DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29507456

ISED CABid: ES1909

Test Report No:
NIE: 69323RRF.001

Test Report
USA FCC Part 15.247, 15.209
CANADA RSS-247, RSS-Gen

(*) Identification of item tested	TCAM: Telematics and Connectivity Antenna Module
(*) Trademark	Continental
(*) Model and /or type reference	TCAM1NA2
Other identification of the product	HW version: E4.4 SW version: 11.16.11 FCC ID: KR5TCAM1NA2 IC: 7812D-TCAM1NA2
(*) Features	2G, 3G, LTE, GNSS, WLAN, BLE, ISM Receiver
Applicant	Continental Automotive GmbH Siemensstrasse 12, 93055 Regensburg, Germany
Test method requested, standard	USA FCC Part 15.247 (10-1-20) Edition: Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.209 (10-1-20) Edition: Radiated emission limits; general requirements. CANADA RSS-247 Issue 2 (February 2017). CANADA RSS-Gen Issue 5, Amendment 2 (February 2021). 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 v05r02 dated April 2, 2019. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	Rafael López EMC Consumer & RF Lab. Manager 2021.11.04 13:40:58 +01'00'
Date of issue	2021-11-04
Report template No	FDT08_23 (*) "Data provided by the client"

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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.

DEKRA Testing and Certification is a FCC-recognized accredited testing laboratory with appropriate scope of accreditation that covers the performed tests in this report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory, CABid: ES1909, with the appropriate scope of accreditation that covers the performed tests in this report.

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.

DEKRA Testing and Certification S.A.U. guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at DEKRA Testing and Certification S.A.U. at the time of performance of the test.

DEKRA Testing and Certification S.A.U. is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

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.
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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 following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample of the TCAM model TCAM1NA2 is a vehicle antenna module for telematic and connectivity purposes.

   It consists of a fin antenna with integrated telematics transceivers for different wireless services as well as several interfaces to the vehicle.

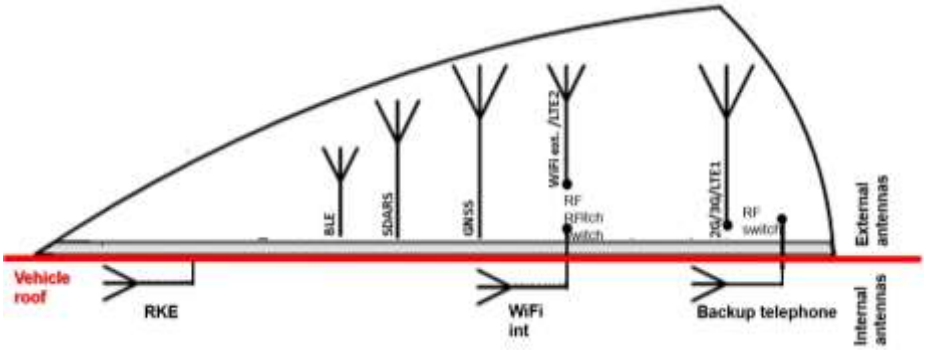
The TCAM1NA2 main parts are:

Antennas for cellular, WLAN, BLE, ISM receiver (RKE), SDARS with LNA
GNSS with LNA for Navigation: Beidou, Galileo, GPS, Glonass
Antenna selection via RF switches
TCAM internal antennas (all are TCAM internal, no extern antenna connections):
Tel1 ant: 2G, 3G, 4G/LTE1 (vehicle outside)
Tel2 ant: LTE2 (Rx only) (vehicle outside)
MIMO with LTE1- and LTE2-antenna. LTE2 is Rx only
Backup telephone antenna: 2G, 3G, 4G/LTE (vehicle inside)
Wi-Fi internal antenna (vehicle inside)
Wi-Fi external antenna (vehicle outside)
BLE antenna (vehicle outside)
Stacked patch antenna featuring GNSS
ISM receiver antenna
SDARS antenna

CAT4 NAD with 2G/3G/4G/LTE and GNSS, FCC certified
VoLTE
ISM receiver module (434MHz) for: RKE (Remote Keyless Entry), PASE (Passive Start and Entry, TPMS (Tire Pressure Monitoring System), FCC tested
Wi-Fi chip
BLE chip
1st internal embedded Sim-IC
Service calls

External interfaces:

Main power supply
External backup battery
External SIM card slot (2nd private customer SIM, optional)
External microphone in the OHC (Overhead Compartment)
A2B
External backup speaker
BroadR-Reach
CEM connection (K-Line)
Infotainment CAN
Airbag input
Debug interfaces (USB, UART)



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	Date of reception
69323/002	TCAM: Telematics and Connectivity Antenna Module	TCAM1NA2	00076362	2021/07/13
69323/008	Harness	--	--	2021/07/13

Sample S/01 has undergone the following test(s): The RADIATED tests indicated in Appendix A.

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

Control Nº	Description	Model	Serial Nº	Date of reception
69323/003	TCAM: Telematics and Connectivity Antenna Module	TCAM1NA2	00076364	2021/07/13
69323/008	Harness	--	--	2021/07/13

Sample S/02 has undergone the following test(s): The CONDUCTED tests indicated in Appendix A.

Test sample description

Ports…… :	Port name and description	Cable					
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)		
	USB diagnostic	~3m	☐	☐	☐		
	UART diagnostic	~3m	☐	☐	☐		
	BRR diagnostic	~3m	☐	☐	☐		
	-		☐	☐	☐		
	-		☐	☐	☐		
	-		☐	☐	☐		
Supplementary information to the ports…… :	-						
Rated power supply ……:	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 12V					
	☐	DC:					
Rated Power ……:	4.2 W dc (cellular, Wi-Fi, BLE, GNSS active)						
Clock frequencies ……:	32.768kHz, 16MHz, 19.2MHz, 24MHz, 25MHz, 27.6MHz, 48MHz						
Other parameters……:	Operating temperature Range: -10°C to 55°C Supply Voltage Range: 8 V to 16 V DC						

Software version .....:	11.16.11		
Hardware version.....:	E4.4		
Dimensions in cm (W x H x D)....:	10.5cm x 15.5cm x 9cm		
Mounting position.....:	☐	Table top equipment	
	☐	Wall/Ceiling mounted equipment	
	☐	Floor standing equipment	
	☐	Hand-held equipment	
	☒	Other: Vehicular environment equipment	
Modules/parts .....:	Module/parts of test item	Type	Manufacturer
	Network Access Device (NAD), (cellular, GNSS)	Model: BL28NA-RD1	Continental Automotive Systems
	ISM/RKE 434 MHz RF receiver module	Model: A2C38291300	Continental Automotive Systems
Accessories (not part of the test item) .....:	Description	Type	Manufacturer
	1-2 x test harnesses with USB 1 x test harness without USB (if necessary)		Continental
	Laptop (if necessary)	Elite Book	HP
	BLE eval board (if necessary)		TI
	Load boxes (if necessary)	multiple	multiple
Documents as provided by the applicant.....:	Description	File name	Issue date
	RF guide	21cw12_TCAM_Country_RF_Manual	
	Functional Guide	User Guide for Functional Testing on Component Level 2	
	Additional Guides (if necessary)	multiple	
	-		

(3) Only for Medical Equipment

Identification of the client

Continental Automotive GmbH

Siemensstrasse 12, 93055 Regensburg, Germany

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2021-07-21
Date (finish)	2021-08-30

Document history

Report number	Date	Description
69323RRF.001	2021-11-04	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 %

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 %

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. = 75 %

Remarks and comments

The tests have been performed by the technical personnel: Pablo Redondo, Nicolás Salguero, Cristina Calle, Javier Miguel Nadales and Alfonso Gutiérrez.

Used instrumentation:

Conducted Measurements:

		Last Calibration	Due Calibration
1.	Shielded Room ETS LINDGREN S101	N/A	N/A
2.	Signal and Spectrum Analyzer 10 Hz - 40 GHz ROHDE AND SCHWARZ FSV40	2019/09	2021/09
3.	OPEN SWITCH UNIT UP TO 7.5 GHz	2021/08	2023/08
4.	Open Switch Unit up to 18 GHz ROHDE AND SCHWARZ OSP 150	N/A	N/A
5.	Analog Power Supply DC 40V/40A NGPE 40/40 Rohde and Schwarz	N/A	N/A
6.	Digital Multimeter FLUKE 175	2020/11	2021/11

Radiated Measurements:

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP	N/A	N/A
2.	Shielded Room ETS LINDGREN S101	N/A	N/A
3.	Biconical/Log Antenna 30 MHz - 6 GHz ETS LINDGREN 3142E	2020/04	2023/04
4.	Preamplifier G>40dB 10MHz-6GHz, BONN ELEKTRONIK, BLNA 0160-01N	2021/03	2022/03
5.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2020/12	2022/12
6.	DC Power Supply, 30V/5A KEYSIGHT TECHNOLOGIES U8002A	N/A	N/A
7.	Digital Multimeter FLUKE 175	2020/11	2021/11
8.	Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2019/11	2022/11
9.	Horn Antenna 18-40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2020/05	2023/05
10.	RF Preamplifier, 40 dB ,1-18 GHz BONN ELEKTRONIK BLMA 0118-1M	2021/06	2022/06
11.	Spectrum Analyzer ROHDE AND SCHWARZ FSW50	2020/07	2022/07

Testing verdicts

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

Summary

1. WLAN 2.4 GHz: 802.11 bgn20 1x1.

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		**Verdict**	**Remark**
15.35 (c) / RSS-Gen 8.2.	Transmitter Duty Cycle	P	
15.247 (a) (2) / RSS-247 5.2. (a)	6 dB Bandwidth	P	
15.247 (b) / RSS-247 5.4. (d)	Maximum output power and antenna gain	P	
15.247 (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)	P	
15.247 (e) / RSS-247 5.2. (b)	Power spectral density	P	
15.247 (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)	P	
Supplementary information and remarks: None.			

Appendix A: Test results. 802.11 bgn20 1x1

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TEST CONDITIONS

(*): Data provided by the Applicant.

POWER SUPPLY (*):

V nonimal:	12 Vdc.
Type of Power Supply:	External power supply (Car Battery).

ANTENNA (*):

Type of Antenna:	Indoor the vehicle (Direct feed (main PCB)).		
	Outdoor the vehicle (3D).		
Maximum Declared Antenna Gain:		Indoor:	+2.9 dBi.
		Outdoor:	+0.3 dBi.

TEST FREQUENCIES (*):

802.11 bgn20 1x1:

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

RF OUTPUT POWER ADJUSTMENTS **(*)**:

Indoor Antenna (radiated and conducted tests). Outdoor Antenna (conducted tests):

802.11 b:	Adjustment of Maximum RF Output Power (electrical chipset power):	+16 dBm
802.11 g:	Adjustment of Maximum RF Output Power (electrical chipset power):	+15 dBm
802.11 n20:	Adjustment of Maximum RF Output Power (electrical chipset power):	+14 dBm

Outdoor Antenna (radiated tests):

802.11 b:	Adjustment of Maximum RF Output Power (electrical chipset power):	+12 dBm
802.11 g:	Adjustment of Maximum RF Output Power (electrical chipset power):	+15 dBm
802.11 n20:	Adjustment of Maximum RF Output Power (electrical chipset power):	+14 dBm

WORST-CASES: The following modes and data rates were selected based on preliminary testing that identified those corresponding to the worst-cases:

- 802.11 b: 1 Mbit/s / SISO on Indoor Antenna.
- 802.11 g: 6 Mbit/s / SISO on Indoor Antenna.
- 802.11 n HT20: MCS0 / SISO on Indoor Antenna.

The test set-up was made in accordance to the general provisions of 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 v05r02 dated April 2, 2019.

The EUT was tested in the following operating mode(s):

- Non-TxBF modes: Continuously transmitting with a modulated carrier at maximum power in all required channels using the supported data rates/modulations types.

The field strength at the band edges was evaluated for each mode for the channel under test.
During transmitter test the EUT was being controlled by the SW tool to operate in a continuous transmit mode on the test channel as required and in each of the different modulation modes.

For non-TxBF modes, the EUT was configured in test mode using a software application. The application was used to enable a continuous transmission and to select the test channels as required. The client supplied the SW to configure the EUT. The customer supplied a document containing the setup instructions.

The conducted test sample has only one antenna connector. The client provided the antenna gains for both antennas (including the losses of lines and switches). The client considered the transmission lines and rf switches as part of the indoor and outdoor antenna.

The client supplied U.FL RF cables with the EUT in order to perform conducted measurements. The measured additional path loss was included in any path loss calculations.

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.

The DC supply voltage is applied using an external calibrated power supply with a multimeter.

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) and range 1GHz to 17GHz (1 GHz-18 GHz Double ridge horn antenna) are situated at a distance of 3 m and at a distance of 1m for the frequency range 17 GHz-26 GHz (18 GHz-40 GHz horn antenna).

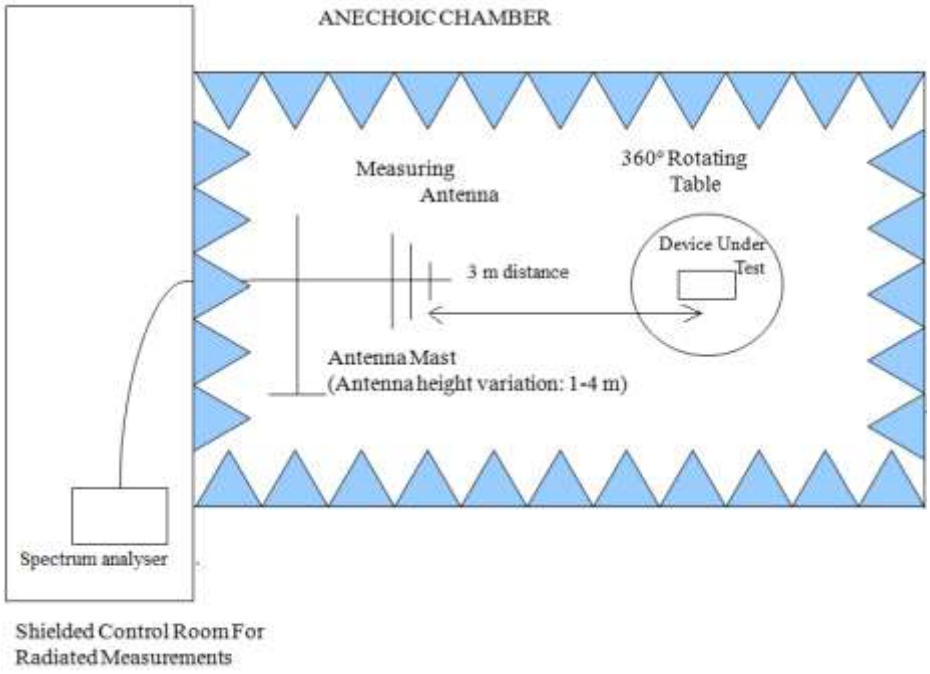
For radiated emissions in the range 1 GHz-26 GHz that is performed at a distance closer than the specified distance. an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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.

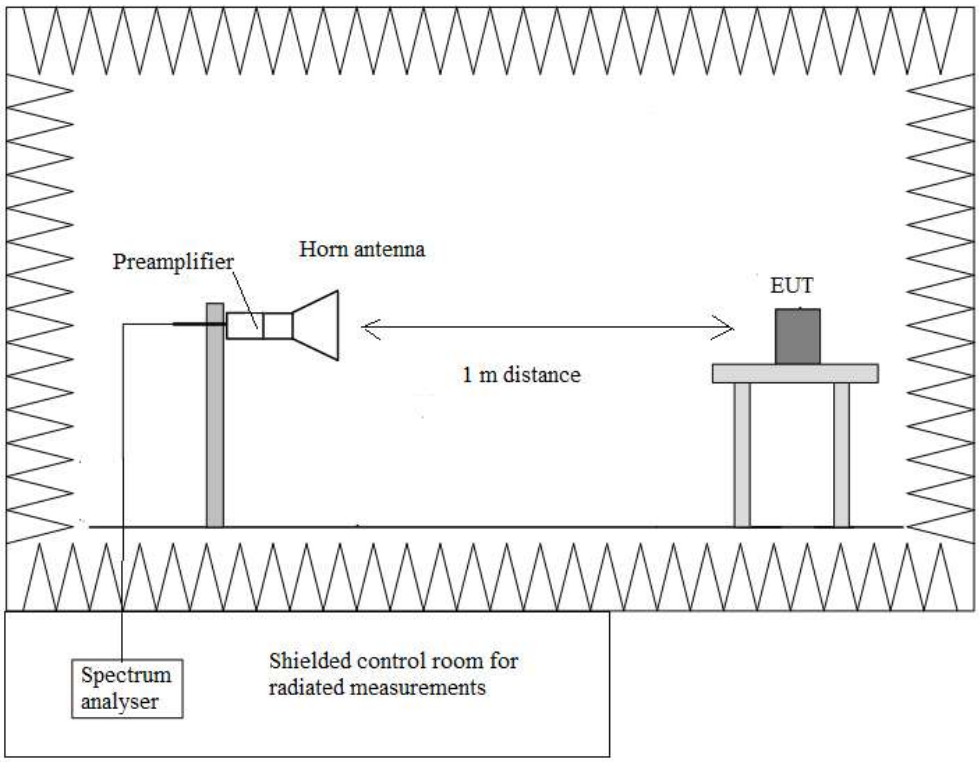
A resolution bandwidth/video bandwidth of 100 kHz/300 kHz was used for frequencies below 1 GHz and 1MHz/3MHz for frequencies above 1 GHz.

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:

- **802.11 b:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% bandwidth (MHz)	13.3000	13.5000	13.2000
Measurement uncertainty (%)	<± 1.40		

- **802.11 g:**

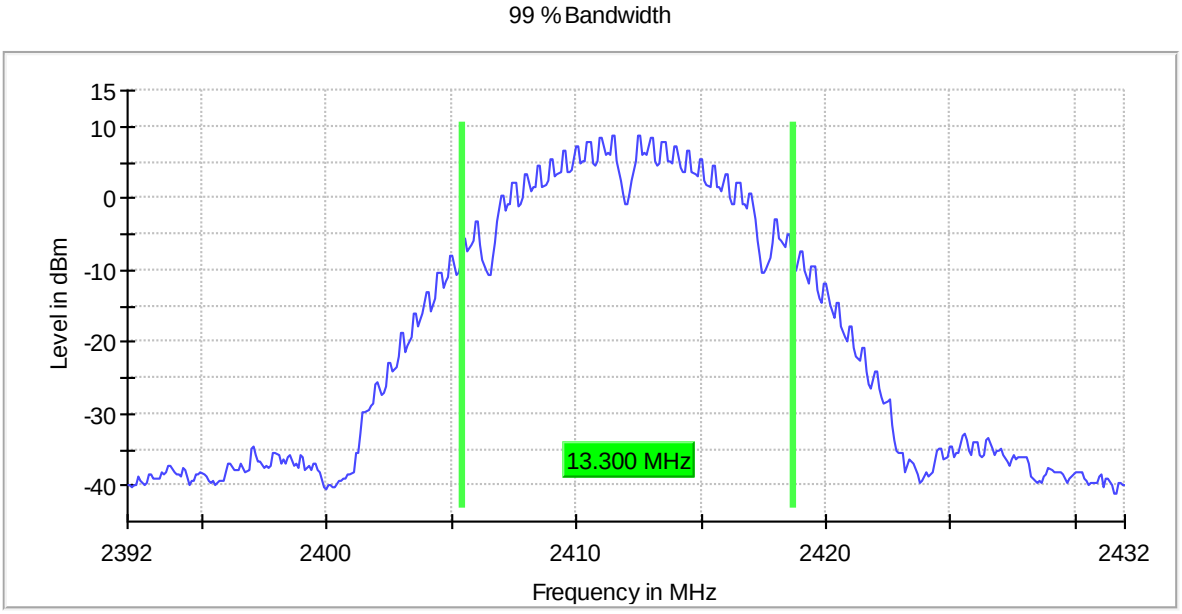
	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% bandwidth (MHz)	16.4000	16.5000	16.4000
Measurement uncertainty (%)	<± 1.40		

- **802.11 n20:**

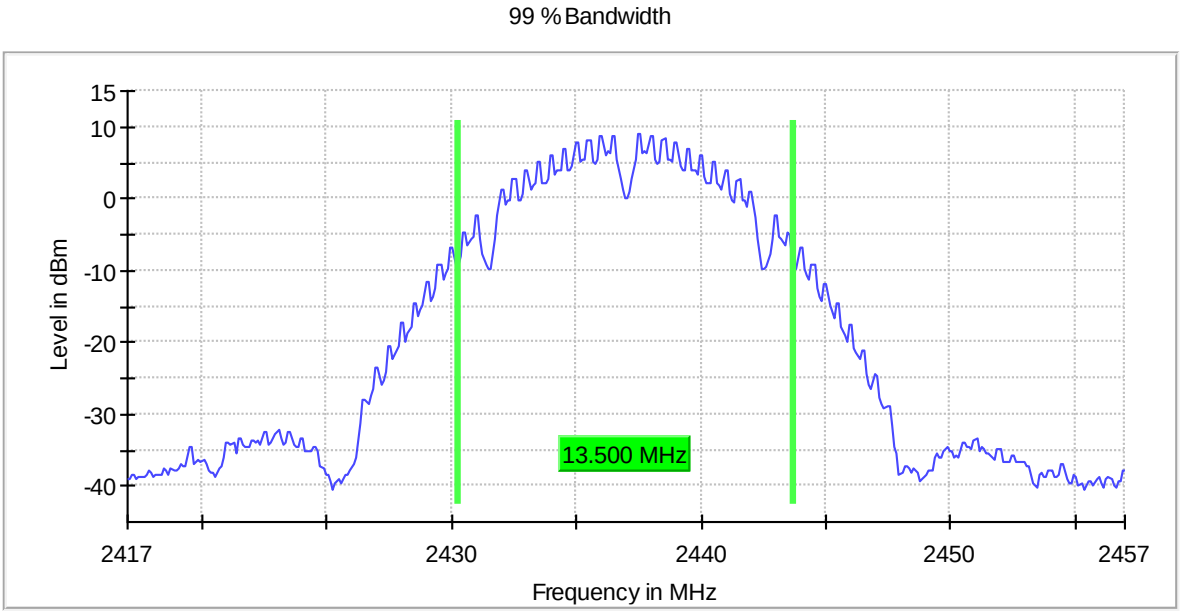
	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% bandwidth (MHz)	17.6000	17.7000	17.6000
Measurement uncertainty (%)	<± 1.40		

- **802.11 b – Occupied Bandwidth**

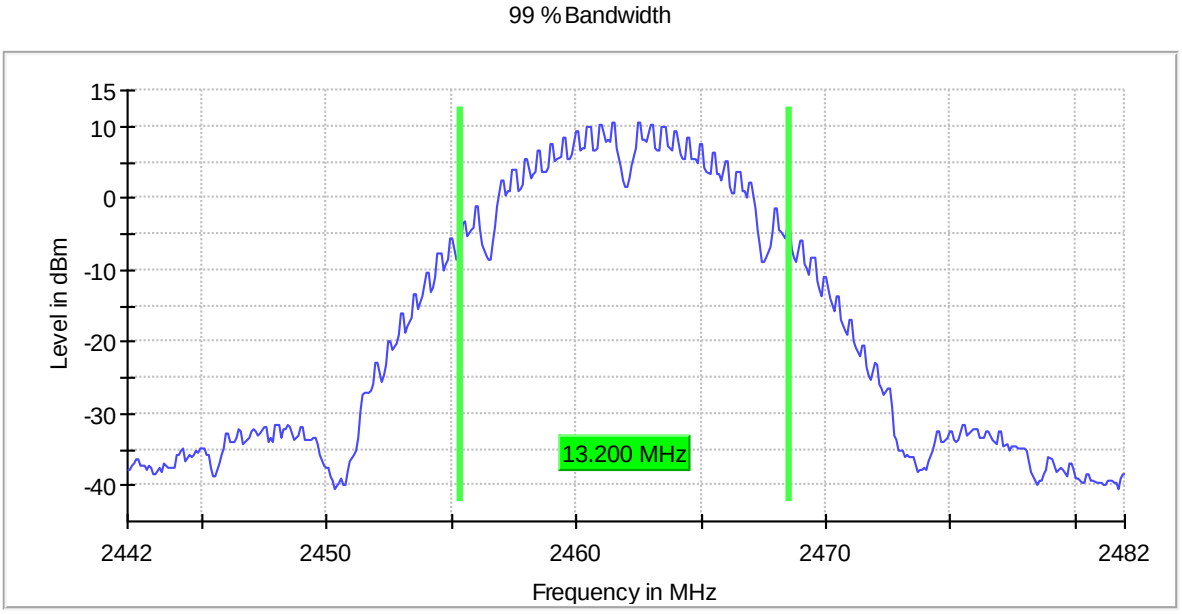
- Low Channel:



- Middle Channel:

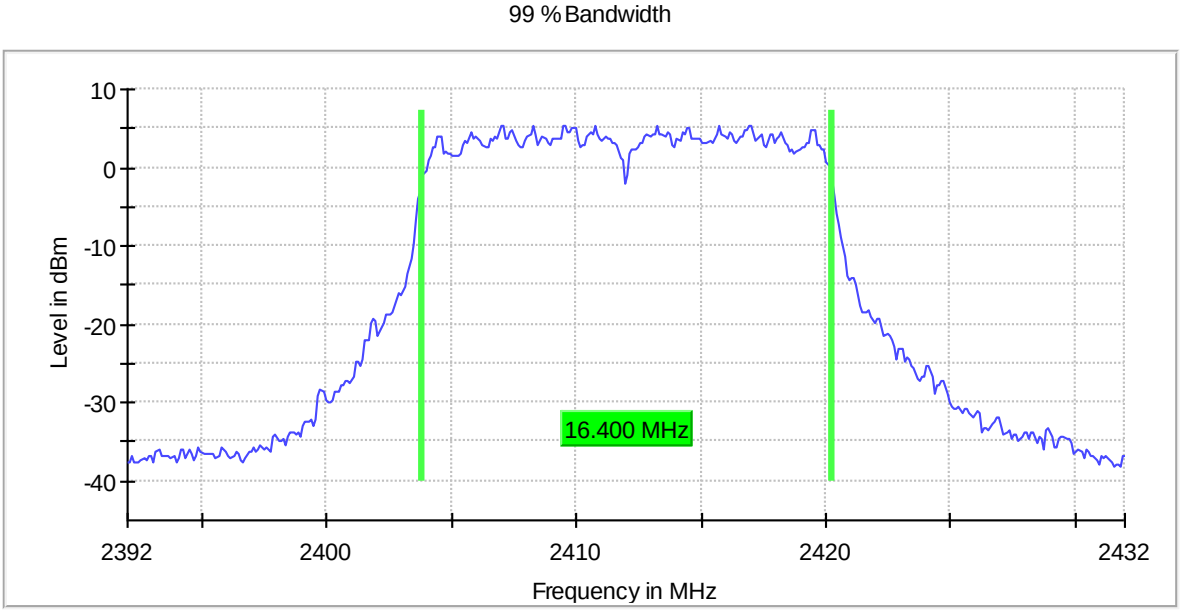


- High Channel:

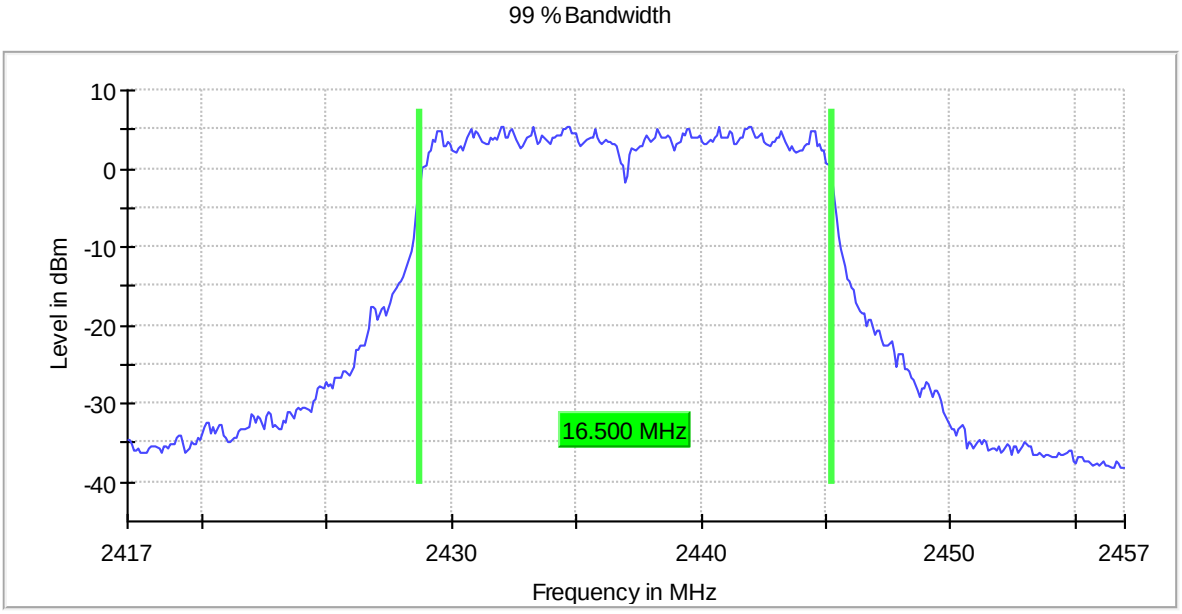


- **802.11 g – Occupied Bandwidth**

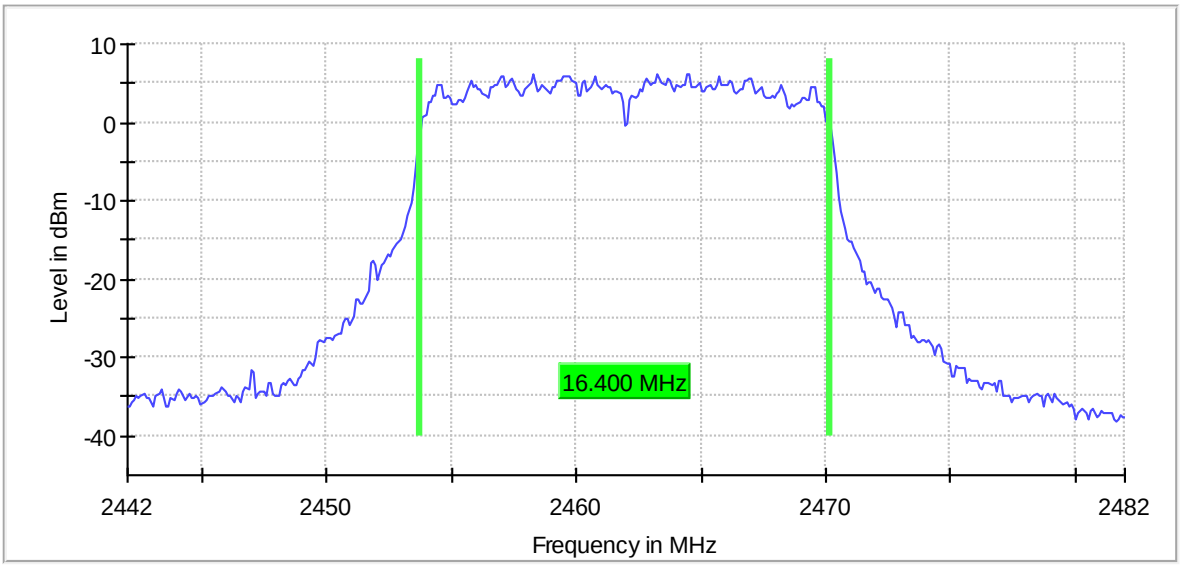
- Low Channel:



- Middle Channel:

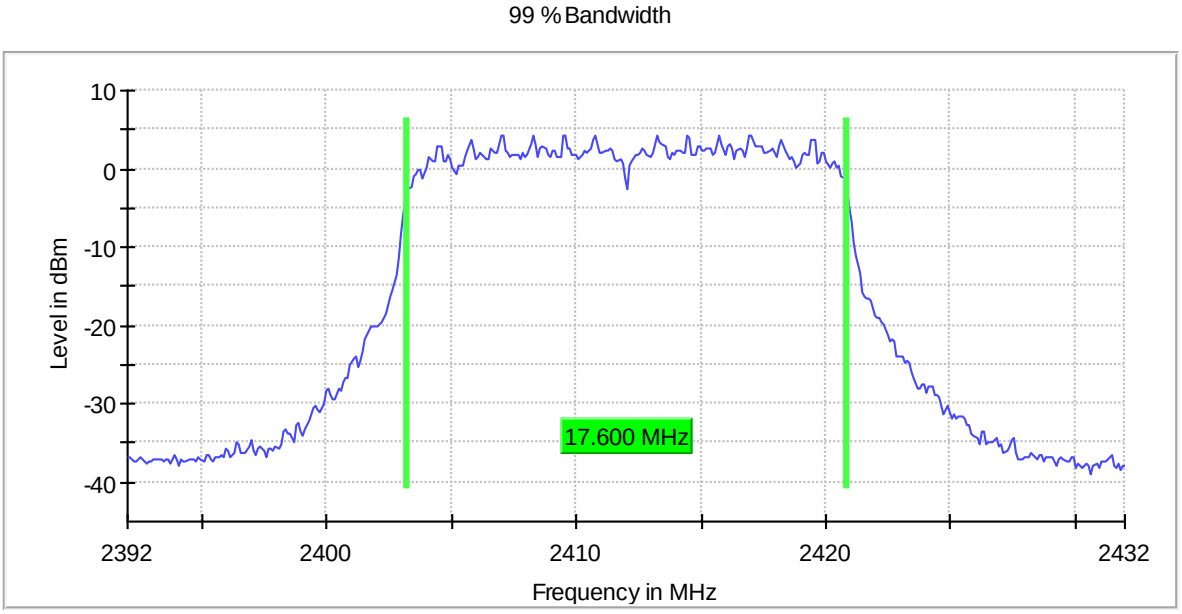


- High Channel:

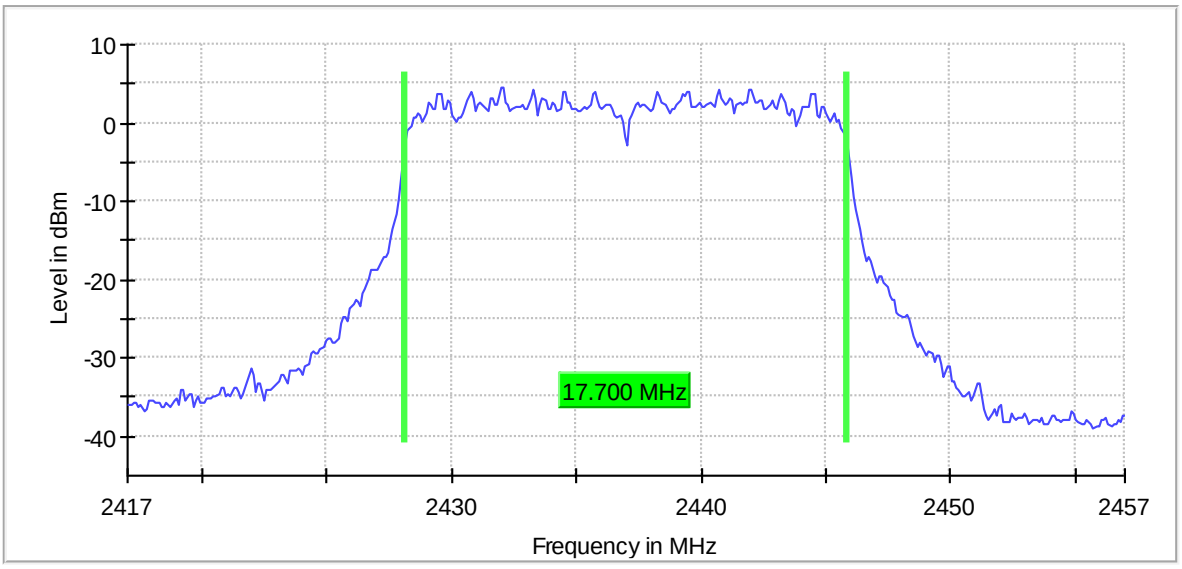


- **802.11 n20 – Occupied Bandwidth**

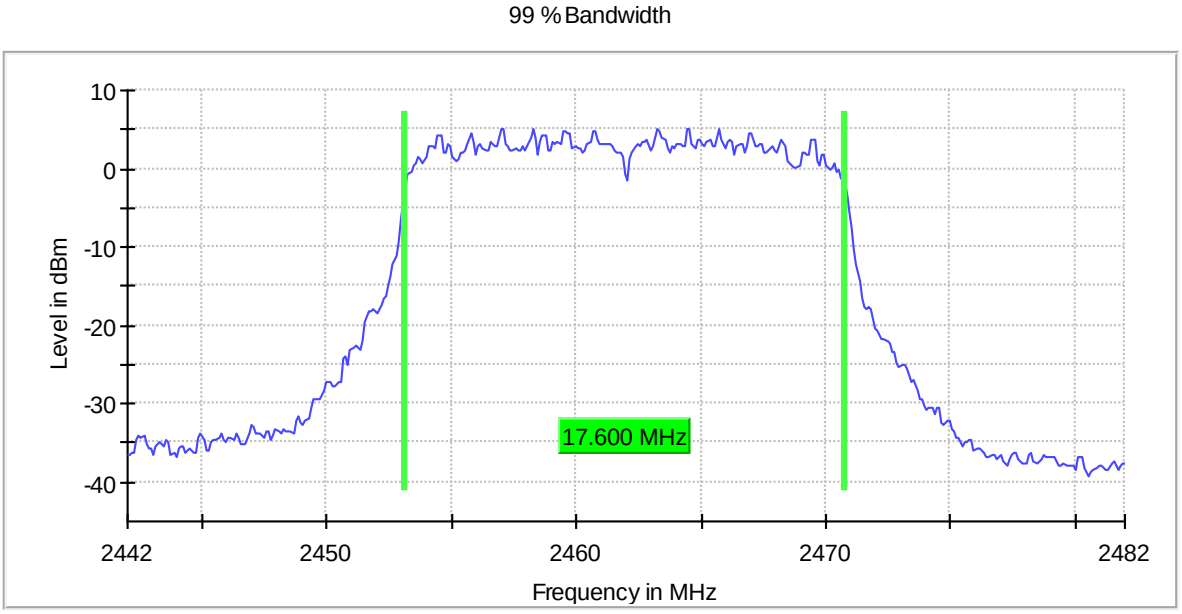
- Low Channel:



- Middle Channel:



- High Channel:



FCC 15.247 (a) (2) / RSS-247 5.2 (a) 6 dB Bandwidth

SPECIFICATION:

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

RESULTS:

- **802.11 b:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum Bandwidth (MHz)	8.1500	8.1500	8.1500
Measurement uncertainty (%)	<± 1.40		

- **802.11 g:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum Bandwidth (MHz)	16.0000	16.3500	16.1000
Measurement uncertainty (%)	<± 1.40		

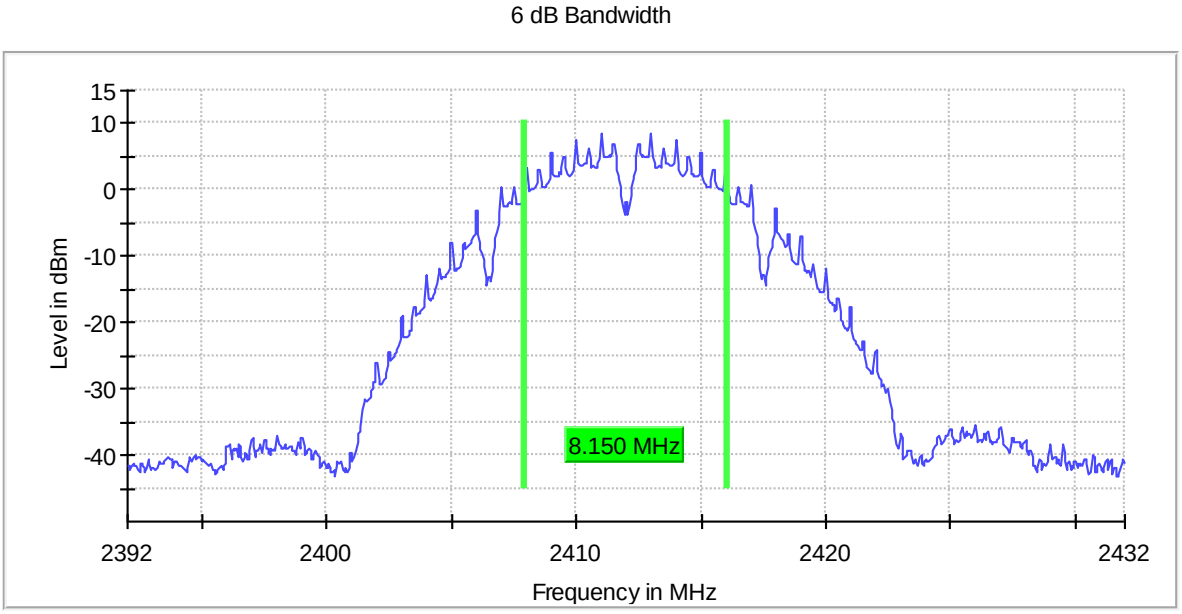
- **802.11 n20:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum Bandwidth (MHz)	16.9000	16.9500	16.8500
Measurement uncertainty (%)	<± 1.40		

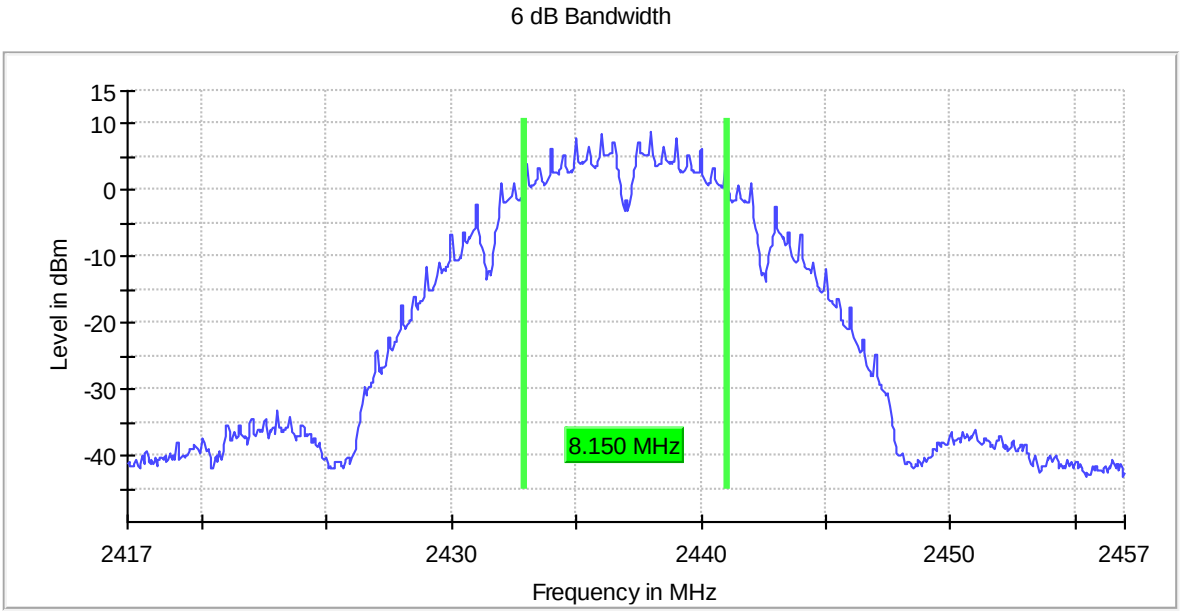
Verdict: PASS

- **802.11 b – 6 dB Bandwidth**

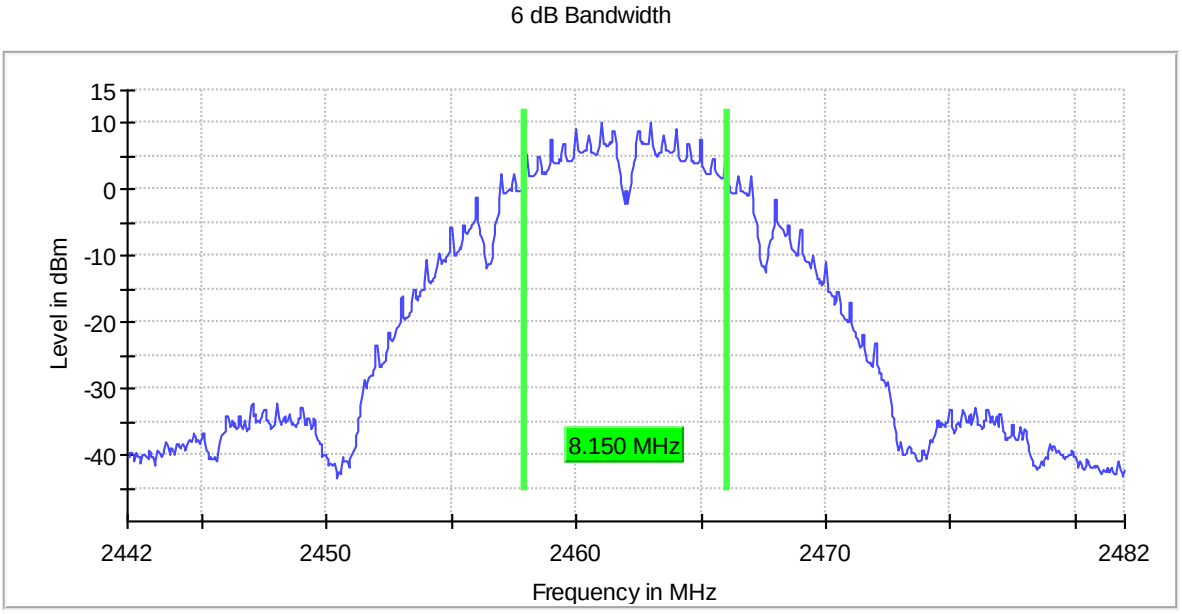
- Low Channel:



- Middle Channel:

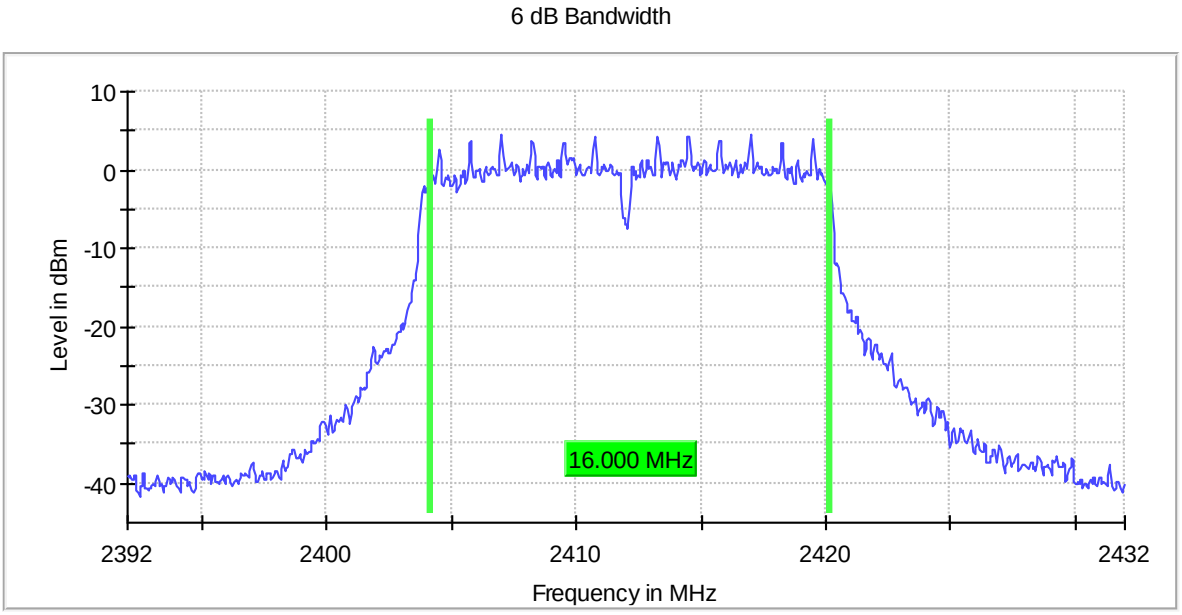


- High Channel:

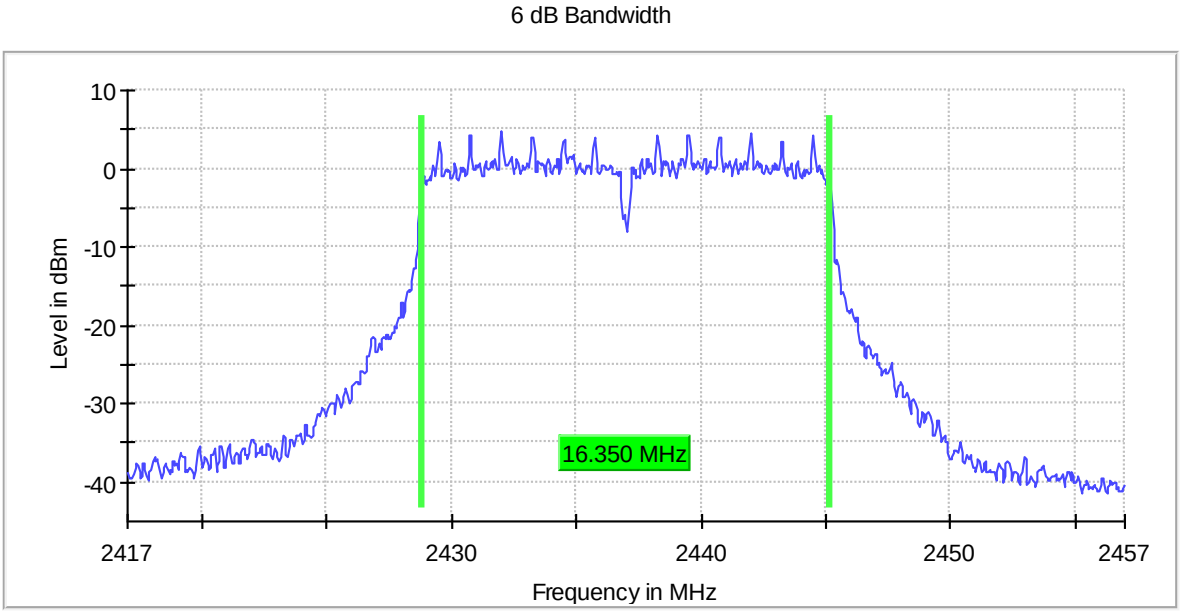


- **802.11 g – 6 dB Bandwidth**

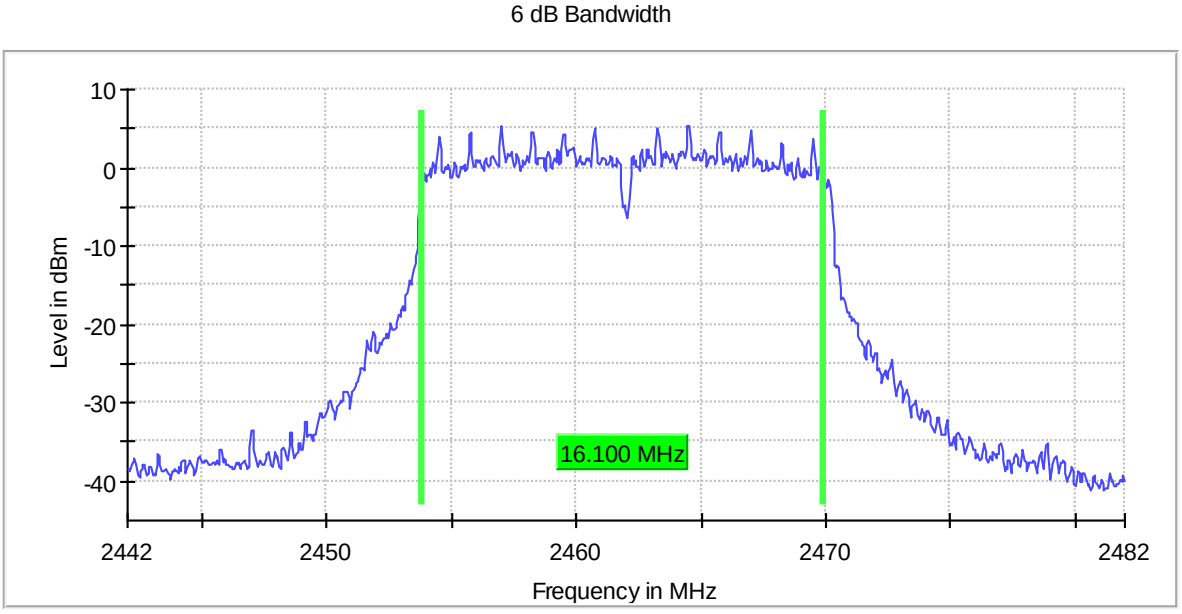
- Low Channel:



- Middle Channel:

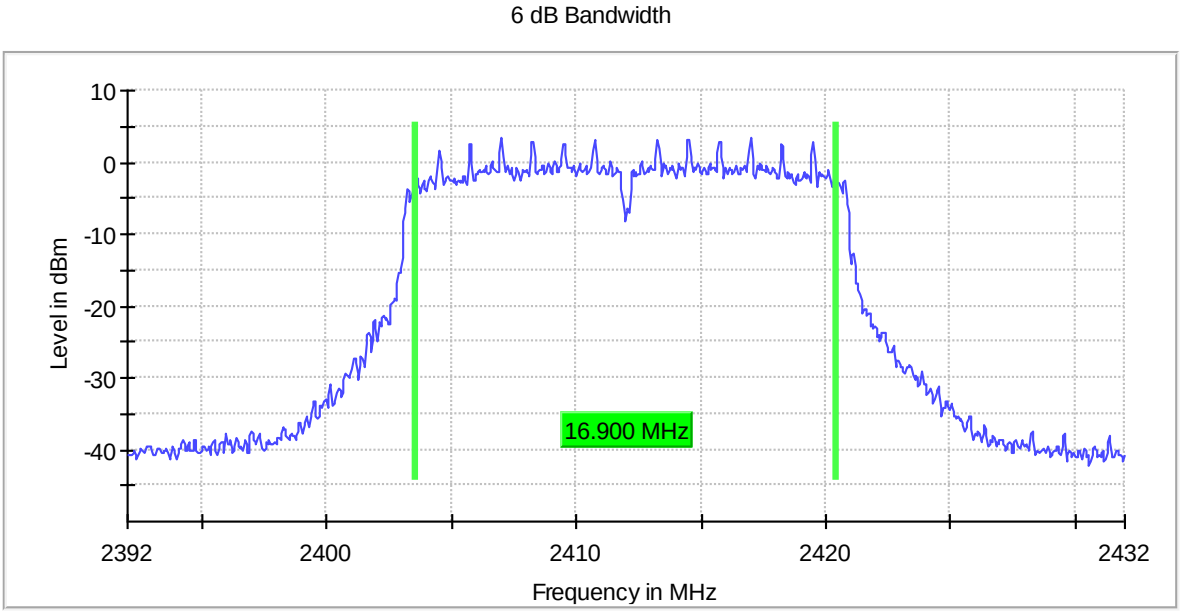


- High Channel:

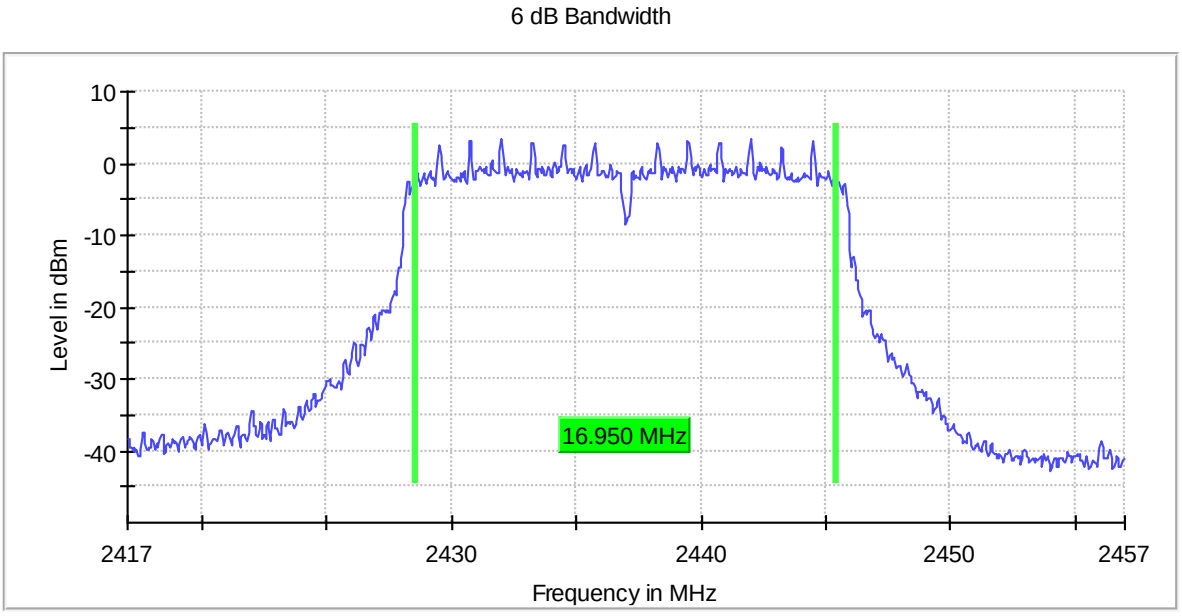


- **802.11 n20 – 6 dB Bandwidth**

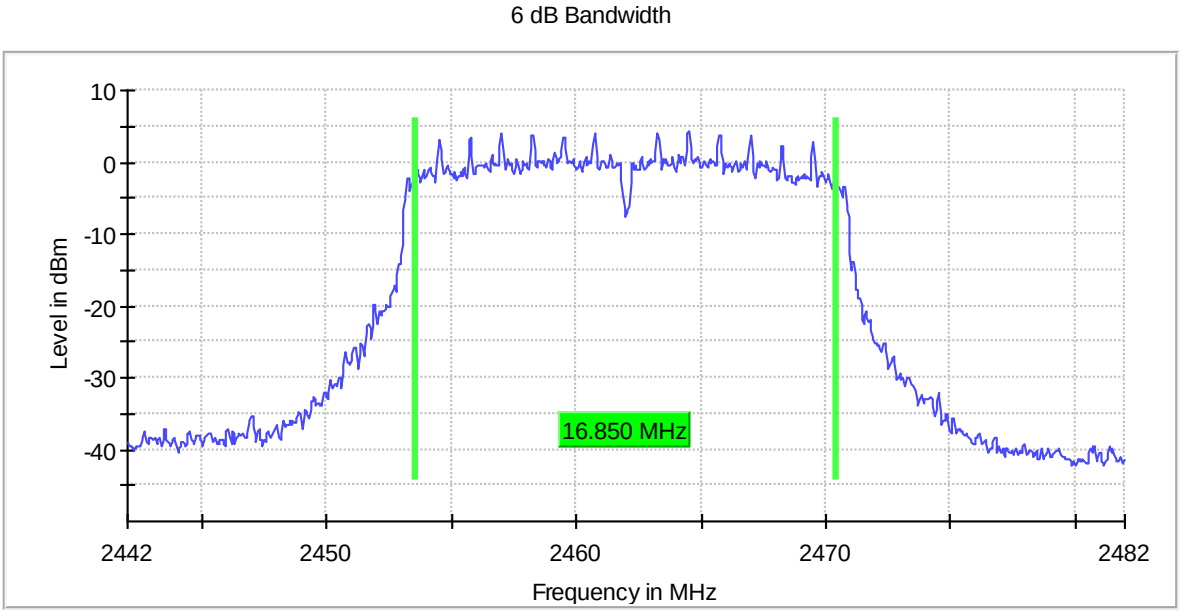
- Low Channel:



- Middle Channel:



- High Channel:



FCC 15.35 (c) / RSS-Gen 8.2. Transmitter Duty Cycle

SPECIFICATION:

When the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value.

RESULTS:

The results below are for data rates with a duty cycle less than 98%.
The results for all rest of modes having a value > 98%.

INDOOR ANTENNA:

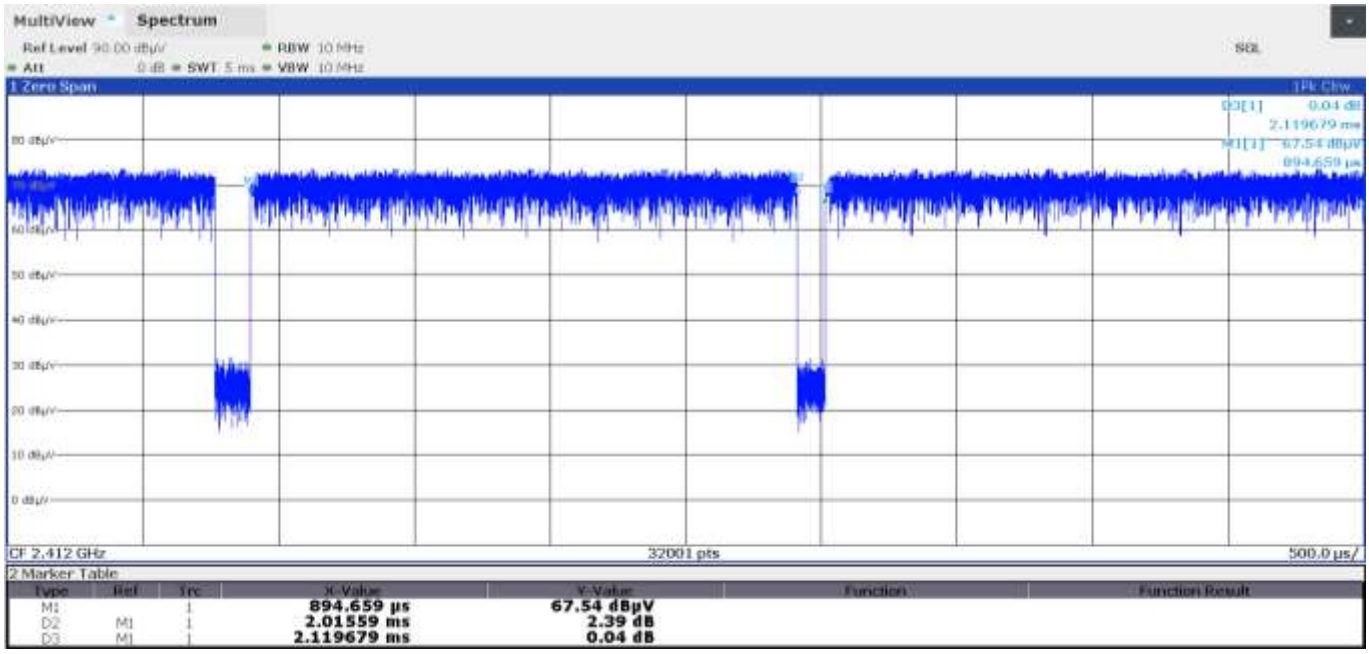
Technique	Mode	Pulse Duration (ms)	Period (ms)	Duty Cycle Correction (dB)
SISO	802.11 g	2.01559	2.119679	0.218679022
SISO	802.11 n20	1.878757	1.983004	0.234529785

OUTDOOR ANTENNA:

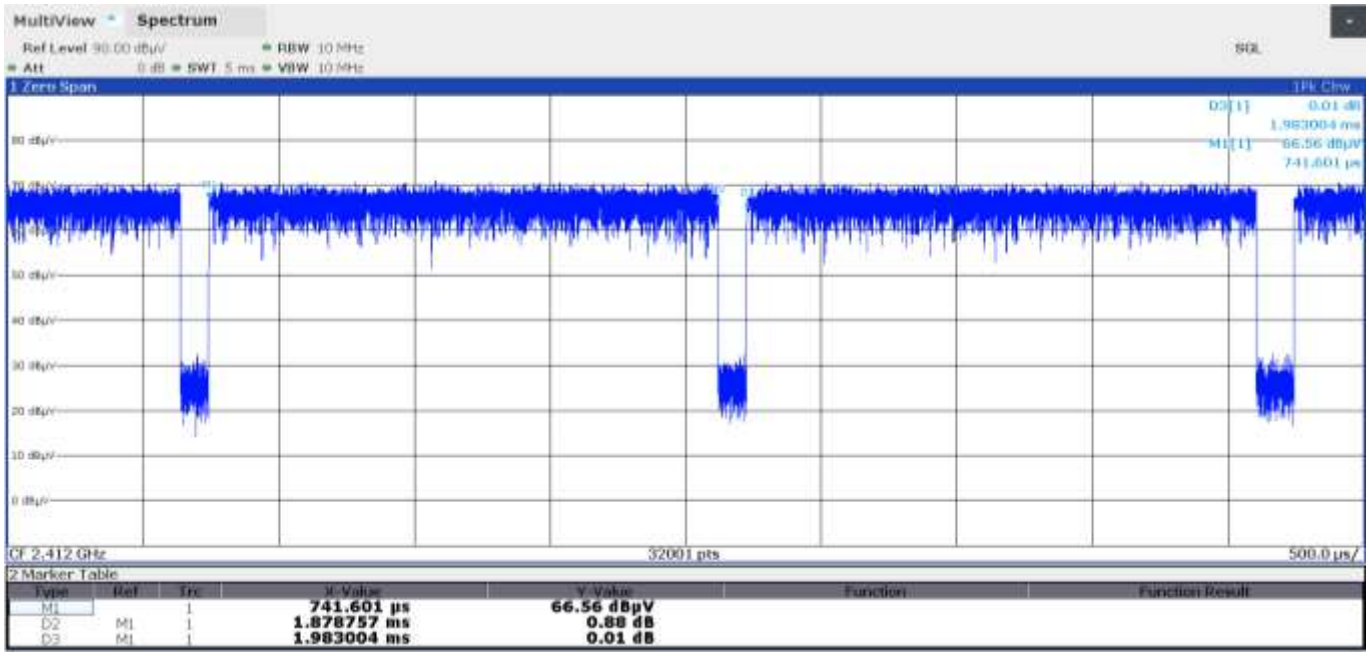
Technique	Mode	Pulse Duration (ms)	Period (ms)	Duty Cycle Correction (dB)
SISO	802.11 g	2.014531	2.180835	0.344488537
SISO	802.11 n20	1.898594	1.991941	0.208443667

INDOOR ANTENNA:

802.11 g:

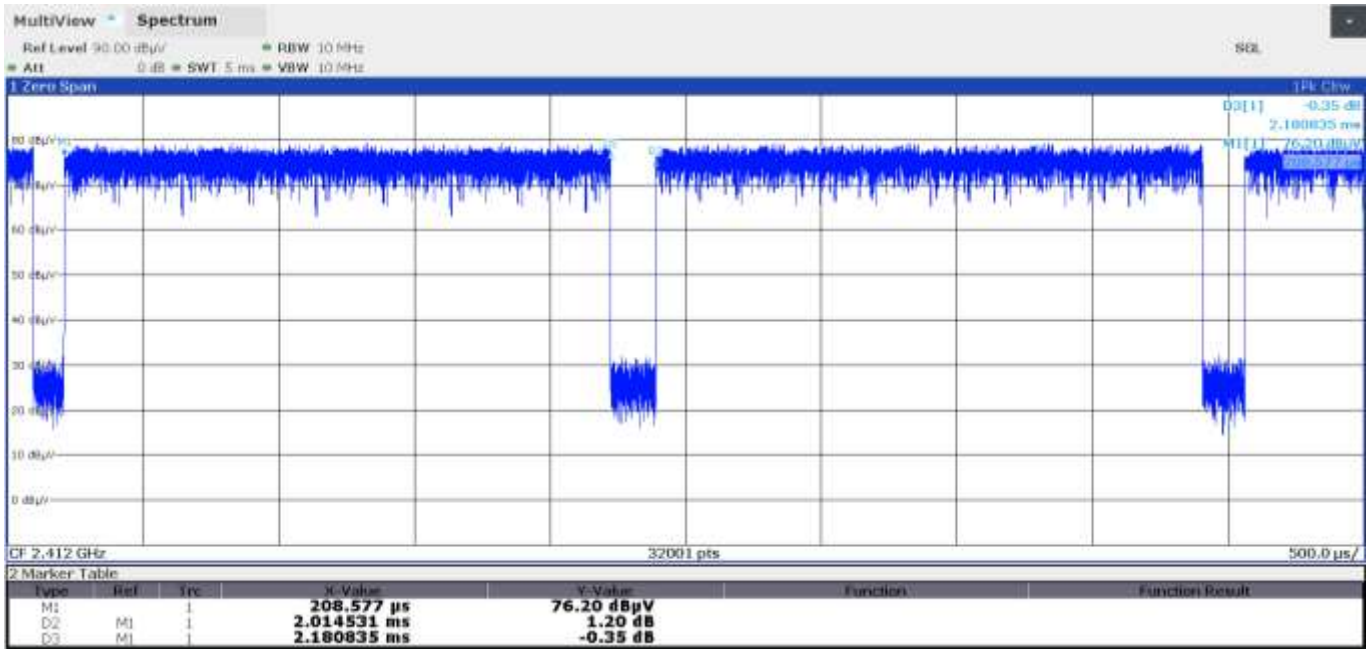


802.11 n20:

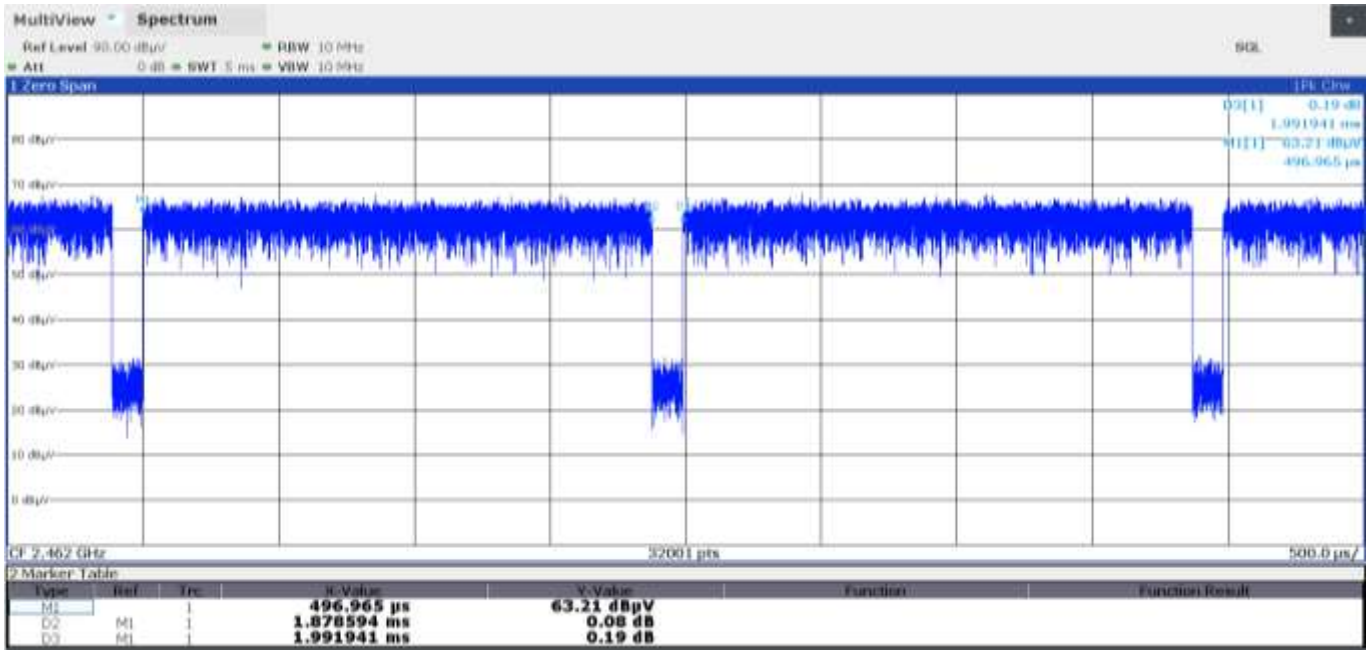


OUTDOOR ANTENNA:

802.11 g:



802.11 n20:



FCC 15.247 (b) / RSS-247 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:

INDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +2.9 dBi.

OUTDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +0.3 dBi.

For modes b, g, n20, the maximum conducted output power was measured using the method according to point 11.9.2.3.2 “Method AVGPM-G” of ANSI C.63.10-2013.

Results showed are in the worts case of antenna Gain.

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

- **802.11 b (Indoor antenna):**

Channels	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Corrected Conducted Power (dBm)	15.69	16.12	17.76
Maximum EIRP Corrected Conducted Power (dBm)	18.59	19.02	20.66
Measurement uncertainty (dB)	<± 0.99		

- **802.11 g (Indoor antenna):**

Channels	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Corrected Conducted Power (dBm)	14.81	15.02	15.57
Maximum EIRP Corrected Conducted Power (dBm)	17.71	17.92	18.47
Measurement uncertainty (dB)	<± 0.99		

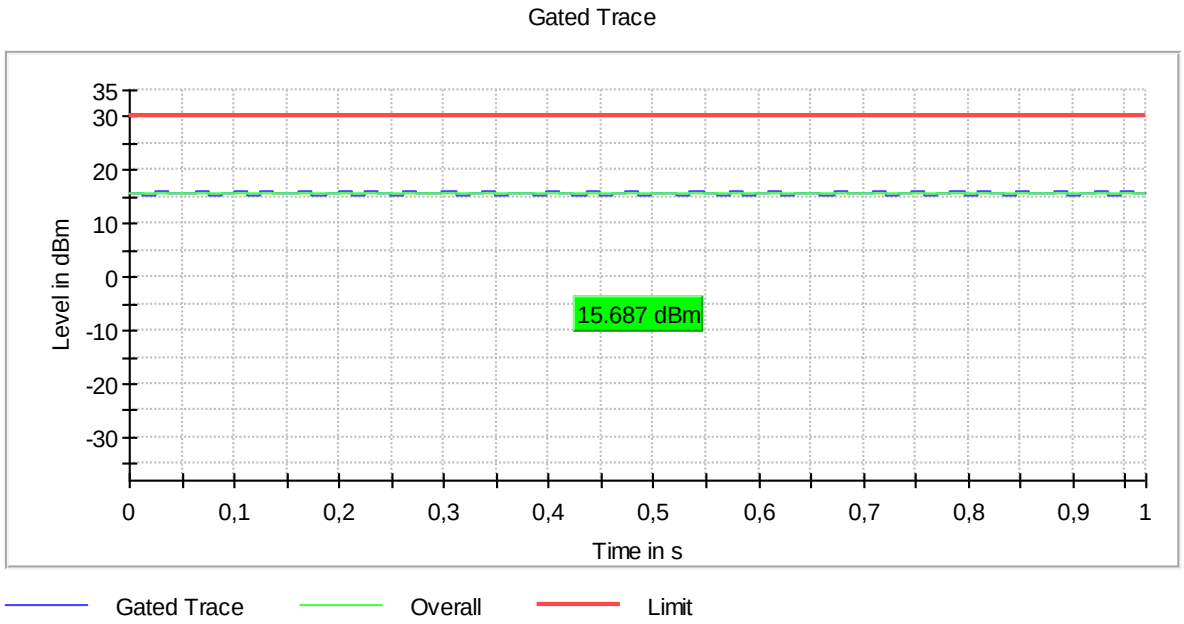
- **802.11 n20 (Indoor antenna):**

Channels	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Corrected Conducted Power (dBm)	13.65	13.79	14.44
Maximum EIRP Corrected Conducted Power (dBm)	16.55	16.69	17.34
Measurement uncertainty (dB)	<± 0.99		

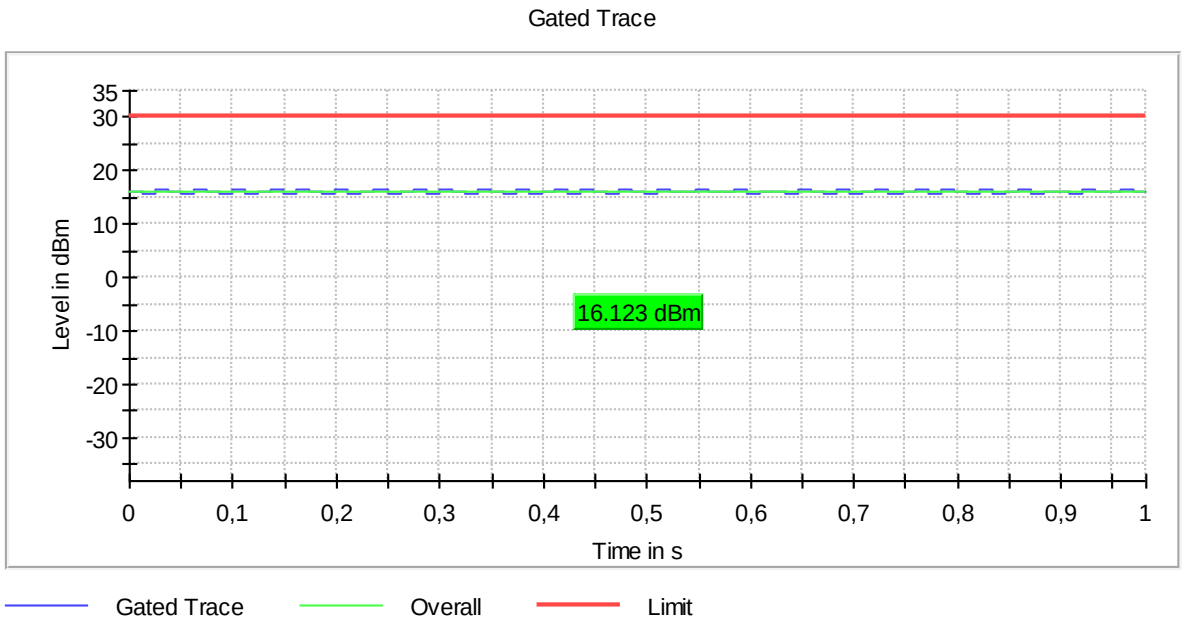
Verdict: PASS

- **802.11 b (Indoor antenna):**

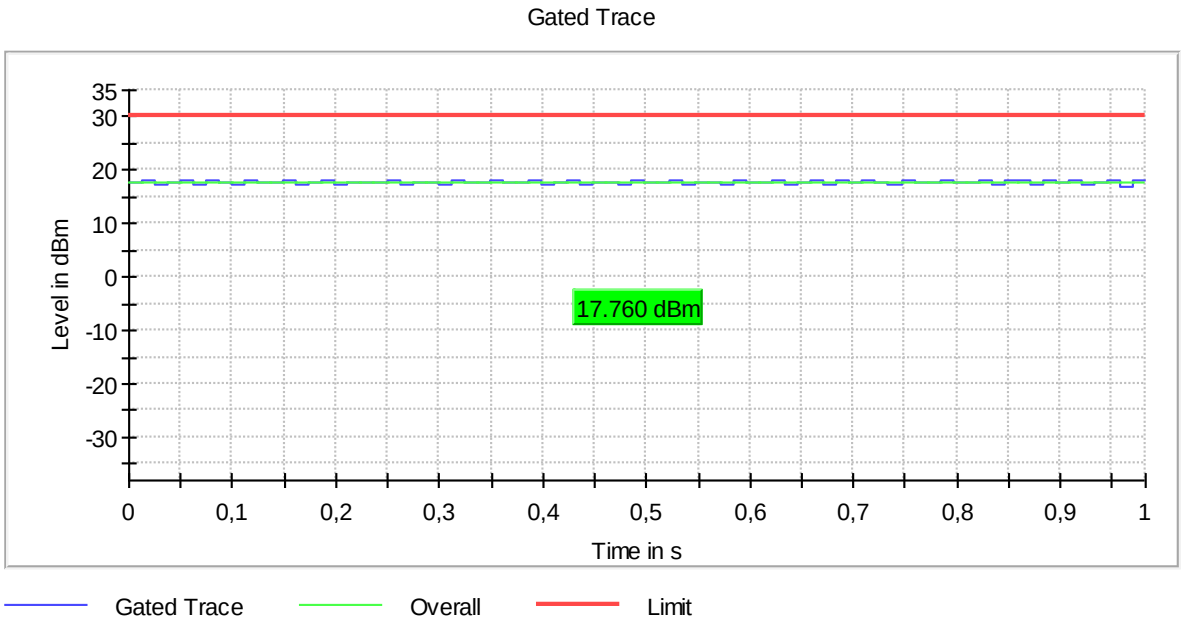
- Low Channel:



- Middle Channel:

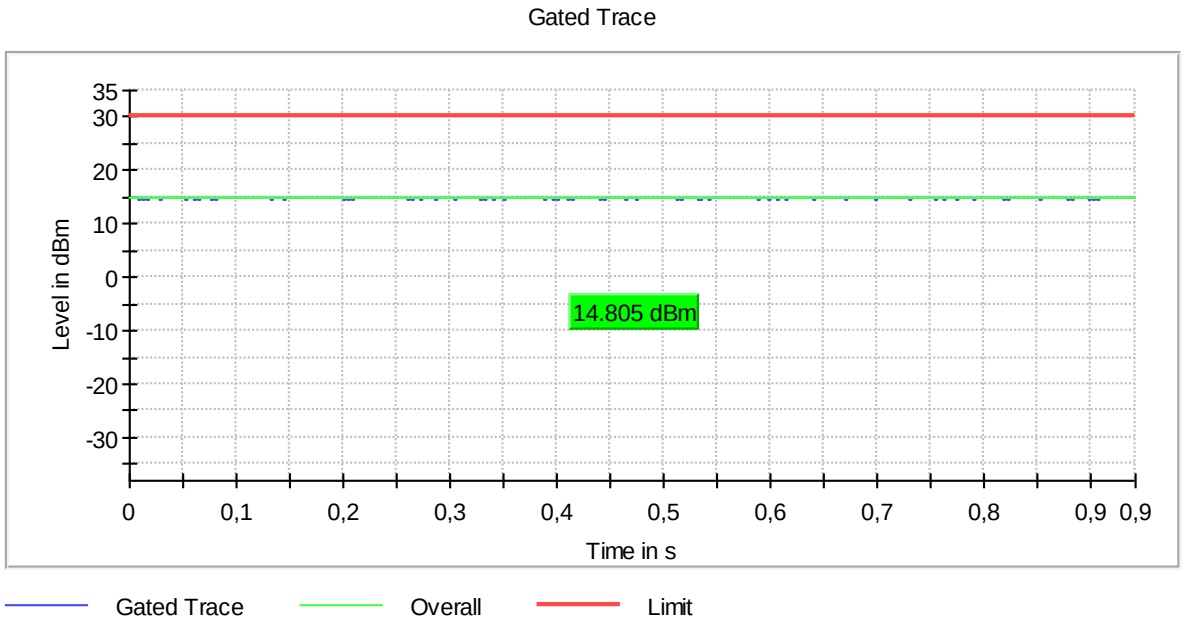


- High Channel:

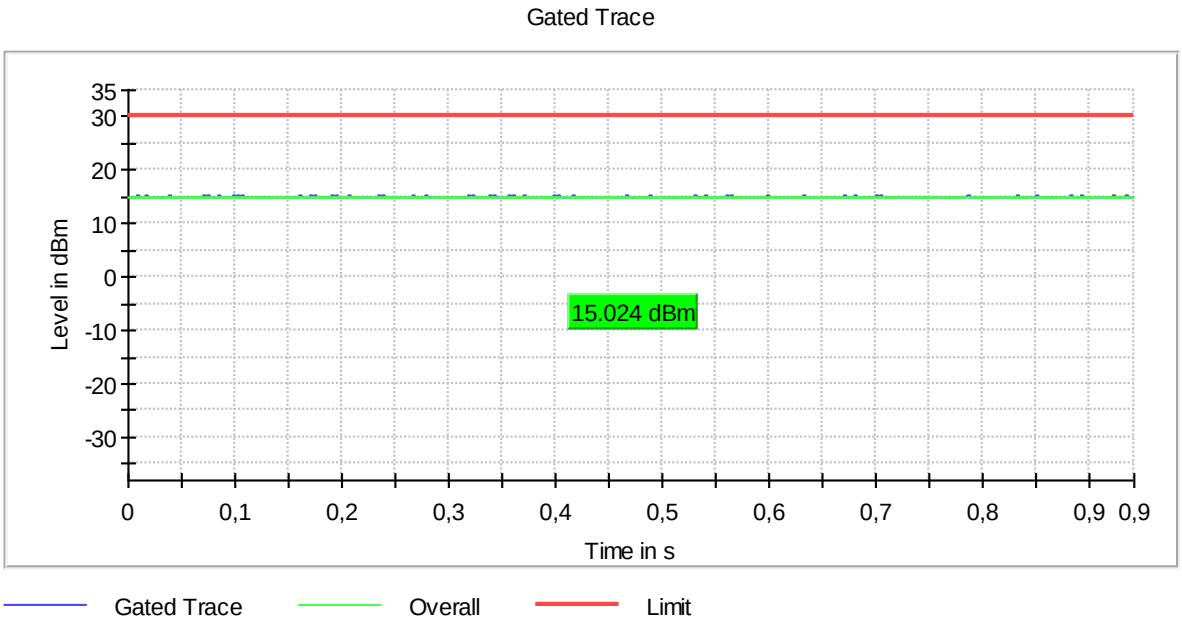


- **802.11 g (Indoor antenna):**

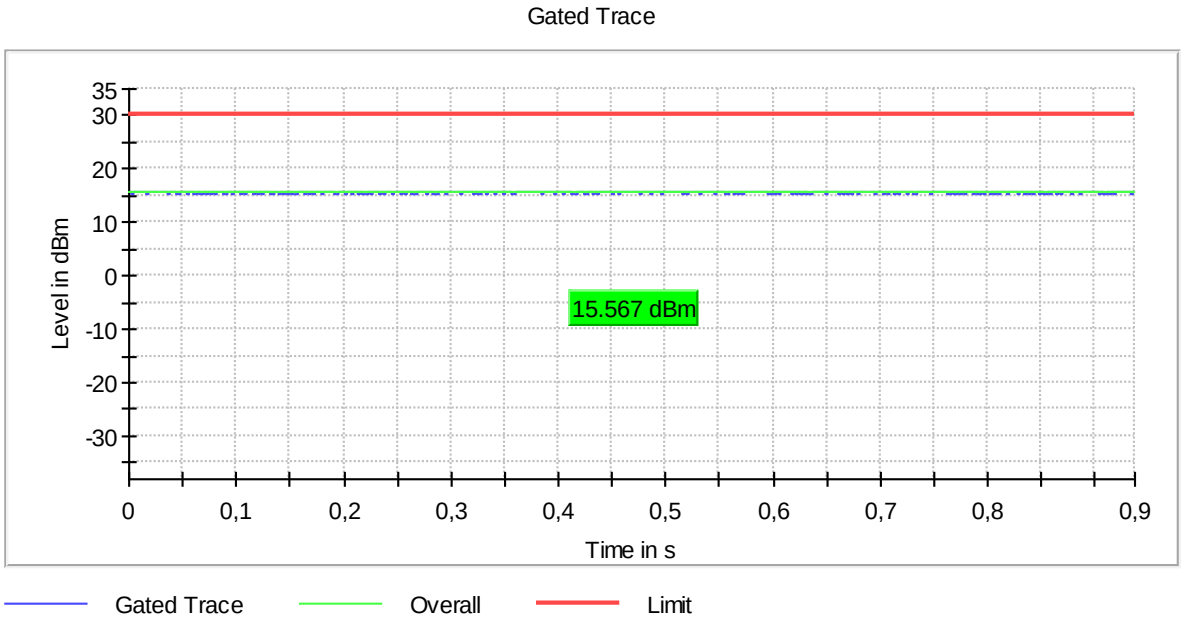
- Low Channel:



- Middle Channel:

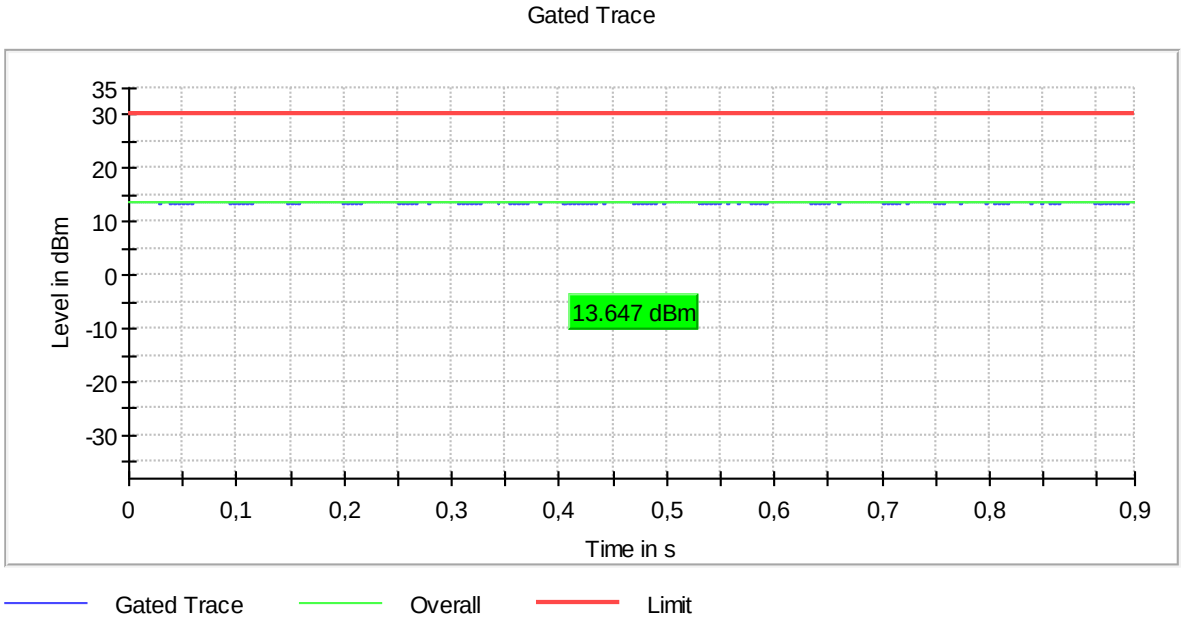


- High Channel:

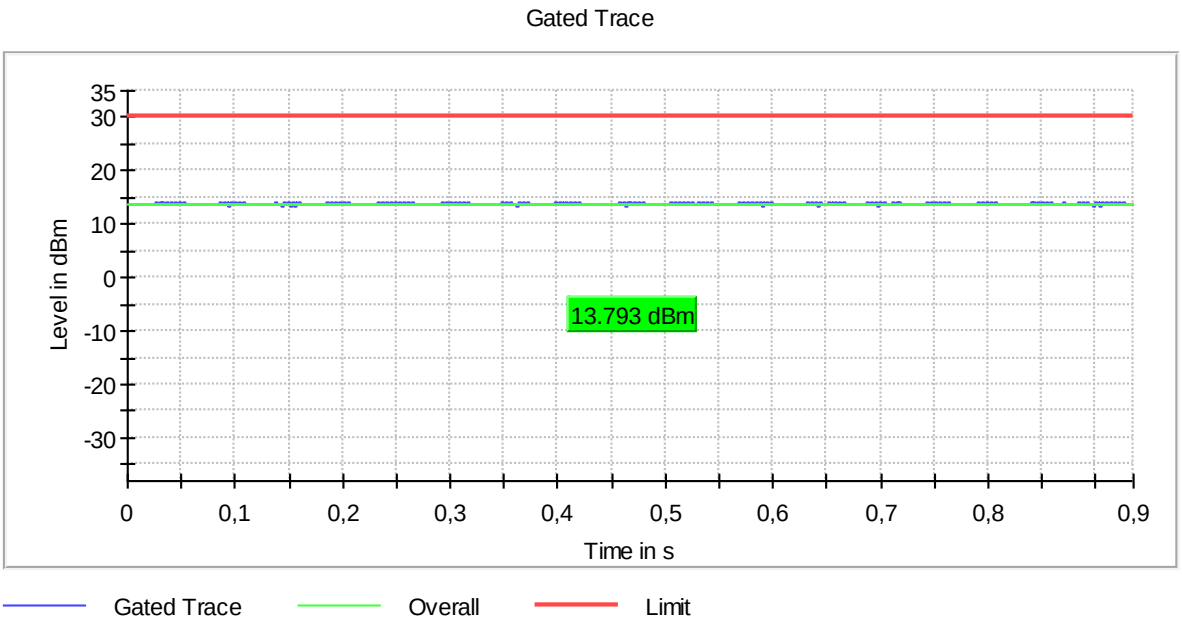


- **802.11 n20 (Indoor antenna):**

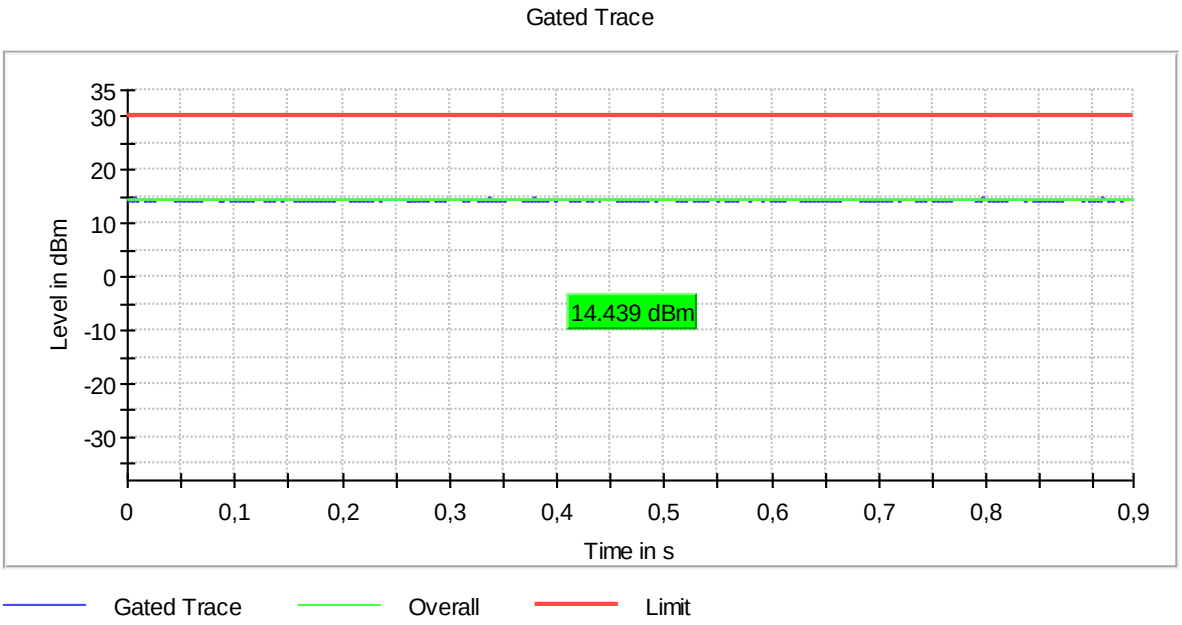
- Low Channel:



- Middle Channel:



- High Channel:



FCC 15.247 (d) / RSS-247 5.5. Band-edge emissions compliance (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.

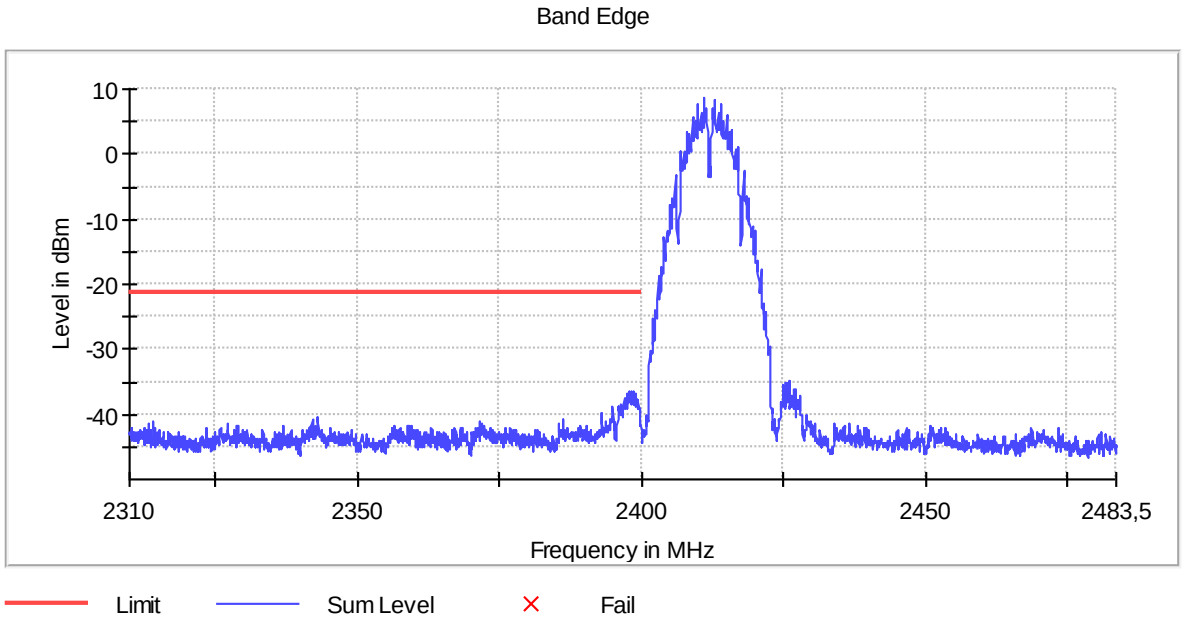
RESULTS:

Radiated measurements were used to show compliance with the limits in the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Measurement uncertainty (dB)	<±0.89

- **802.11 b – Band-edge emissions compliance**

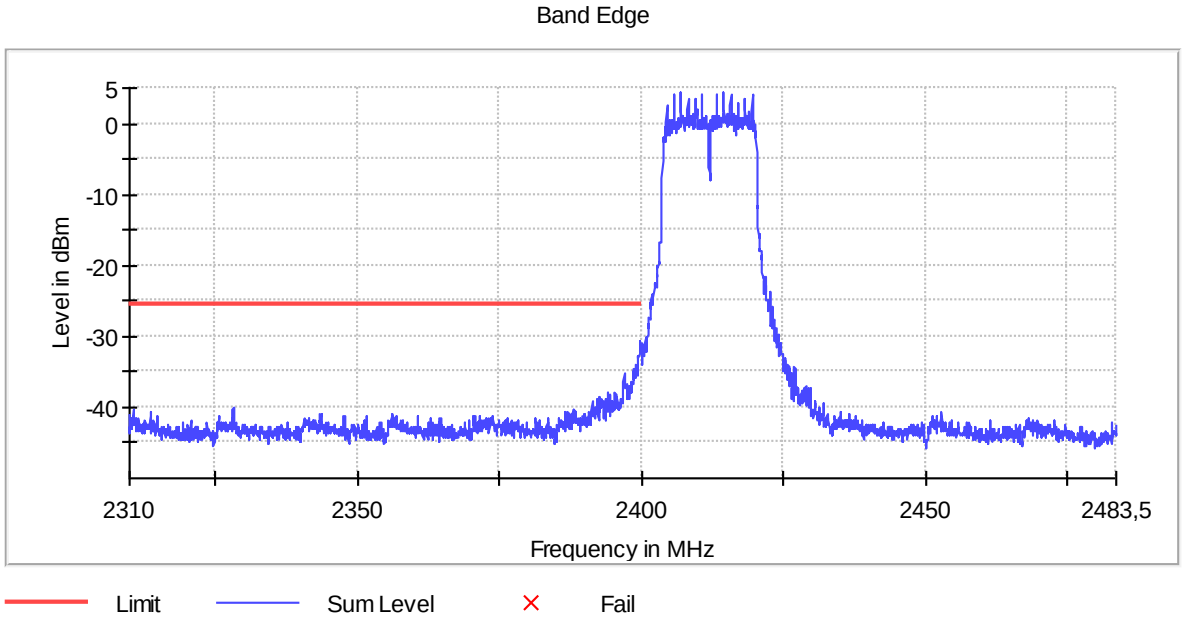
  - Low Channel:



Verdict: PASS

- **802.11 g – Band-edge emissions compliance**

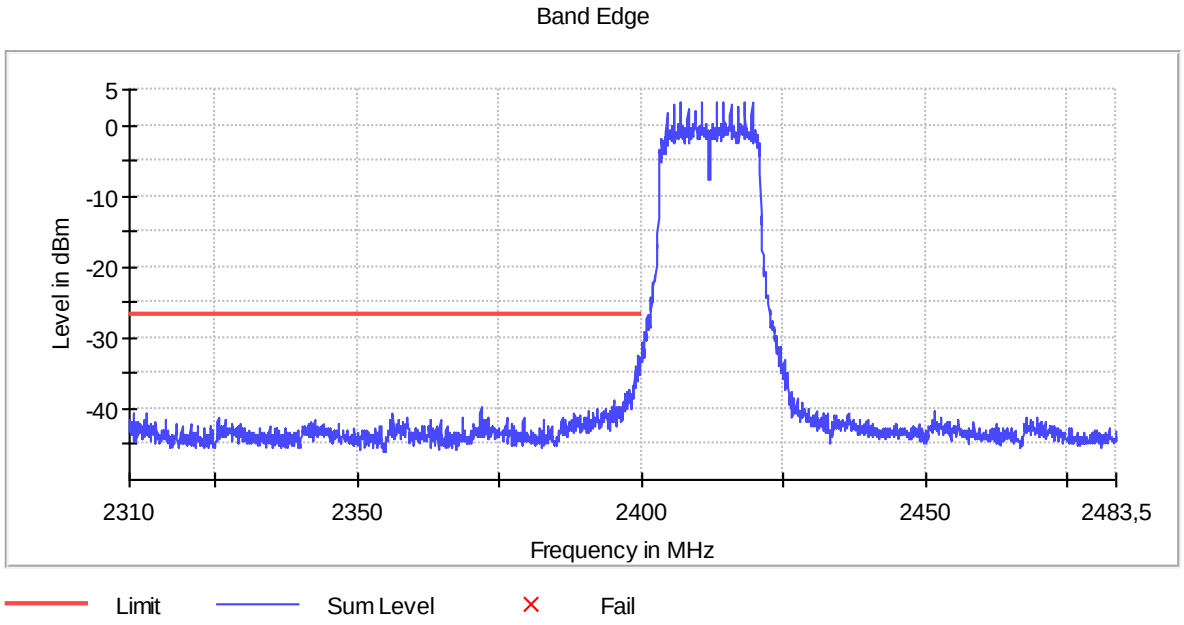
  - Low Channel:



Verdict: PASS

- **802.11 n20 – Band-edge emissions compliance**

  - Low Channel:



Verdict: PASS

FCC 15.247 (e) / RSS-247 5.2. (b) Power spectral density

SPECIFICATION:

For digitally modulated systems. 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.

RESULTS:

For modes 802.11 b, g, n20, the power spectral density was measured using the method according to point 11.10.3 “Method AVGPSD-1” of ANSI C.63.10-2013.

INDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +2.9 dBi.

OUTDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +0.3 dBi.

Results showed are in the worts case of antenna Gain.

- **802.11 b:**

Channels	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Corrected Conducted PSD (dBm)	-0.33	0.12	1.54
Maximum EIRP Corrected Conducted PSD (dBm)	2.56	3.02	4.44
Measurement uncertainty (dB)	<±0.99		

- **802.11 g:**

Channels	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Corrected Conducted PSD (dBm)	-4.75	-4.58	-4.27
Maximum EIRP Corrected Conducted PSD (dBm)	-1.85	-1.68	-1.37
Measurement uncertainty (dB)	<±0.99		

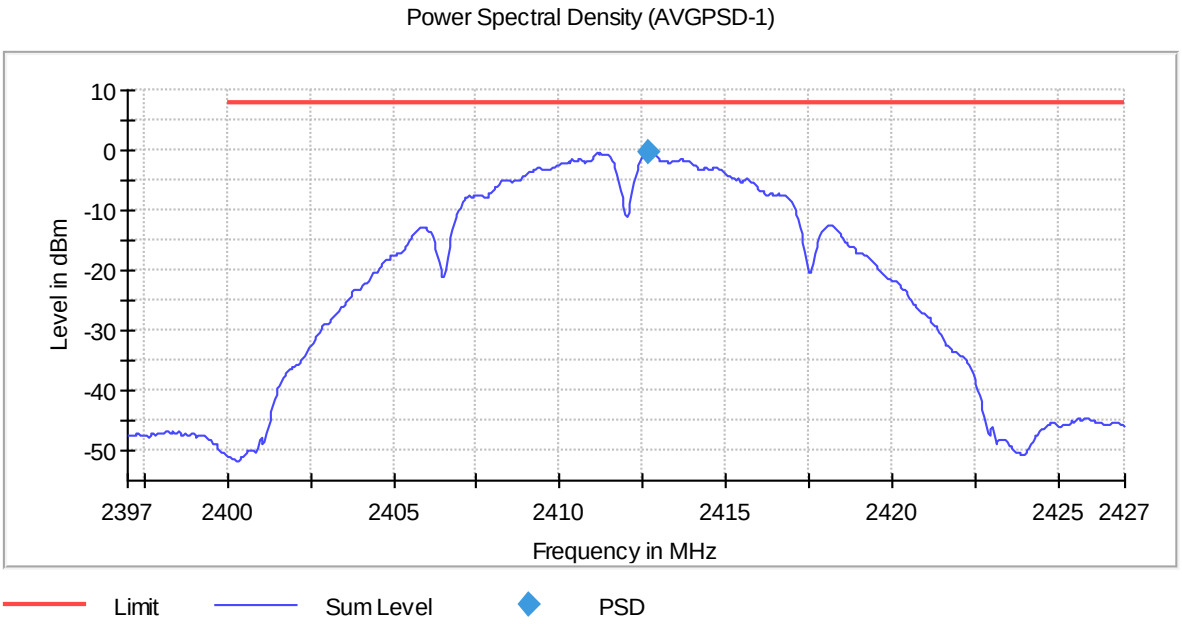
- **802.11 n20:**

Channels	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Corrected Conducted PSD (dBm)	-6.40	-6.26	-5.45
Maximum EIRP Corrected Conducted PSD (dBm)	-3.50	-3.36	-2.55
Measurement uncertainty (dB)	<±0.99		

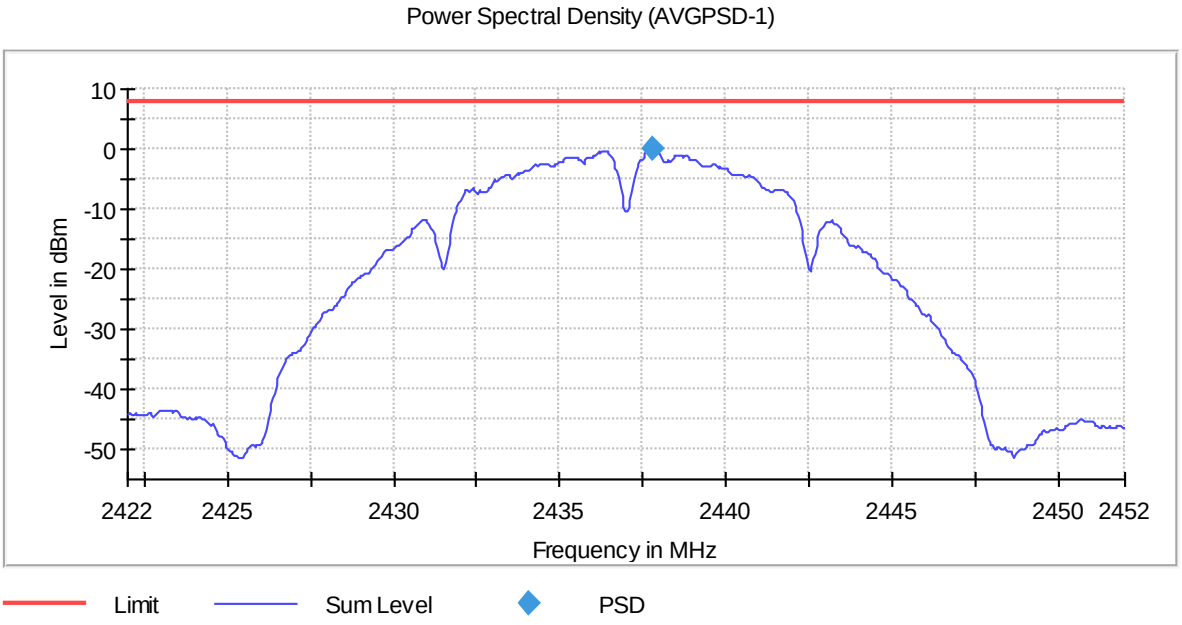
Verdict: PASS

- **802.11 b – Power Spectral Density:**

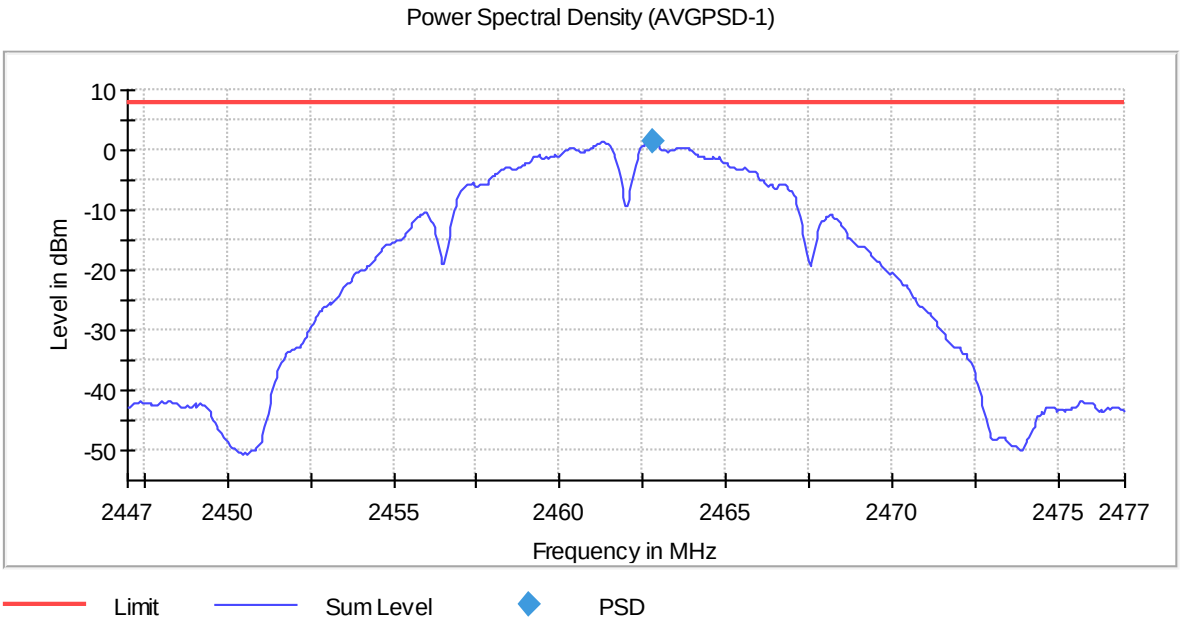
- Low Channel:



- Middle Channel:

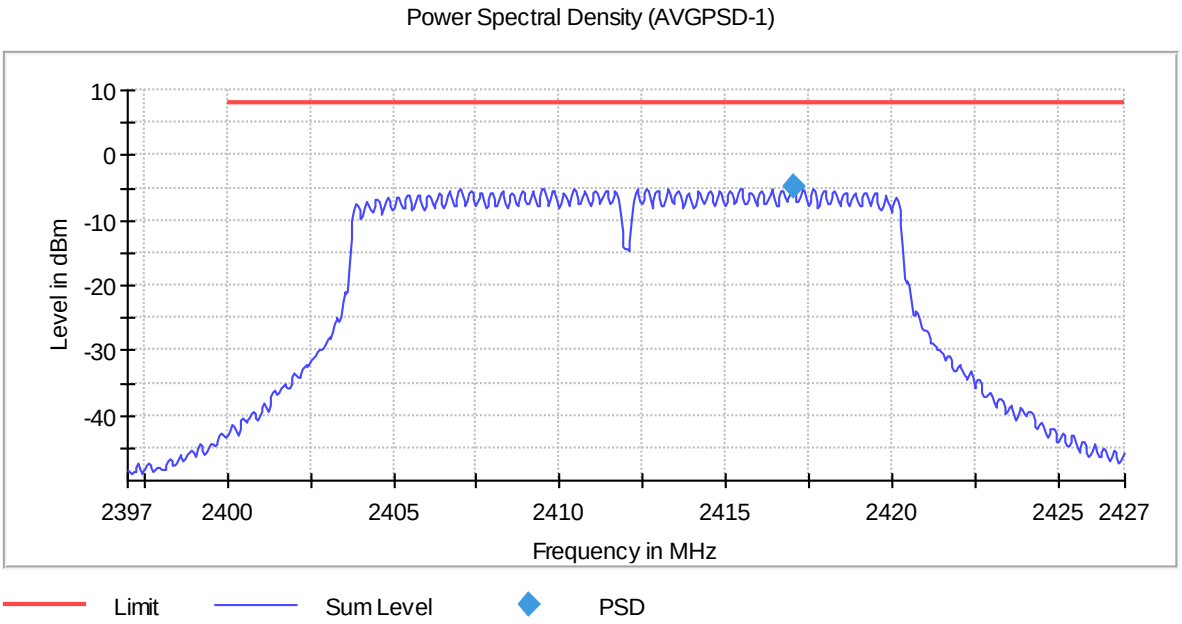


- High Channel:

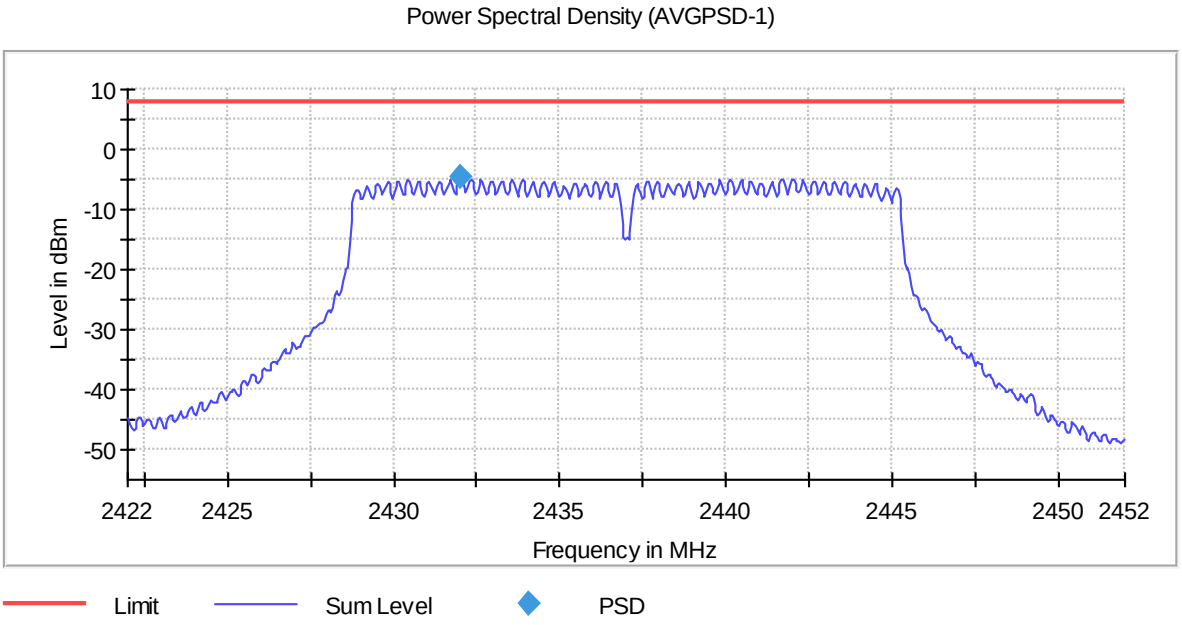


- **802.11 g – Power Spectral Density:**

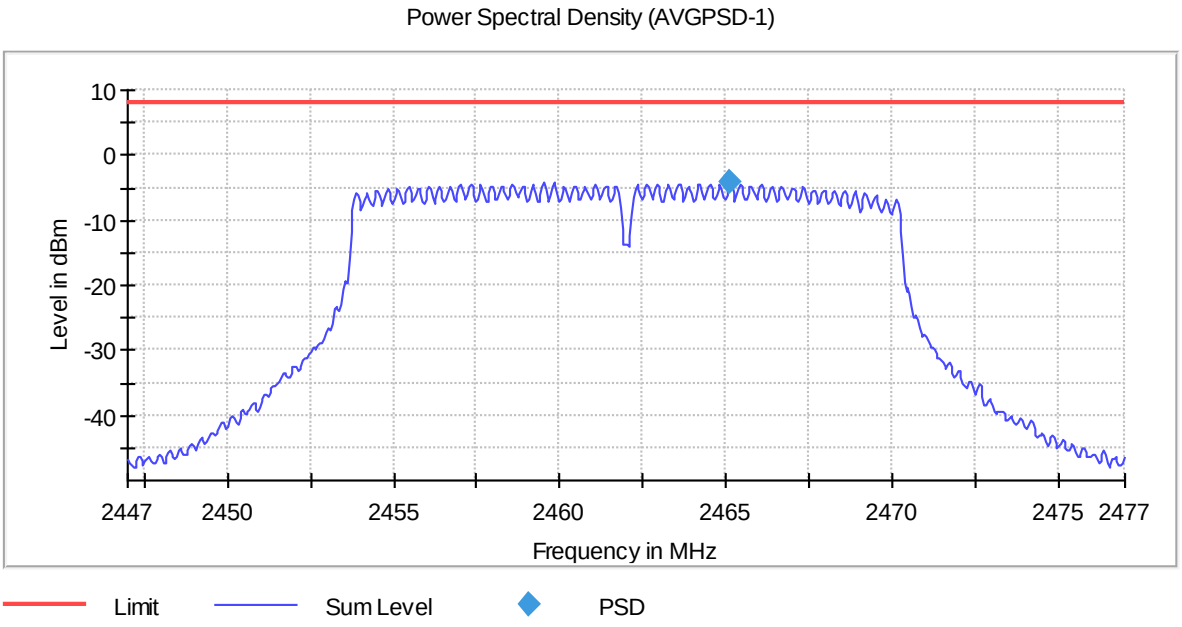
- Low Channel:



- Middle Channel:

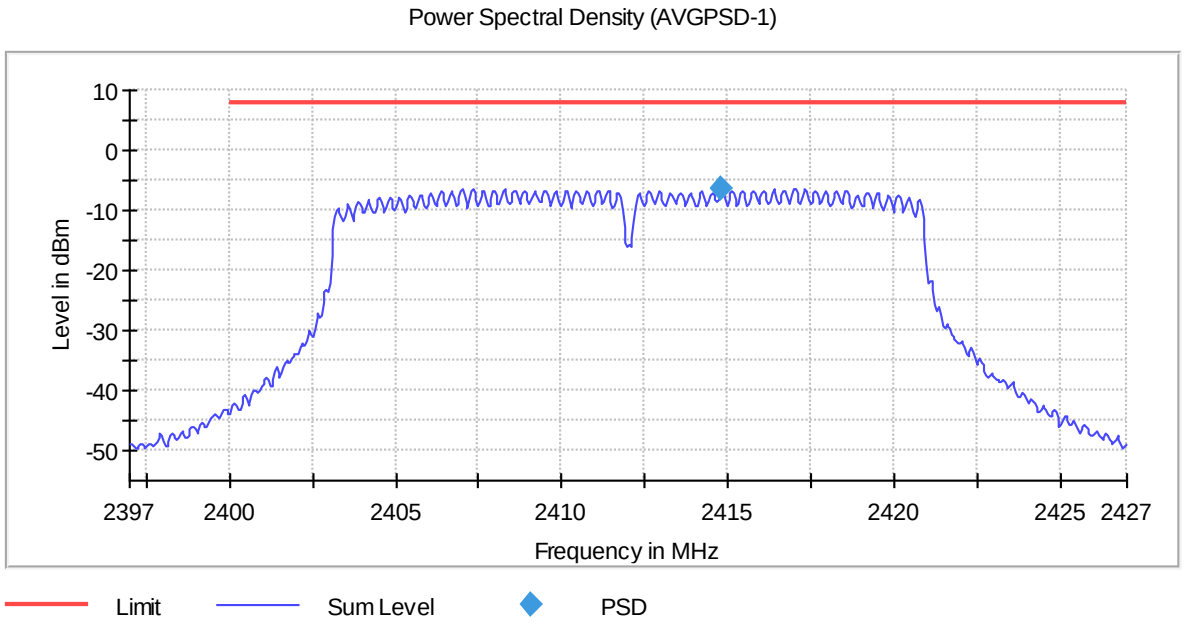


- High Channel:

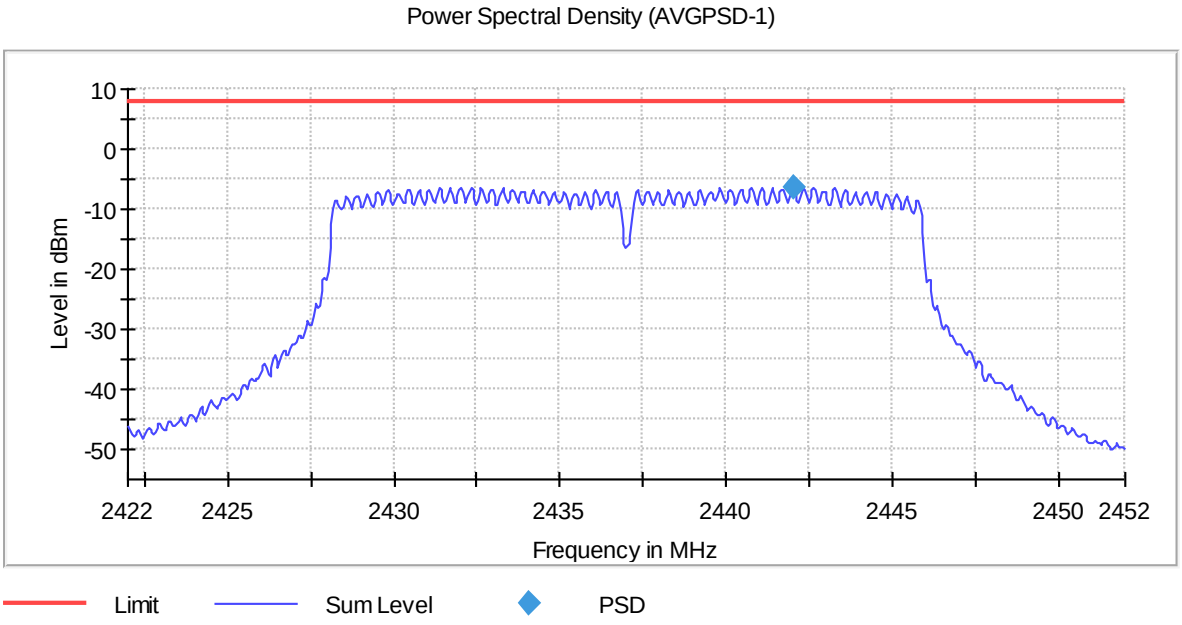


- **802.11 n20 – Power Spectral Density:**

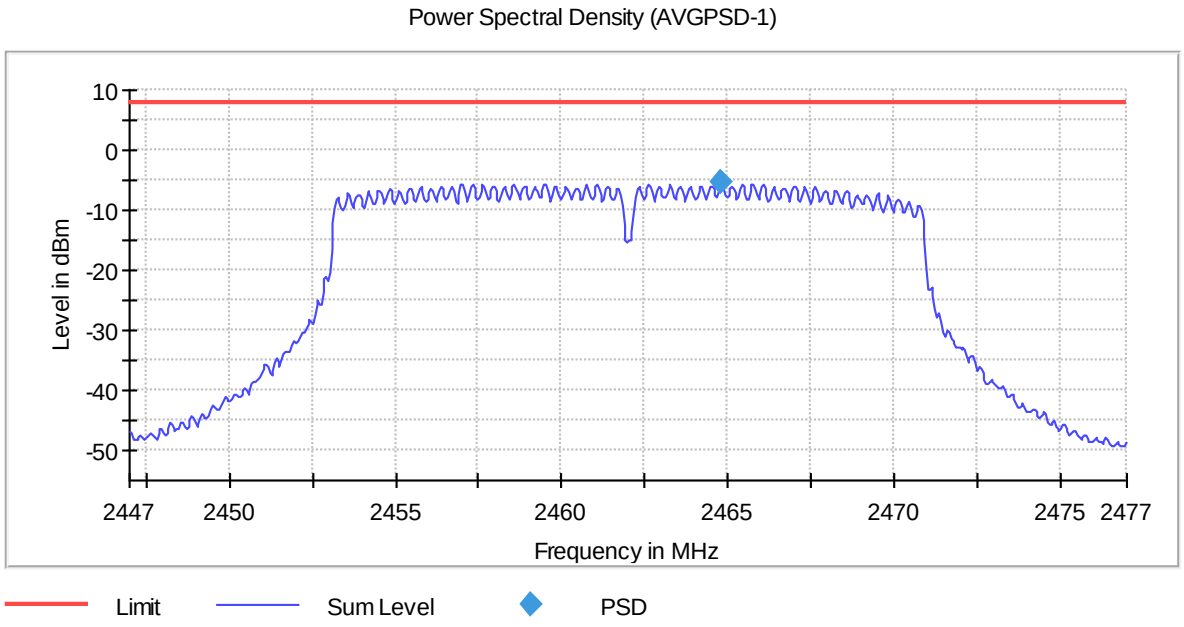
- Low Channel:



- Middle Channel:



- High Channel:



FCC 15.247 (d) / RSS-247 5.5. Emission limitations radiated (Transmitter)

SPECIFICATION:

Radiated emissions which fall in the restricted bands. as defined in Section 15.205(a). must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)/RSS-Gen):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 10000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz. 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz. there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RSS-247: Attenuation below the general field strength limits specified in RSS-Gen is not required.

RESULTS:

The situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

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

All tests were performed in a semi-anechoic chamber at a distance of 3 m for the frequency range 30 MHz-17 GHz and at distance of 1 m for the frequency range 17 GHz-26 GHz.

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor. cable loss and pre-amplifiers gain.

INDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +2.9 dBi.

Frequency range 30 MHz - 1 GHz:

The spurious frequencies do not depend neither on the operating channel nor the modulation mode.

No spurious frequencies at less than 20 dB below the limit:

Measurement Uncertainty <± 4.99 dB

- **802.11 b:**

  Frequency range 1 - 26 GHz:

  The results in the next tables show the maximum measured levels in the 1-26 GHz range including the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

  Spurious frequencies with peak levels above the average limit (54 dBµV/m at 3 m) are measured with average detector for checking compliance with the average limit.

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4824.000000	45.05	V	Peak
7236.000000	51.65	V	Peak

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4874.000000	48.43	V	Peak
7310.000000	50.37	V	Peak

- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4924.000000	49.51	V	Peak
7386.000000	52.80	V	Peak
9848.000000	48.84	V	Peak

- RESTRICTED BAND 2.31-2.39 GHz. LOW CHANNEL. No spurious frequencies at less than 20 dB below the limit.

- RESTRICTED BAND 2.4835-2.5 GHz. HIGH CHANNEL. No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB): 1 GHz $\leq$ f $\leq$ 17 GHz: <± 4.98
17 GHz $\leq$ f $\leq$ 26 GHz: <± 5.08

Verdict: PASS

OFDM modes:

For spurious emissions in the range 30 MHz - 26 GHz (except field strength at the band edges that was performed for all modes) a preliminary scan was performed to determine the worst-case mode.

Spurious emissions in the Restricted Bands 2.31-2.39 GHz and 2.4835-2.5 GHz are measured for all modes.
The following results and plots are for the worst-case OFDM mode.

- **Worst-case OFDM mode: 802.11 g.**
  - **802.11 g (OFDM worst-case for spurious emissions):**

    Frequency range 1 - 26 GHz:

    The results in the next tables show the maximum measured levels in the 1-26 GHz range including the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

    Spurious frequencies with peak levels above the average limit (54 dBµV/m at 3 m) are measured with average detector for checking compliance with the average limit.

** Duty Cycle Correction Factor (dB): 0.2187*

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4814.500000	47.84	V	Peak
7242.500000	48.83	V	Peak

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4871.500000	48.03	V	Peak
7312.500000	47.01	V	Peak

- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4925.500000	47.87	V	Peak
7393.000000	49.11	V	Peak

- RESTRICTED BAND 2.31-2.39 GHz. LOW CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
2389.400000	60.59	60.59	V	Peak
	45.97	46.1887		Average
2389.666667	59.87	59.87	V	Peak
	45.28	45.4987		Average

- RESTRICTED BAND 2.4835-2.5 GHz. HIGH CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
2483.800000	64.52	64.52	V	Peak
	48.34	48.5587		Average

Measurement Uncertainty (dB): 1 GHz ≤ f ≤ 17 GHz: <± 4.98
17 GHz ≤ f ≤ 26 GHz: <± 5.08

Verdict: PASS

- **802.11 n20:**

The results in the next tables show the maximum measured levels in the Restricted Bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Spurious frequencies with peak levels above the average limit (54 dBµV/m at 3 m) are measured with average detector for checking compliance with the average limit.

** Duty Cycle Correction Factor (dB): 0.2345*

- RESTRICTED BAND 2.31-2.39 GHz. LOW CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
2389.866667	56.84	56.84	V	Peak
	43.61	43.8445		Average

- RESTRICTED BAND 2.4835-2.5 GHz. HIGH CHANNEL. Spurious frequencies at less than 20 dB below the limit:

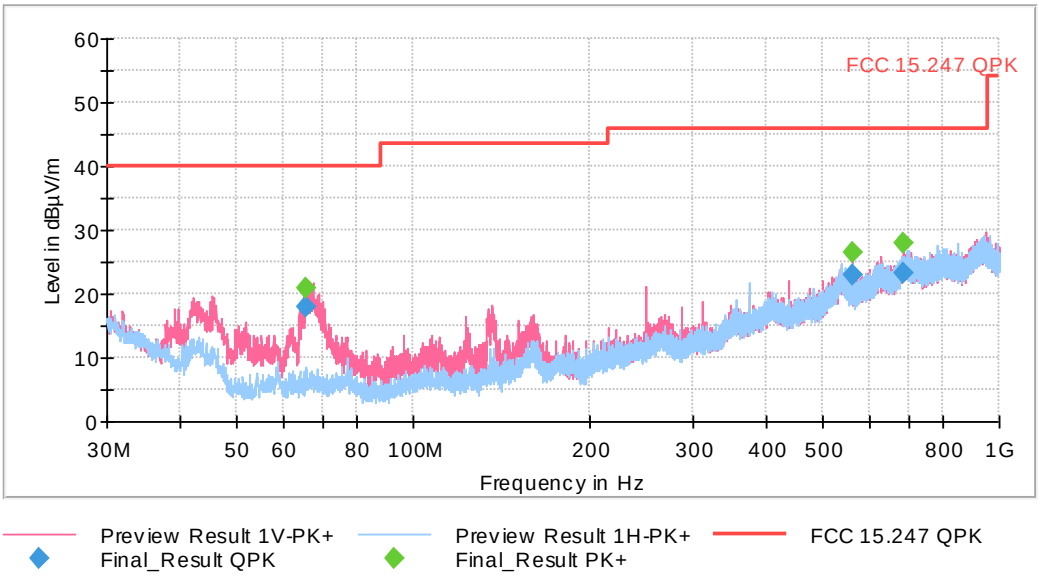
Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
2483.533333	62.31	62.31	V	Peak
	47.59	47.8245		Average
2483.800000	61.88	61.88	V	Peak
	47.65	47.8845		Average

Measurement Uncertainty (dB): 1 GHz ≤ f ≤ 17 GHz: <± 4.98
17 GHz ≤ f ≤ 26 GHz: <± 5.08

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

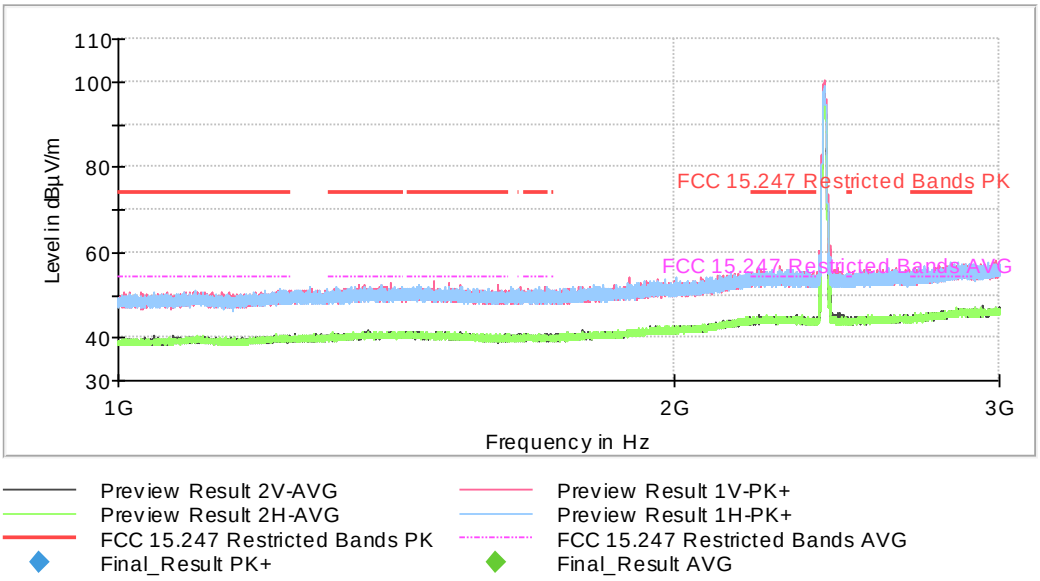
The spurious frequencies detected do not depend neither on the operating channel nor the modulation mode.



- **802.11 b:**

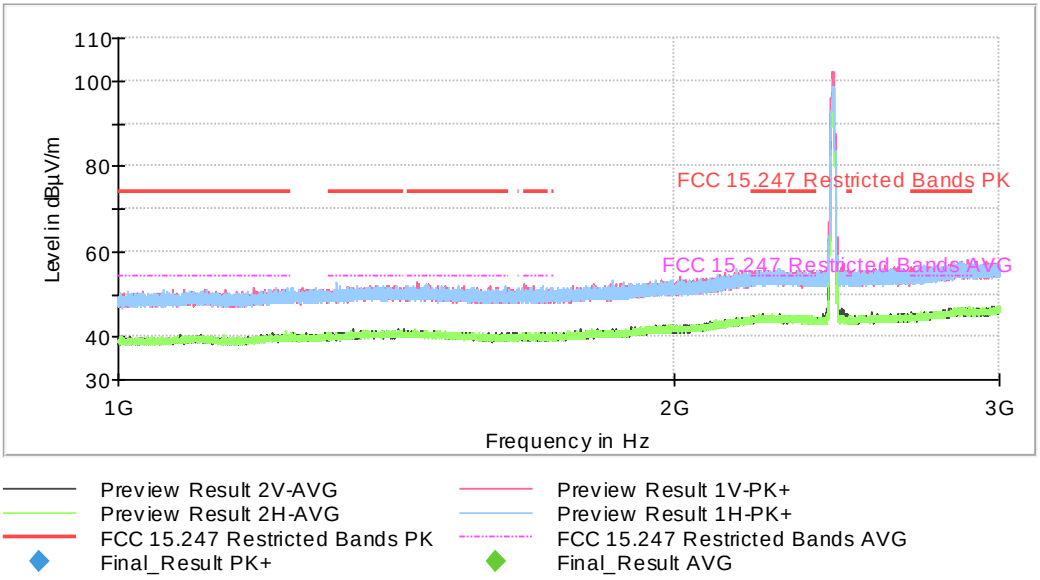
FREQUENCY RANGE 1 - 3 GHz:

- Low Channel:



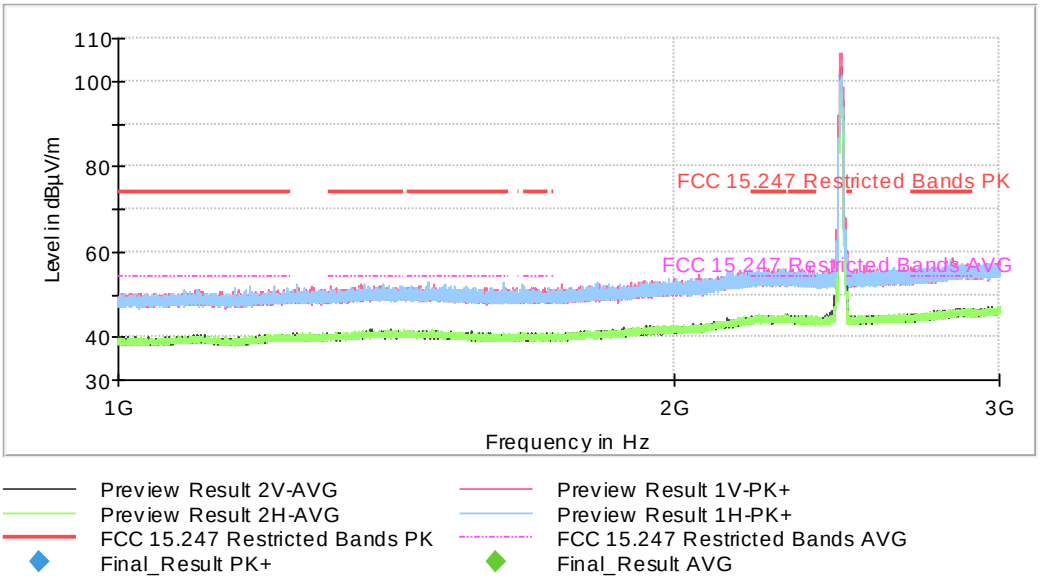
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

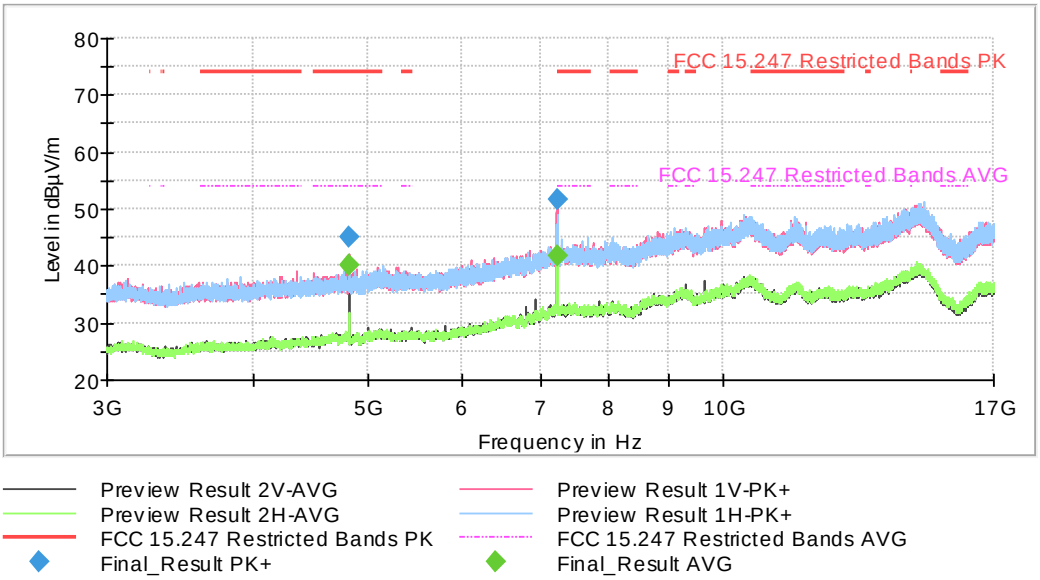
- High Channel:



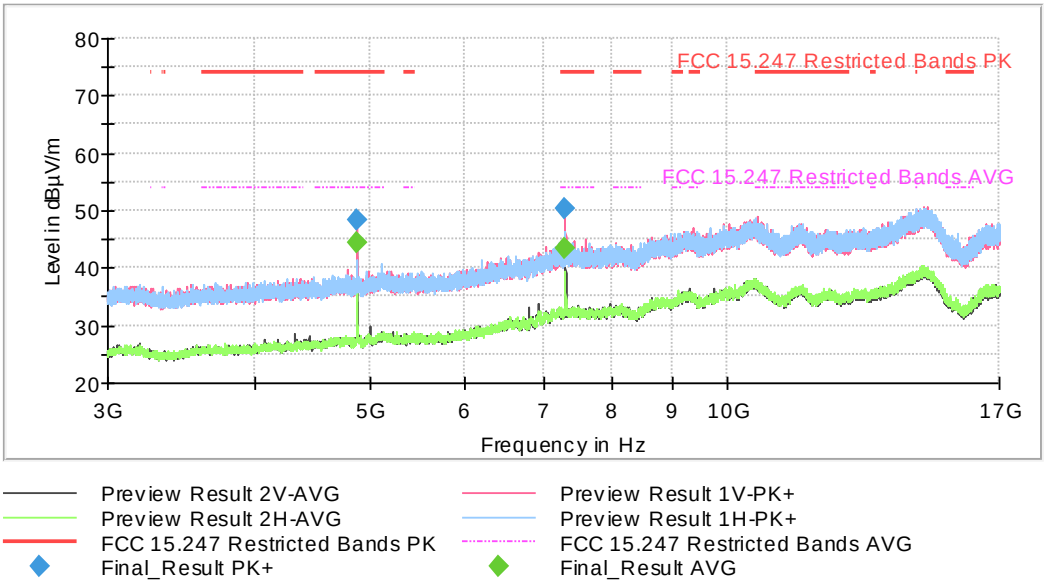
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

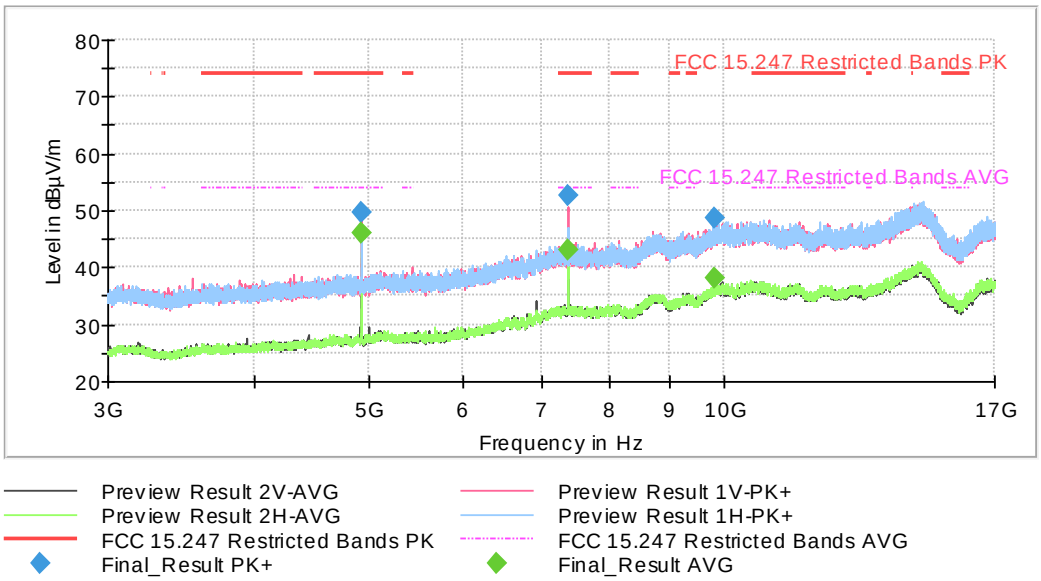
- Low Channel:



- Middle Channel:

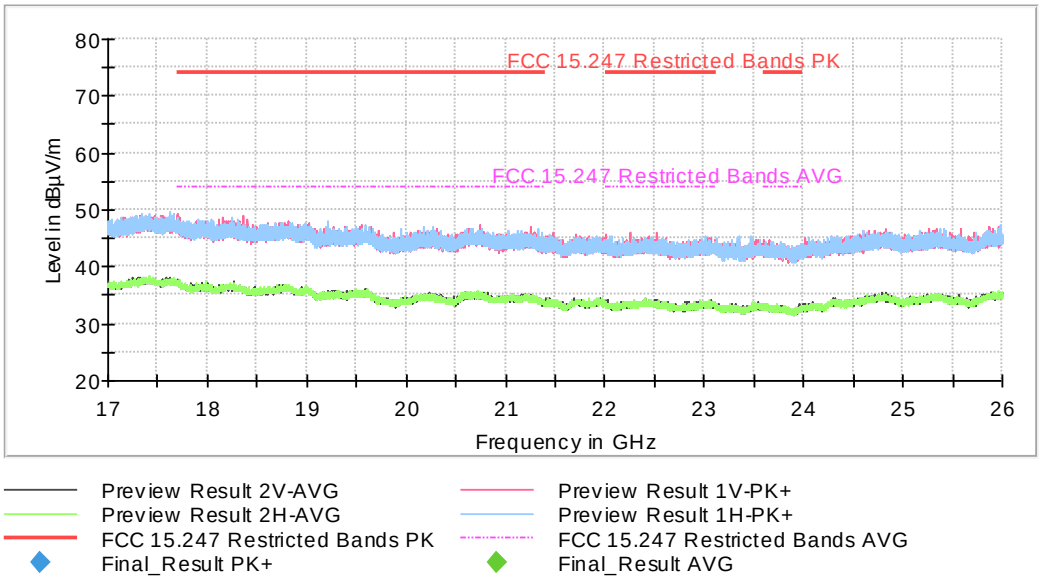


- High Channel:



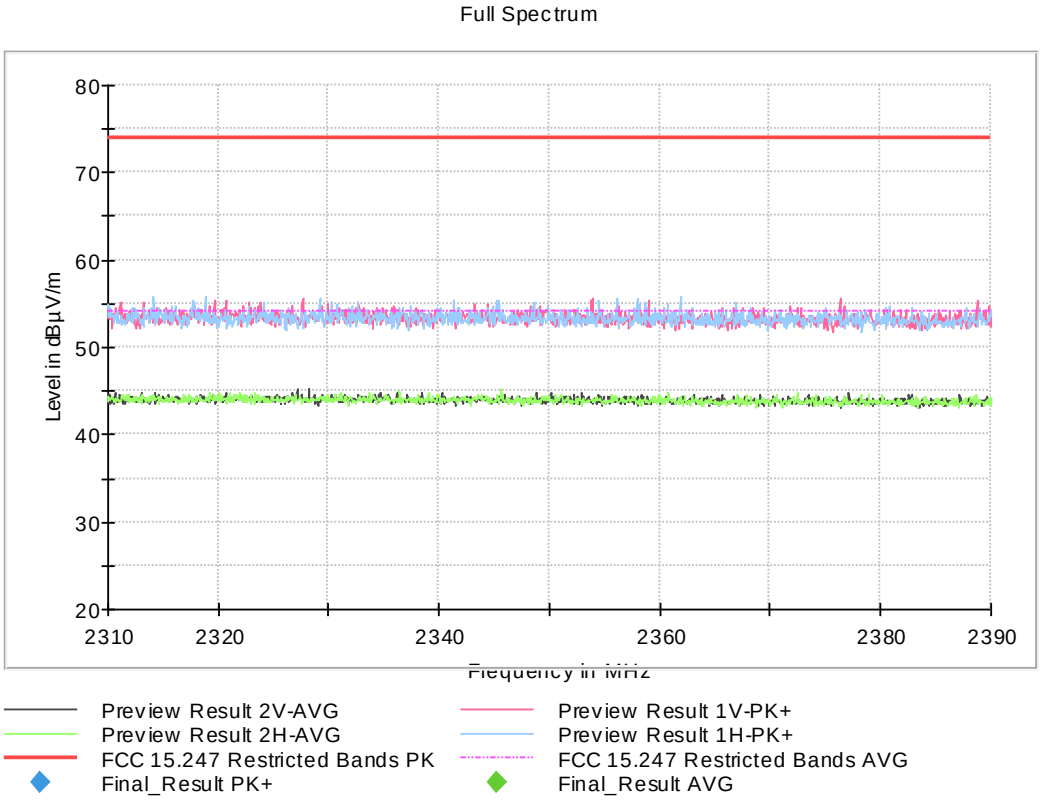
FREQUENCY RANGE 17 - 26 GHz:

The spurious frequencies detected do not depend on the operating channel.



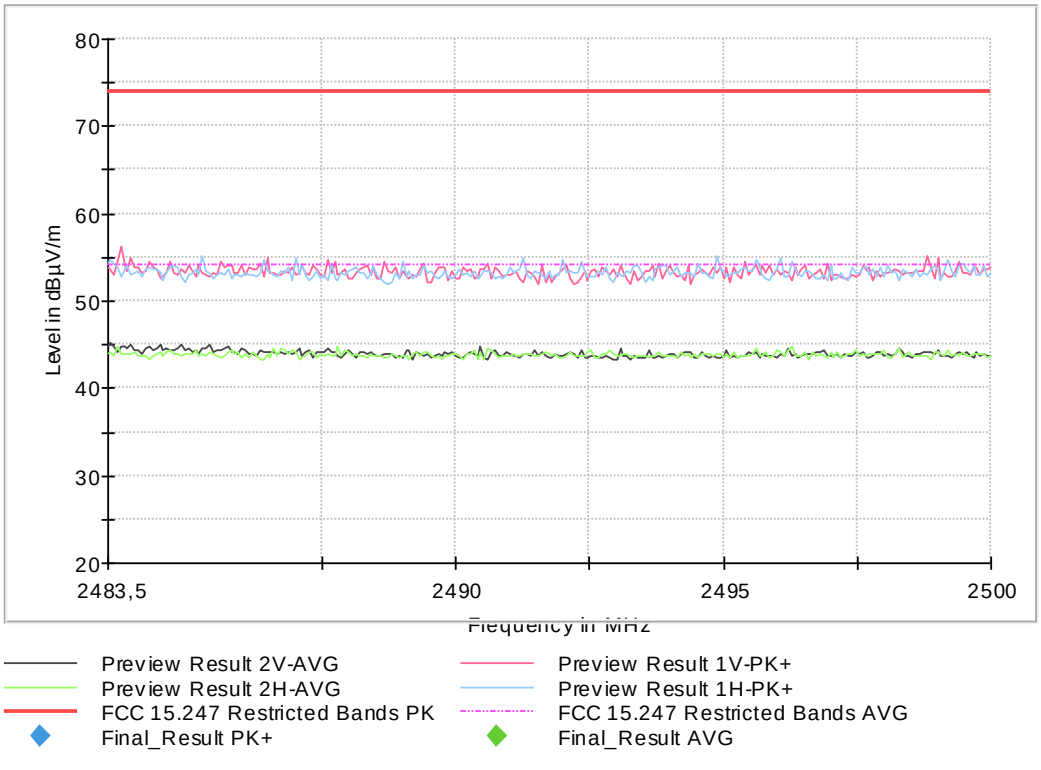
RESTRICTED BAND 2.31-2.39 GHz:

- Low Channel:



RESTRICTED BAND 2.4835-2.5 GHz:

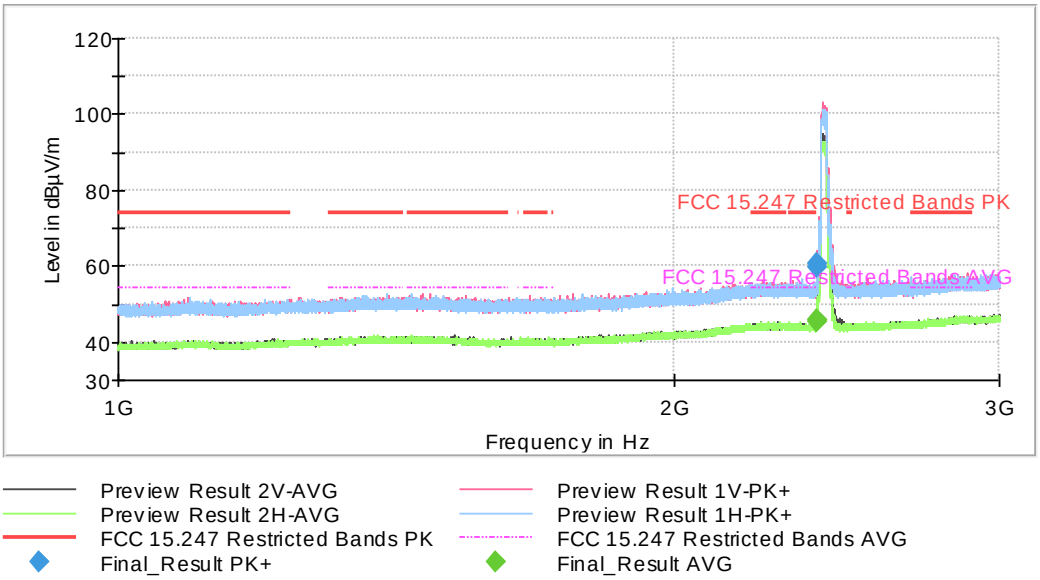
- High Channel:



- **802.11 g (OFDM worst-case for spurious emissions):**

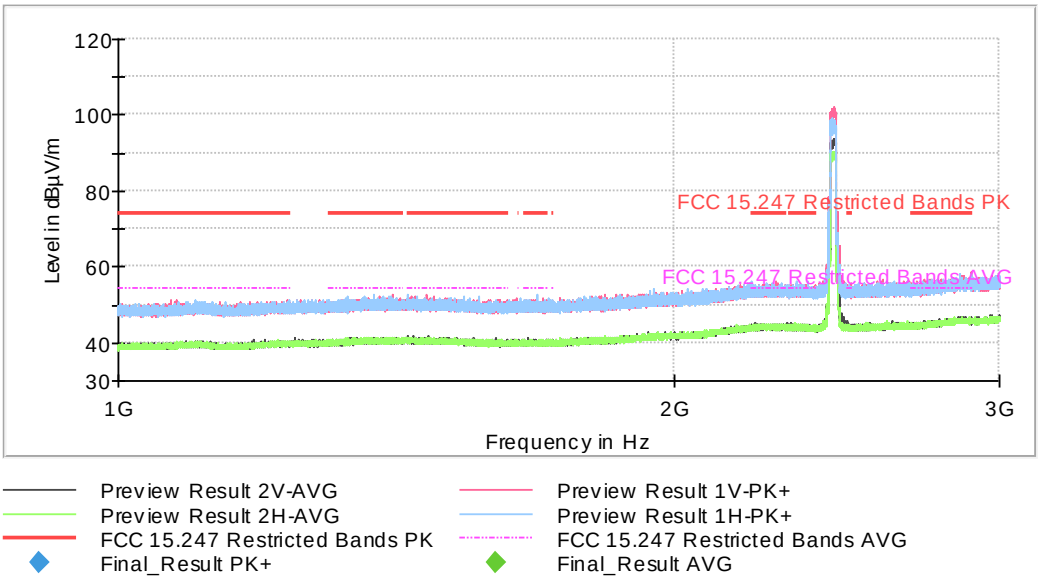
FREQUENCY RANGE 1 - 3 GHz:

- Low Channel:



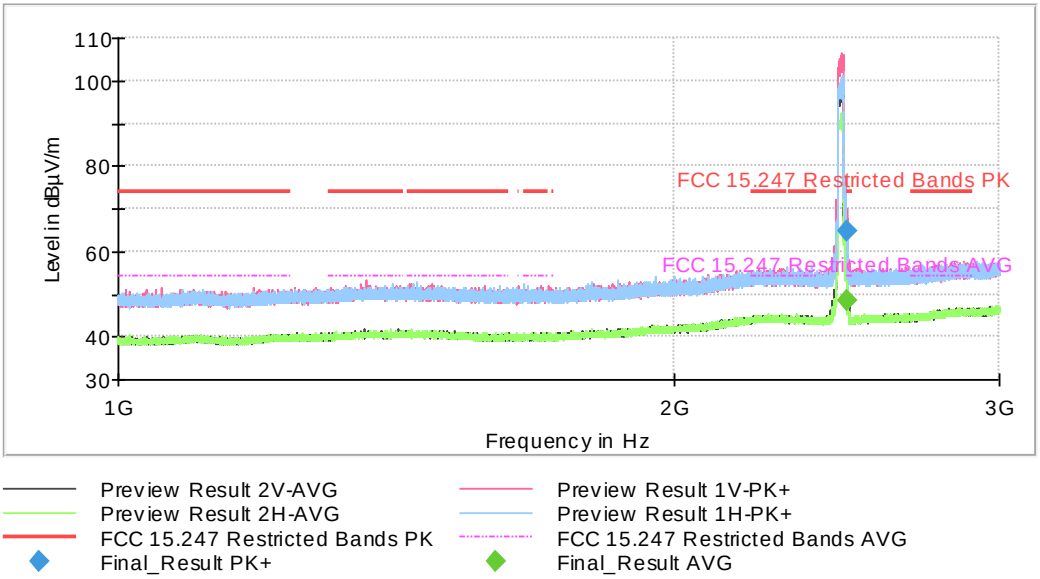
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

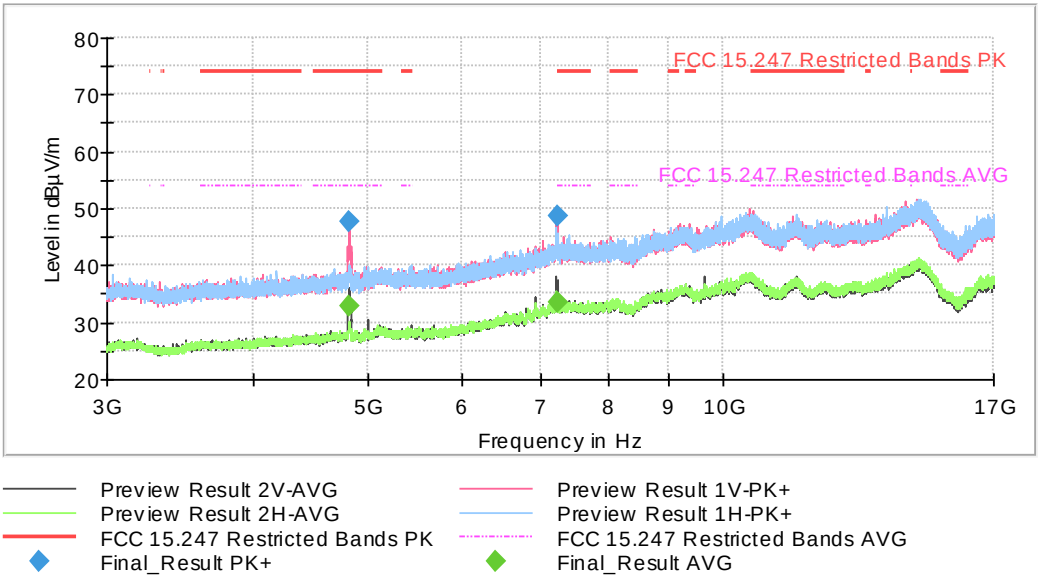
- High Channel:



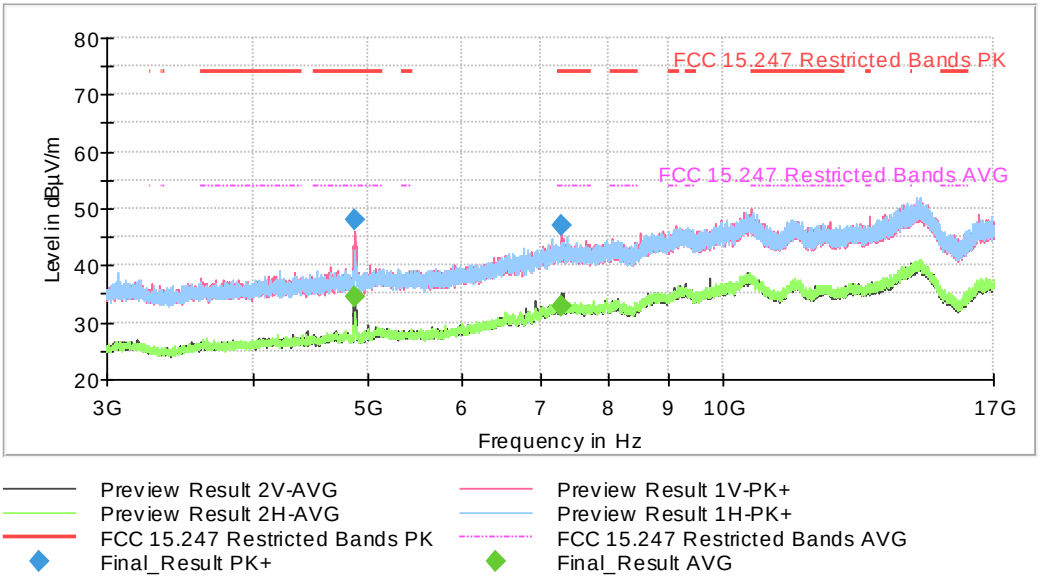
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

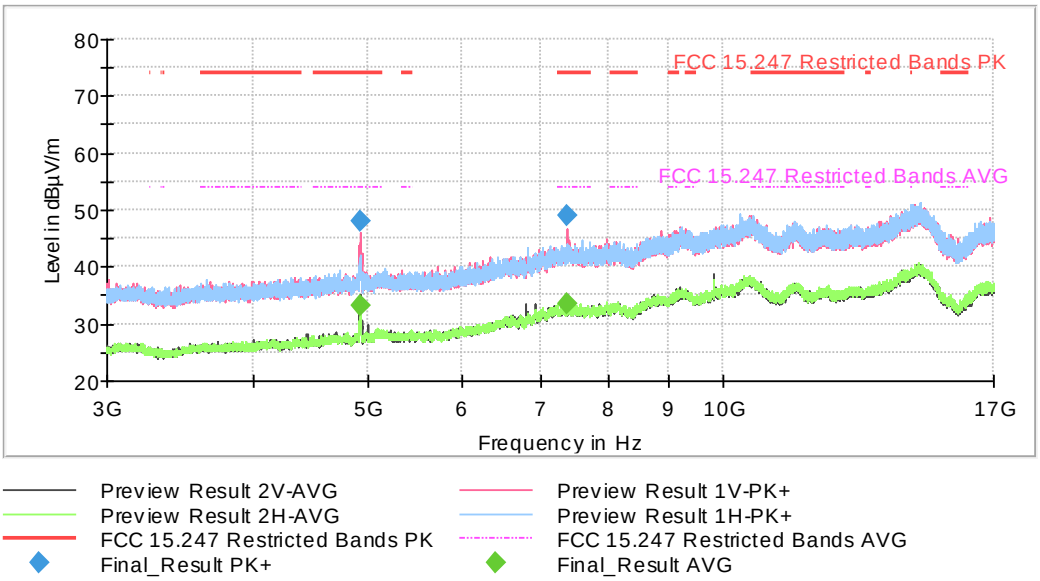
- Low Channel:



- Middle Channel:

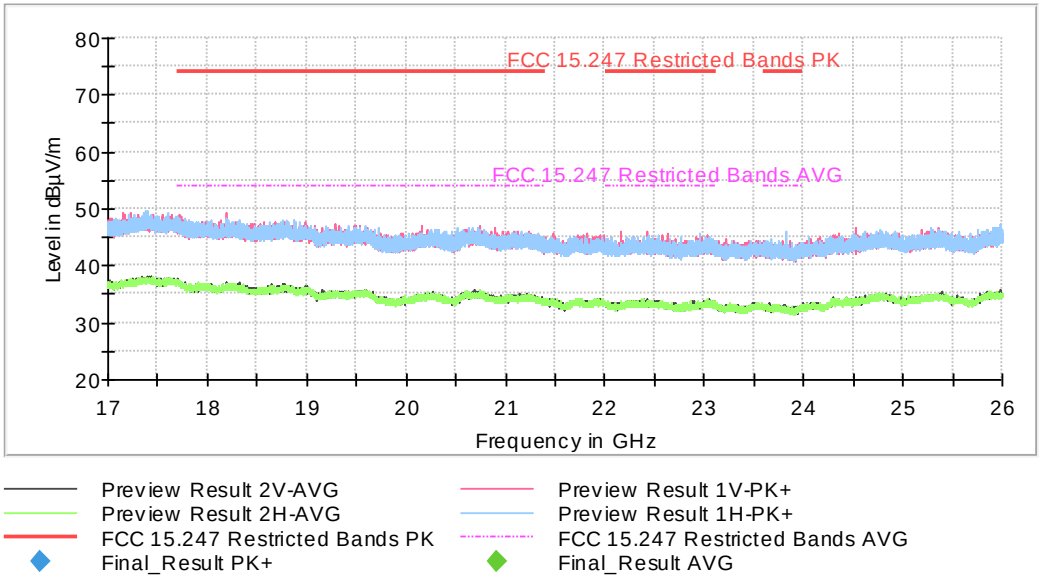


- High Channel:



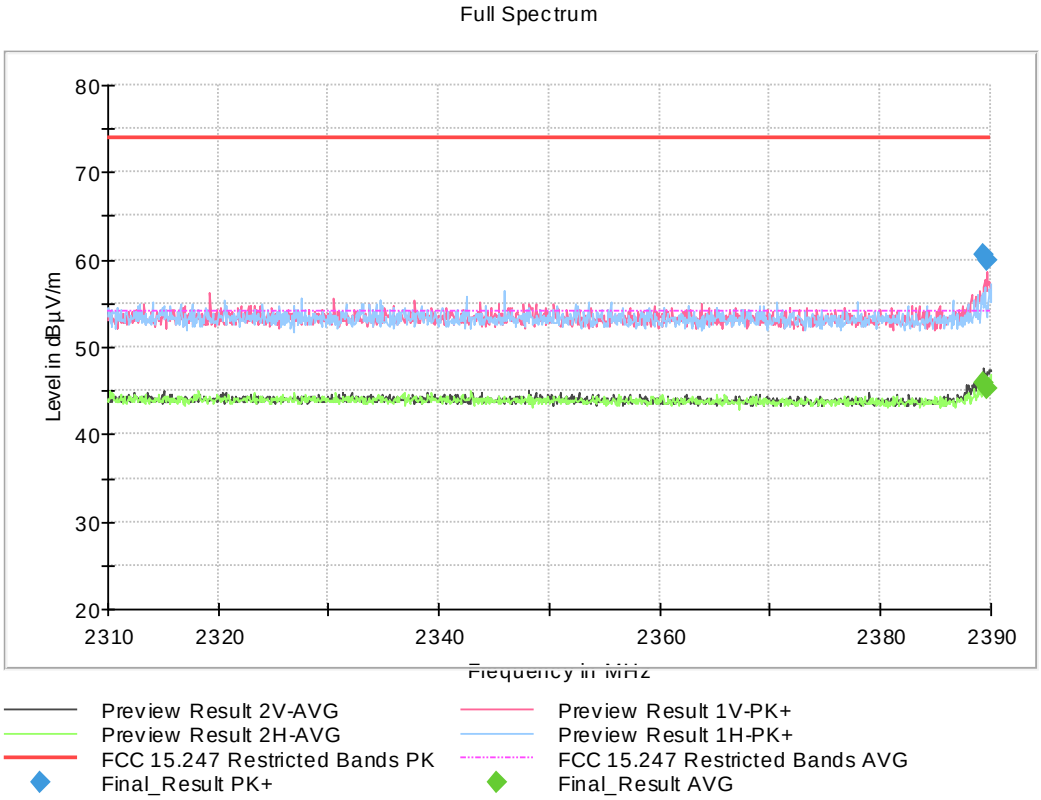
FREQUENCY RANGE 17 - 26 GHz:

The spurious frequencies detected do not depend on the operating channel.



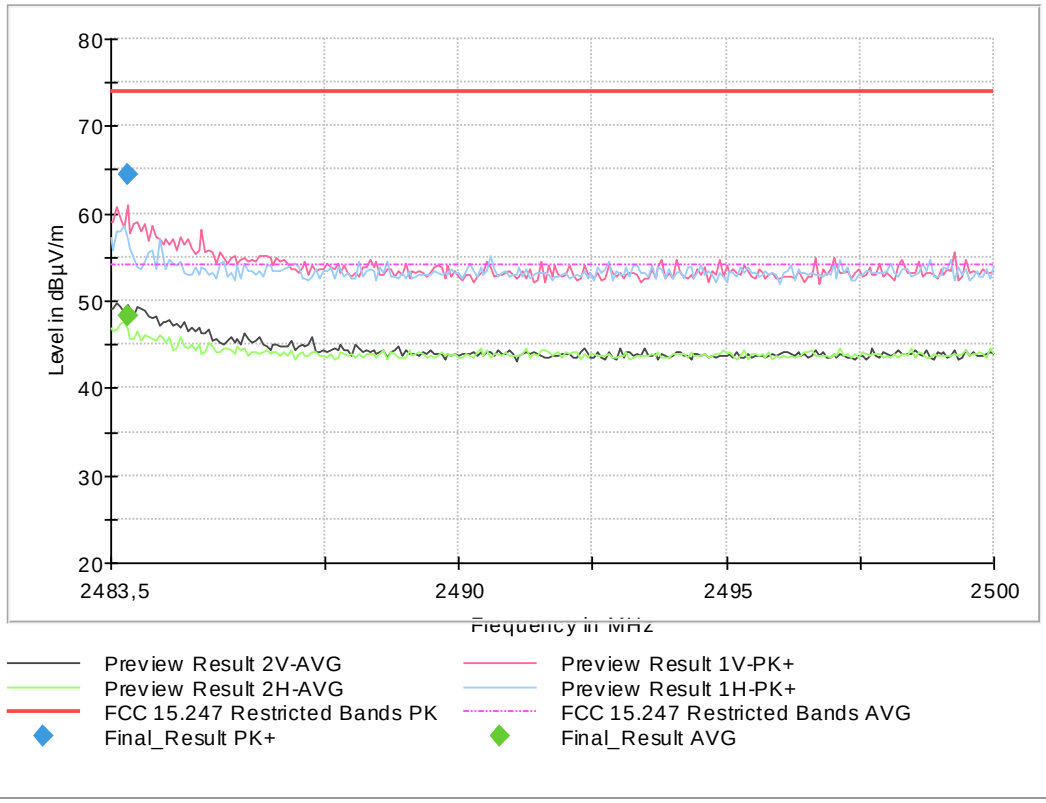
RESTRICTED BAND 2.31-2.39 GHz:

- Low Channel:



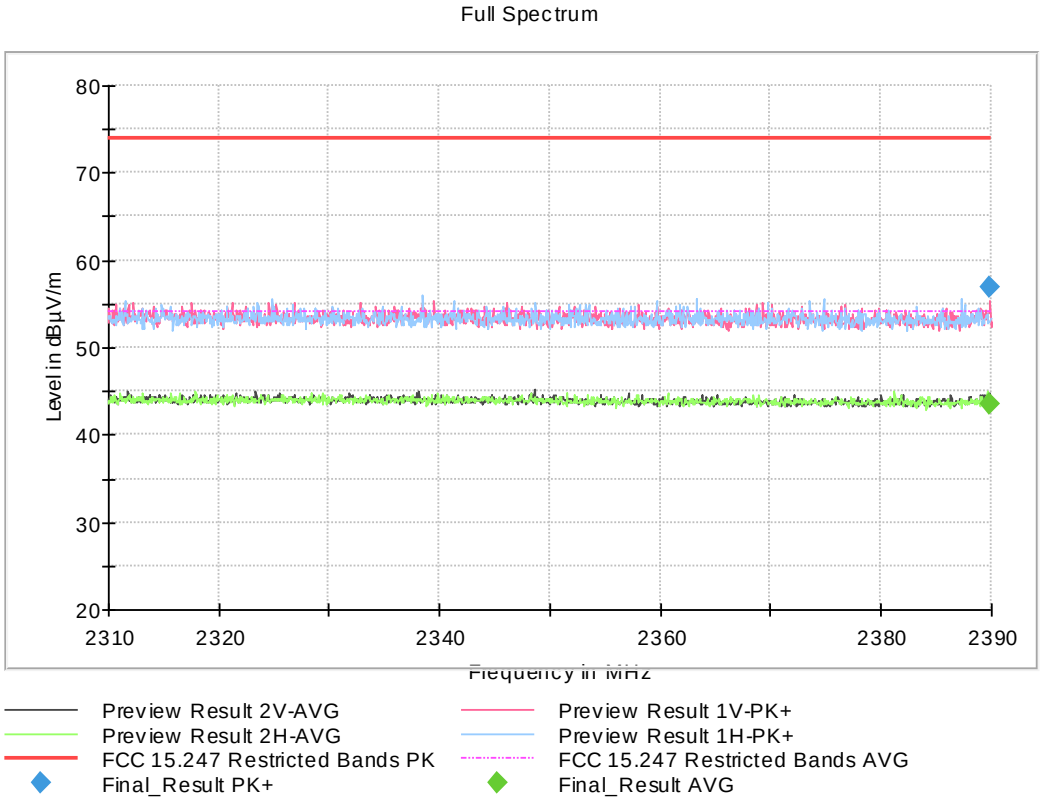
RESTRICTED BAND 2.4835-2.5 GHz:

- High Channel:

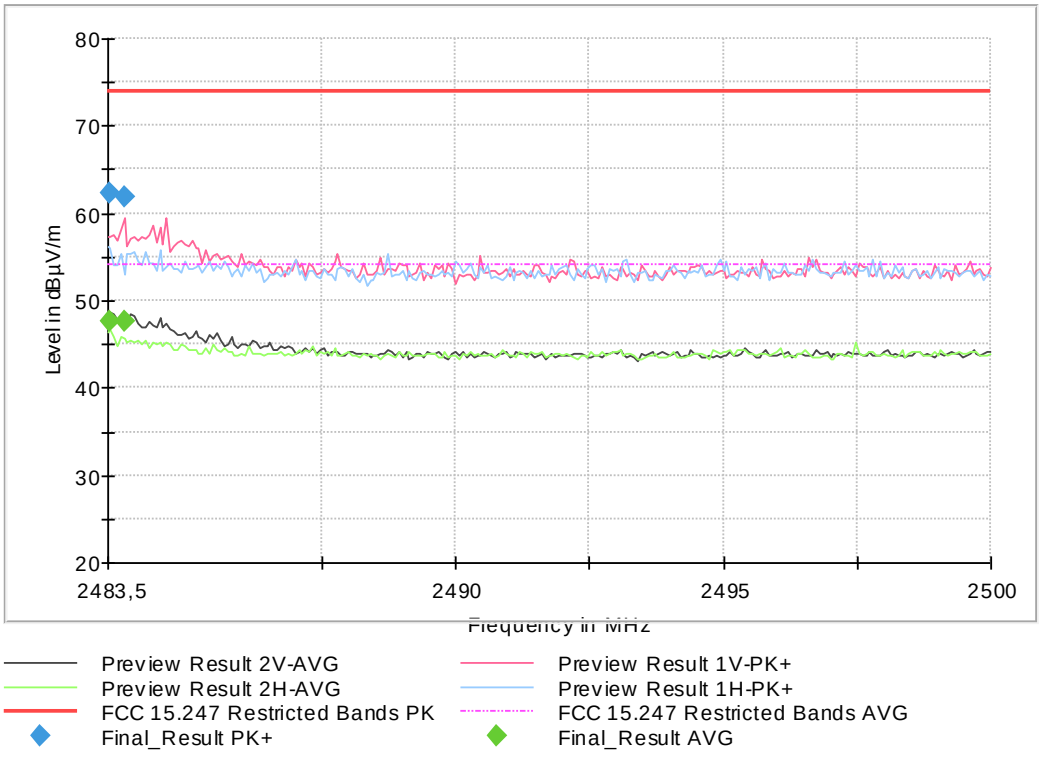


- **802.11 n20:**

RESTRICTED BAND 2.31-2.39 GHz:
- Low Channel:



RESTRICTED BAND 2.4835-2.5 GHz:
- High Channel:



OUTDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +0.3 dBi.

Frequency range 30 MHz - 1 GHz:

The spurious frequencies do not depend neither on the operating channel nor the modulation mode.

No spurious frequencies at less than 20 dB below the limit:

Measurement Uncertainty <± 4.99 dB

- **802.11 b:**

  Frequency range 1 - 26 GHz:

  The results in the next tables show the maximum measured levels in the 1-26 GHz range including the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

  Spurious frequencies with peak levels above the average limit (54 dBµV/m at 3 m) are measured with average detector for checking compliance with the average limit.

  - LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4823.500000	45.02	V	Peak
7235.000000	51.89	V	Peak
9648.000000	49.01	V	Peak

  - MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4873.500000	46.02	V	Peak
7312.000000	48.15	H	Peak
9748.000000	47.59	V	Peak

  - HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
4924.000000	51.31	V	Peak
7385.000000	58.37	H	Peak
	53.60		Peak
9848.000000	56.13	V	Peak
	49.84		Peak
12309.000000	49.48	V	Peak

  - RESTRICTED BAND 2.31-2.39 GHz. LOW CHANNEL. No spurious frequencies at less than 20 dB below the limit.

- RESTRICTED BAND 2.4835-2.5 GHz. HIGH CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector
2484.800000	57.41	V	Peak
	45.54		Average

Measurement Uncertainty (dB): 1 GHz $\leq$ f $\leq$ 17 GHz: <± 4.98
17 GHz $\leq$ f $\leq$ 26 GHz: <± 5.08

Verdict: PASS

OFDM modes:

For spurious emissions in the range 30 MHz - 26 GHz (except field strength at the band edges that was performed for all modes) a preliminary scan was performed to determine the worst-case mode.

Spurious emissions in the Restricted Bands 2.31-2.39 GHz and 2.4835-2.5 GHz are measured for all modes.
The following results and plots are for the worst-case OFDM mode.

- **Worst-case OFDM mode: 802.11 g.**
  - **802.11 g (OFDM worst-case for spurious emissions):**

    Frequency range 1 - 26 GHz:

    The results in the next tables show the maximum measured levels in the 1-26 GHz range including the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

    Spurious frequencies with peak levels above the average limit (54 dBµV/m at 3 m) are measured with average detector for checking compliance with the average limit.

** Duty Cycle Correction Factor (dB): 0.3445*

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
4813.500000	48.40	48.40	V	Peak
7241.500000	58.83	58.83	V	Peak
	42.75	43.0945		Average
9651.500000	48.65	48.65	V	Peak

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
4884.000000	48.94	48.94	V	Peak
7302.500000	57.39	57.39	V	Peak
	41.35	41.6945		Average

- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
4924.000000	51.01	51.01	V	Peak
7381.000000	63.88	63.88	V	Peak
	49.79	50.1345		Average
9840.500000	49.41	49.41	V	Peak
12307.000000	48.56	48.56	V	Peak

- RESTRICTED BAND 2.31-2.39 GHz. LOW CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
2389.266667	58.56	58.56	V	Peak
	45.16	45.5045		Average

- RESTRICTED BAND 2.4835-2.5 GHz. HIGH CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
2483.533333	65.04	65.04	V	Peak
	50.25	50.5945		Average
2486.200000	60.37	60.37	V	Peak
	47.02	47.3645		Average

Measurement Uncertainty (dB): 1 GHz $\leq$ f $\leq$ 17 GHz: <± 4.98
17 GHz $\leq$ f $\leq$ 26 GHz: <± 5.08

Verdict: PASS

- **802.11 n20:**

The results in the next tables show the maximum measured levels in the Restricted Bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Spurious frequencies with peak levels above the average limit (54 dBµV/m at 3 m) are measured with average detector for checking compliance with the average limit.

** Duty Cycle Correction Factor (dB): 0.2084*

- RESTRICTED BAND 2.31-2.39 GHz. LOW CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
2389.933333	60.63	60.63	V	Peak
	44.94	45.1484		Average

- RESTRICTED BAND 2.4835-2.5 GHz. HIGH CHANNEL. Spurious frequencies at less than 20 dB below the limit:

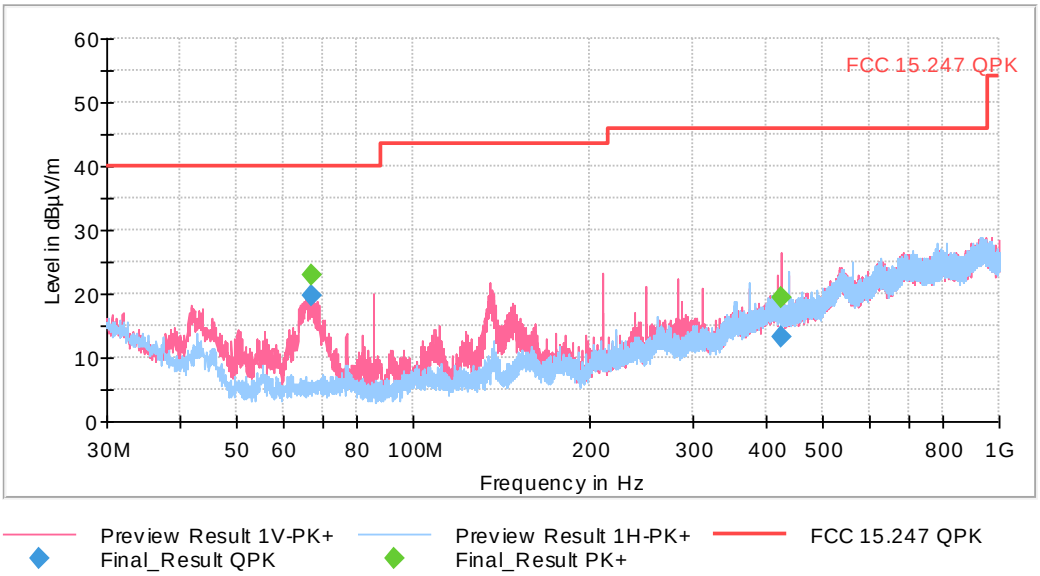
Spurious frequency (MHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector
2483.600000	63.55	63.55	V	Peak
	49.52	49.7284		Average
2485.066667	60.64	60.64	V	Peak
	45.51	45.7184		Average

Measurement Uncertainty (dB): 1 GHz $\leq$ f $\leq$ 17 GHz: $<\pm$ 4.98
17 GHz $\leq$ f $\leq$ 26 GHz: $<\pm$ 5.08

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

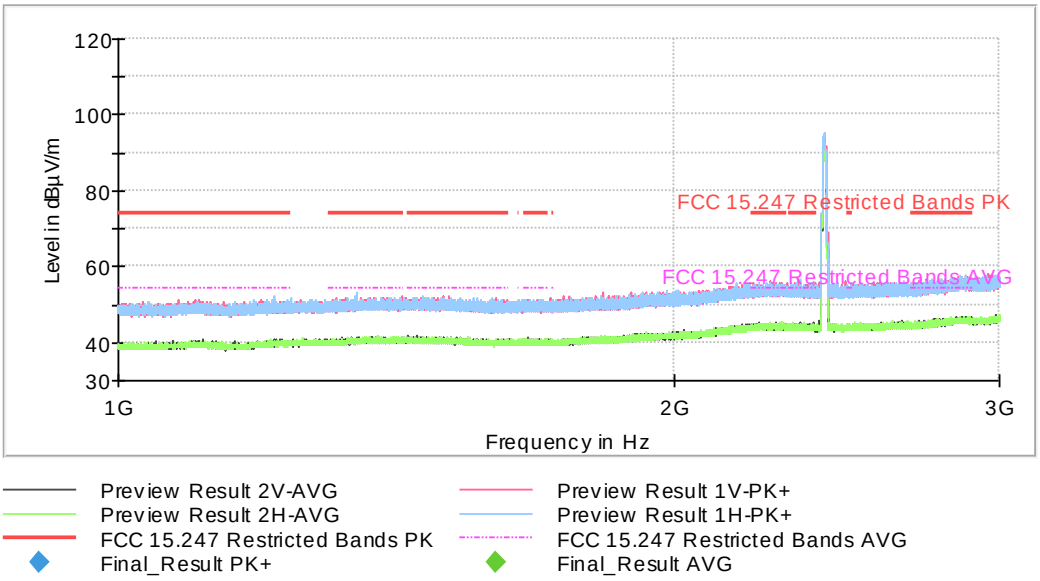
The spurious frequencies detected do not depend neither on the operating channel nor the modulation mode.



- **802.11 b:**

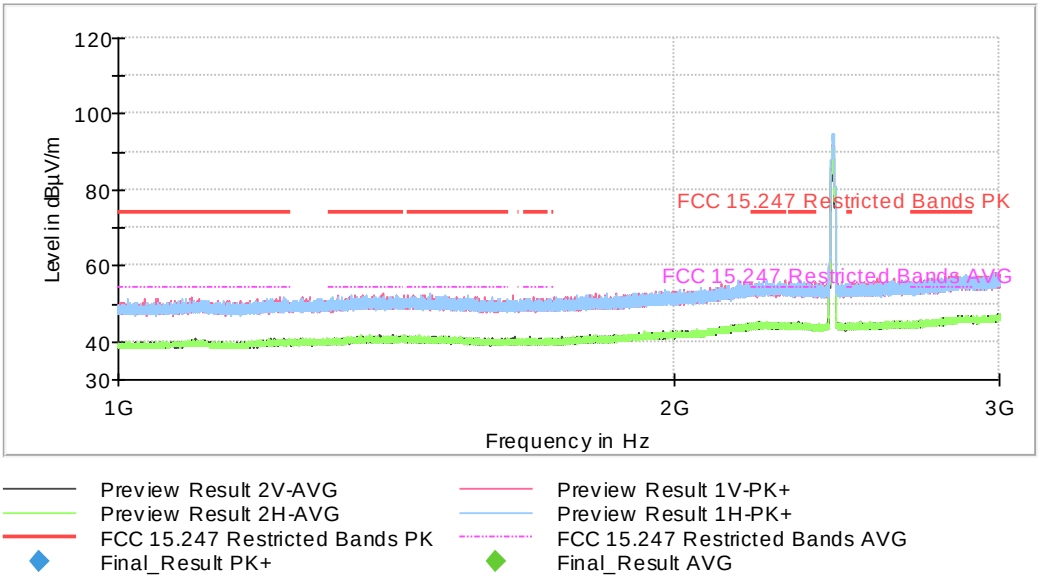
FREQUENCY RANGE 1 - 3 GHz:

- Low Channel:



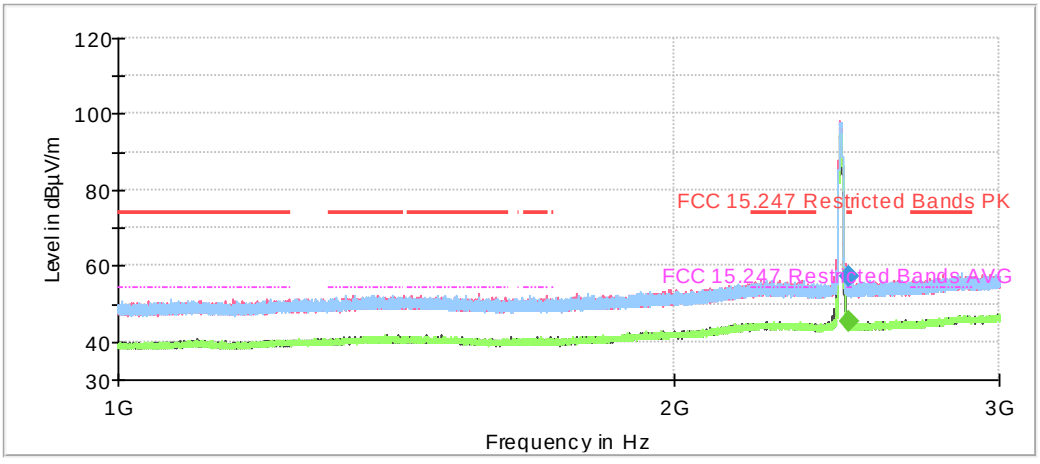
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

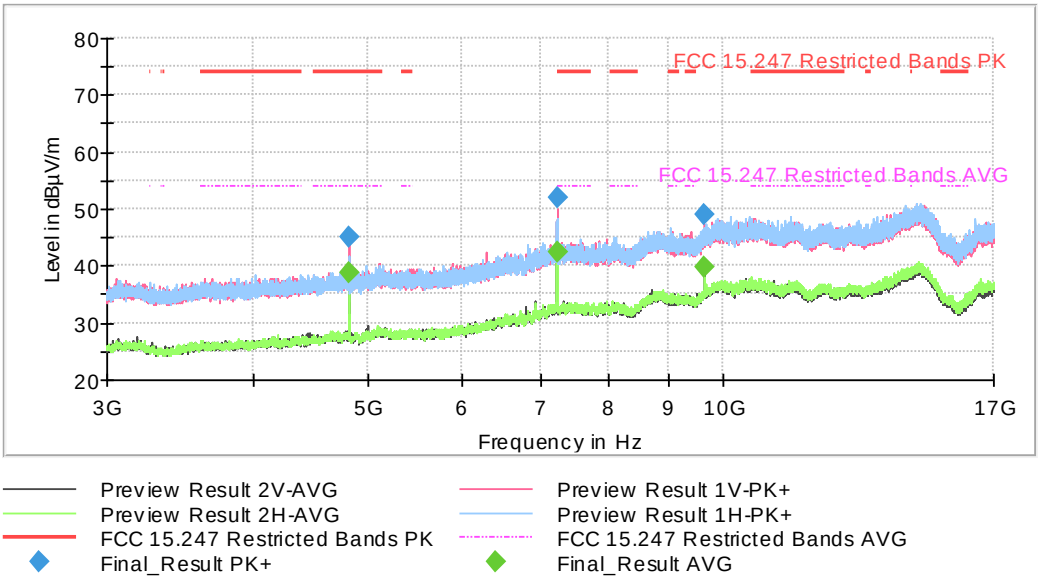
- High Channel:



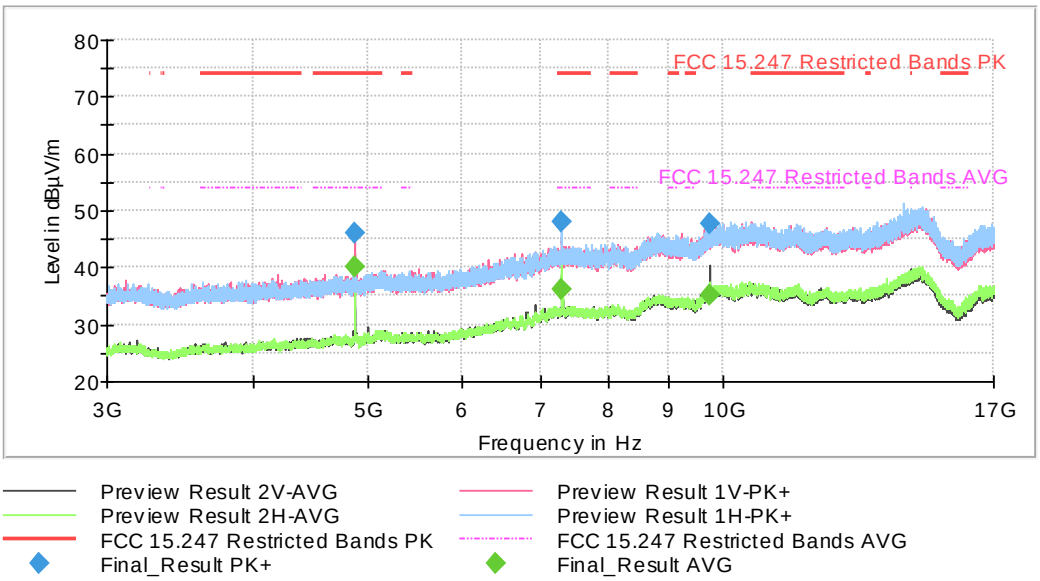
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

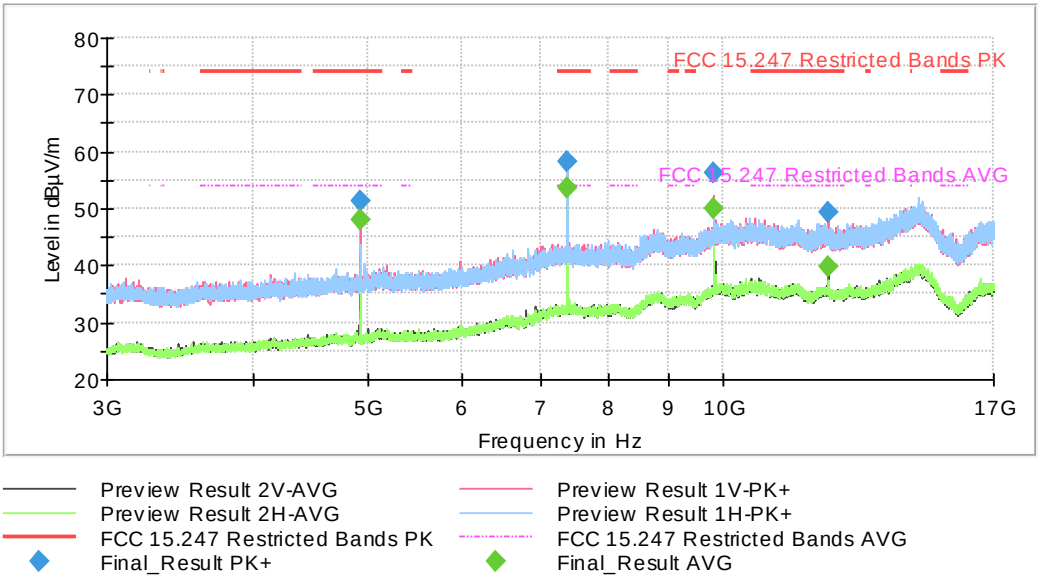
- Low Channel:



- Middle Channel:

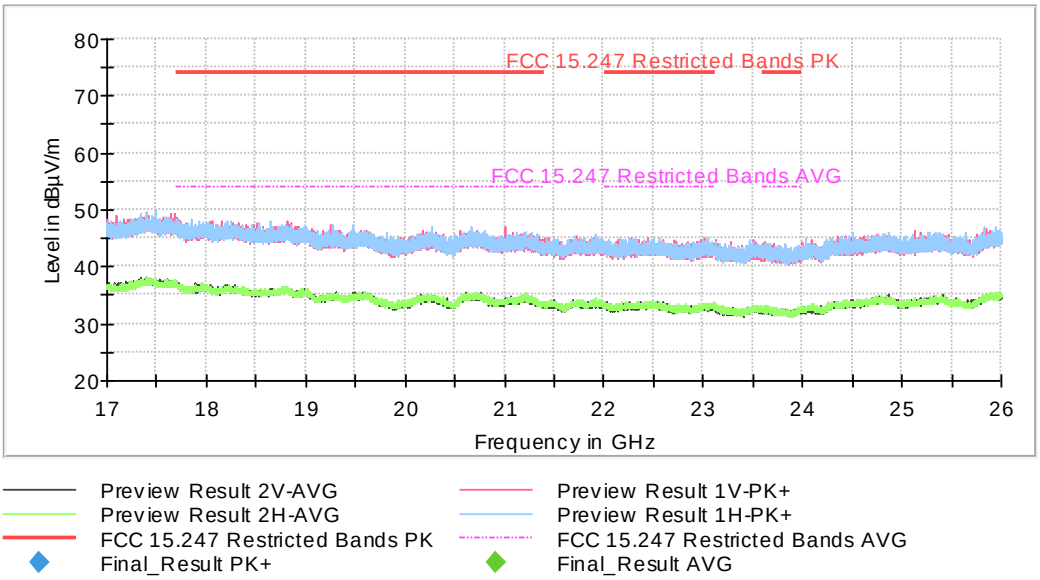


- High Channel:



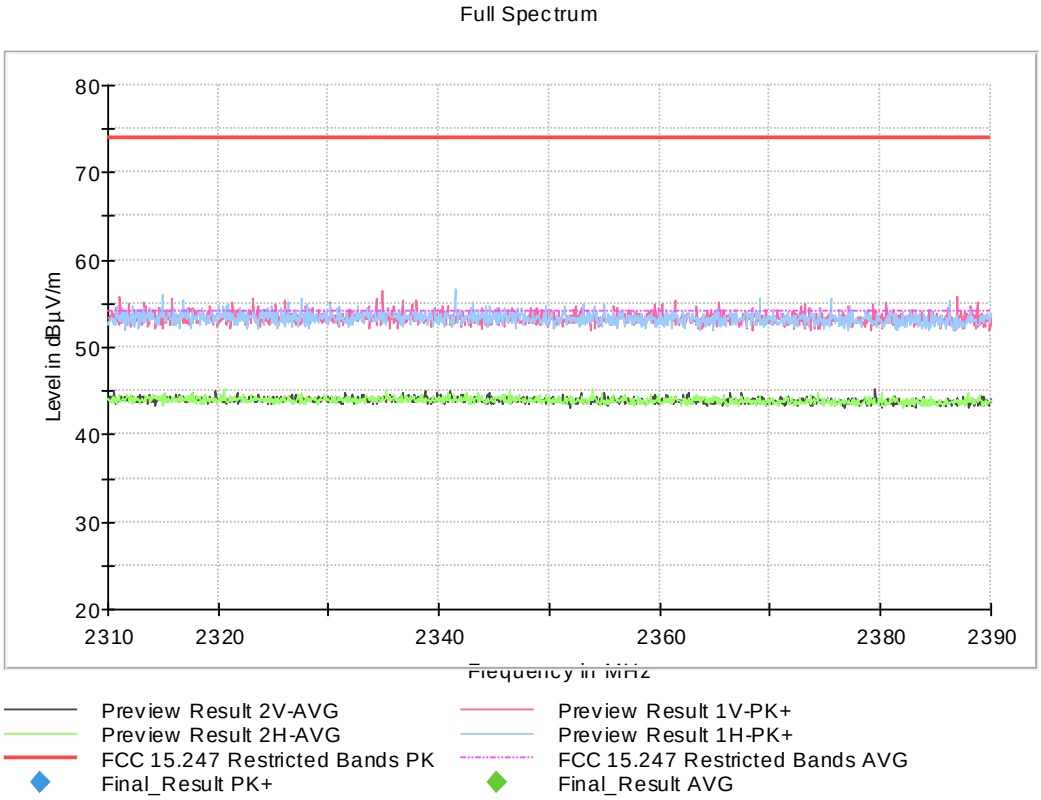
FREQUENCY RANGE 17 - 26 GHz:

The spurious frequencies detected do not depend on the operating channel.



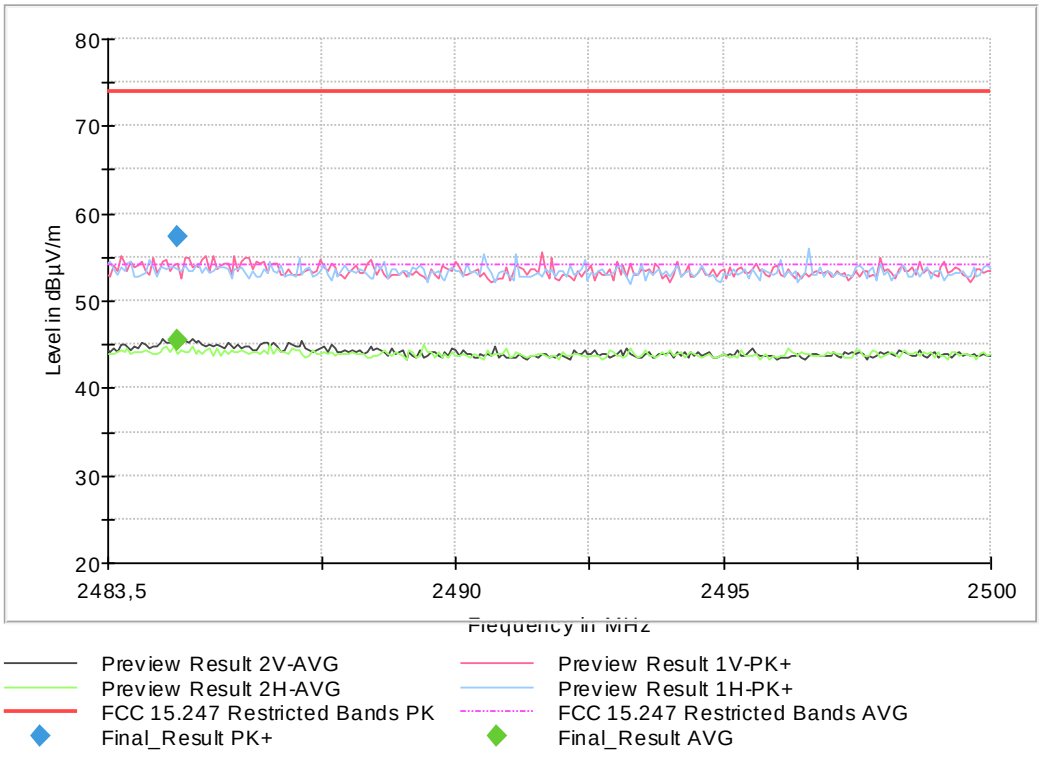
RESTRICTED BAND 2.31-2.39 GHz:

- Low Channel:



RESTRICTED BAND 2.4835-2.5 GHz:

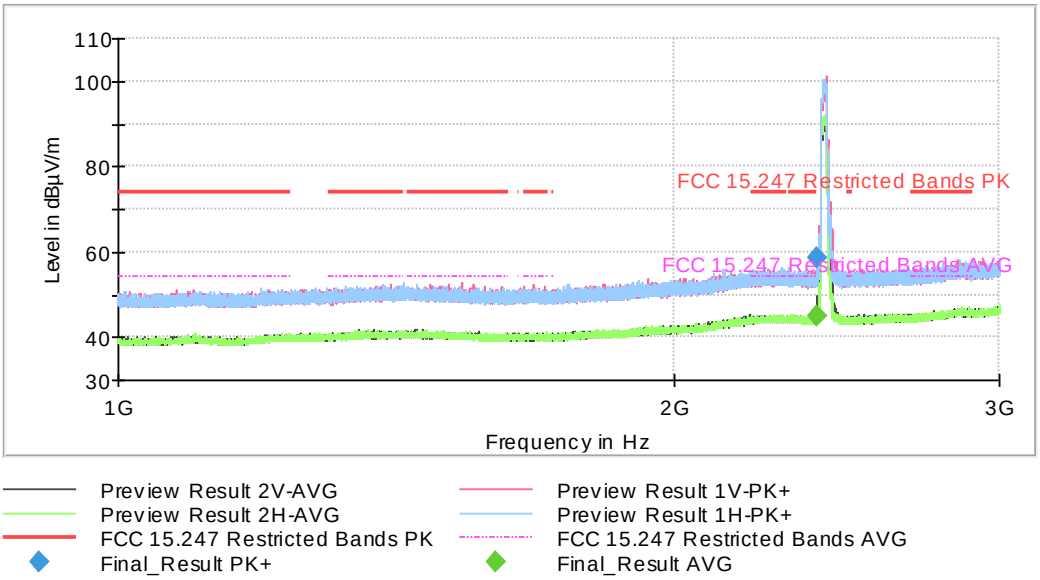
- High Channel:



- **802.11 g (OFDM worst-case for spurious emissions):**

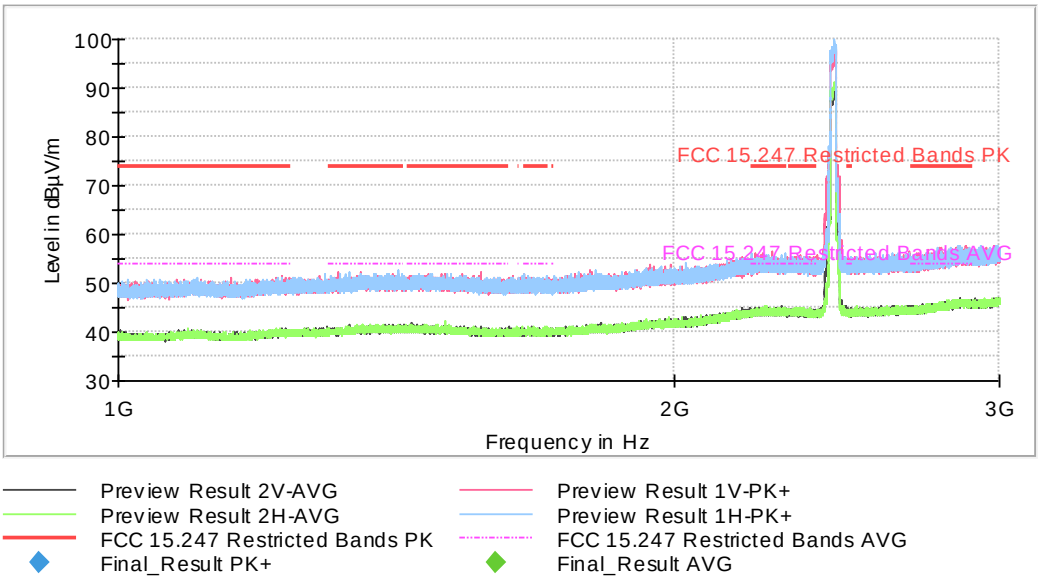
FREQUENCY RANGE 1 - 3 GHz:

- Low Channel:



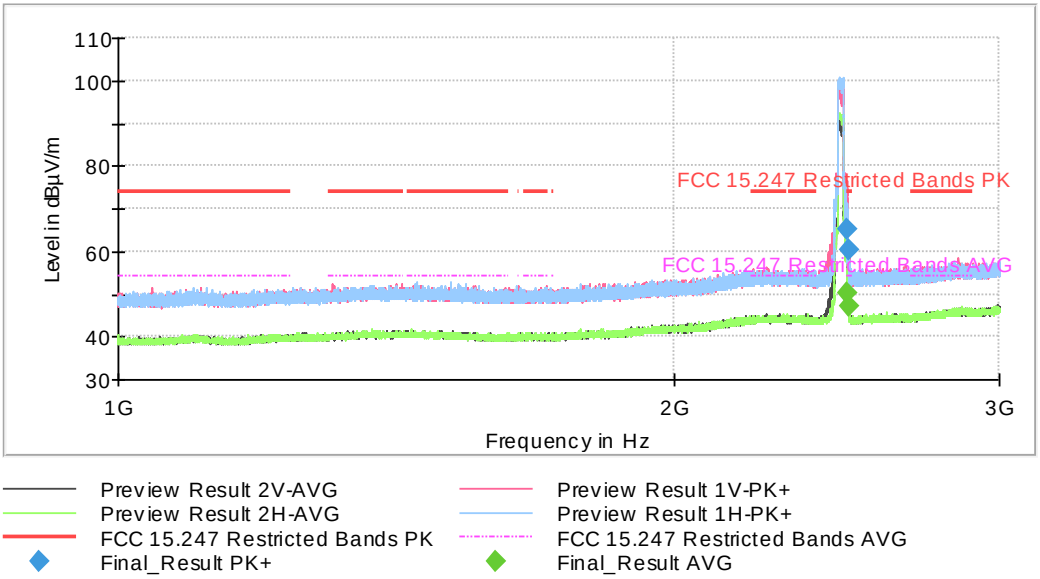
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

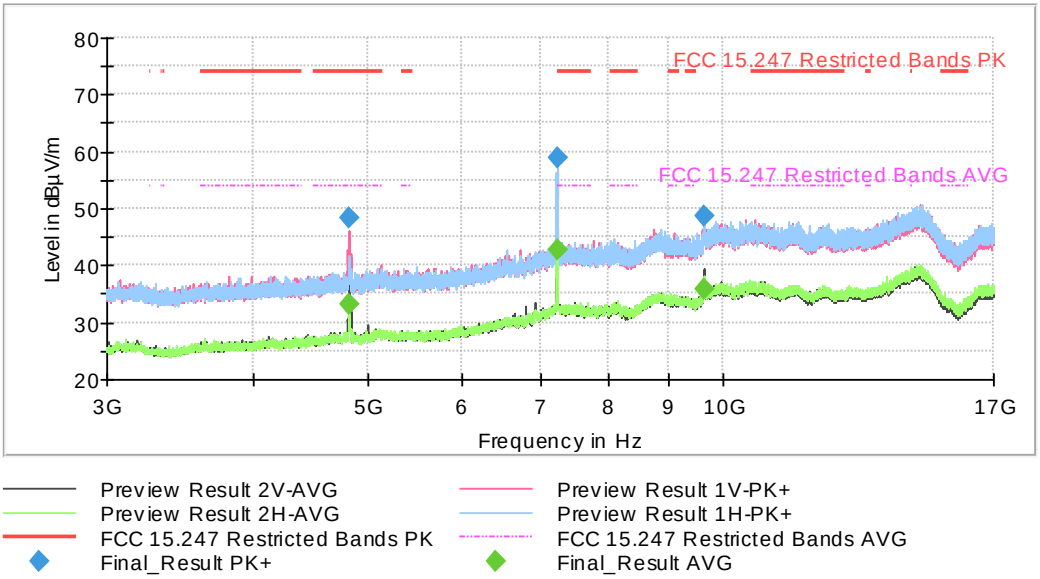
- High Channel:



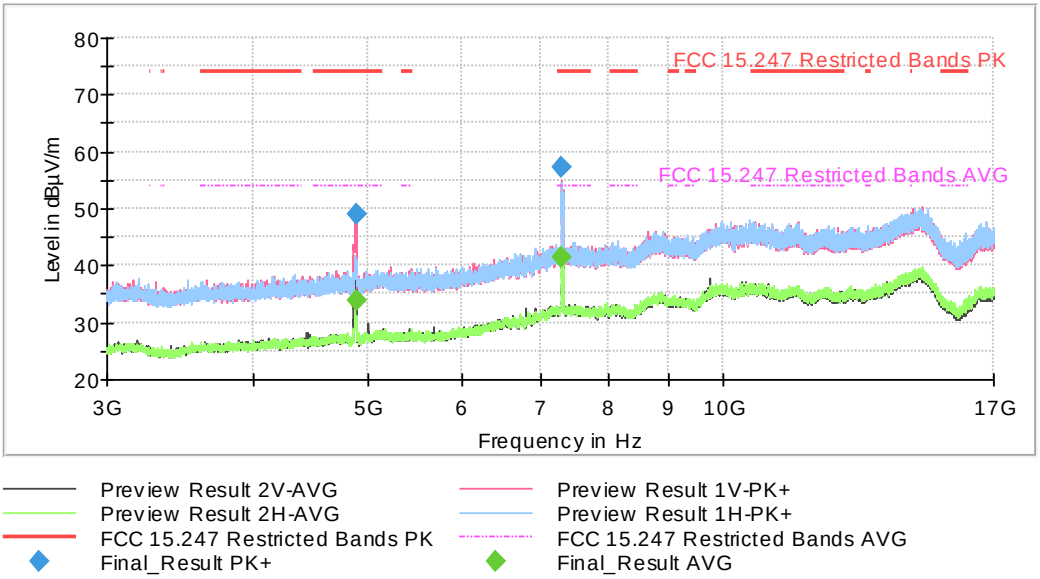
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

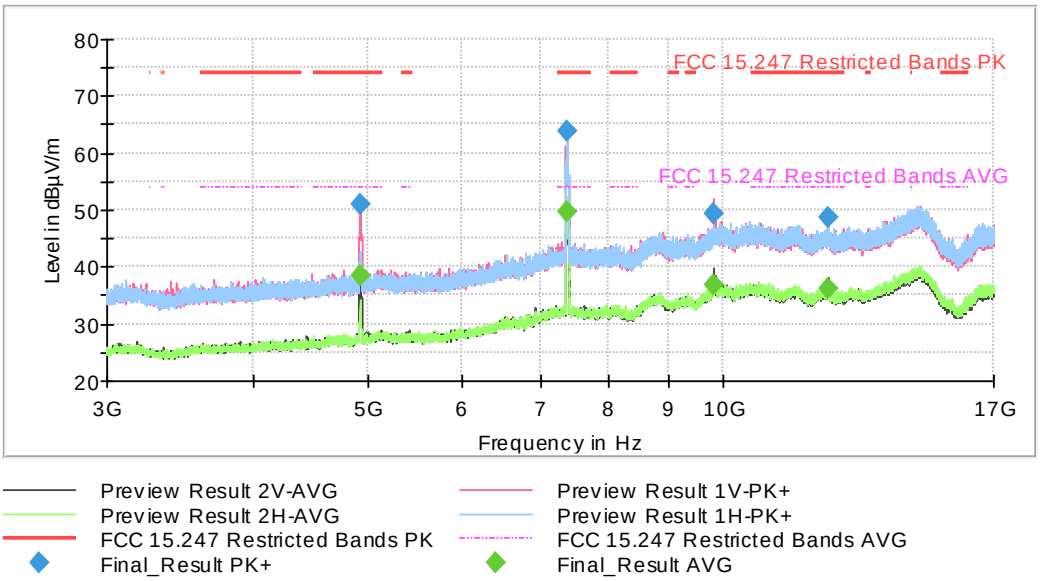
- Low Channel:



- Middle Channel:

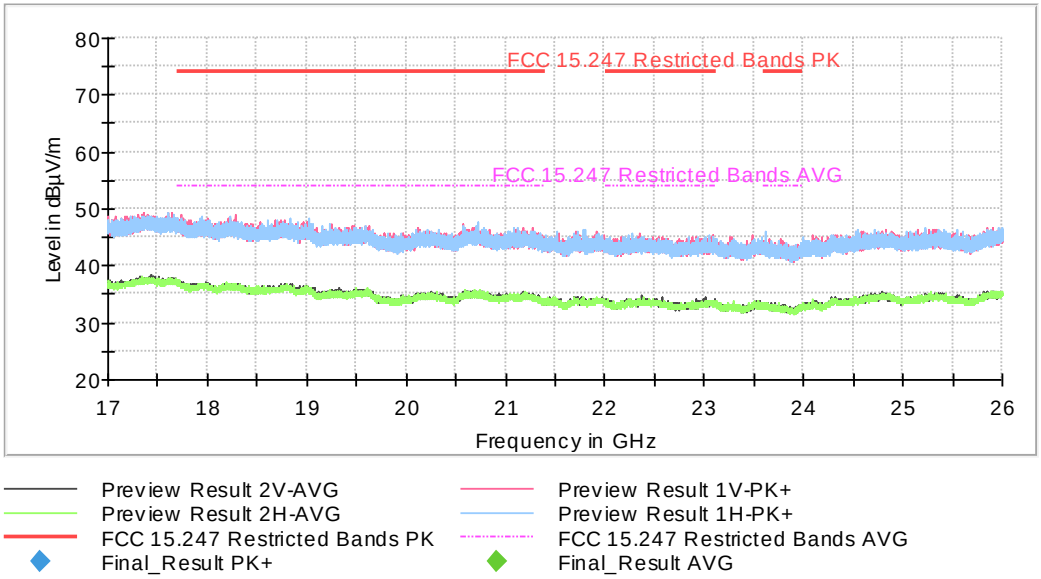


- High Channel:



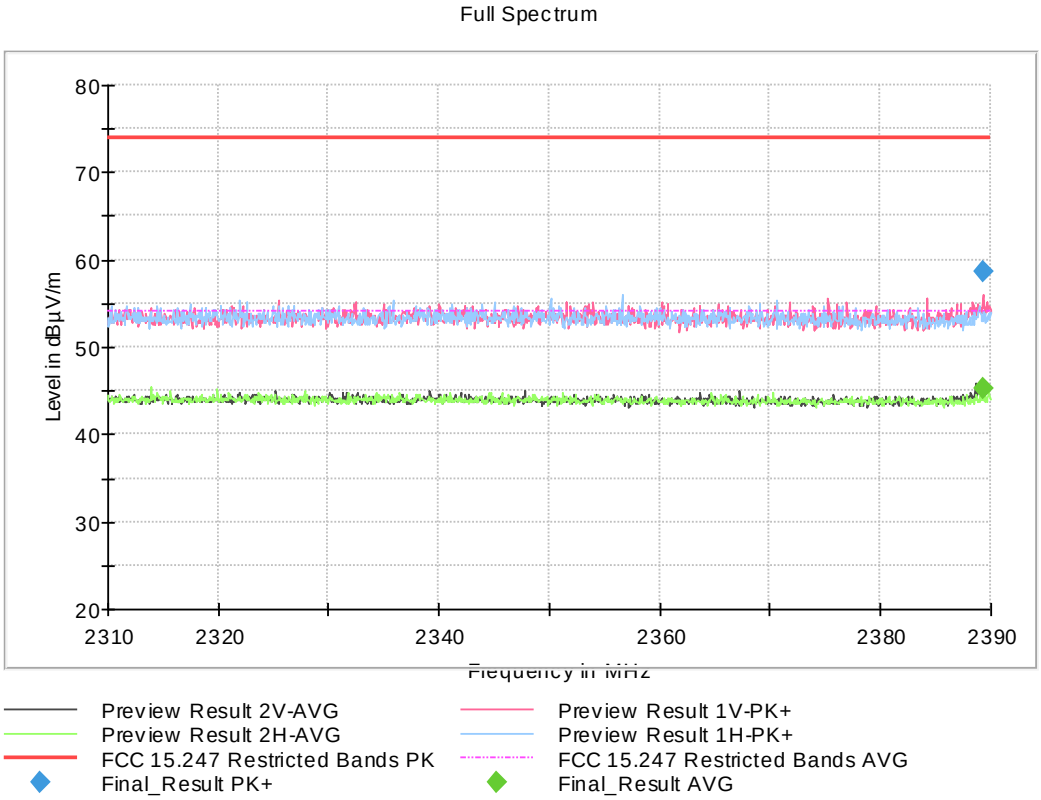
FREQUENCY RANGE 17 - 26 GHz:

The spurious frequencies detected do not depend on the operating channel.



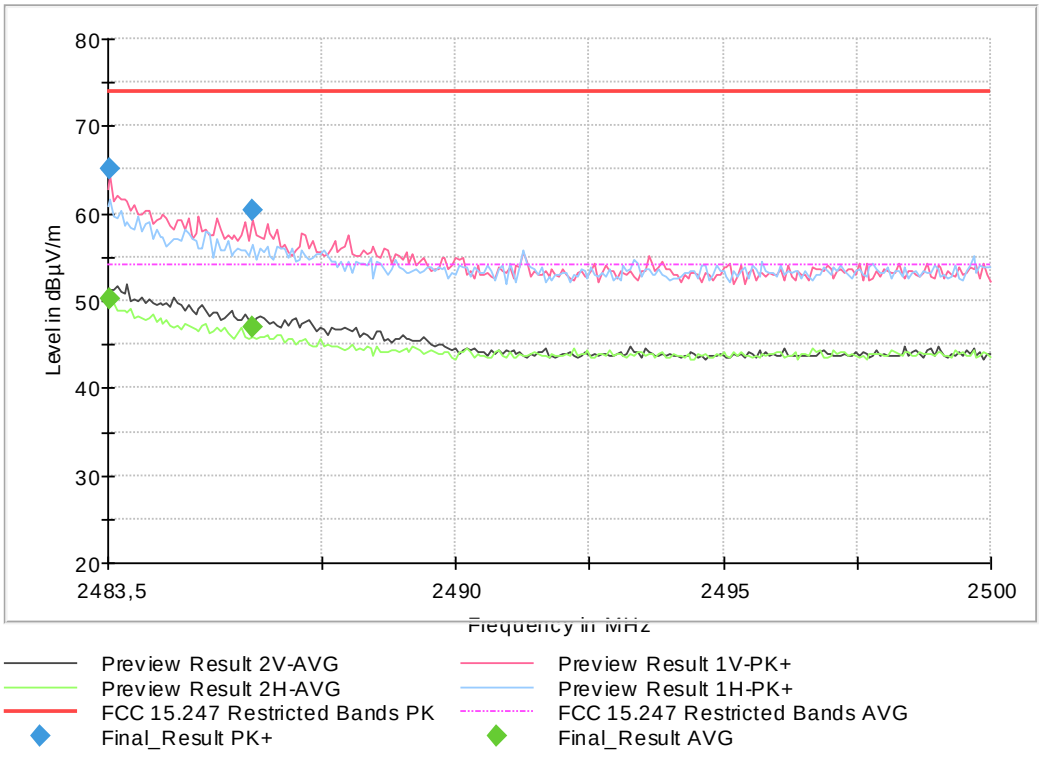
RESTRICTED BAND 2.31-2.39 GHz:

- Low Channel:



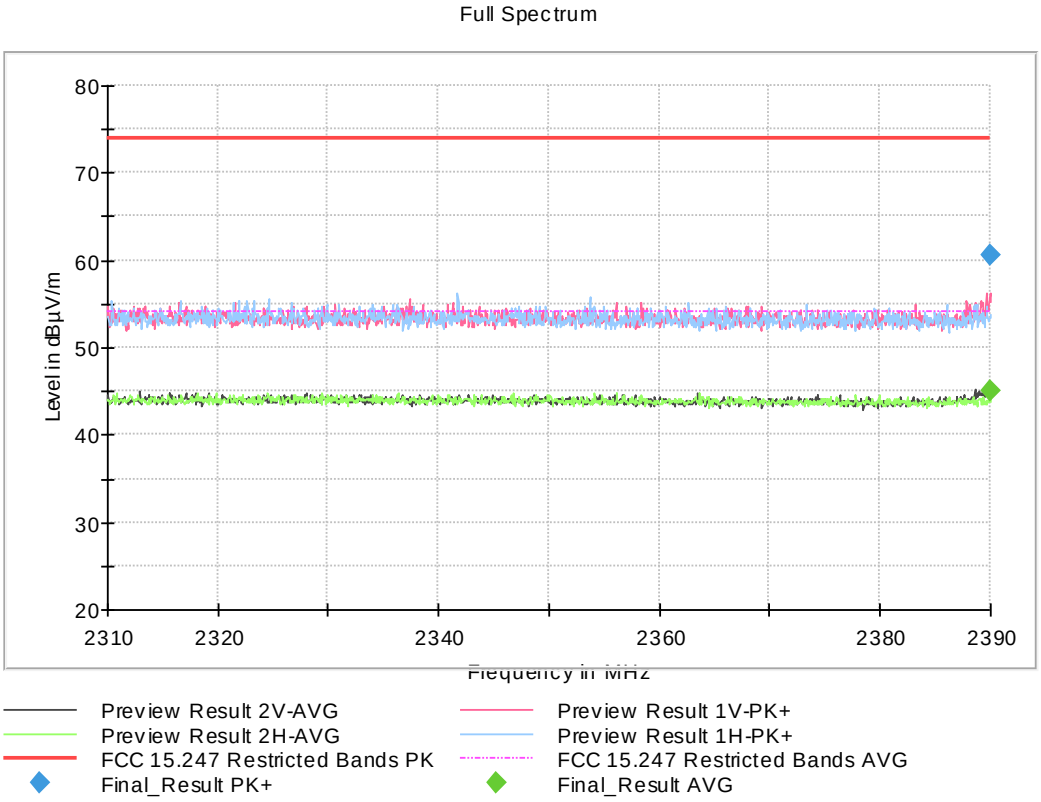
RESTRICTED BAND 2.4835-2.5 GHz:

- High Channel:



- **802.11 n20:**

RESTRICTED BAND 2.31-2.39 GHz:
- Low Channel:



RESTRICTED BAND 2.4835-2.5 GHz:
- High Channel: