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

Test report No:

NIE: 65408RRF.007

Test Report

USA FCC Part 15.247, 15.209
CANADA RSS-247, 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	Automotive infotainment system
(*) Trademark	BMW
(*) Model and /or type reference	MGU21 APN
Other identification of the product	HW version: 1.4 SW version: 20w37.5-1 FCC ID: A269ZUA163 IC: 700B-UA163
(*) Features	BT, WiFi, USB2/3, GPS
Applicant	ALPSALPINE INC. 20-1 YOSHIMA INDUSTRIAL PARK, IWAKI, FUKUSHIMA 970-1192, JAPAN
Test method requested, standard	USA FCC Part 15.247 (10-1-19) Edition: Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.209 (10-1-19) Edition: Radiated emission limits; general requirements. CANADA RSS-247 Issue 2 (February 2017). CANADA RSS-Gen Issue 5 Amendment 1 (March 2019). 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/RF Lab. Manager RAFAEL LÓPEZ MARTÍN 2021.03.05 13:03:37 +01'00'
Date of issue	2021-03-05
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 include testing performed in this test report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test 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.

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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 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 model MGU21 APN is a Device for entertainment and communication inside the car, this includes playing music from several external sources or internal flash-memory, connecting mobile devices (e.g. Apple Car Play) and a Navigation system.

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 result.

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
65408/001	Automotive infotainment system	MGU21 APN	ALB458L1300040	2020/10/06
65408/006	Main Wireharness	--	--	2020/10/06

Auxiliary elements used with the Sample S/01:

Control Nº	Description	Model	Serial Nº	Date of reception
65408/002	CAN-Box	--	80008154	2020/10/06
65408/003	OABR-Converter Board	--	--	2020/10/06
65408/004	OABR-Converter Cable	--	--	2020/10/06
65408/005	Ethernet / USB Adaptor	EU-4306	--	2020/10/06

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

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

Control Nº	Description	Model	Serial Nº	Date of reception
65408/001	Automotive infotainment system	MGU21 APN	ALB458L1300040	2020/10/06
65408/018	BT / WLAN Antenna	--	--	2020/10/06
65408/006	Main Wireharness	--	--	2020/10/06

Auxiliary elements used with the Sample S/02:

Control Nº	Description	Model	Serial Nº	Date of reception
65408/002	CAN-Box	--	80008154	2020/10/06
65408/003	OABR-Converter Board	--	--	2020/10/06
65408/004	OABR-Converter Cable	--	--	2020/10/06
65408/005	Ethernet / USB Adaptor	EU-4306	--	2020/10/06

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

Test sample description

Ports……..:	Port name and description	Cable			
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)
	BT/WLAN		☒	☐	☐
	GPS		☒	☐	☐
	USB2		☒	☐	☐
	APIX		☒	☐	☐
	AR-CAM		☒	☐	☐
	OABR		☒	☐	☐
	Gbit Ethernet		☒	☐	☐
Supplementary information to the ports…… :	-				

Rated power supply .....:	Voltage and Frequency		Reference poles			
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC:					
	☐	DC:					

Rated Power .....:	12V
Clock frequencies.....:	-
Other parameters .....:	-
Software version .....:	20w37.5-1
Hardware version .....:	1.4
Dimensions in cm (W x H x D) ....:	-

Mounting position .....:	☐	Table top equipment
	☐	Wall/Ceiling mounted equipment
	☐	Floor standing equipment
	☐	Hand-held equipment

	☒	Other: Installed in cars	
Modules/parts.....:	Module/parts of test item	Type	Manufacturer
	BT		WNC
	WiFi		WNC
	-		
	-		
Accessories (not part of the test item) .....:	Description	Type	Manufacturer
	Can Box		Harman
	Display		Visteon
	OABR-converter		Harman
	-		
	-		
	-		
Documents as provided by the applicant.....:	Description	File name	Issue date
	Testing manual for BT and WLAN	I&K MGU_Testing Manual (Radio_WLAN_BT)_v11_2018-01-18	18.1.2018
	-		
	-		
	-		

(3) Only for Medical Equipment

Identification of the client

ALPS ALPINE EUROPE GmbH
Ohmstrasse 4, 85716 Unterschleißheim, Germany

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2020-10-13
Date (finish)	2020-11-25

Document history

Report number	Date	Description
65408RRF.007	2021-03-05	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: José Manuel Jiménez, Pablo Redondo, Verónica García, Javier Miguel Nadales and Cristina Calle.

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 ROHDE AND SCHWARZ OSP120	2019/10	2021/10
4.	Open Switch Unit up to 18 GHz ROHDE AND SCHWARZ OSP 150	2019/09	2021/09
5.	DC Power Supply 30V/5A 150W AGILENT TECHNOLOGIES U8002A	N.A.	N.A.
6.	Digital Multimeter FLUKE 179	2020/10	2021/10

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.	Hybrid Bilog Antenna 30MHz-6GHz SUNOL SCIENCES CORPORATION JB6	2018/10	2021/10
4.	RF Preamplifier 40 dB, 10 MHz - 6 GHz BONN ELEKTRONIK BLNA 0160-01N	2020/02	2021/02
5.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2019/10	2021/10
6.	Attenuator 10dB, 2W, DC-18GHz, TECHNIWAVE TWTS2G	2020/01	2021/01
7.	DC Power Supply 150V/22A, AGILENT TECHNOLOGIES N8740A	N.A.	N.A.
8.	Digital Multimeter, FLUKE 175	2020/11	2021/11
9.	Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2018/01	2021/01
10.	Horn Antenna 18-40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2020/05	2023/05
11.	RF Preamplifier G>30dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-3A	2020/10	2021/10
12.	Low Noise Amplifier G>30dB, 18 - 40 GHz BONN ELEKTRONIK BLMA 1840-1M	2019/02	2021/02
13.	Signal and Spectrum Analyzer 10 Hz - 40 GHz ROHDE AND SCHWARZ FSV40	2019/10	2021/10
14.	DC Power Supply 30V/5A 150W AGILENT TECHNOLOGIES U8002A	N.A.	N.A.

Testing verdicts

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

Summary

1. Bluetooth EDR:

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		**Verdict**	**Remark**
15.247 (a) (1) / RSS-247 5.1. (b)	20 dB Bandwidth and Carrier frequency separation	P	
15.247 (a)(1)(iii) / RSS-247 Clause 5.1 (d)	Number of hopping channels	P	
15.247 (a)(1)(iii) / RSS-247 Clause 5.1 (d)	Time of occupancy (Dwell Time)	P	
15.247 (b) / RSS-247 5.4. (b)	Maximum peak output power and antenna gain	P	
15.247 (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)	P	
15.247 (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)	P	
Supplementary information and remarks: None.			

2. WLAN 2.4 GHz (802.11 b/g/n20 1x1):

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		**Verdict**	**Remark**
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. Bluetooth EDR (GFSK, Pi/4-DQPSK, 8DPSK)

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TEST CONDITIONS

POWER SUPPLY (V):

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

ANTENNA:

Type of Antenna:	External antenna.
Maximum Declared Antenna Gain:	-6.2 dBi (Antenna gain plus antenna cable loss).

TEST FREQUENCIES:

Low Channel:	2402 MHz
Middle Channel:	2441 MHz
High Channel:	2480 MHz

CONDUCTED MEASUREMENTS:

The equipment under test was set up in a shielded room and it is connected to the TS8997 system 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 1 GHz-18 GHz Double ridge horn antenna is situated at a distance of 3 m and a distance of 1 m for the frequency range 17 GHz-26 GHz (18 GHz-40 GHz horn antenna).

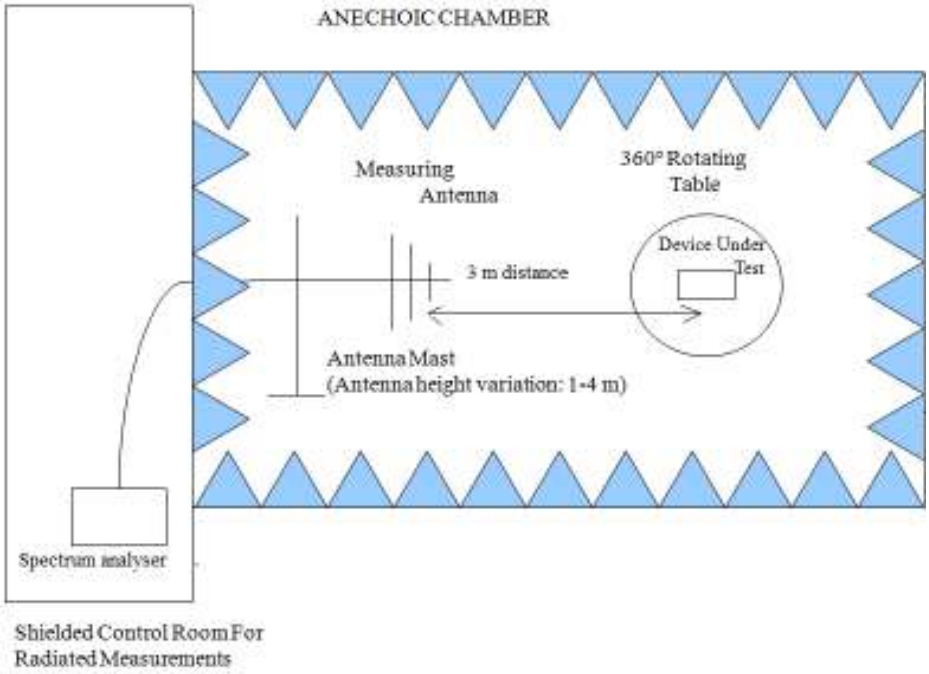
For radiated emissions in the range 17 GHz-26 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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.

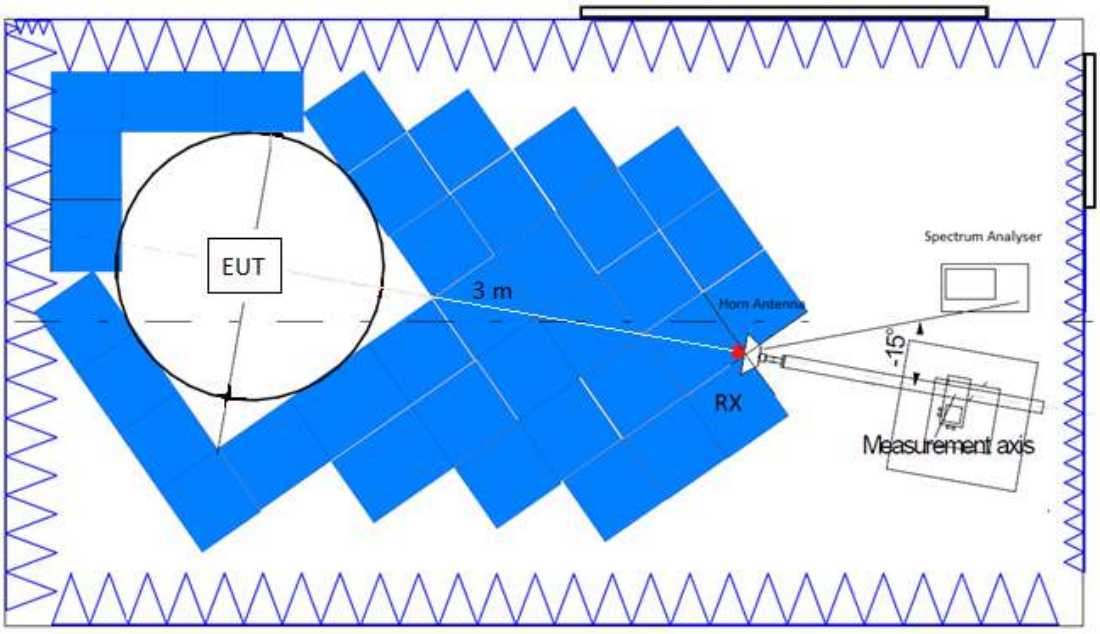
Measurements were made in both horizontal and vertical planes of polarization.

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

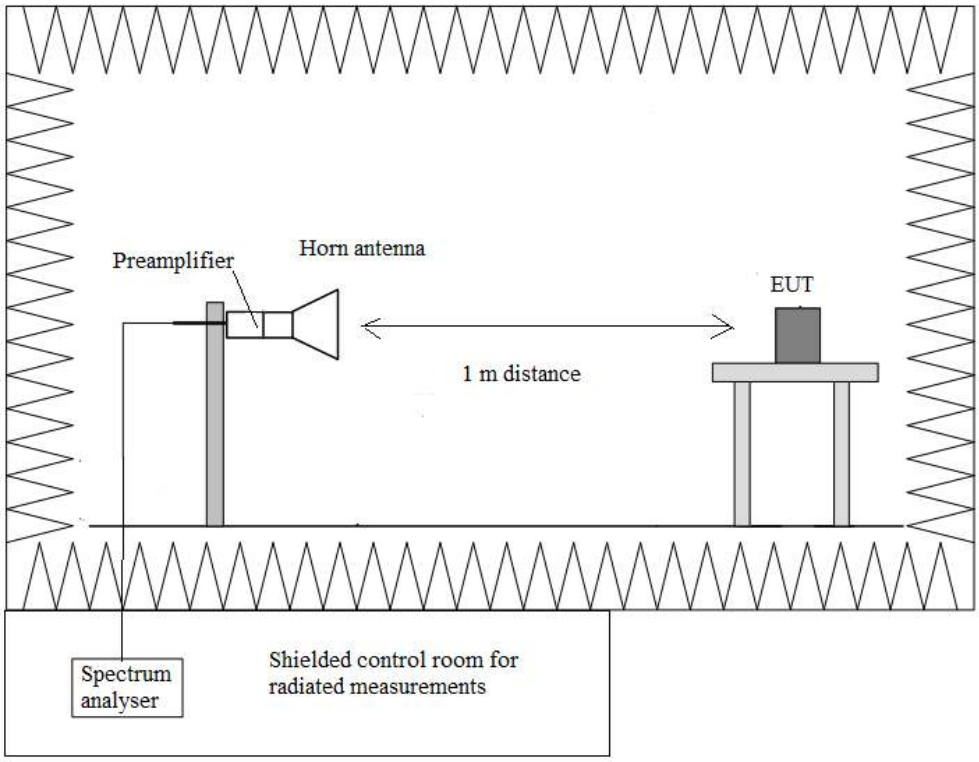
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup f > 17 GHz:



FCC 15.247 (a) (1) / RSS-247 5.1. (b) 20 dB Bandwidth and Carrier frequency separation

SPECIFICATION:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

RESULTS:

- **GFSK**

	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
20 dB Spectrum Bandwidth (MHz)	0.930	0.930	0.925
99% Bandwidth (MHz)	0.870	0.875	0.870
Measurement uncertainty (kHz)	<±3.64		

- **Pi/4 DQPSK**

	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
20 dB Spectrum Bandwidth (MHz)	1.345	1.345	1.340
99% Bandwidth (MHz)	1.210	1.210	1.210
Measurement uncertainty (kHz)	<±3.64		

- **8DPSK**

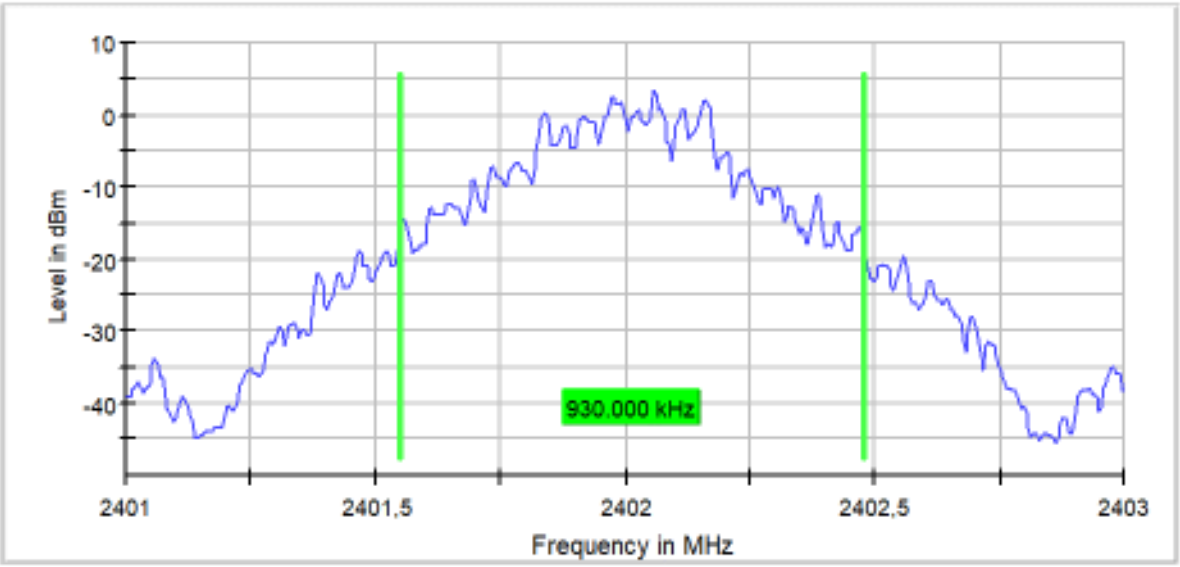
	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
20 dB Spectrum Bandwidth (MHz)	1.350	1.350	1.350
99% Bandwidth (MHz)	1.215	1.215	1.210
Measurement uncertainty (kHz)	<±3.64		

Verdict: PASS

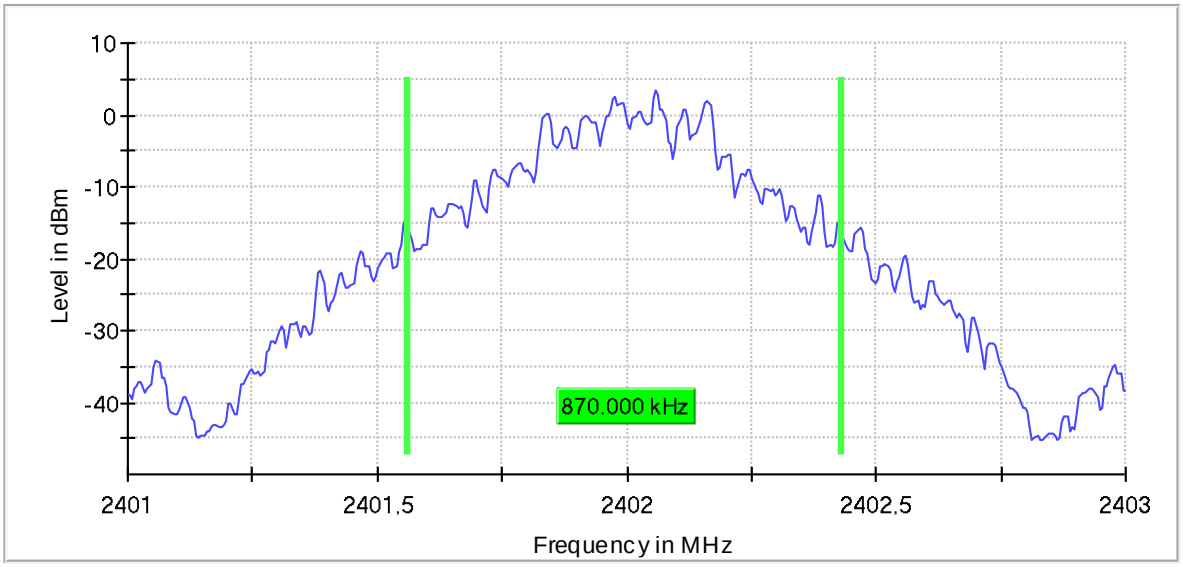
- **GFSK – Bandwidths**

  - Low Channel:

20 dB Bandwidth

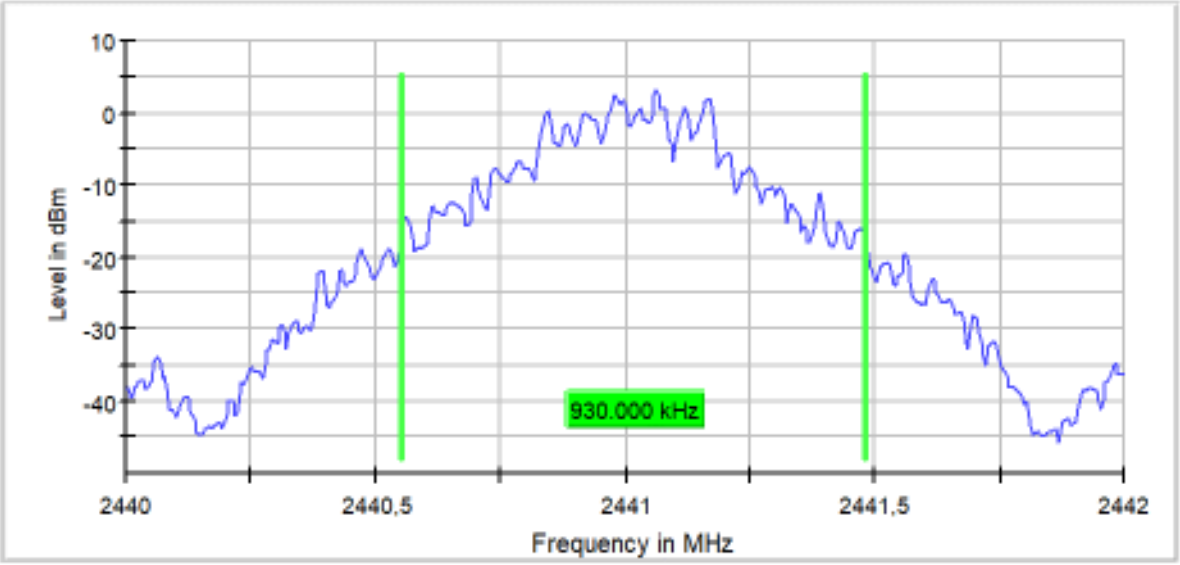


99 % Bandwidth

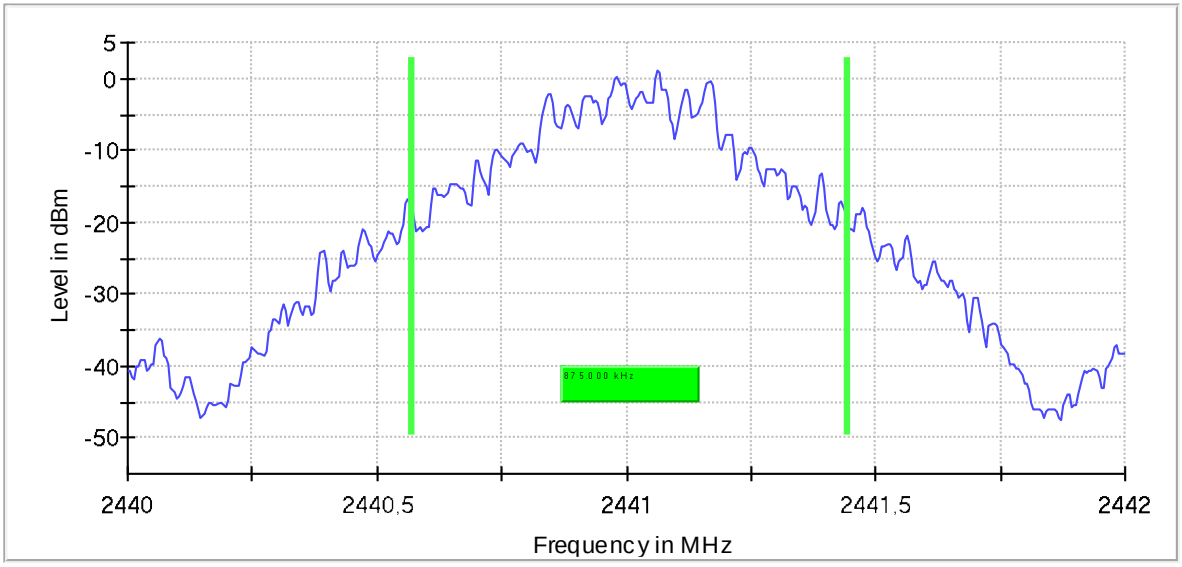


- Middle Channel:

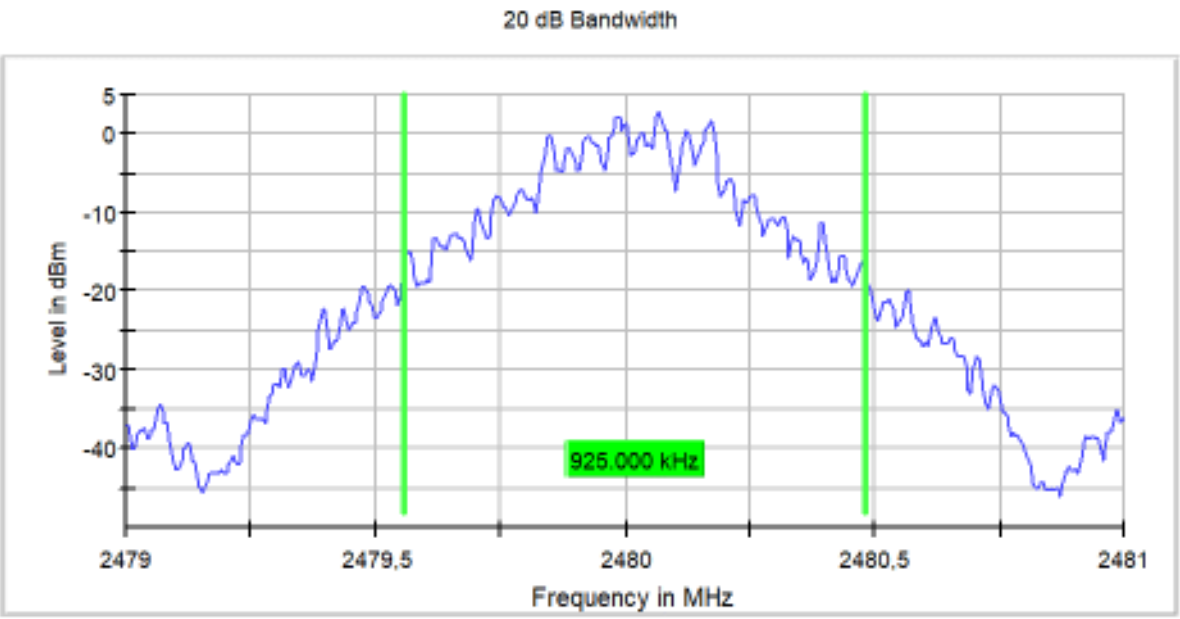
20 dB Bandwidth

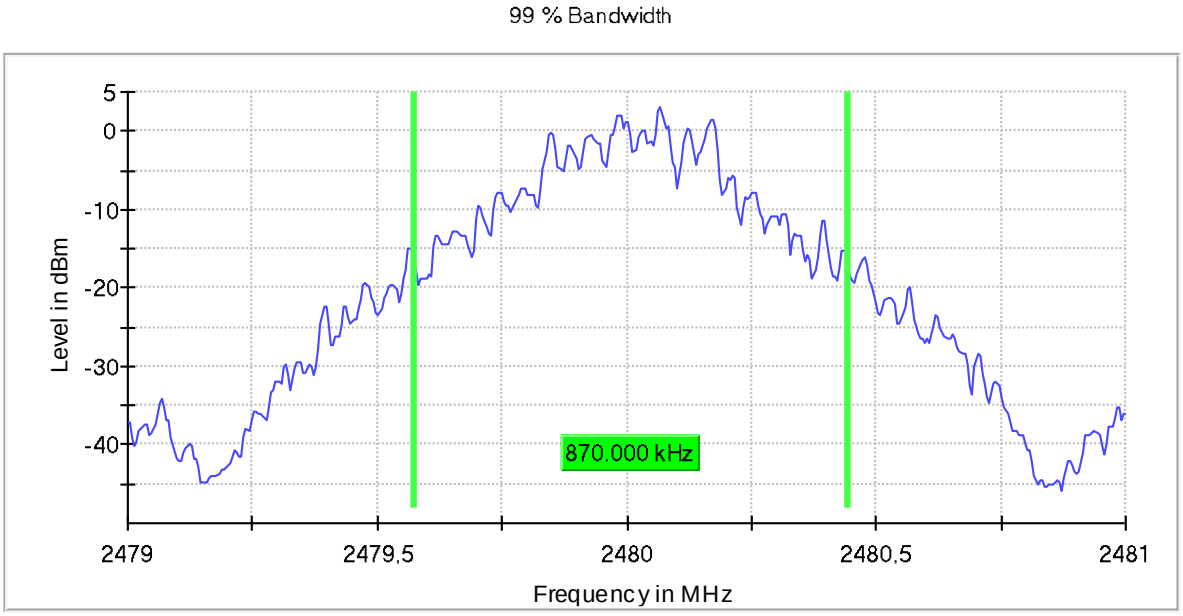


99 % Bandwidth



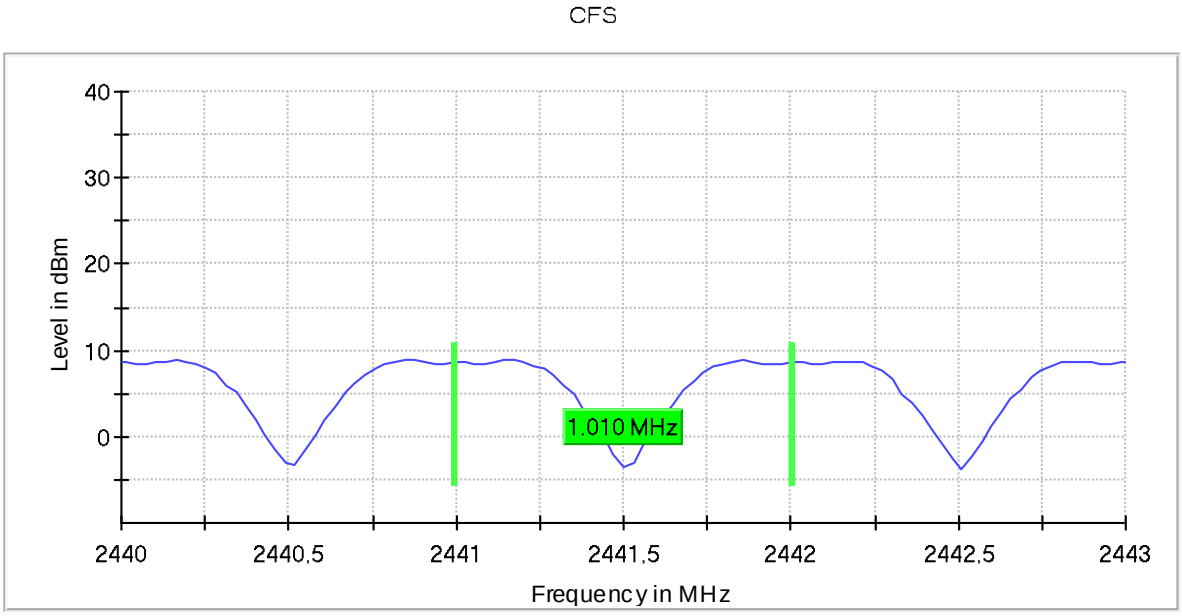
- High Channel:





Carrier frequency separation - GFSK

Carrier frequency separation: 1.009900 MHz



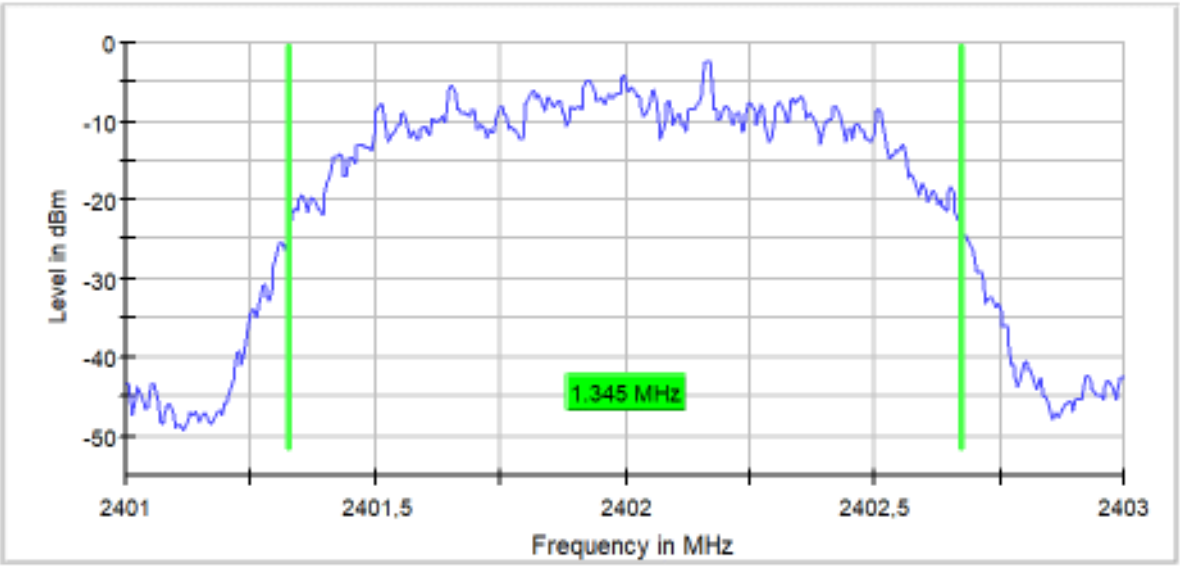
The hopping channel carrier frequencies are separated by a minimum two-thirds of the 20 dB bandwidth of the hopping channel.

Verdict: PASS

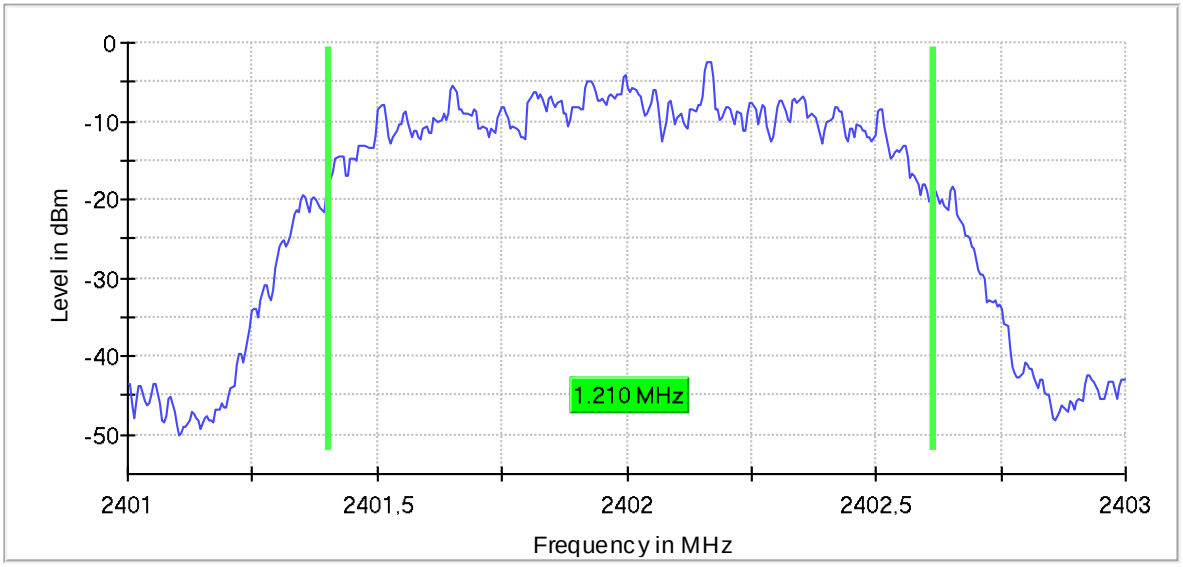
- **Pi/4 DQPSK – Bandwidths**

  - Low Channel:

20 dB Bandwidth

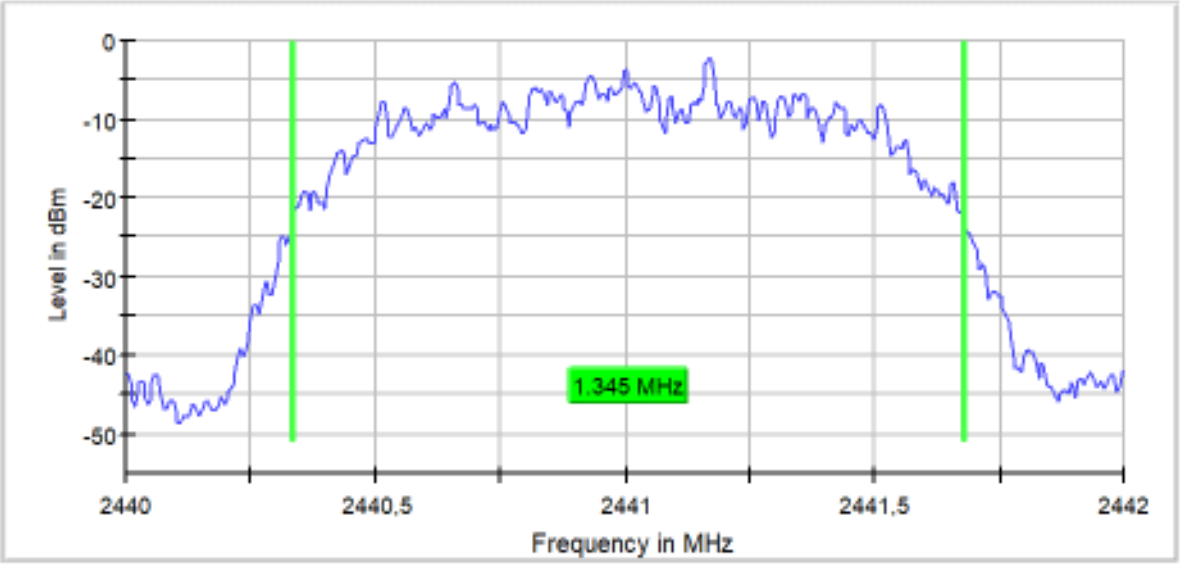


99 % Bandwidth

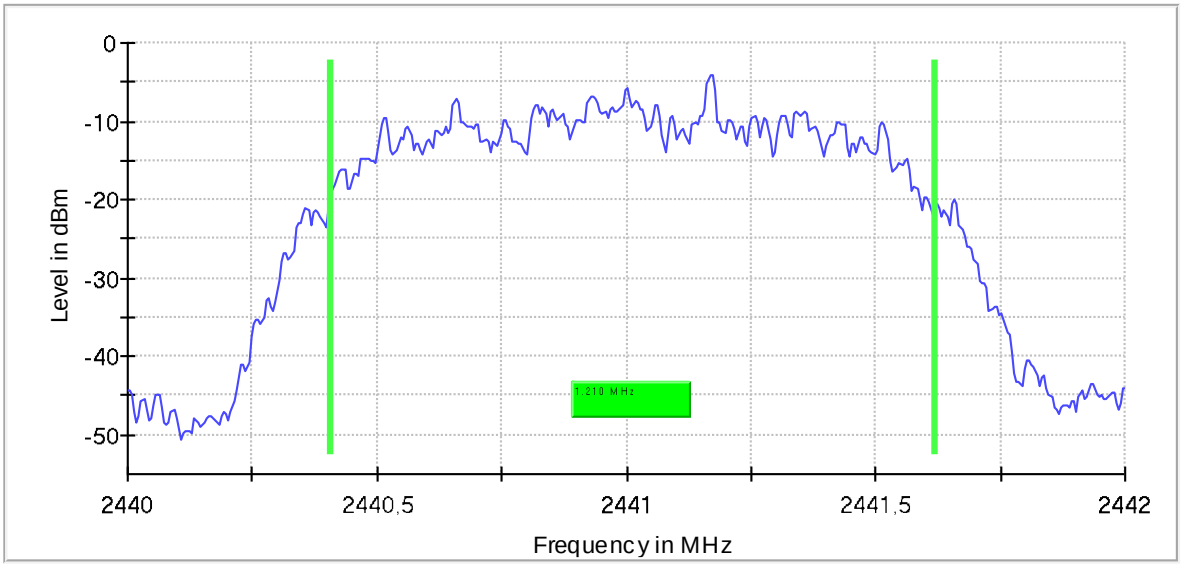


- Middle Channel:

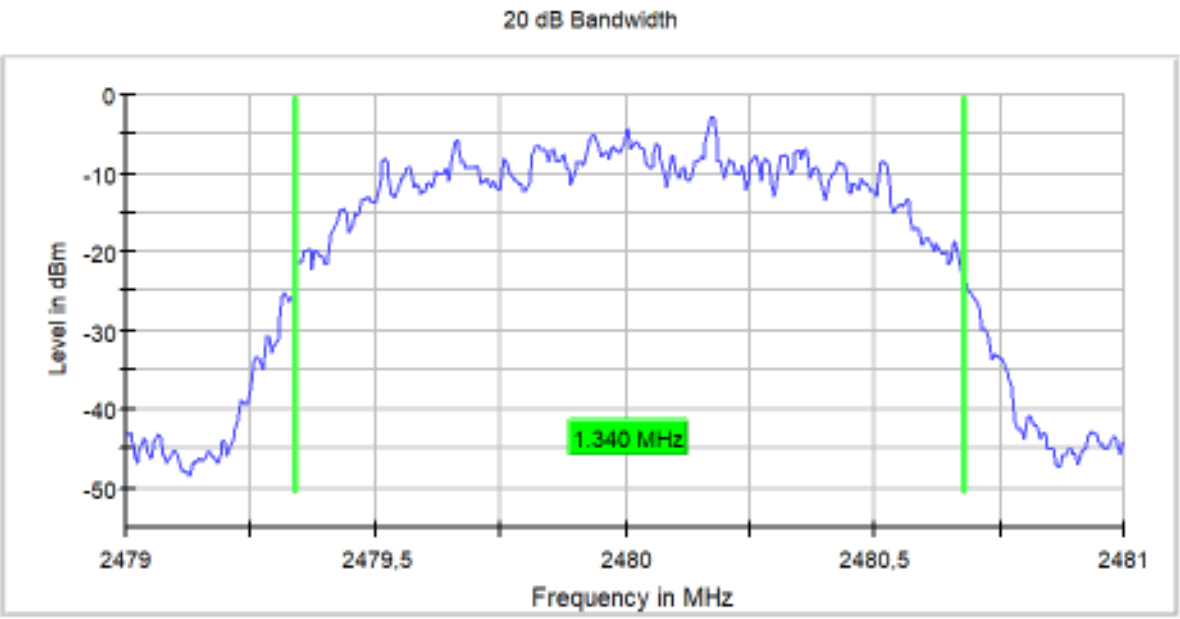
20 dB Bandwidth

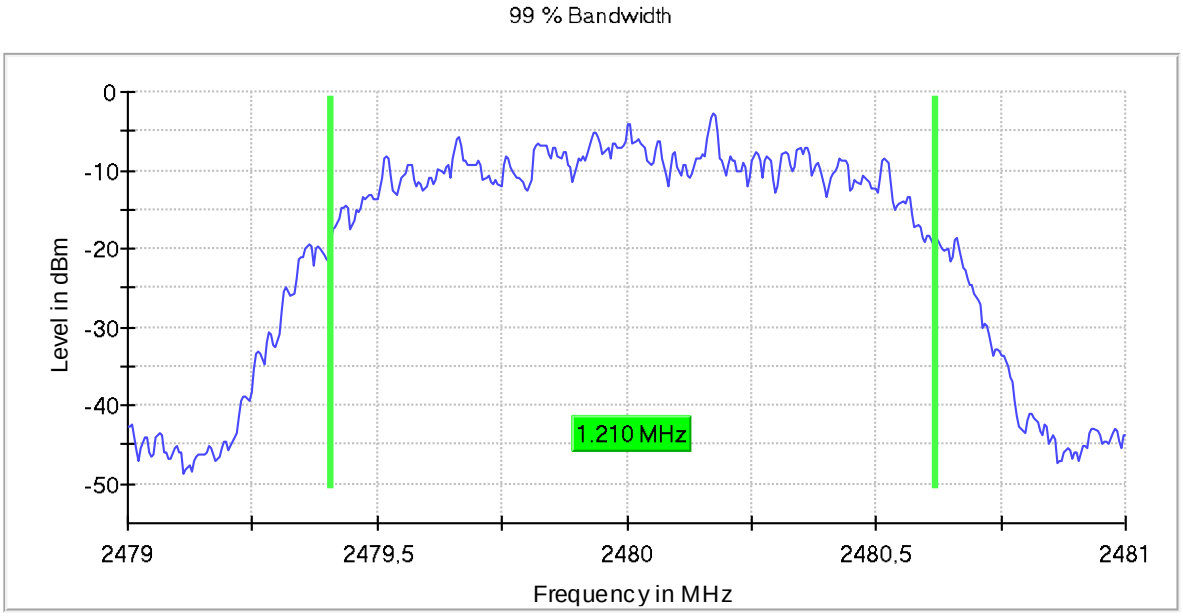


99 % Bandwidth



- High Channel:

