

Appendix B: Test results. 802.11 bgn20 1x1

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TEST CONDITIONS

POWER SUPPLY (V):

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

ANTENNA:

Type of Antenna:	External.
Maximum Declared Antenna Gain:	+2.2 dBi (antenna gain regarding of cable/connector attenuation)

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).

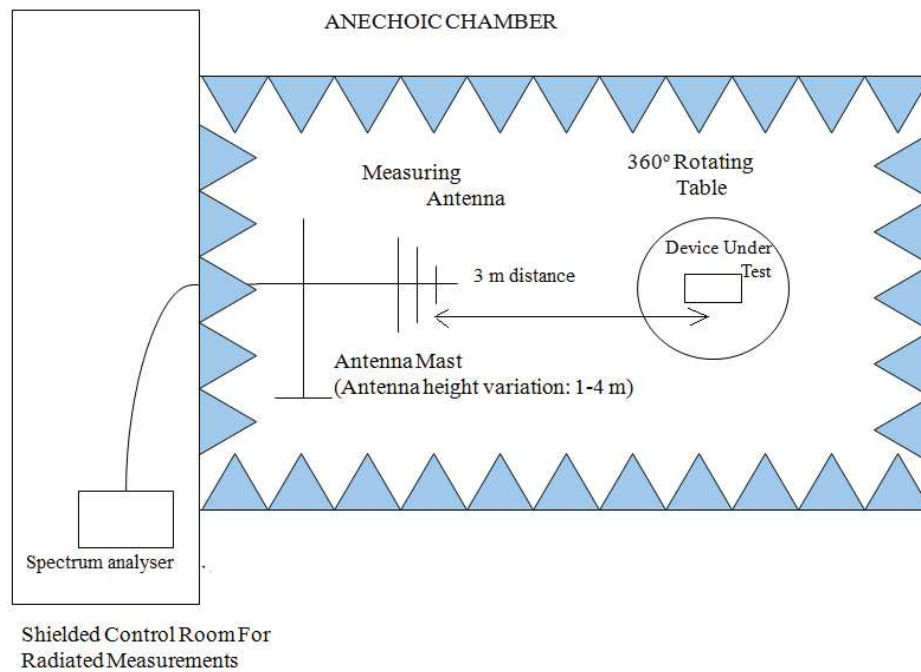
For radiated emissions in the range 17 GHz-26 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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 360° and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find the maximum radiated emission.

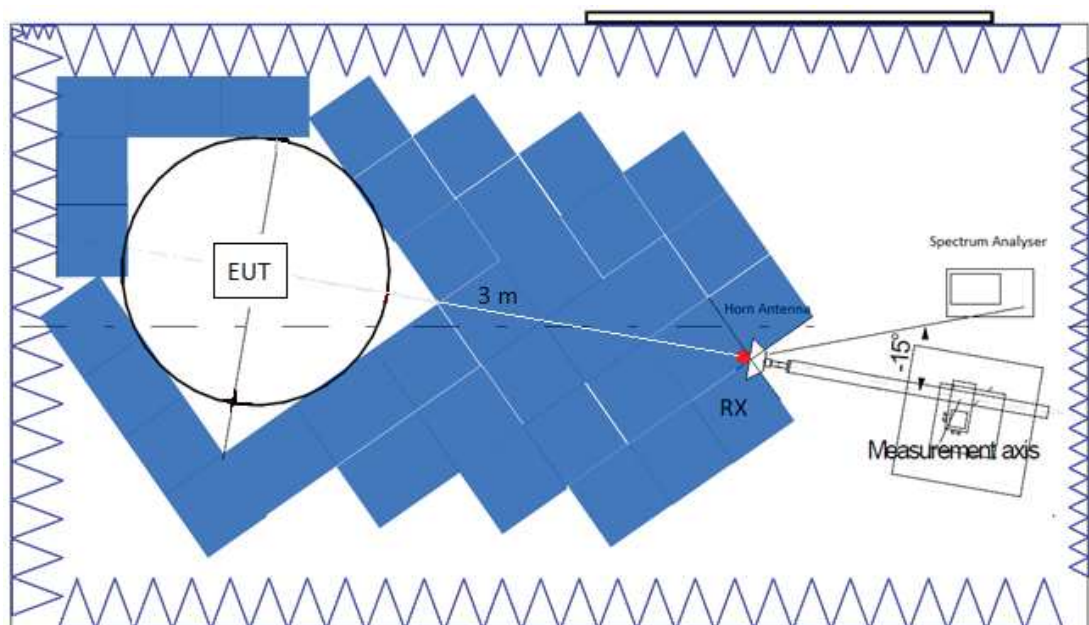
Measurements were made in both horizontal and vertical planes of polarization.

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.

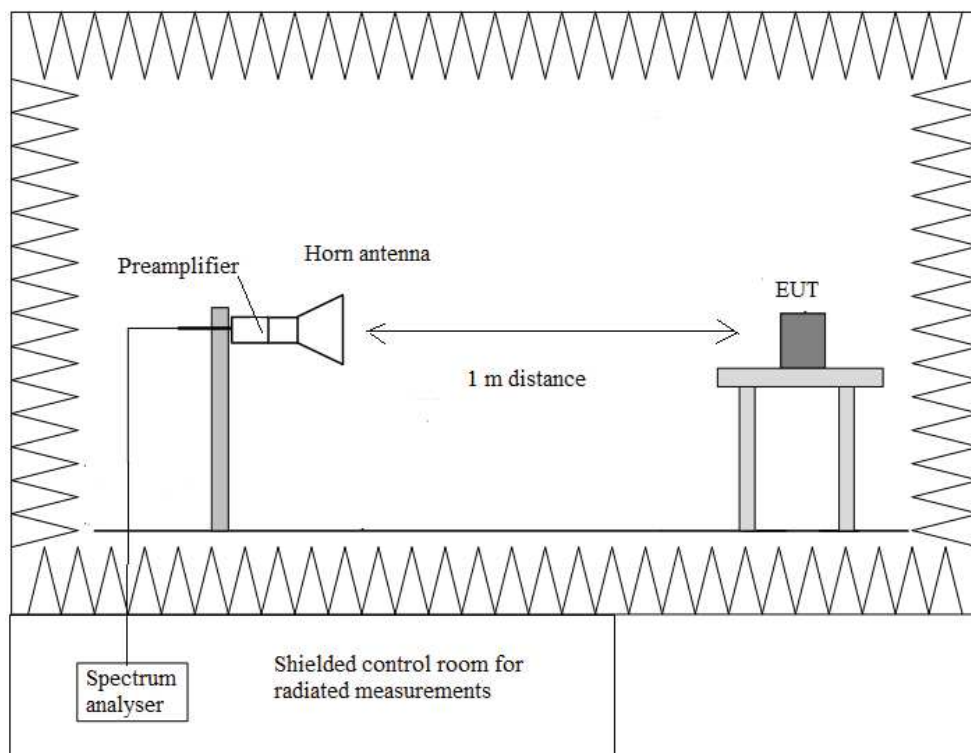
Radiated measurements setup from 30 MHz to 1 GHz:



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	10.900000	10.900000
Measurement uncertainty (%)	<± 1.40		

- **Mode 802.11 g:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% Bandwidth (MHz)	16.500000	16.600000	16.500000
Measurement uncertainty (%)	<± 1.40		

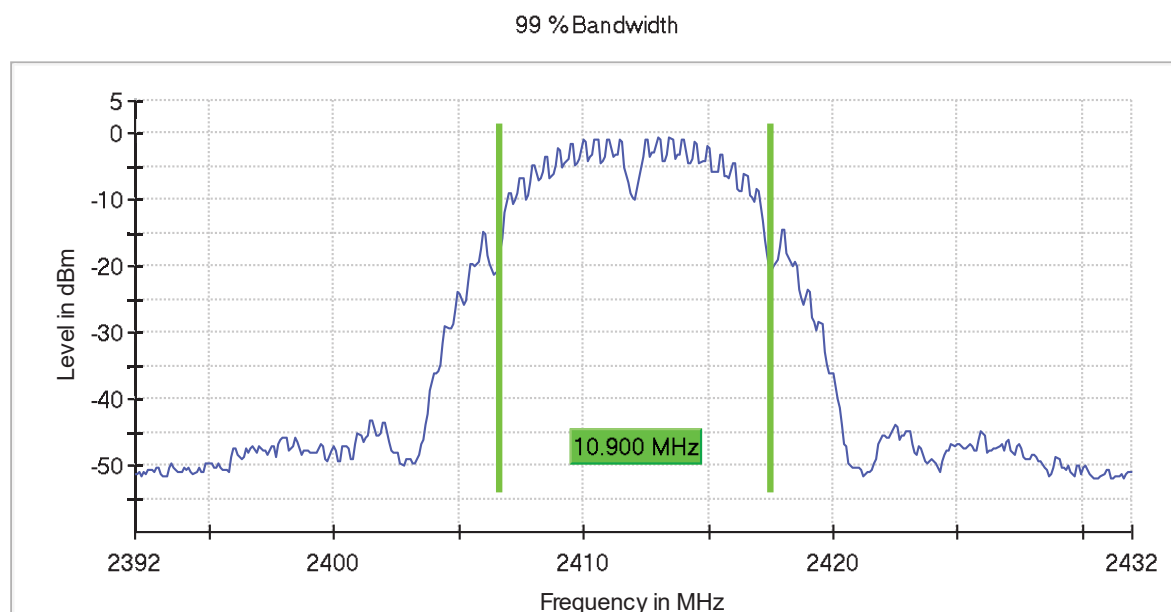
- **Mode 802.11 n20:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
99% Bandwidth (MHz)	17.700000	17.900000	17.900000
Measurement uncertainty (%)	<± 1.40		

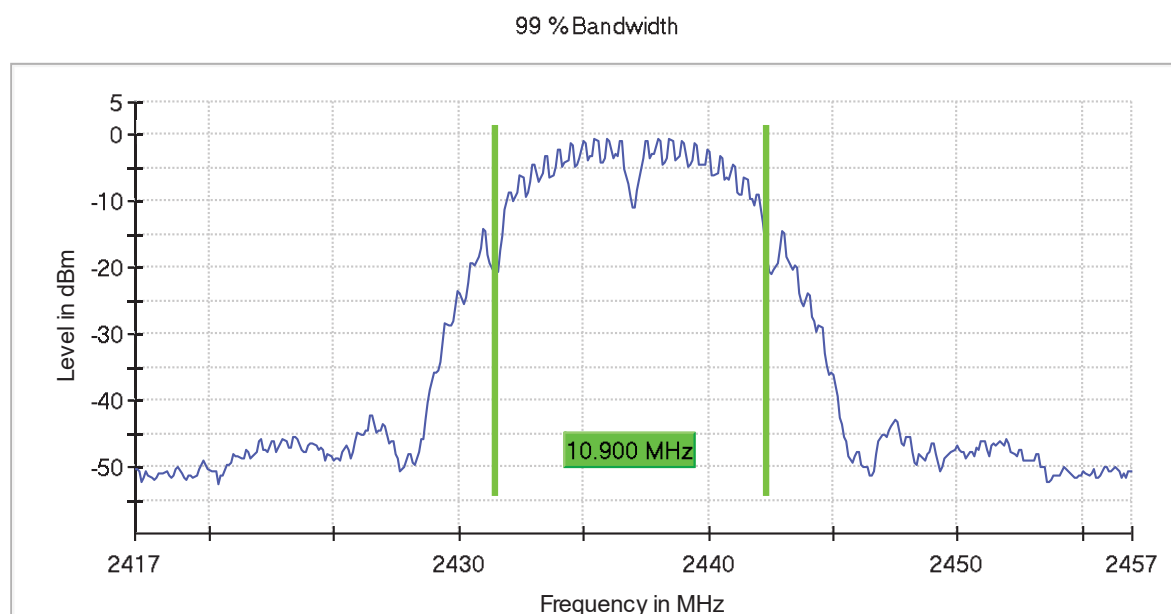
Verdict: PASS

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

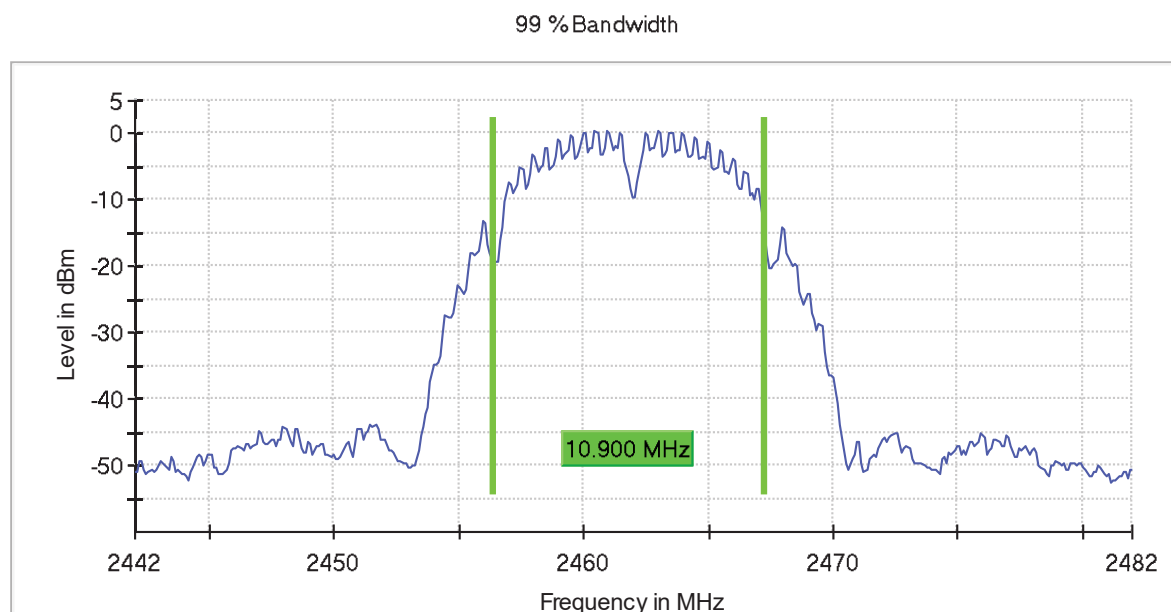
- Low Channel:



