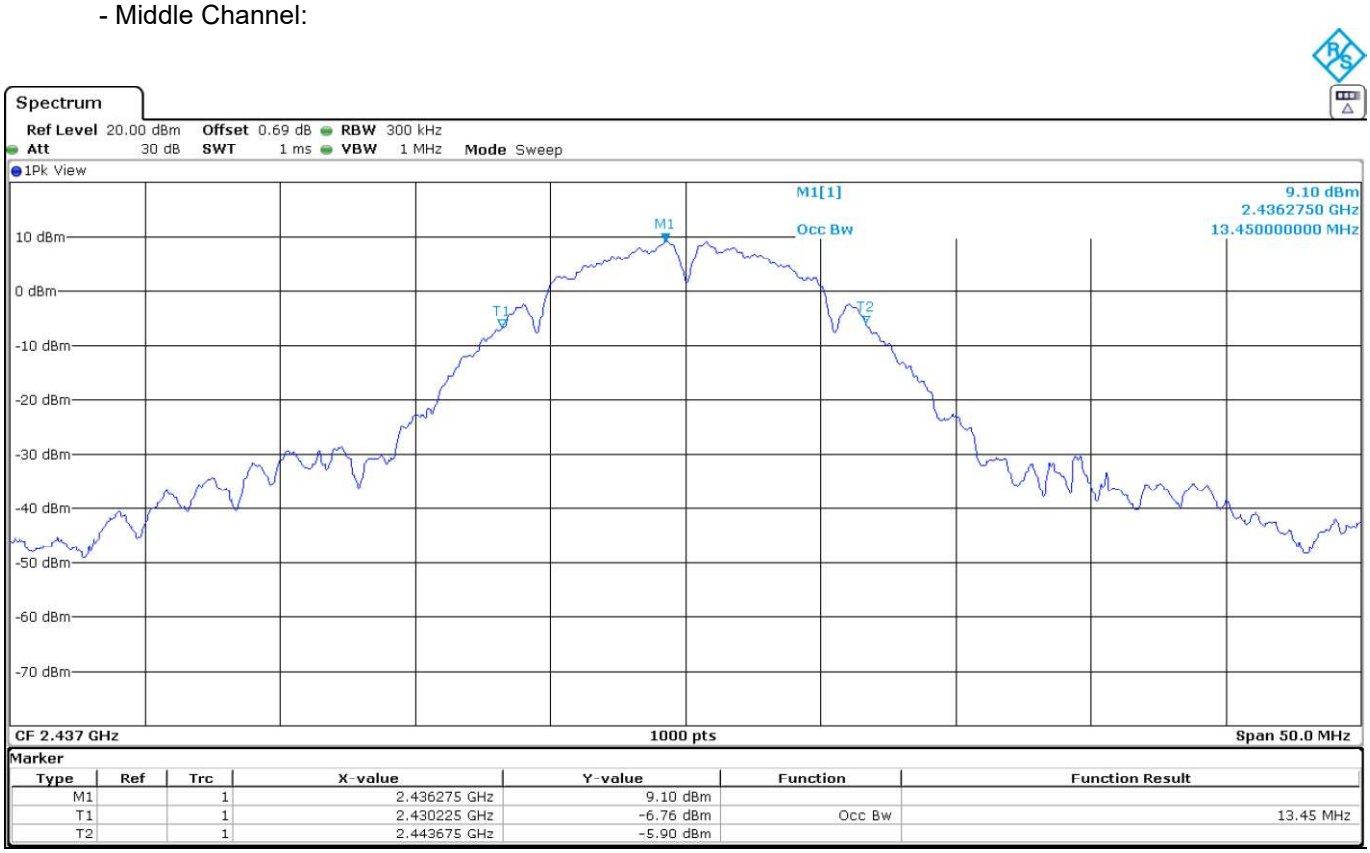
	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% bandwidth (MHz)	17.65	24.15	17.60
Measurement uncertainty (kHz)	<± 28.03		

- **Mode 802.11 b – Occupied Bandwidth**

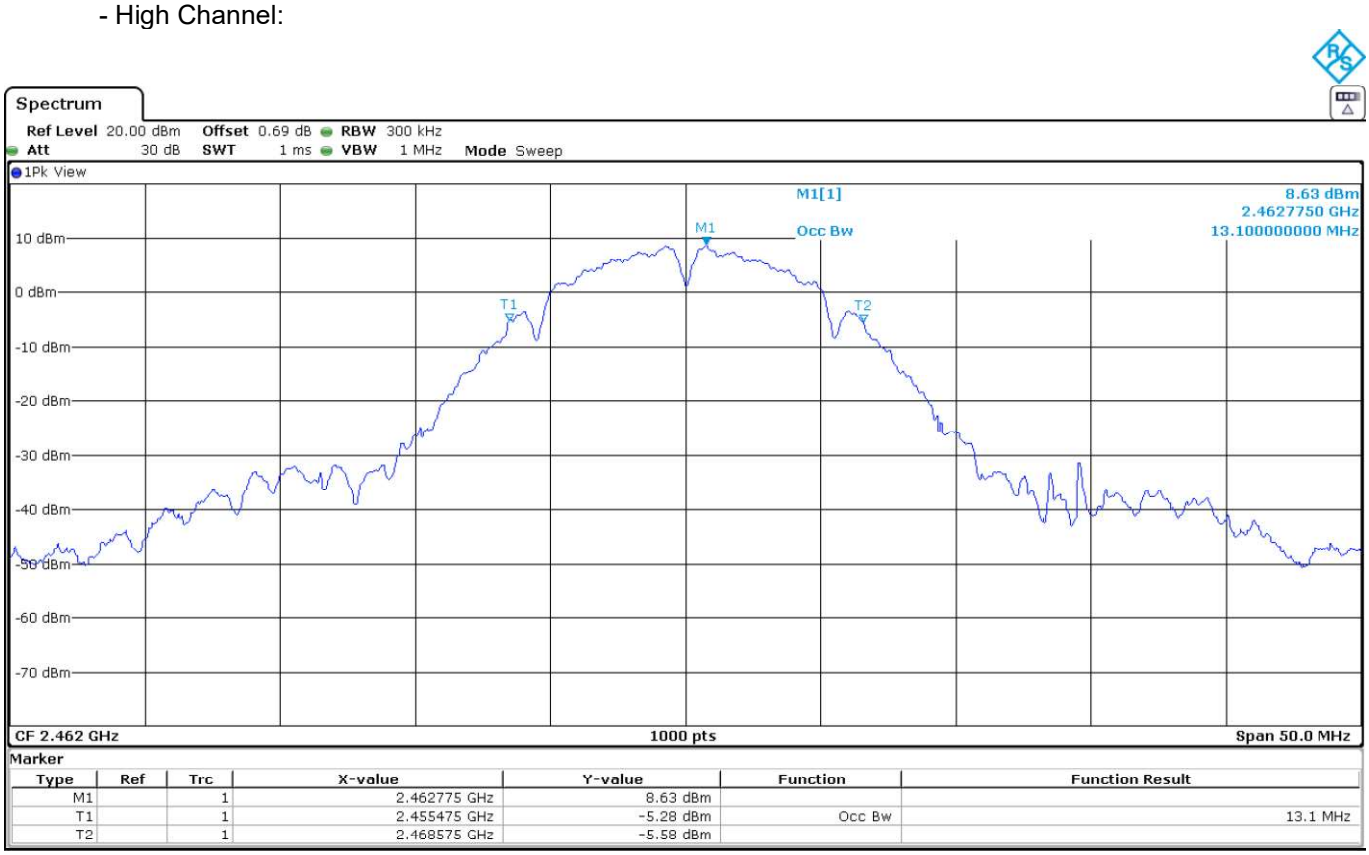
- Low Channel:



- Middle Channel:



- High Channel:

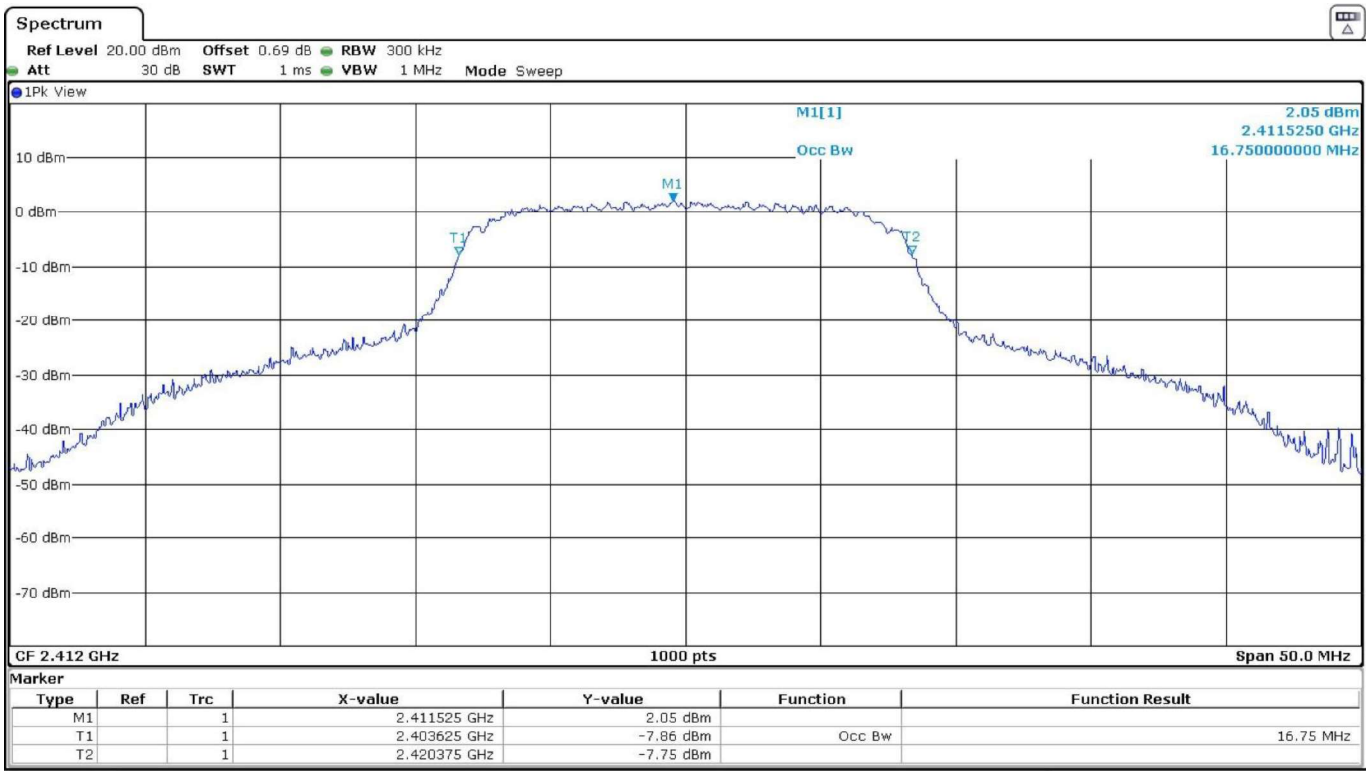


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.462775 GHz	8.63 dBm		
T1		1	2.455475 GHz	-5.28 dBm	Occ Bw	13.1 MHz
T2		1	2.468575 GHz	-5.58 dBm		

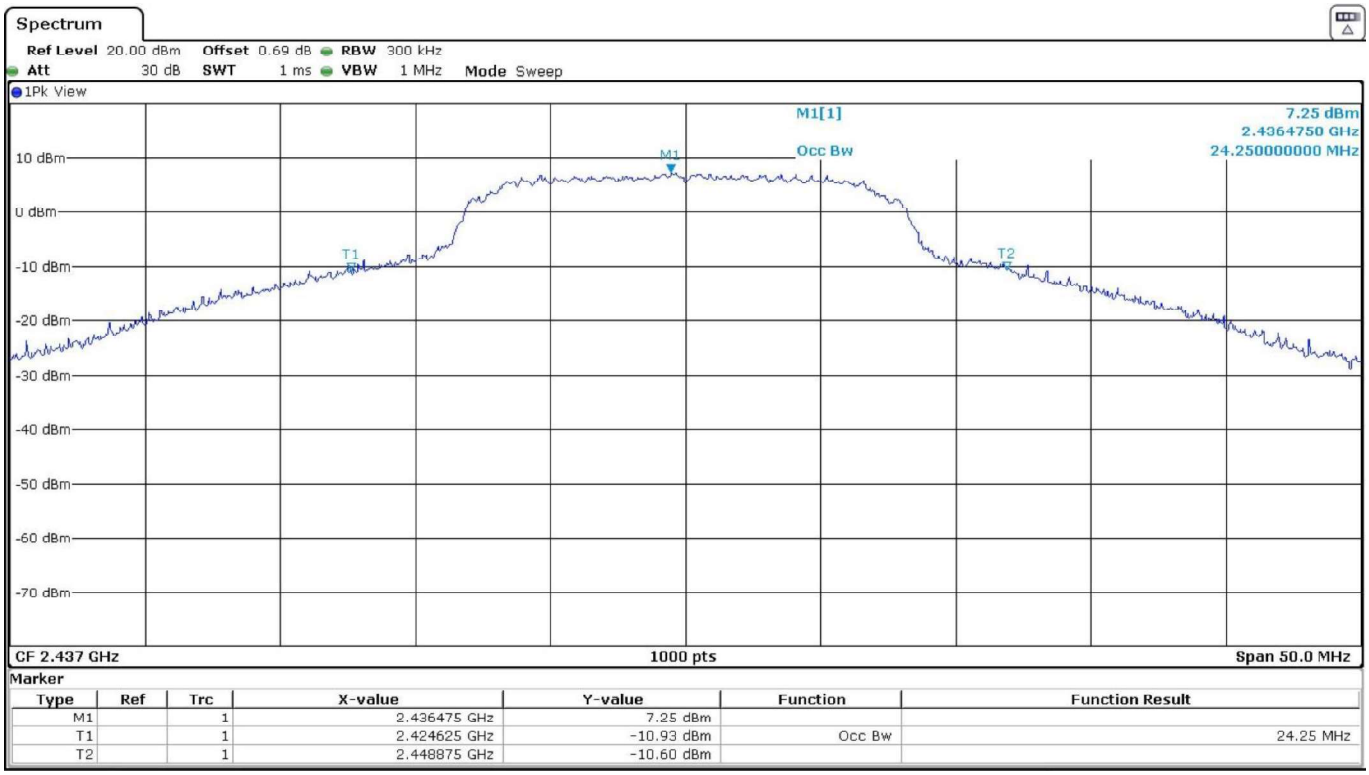
- **Mode 802.11 g – Occupied Bandwidth**

- Low Channel:



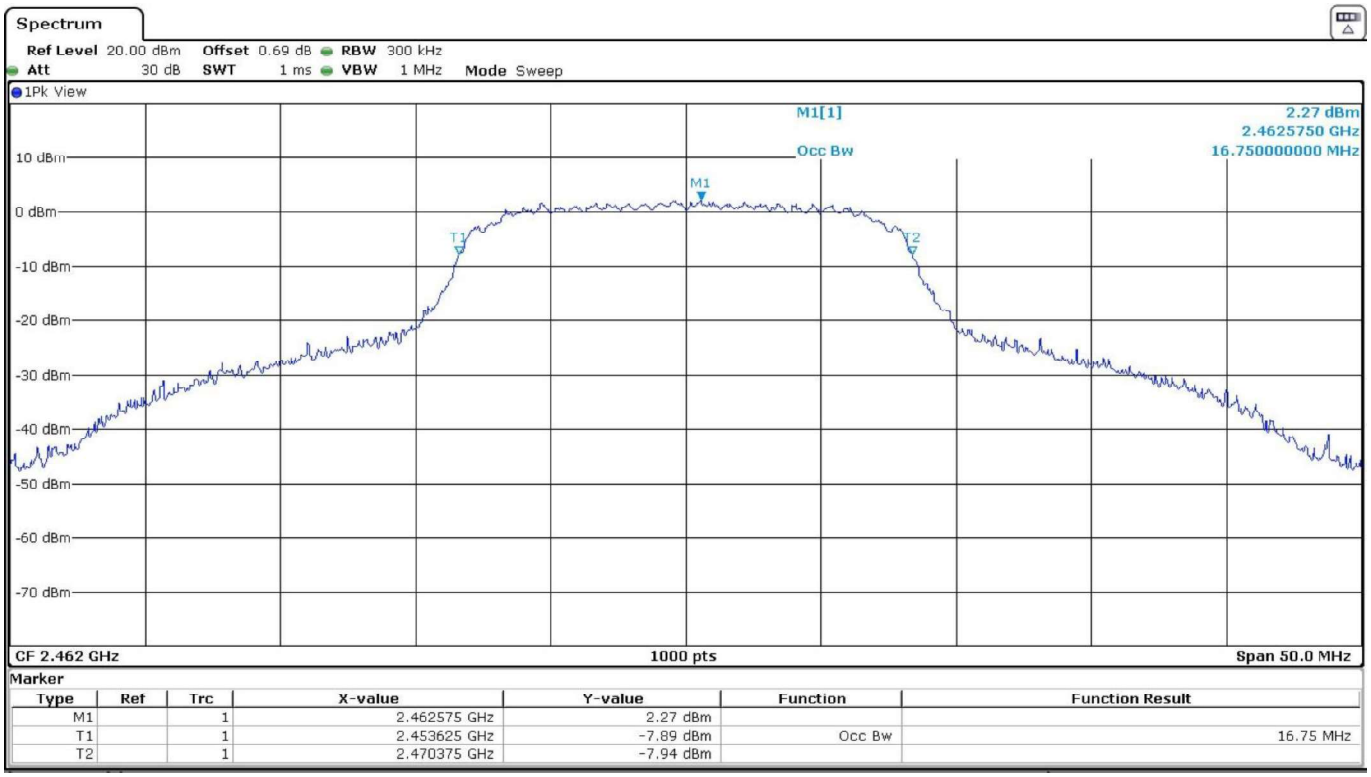
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.411525 GHz	2.05 dBm		
T1		1	2.403625 GHz	-7.86 dBm	Occ Bw	16.75 MHz
T2		1	2.420375 GHz	-7.75 dBm		

- Middle Channel:



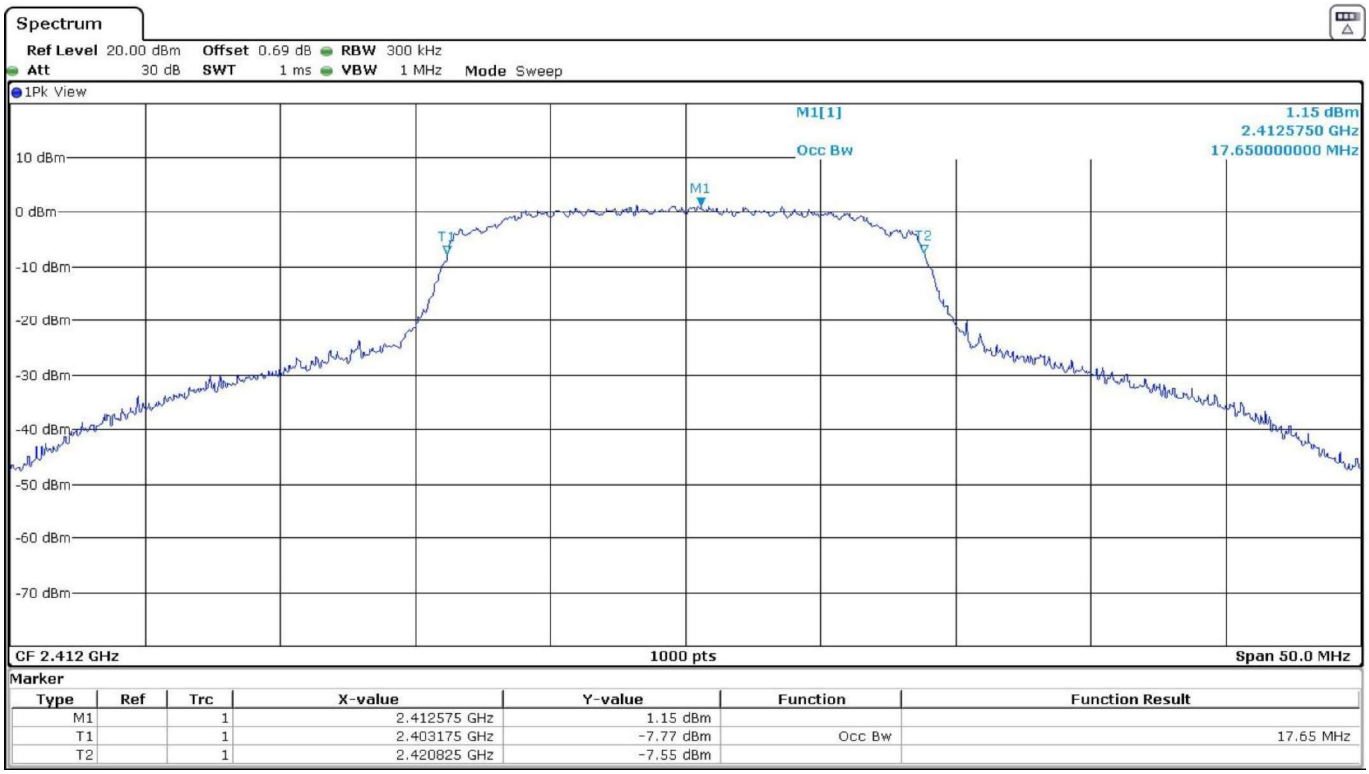
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.436475 GHz	7.25 dBm		
T1		1	2.424625 GHz	-10.93 dBm	Occ Bw	24.25 MHz
T2		1	2.448875 GHz	-10.60 dBm		

- High Channel:

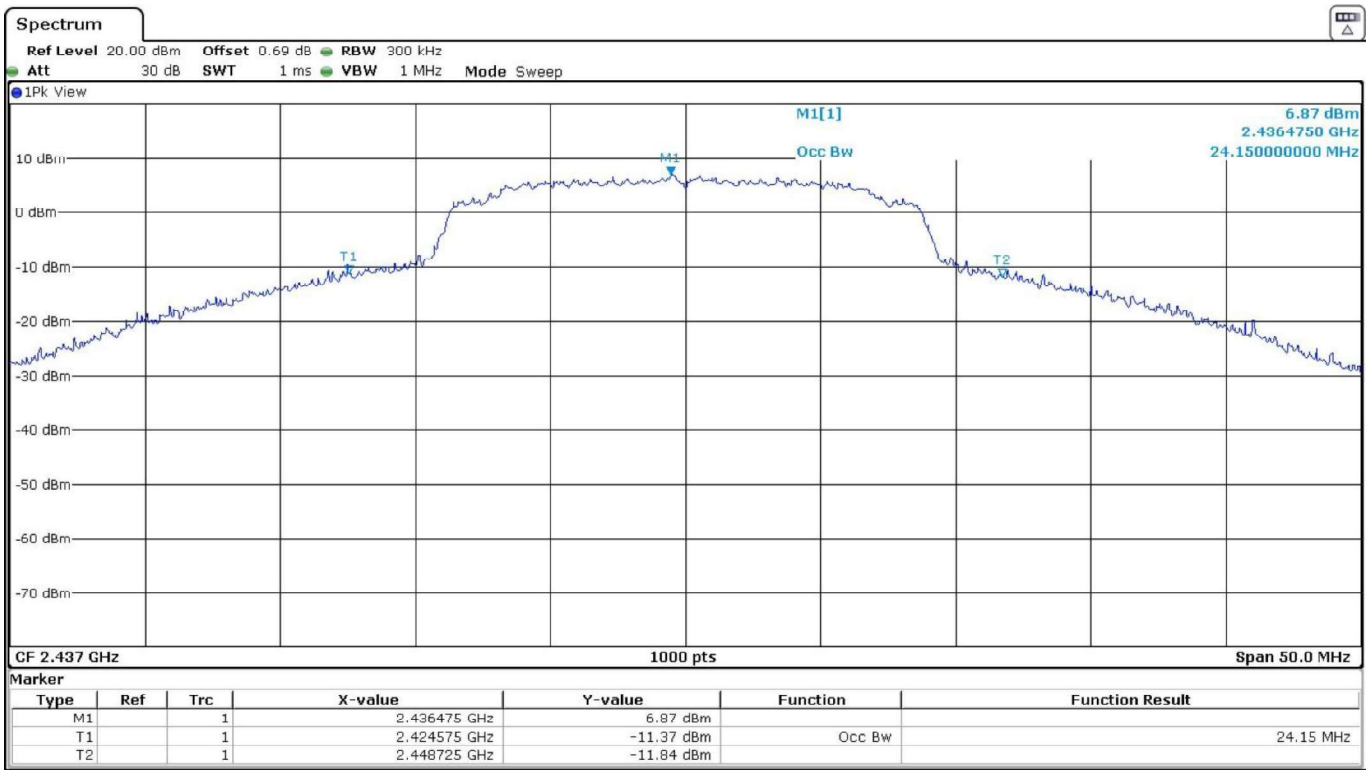


- **Mode 802.11 n20 – Occupied Bandwidth**

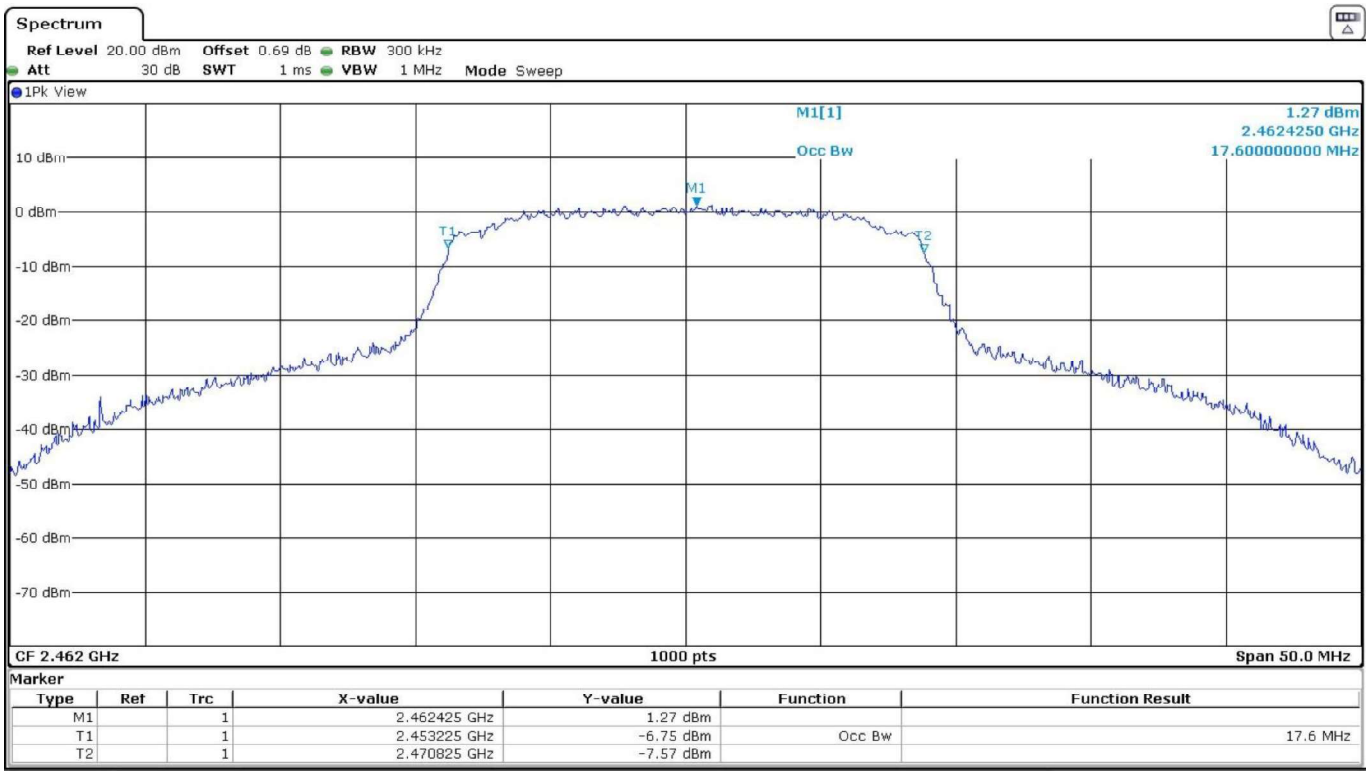
- Low Channel:



- Middle Channel:



- High Channel:



FCC Section 15.247 Subclause (a) (2) / RSS-247 Clause 5.2 (a) 6 dB Bandwidth.

SPECIFICATION:

The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS:

- **Mode 802.11 b**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum andwidth (MHz)	8.094	7.958	7.960
Measurement uncertainty (kHz)	<±11.01		

- **Mode 802.11 g**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum bandwidth (MHz)	15.116	15.076	15.119
Measurement uncertainty (kHz)	<±11.01		

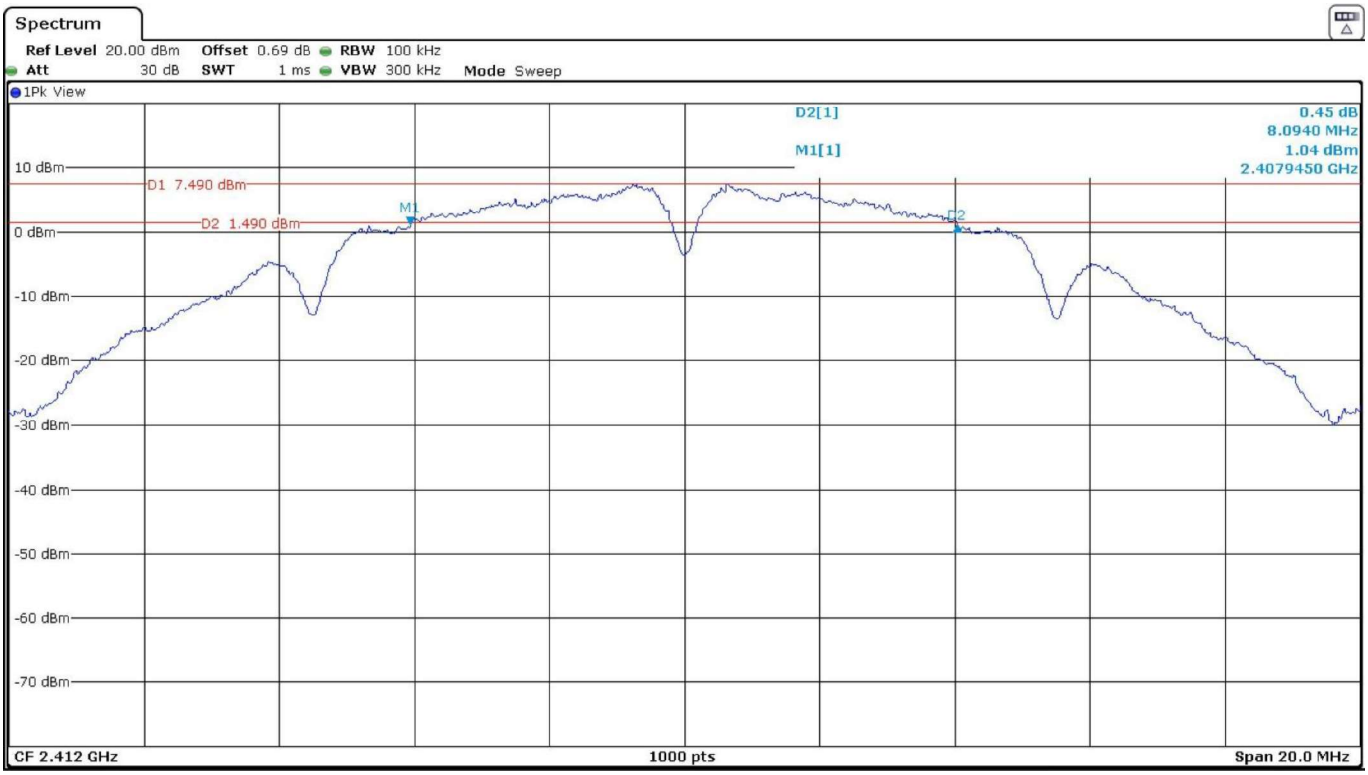
- **Mode 802.11 n20**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum bandwidth (MHz)	15.123	15.709	14.597
Measurement uncertainty (kHz)	<±11.01		

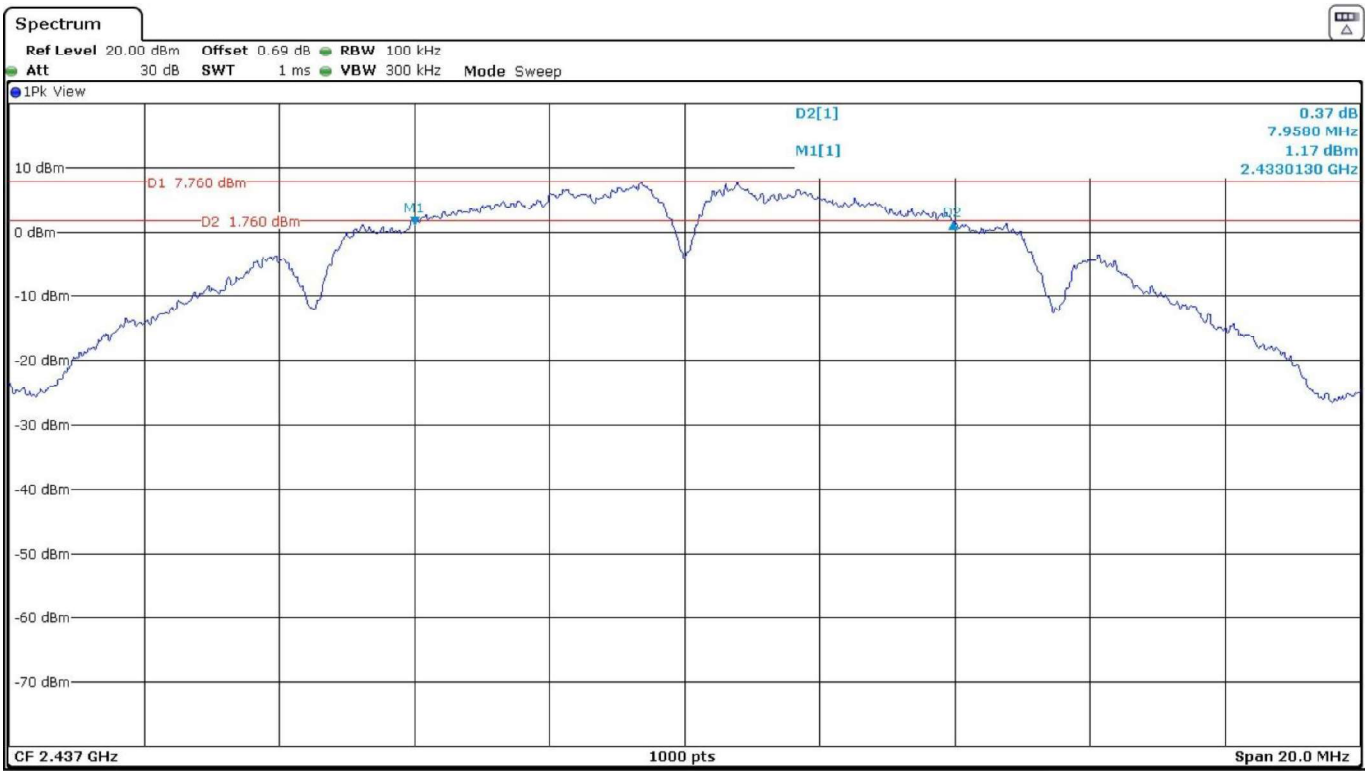
Verdict: PASS

- **Mode 802.11 b – 6 dB Bandwidth**

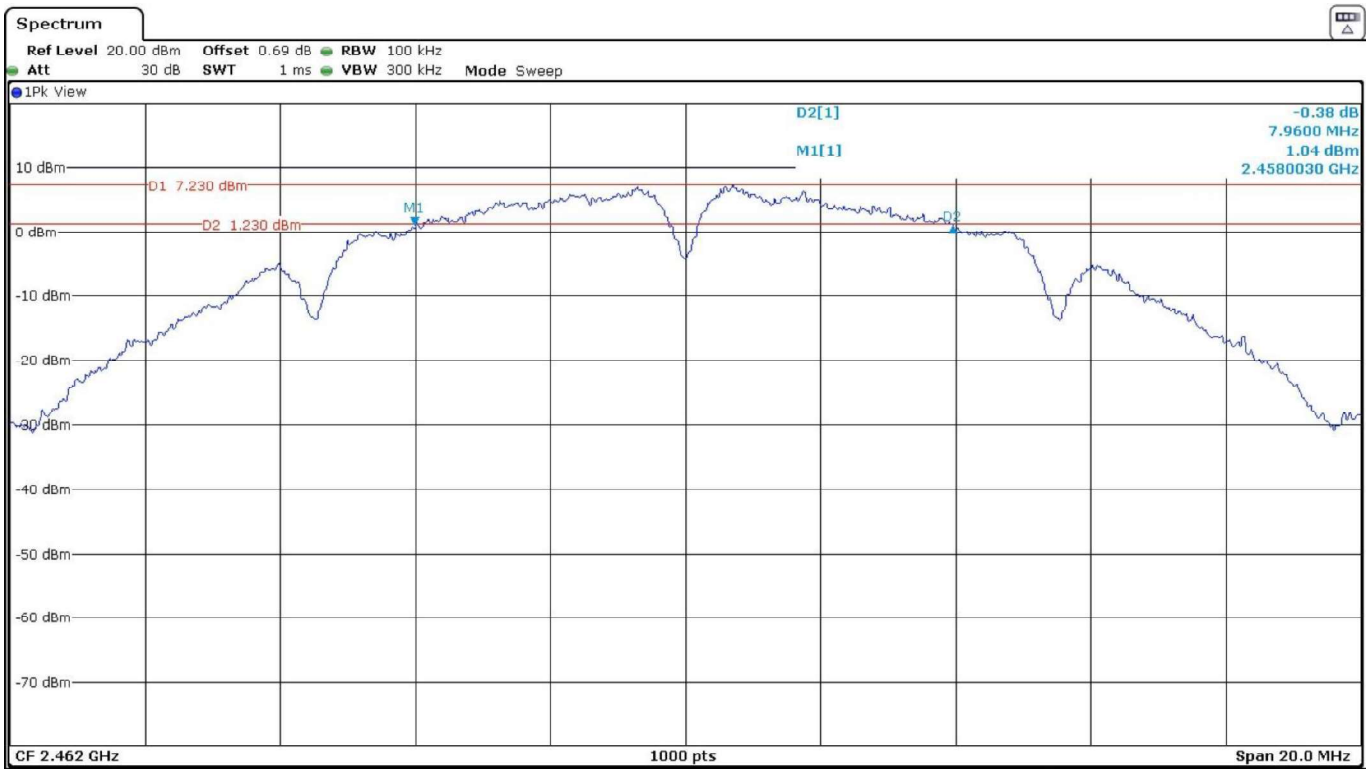
- Low Channel:



- Middle Channel:

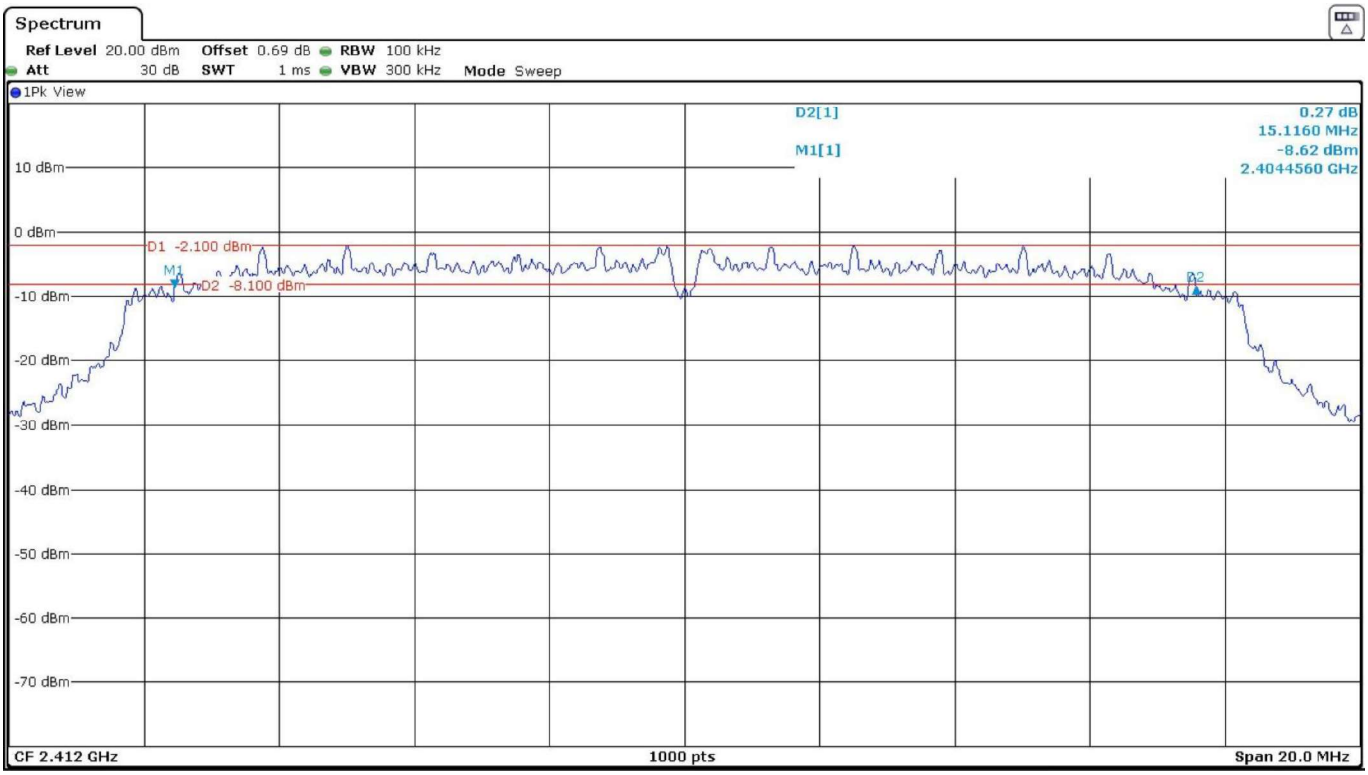


- High Channel:

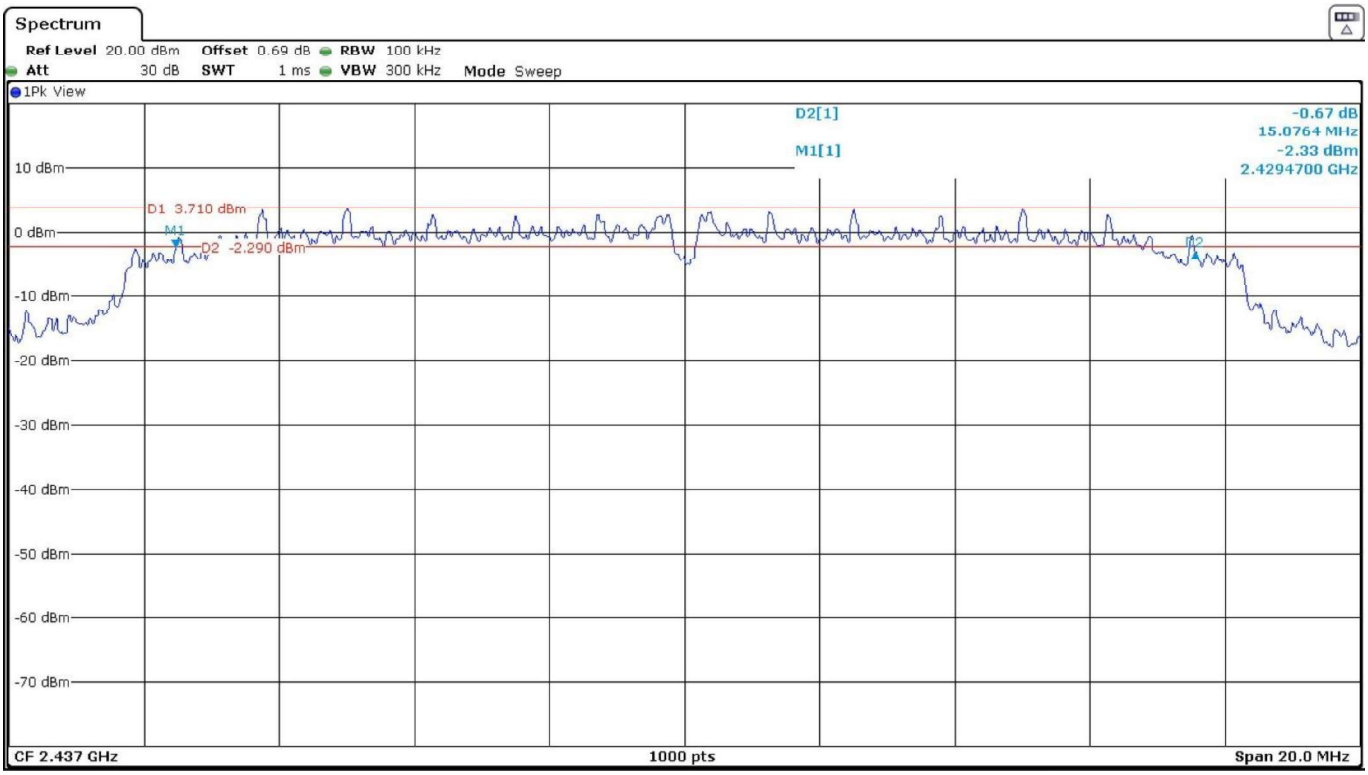


- **Mode 802.11 g – 6 dB Bandwidth**

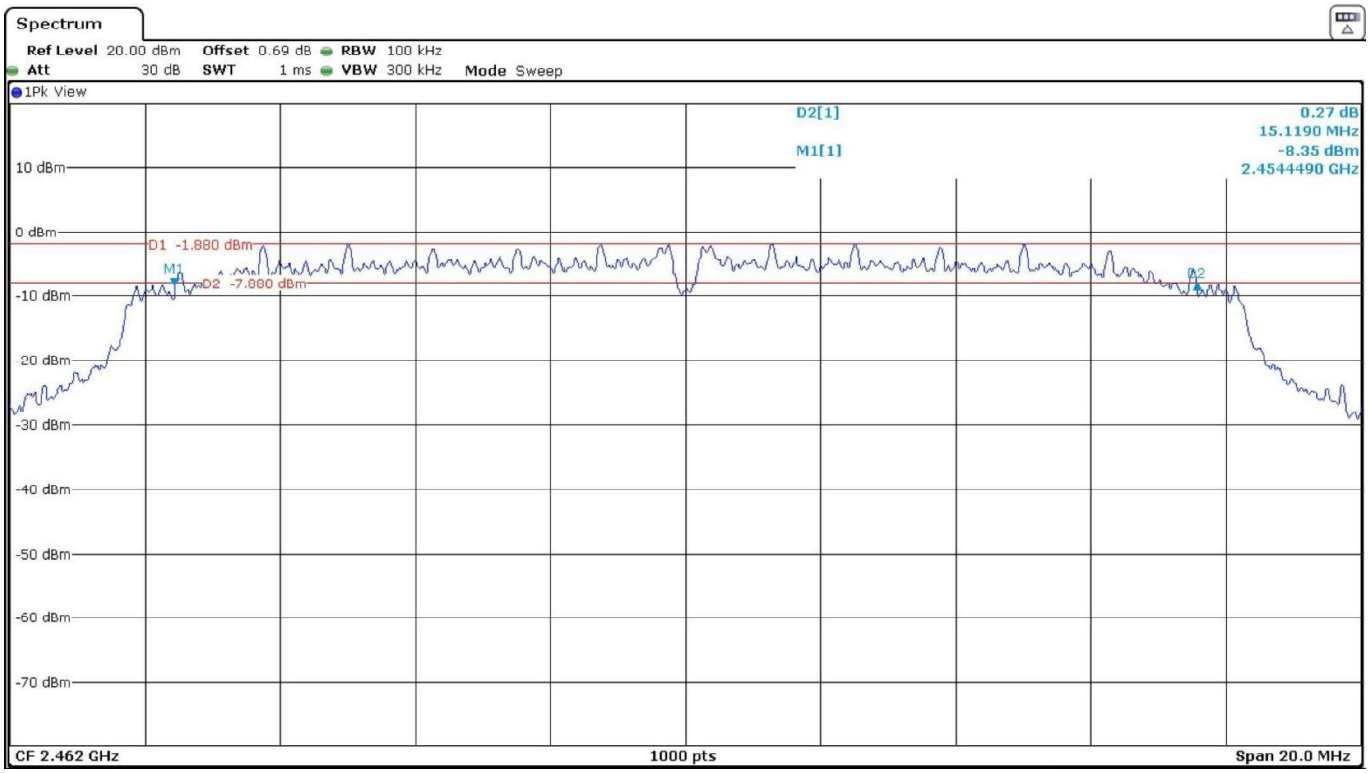
- Low Channel:



- Middle Channel:

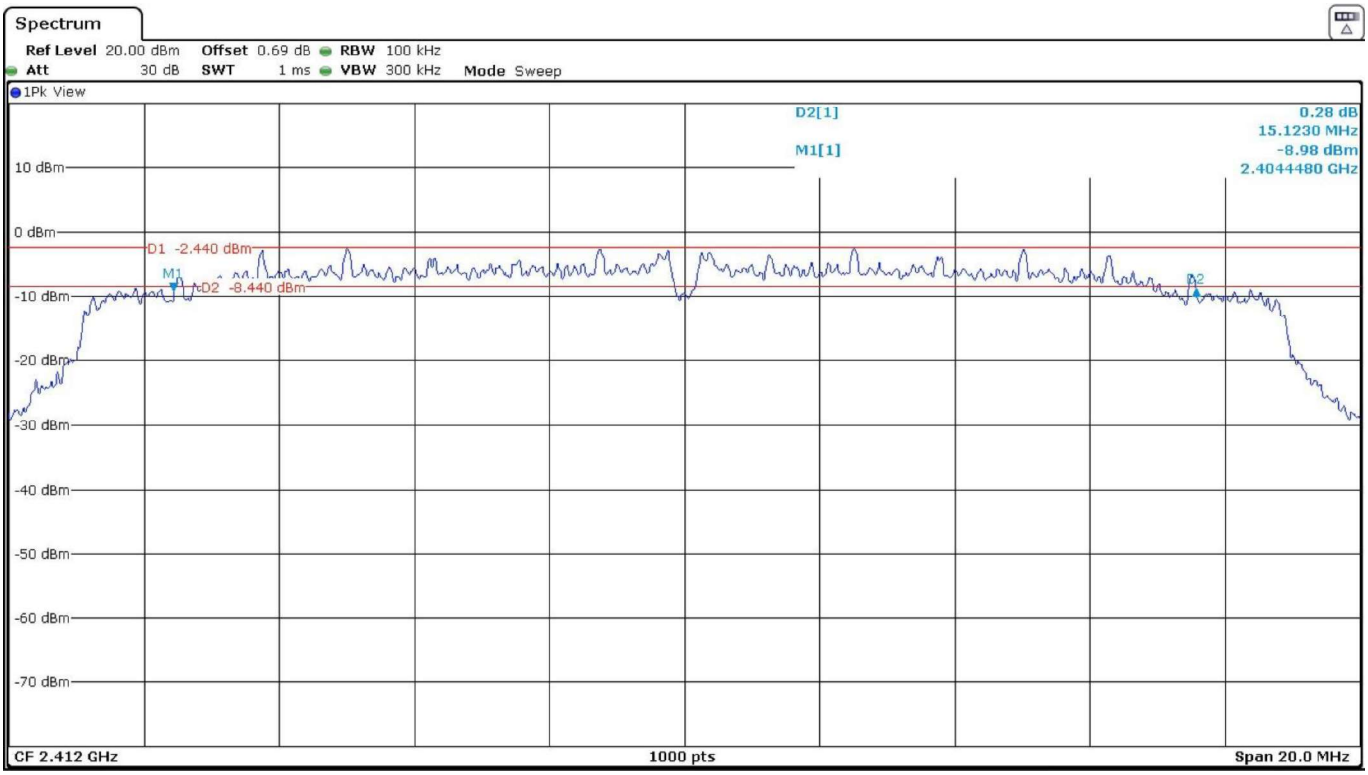


- High Channel:

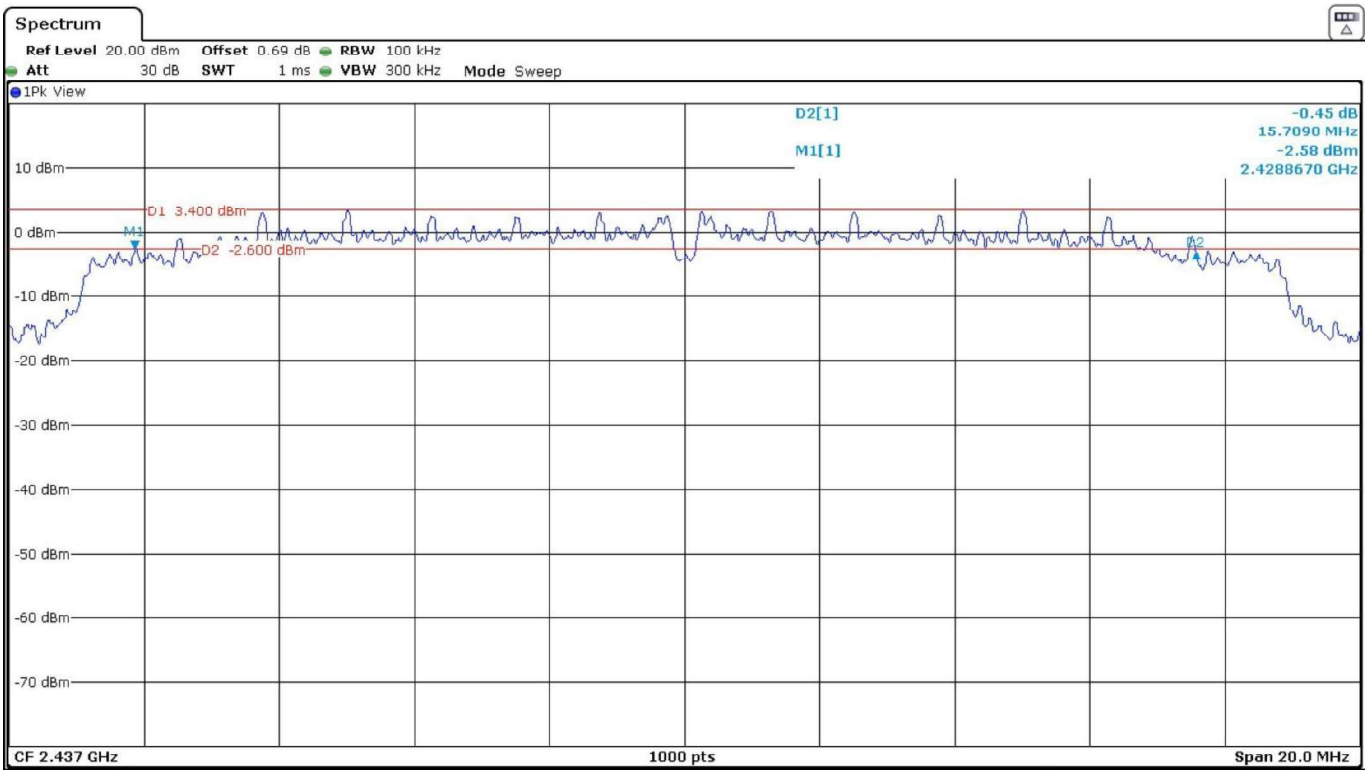


- **Mode 802.11 n20 – 6 dB Bandwidth**

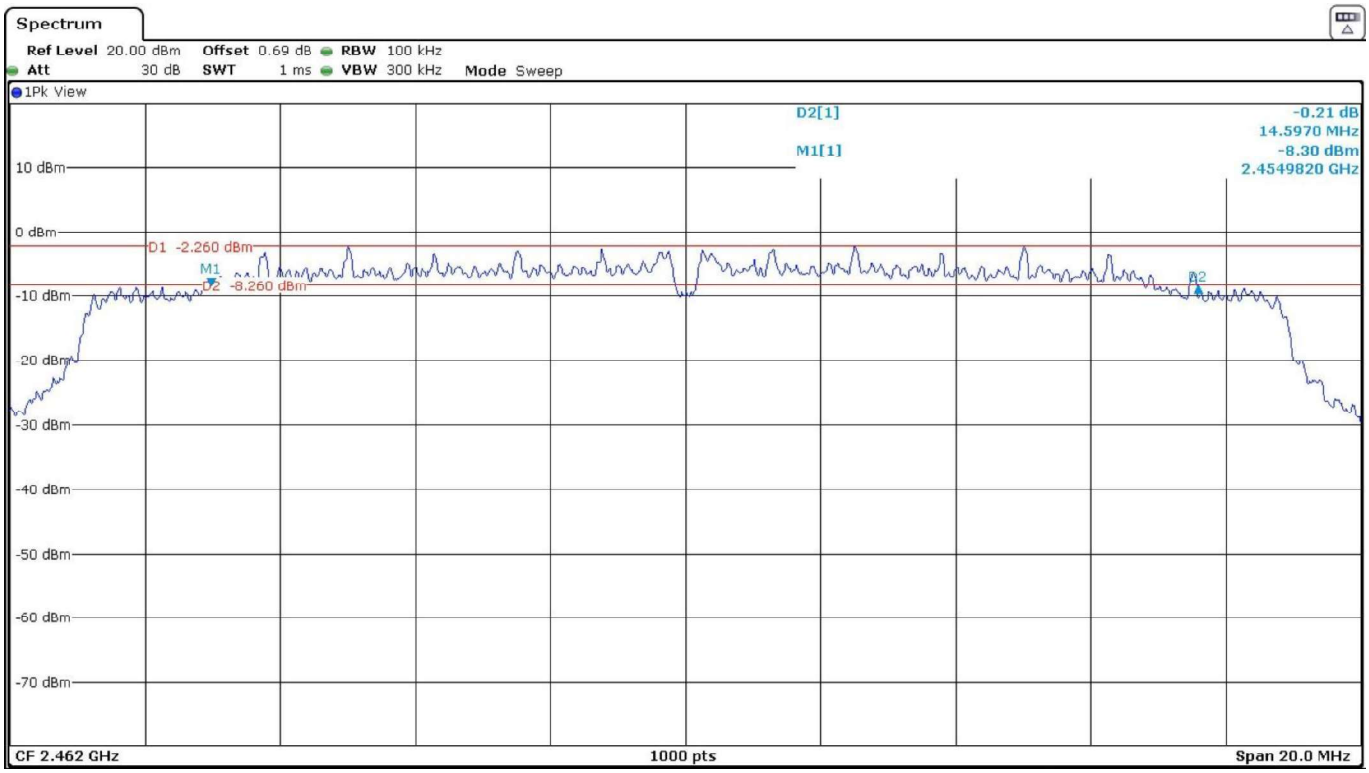
- Low Channel:



- Middle Channel:



- High Channel:



FCC Section 15.247 Subclause (b) / RSS-247 Clause 5.4 (d) Maximum output power and antenna gain

SPECIFICATION:

For systems using digital modulation in the 2400-2483.5 MHz band: 1 watt (30 dBm).
The e.i.r.p. shall not exceed 4 W (36 dBm) (Canada).

RESULTS:

For all modes, the maximum conducted output power was measured using the method according to point 11.9.1.3 “PKPM1 Peak power meter method” of ANSI C.63.10-2013.

The EIRP power (dBm) is calculated by adding the declared maximum antenna gain to the measured conducted power.

Maximum declared antenna gain: 2.14 dBi.

The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

- **Mode 802.11 b**

Peak Conducted Output Power	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Conducted Power (dBm)	17.91	18.43	17.76
Maximum EIRP Power (dBm)	20.05	20.57	19.90
Measurement uncertainty (dB)	<±0.33		

- **Mode 802.11 g**

Peak Conducted Output Power	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Conducted Power (dBm)	14.72	18.82	14.52
Maximum EIRP Power (dBm)	16.86	20.96	16.66
Measurement uncertainty (dB)	<±0.33		

- **Mode 802.11 n20**

Peak Conducted Output Power	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Conducted Power (dBm)	13.91	18.81	14.11
Maximum EIRP Power (dBm)	16.05	20.95	16.25
Measurement uncertainty (dB)	<±0.33		

Verdict: PASS

FCC Section 15.247 Subclause (d) / RSS-247 Clause 5.5. Emission limitations conducted (Transmitter)

SPECIFICATION:

In any 100 kHz bandwidths outside the frequency band in which the 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, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

RESULTS:

- **Mode 802.11 b**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Reference Level Measurement (dBm)	7.3	8.13	6.95
Measurement uncertainty (dB)	<±1.56		

No spurious peaks were found at less than 20 dB below the limit.

- **Mode 802.11 g**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Reference Level Measurement (dBm)	-1.79	3.82	-1.81
Measurement uncertainty (dB)	<±1.56		

No spurious peaks were found at less than 20 dB below the limit.

- **Mode 802.11 n20**

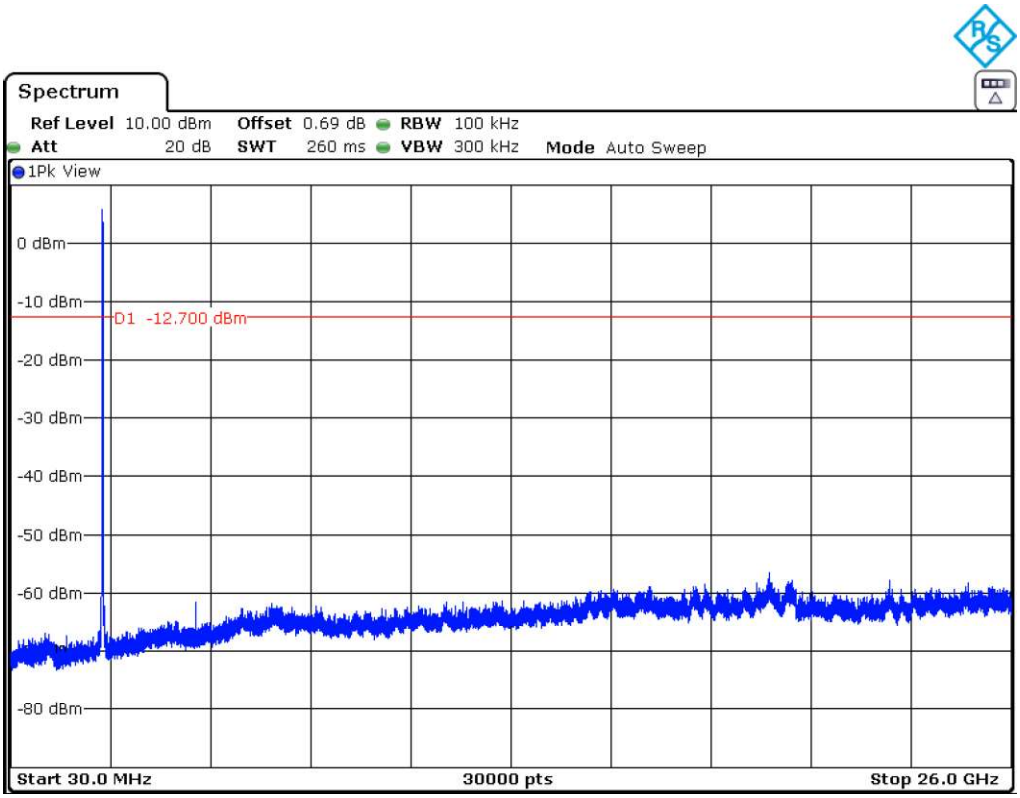
	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Reference Level Measurement (dBm)	-2.17	3.61	-2.75
Measurement uncertainty (dB)	<±1.56		

No spurious peaks were found at less than 20 dB below the limit.

Verdict: PASS

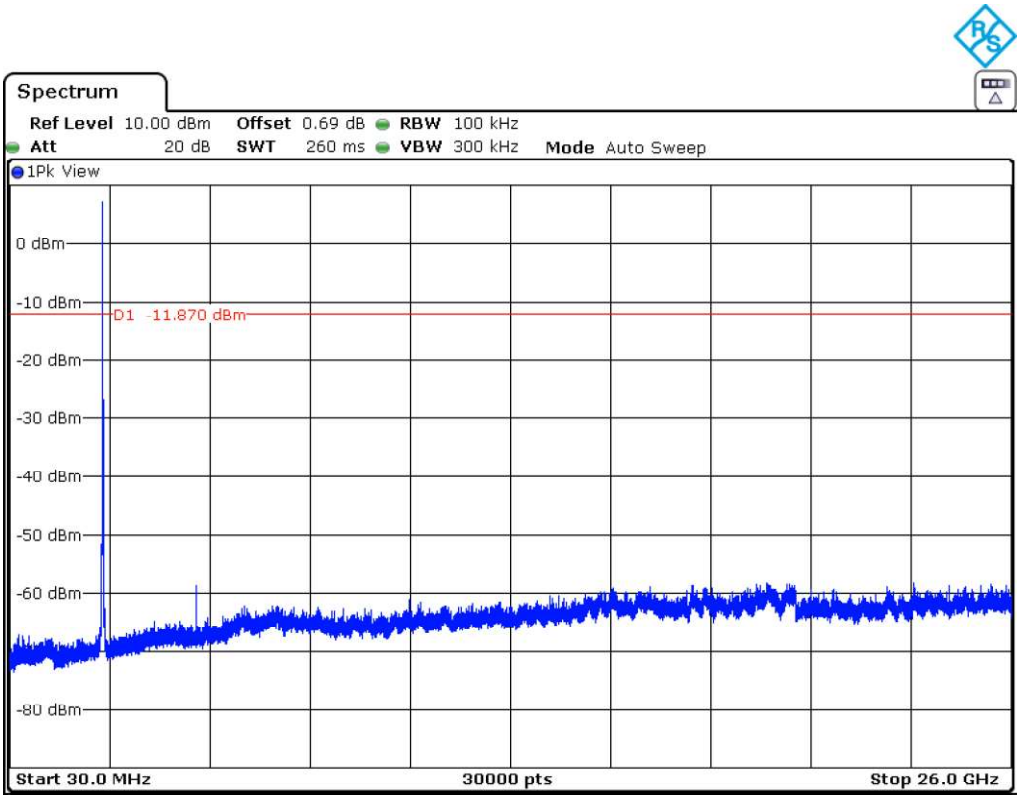
- **Mode 802.11 b – Emission limitations conducted**

- Low Channel:



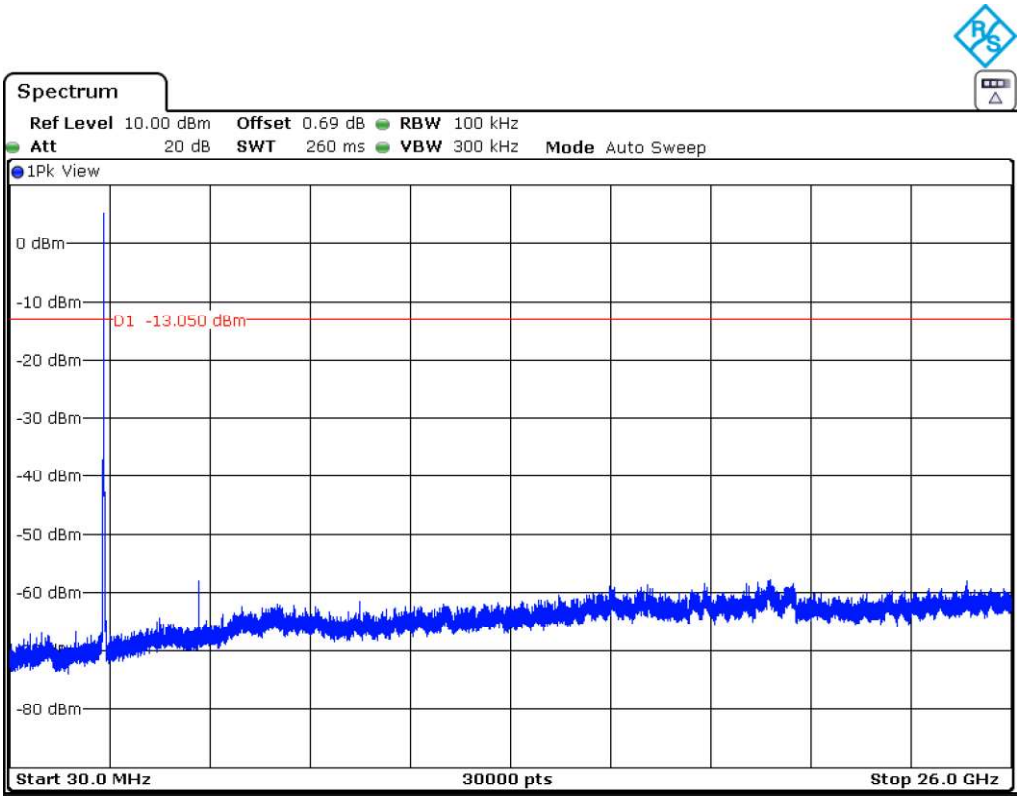
The peak shown in the plot above the limit is the carrier frequency.

- Middle Channel:



The peak shown in the plot above the limit is the carrier frequency.

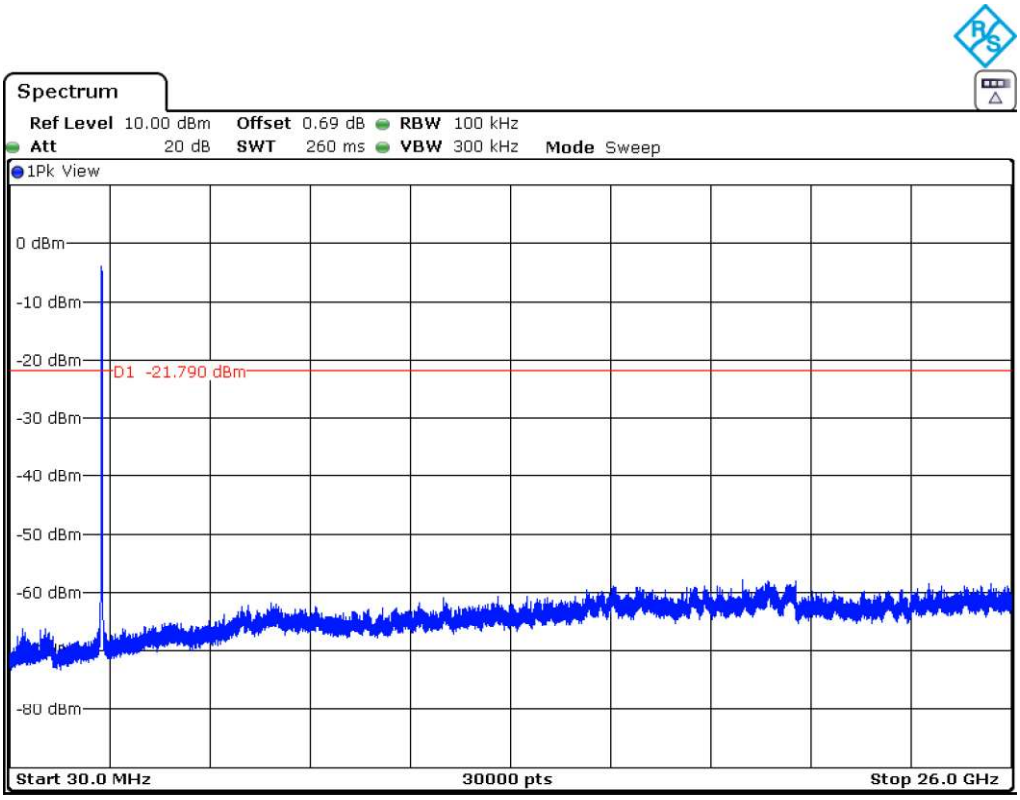
- High Channel:



The peak shown in the plot above the limit is the carrier frequency.

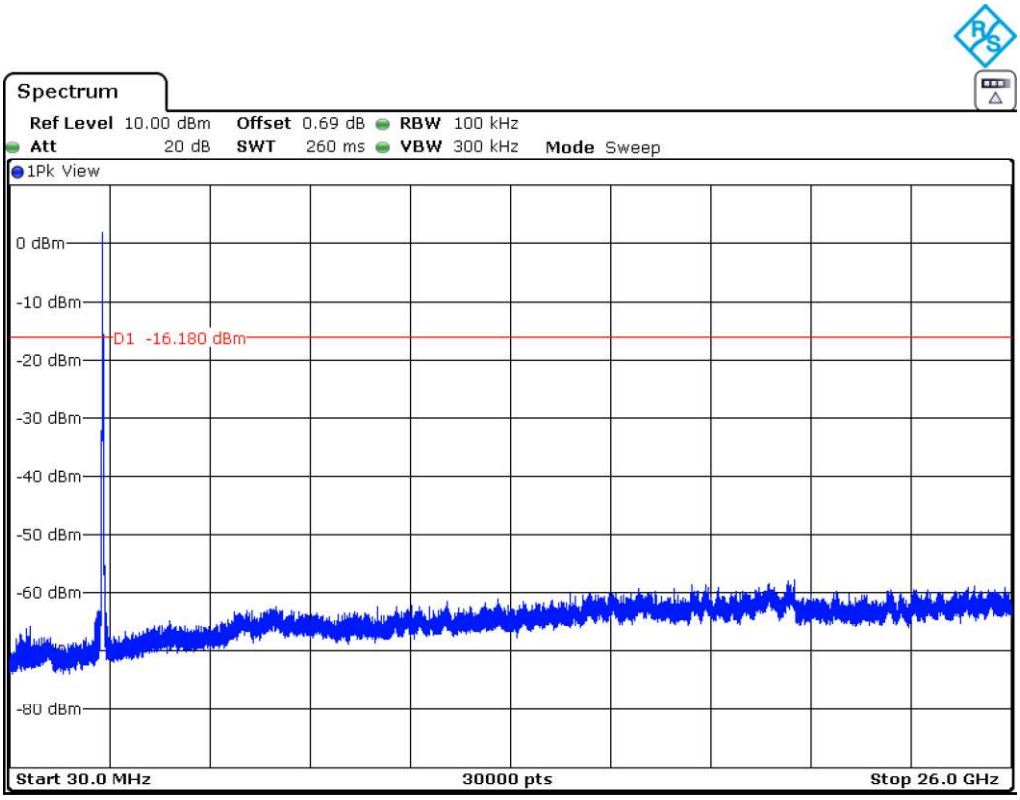
- **Mode 802.11 g – Emission limitations conducted**

- Low Channel:



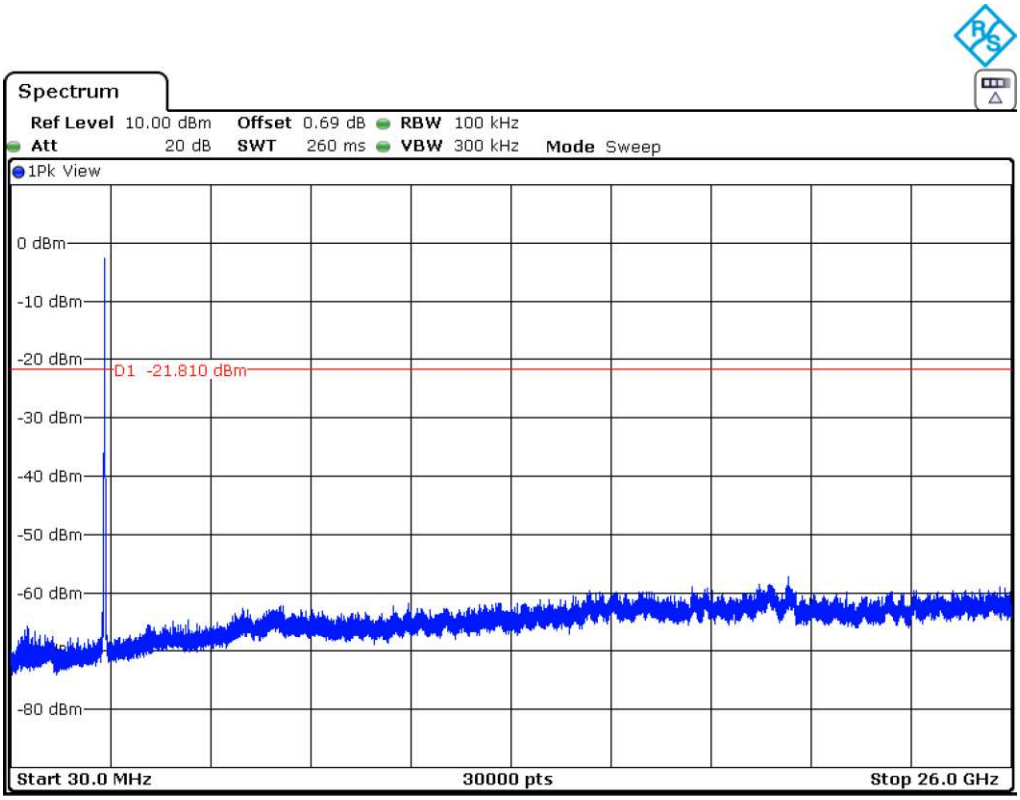
The peak shown in the plot above the limit is the carrier frequency.

- Middle Channel:



The peak shown in the plot above the limit is the carrier frequency.

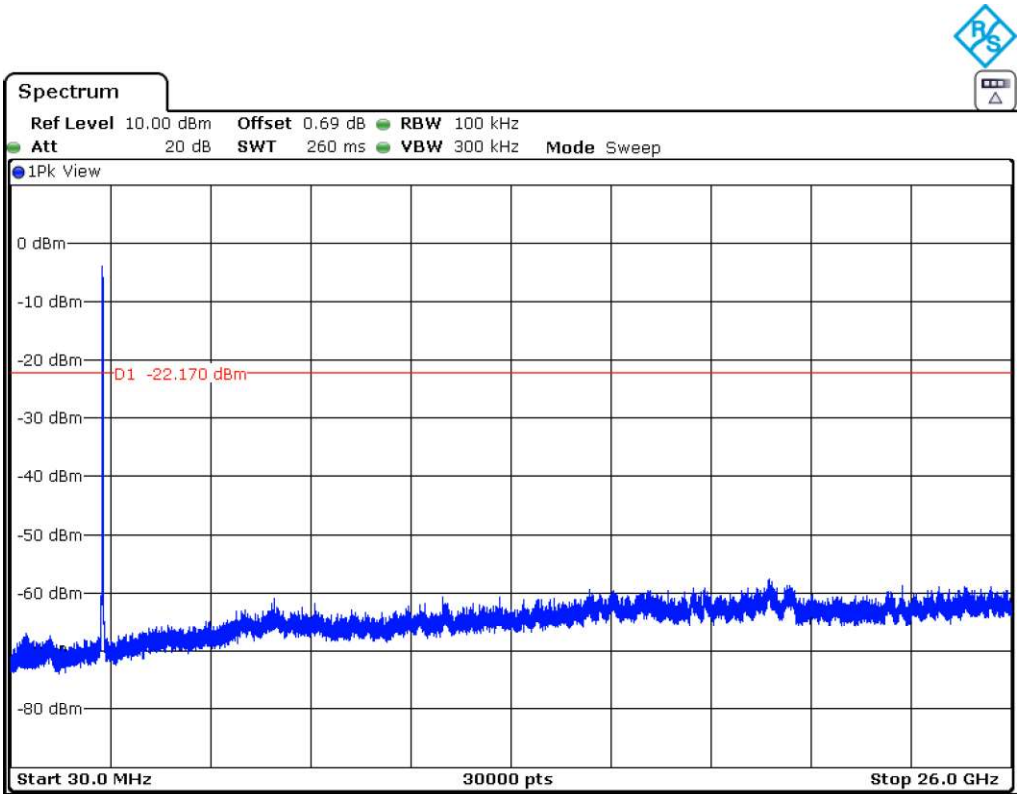
- High Channel:



The peak shown in the plot above the limit is the carrier frequency.

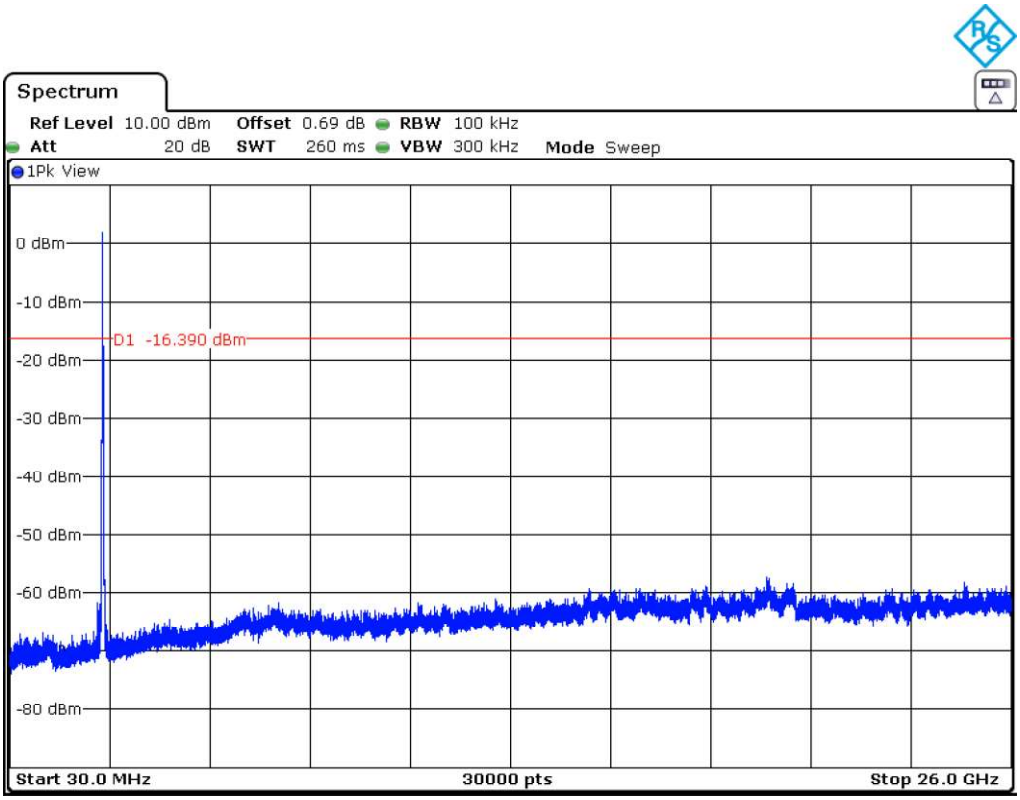
- **Mode 802.11 n20 – Emission limitations conducted**

- Low Channel:



The peak shown in the plot above the limit is the carrier frequency.

- Middle Channel:



The peak shown in the plot above the limit is the carrier frequency.