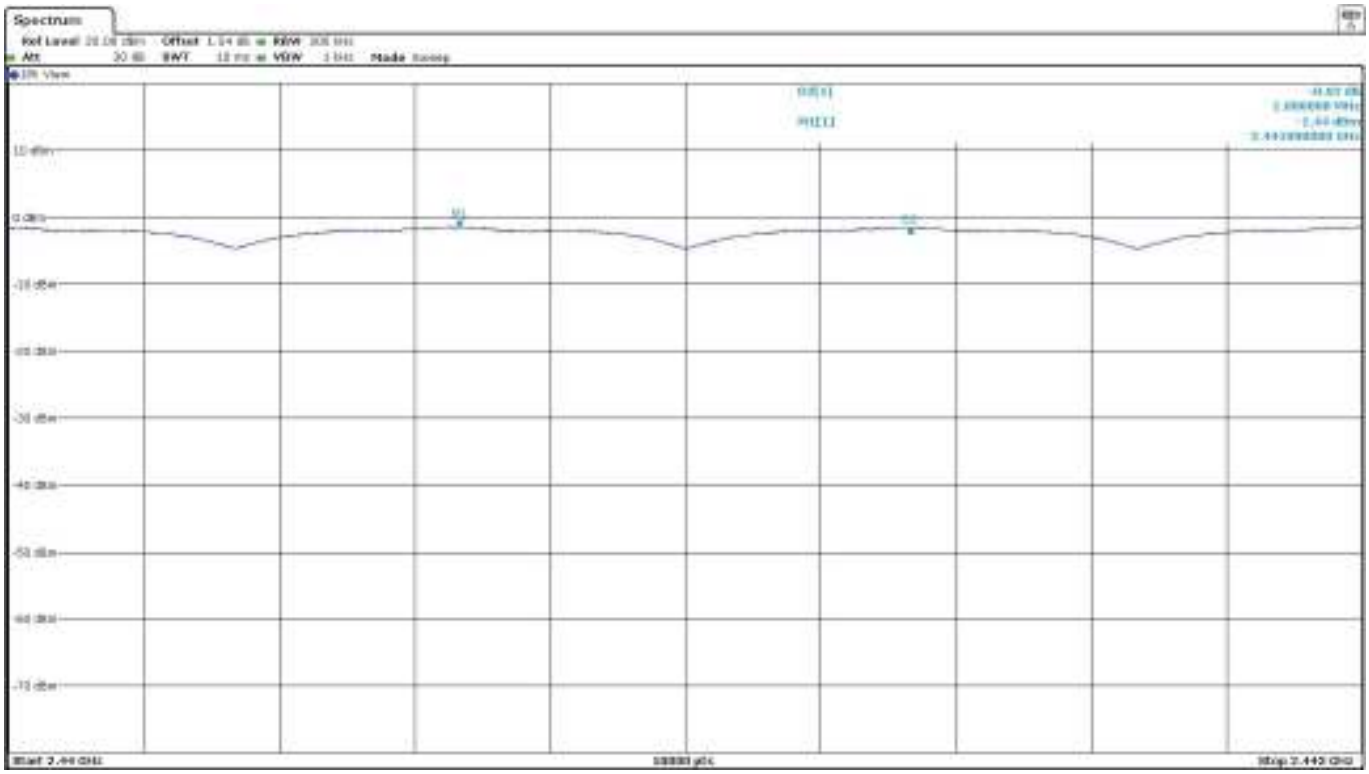




Carrier frequency separation - Pi/4 DQPSK

Carrier frequency separation: 1.000 MHz

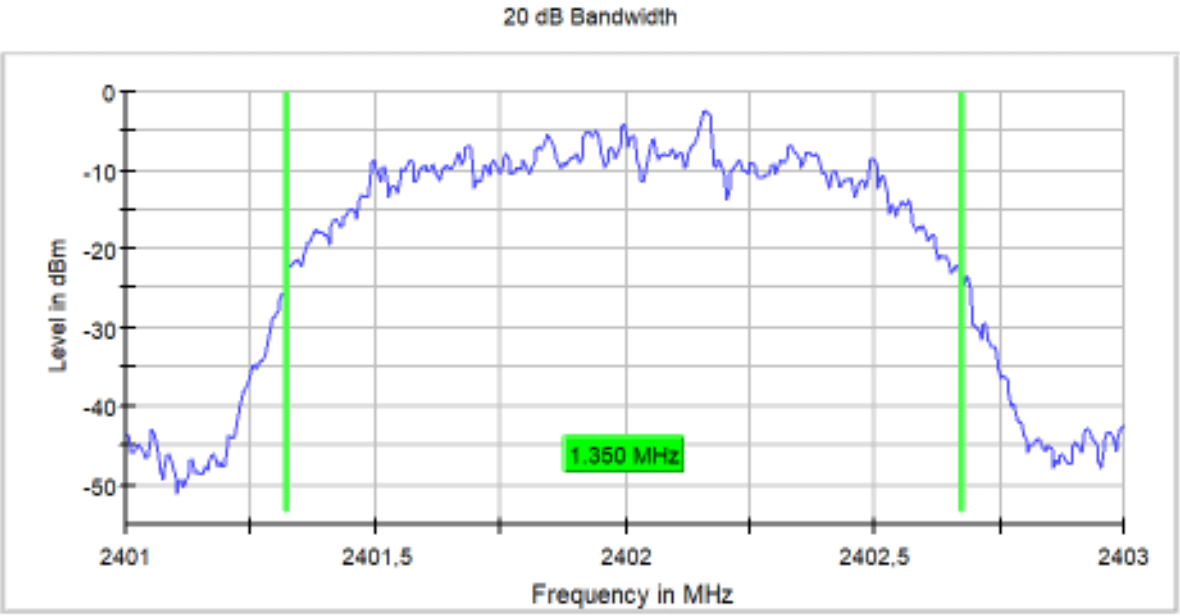
The hopping channel carrier frequencies are separated by a minimum two-thirds of the 20 dB bandwidth of the hopping channel.

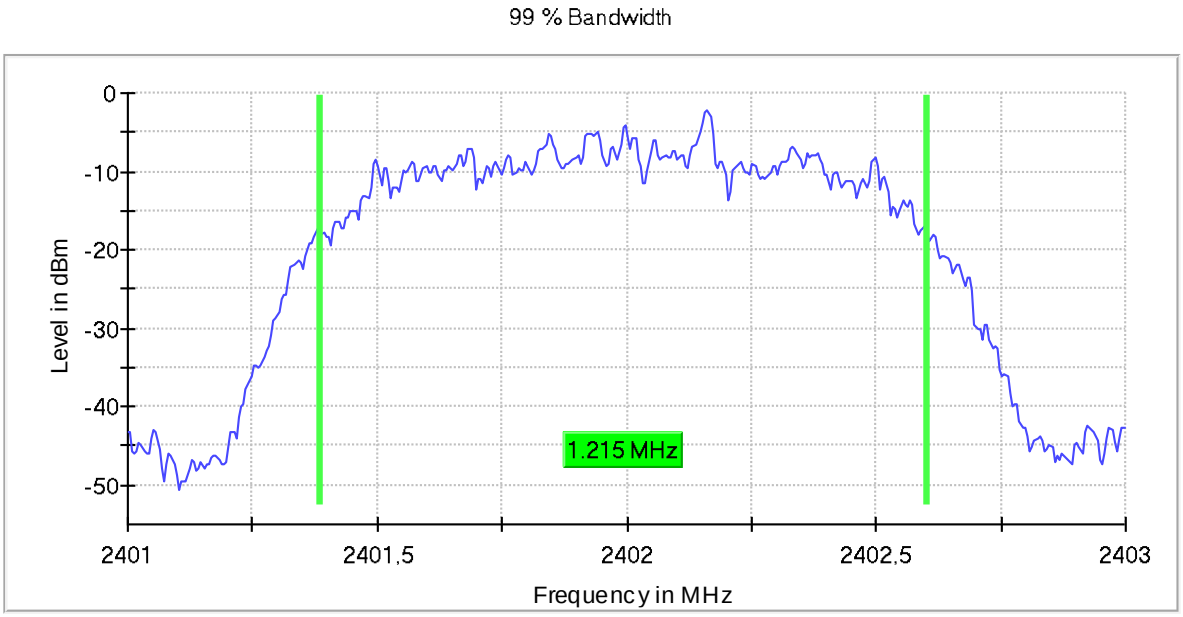


Verdict: PASS

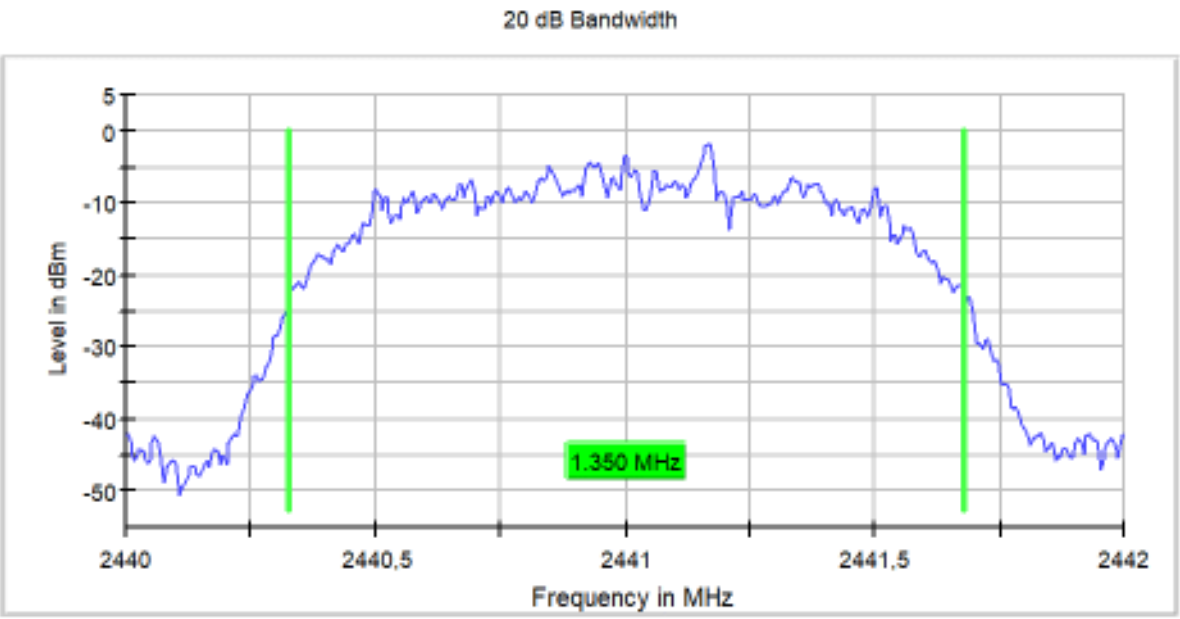
- **8DPSK – Bandwidths**

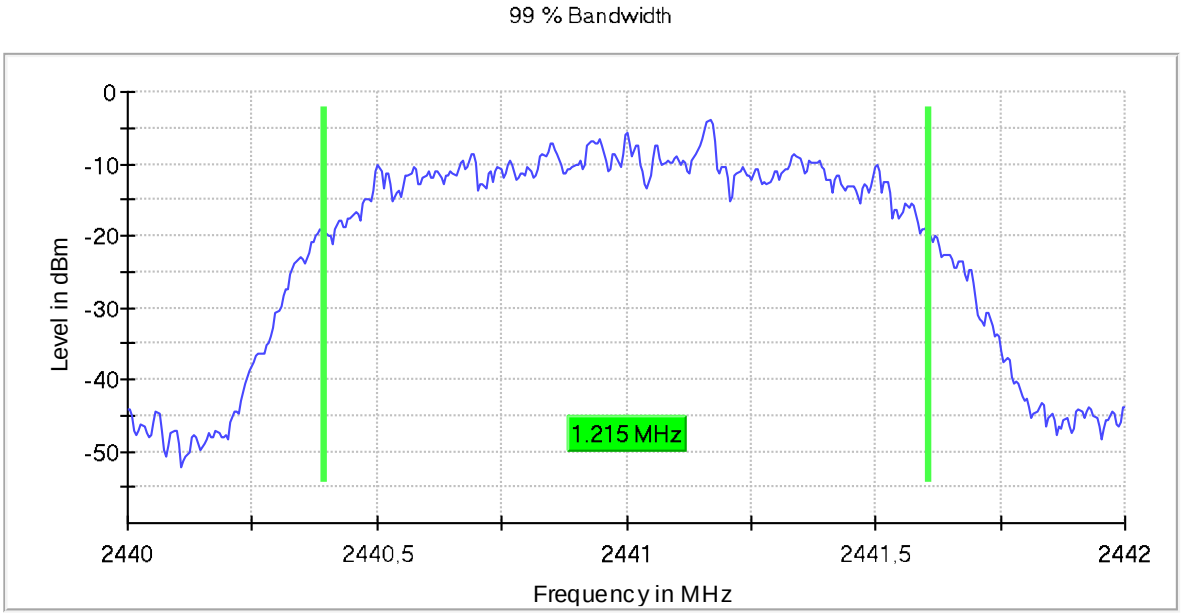
  - Low Channel:



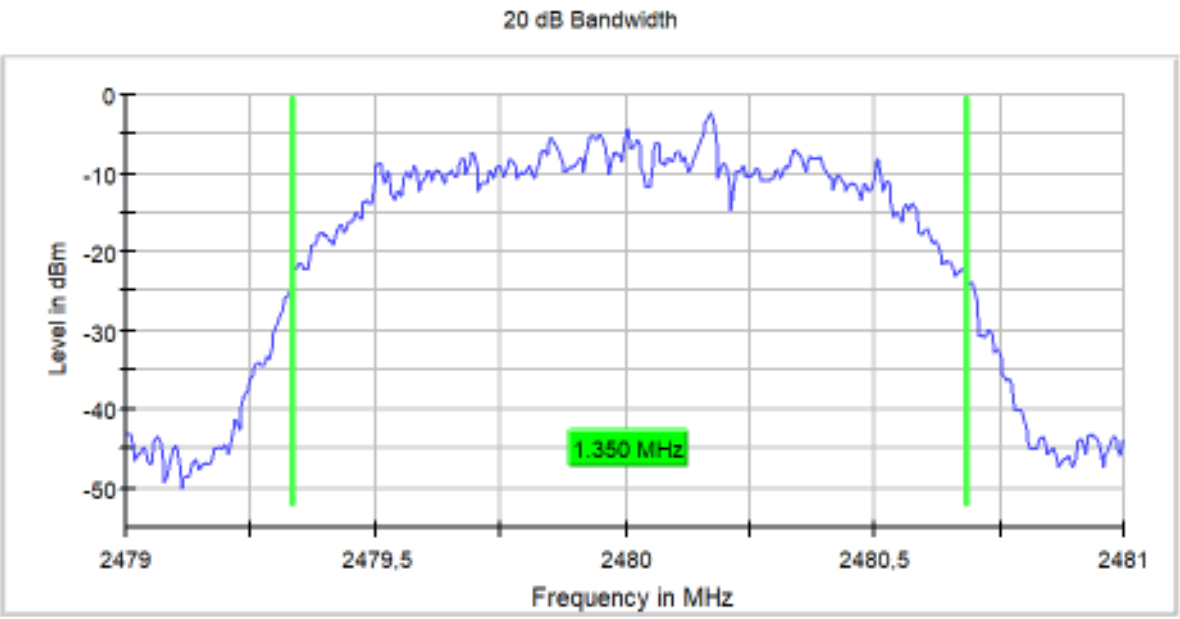


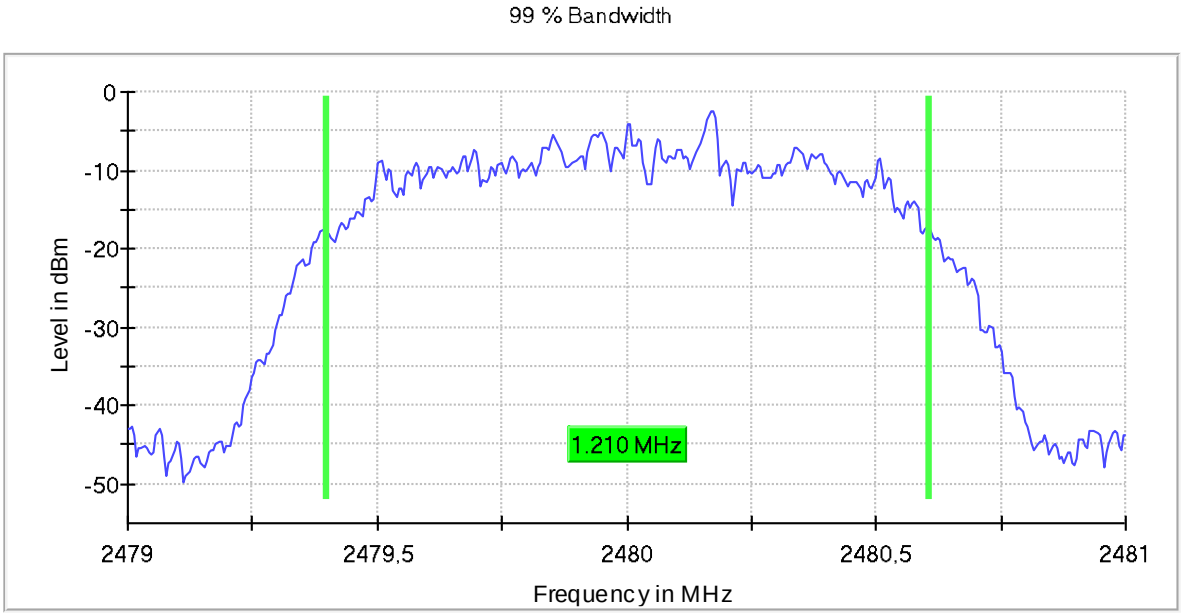
- Middle Channel:





- High Channel:

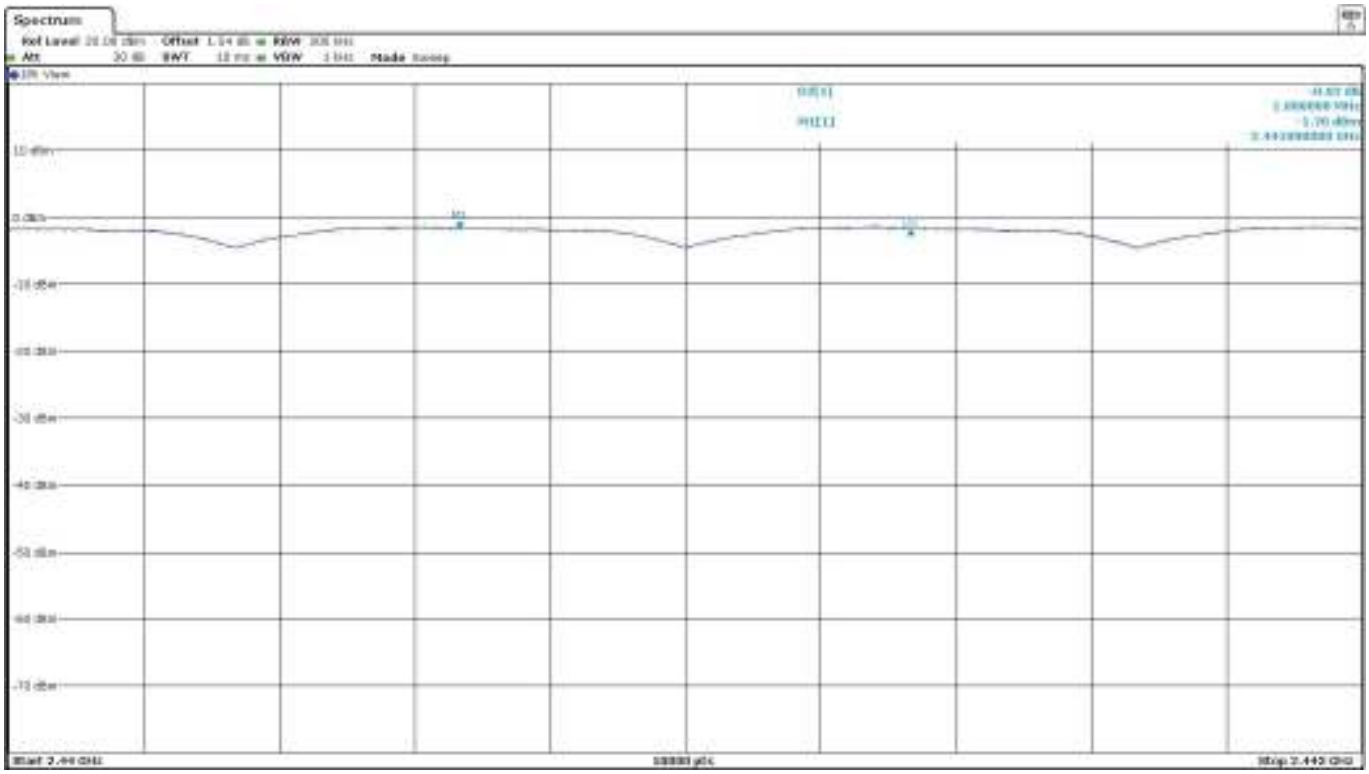




Carrier frequency separation - 8DPSK

Carrier frequency separation: 1.000 MHz

The hopping channel carrier frequencies are separated by a minimum two-thirds of the 20 dB bandwidth of the hopping channel.



Verdict: PASS

FCC 15.247 (a)(1)(iii) / RSS-247 5.1 (d) Number of hopping channels

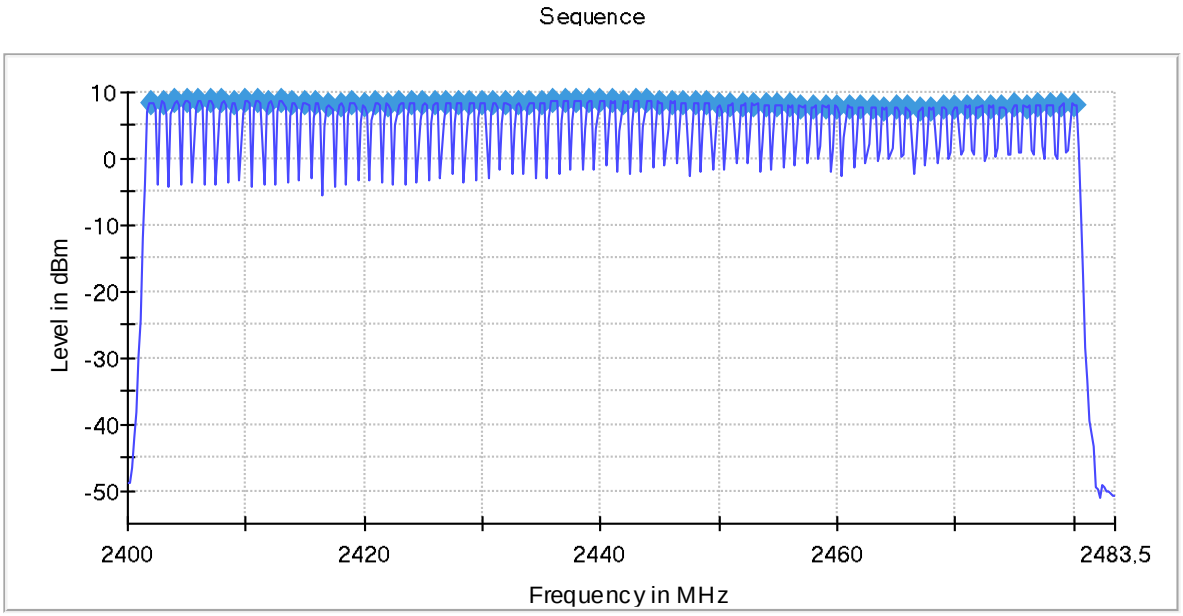
SPECIFICATION:

Frequency hopping system in the 2400-2483.5 MHz band shall use at least 15 channels.

RESULTS:

The number of hopping channels is 79 for all three modes.

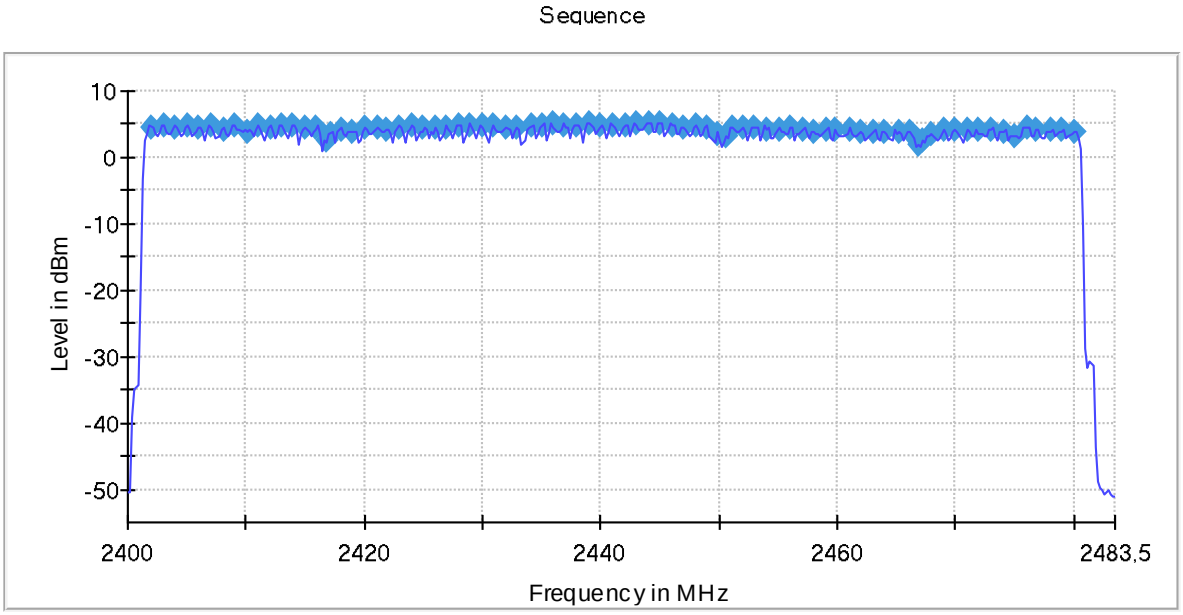
- **GFSK – Number of hopping channels:**



Total number of hopping channels: 79

Verdict: PASS

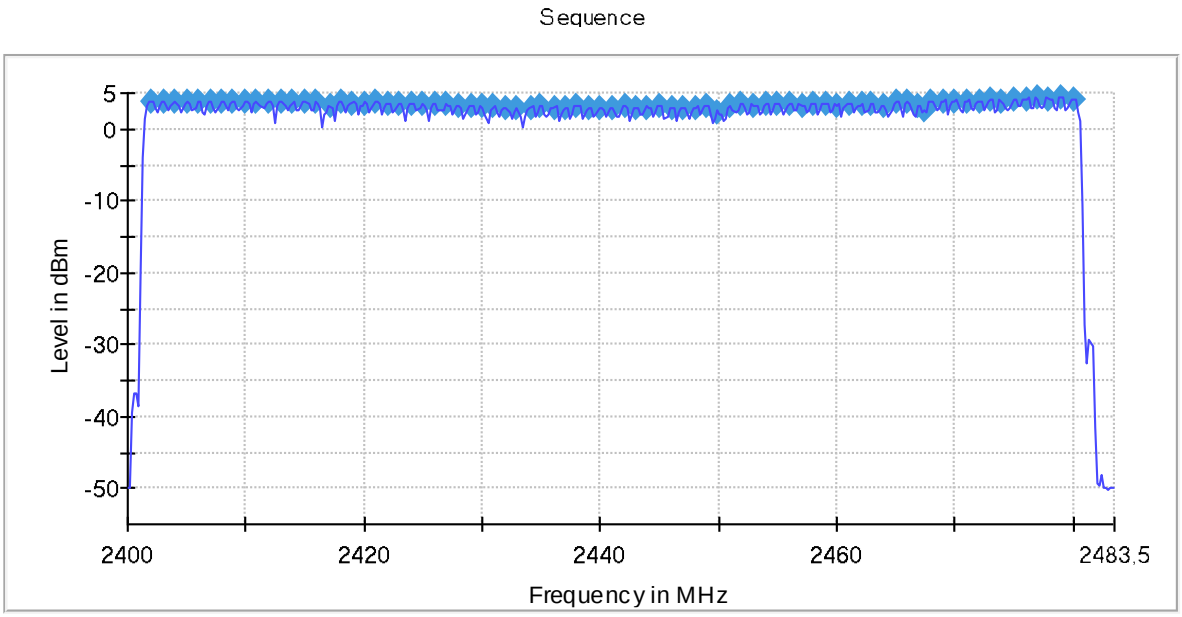
- **Pi/4 DQPSK – Number of hopping channels:**



Total number of hopping channels: 79

Verdict: PASS

- **8DPSK – Number of hopping channels:**



Total number of hopping channels: 80

Verdict: PASS

FCC 15.247 (a)(1)(iii) / RSS-247 5.1 (d) Time of occupancy (Dwell Time)

SPECIFICATION:

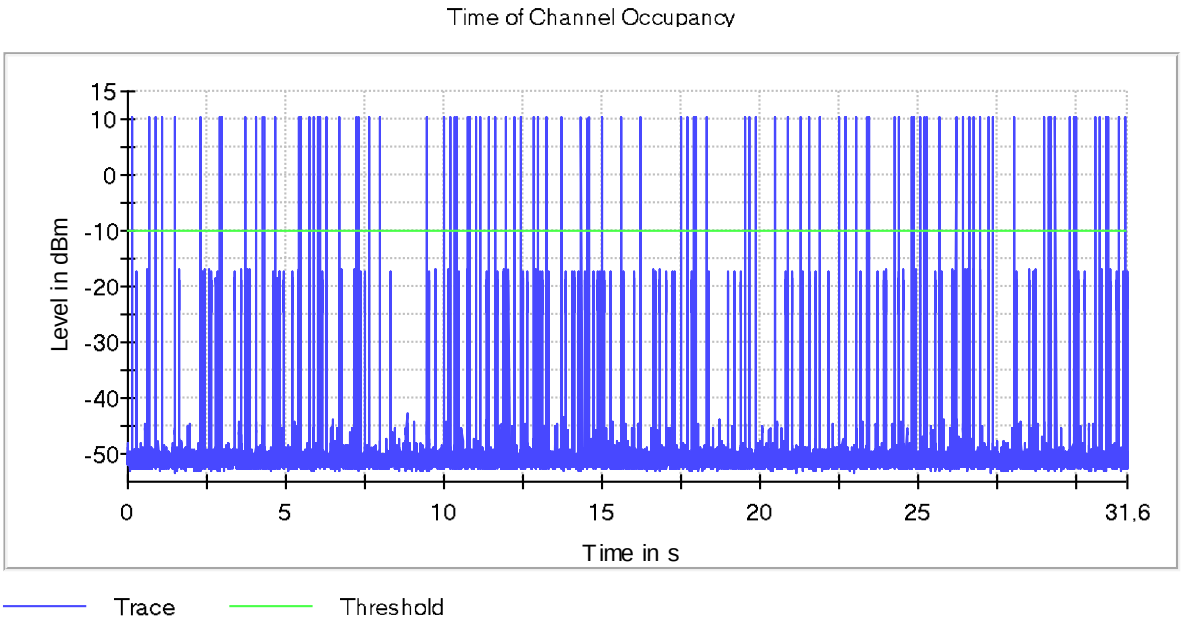
The average time of occupancy on any channel shall not be greater than 0.4 seconds (400 ms) within a period of 0.4 seconds multiplied by the number of hopping channels employed = 0.4 x 79= 31.6 seconds.

RESULTS:

- **GFSK (packet type DH5) – Time of Occupancy (Dwell Time)**

  - Time of Occupancy:

Nº of hops over the period	97	
Average Time of Occupancy	284.090	ms



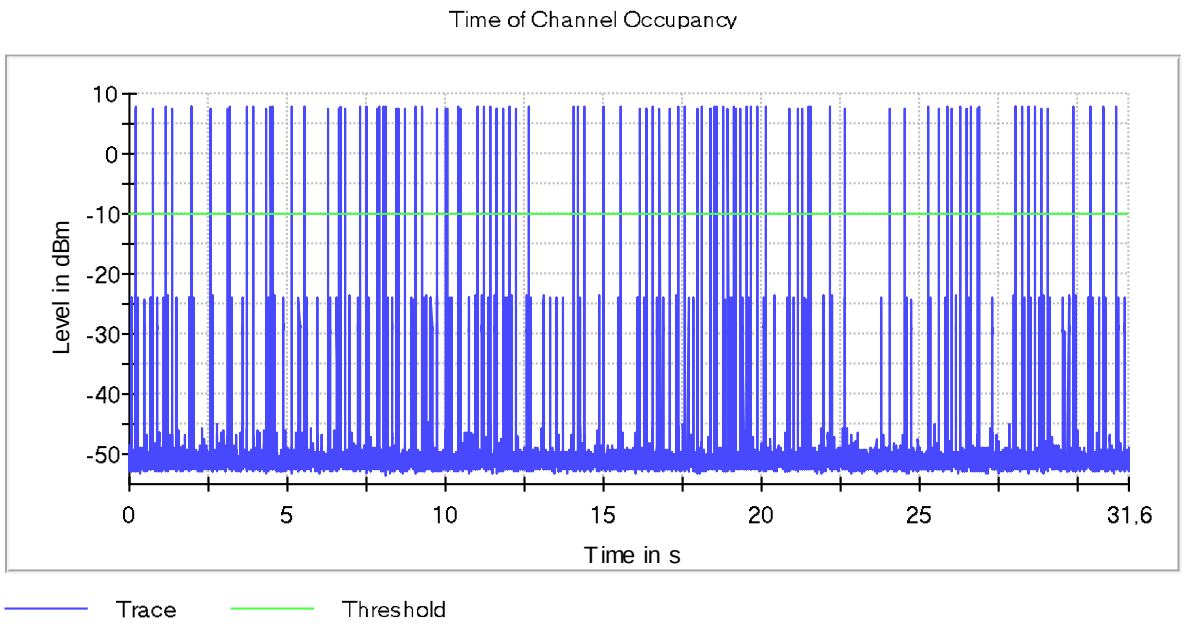
Measurement uncertainty (ms)	<±0.546

Verdict: PASS

- **Pi/4 DQPSK (packet type 2DH5) – Time of Occupancy (Dwell Time)**

  - Time of Occupancy:

Nº of hops over the period	103	
Average Time of Occupancy	300.8	ms



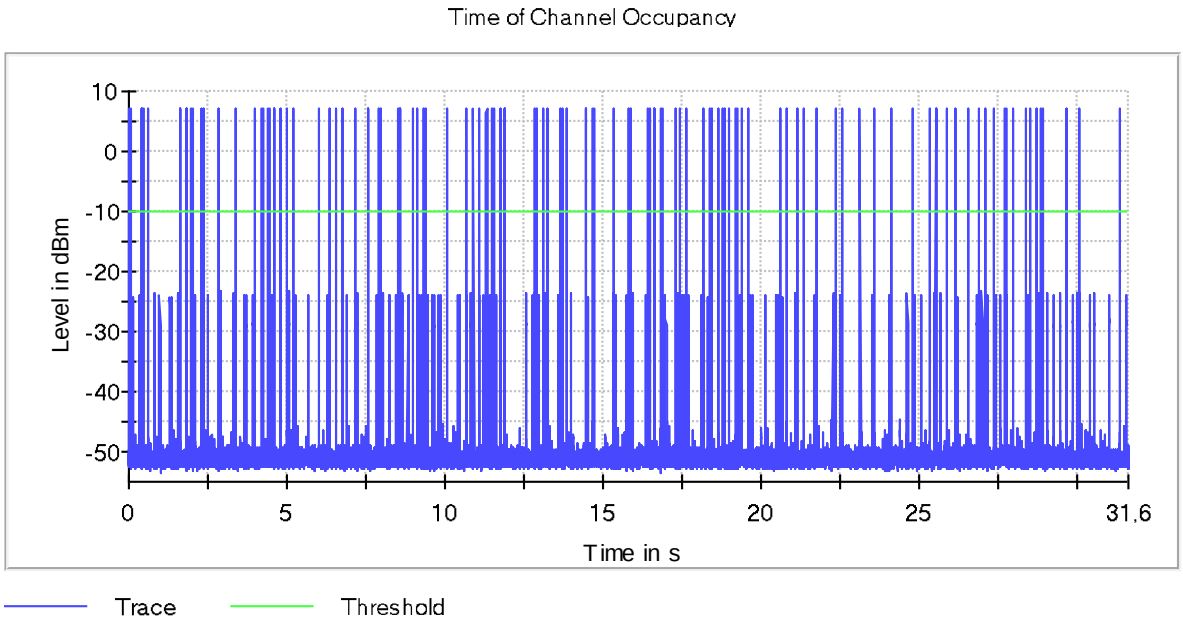
Measurement uncertainty (ms)	<±0.546

Verdict: PASS

- **8DPSK (packet type 3DH5) – Time of Occupancy (Dwell Time)**

  - Time of Occupancy:

Nº of hops over the period	106	
Average Time of Occupancy	310.550	ms



Measurement uncertainty (ms)	<±0.546

Verdict: PASS

FCC 15.247 (b) / RSS-247 5.4 (b) Maximum peak output power and antenna gain

SPECIFICATION:

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 hopping channels: 1 watt (30 dBm). The e.i.r.p. shall not exceed 4 W (RSS-247).

RESULTS:

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

Maximum Declared Antenna Gain: -6.2 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.