- Middle Channel:

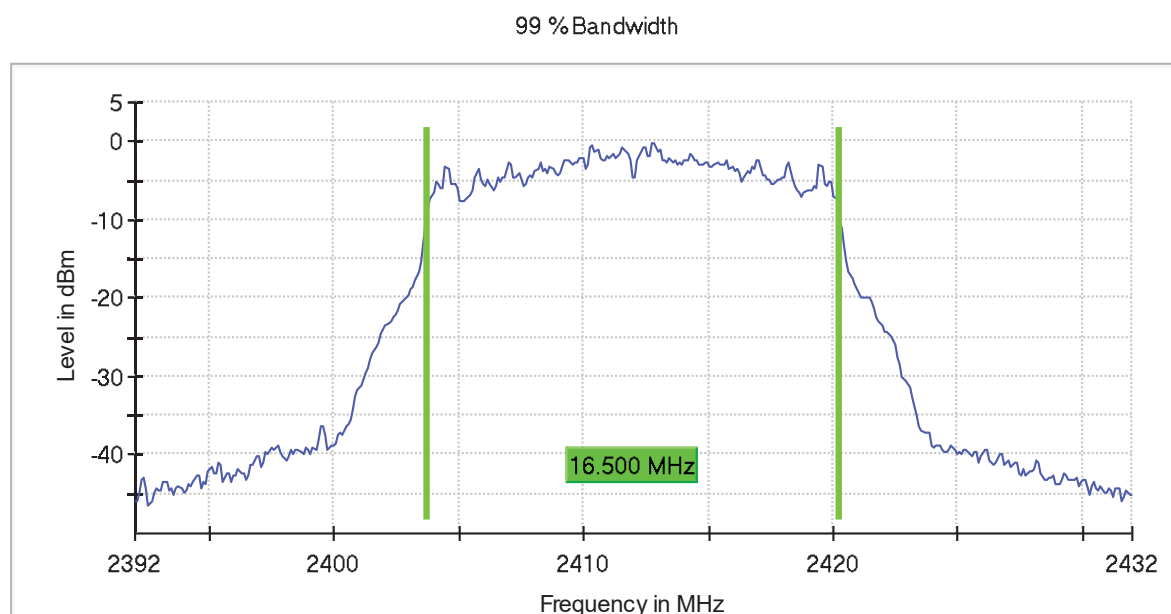


- High Channel:

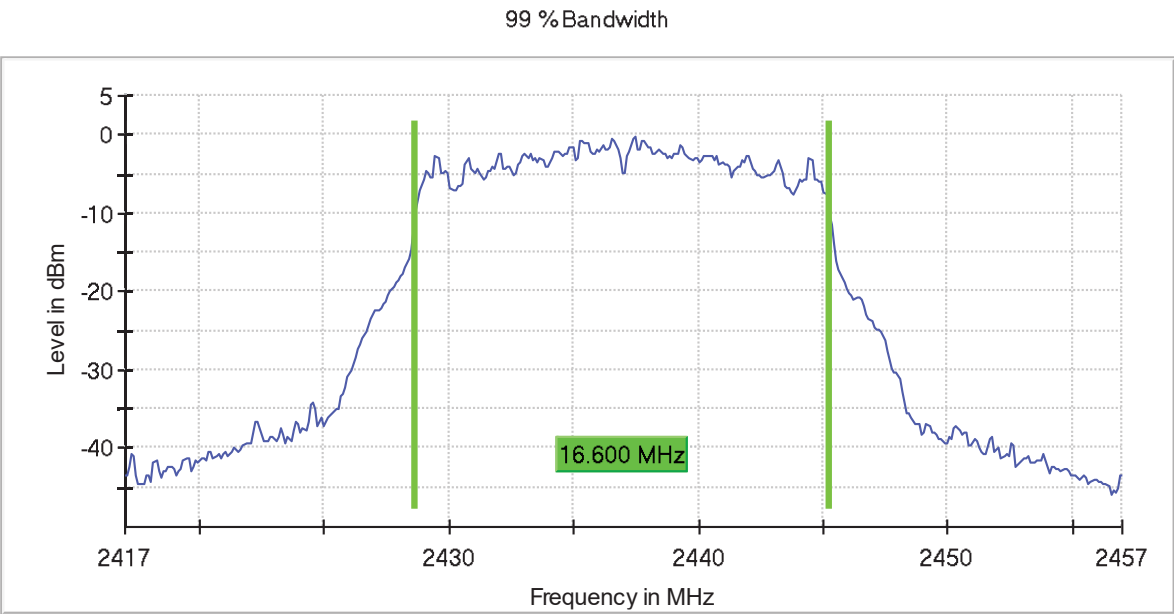


- **Mode 802.11 g – Occupied Bandwidth:**

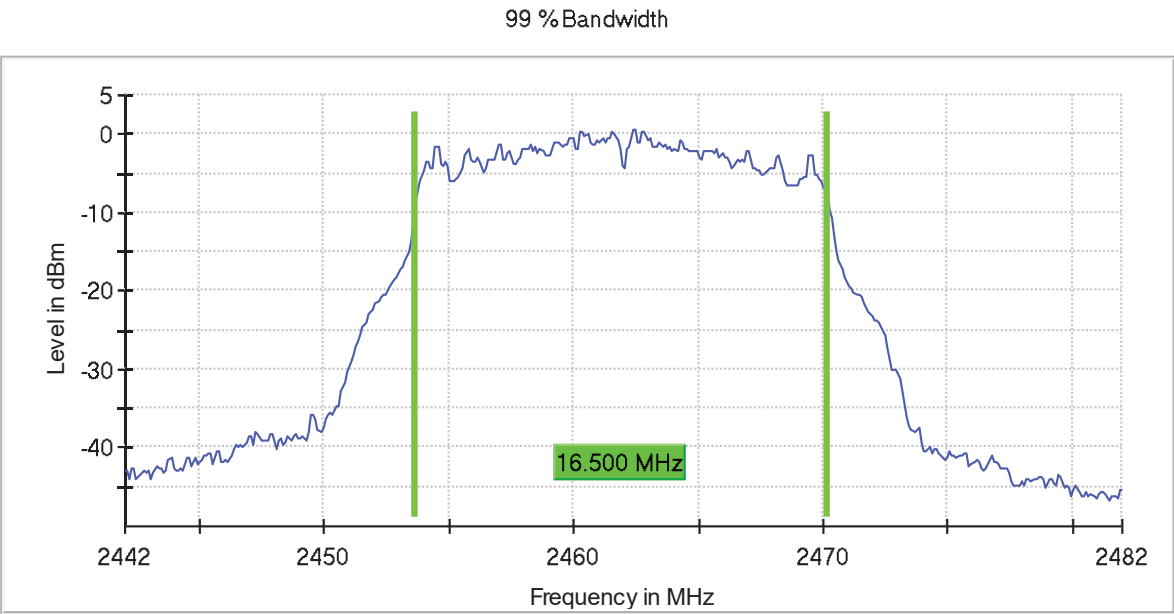
- Low Channel:



- Middle Channel:



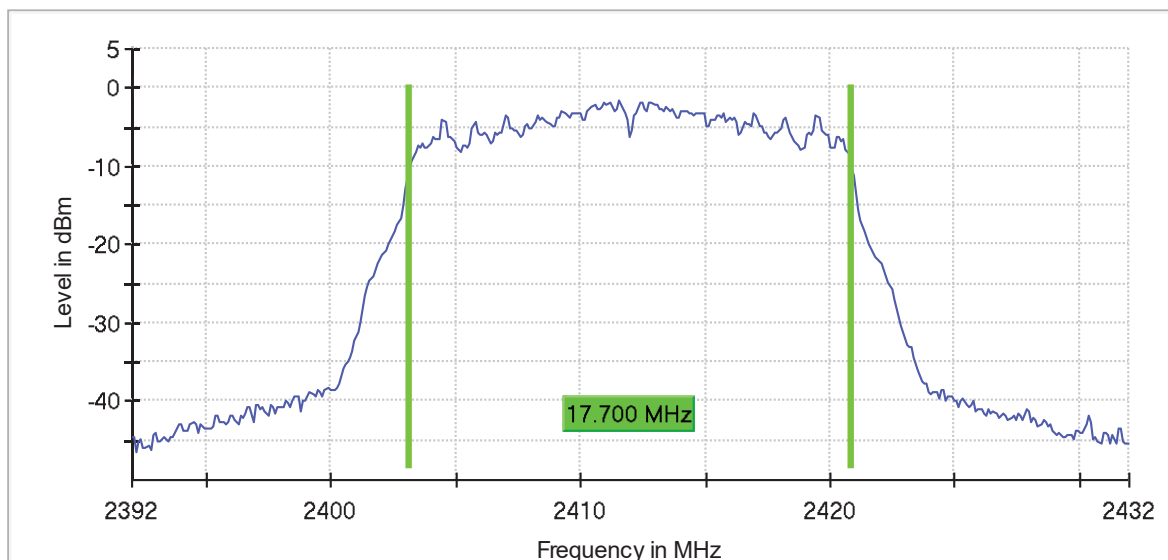
- High Channel:



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

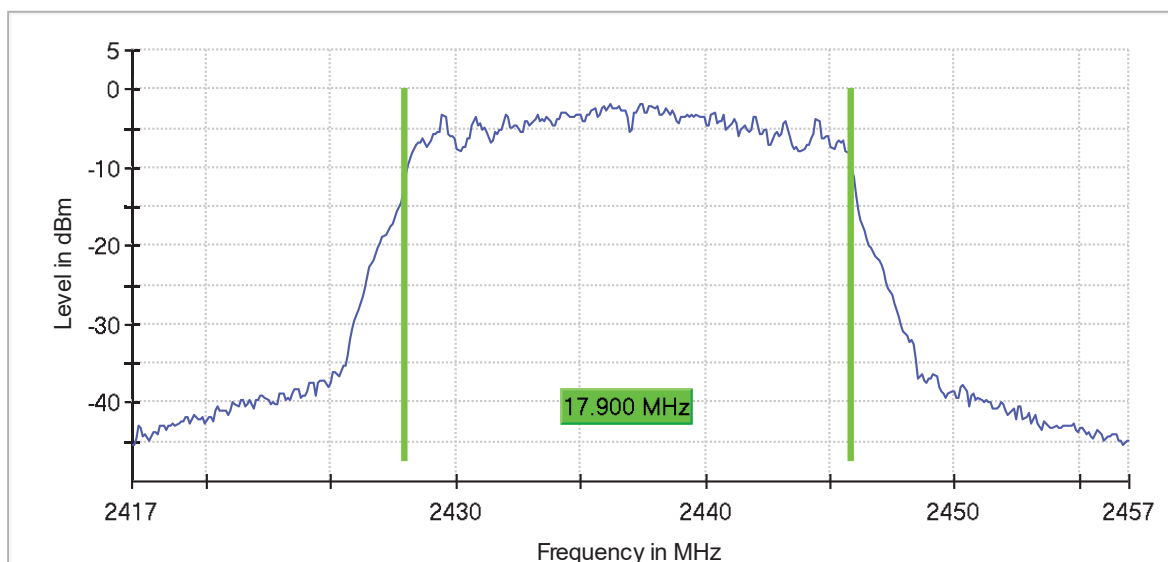
- Low Channel:

99 % Bandwidth

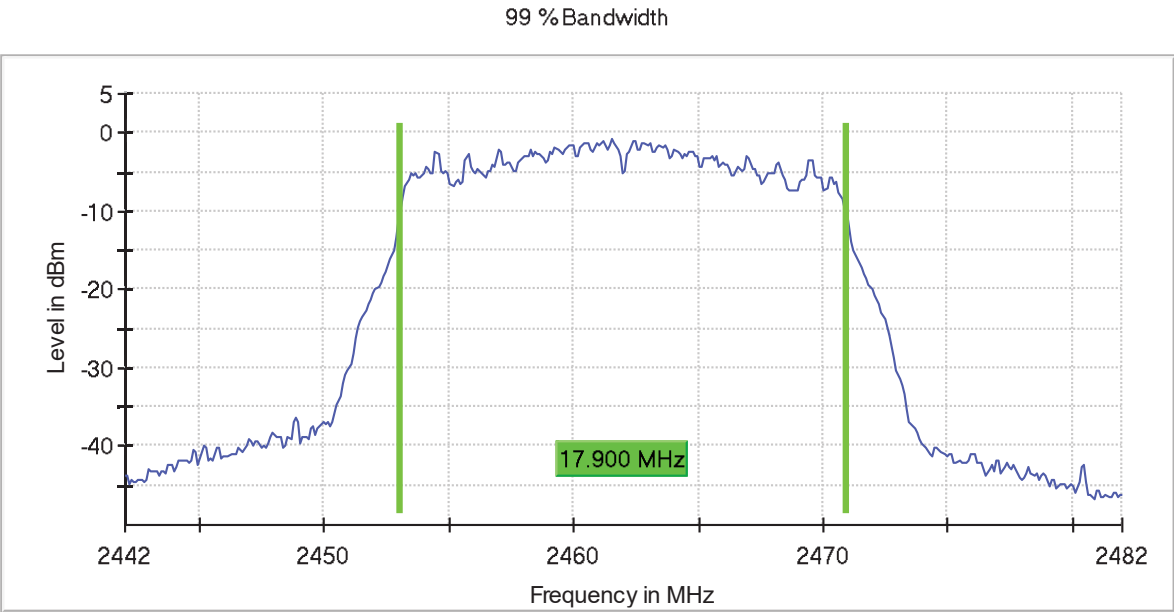


- Middle Channel:

99 % Bandwidth



- 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 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum Bandwidth (MHz)	9.150000	9.100000	8.650000
Measurement uncertainty (%)	<± 1.14		

- Mode 802.11 g:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum Bandwidth (MHz)	16.100000	16.400000	16.150000
Measurement uncertainty (%)	<± 1.14		

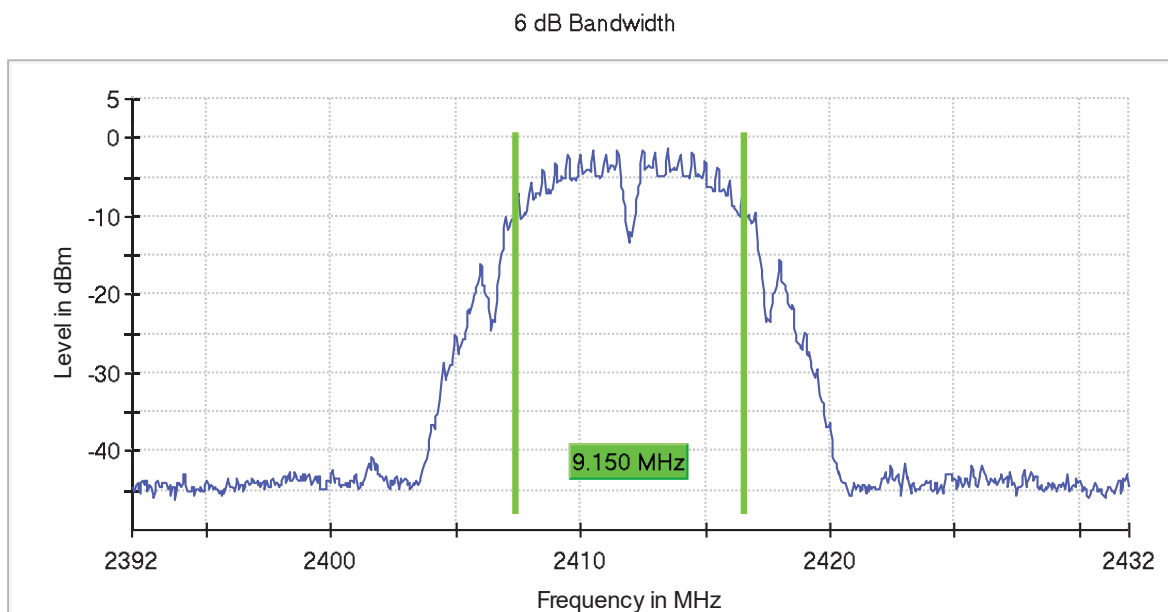
- Mode 802.11 n20:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
6 dB Spectrum Bandwidth (MHz)	17.350000	17.400000	17.250000
Measurement uncertainty (%)	<± 1.14		

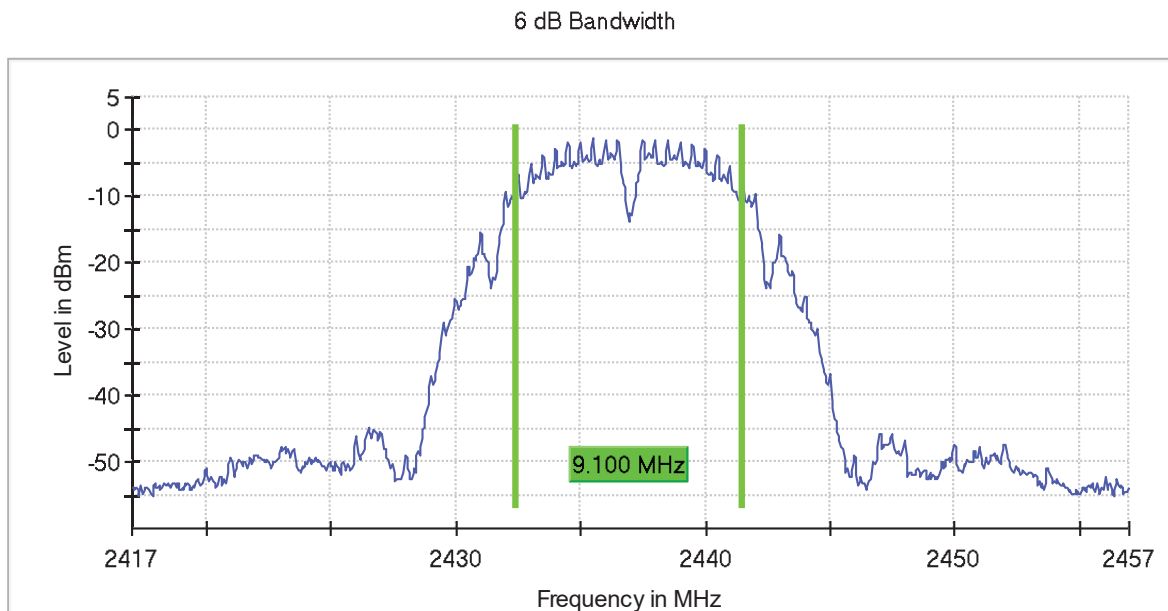
Verdict: PASS

- **Mode 802.11 b – 6 dB Bandwidth:**

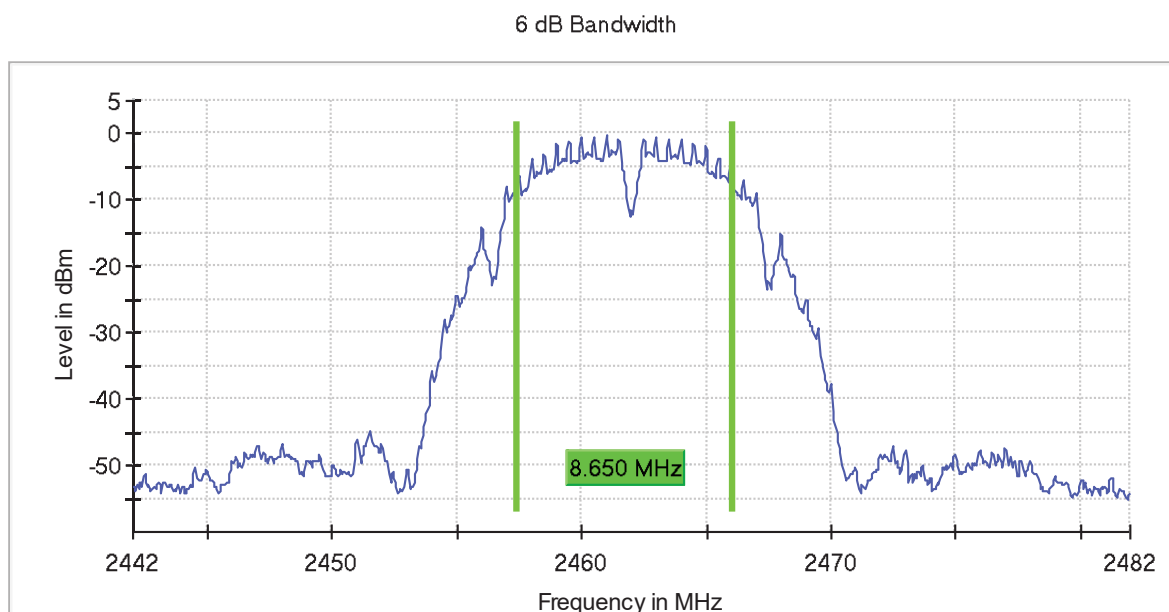
- Low Channel:



- Middle Channel:



- High Channel:

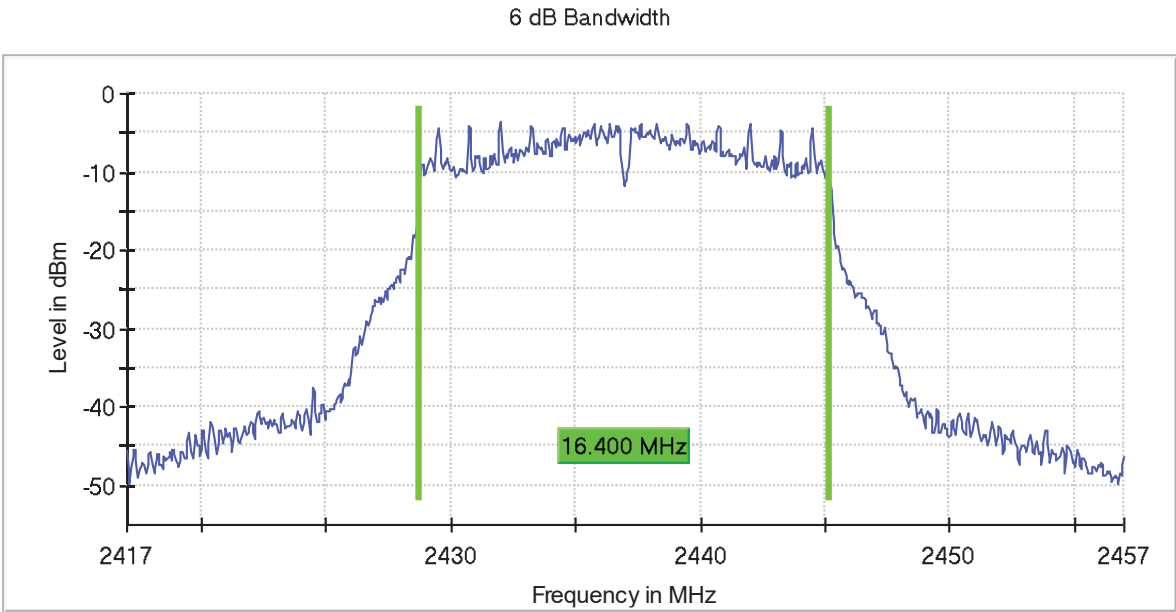


• **Mode 802.11 g – 6 dB Bandwidth:**

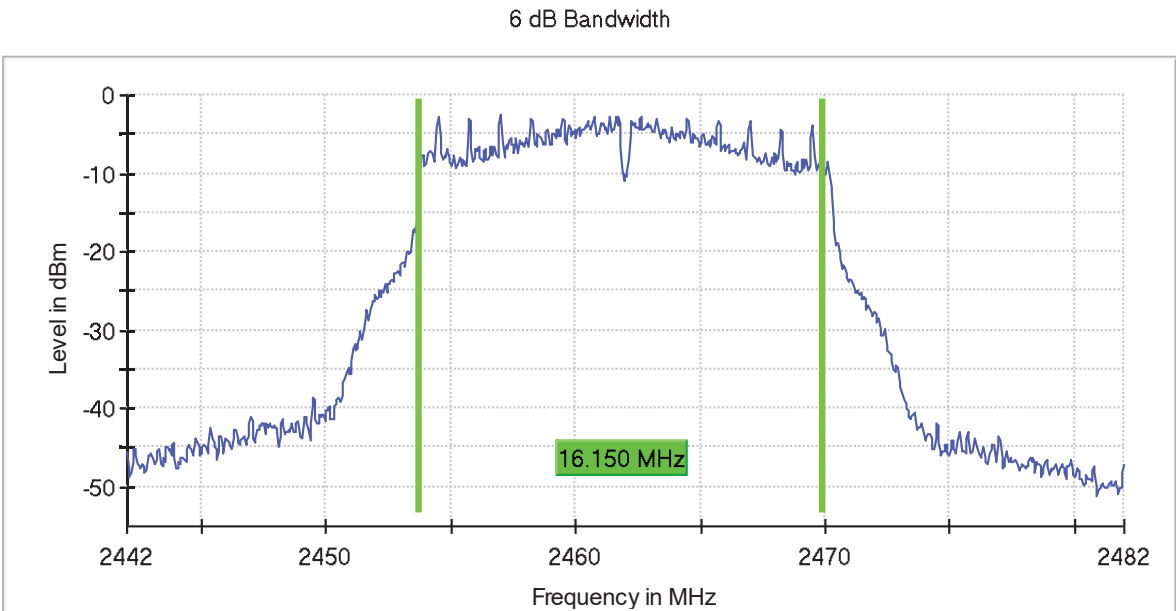
- Low Channel:



- Middle Channel:

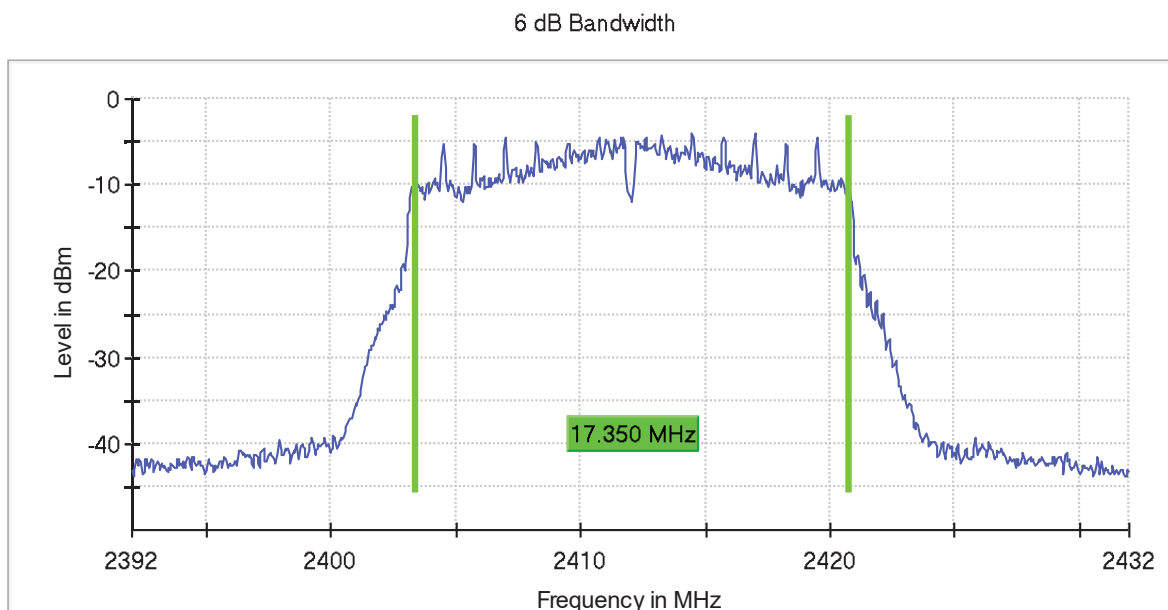


- High Channel:

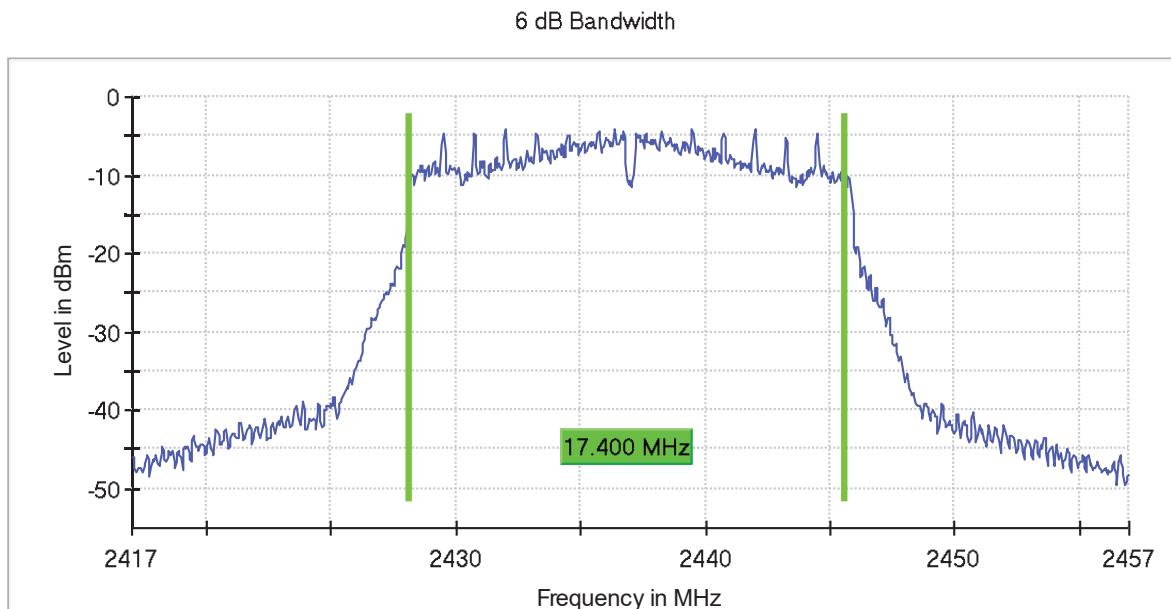


- **Mode 802.11 n20 – 6 dB Bandwidth:**

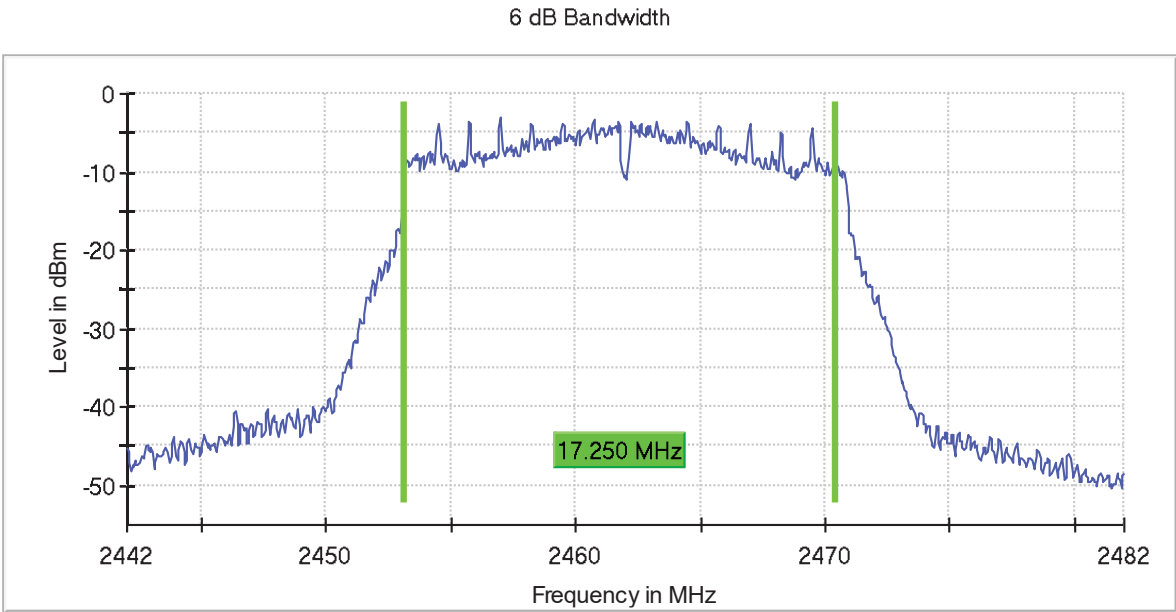
- Low Channel:



- Middle Channel:



- High Channel:



FCC 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: +2.2 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 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Average Conducted Power (dBm)	7.0	7.2	8.4
Maximum EIRP Power (dBm)	9.2	9.4	10.6
Measurement uncertainty (dB)	<±0.99		

- Mode 802.11 g:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Average Conducted Power (dBm)	7.9	8.1	9.2
Maximum EIRP Power (dBm)	10.1	10.3	11.4
Measurement uncertainty (dB)	<±0.99		

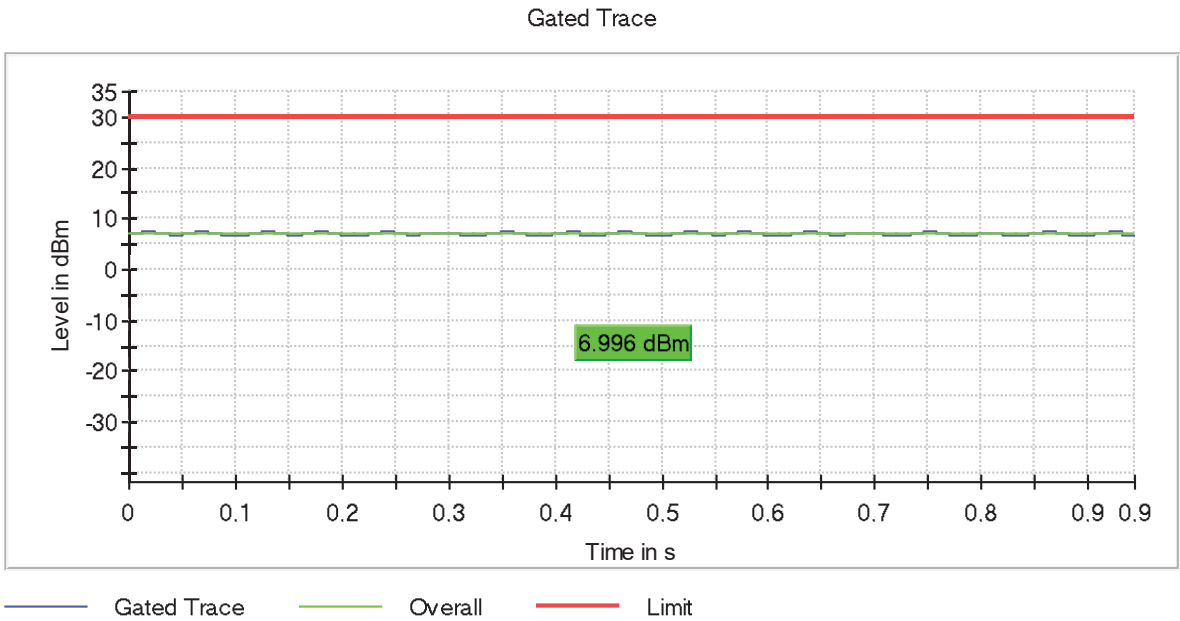
- Mode 802.11 n20:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Maximum Average Conducted Power (dBm)	7.2	7.5	8.3
Maximum EIRP Power (dBm)	9.4	9.7	10.5
Measurement uncertainty (dB)	<±0.99		

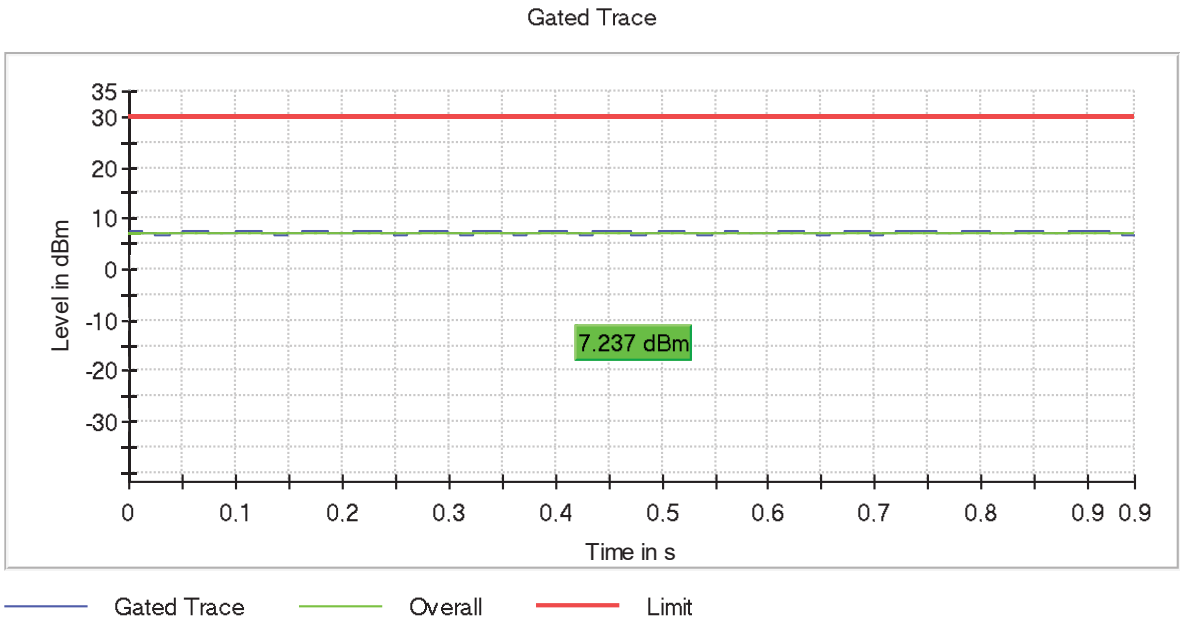
Verdict: PASS

• Mode 802.11 b:

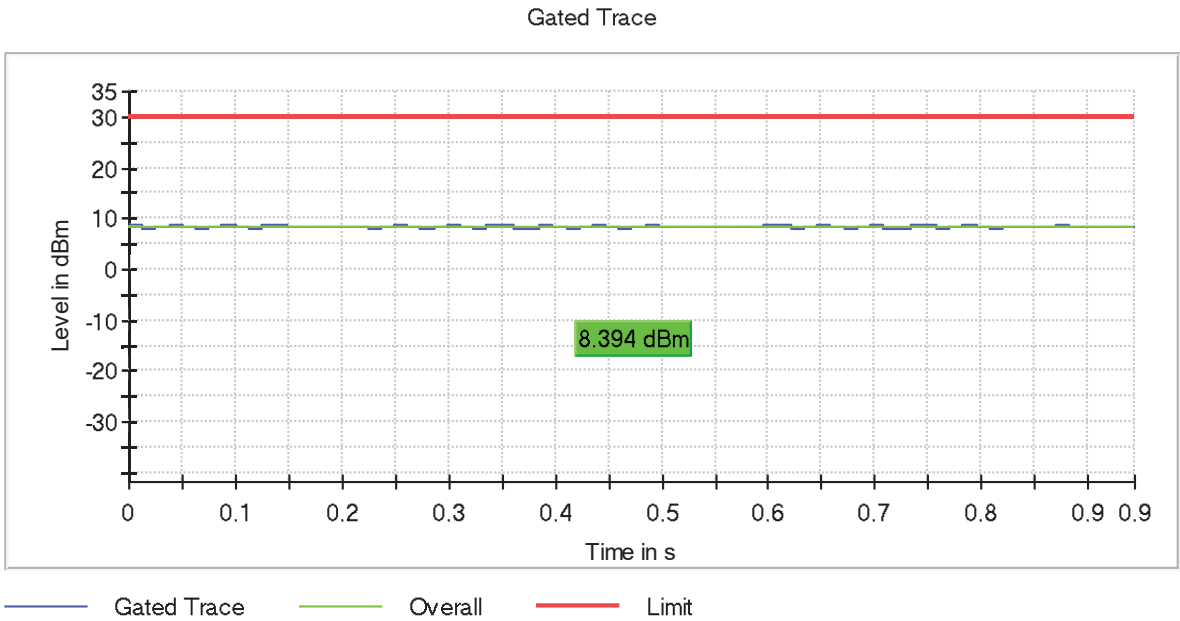
- Low Channel:



- Middle Channel:

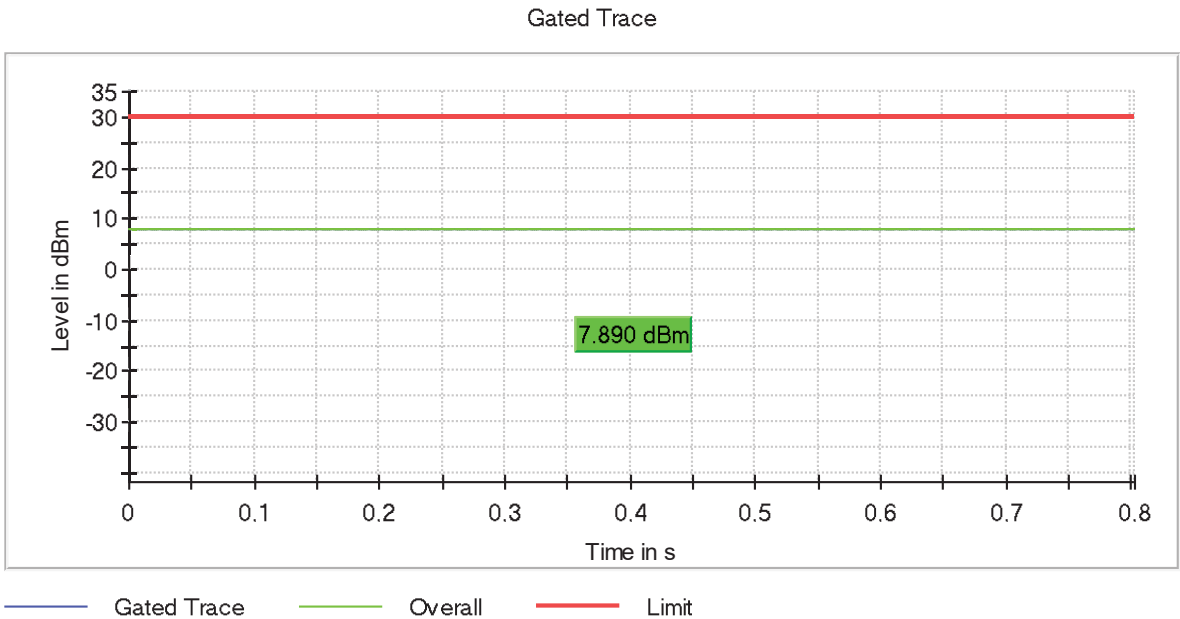


- High Channel:

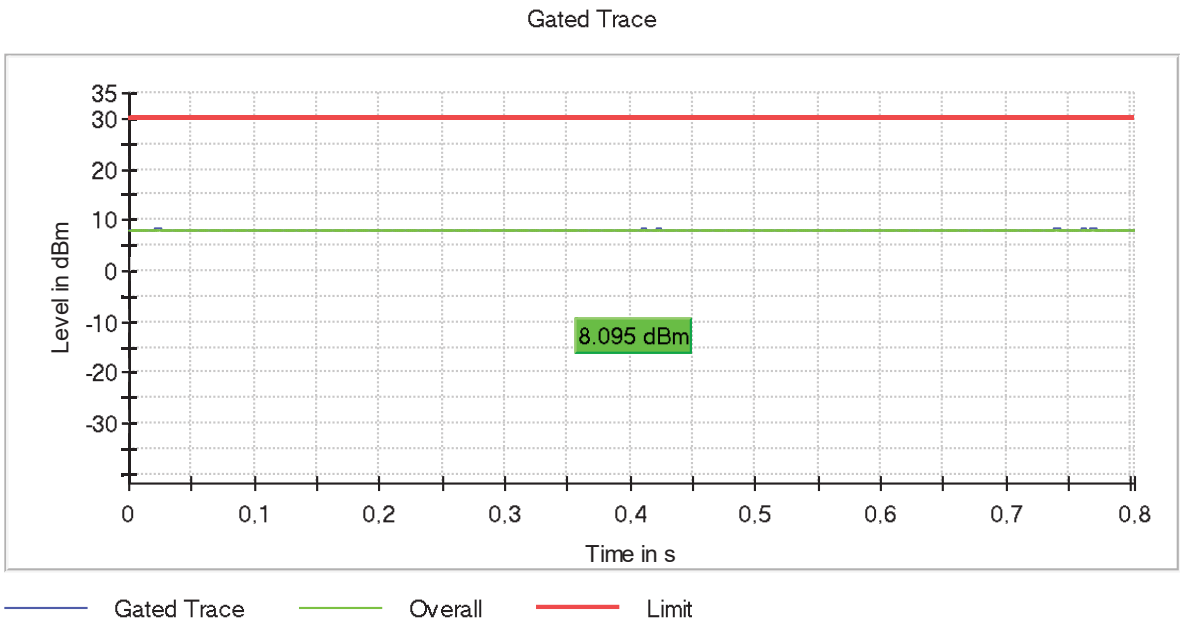


- **Mode 802.11 g:**

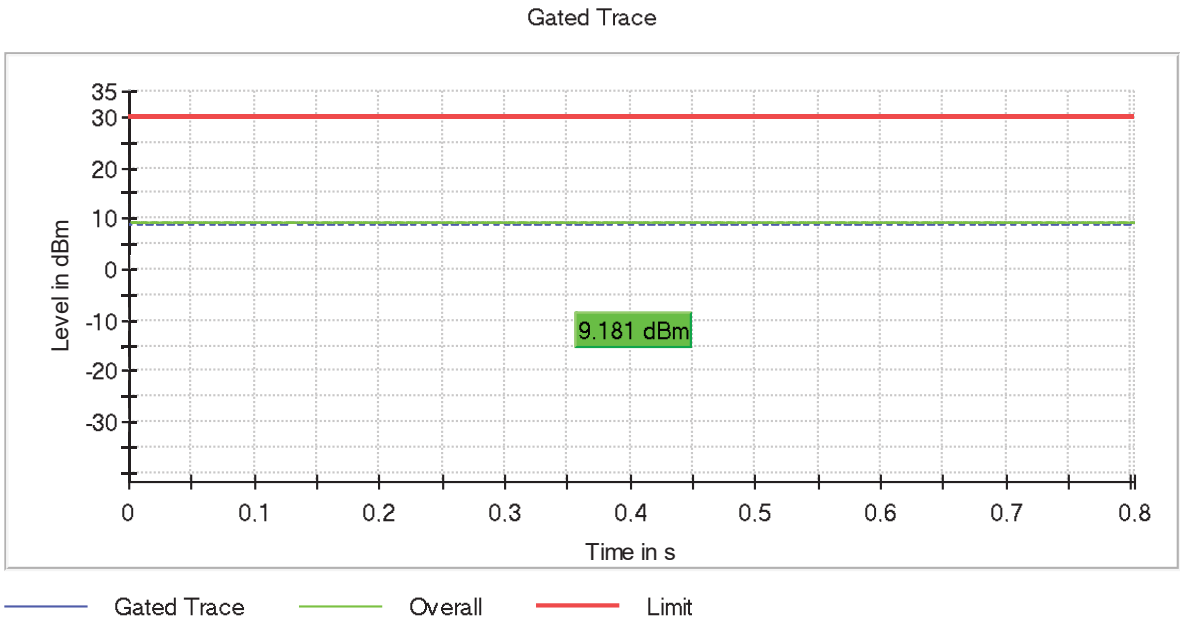
- Low Channel:



- Middle Channel:

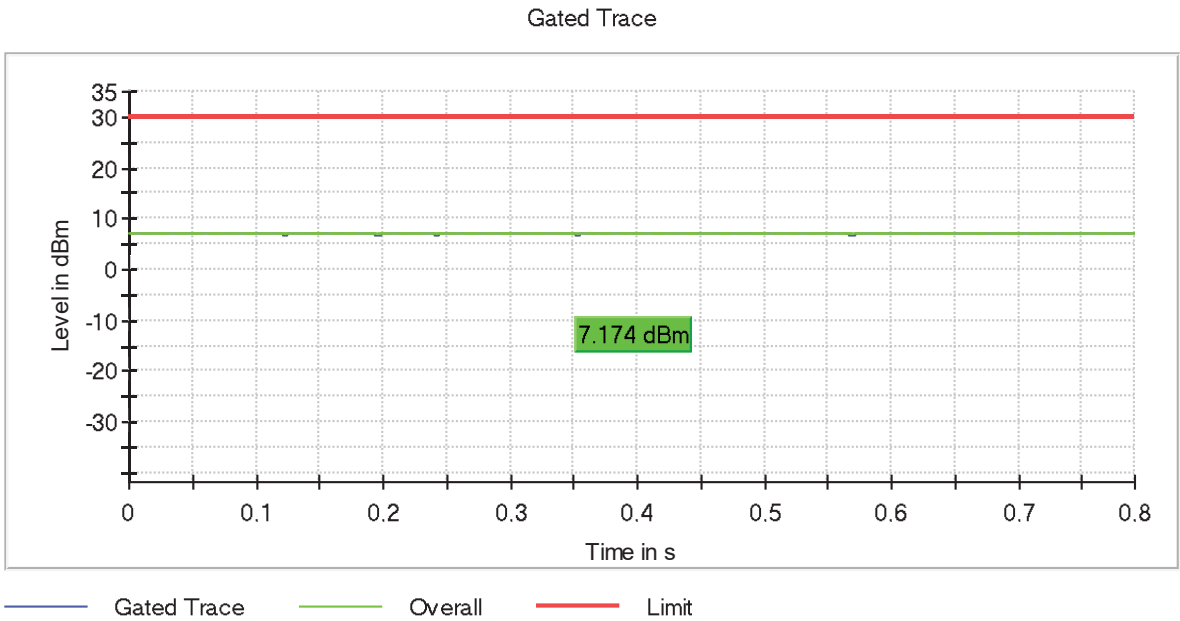


- High Channel:

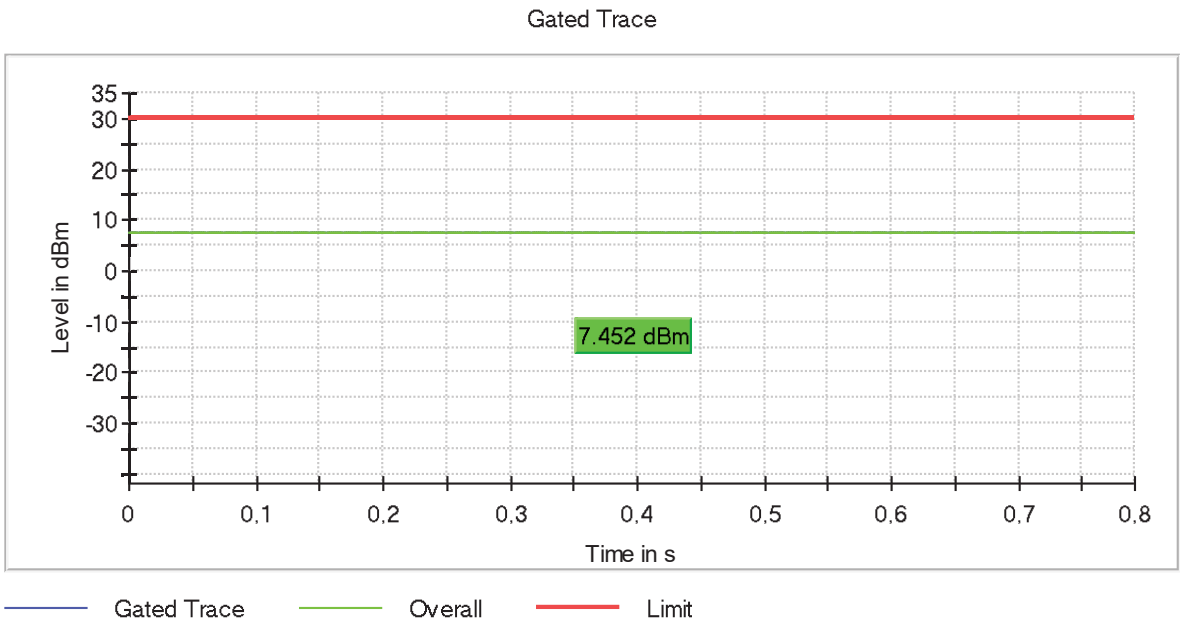


• **Mode 802.11 n20:**

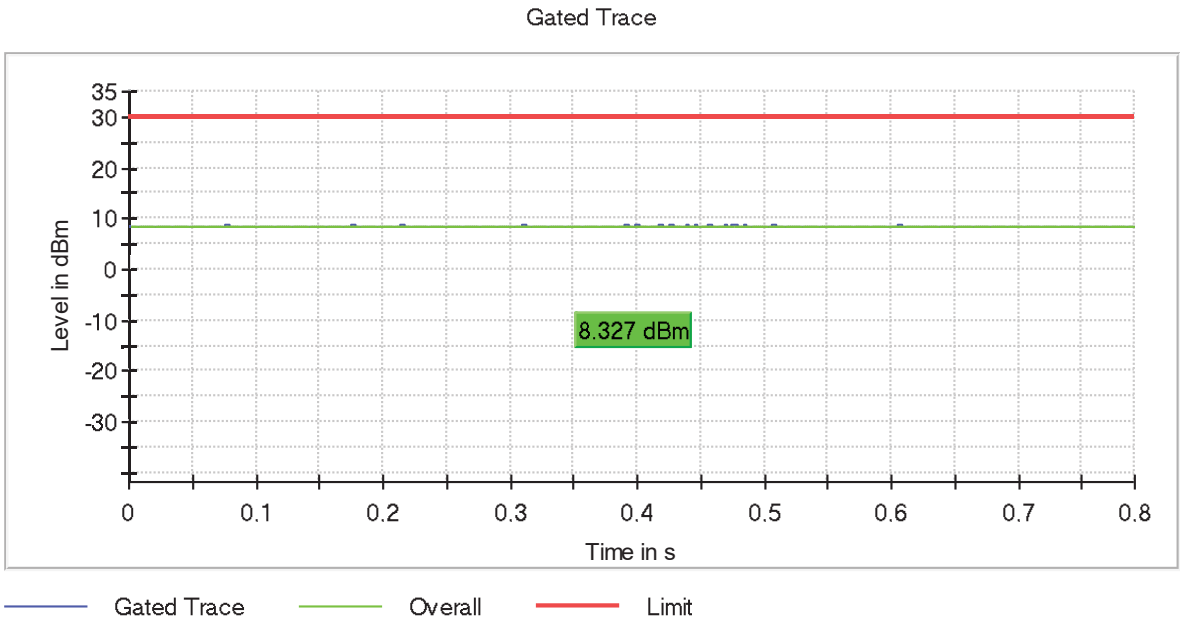
- Low Channel:



- 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.

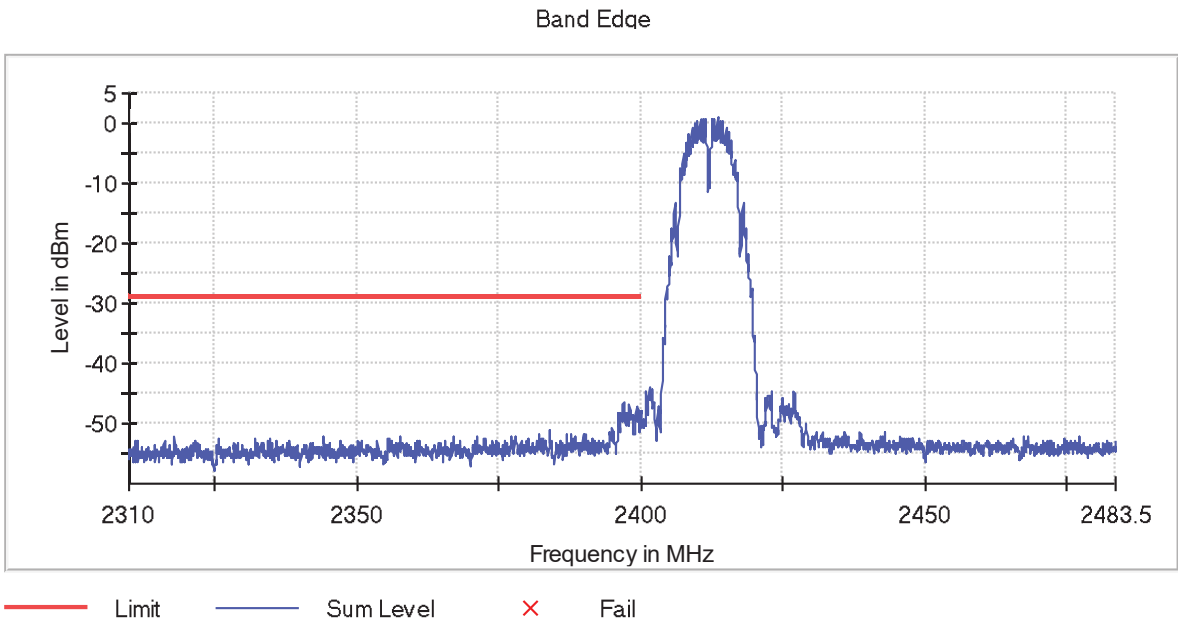
RESULTS:

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)	<±1.53
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• Mode 802.11 b – Band-edge emissions compliance:

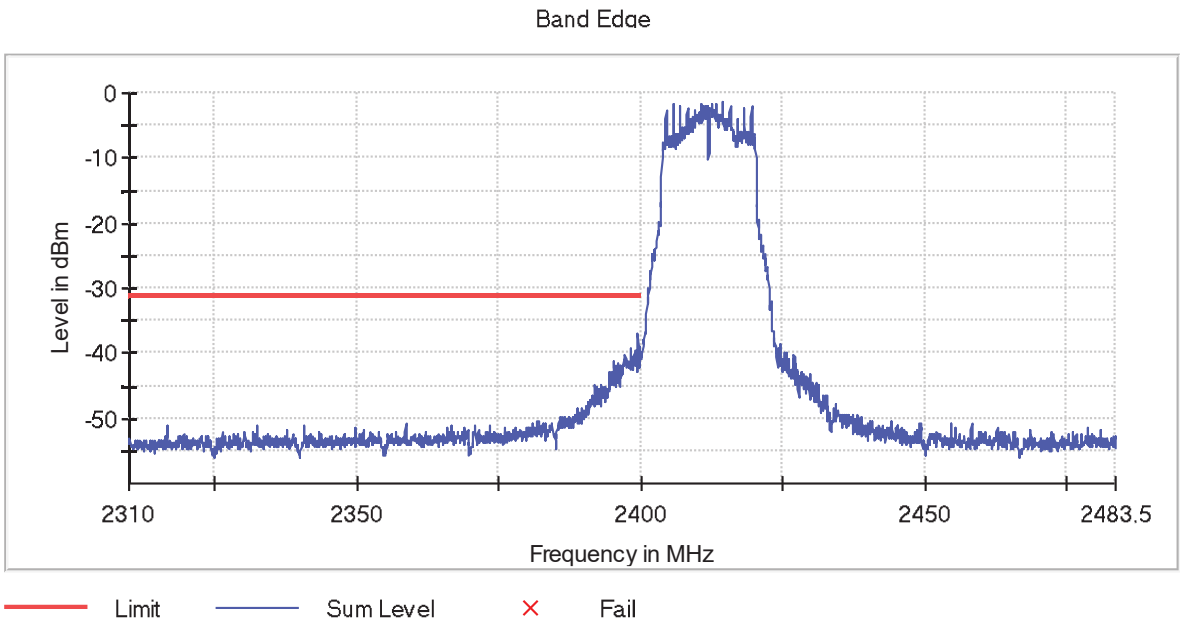
- Low Channel:



Verdict: PASS

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

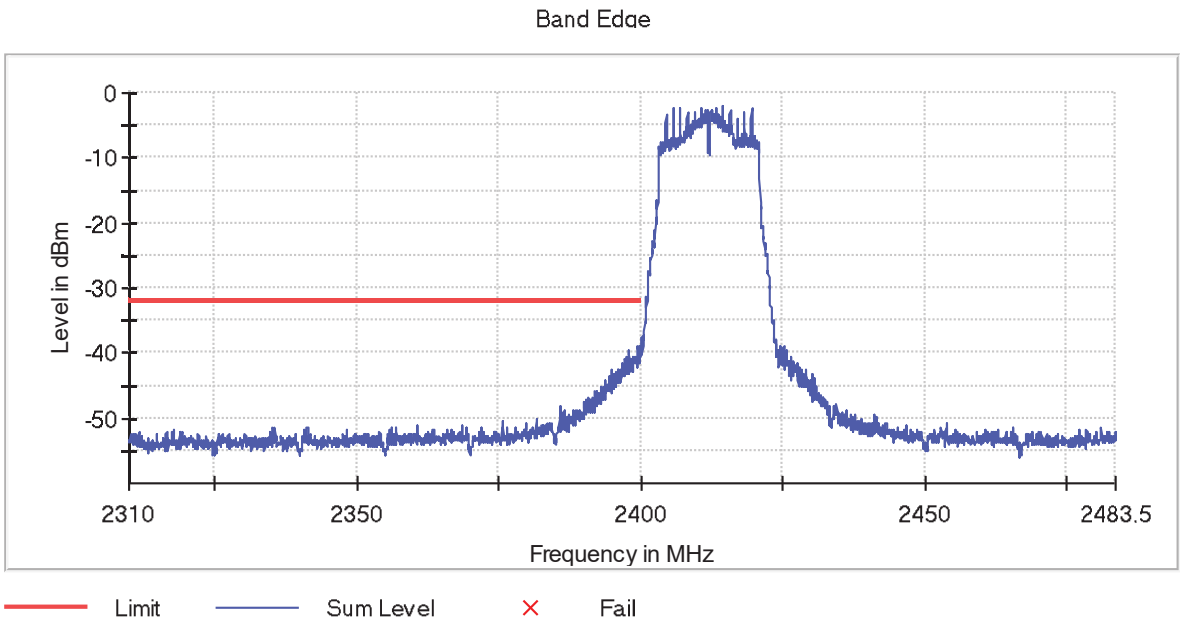
- Low Channel:



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 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Average Power Spectral Density (dBm)	-9.874	-9.807	-8.721
Measurement uncertainty (dB)	<±0.99		

- **Mode 802.11 g:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Average Power Spectral Density (dBm)	-10.175	-9.856	-9.290
Measurement uncertainty (dB)	<±0.99		

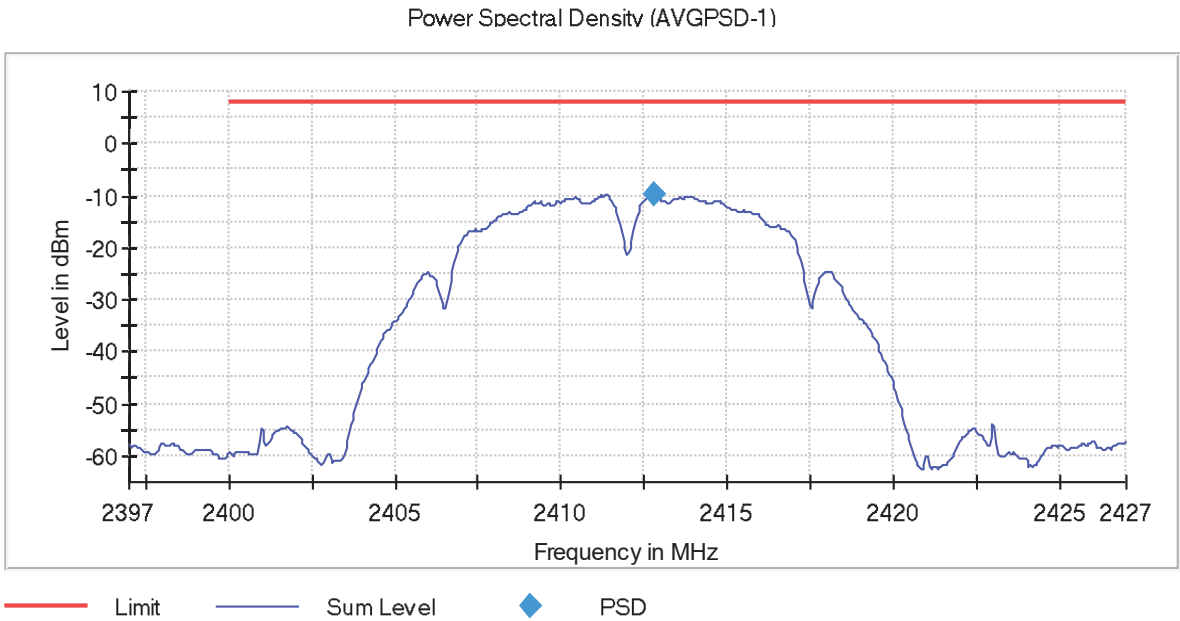
- **Mode 802.11 n20:**

	Low Channel 2412 MHz	Middle Channel 2437 MHz	High Channel 2462 MHz
Average Power Spectral Density (dBm)	-11.593	-11.208	-10.413
Measurement uncertainty (dB)	<±0.99		

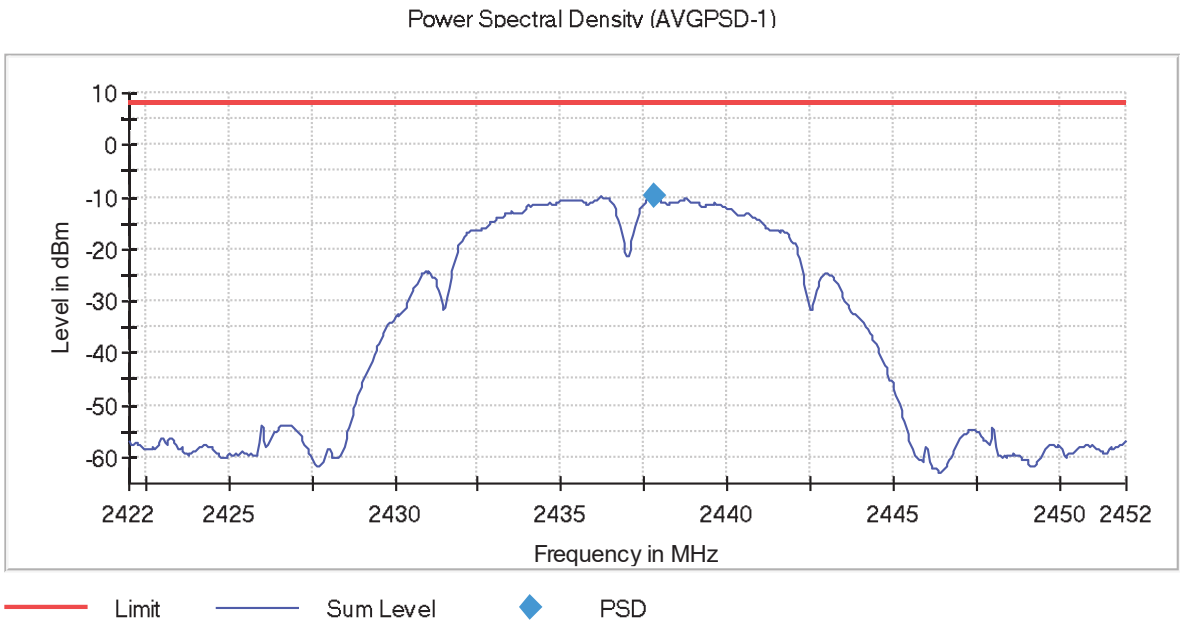
Verdict: PASS

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

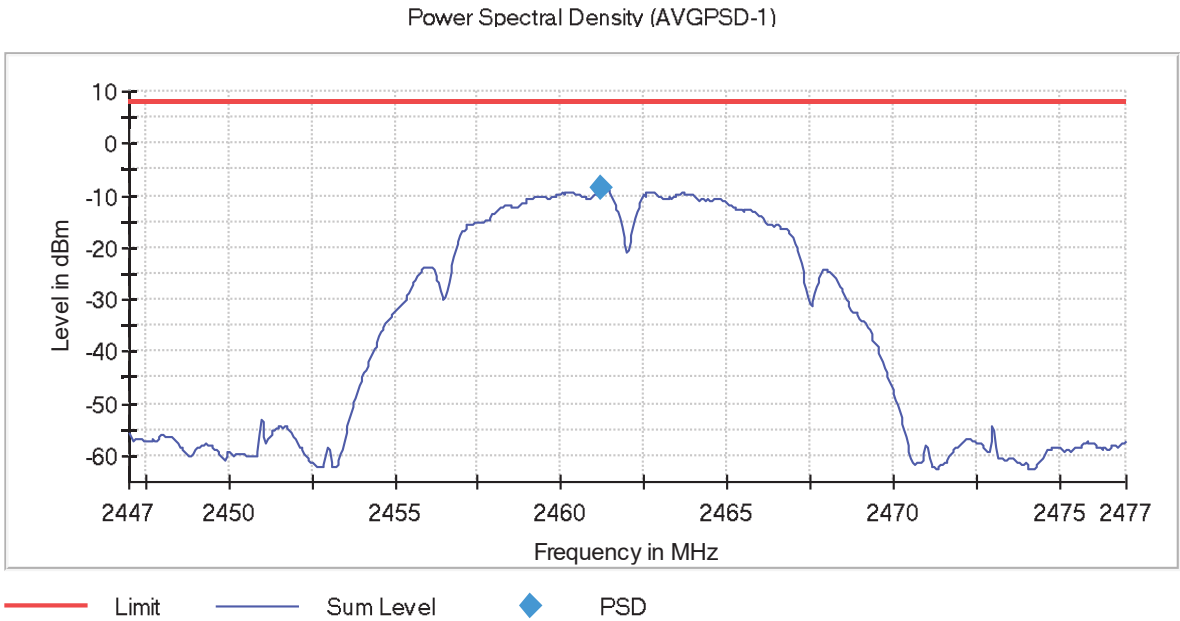
- Low Channel:



- Middle Channel:

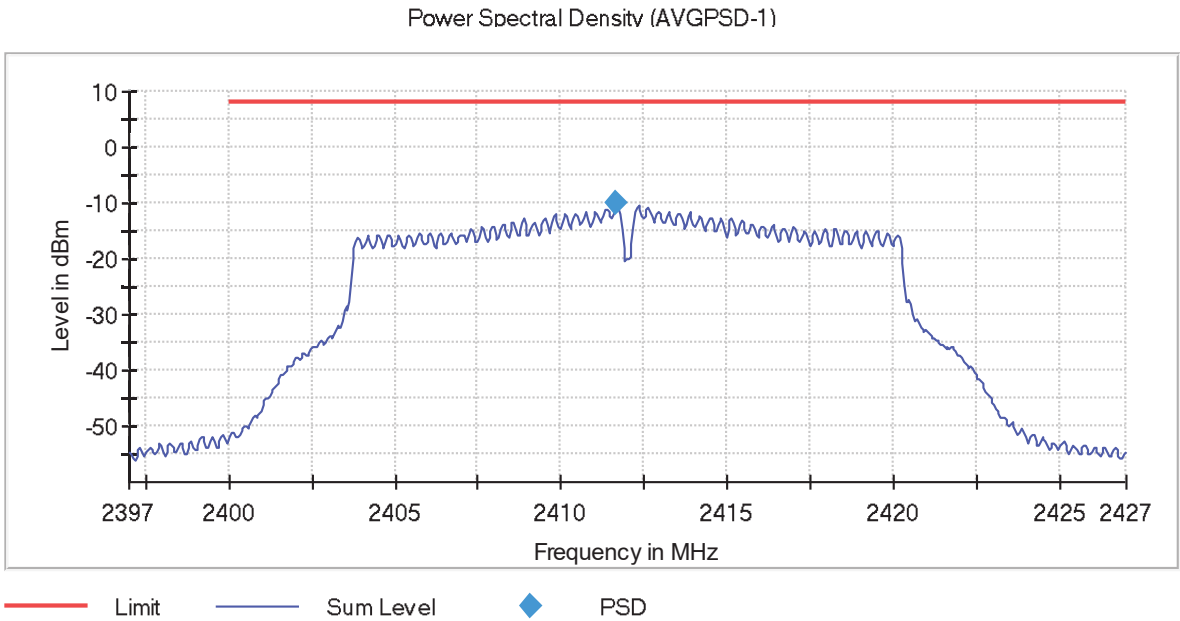


- High Channel:

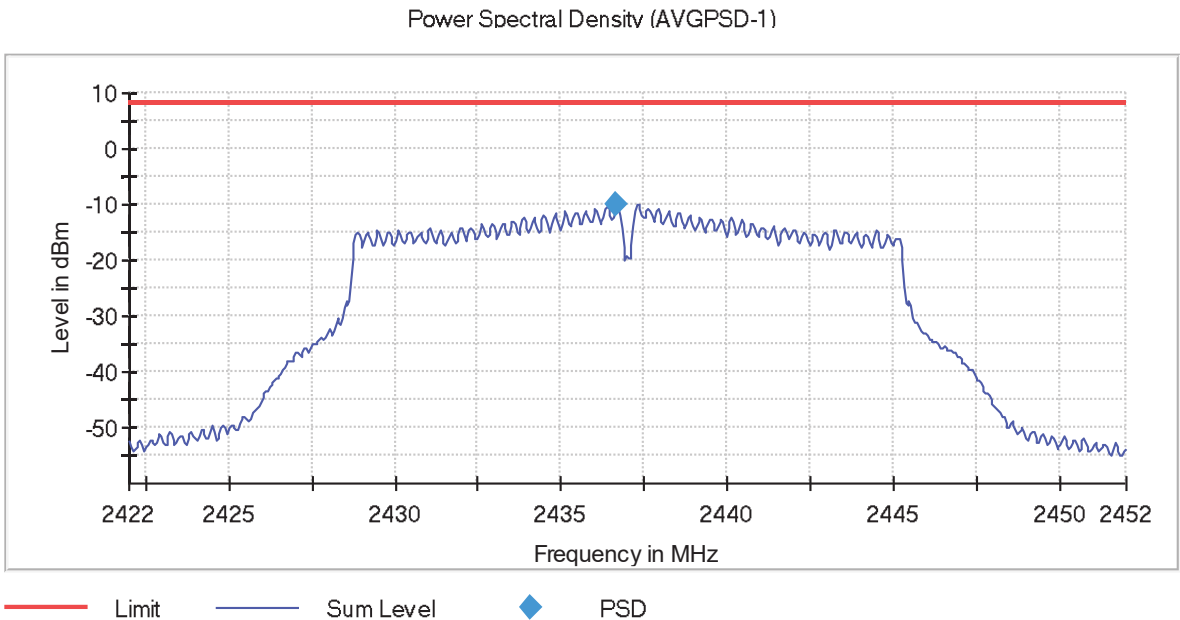


• Mode 802.11 g – Power Spectral Density:

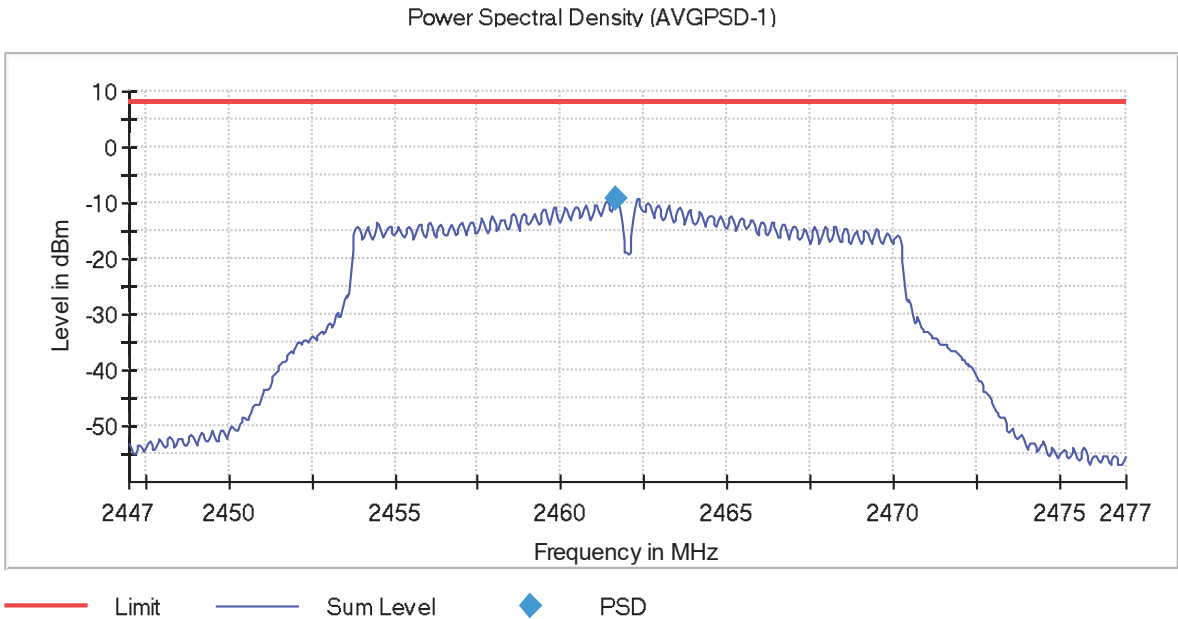
- Low Channel:



- Middle Channel:

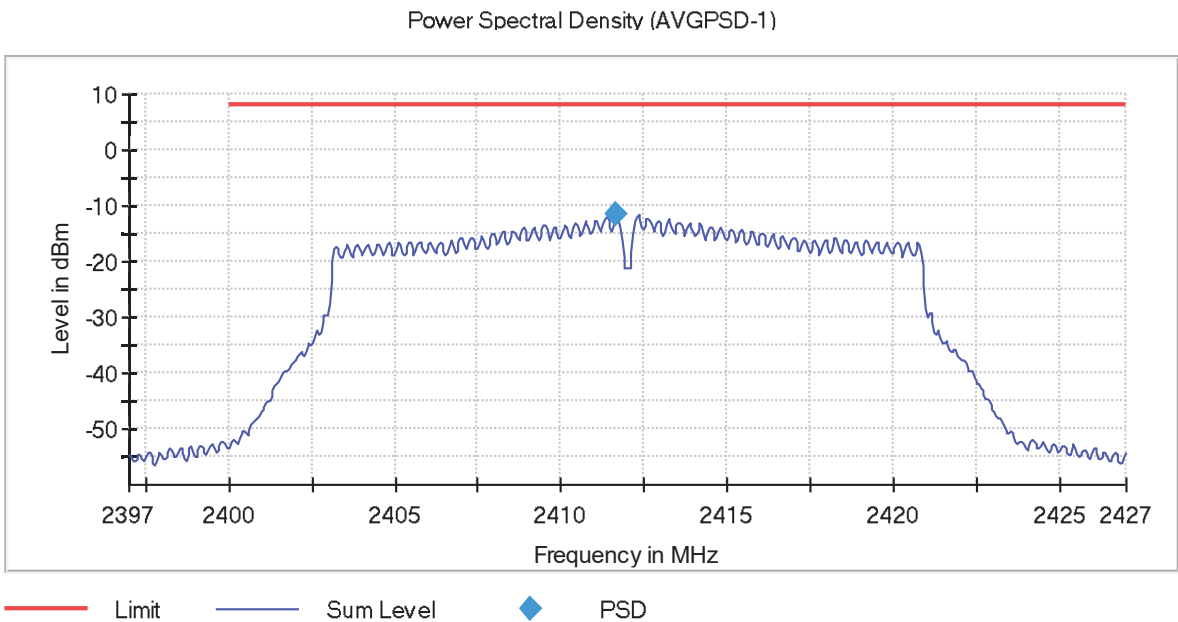


- High Channel:

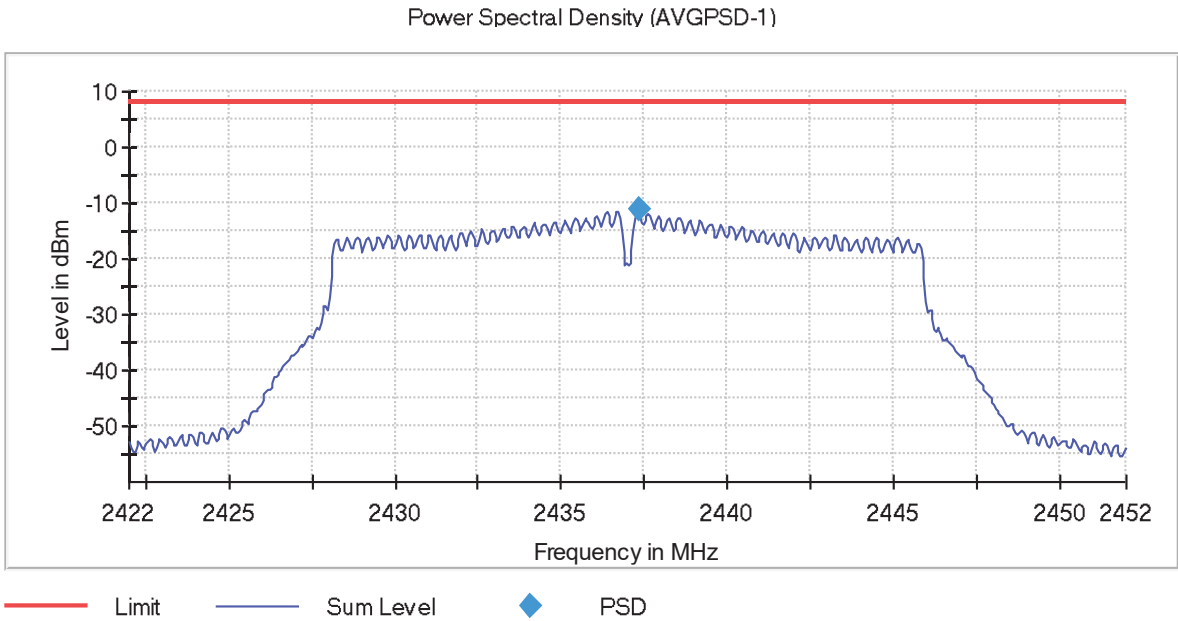


• Mode 802.11 n20 – Power Spectral Density:

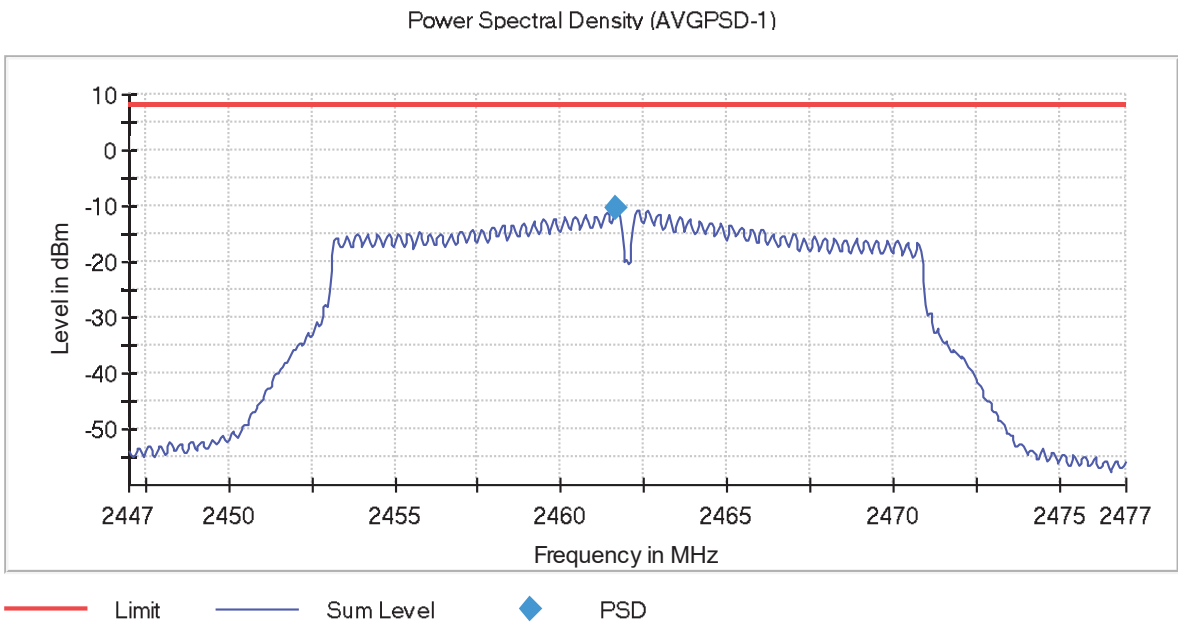
- Low Channel:



- 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 360° 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)
786.4545	30.84	H	Quasi-peak	<± 5.17
884.764	32.23	V	Quasi-peak	<± 5.17

- **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)
5.3410	43.84	H	Peak	<± 5.13
5.3735	46.57	V	Peak	<± 5.13

- **MIDDLE CHANNEL.** Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.3410	42.65	H	Peak	<± 5.13
5.3745	44.56	V	Peak	<± 5.13

- **HIGH CHANNEL.** Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.3410	43.13	V	Peak	<± 5.13
5.3745	44.89	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. LOW CHANNEL.** No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB): 1 GHz ≤ f ≤ 3 GHz: <± 4.11
3 GHz < f ≤ 17 GHz: <± 5.13
17 GHz < f ≤ 26 GHz: <± 4.81

Verdict: PASS

OFDM modes:

For spurious emissions in the range from 30 MHz to 26 GHz (except the field strength at the edges of the band that was performed for all modes) the worst case conducted power and spectral density was measured.

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.**

- **Mode 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.

- **LOW CHANNEL.** Spurious frequencies closest to the limit

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.3425	44.24	H	Peak	<± 5.13
5.3745	45.49	V	Peak	<± 5.13

- **MIDDLE CHANNEL.** Spurious frequencies closest to the limit

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.3415	43.48	V	Peak	<± 5.13
5.3740	44.46	V	Peak	<± 5.13

- **HIGH CHANNEL.** Spurious frequencies closest to the limit

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.3410	42.31	H	Peak	<± 5.13
5.3745	44.83	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 ≤ 3 GHz: <± 4.11
3 GHz < f ≤ 17 GHz: <± 5.13
17 GHz < f ≤ 26 GHz: <± 4.81

Verdict: PASS

- **Mode 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.

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

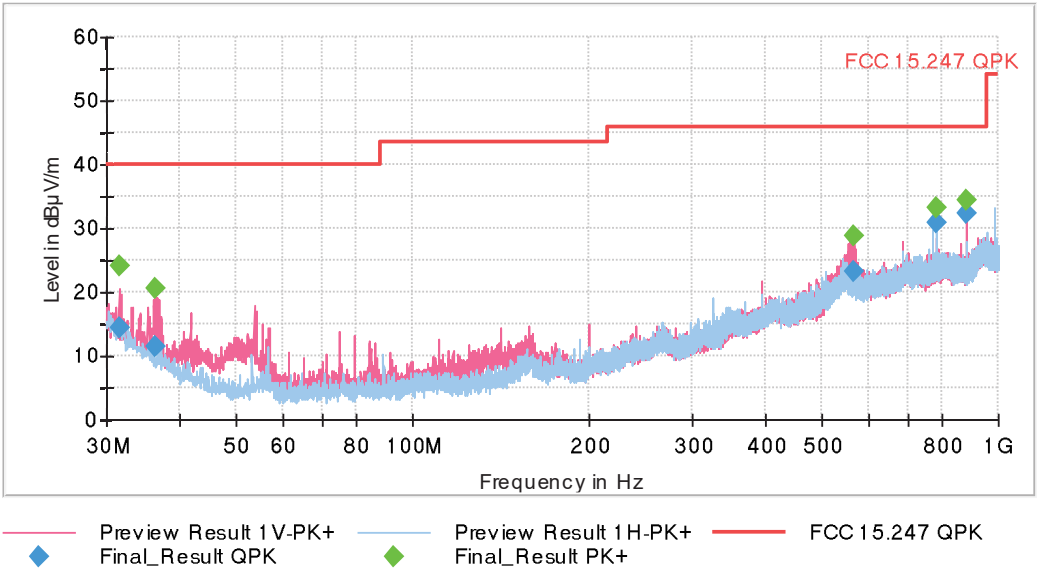
- RESTRICTED BAND 2.4835-2.5 GHz. HIGH CHANNEL. No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB): 1 GHz $\leq$ f $\leq$ 3 GHz: $\leq \pm 4.11$
3 GHz $<$ f $\leq$ 17 GHz: $\leq \pm 5.13$
17 GHz $<$ f $\leq$ 26 GHz: $\leq \pm 4.81$

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

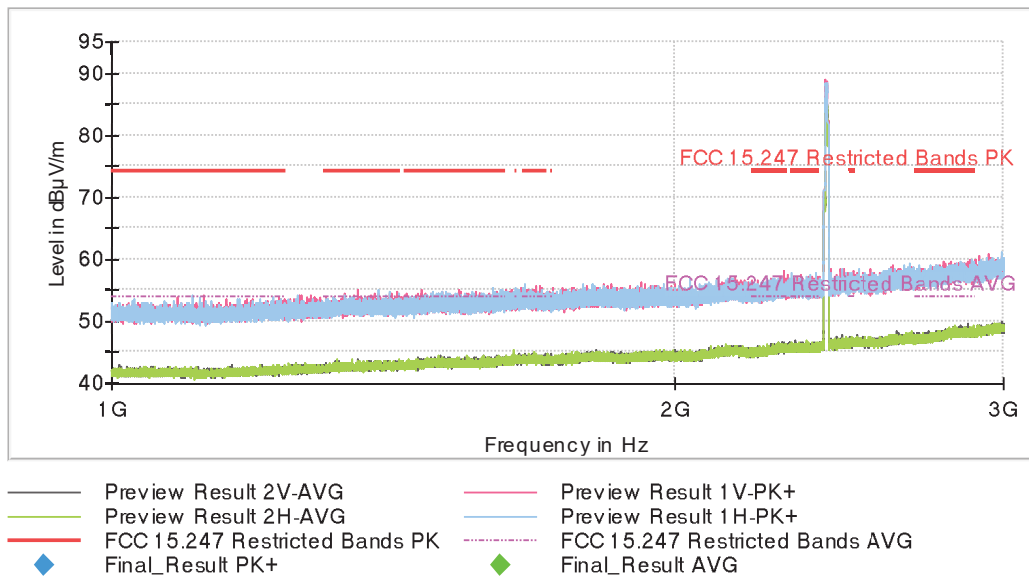
The spurious frequencies detected do not depend neither on the operating channel nor the modulation mode.



• **Mode 802.11 b:**

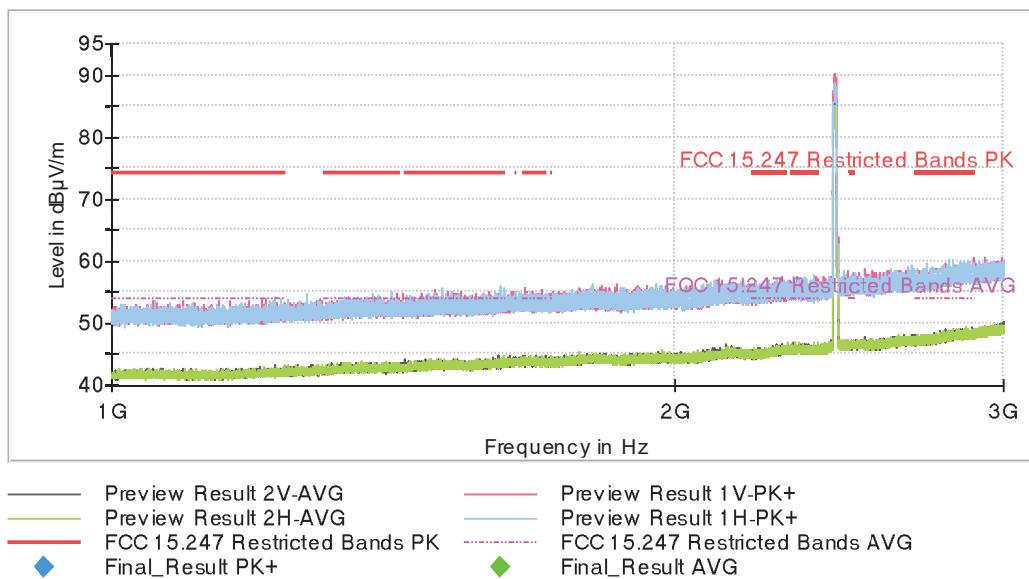
FREQUENCY RANGE 1 - 3 GHz:

- Low Channel:



The peak above the limit is the carrier frequency.

- Middle Channel:



The peak above the limit is the carrier frequency.