- **GFSK** (1 Mbps):

Peak Conducted Output Power	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
Maximum Conducted Power (dBm)	9.0	8.9	8.7
Maximum EIRP Power (dBm)	2.8	2.7	2.5
Measurement uncertainty (dB)	<±2.57		

- **Pi/4 DQPSK** (2 Mbps):

Peak Conducted Output Power	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
Maximum Conducted Power (dBm)	6.9	7.3	6.9
Maximum EIRP Power (dBm)	0.7	1.1	0.7
Measurement uncertainty (dB)	<±2.57		

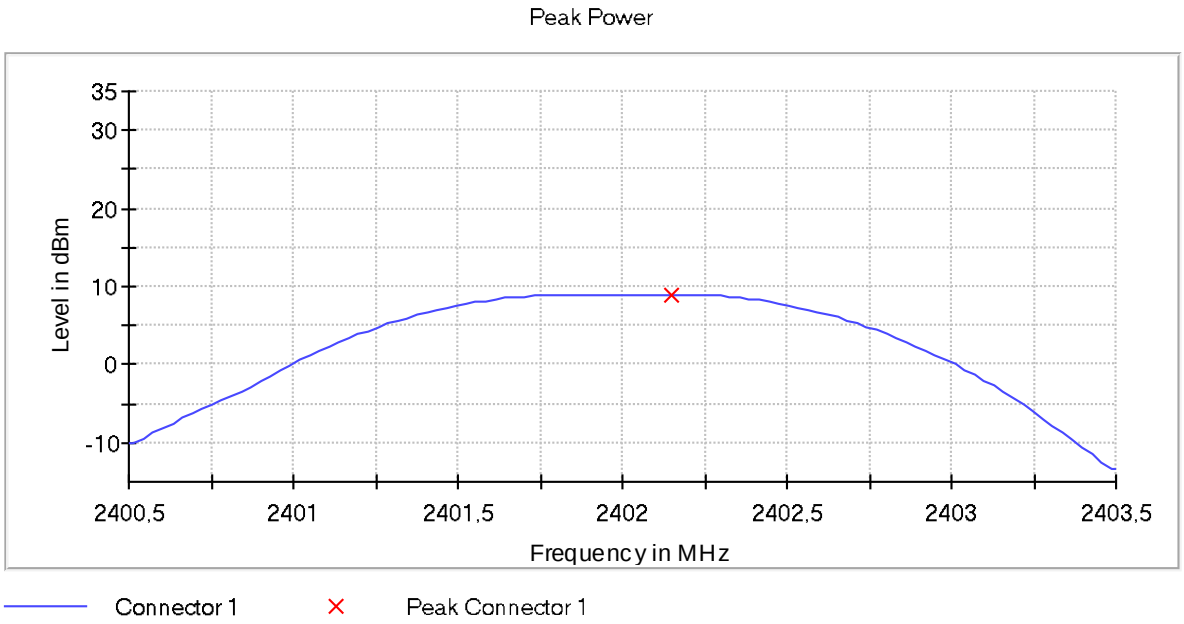
- **8DPSK** (3 Mbps):

Peak Conducted Output Power	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
Maximum Conducted Power (dBm)	7.4	7.5	7.0
Maximum EIRP Power (dBm)	1.2	1.3	0.8
Measurement uncertainty (dB)	<±2.57		

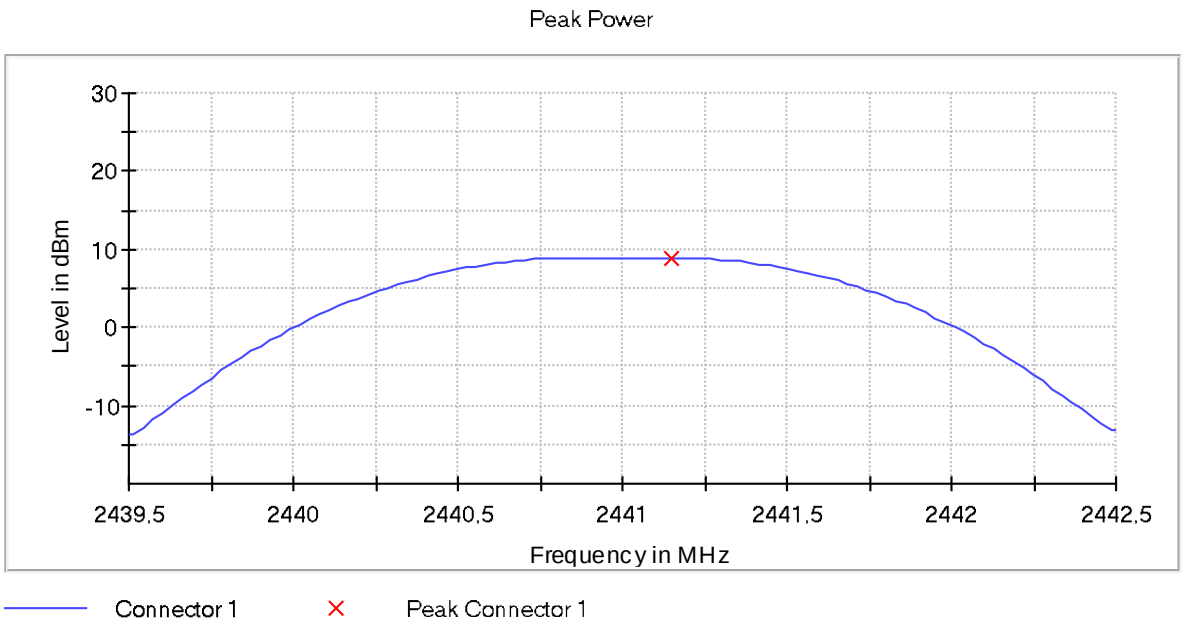
Verdict: PASS

- **GFSK – Peak Output Power**

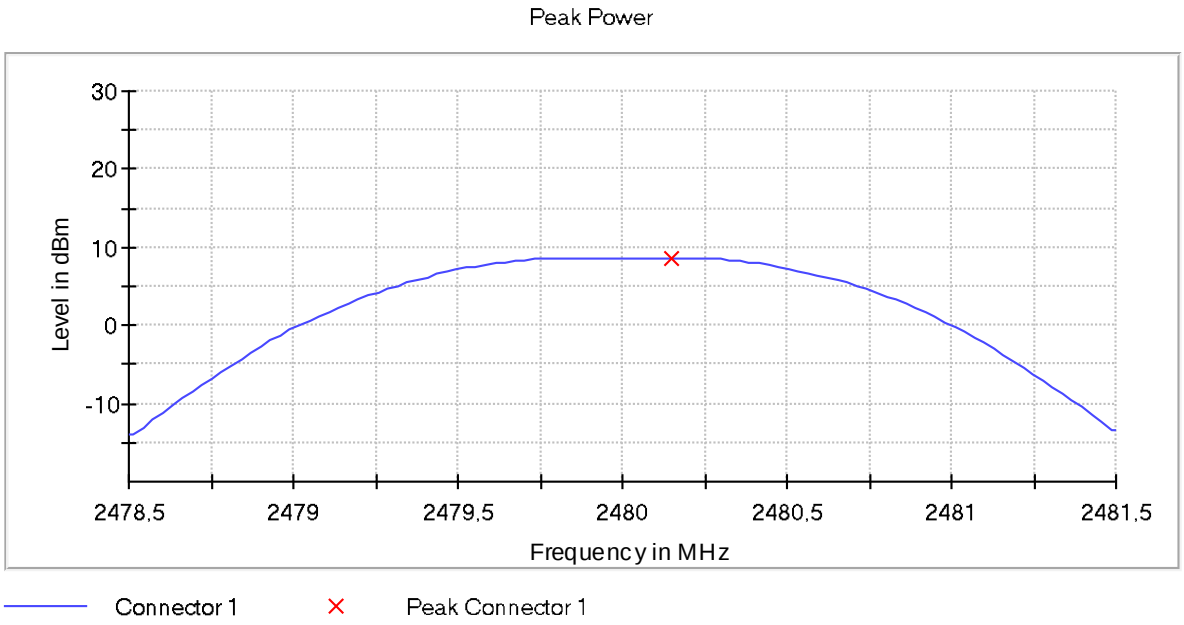
- Low Channel:



- Middle Channel:

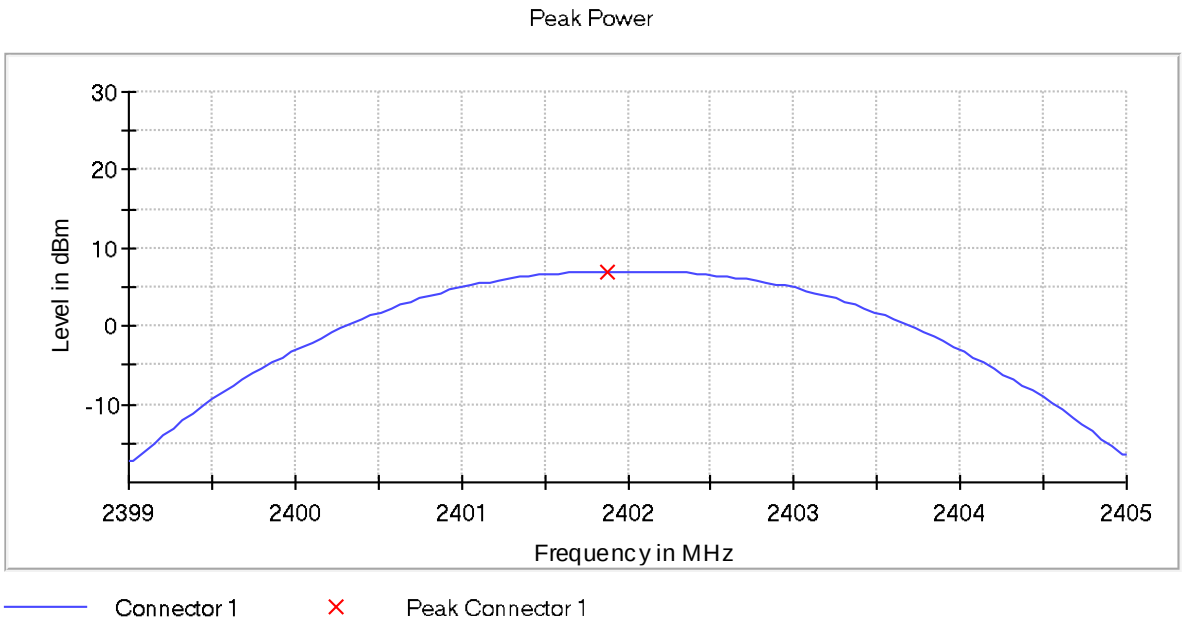


- High Channel:

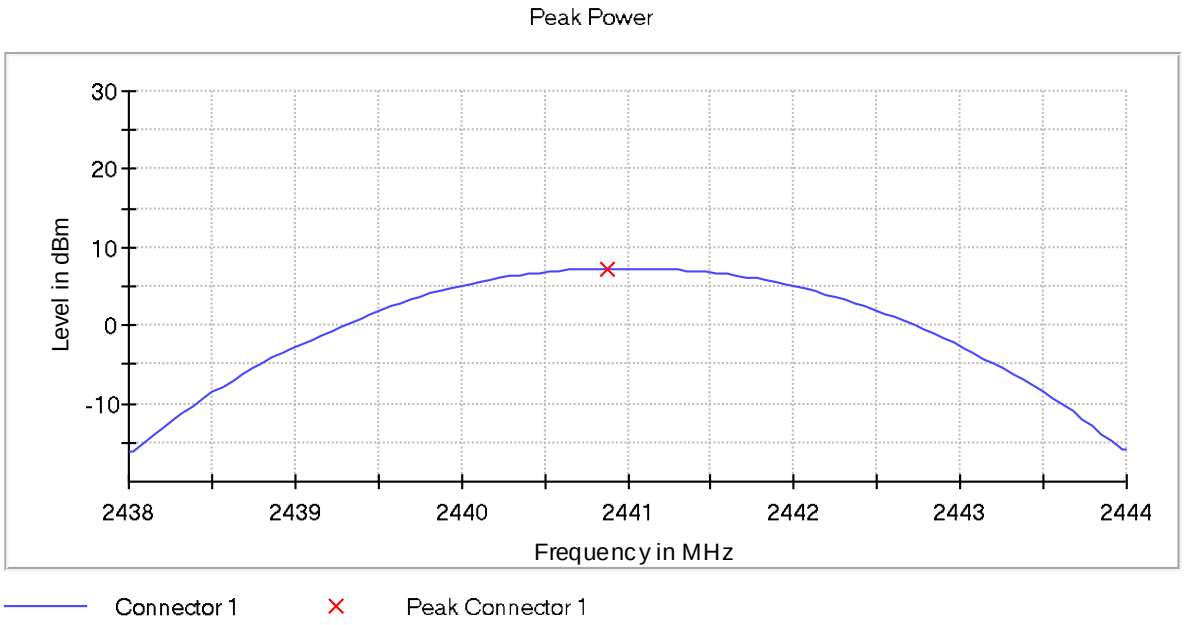


- **Pi/4 DQPSK – Peak Output Power**

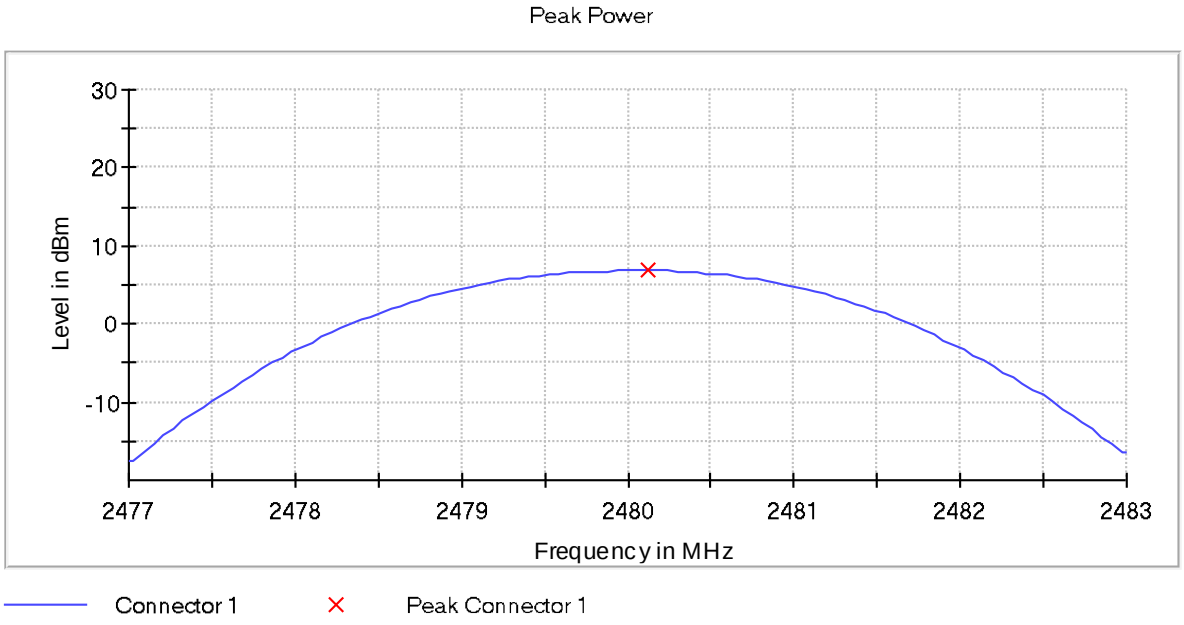
- Low Channel:



- Middle Channel:

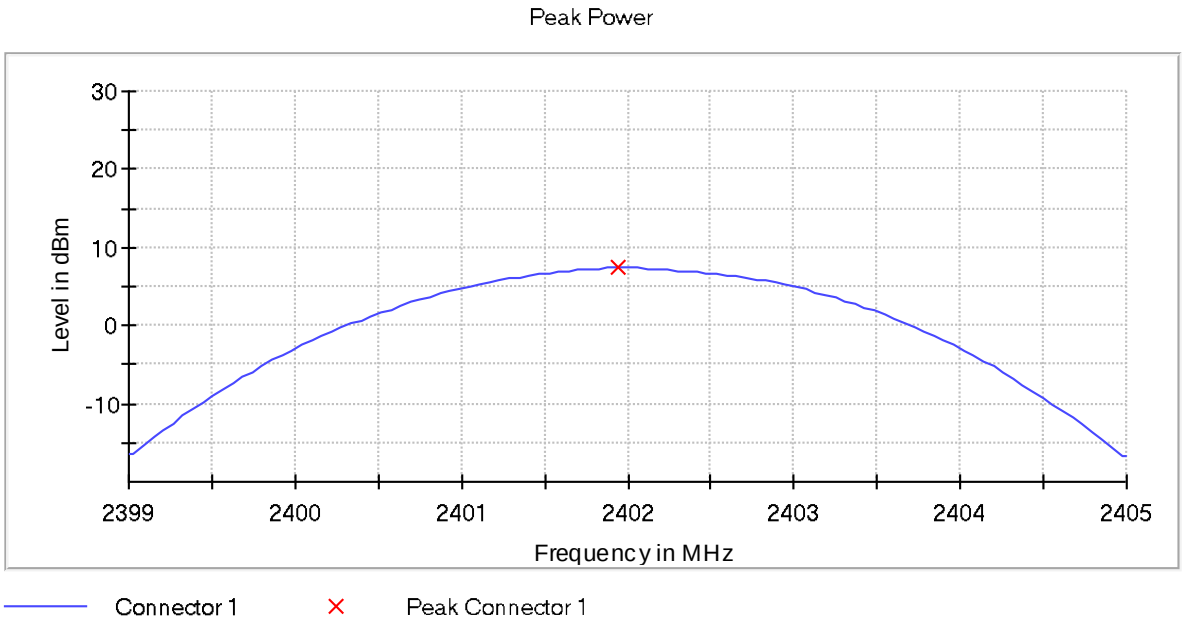


- High Channel:

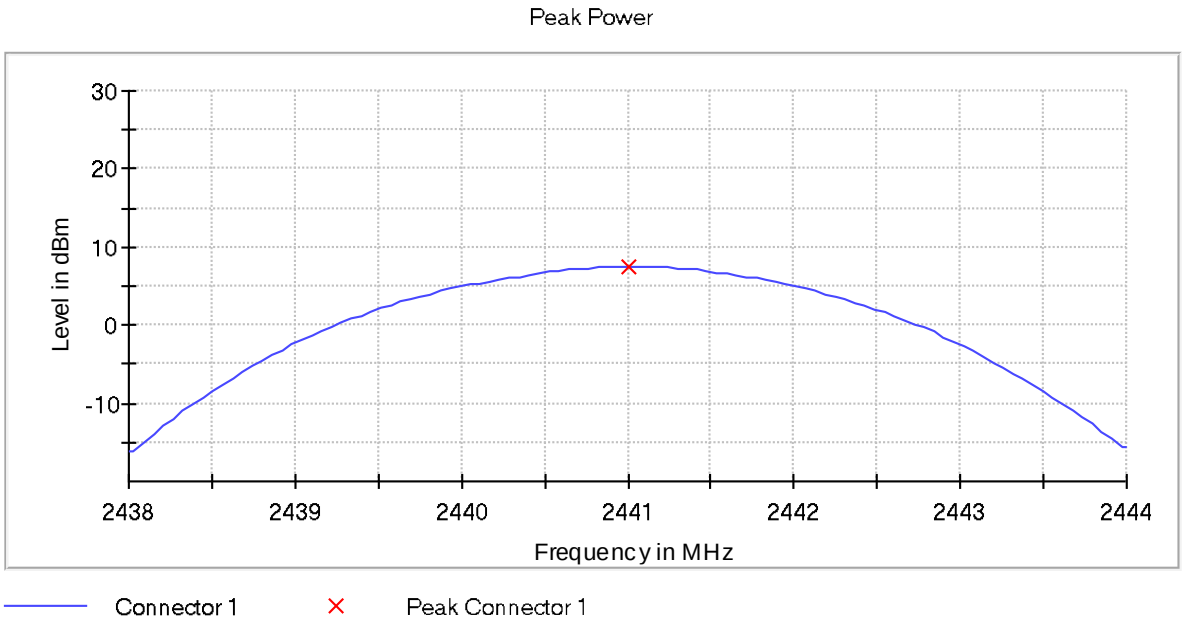


- **8DPSK – Peak Output Power**

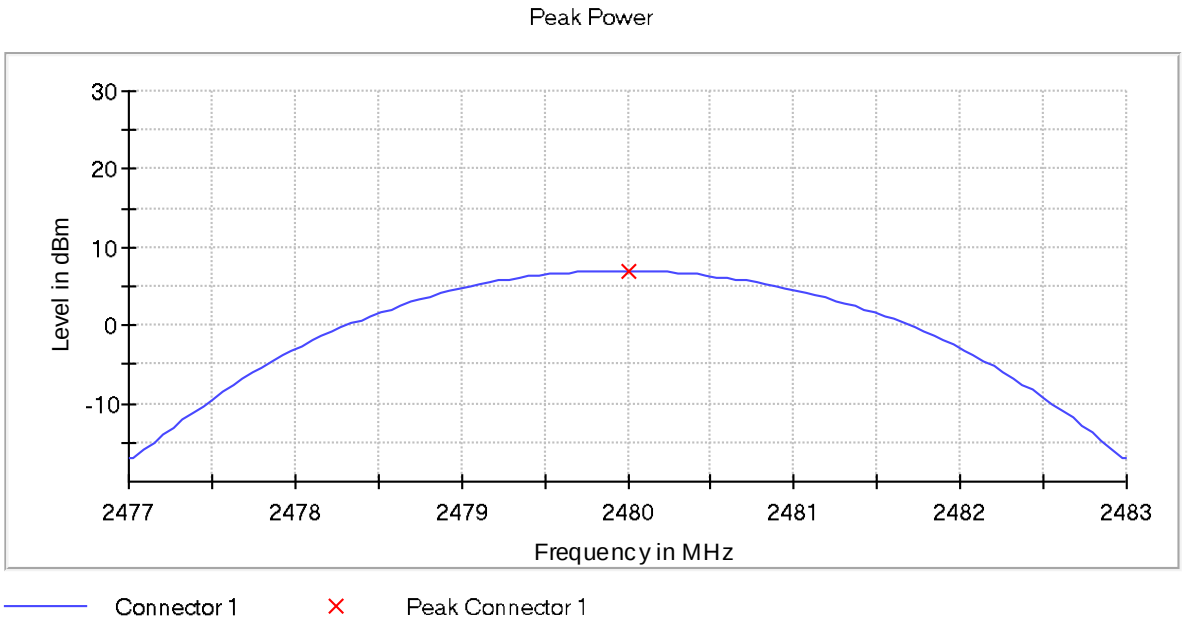
- Low Channel:



- Middle Channel:



- High Channel:



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

SPECIFICATION:

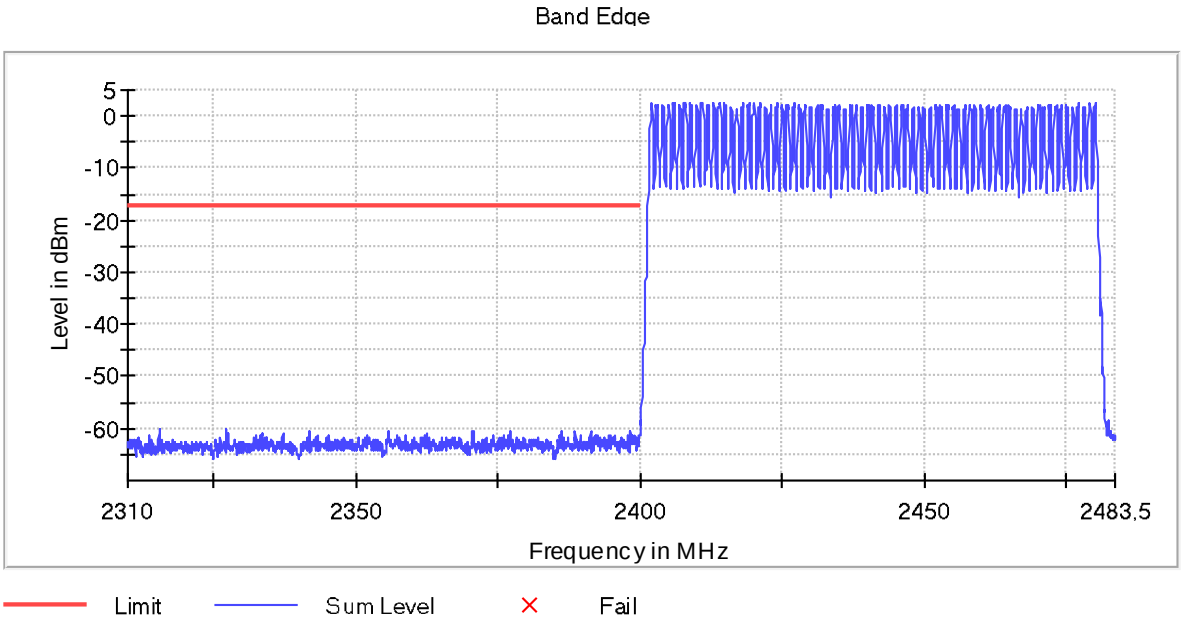
Emissions outside the frequency band in which the intentional radiator is operating shall be at least 20 dB below the highest level of the desired power.

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.

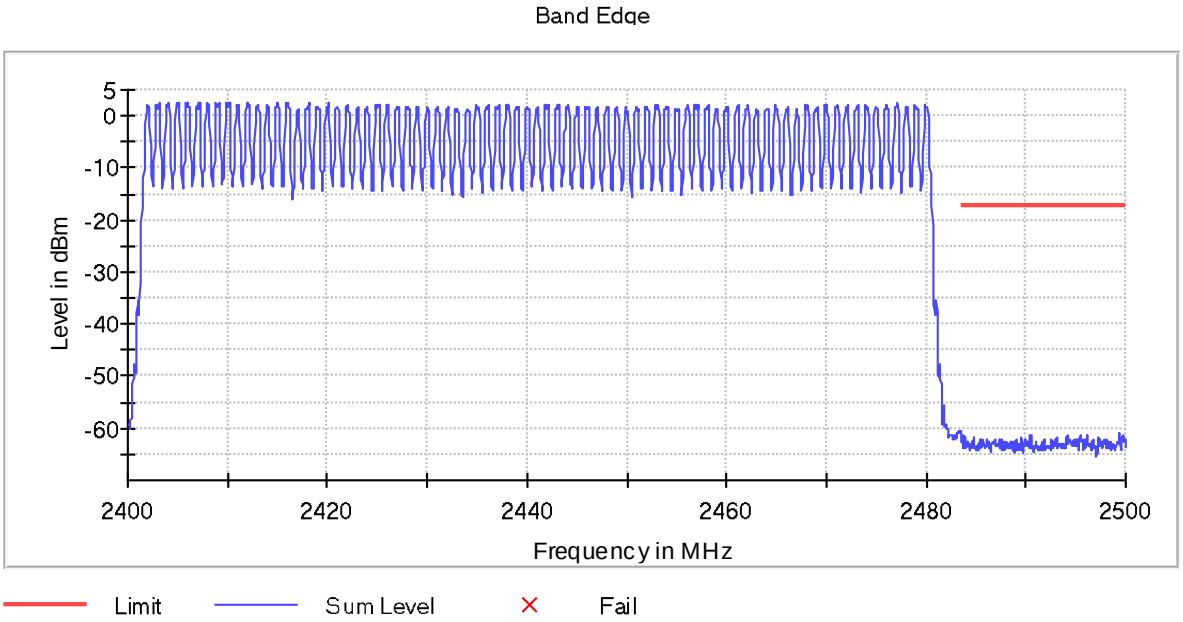
Measurement uncertainty (dB)	<±2.77

- **GFSK – Band-edge emissions compliance:**
  - ❖ HOPPING ON:
    - Low Frequency Section 2402 MHz:



Verdict: PASS

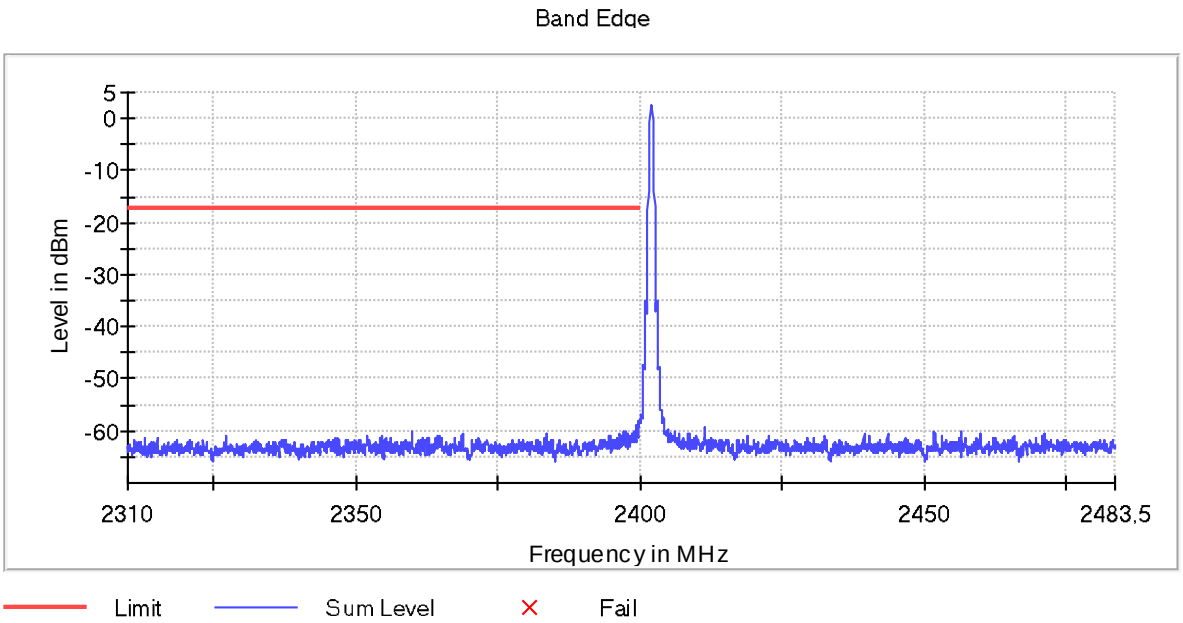
- High Frequency Section 2480 MHz:



Verdict: PASS

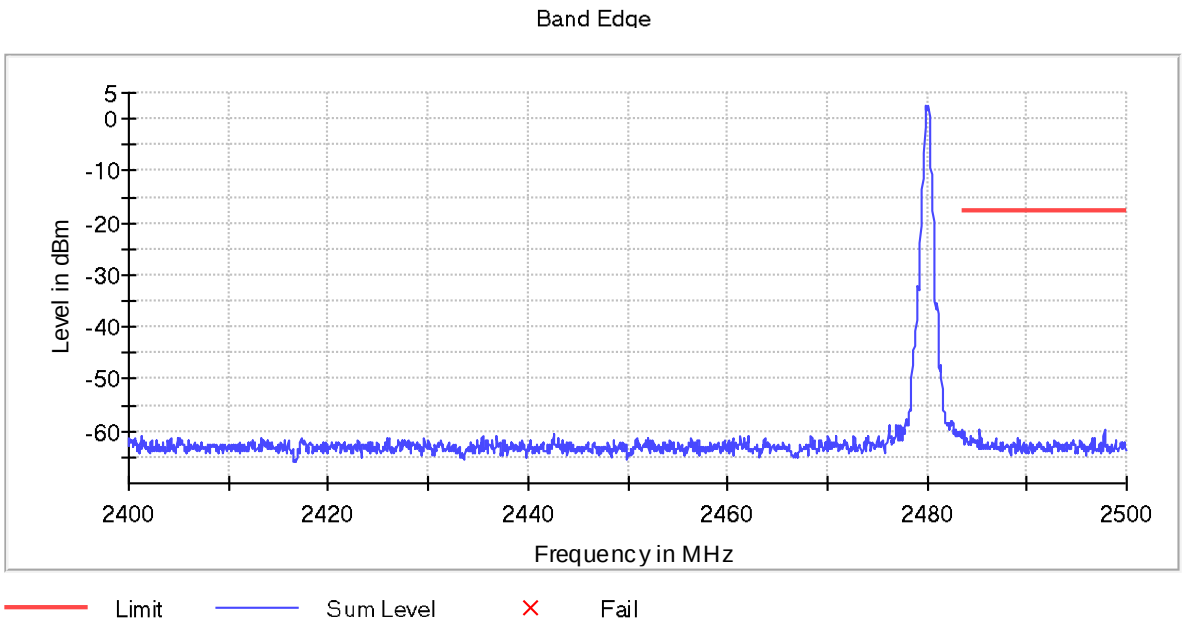
❖ HOPPING OFF:

- Low Frequency Section 2402 MHz:



Verdict: PASS

- High Frequency Section 2480 MHz:

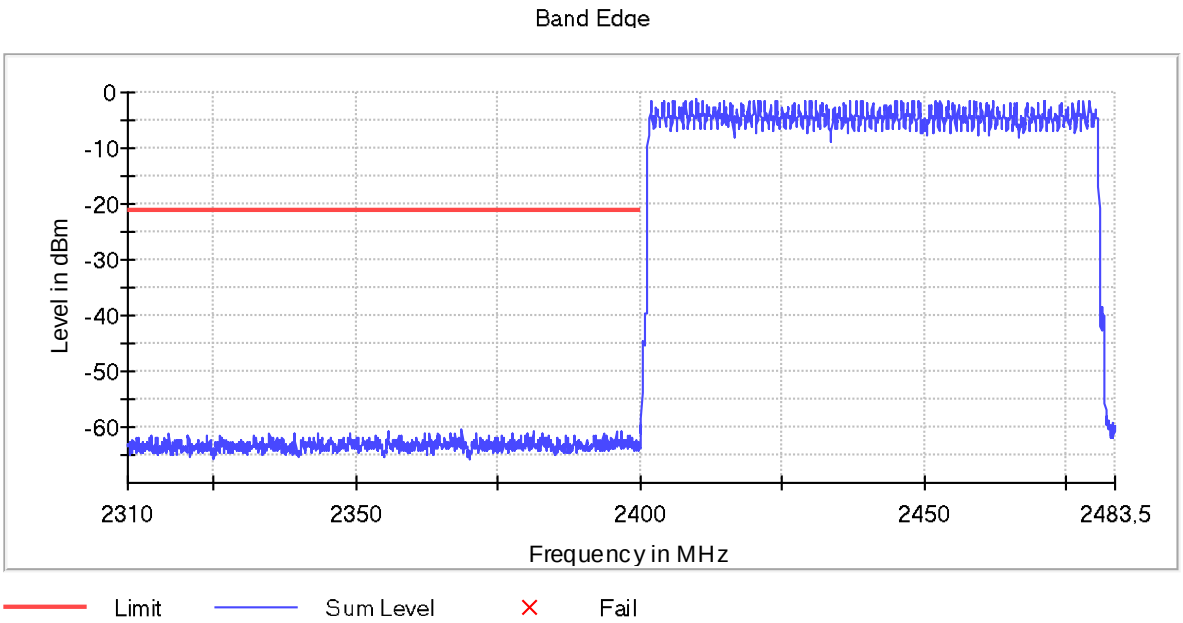


Verdict: PASS

- **Pi/4 DQPSK – Band-edge emissions compliance:**

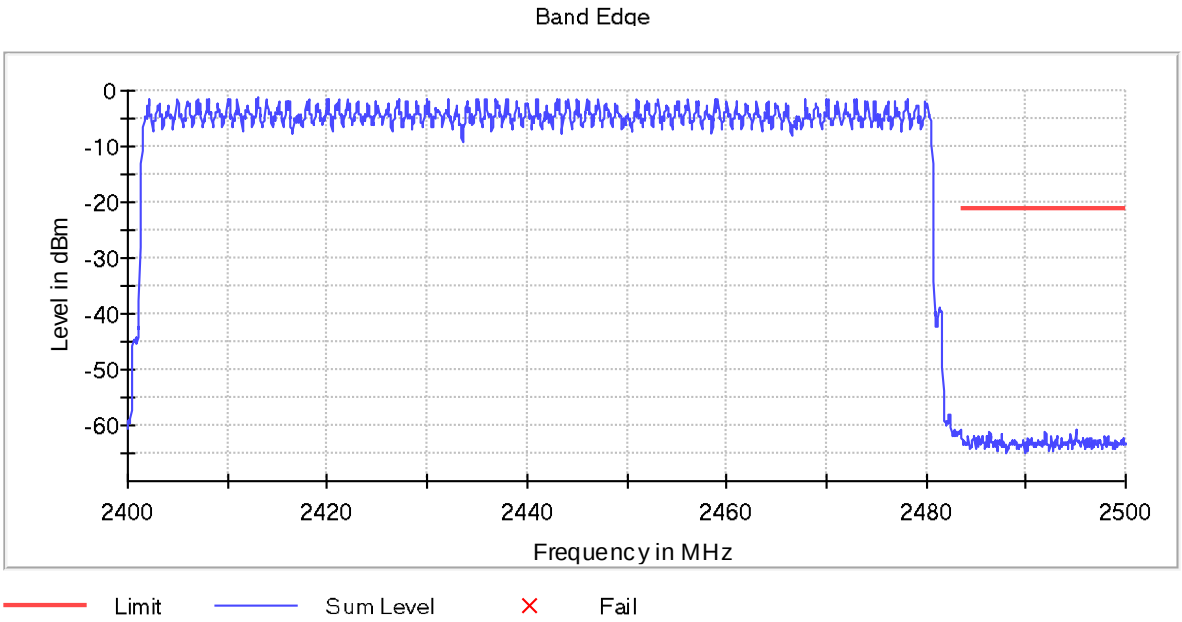
❖ HOPPING ON:

▪ Low Frequency Section 2402 MHz:



Verdict: PASS

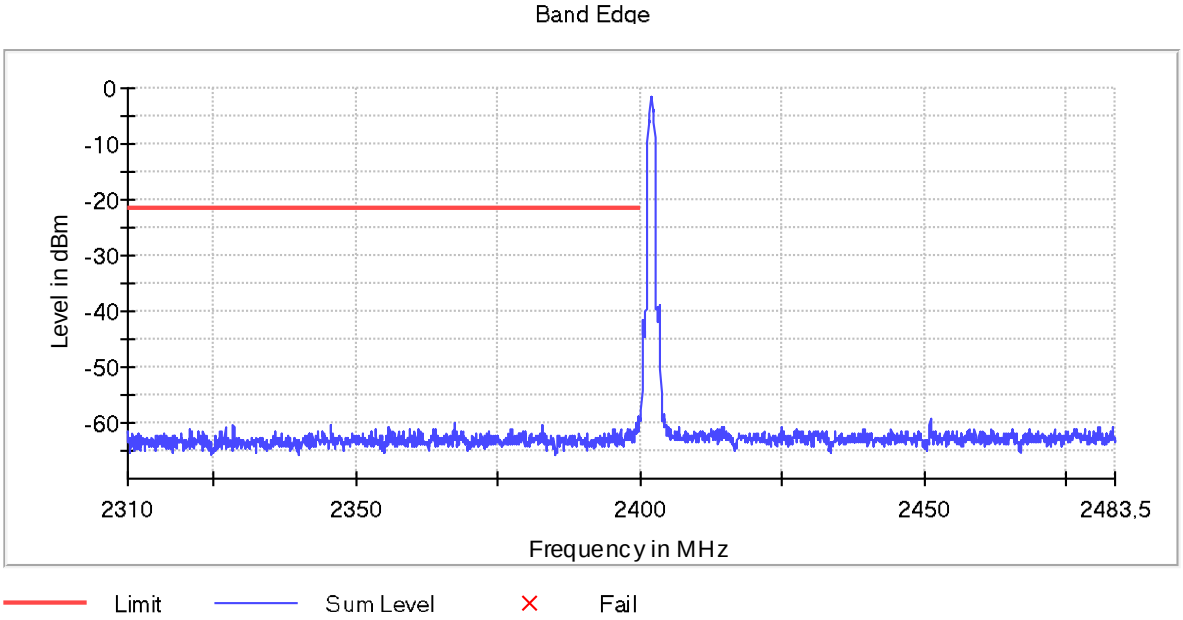
▪ High Frequency Section 2480 MHz:



Verdict: PASS

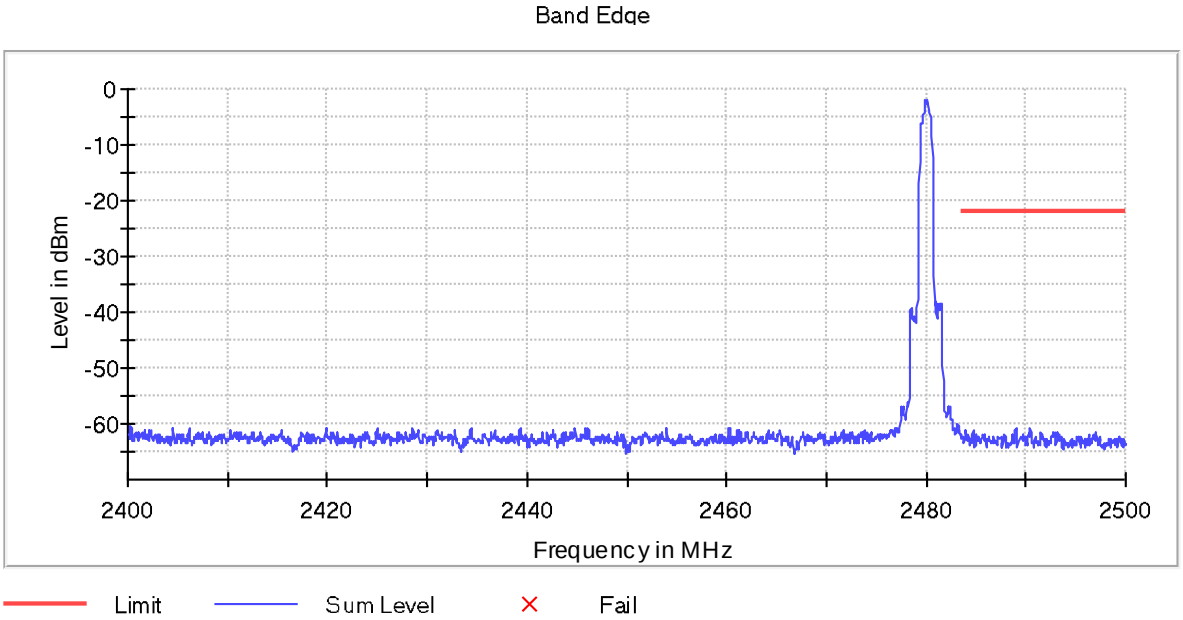
❖ HOPPING OFF:

- Low Frequency Section 2402 MHz:



Verdict: PASS

- High Frequency Section 2480 MHz:

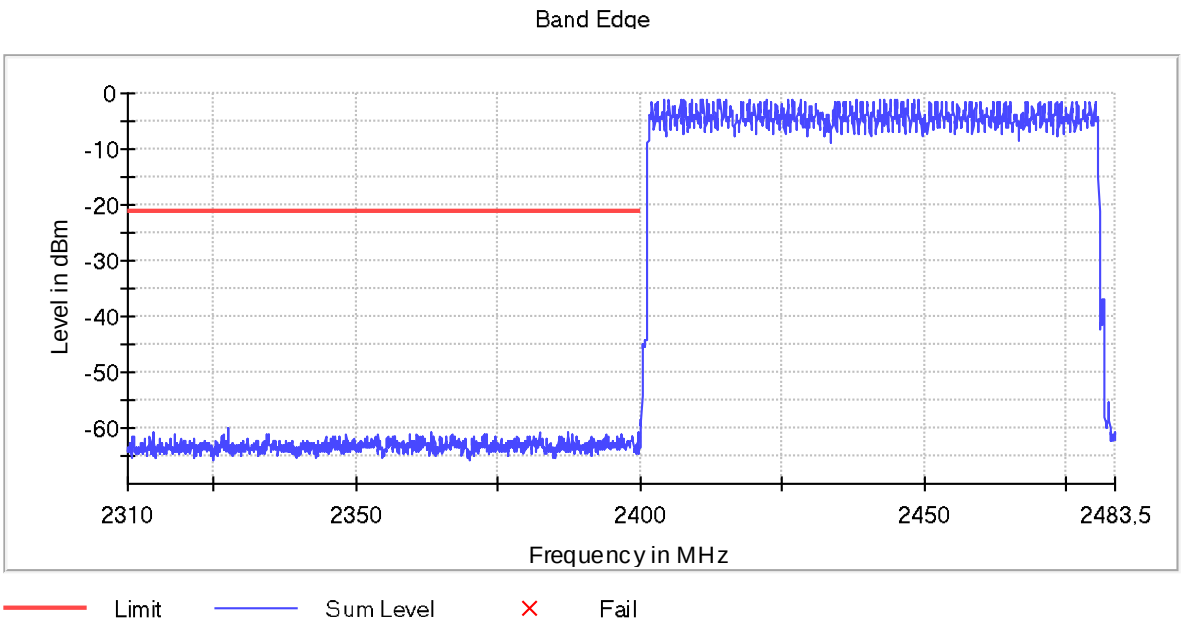


Verdict: PASS

- **8DPSK – Band-edge emissions compliance:**

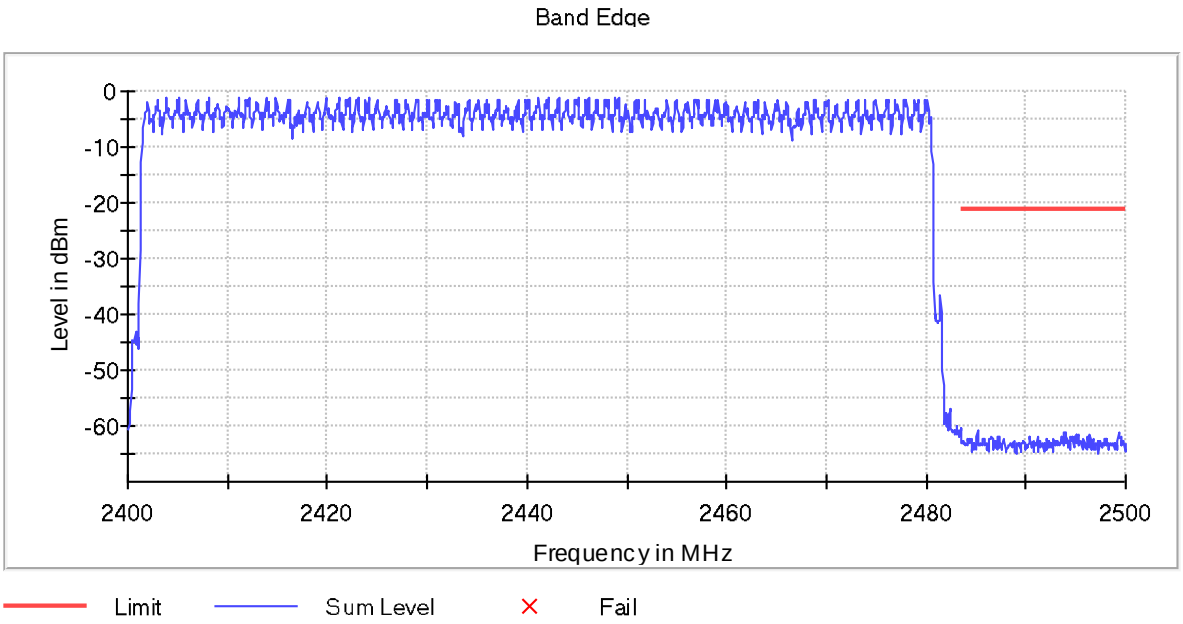
❖ HOPPING ON:

▪ Low Frequency Section 2402 MHz:



Verdict: PASS

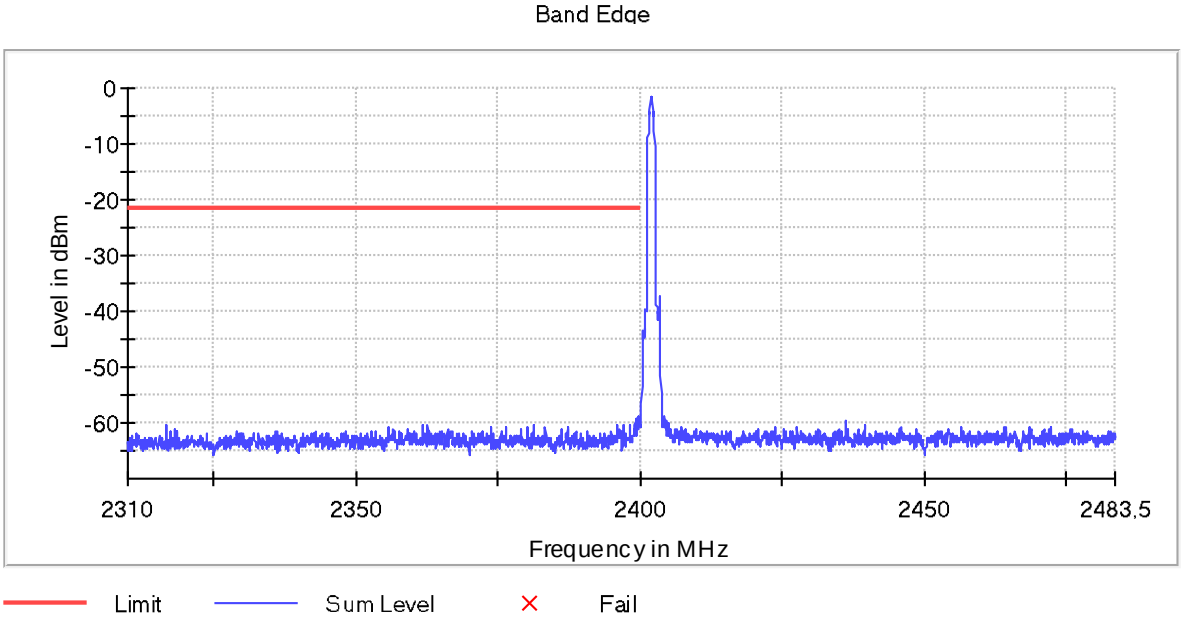
▪ High Frequency Section 2480 MHz:



Verdict: PASS

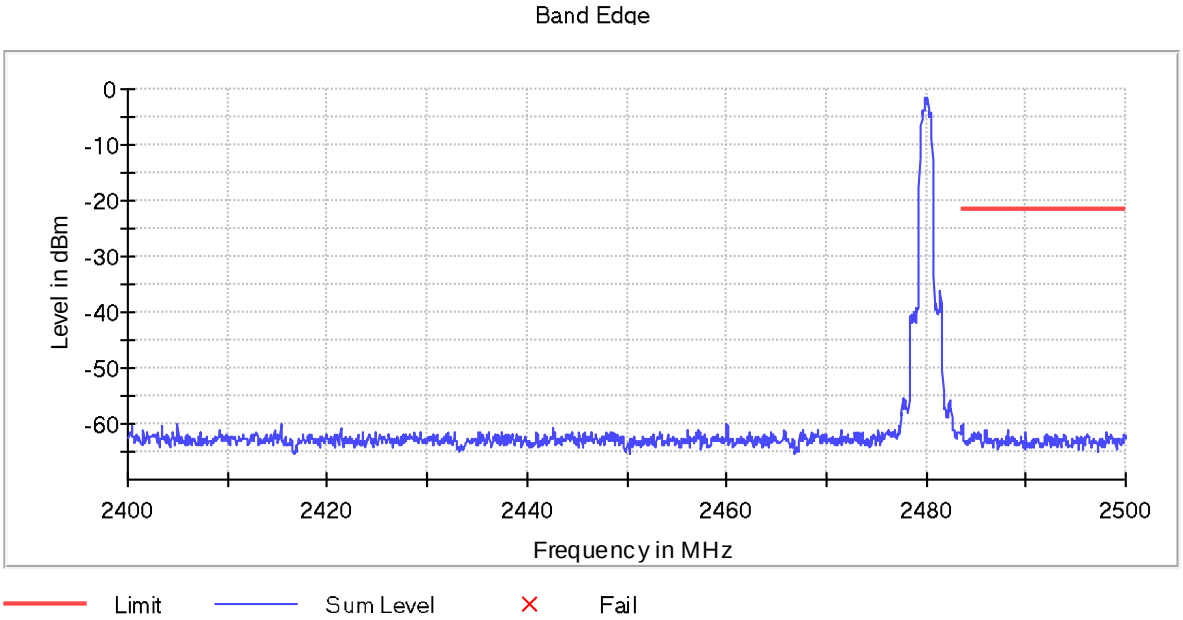
❖ HOPPING OFF:

- Low Frequency Section 2402 MHz:



Verdict: PASS

- High Frequency Section 2480 MHz:



Verdict: PASS

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

SPECIFICATION:

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §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 - 25000	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-25 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.

Frequency range 30 MHz - 1 GHz:

The spurious frequencies detected below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
75.008	26.27	V	Quasi-peak	<± 5.08

Measurement Uncertainty: <± 5.08 dB

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.

- **GFSK modulation (DH5):**

  - LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	48.16	V	Peak	<± 5.13

  - MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	46.71	V	Peak	<± 5.13

  - HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	46.70	V	Peak	<± 5.13

Measurement Uncertainty (dB): 1 GHz ≤ f ≤ 17 GHz: <± 5.13
17 GHz ≤ f ≤ 26 GHz: <± 4.82

Verdict: PASS

- **Pi/4-DQPSK modulation (2-DH5):**

  - LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	48.16	V	Peak	<± 5.13

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	46.71	V	Peak	<± 5.13

- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	47.01	V	Peak	<± 5.13

Measurement Uncertainty (dB): 1 GHz ≤ f ≤ 17 GHz: <± 5.13
17 GHz ≤ f ≤ 26 GHz: <± 4.82

Verdict: PASS

- **8-DPSK modulation (3-DH5):**

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	48.32	V	Peak	<± 5.13

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	48.21	V	Peak	<± 5.13

- HIGH CHANNEL. Spurious frequencies closest to the limit:

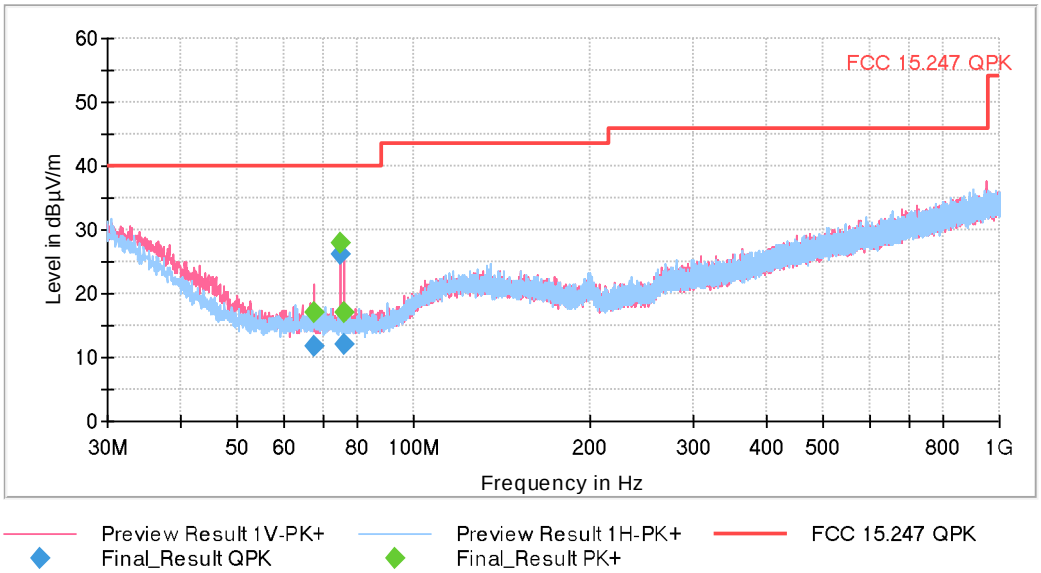
Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	48.33	V	Peak	<± 5.13

Measurement Uncertainty (dB): 1 GHz ≤ f ≤ 17 GHz: <± 5.13
17 GHz ≤ f ≤ 26 GHz: <± 4.82

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

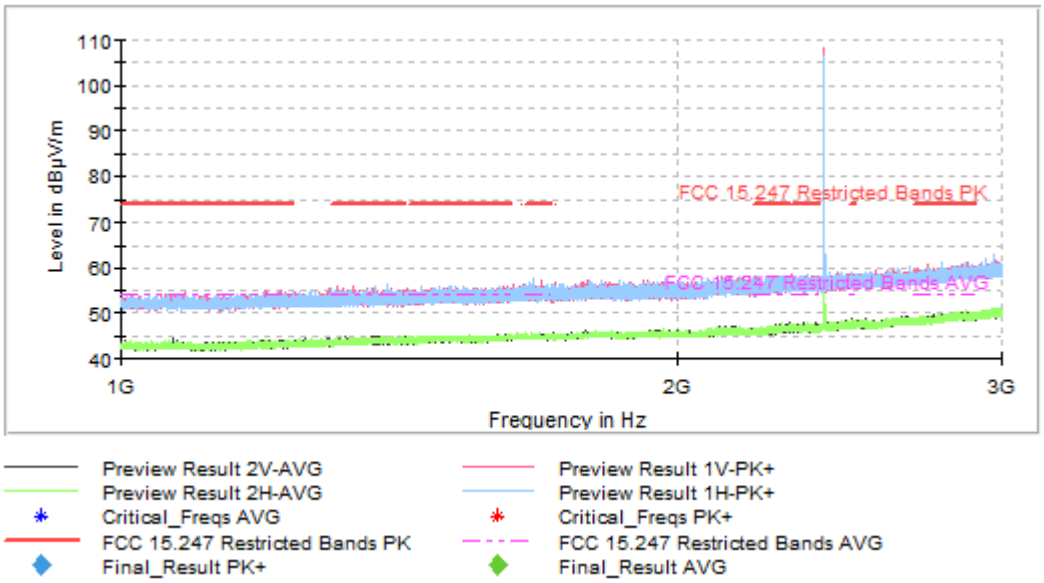
This plot is valid for the Low, Middle and High Channels and all the modulation modes.



FREQUENCY RANGE 1 - 3 GHz:

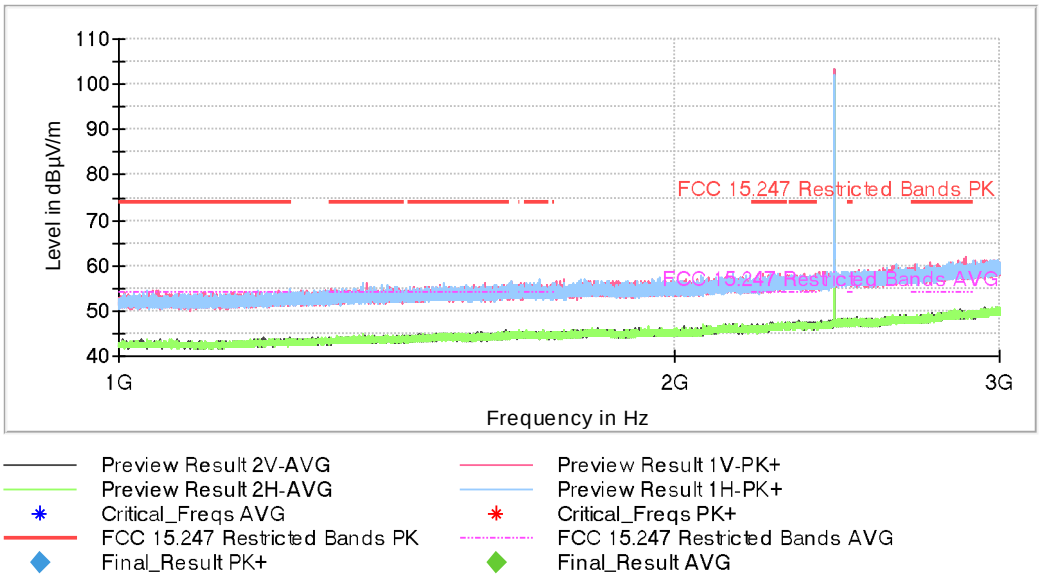
- **GFSK modulation (DH5)**

- Low Channel:



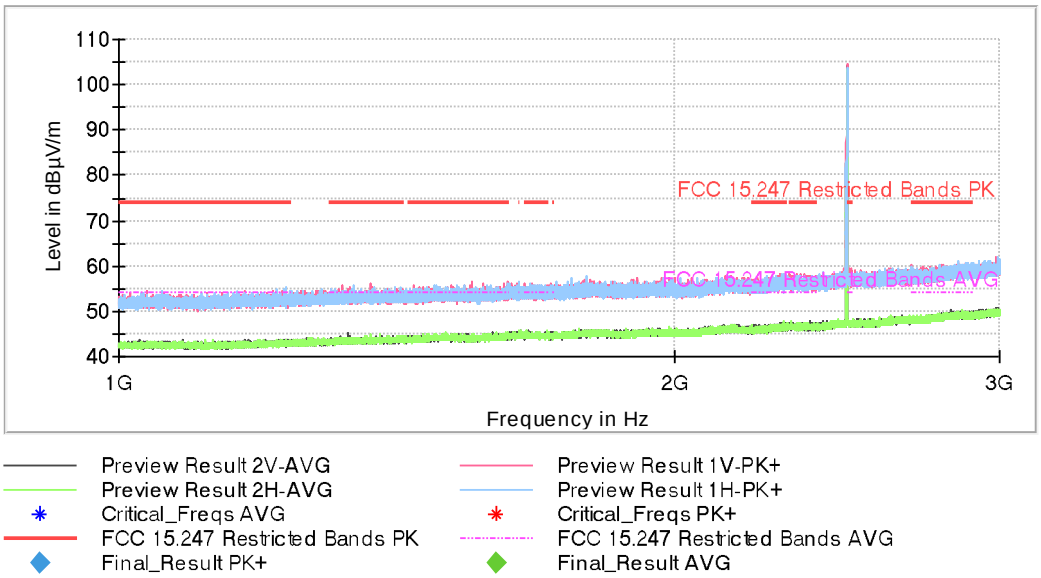
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

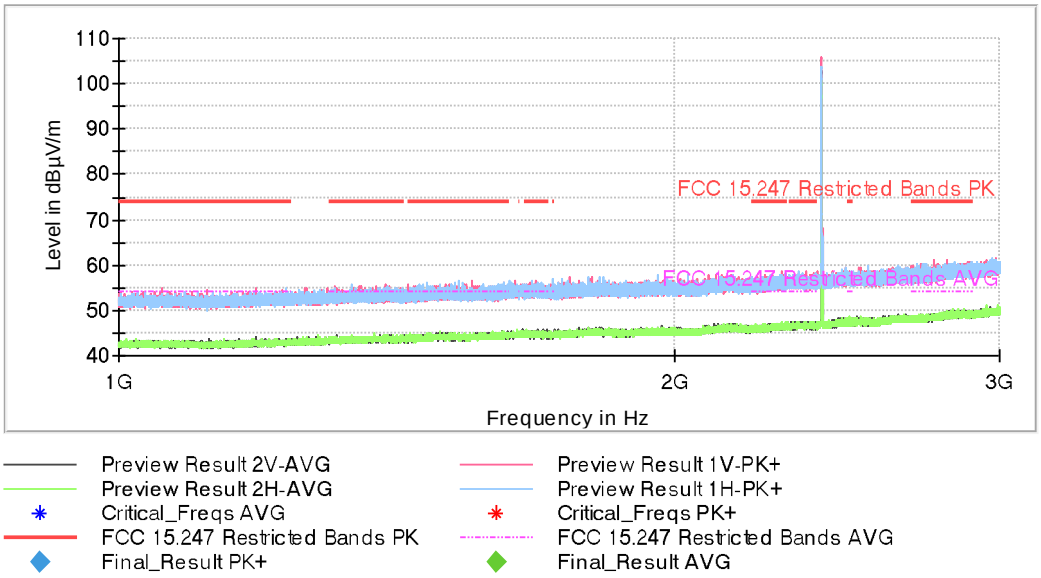
- High Channel:



The peak above the limit is the carrier frequency.

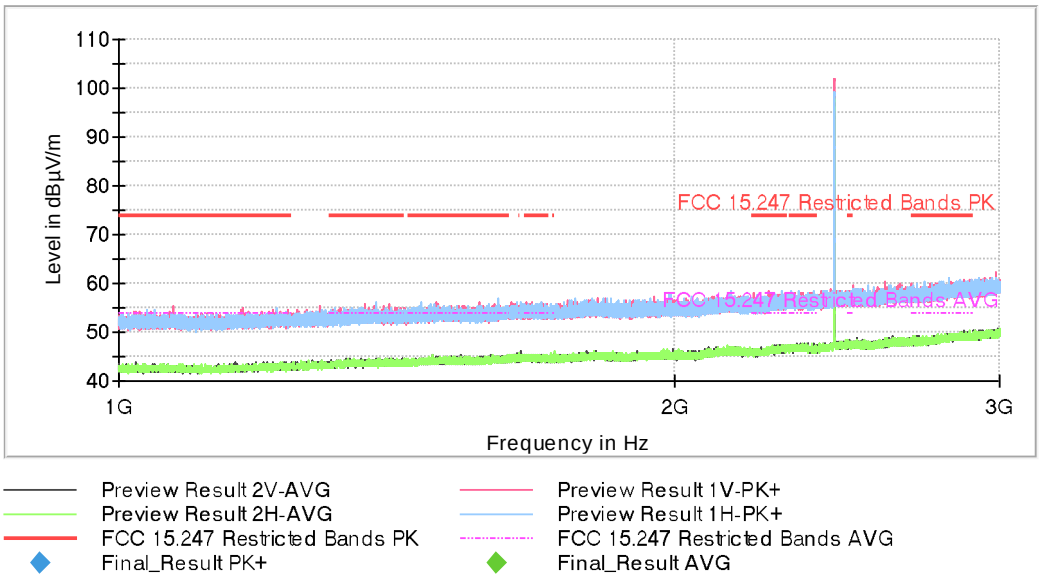
- **Pi/4-DQPSK modulation (2DH5)**

  - Low Channel:



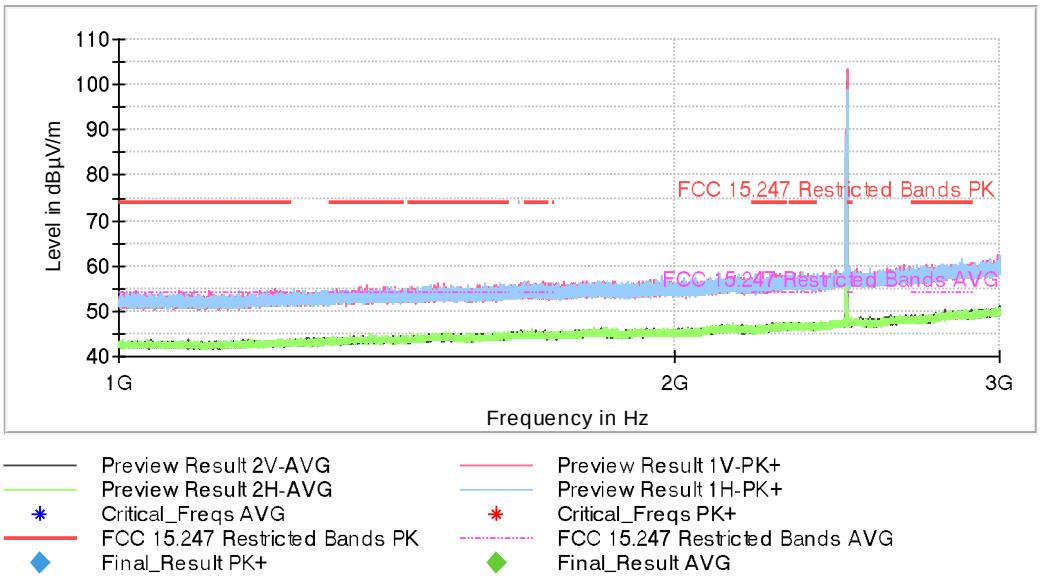
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

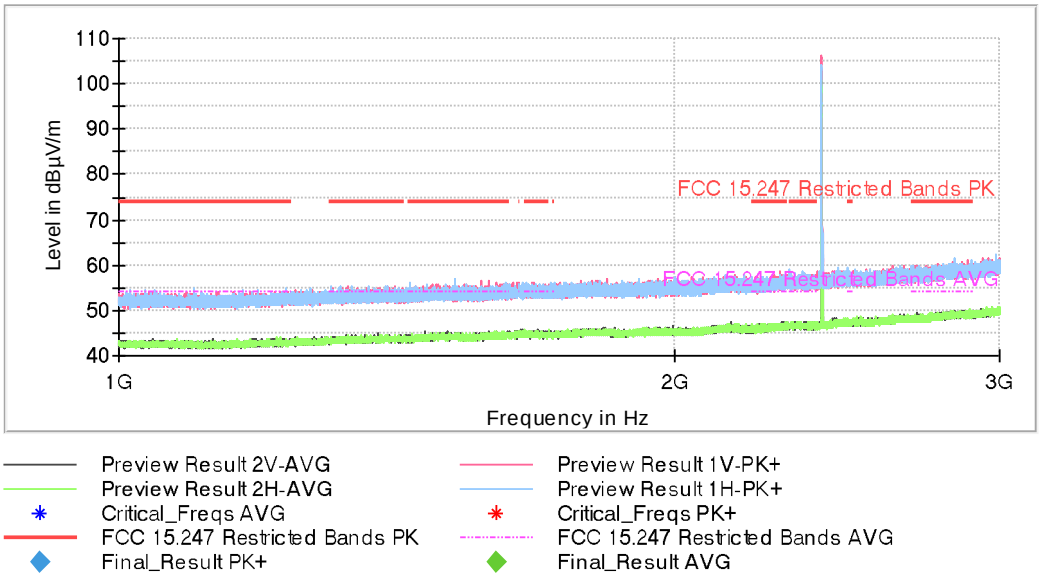
- High Channel:



The peak above the limit is the carrier frequency.

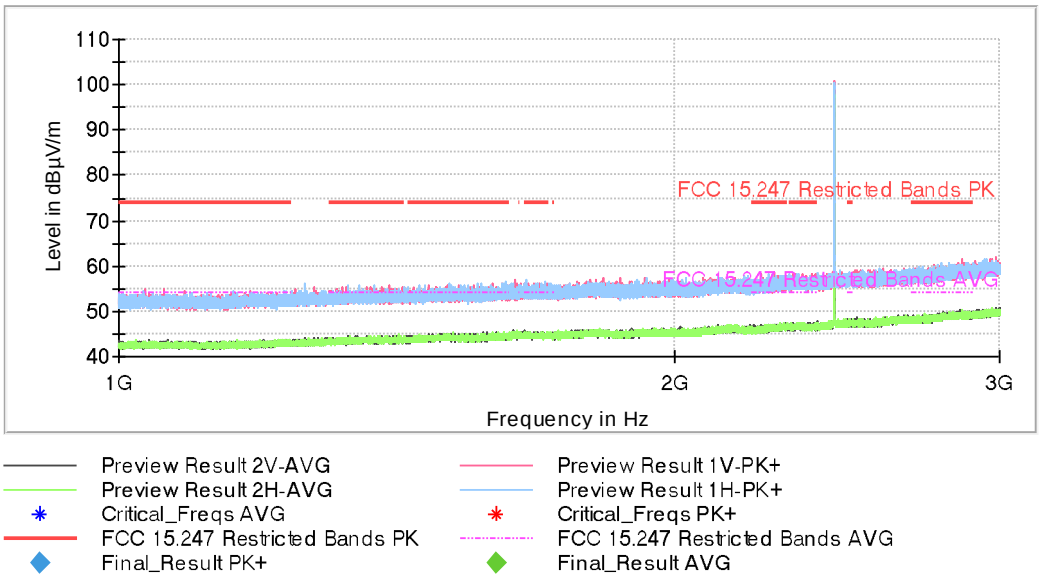
- **8-DPSK modulation (3DH5)**

- Low Channel:



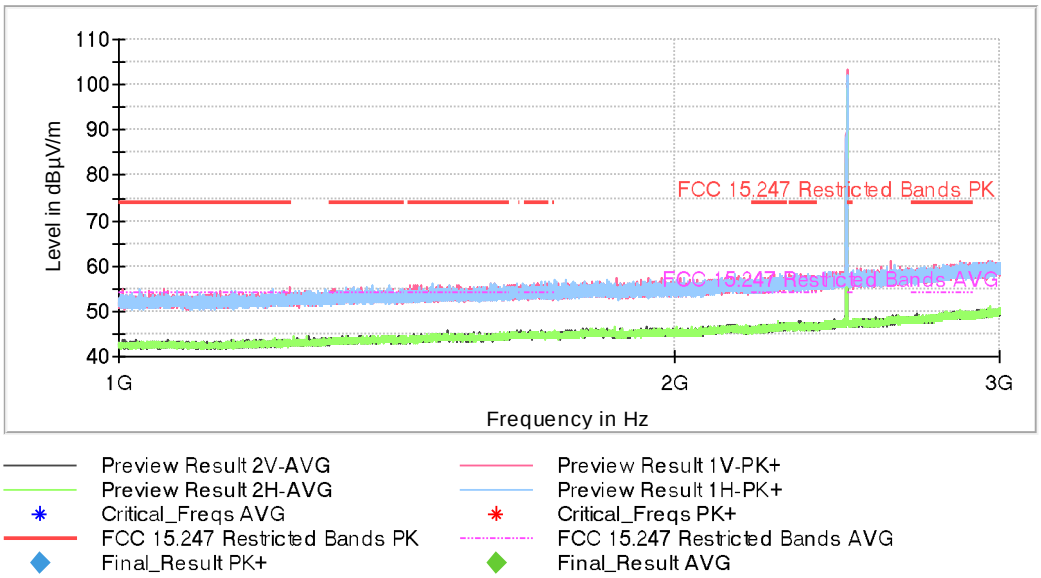
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

- High Channel:

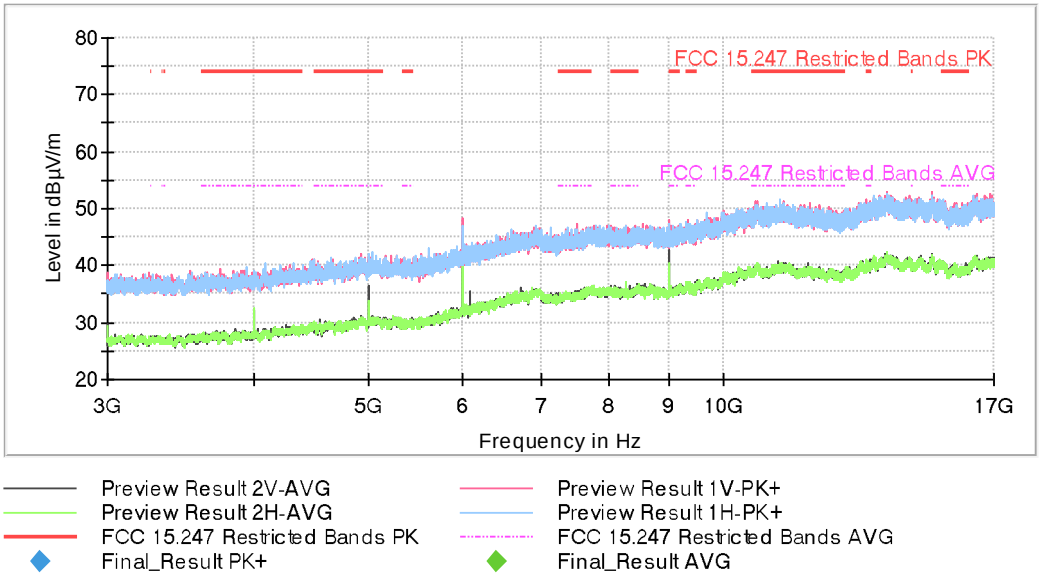


The peak above the limit is the carrier frequency.

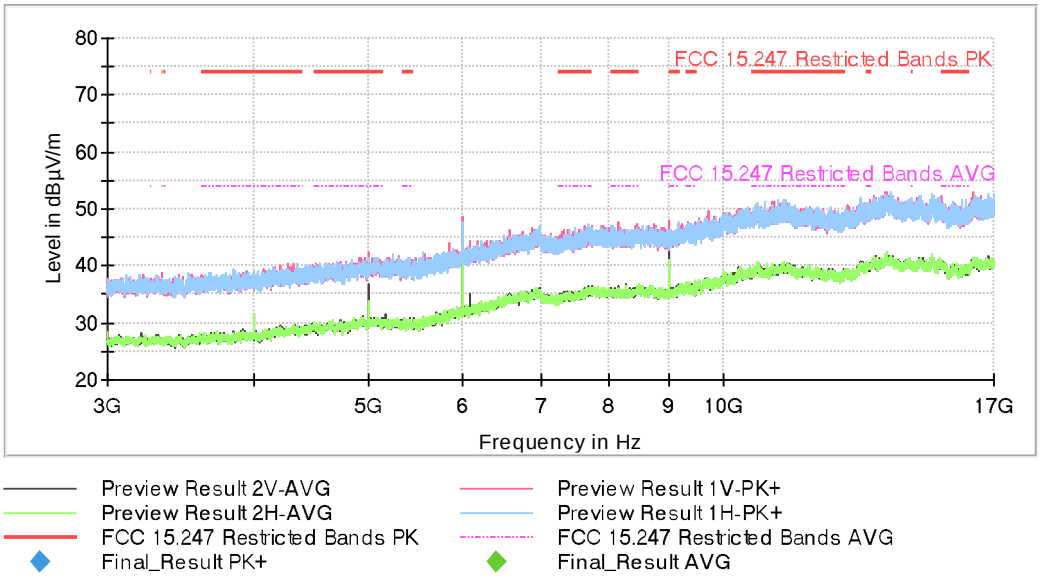
FREQUENCY RANGE 3 - 17 GHz:

- **GFSK modulation (DH5)**

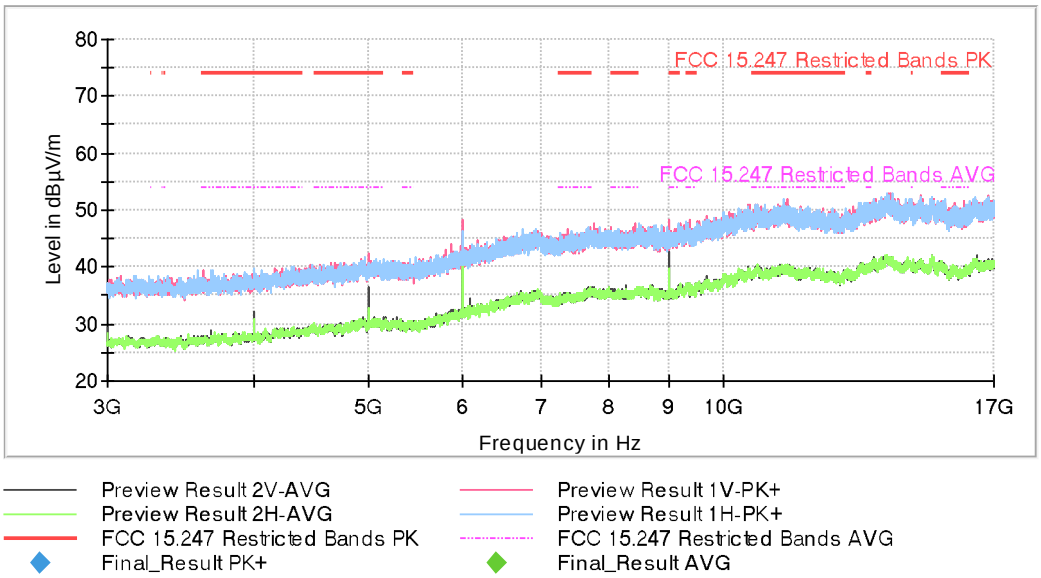
- Low Channel:



- Middle Channel:

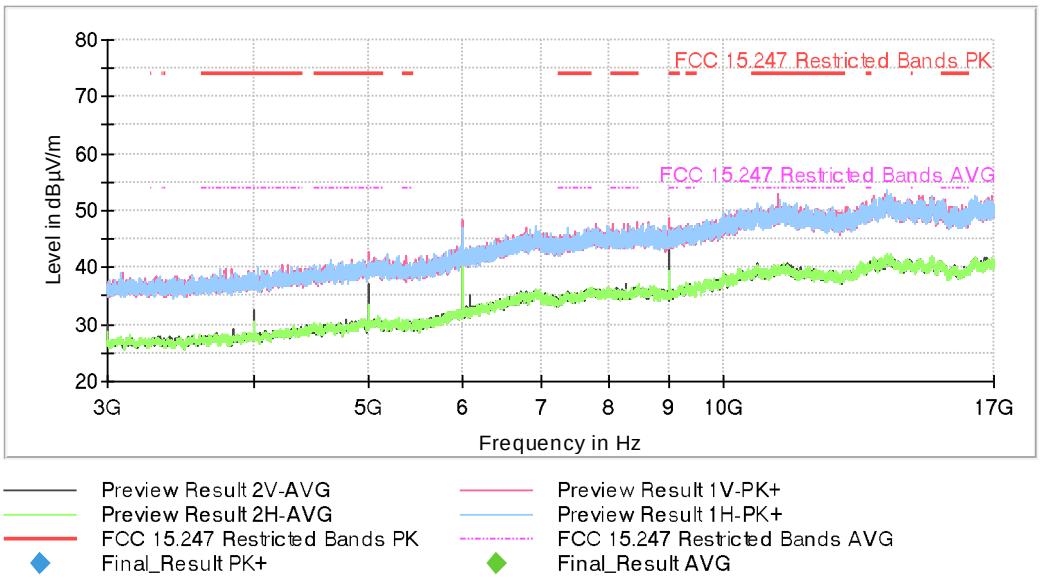


- High Channel:

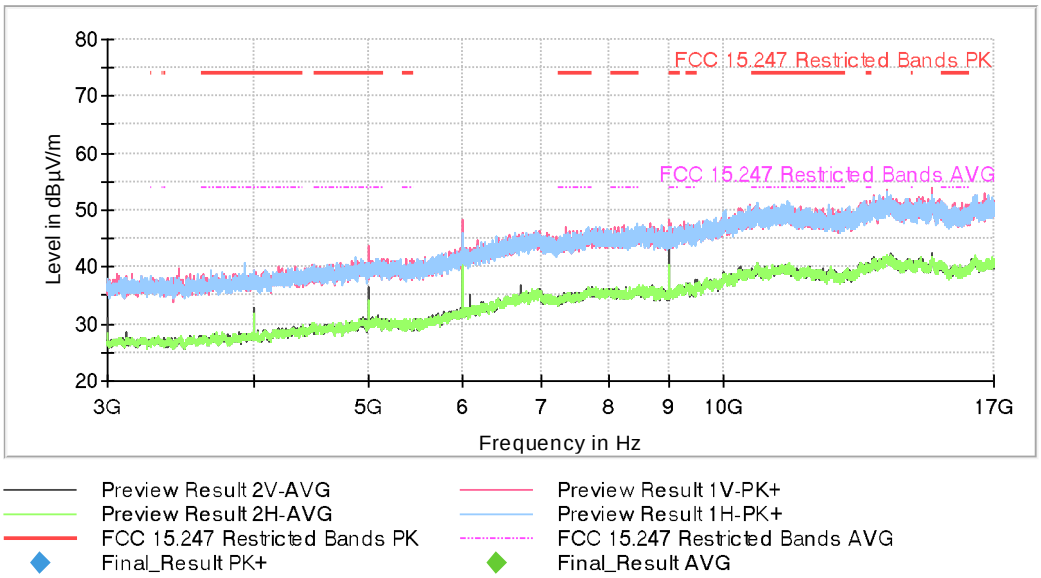


- **Pi/4-DQPSK modulation (2DH5)**

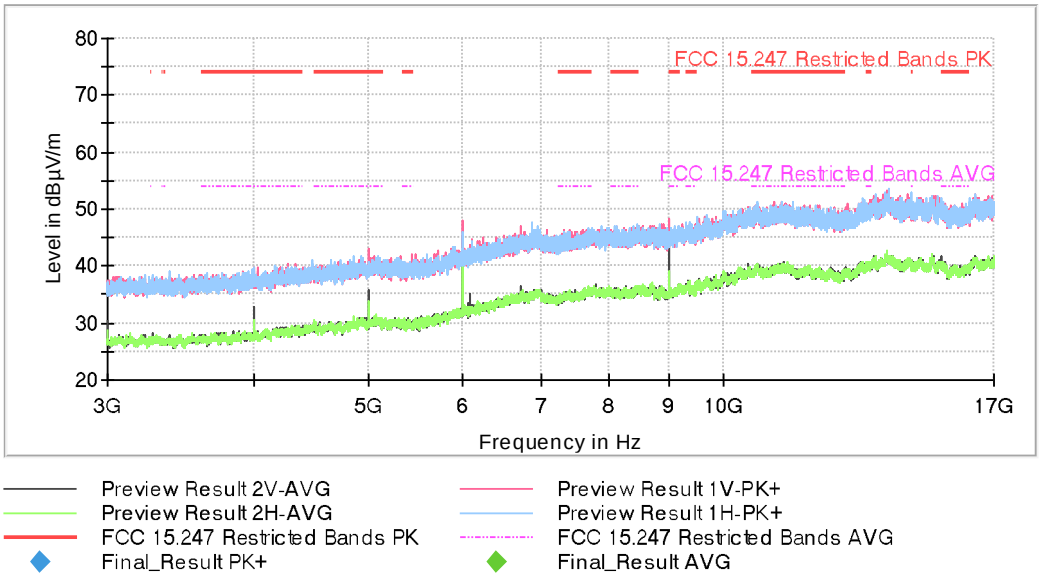
  - Low Channel:



- Middle Channel:

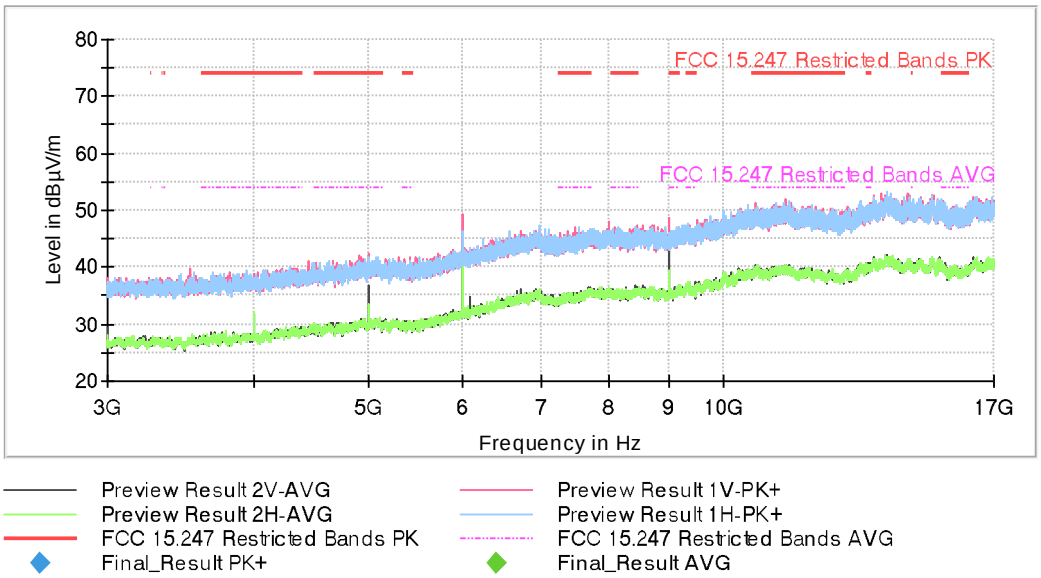


- High Channel:

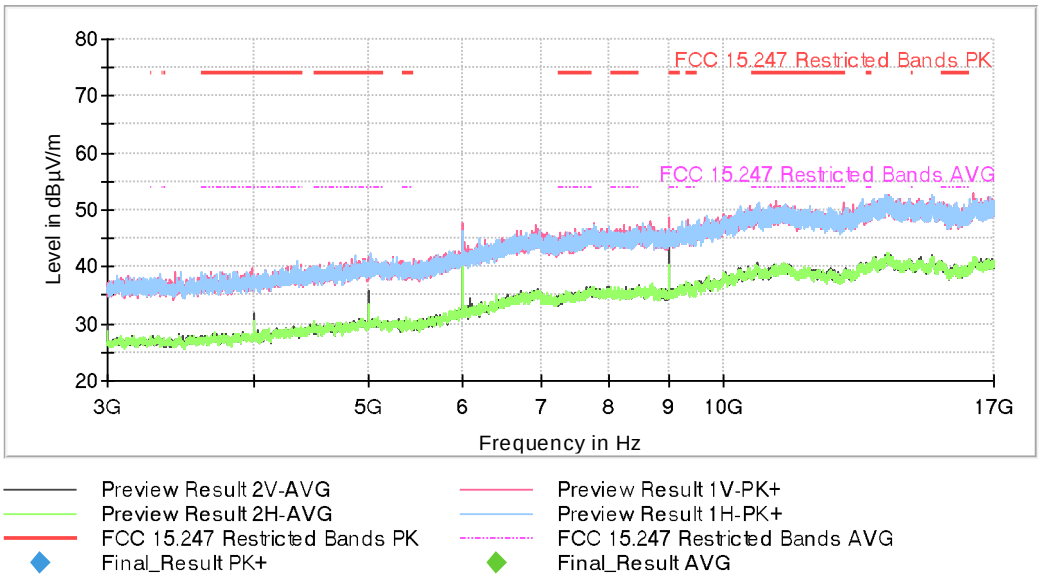


- **8-DPSK modulation (3DH5)**

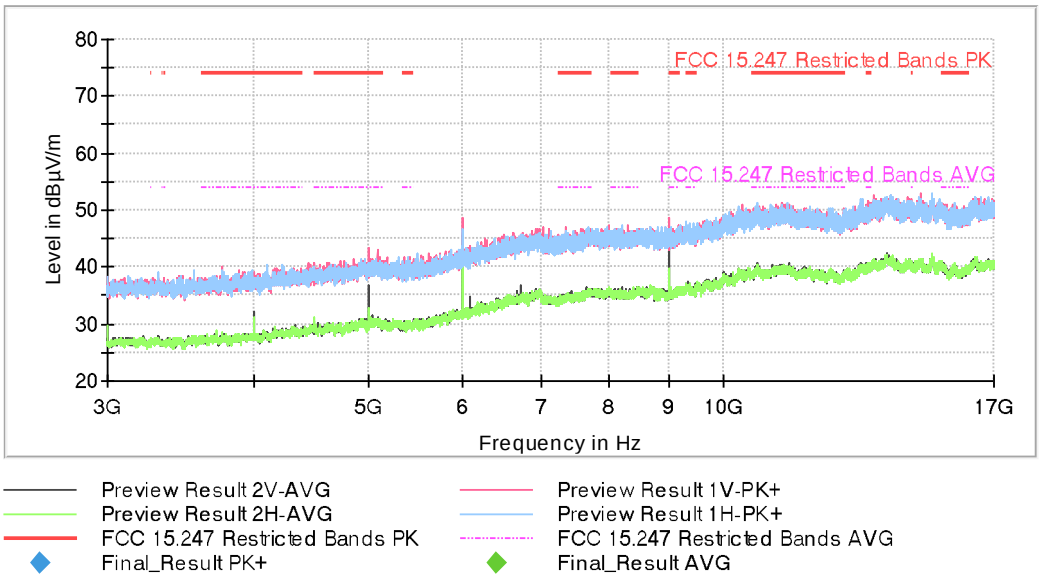
  - Low Channel:



  - Middle Channel:

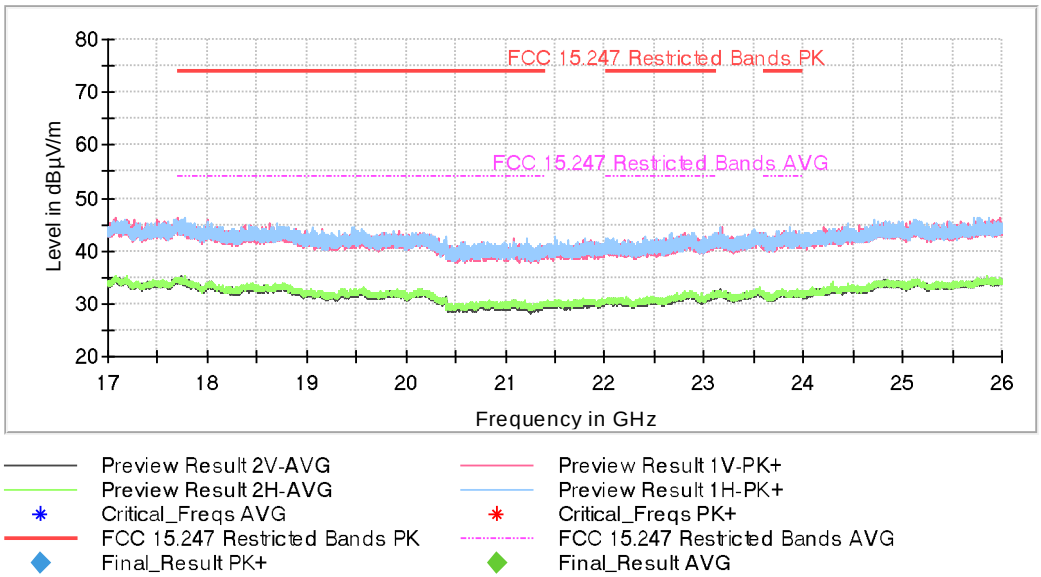


- High Channel:



FREQUENCY RANGE 17 - 26 GHz:

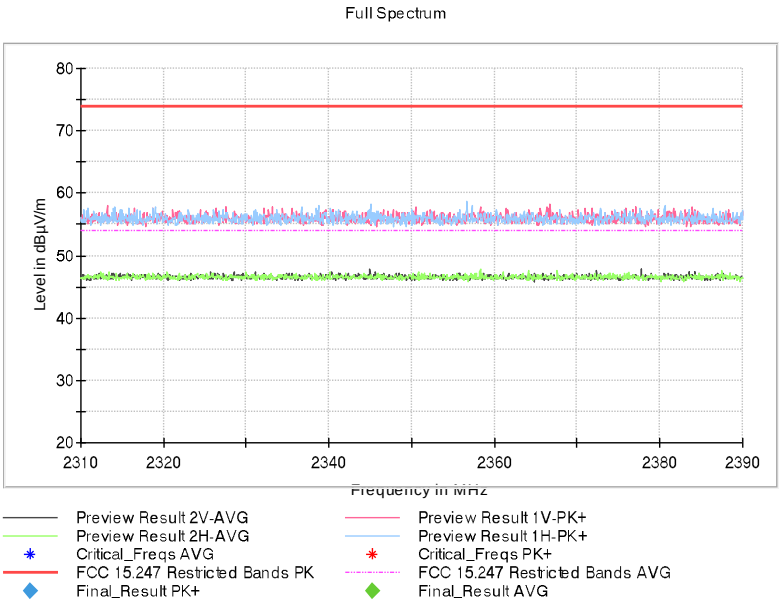
This plot is valid for the Low, Middle and High Channels and all the modulation modes.



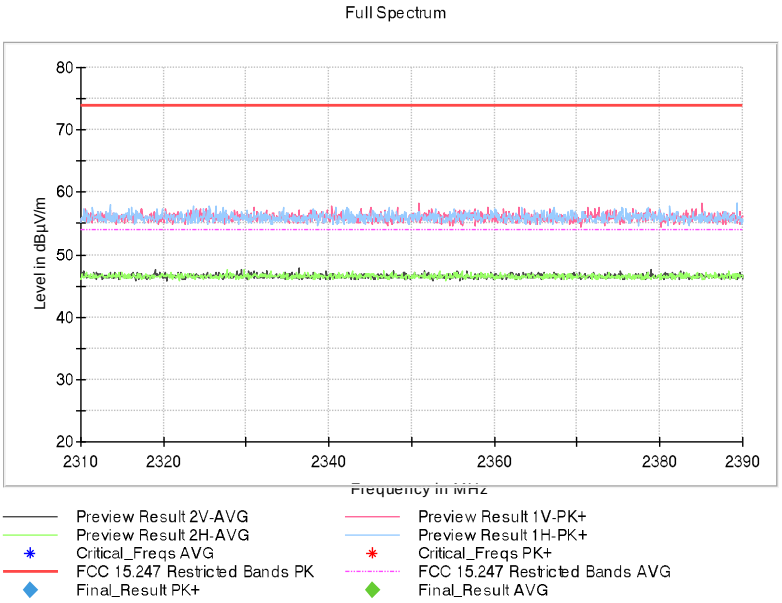
FREQUENCY RANGE 2.31-2.39 GHz:

- **GFSK modulation (DH5)**

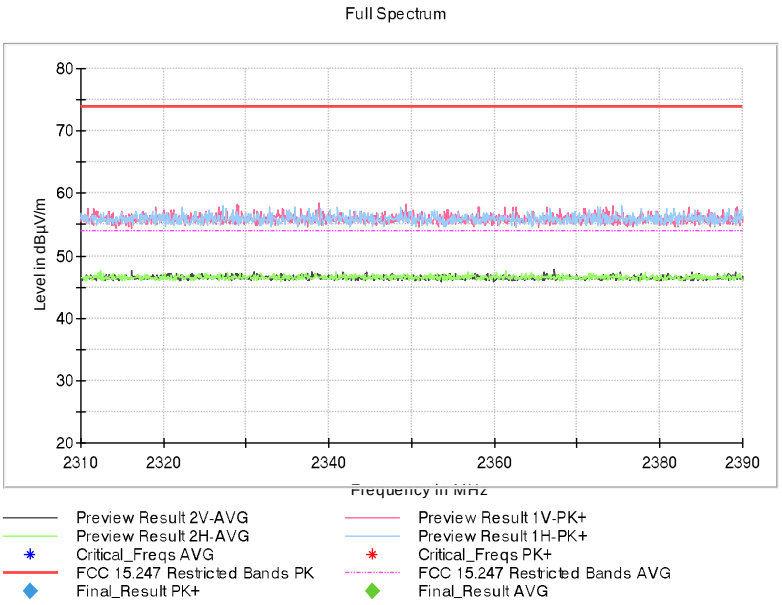
- Low Channel:



- Middle Channel:

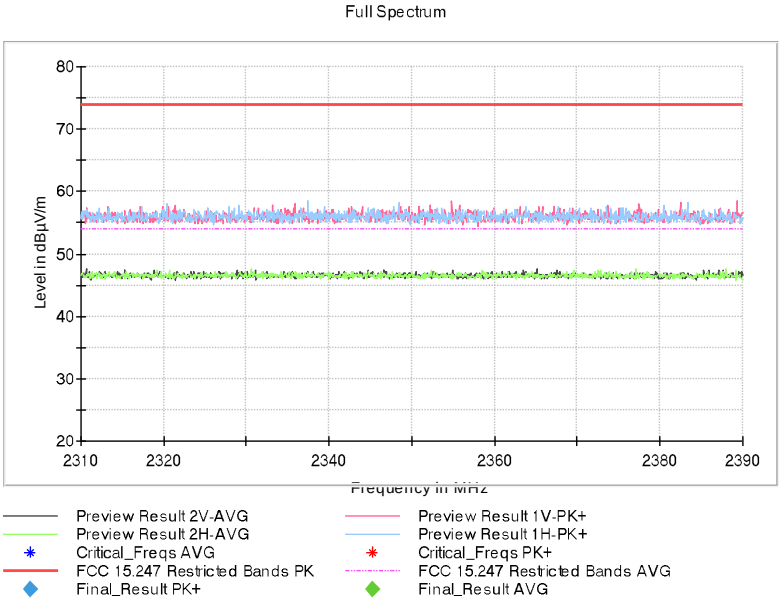


- High Channel:

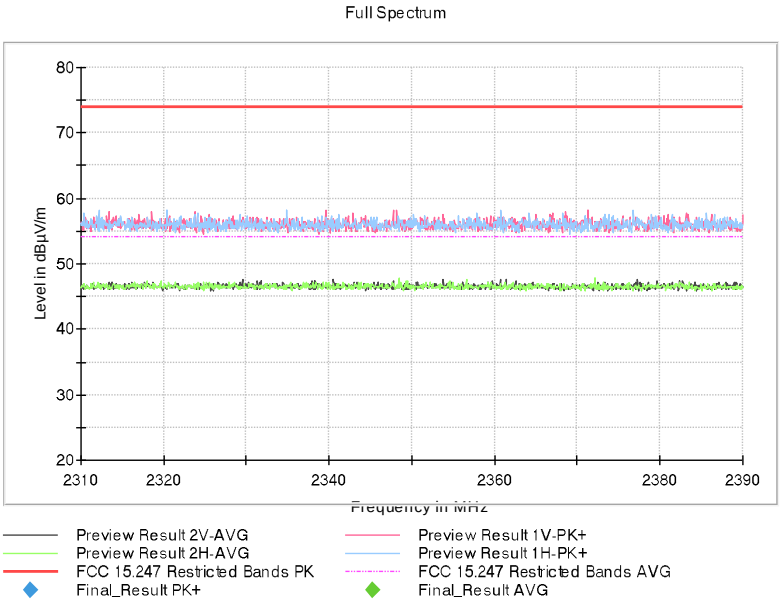


- **Pi/4-DQPSK modulation (2DH5)**

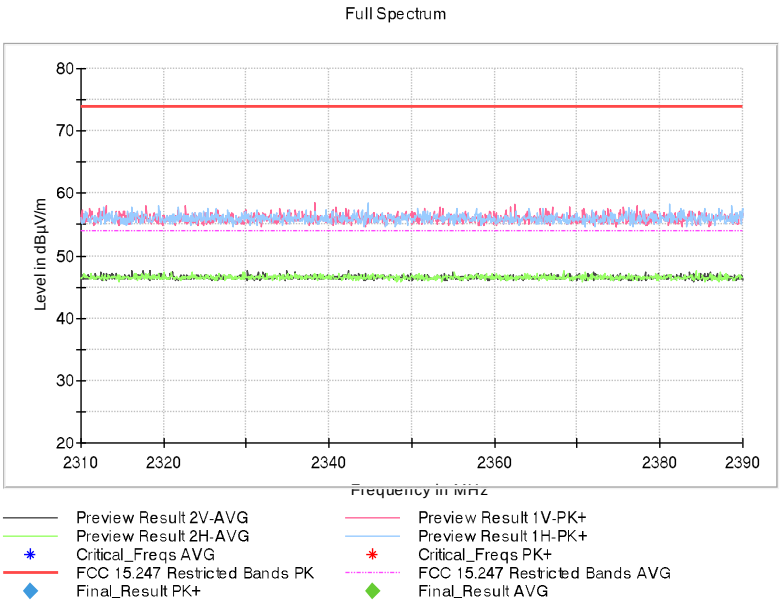
  - Low Channel:



  - Middle Channel:

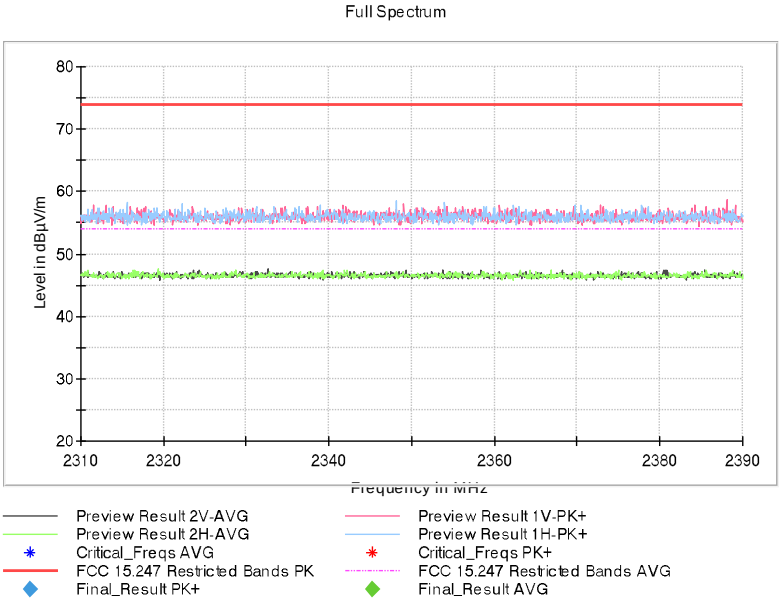


- High Channel:



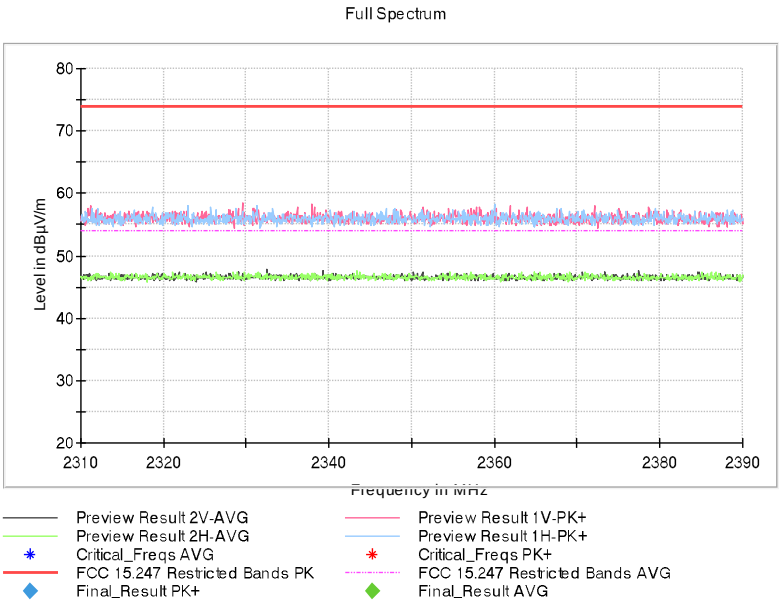
- **8-DPSK modulation (3DH5)**

  - Low Channel:



  - Middle Channel:

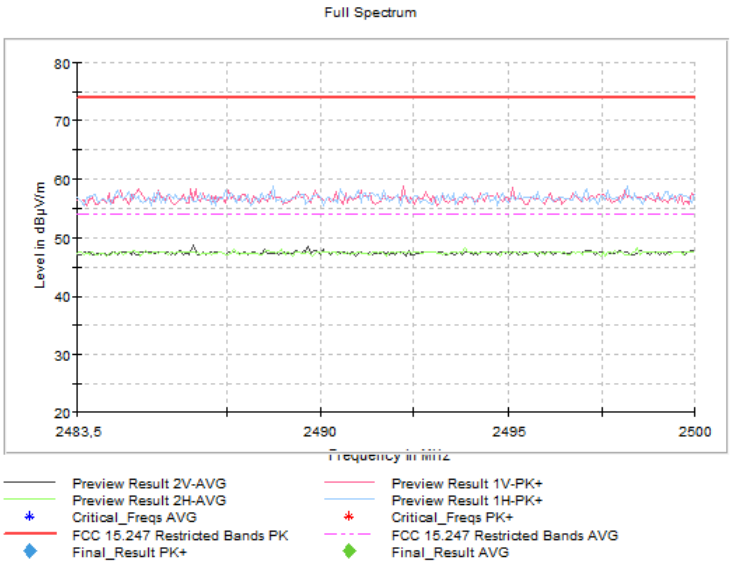
- High Channel:



FREQUENCY RANGE 2.4835-2.5 GHz:

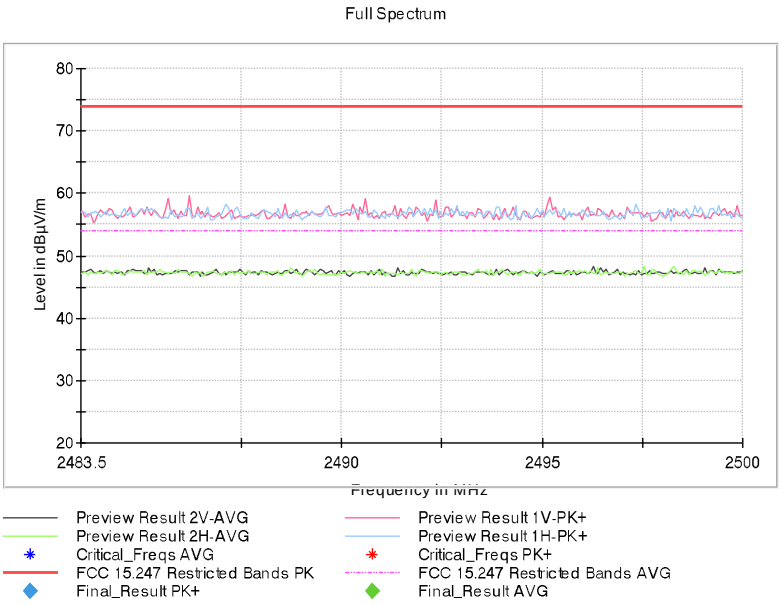
- **GFSK modulation (DH5)**

- Low Channel:



- Middle Channel:

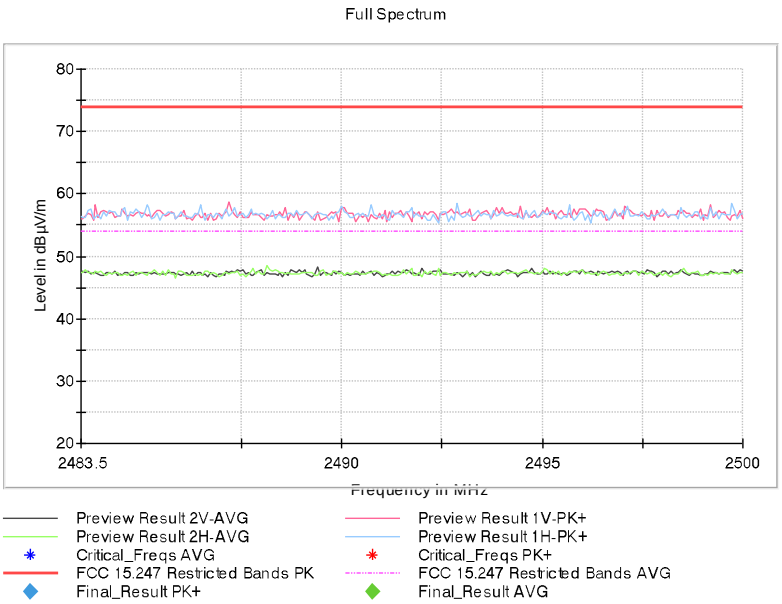
- High Channel:



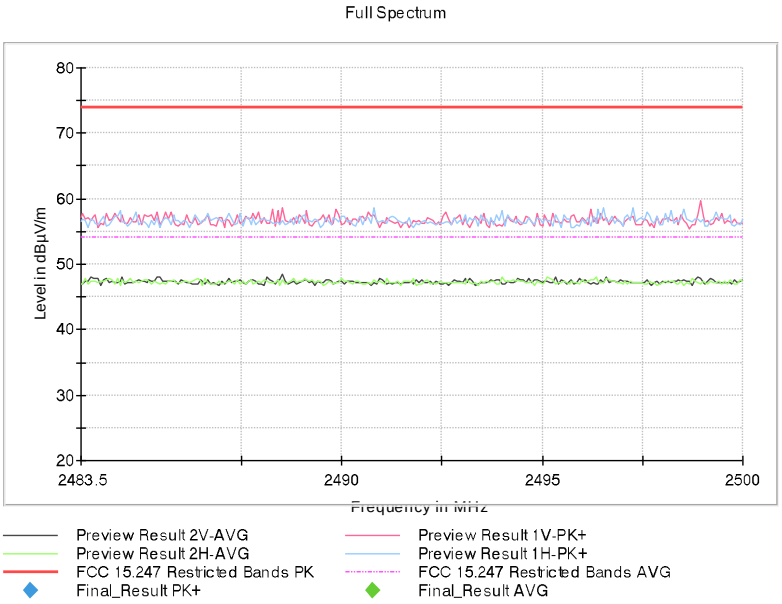
FREQUENCY RANGE 2.4835-2.5 GHz:

- **Pi/4-DQPSK modulation (2DH5)**

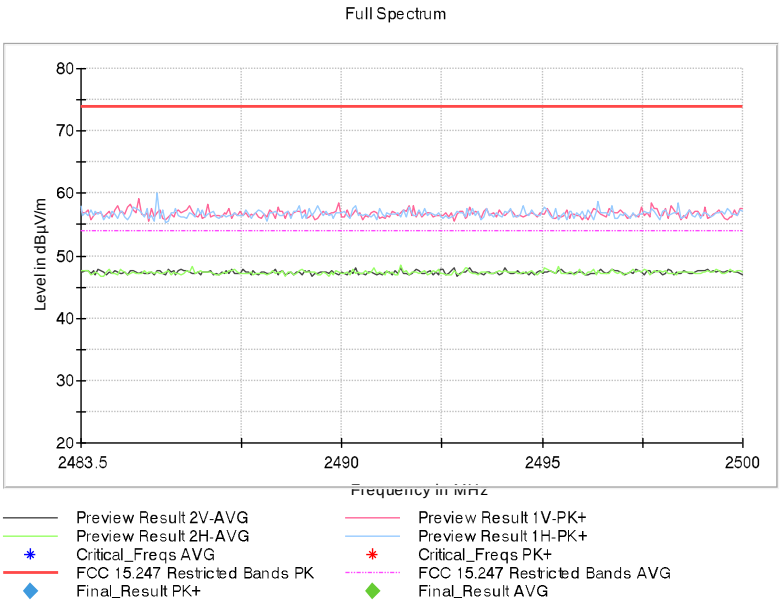
- Low Channel:



- Middle Channel:



- High Channel:



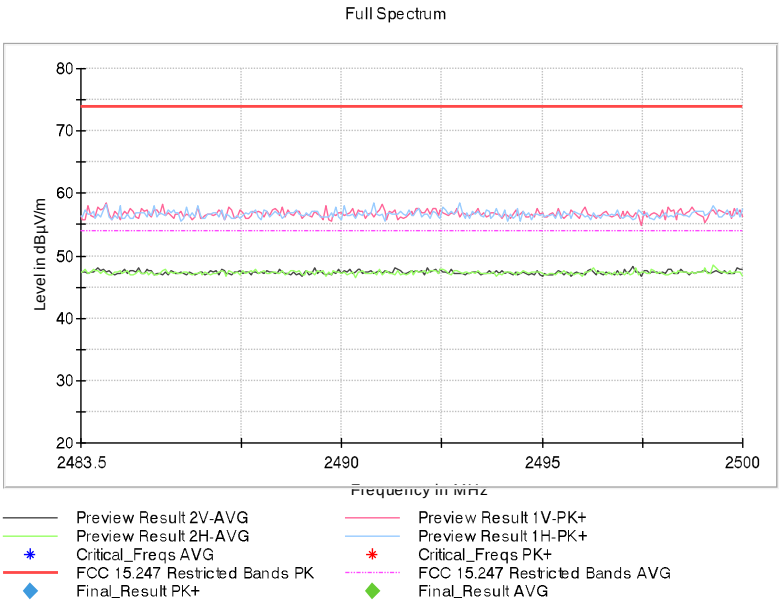
FREQUENCY RANGE 2.4835-2.5 GHz:

- **8-DPSK modulation (3DH5)**

- Low Channel:

- Middle Channel:

- High Channel:



Appendix B: Test results. 802.11 bgn20 1x1

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TEST CONDITIONS

POWER SUPPLY (V):

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

ANTENNA:

Type of Antenna:	External.
Maximum Declared Antenna Gain:	-6.2 dBi

TEST FREQUENCIES FOR 802.11 bgn20:

Low Channel (1):	2412 MHz
Middle Channel (6):	2437 MHz
High Channel (11):	2462 MHz

The sample was used to configure the EUT to continuously transmit at a specified output power in all channels with different modes and modulation schemes.

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.

The EUT has four separate antennas which correspond to one port of the equipment.

The data rates of 1 Mbps for 802.11 b, 6.5 Mbps for 802.11 g, MCS0 for 802.11 n20 were selected based on preliminary testing that identified those rates corresponding to the worst cases for output power and band edge levels at restricted bands.

CONDUCTED MEASUREMENTS:

The equipment under test was set up in a shielded room and it is connected to the TS8997 system 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 1 GHz-18 GHz Double ridge horn antenna is situated at a distance of 3 m and a distance of 1m for the frequency range 17 GHz-26 GHz (18 GHz-40 GHz horn antenna).

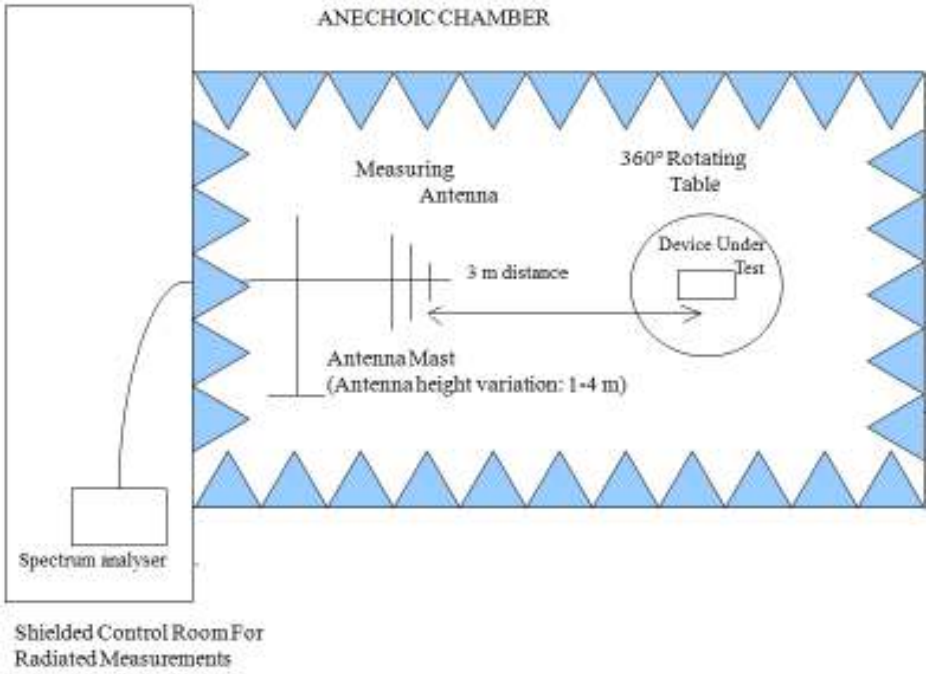
For radiated emissions in the range 17 GHz-26 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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.

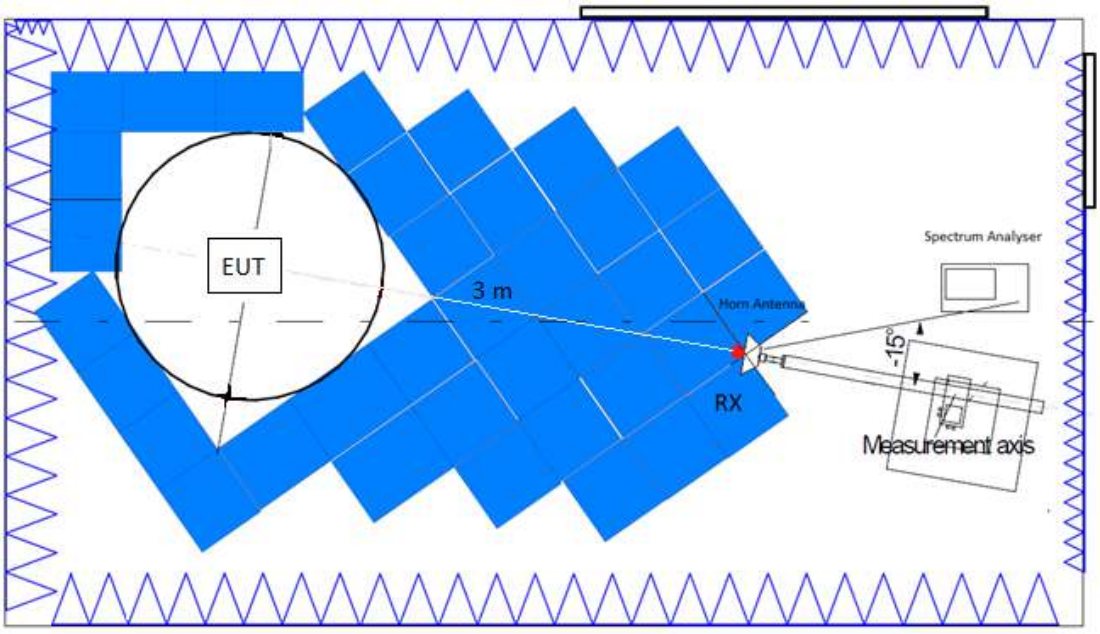
Measurements were made in both horizontal and vertical planes of polarization.

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

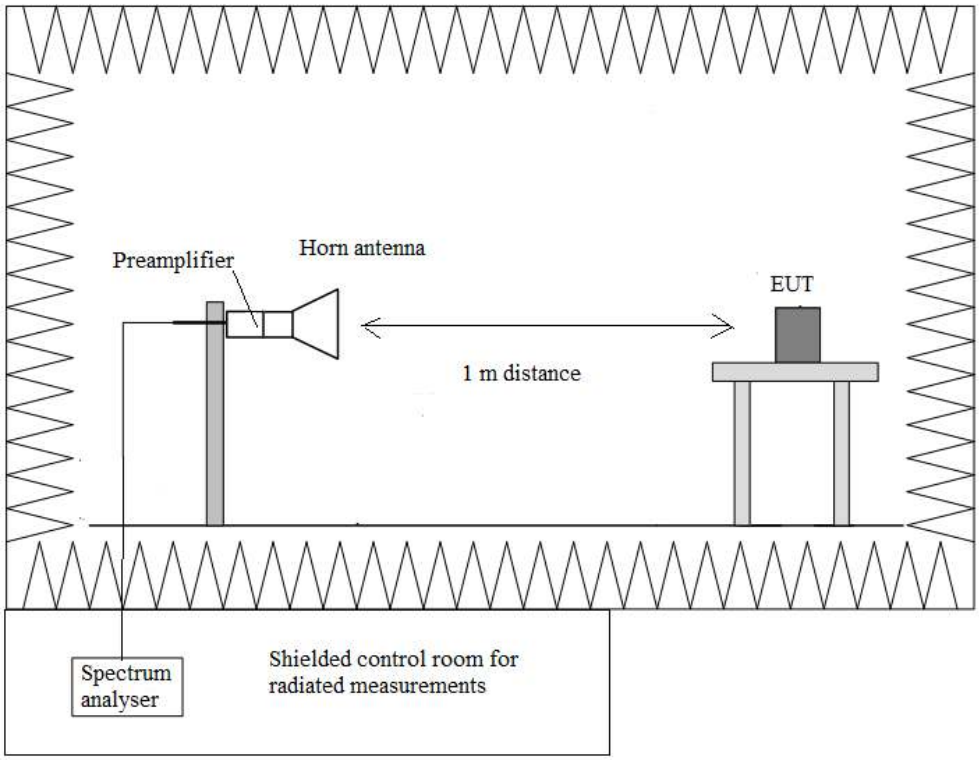
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup f > 17 GHz:



Occupied Bandwidth

RESULTS:

- **Mode 802.11 b:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% Bandwidth (MHz)	10.900000	10.800000	11.000000
Measurement uncertainty (kHz)	<± 35.41		

- **Mode 802.11 g:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% Bandwidth (MHz)	16.600000	16.600000	16.600000
Measurement uncertainty (kHz)	<± 35.41		

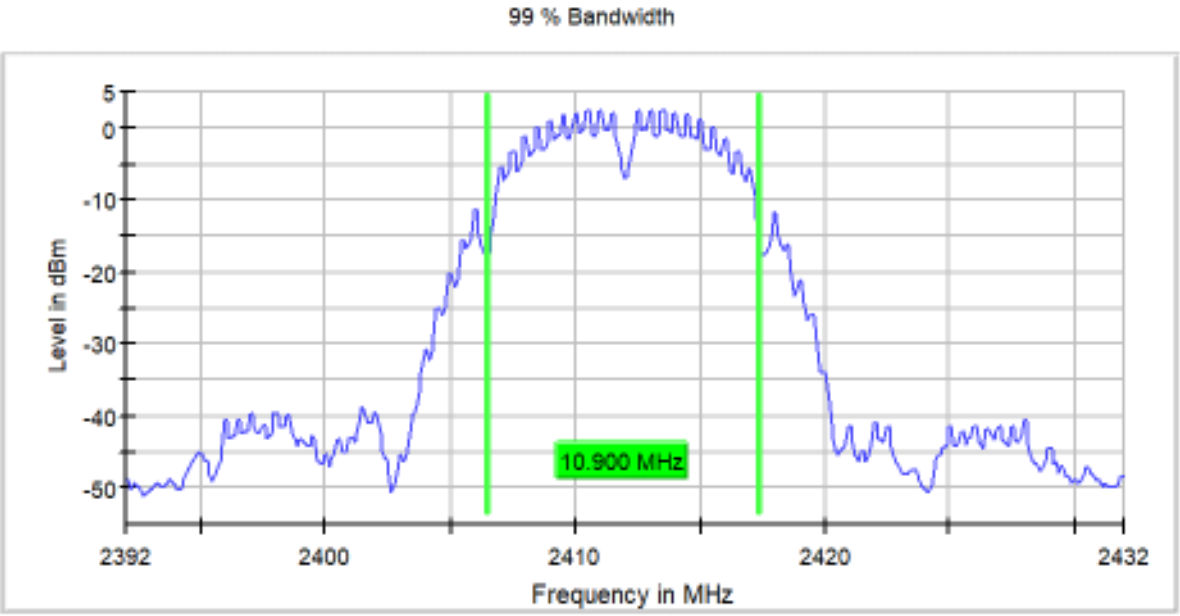
- **Mode 802.11 n20:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% Bandwidth (MHz)	17.700000	17.800000	17.800000
Measurement uncertainty (kHz)	<± 35.41		

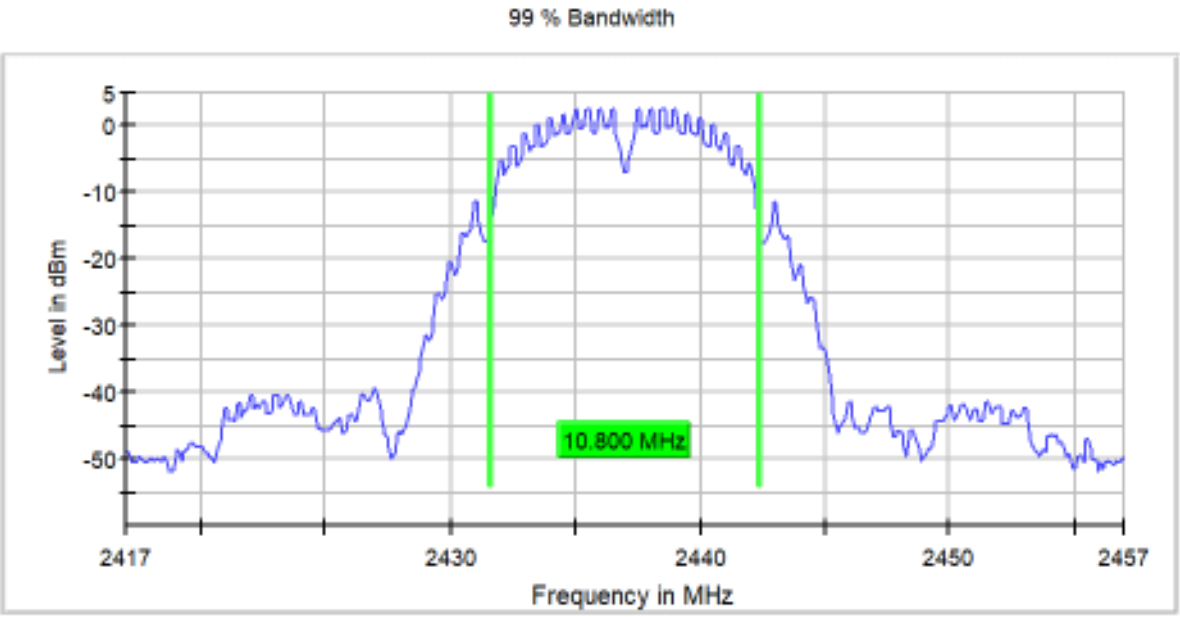
Verdict: PASS

- **Mode 802.11 b – Occupied Bandwidth:**

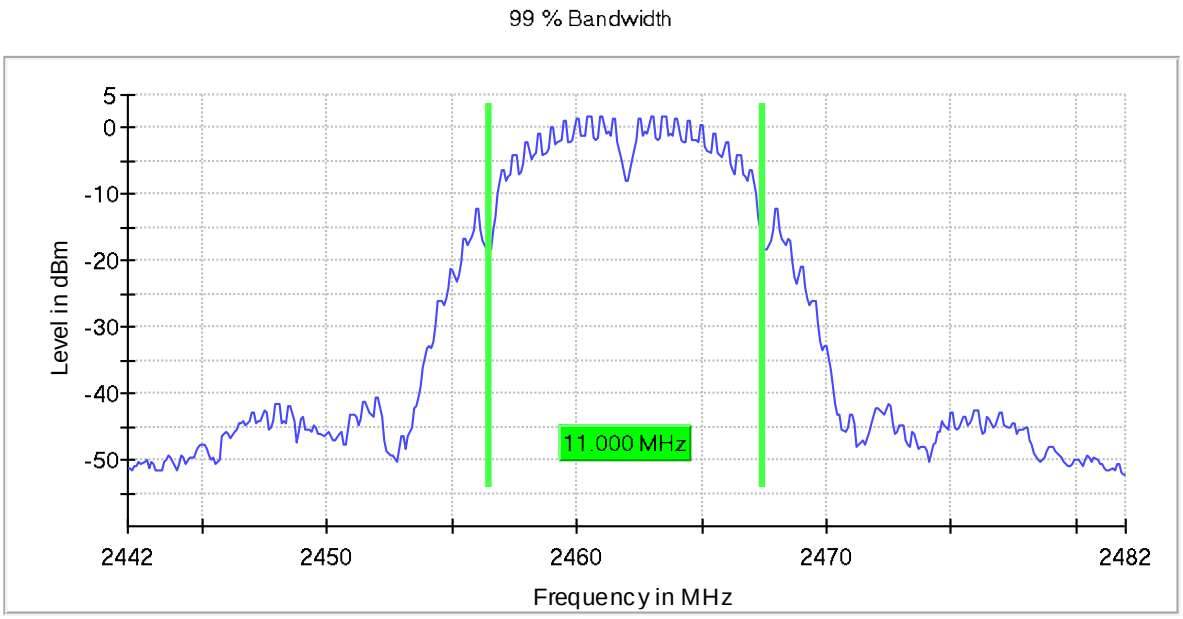
- Low Channel:



- Middle Channel:

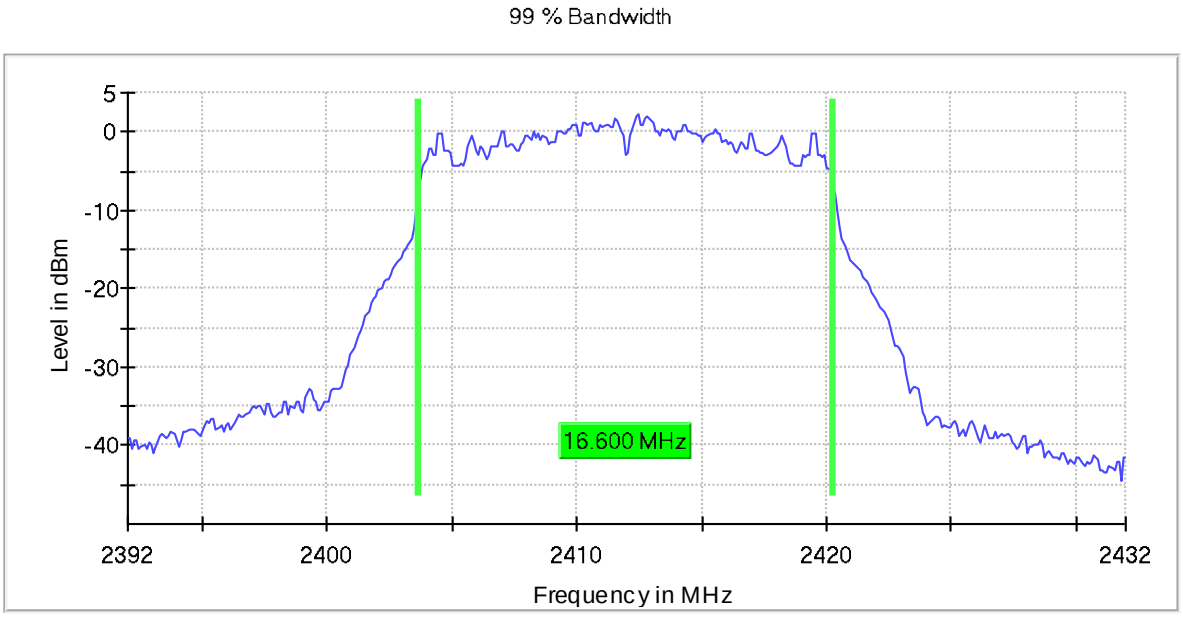


- High Channel:

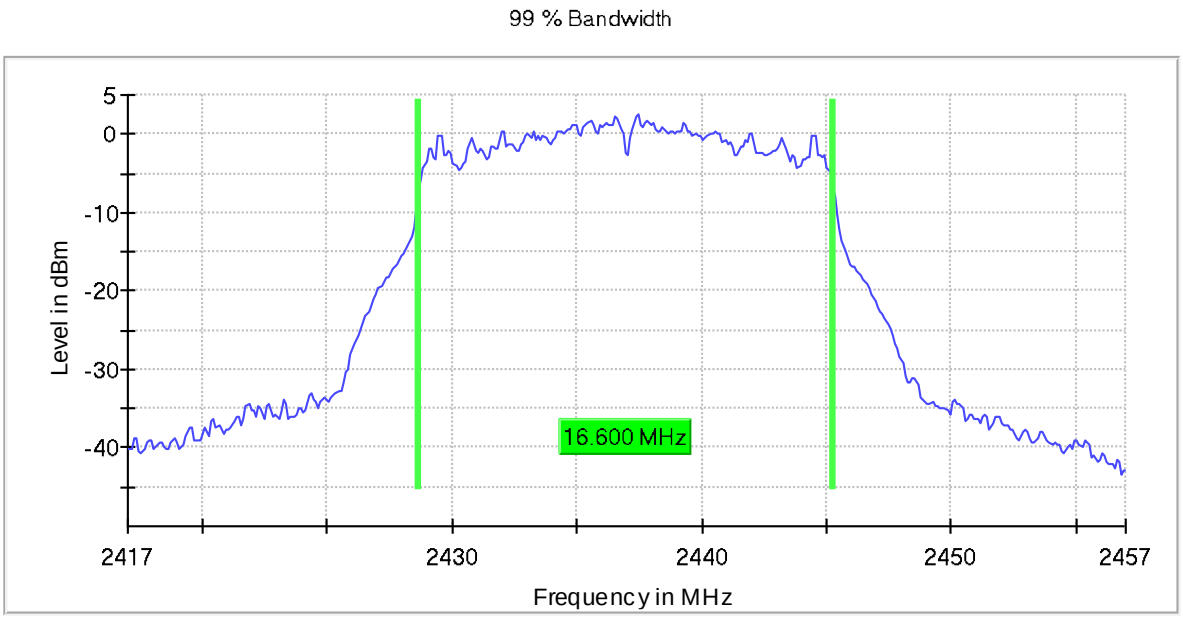


- **Mode 802.11 g – Occupied Bandwidth:**

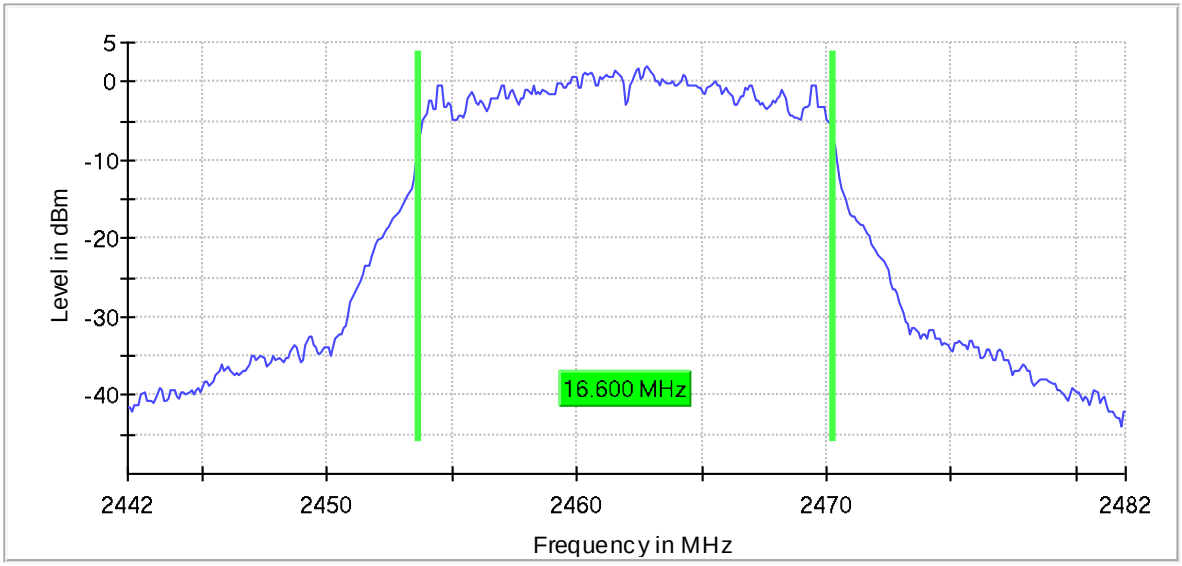
- Low Channel:



- Middle Channel:

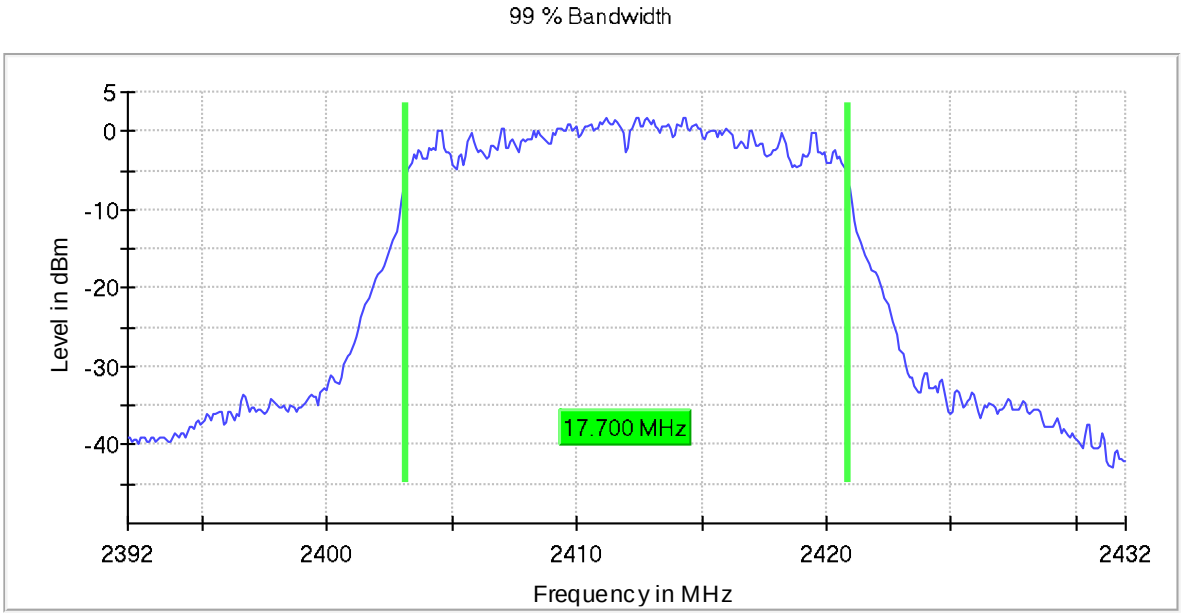


- High Channel:

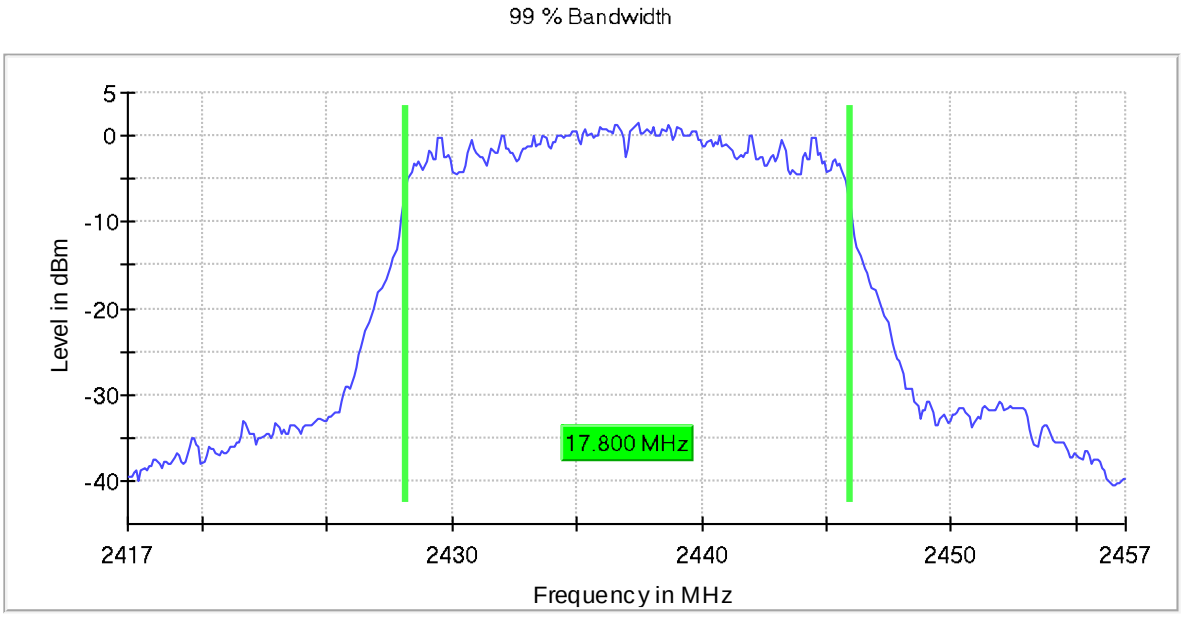


- **Mode 802.11 n20 – Occupied Bandwidth:**

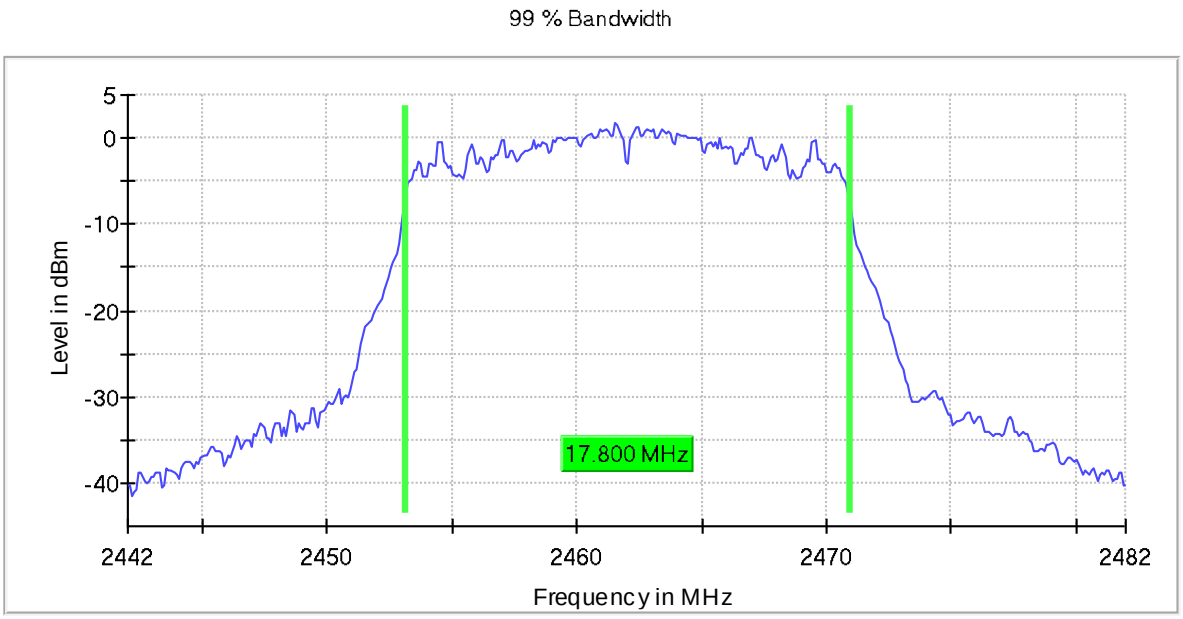
- Low Channel:



- 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:

- **Mode 802.11 b:**

	Low Channel	Middle Channel	High Channel
6 dB Spectrum Bandwidth (MHz)	9.150000	9.150000	9.150000
Measurement uncertainty (kHz)	<± 35.41		

- **Mode 802.11 g:**

	Low Channel	Middle Channel	High Channel
6 dB Spectrum Bandwidth (MHz)	16.350000	16.350000	16.400000
Measurement uncertainty (kHz)	<± 35.41		

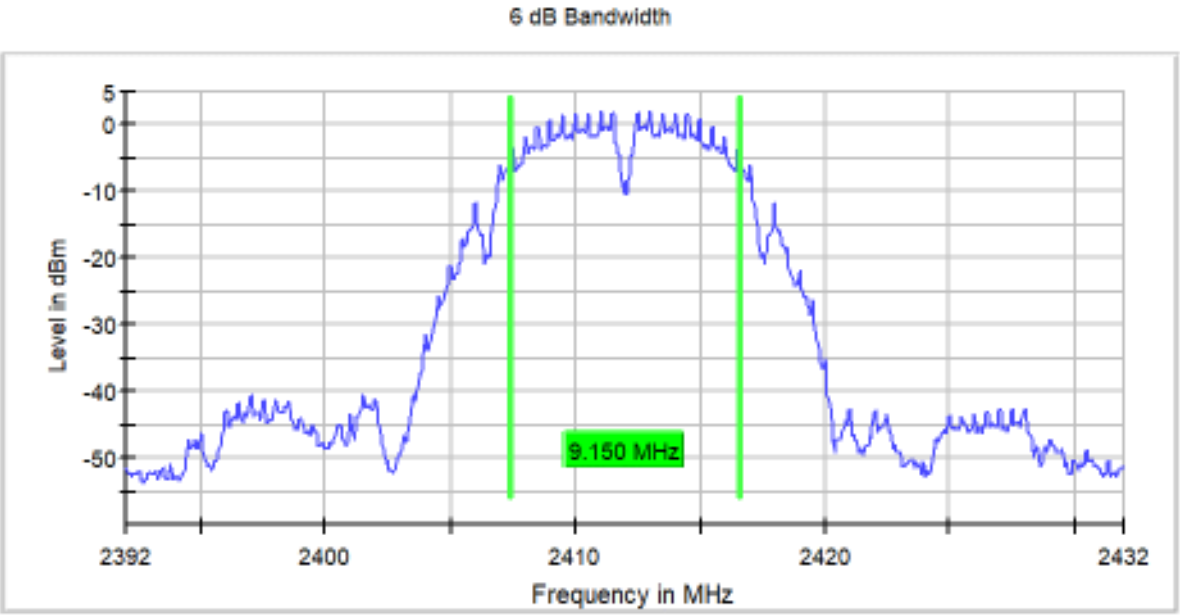
- **Mode 802.11 n20:**

	Low Channel	Middle Channel	High Channel
6 dB Spectrum Bandwidth (MHz)	17.650000	17.650000	17.500000
Measurement uncertainty (kHz)	<± 35.41		

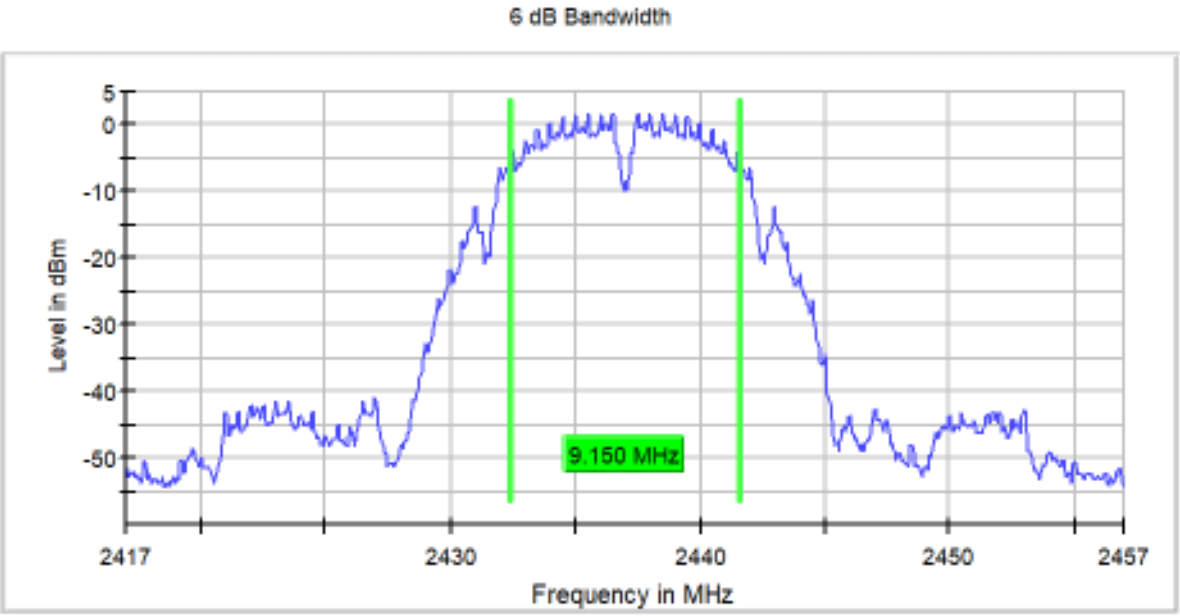
Verdict: PASS

- **Mode 802.11 b – 6 dB Bandwidth:**

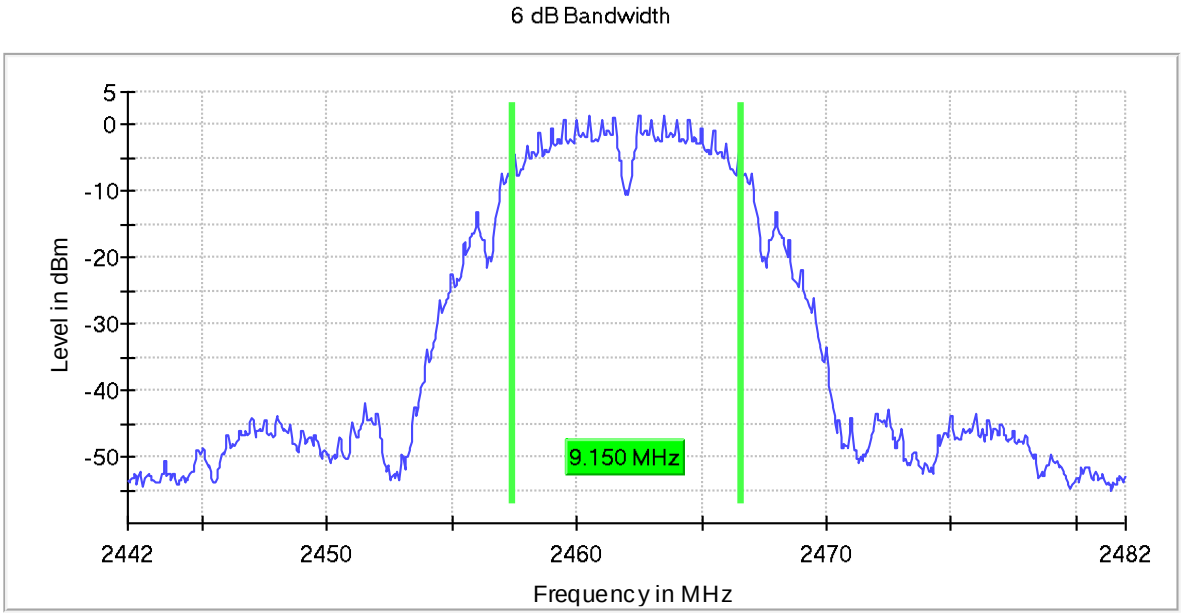
- Low Channel:



- Middle Channel:

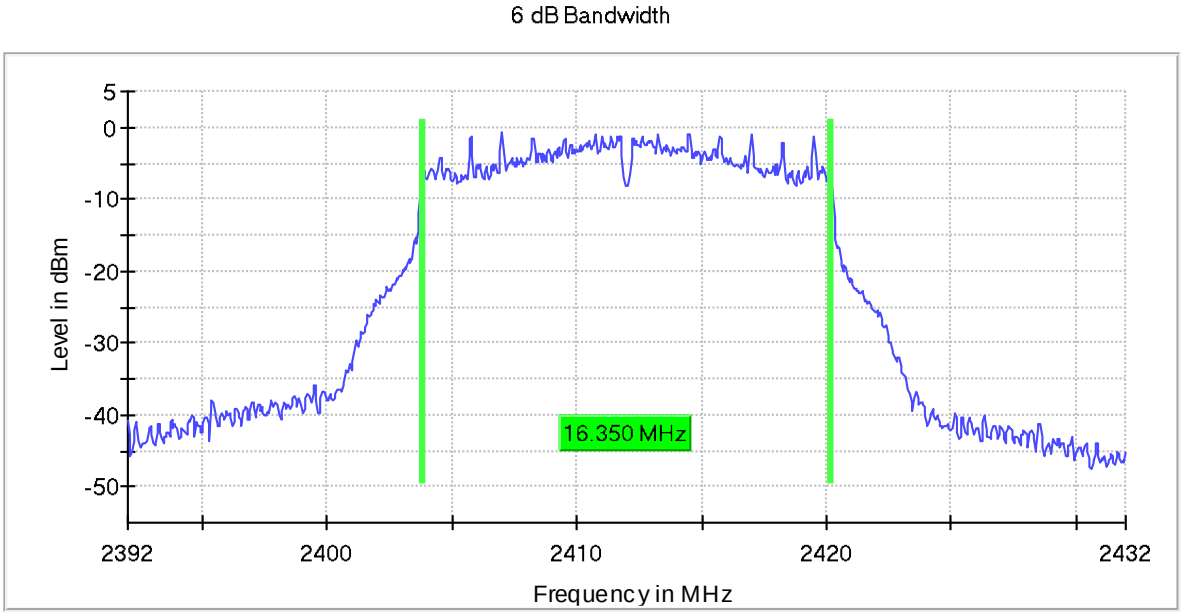


- High Channel:

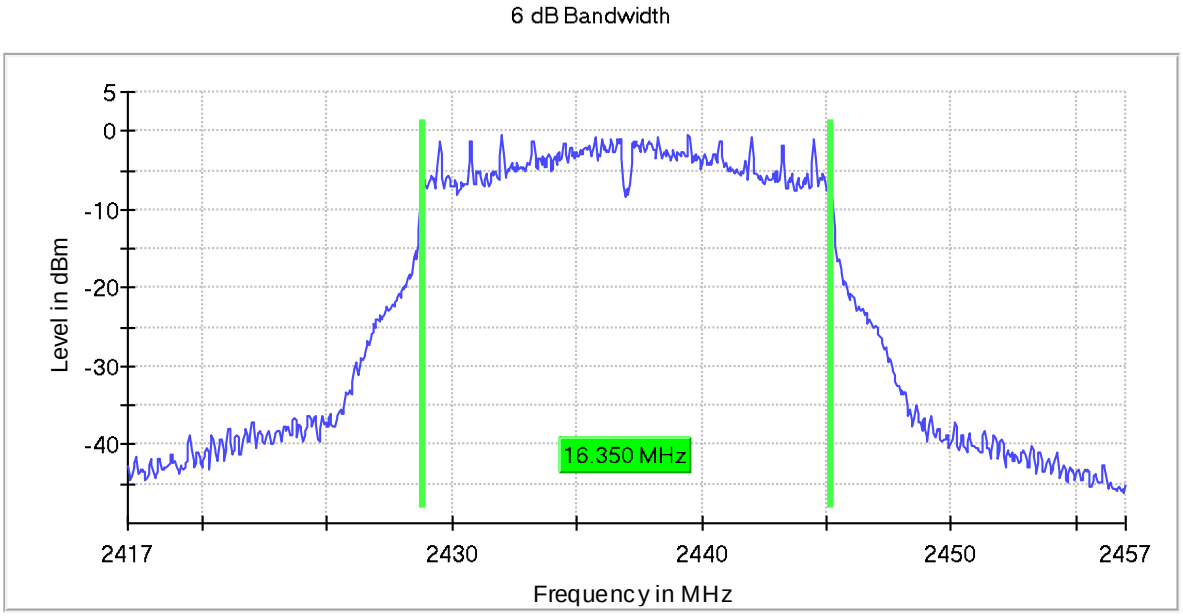


- **Mode 802.11 g – 6 dB Bandwidth:**

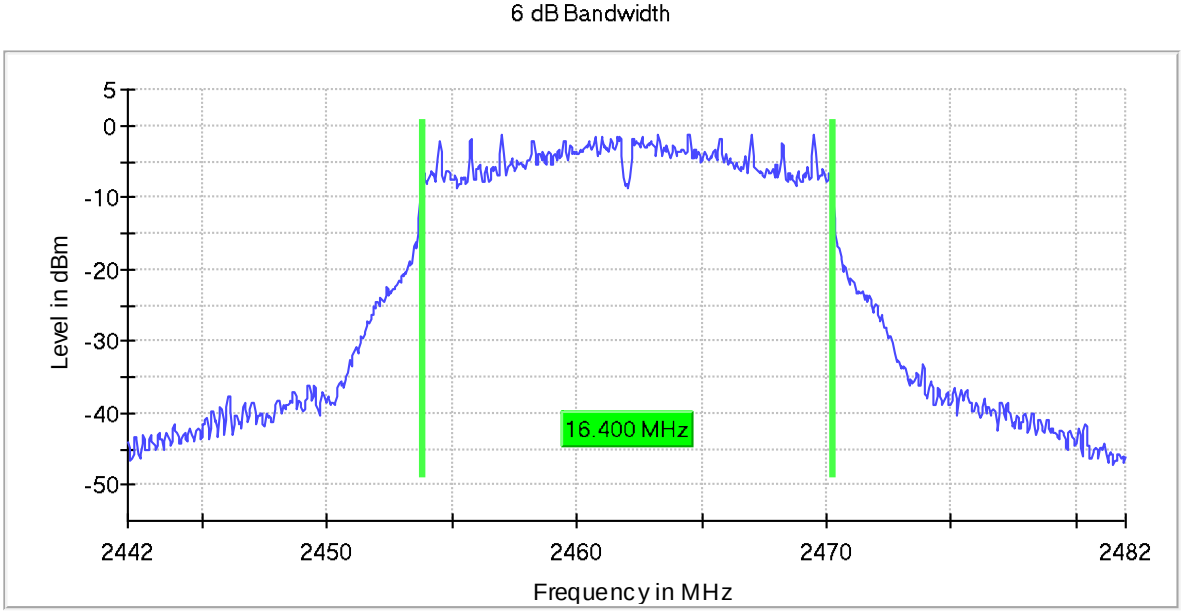
- Low Channel:



- Middle Channel:

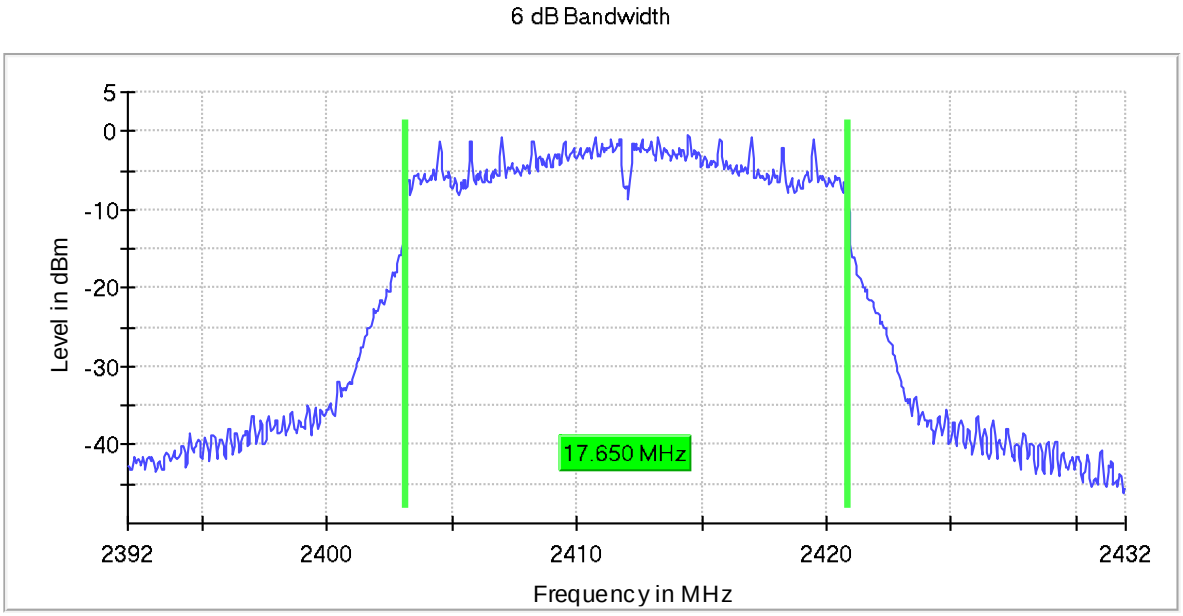


- High Channel:

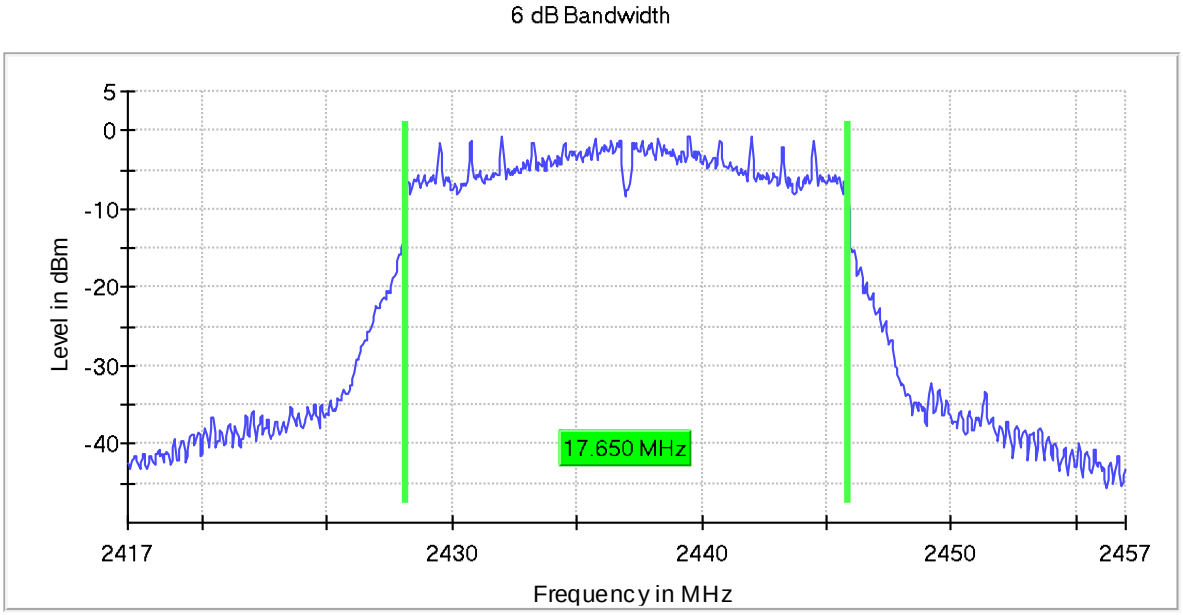


- **Mode 802.11 n20 – 6 dB Bandwidth:**

- Low Channel:

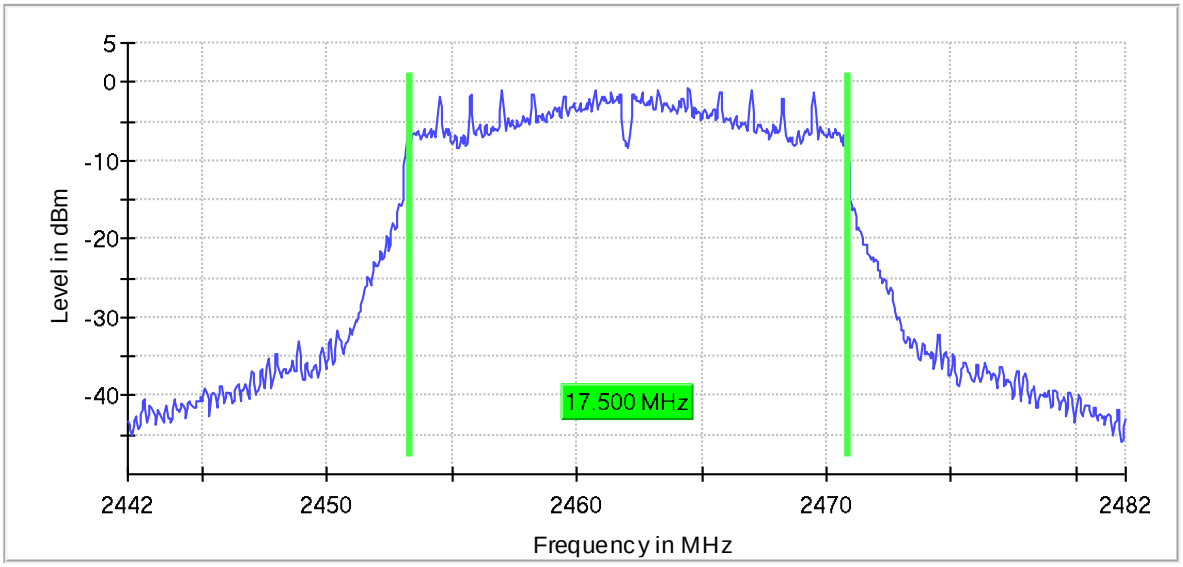


- Middle Channel:



- High Channel:

6 dB Bandwidth



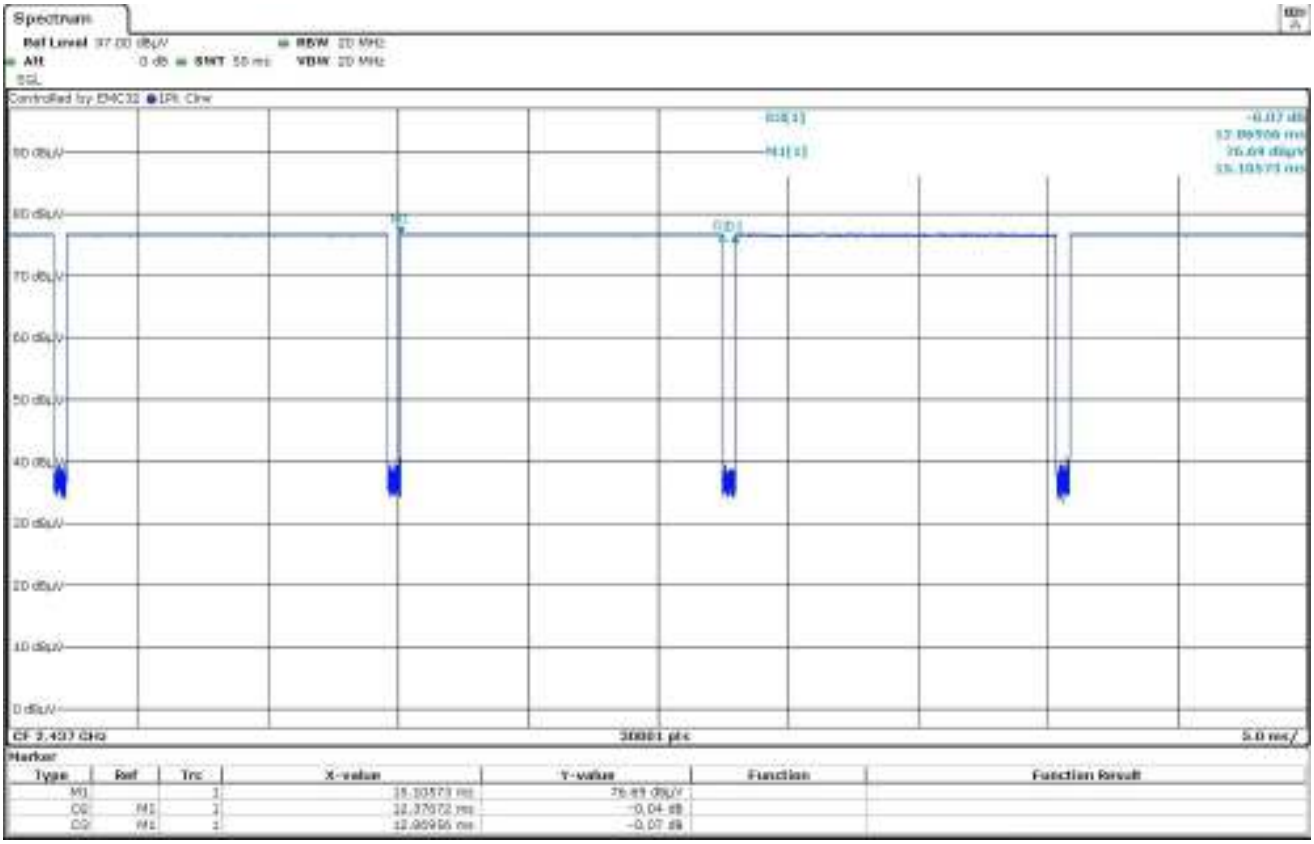
Transmitter Duty Cycle

RESULTS:

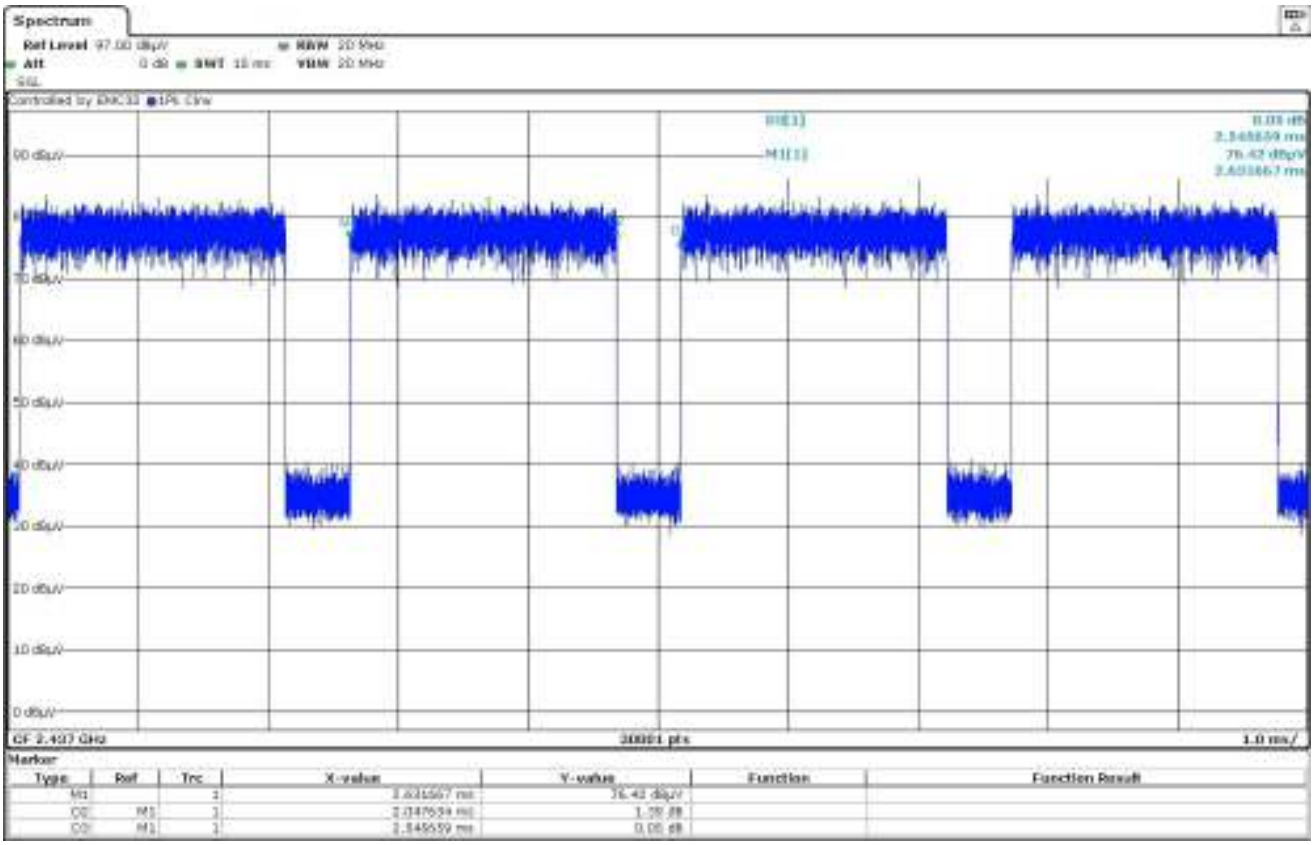
The results below are for data rates with a duty cycle less than 98%. The results for all rest of modes having a value > 98%.

Technique	Mode	Pulse Duration (ms)	Period (ms)	Duty Cycle Correction (dB)
SISO	802.11 b	12.37672	12.86956	0.17
SISO	802.11 g	2.047634	2.545659	0.95
SISO	802.11 n20	1.90475	2.402538	1.01

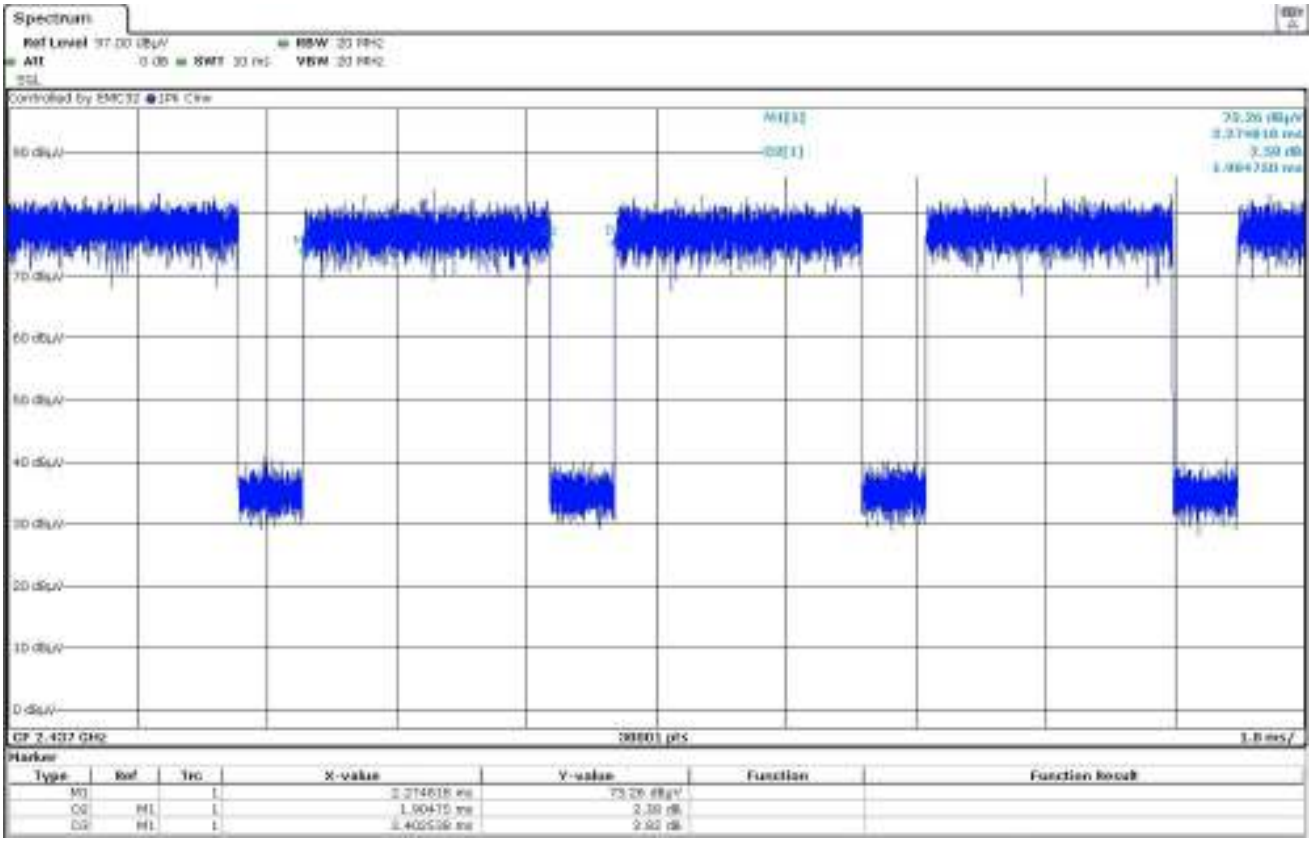
- **Mode 802.11 b:**



- **Mode 802.11 g:**



- **Mode 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:

Maximum Declared Antenna Gain: -6.2 dBi

For modes b, g, n20, the maximum conducted output power was measured using the method according to FCC title 47 part 15 §15.247(b), KDB 558074 D01 DTS Meas Guidance v05r02 and ANSI C63.10-2013 11.9.2.3.2.

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

- **Mode 802.11 b:**

	Low Channel	Middle Channel	High Channel
Maximum Average Conducted Power (dBm)	11.1	11.3	10.6
Maximum EIRP Power with Duty Cycle Correction (dBm)	4.9	5.1	4.4
Measurement uncertainty (dB)	<±2.57		

- **Mode 802.11 g:**

	Low Channel	Middle Channel	High Channel
Maximum Average Conducted Power (dBm)	11.5	11.7	11.1
Maximum EIRP Power with Duty Cycle Correction (dBm)	5.3	5.5	4.9
Measurement uncertainty (dB)	<±2.57		

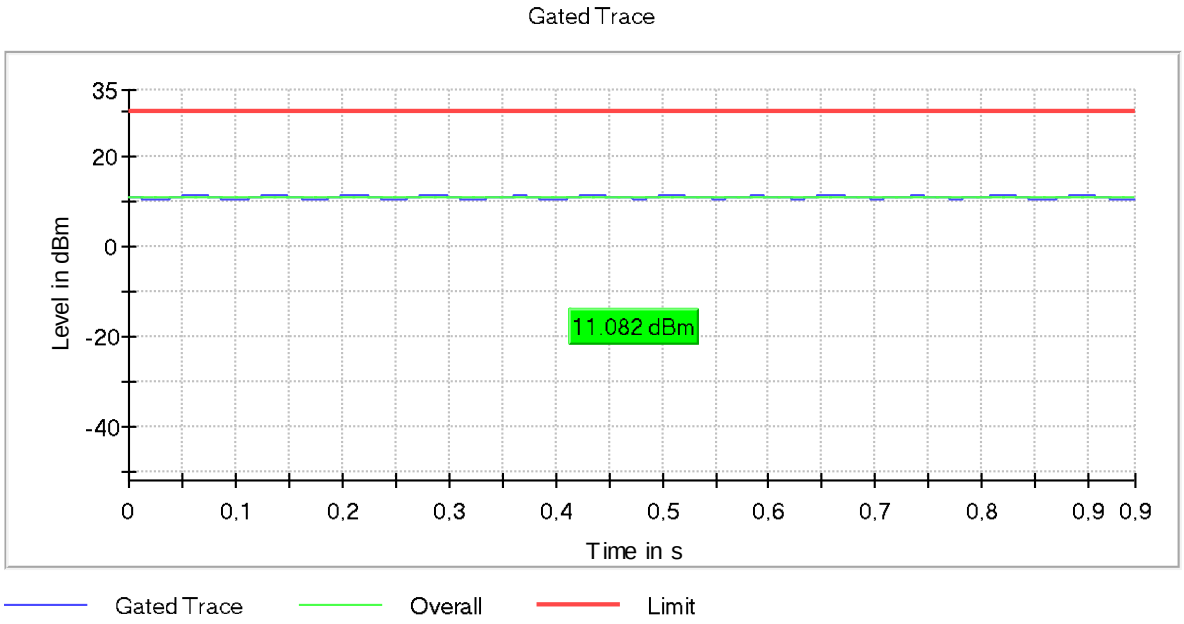
- **Mode 802.11 n20:**

	Low Channel	Middle Channel	High Channel
Maximum Average Conducted Power (dBm)	11.5	11.4	11.1
Maximum EIRP Power with Duty Cycle Correction (dBm)	5.3	5.2	4.9
Measurement uncertainty (dB)	<±2.57		

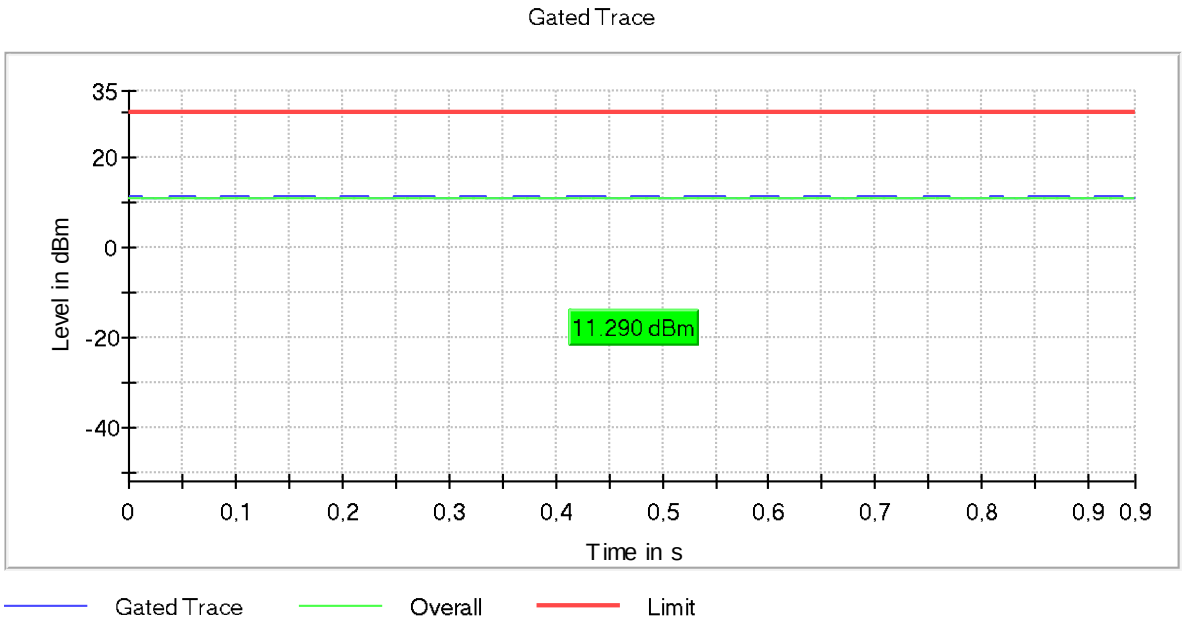
Verdict: PASS

- **Mode 802.11 b:**

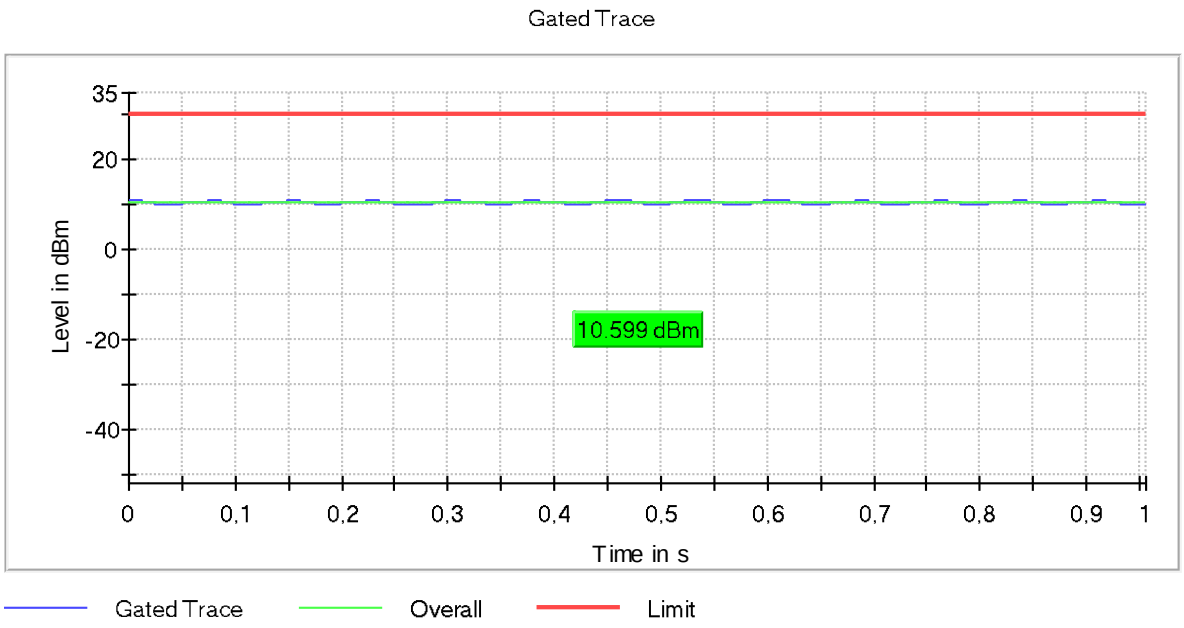
- Low Channel:



- Middle Channel:

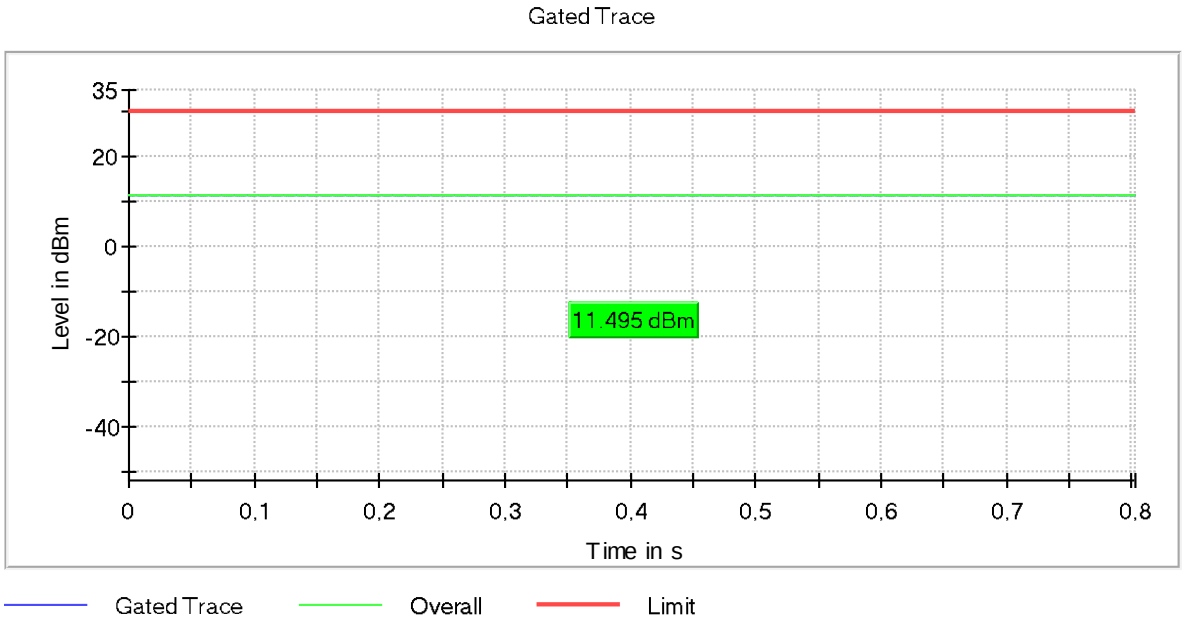


- High Channel:

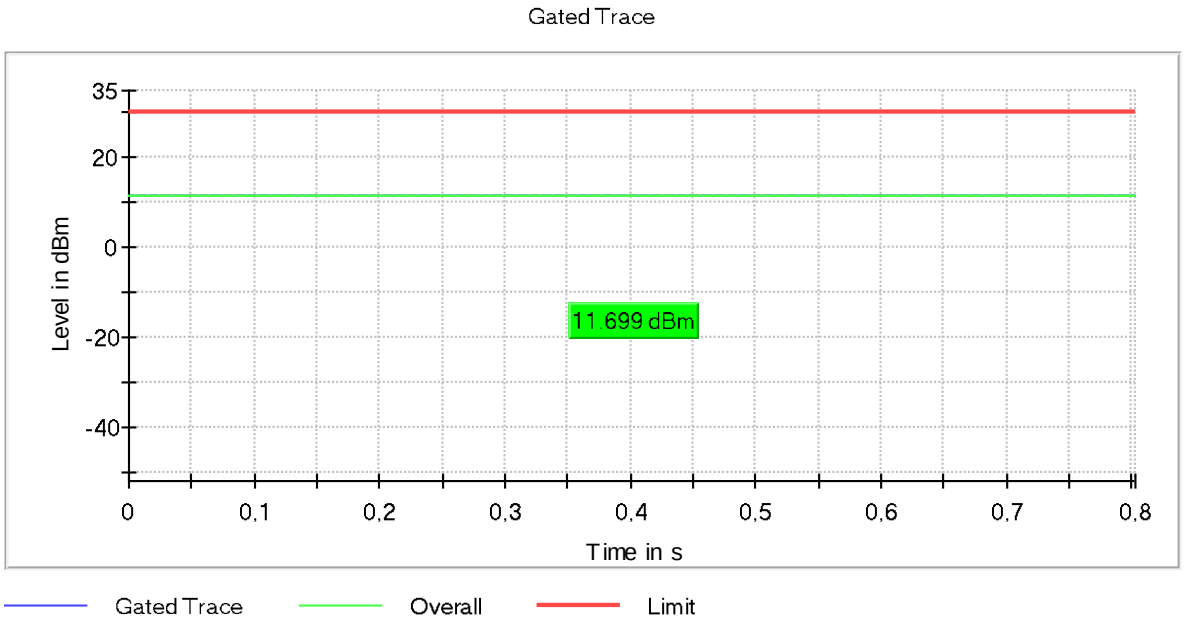


- **Mode 802.11 g:**

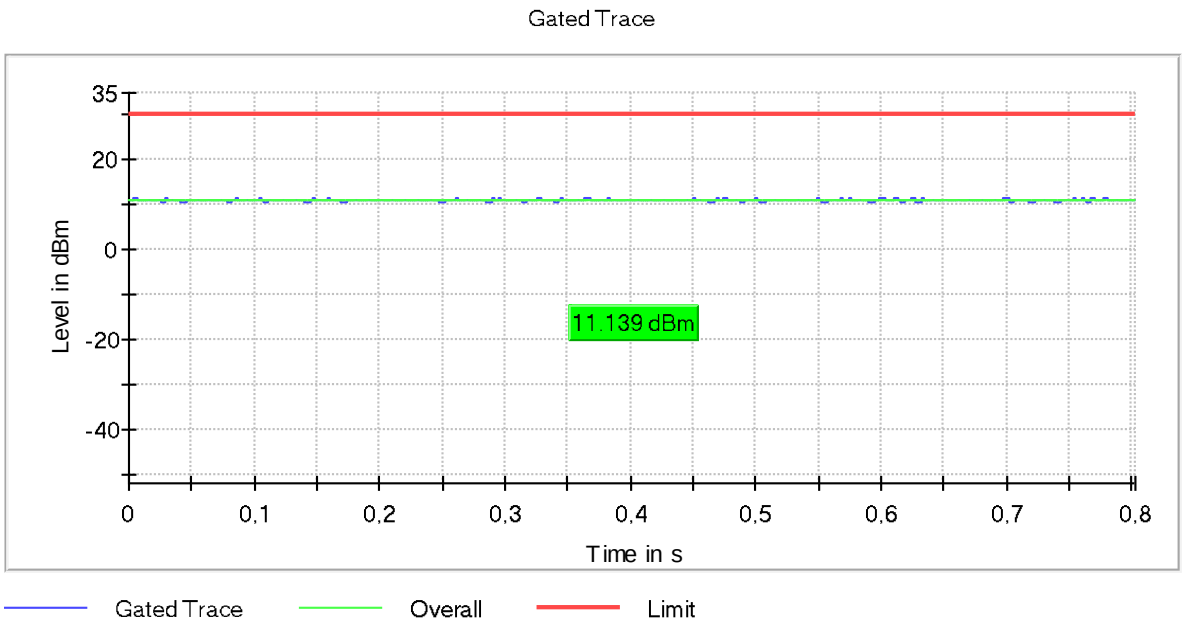
- Low Channel:



- Middle Channel:

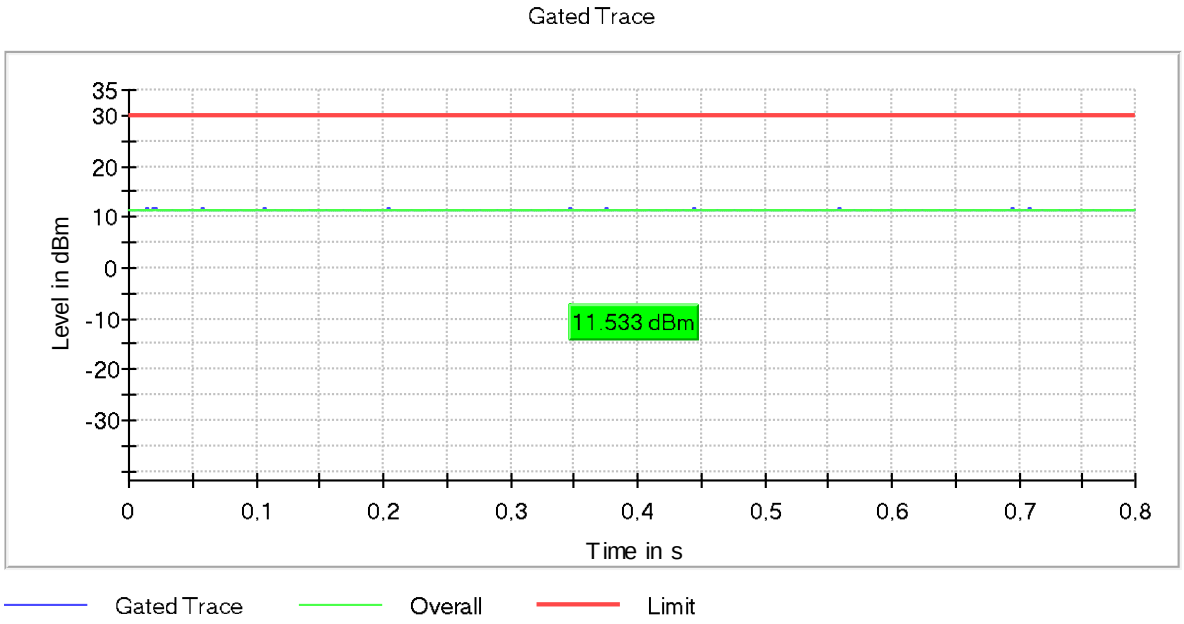


- High Channel:

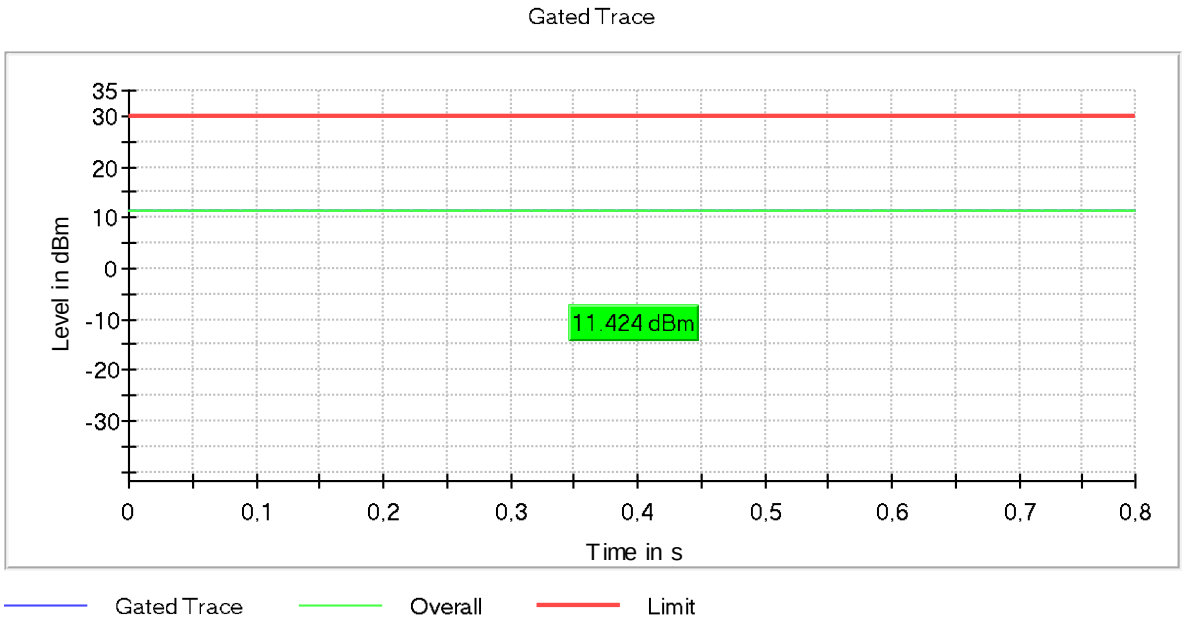


- **Mode 802.11 n20:**

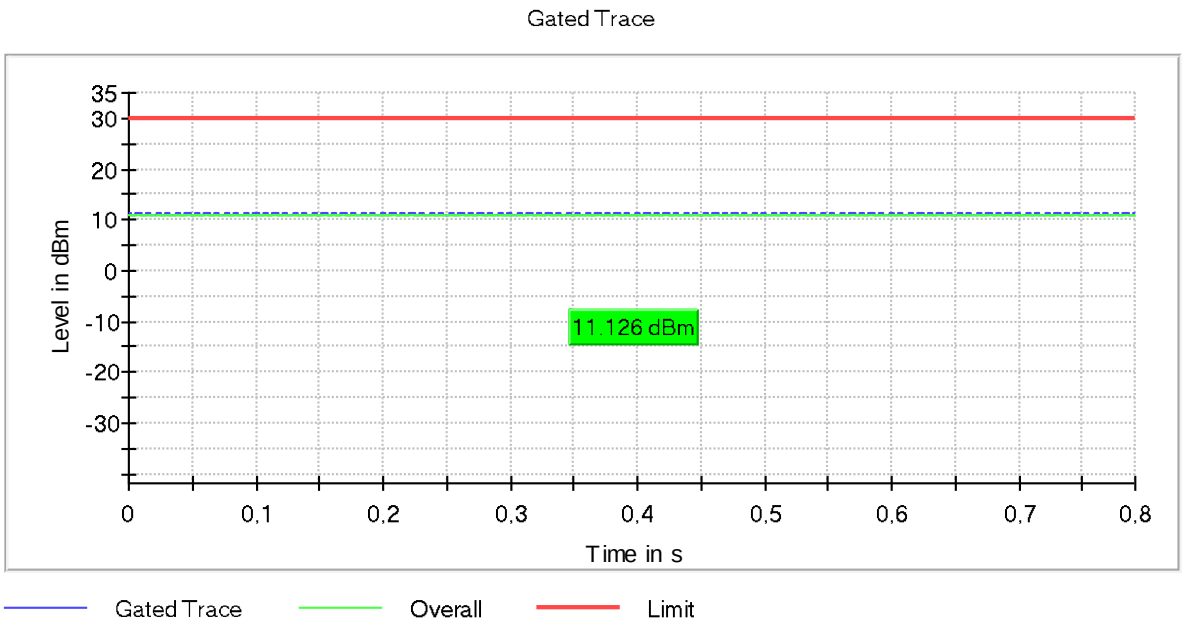
- Low Channel:



- 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.

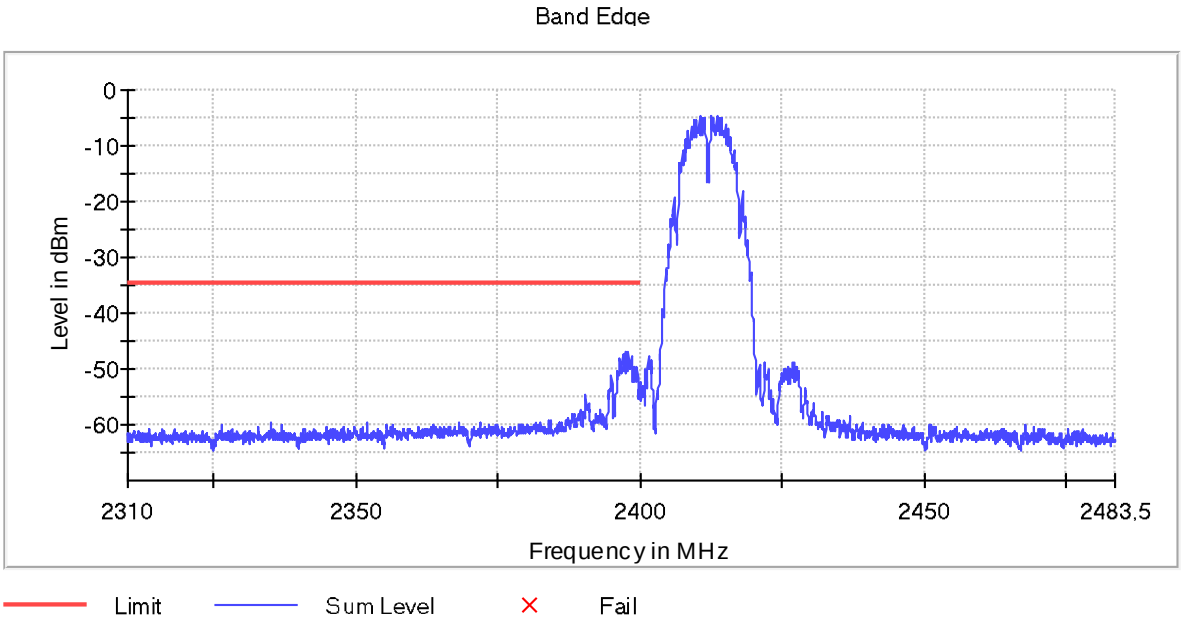
RESULTS:

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)	<±2.574

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

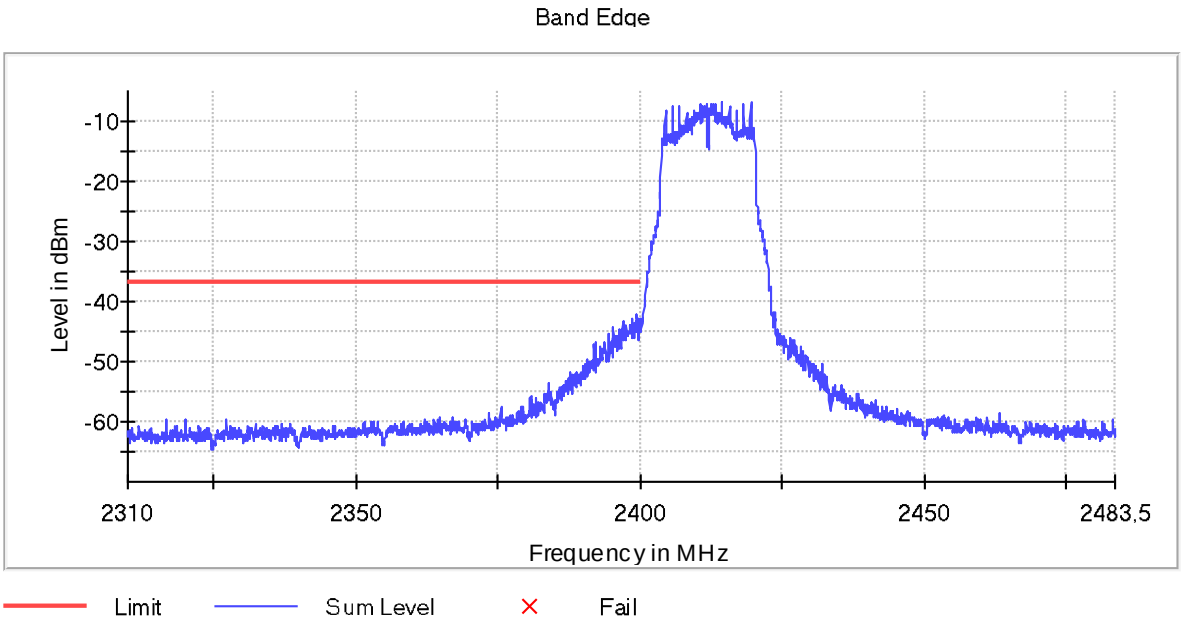
- Low Channel:



Verdict: PASS

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

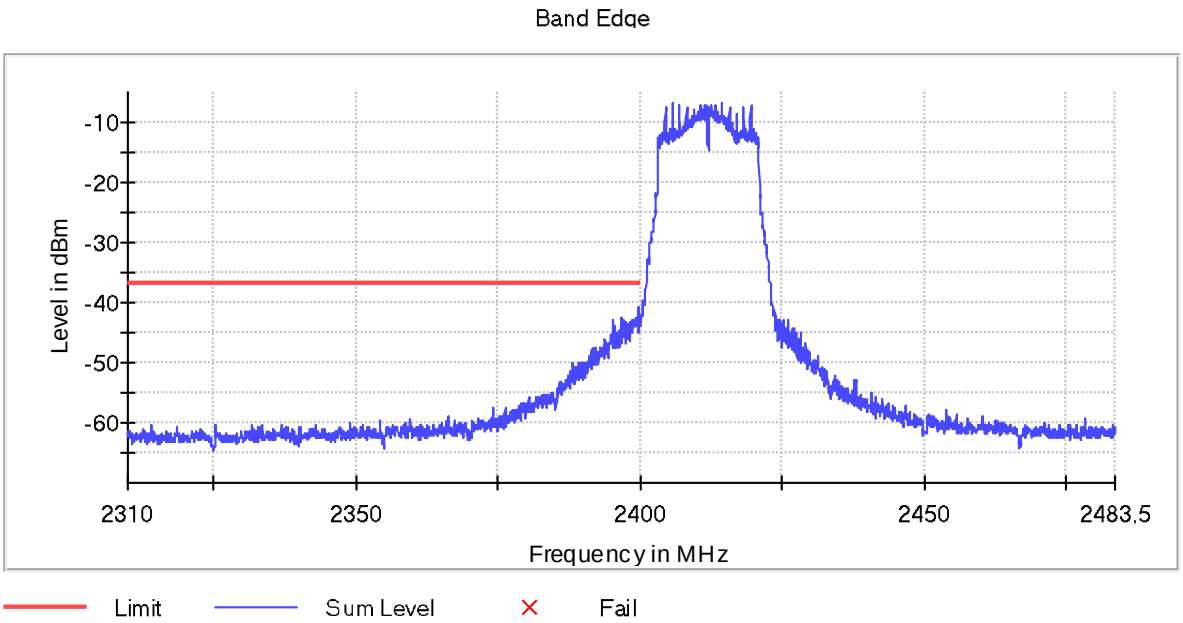
- Low Channel:



Verdict: PASS

- **Mode 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:

The power spectral density was measured using the method according to FCC title 47 part 15 §15.247(a),(e), KDB 558074 D01 DTS Meas Guidance v05r02 F and ANSI C63.10-2013.

- **Mode 802.11 b:**

	Low Channel	Middle Channel	High Channel
Average Power Spectral Density (dBm)	-6.564	-6.594	-7.404
Measurement uncertainty (dB)	<±2.574		

- **Mode 802.11 g:**

	Low Channel	Middle Channel	High Channel
Average Power Spectral Density (dBm)	-7.584	-7.254	-7.966
Measurement uncertainty (dB)	<±2.574		

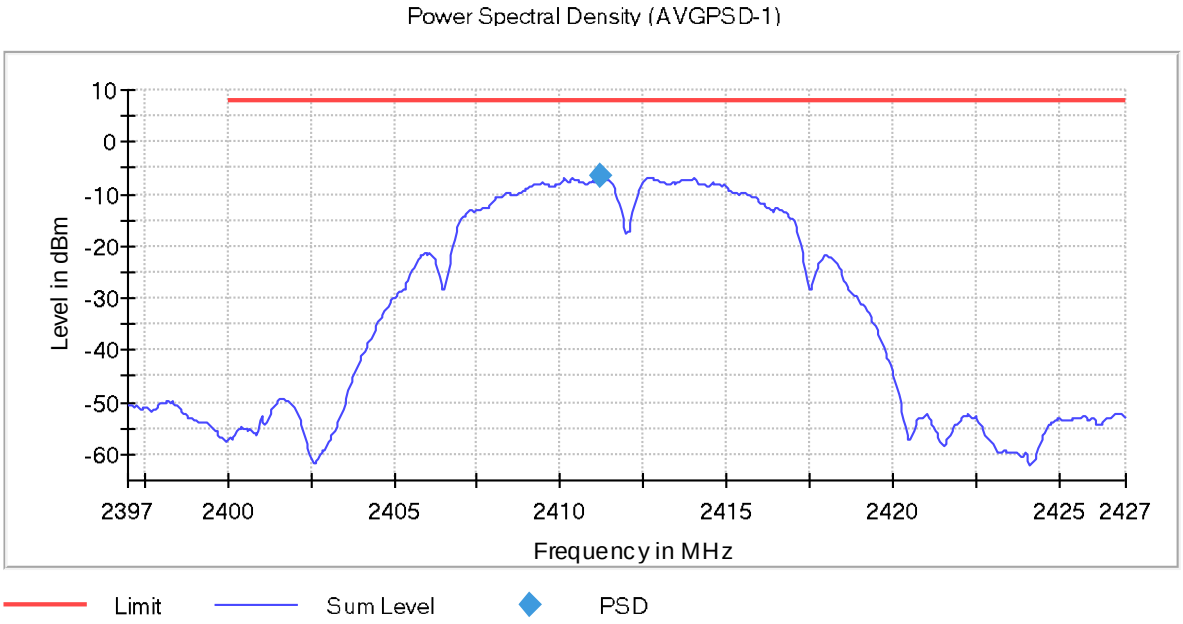
- **Mode 802.11 n20:**

	Low Channel	Middle Channel	High Channel
Average Power Spectral Density (dBm)	-8.069	-7.926	-8.450
Measurement uncertainty (dB)	<±2.574		

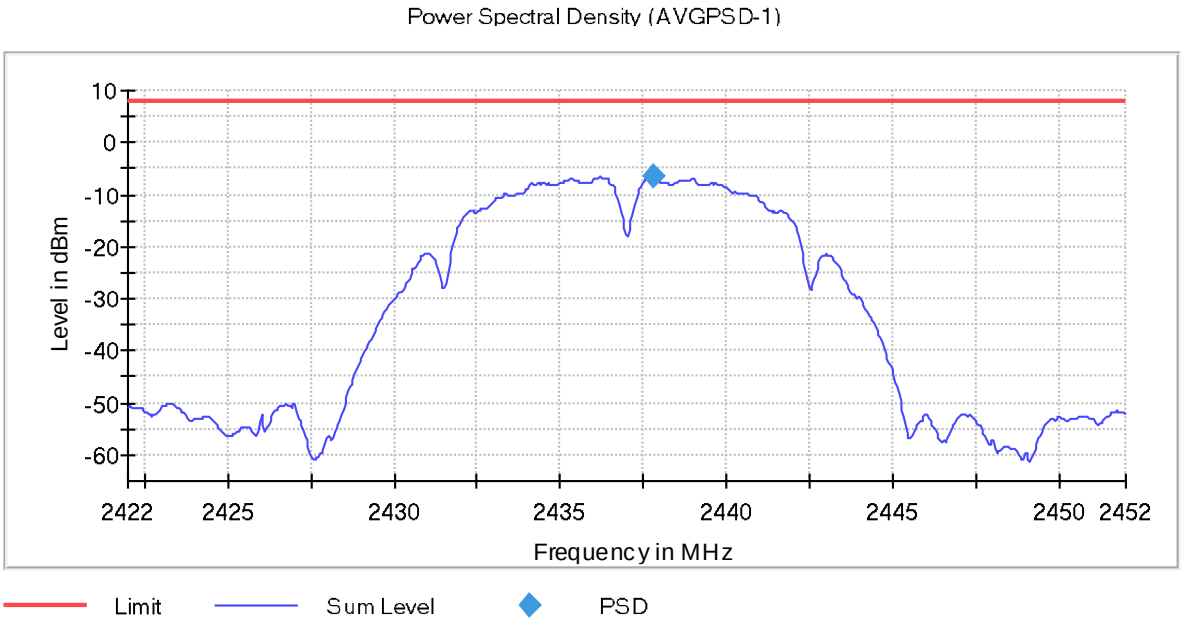
Verdict: PASS

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

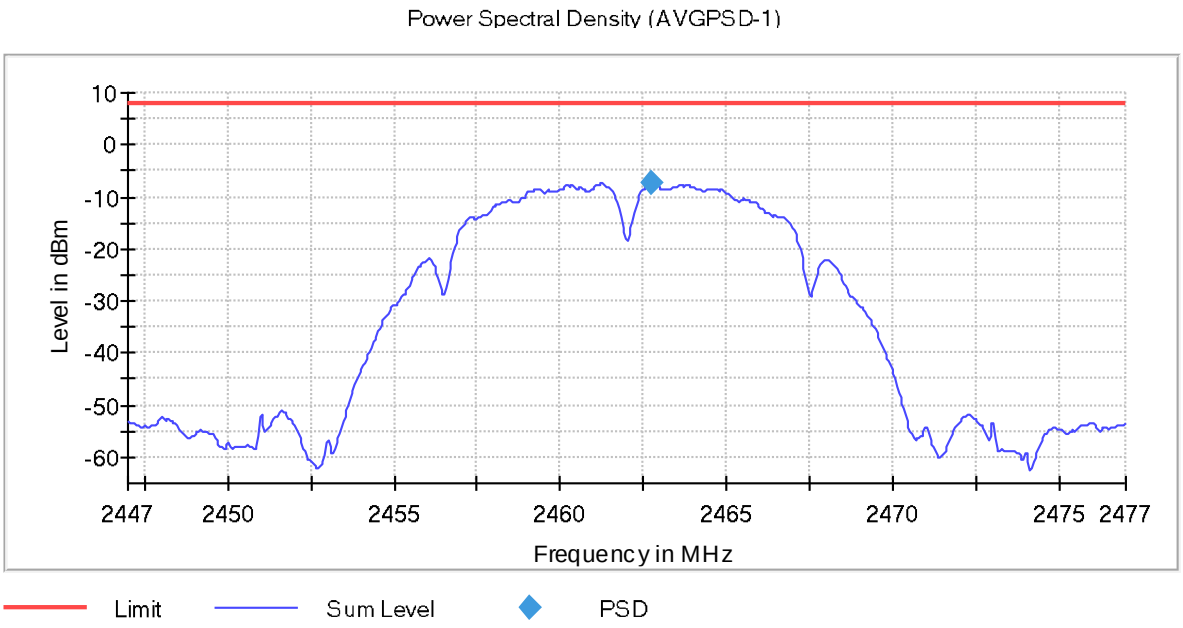
- Low Channel:



- Middle Channel:

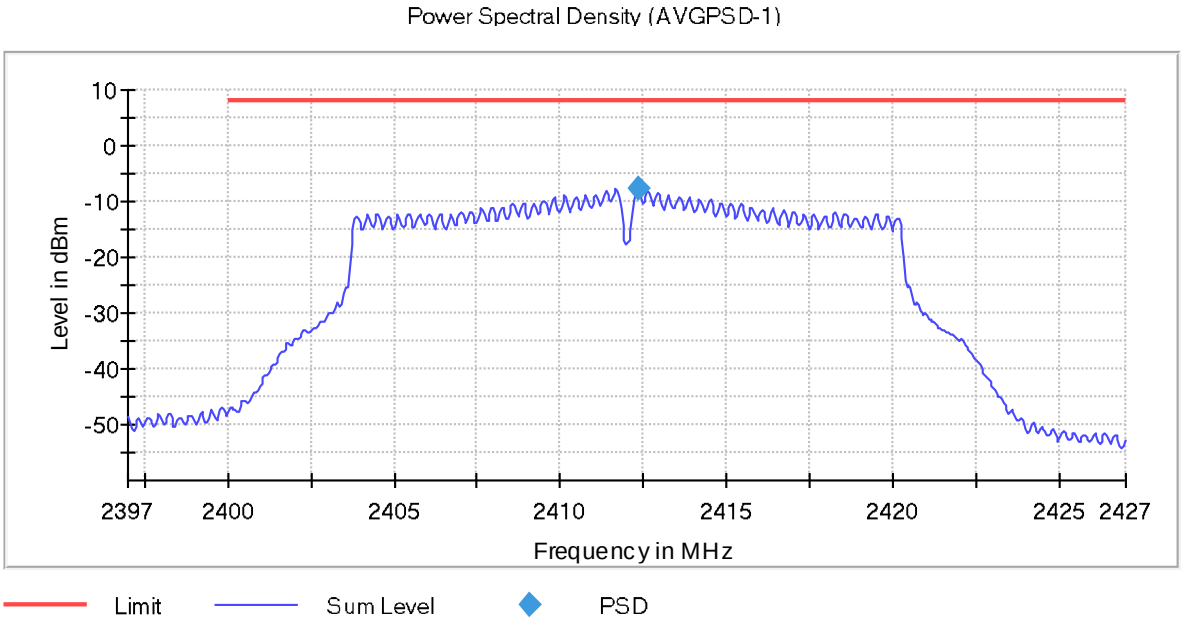


- High Channel:

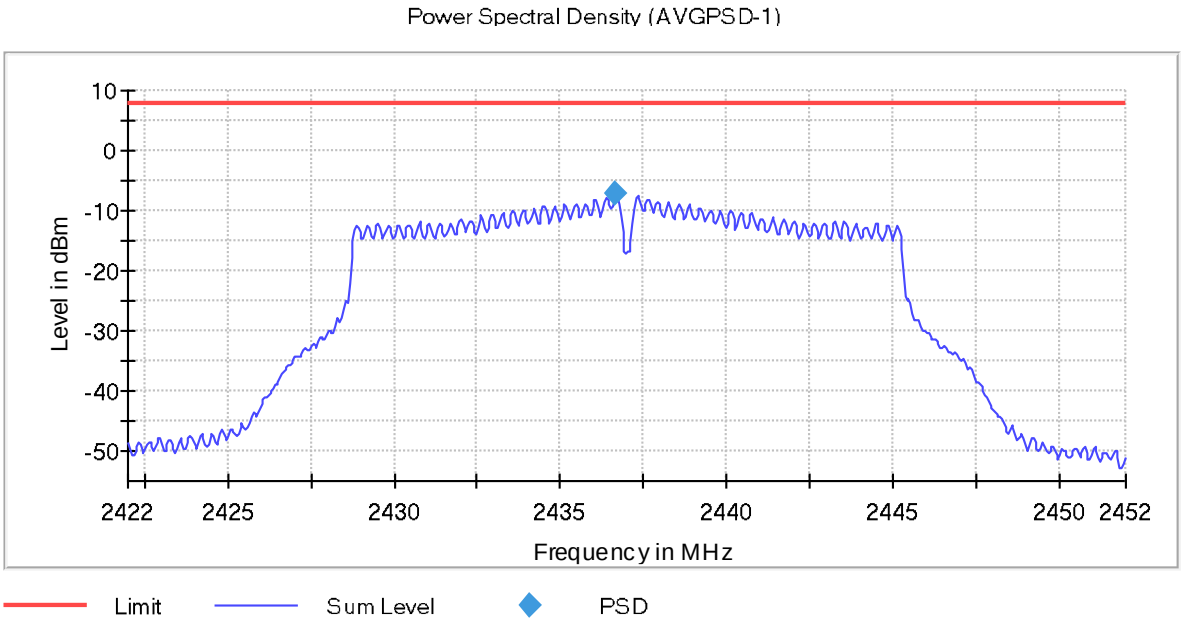


- **Mode 802.11 g – Power Spectral Density:**

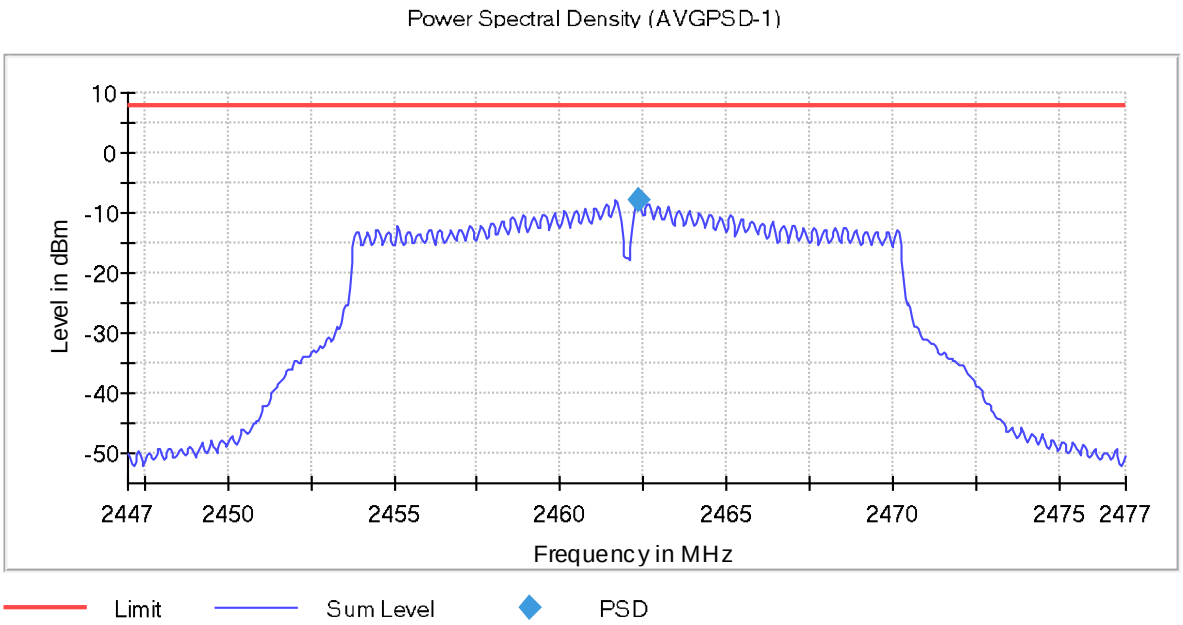
- Low Channel:



- Middle Channel:

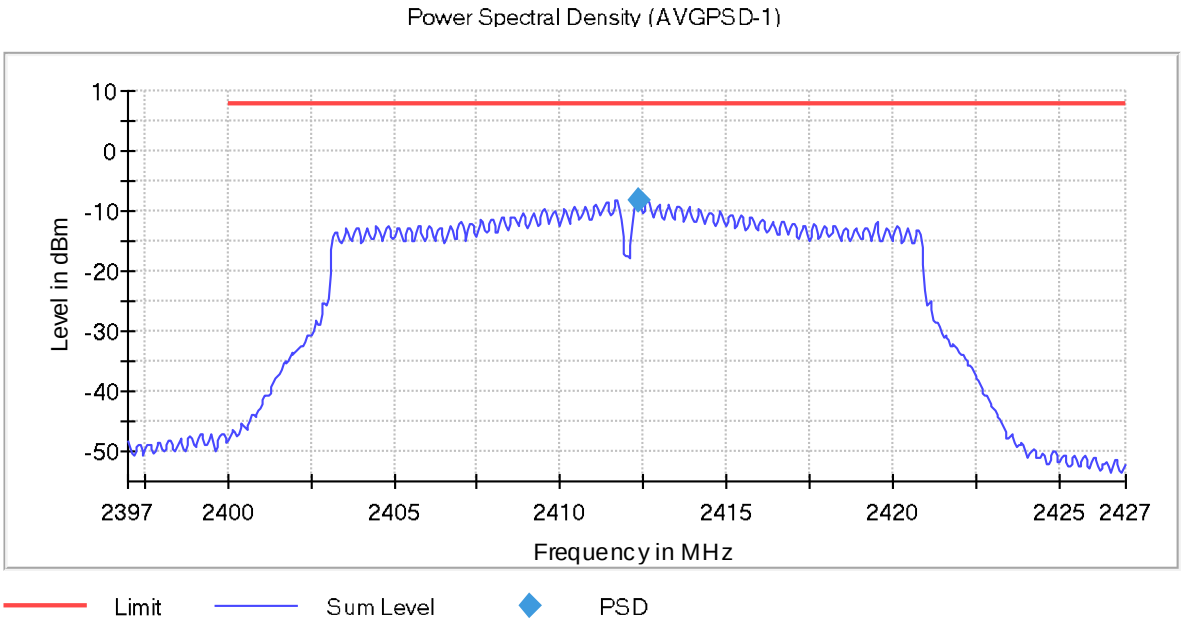


- High Channel:

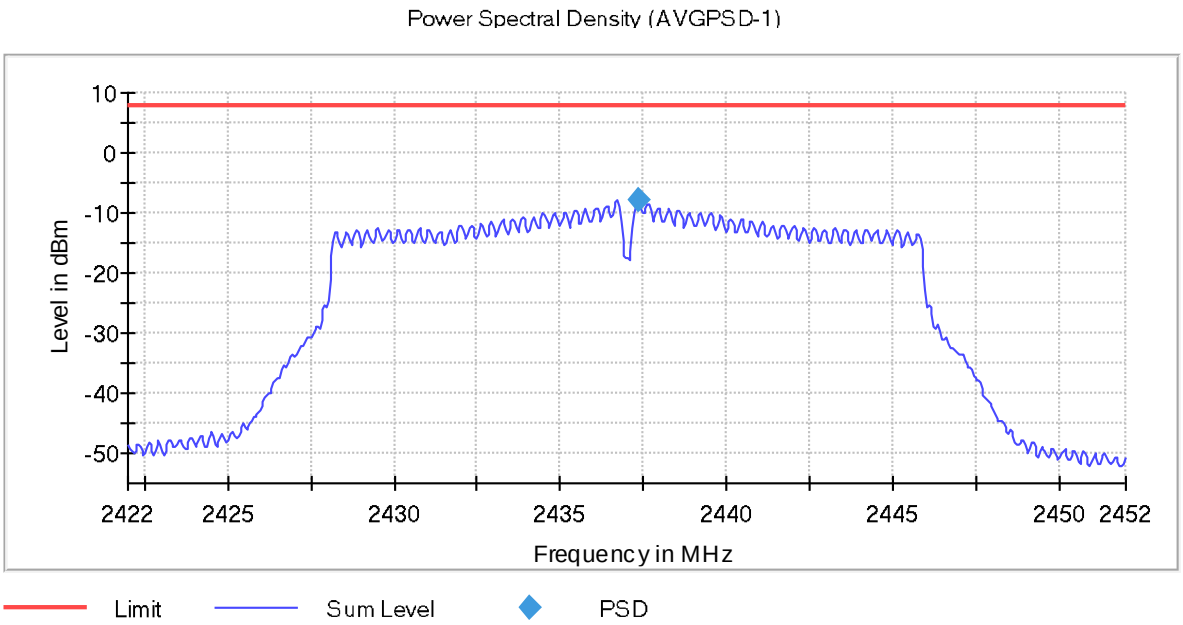


- **Mode 802.11 n20 – Power Spectral Density:**

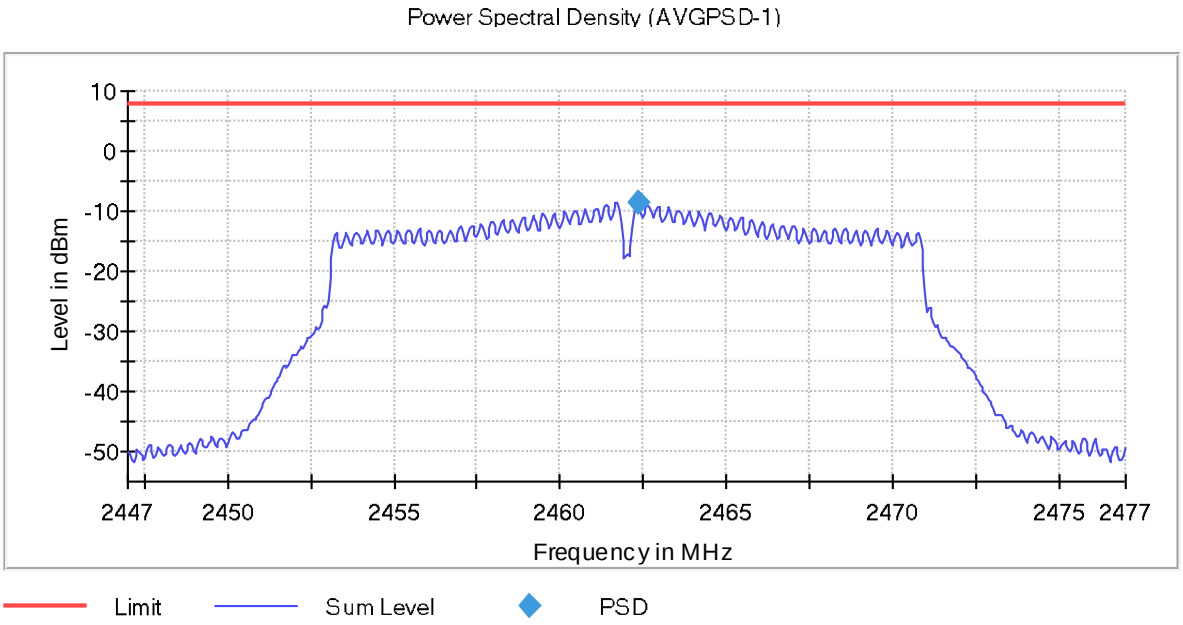
- Low Channel:



- 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 §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §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 - 25000	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.

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.

Frequency range 30 MHz - 1 GHz:

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

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
75.008	24.49	V	Quasi-peak	<± 5.08

Measurement Uncertainty: <± 5.08 dB

- **Mode 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 (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0		V	Peak	<± 5.13

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0		V	Peak	<± 5.13

- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0		V	Peak	<± 5.13

- 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 ≤ f ≤ 17 GHz: <± 5.13
17 GHz ≤ f ≤ 26 GHz: <± 4.82

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 n20.**
  - **Mode 802.11 n20 (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.

- LOW CHANNEL. Spurious frequencies closest to the limit

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	49.65	V	Peak	<± 5.13

- MIDDLE CHANNEL. Spurious frequencies closest to the limit

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	45	V	Peak	<± 5.13

- HIGH CHANNEL. Spurious frequencies closest to the limit

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
9.0	45	V	Peak	<± 5.13

- RESTRICTED BAND 2.31-2.39 GHz. LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
2.389533	67.84	H	Peak	<± 5.13
	51.29		Average	<± 5.13

- 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 ≤ f ≤ 17 GHz: <± 5.13
17 GHz ≤ f ≤ 26 GHz: <± 4.82

Verdict: PASS

- **Mode 802.11 g:**

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.

- RESTRICTED BAND 2.31-2.39 GHz. LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
2.3894	65.61	V	Peak	<± 5.13
	51.11		Average	<± 5.13

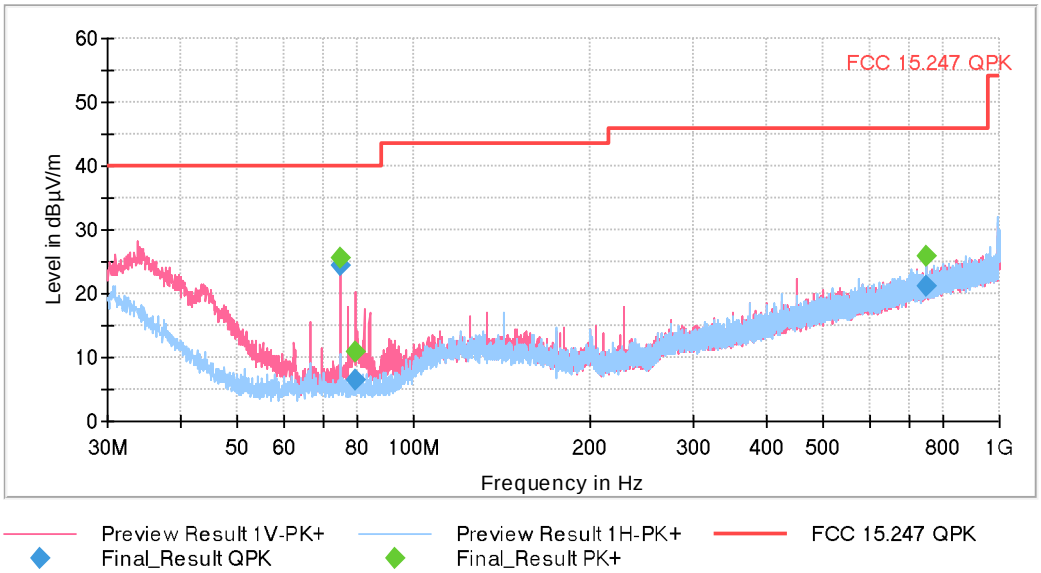
- RESTRICTED BAND 2.4835-2.5 GHz. HIGH CHANNEL. No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB): 1 GHz ≤ f ≤ 17 GHz: <± 5.13
17 GHz ≤ f ≤ 26 GHz: <± 4.82

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

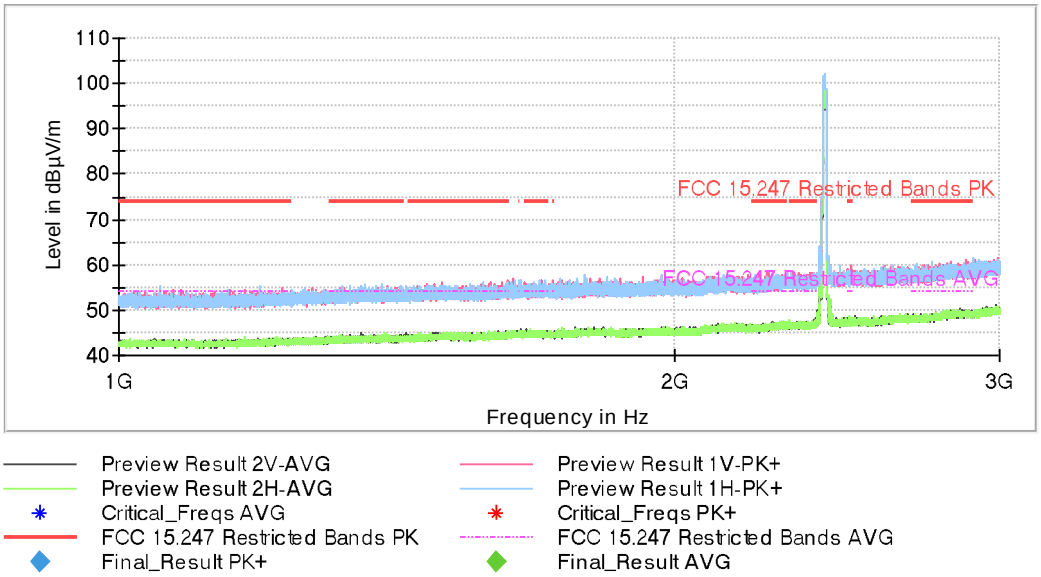
The spurious frequencies detected do not depend neither on the operating channel nor the modulation mode.



- **Mode 802.11 b:**

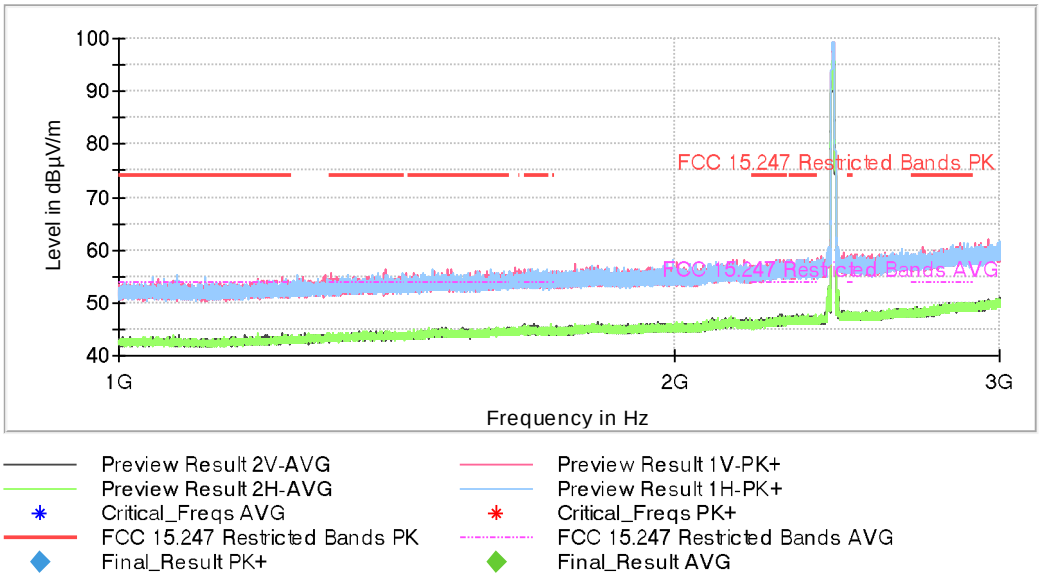
FREQUENCY RANGE 1 - 3 GHz:

- Low Channel:



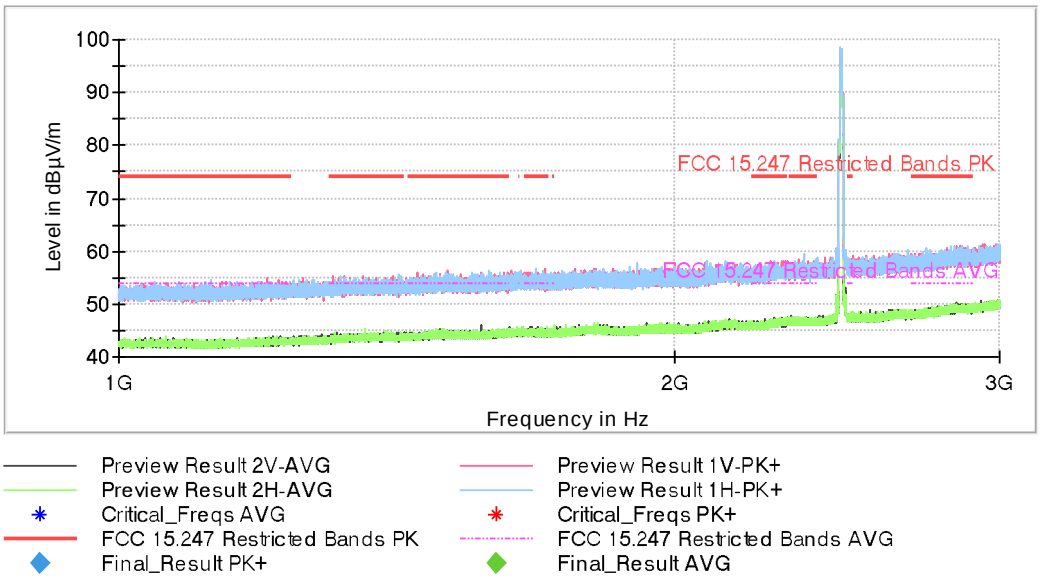
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

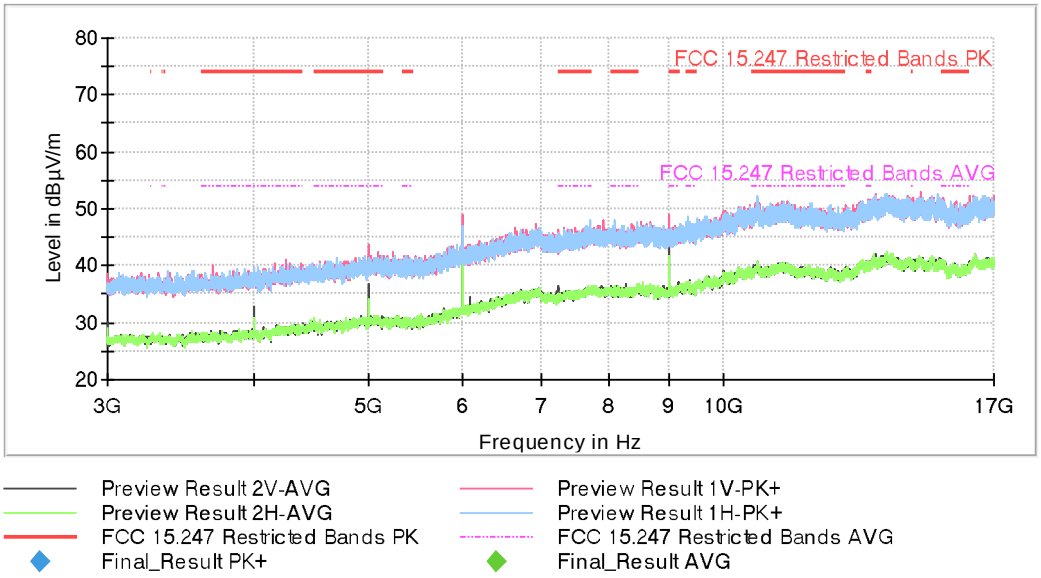
- High Channel:



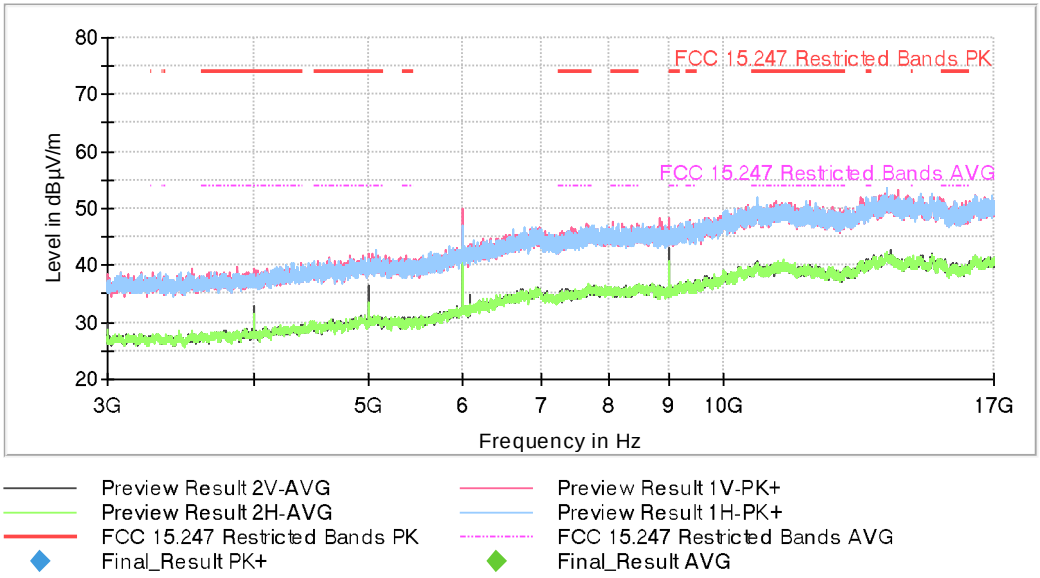
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

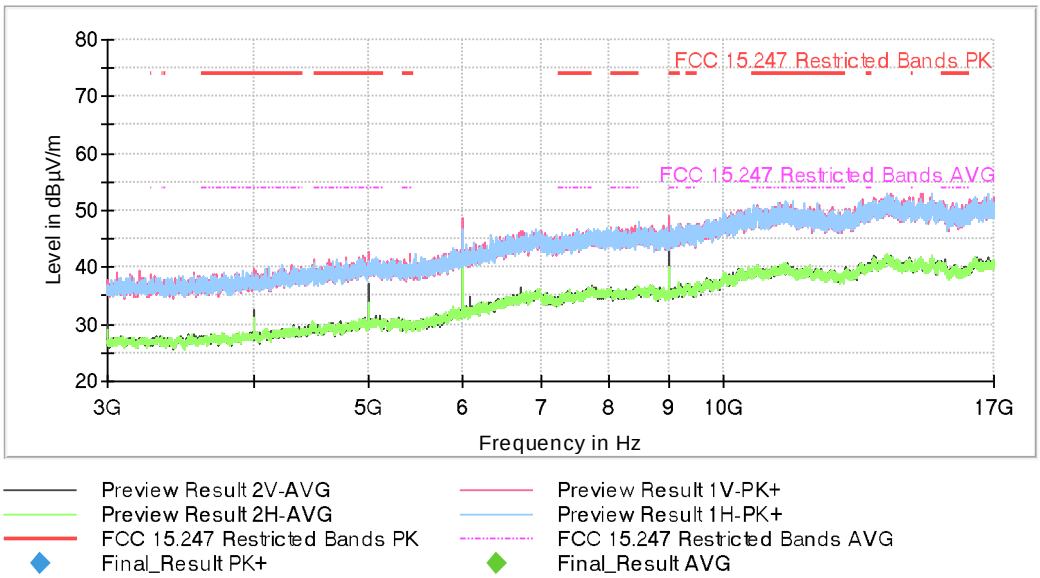
- Low Channel:



- Middle Channel:

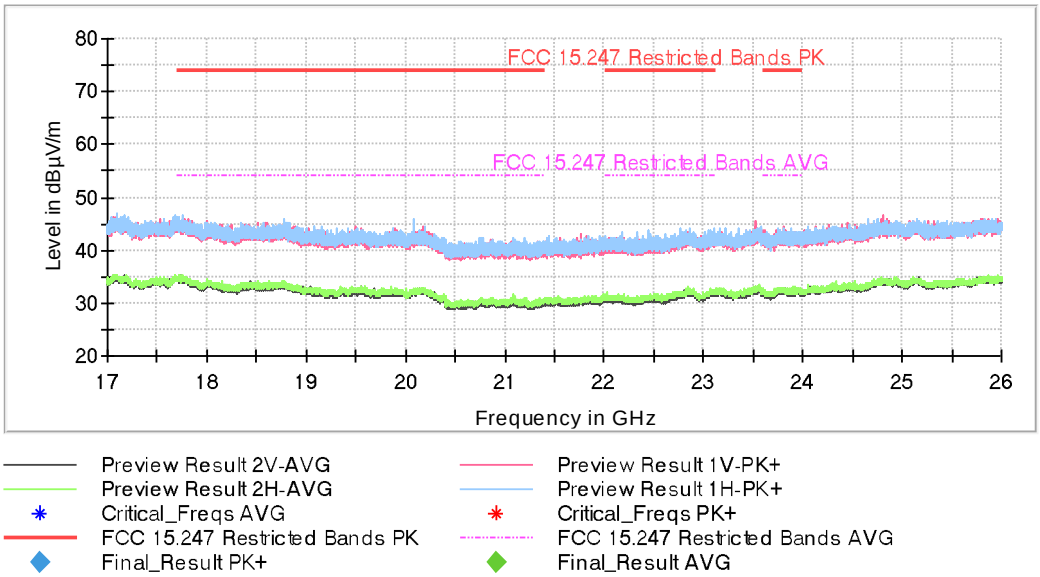


- High Channel:



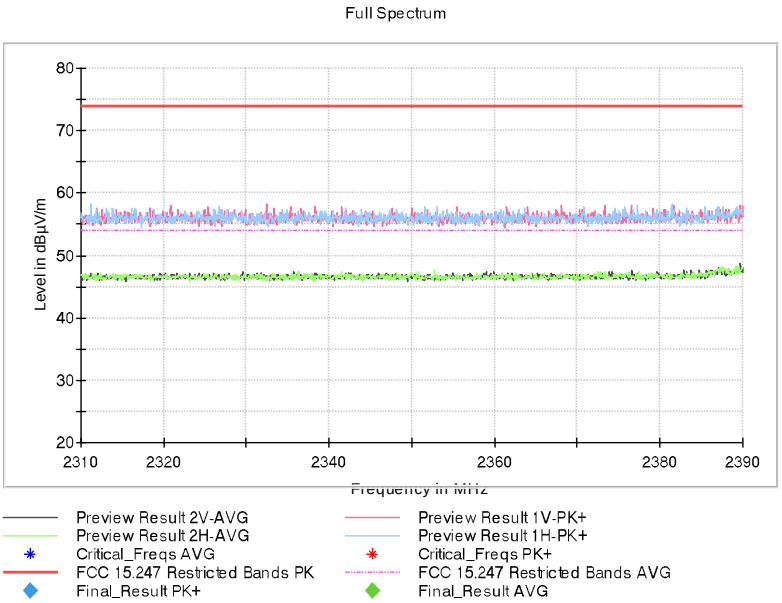
FREQUENCY RANGE 17 - 26 GHz:

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



RESTRICTED BAND 2.31-2.39 GHz:

- Low Channel:



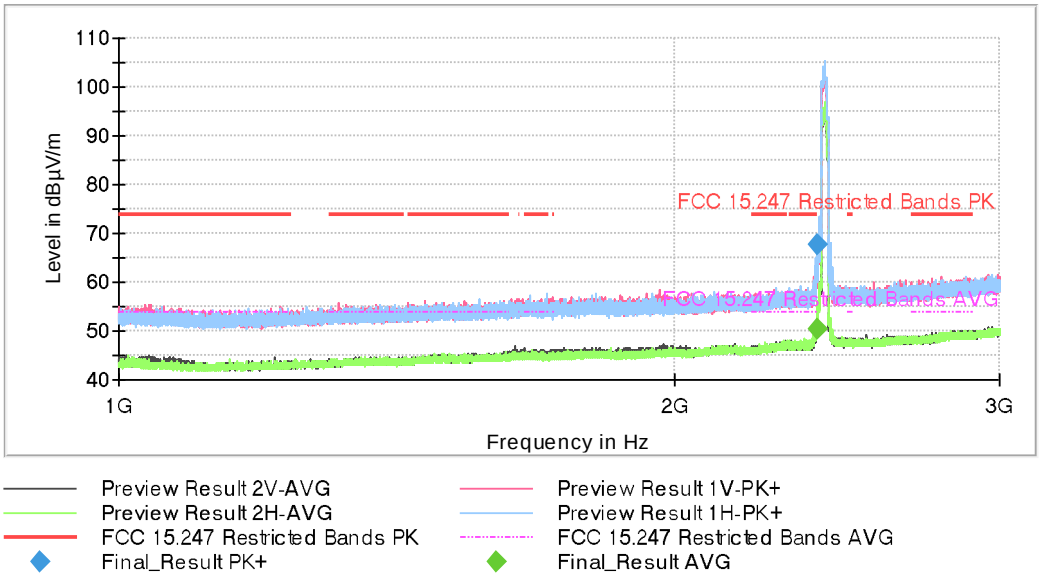
RESTRICTED BAND 2.4835-2.5 GHz:

- High Channel:

- **Mode 802.11 n20 (OFDM worst case for spurious emissions):**

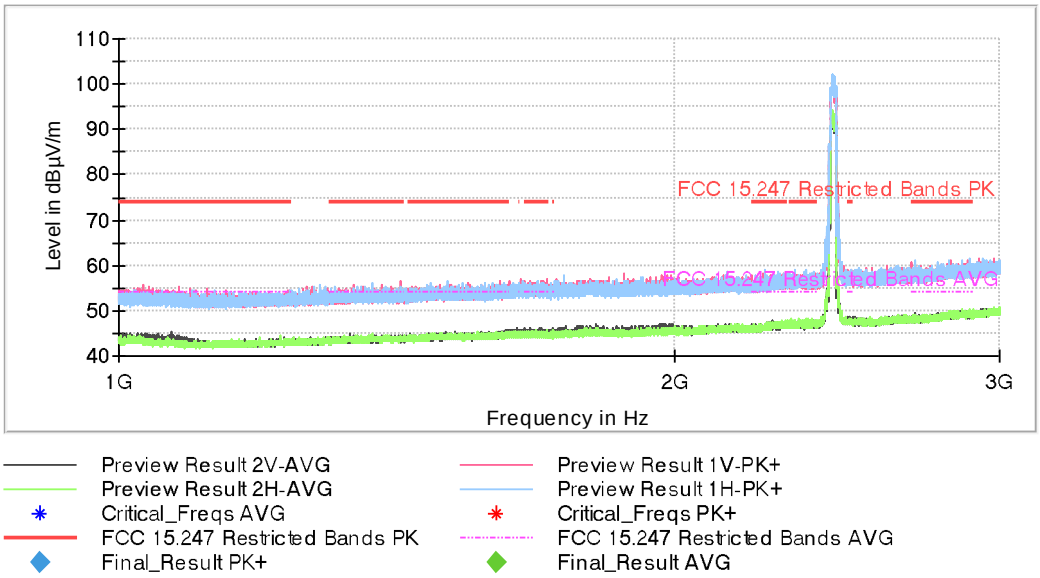
FREQUENCY RANGE 1 - 3 GHz:

- Low Channel:



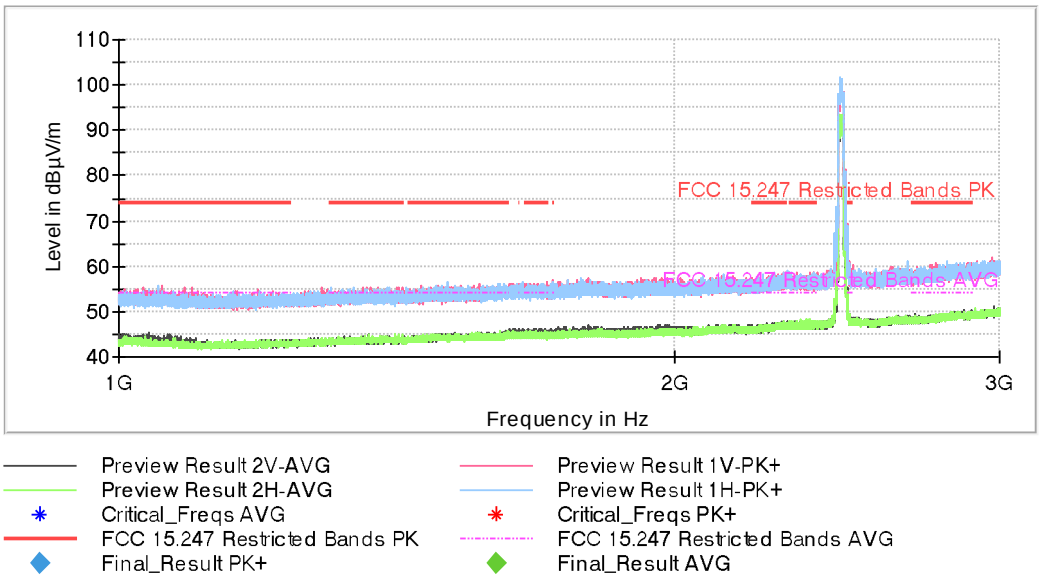
The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.

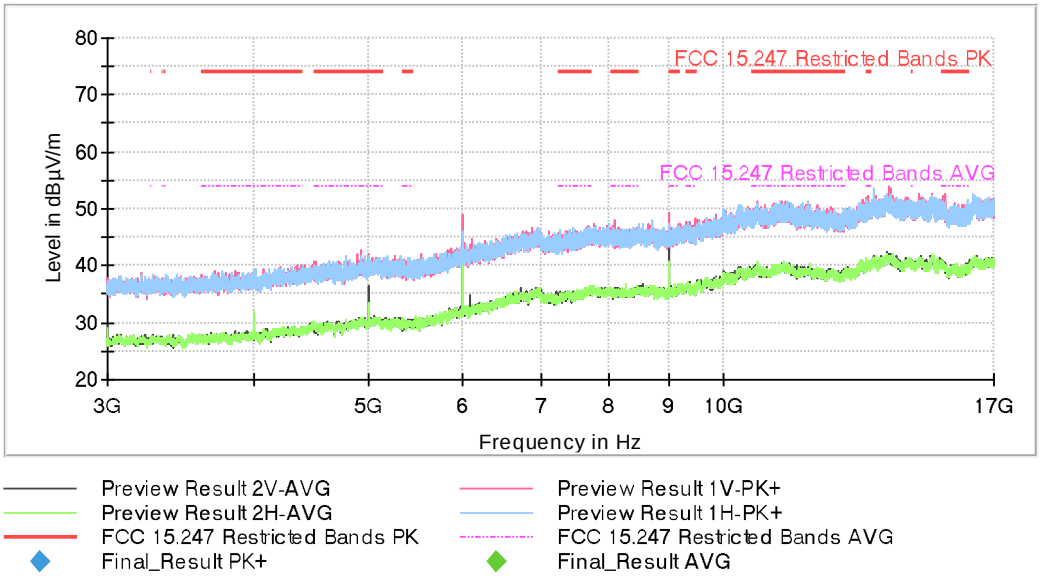
- High Channel:



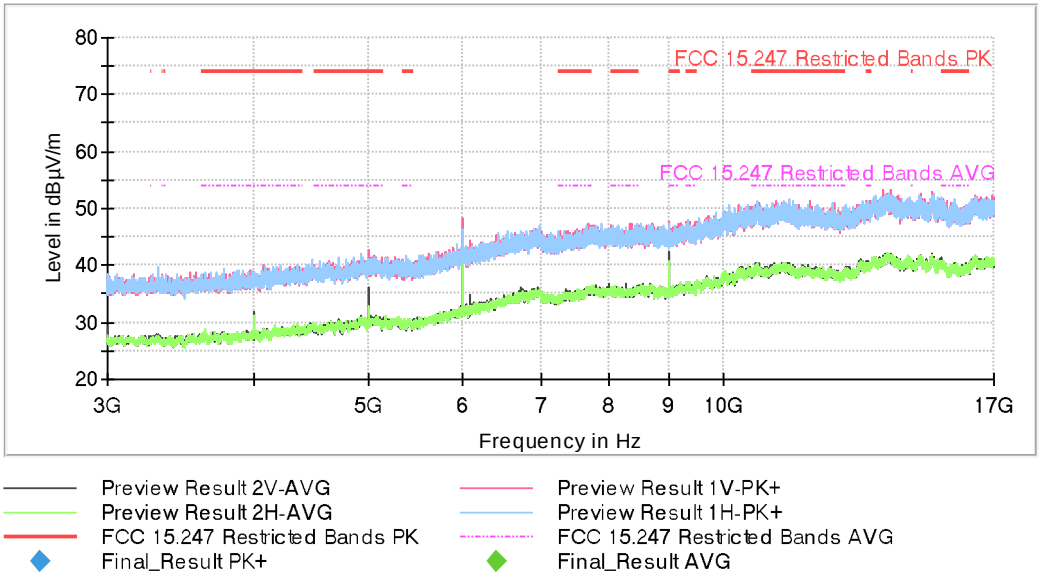
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

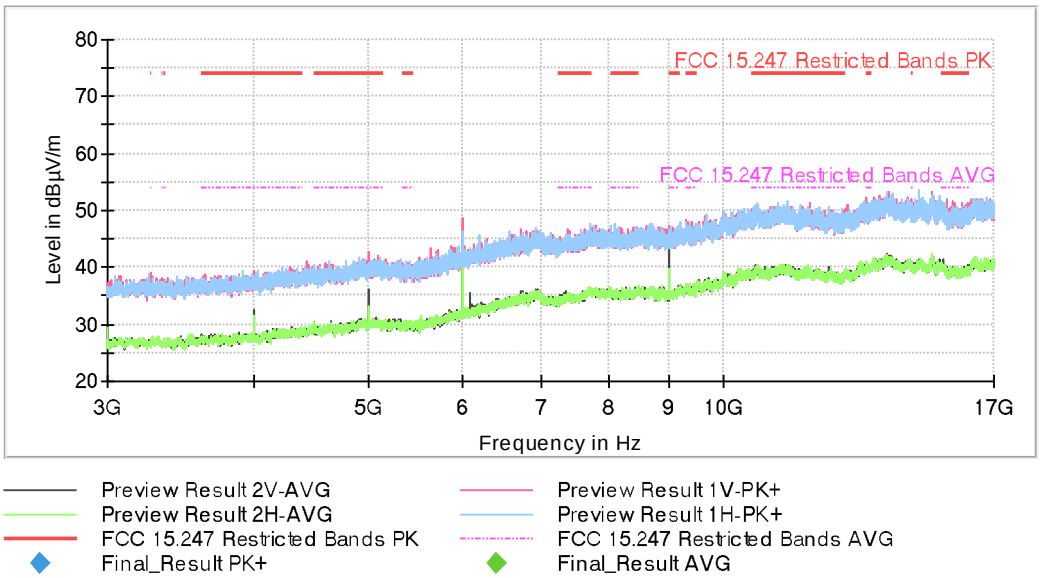
- Low Channel:



- Middle Channel:

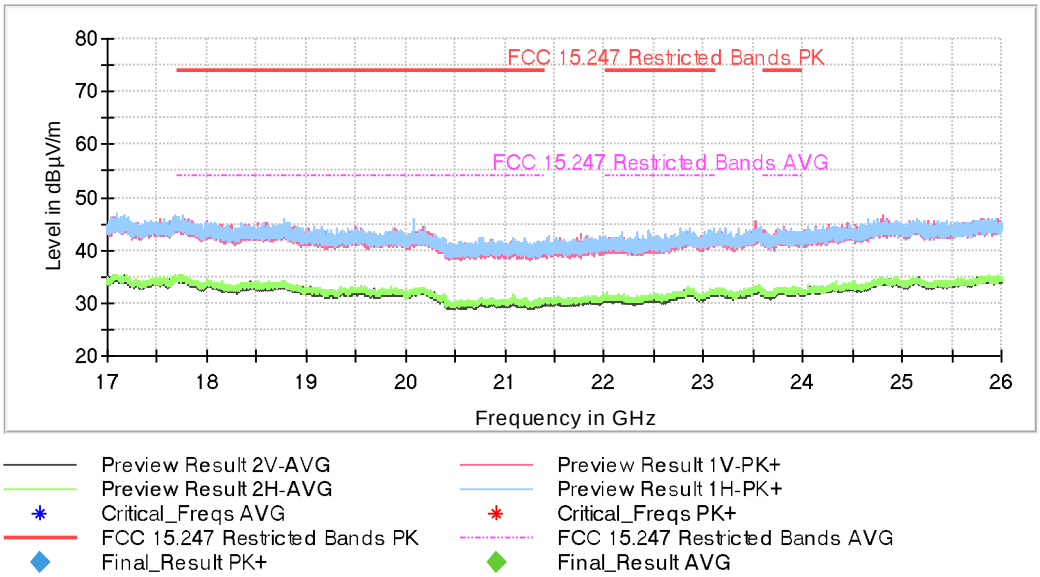


- High Channel:



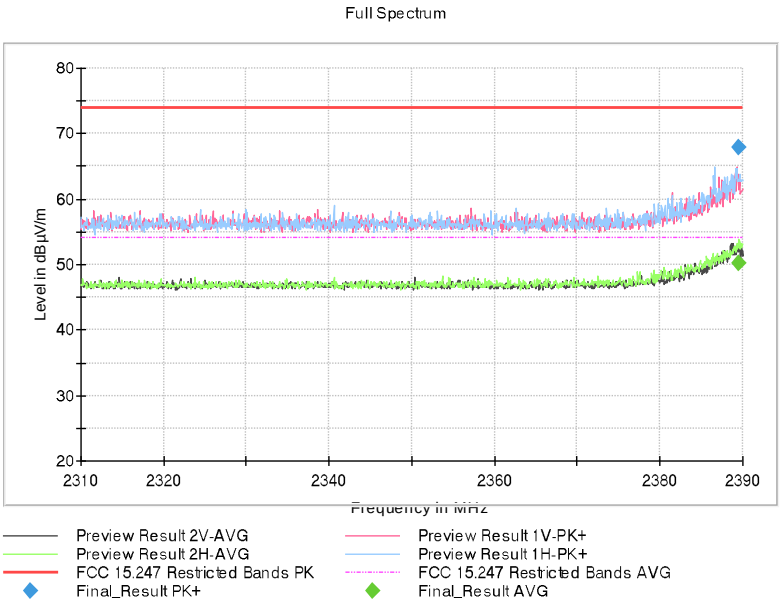
FREQUENCY RANGE 17 - 26 GHz:

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



RESTRICTED BAND 2.31-2.39 GHz:

- Low Channel:



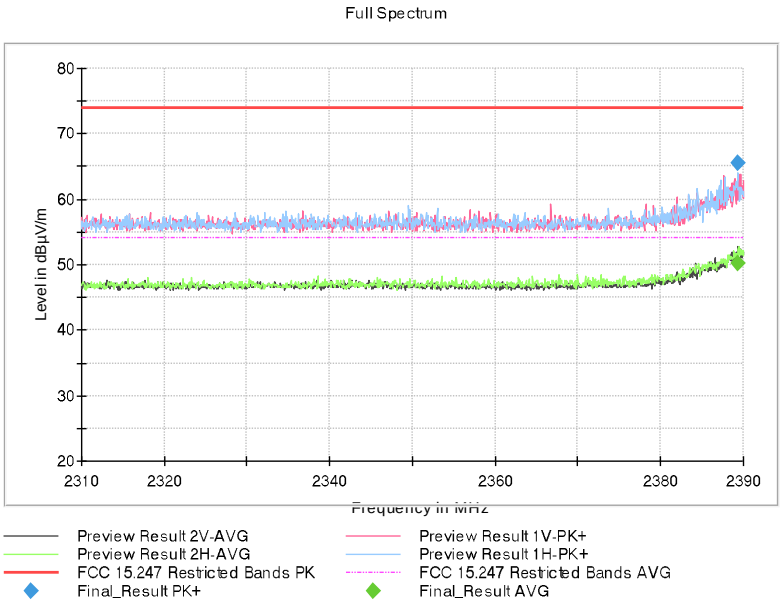
RESTRICTED BAND 2.4835-2.5 GHz:

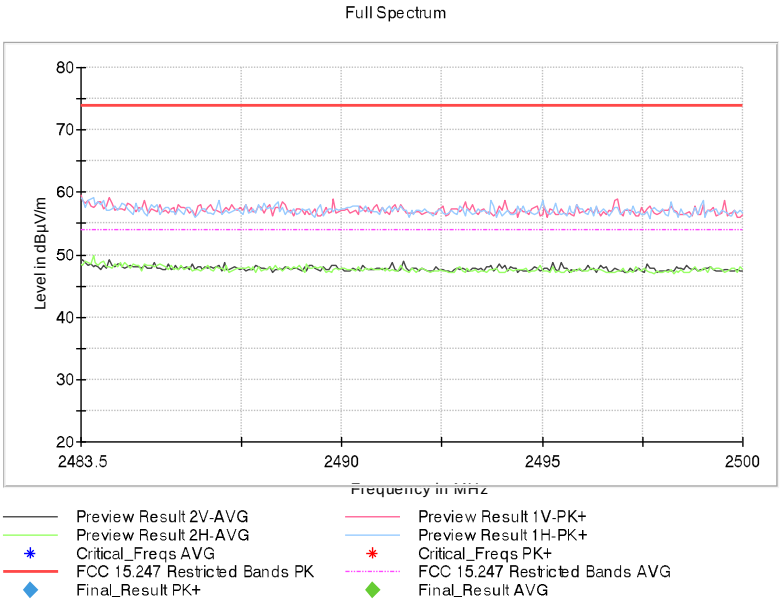
- High Channel:

- **Mode 802.11 g:**

RESTRICTED BAND 2.31-2.39 GHz:

- Low Channel:



RESTRICTED BAND 2.4835-2.5 GHz:

- High Channel: