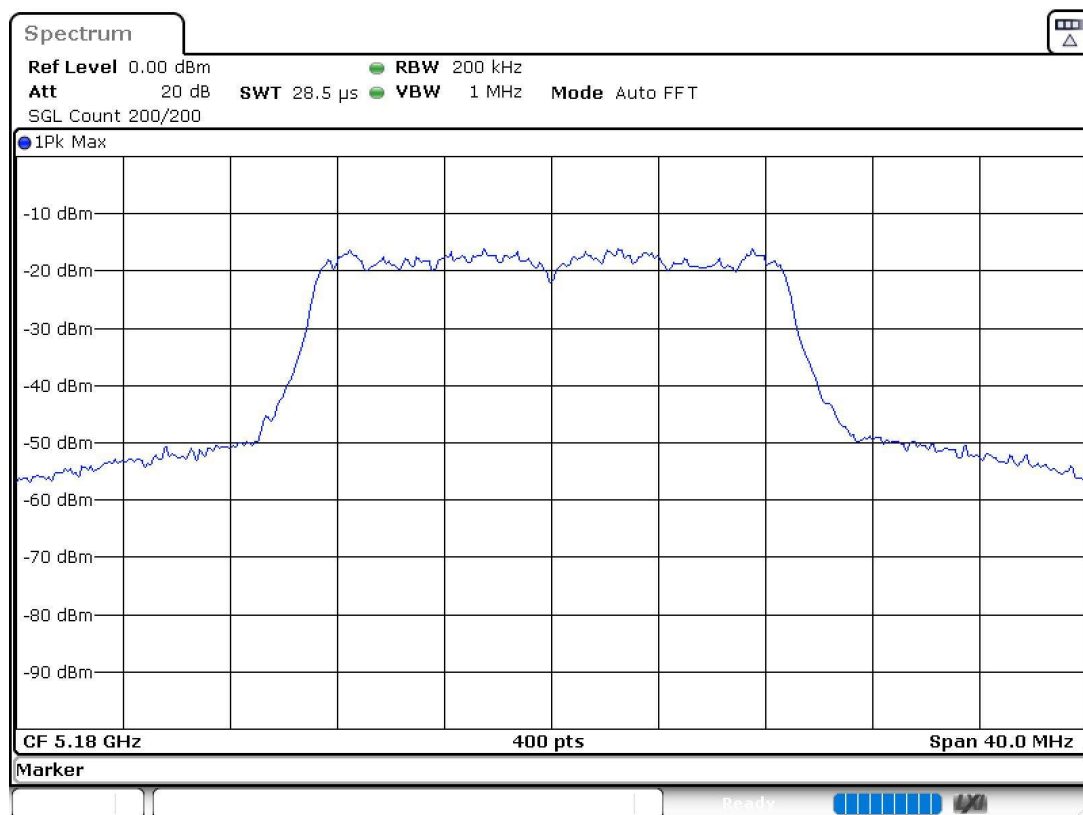
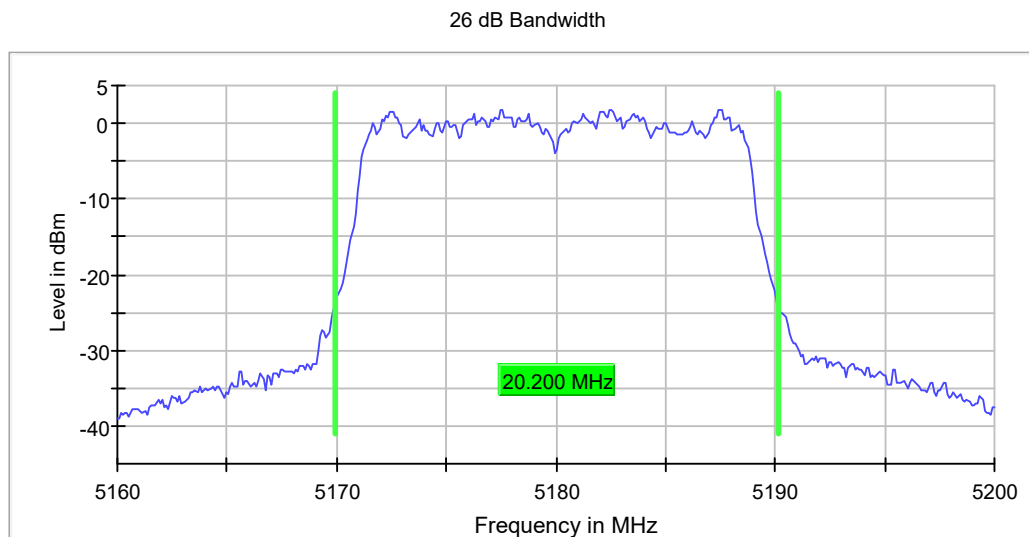


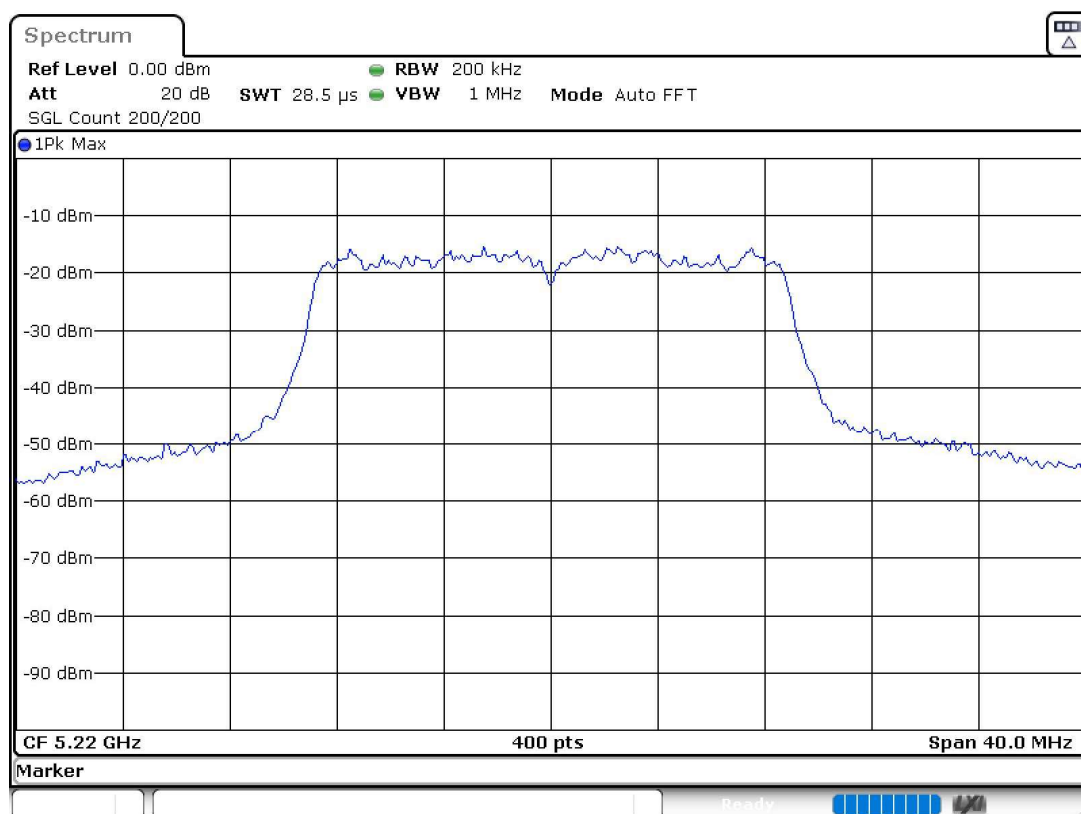
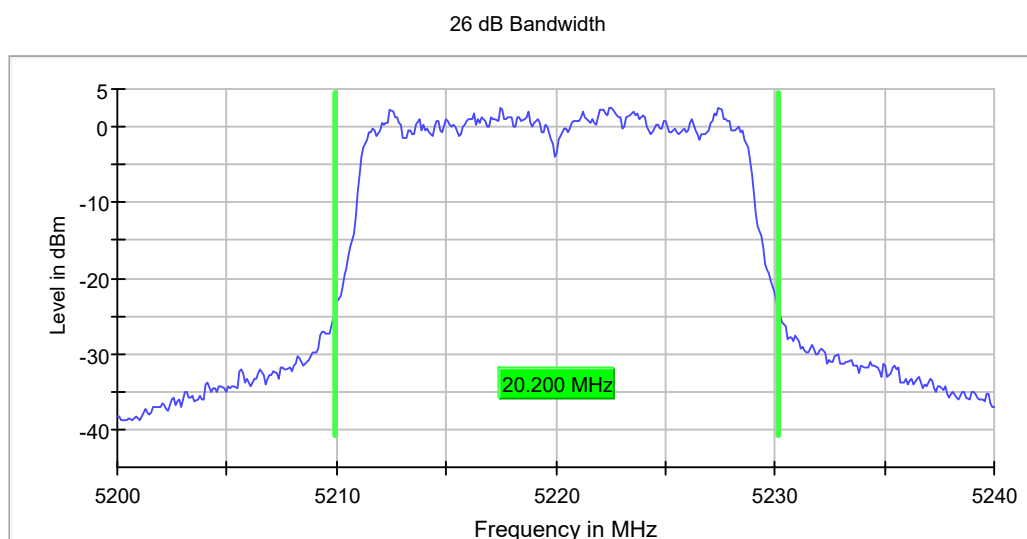
Mode 802.11 ac20 (VHT20):

U-NII-1 (5150-5250 MHz)

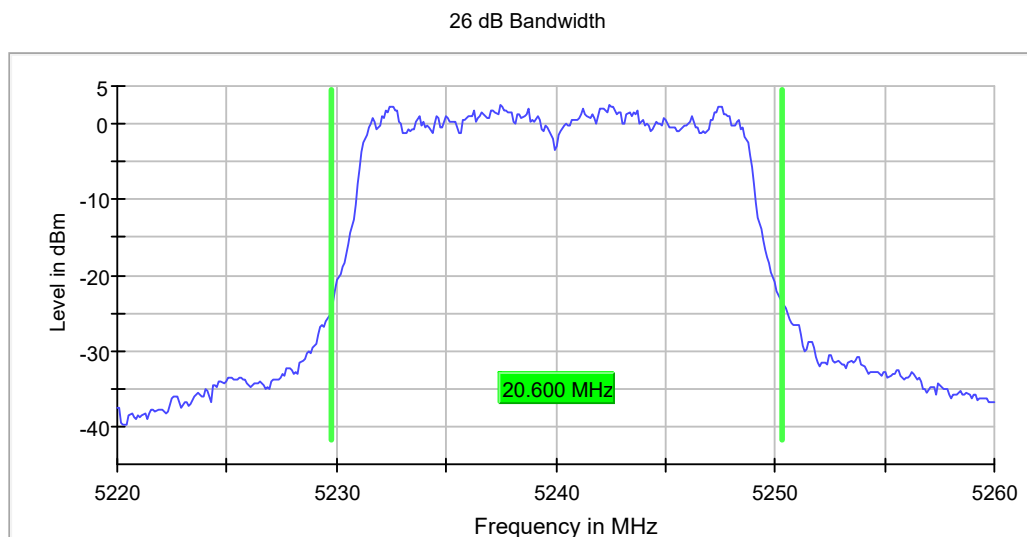
- Low Channel 36 (5180 MHz):



- Middle Channel 44 (5220 MHz):

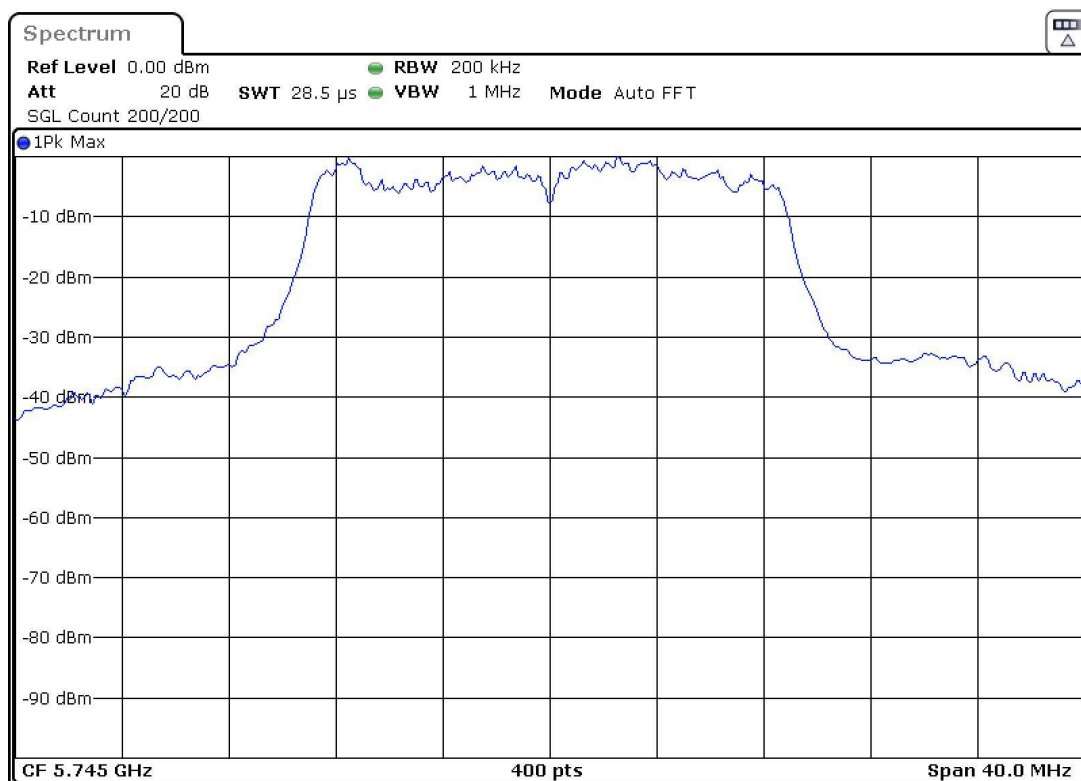
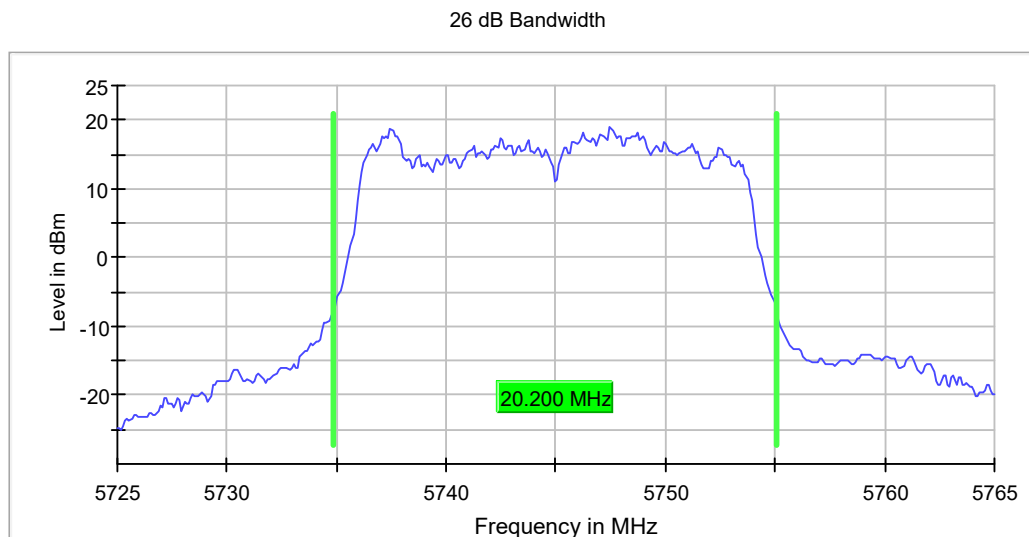


- High Channel 48 (5240 MHz):

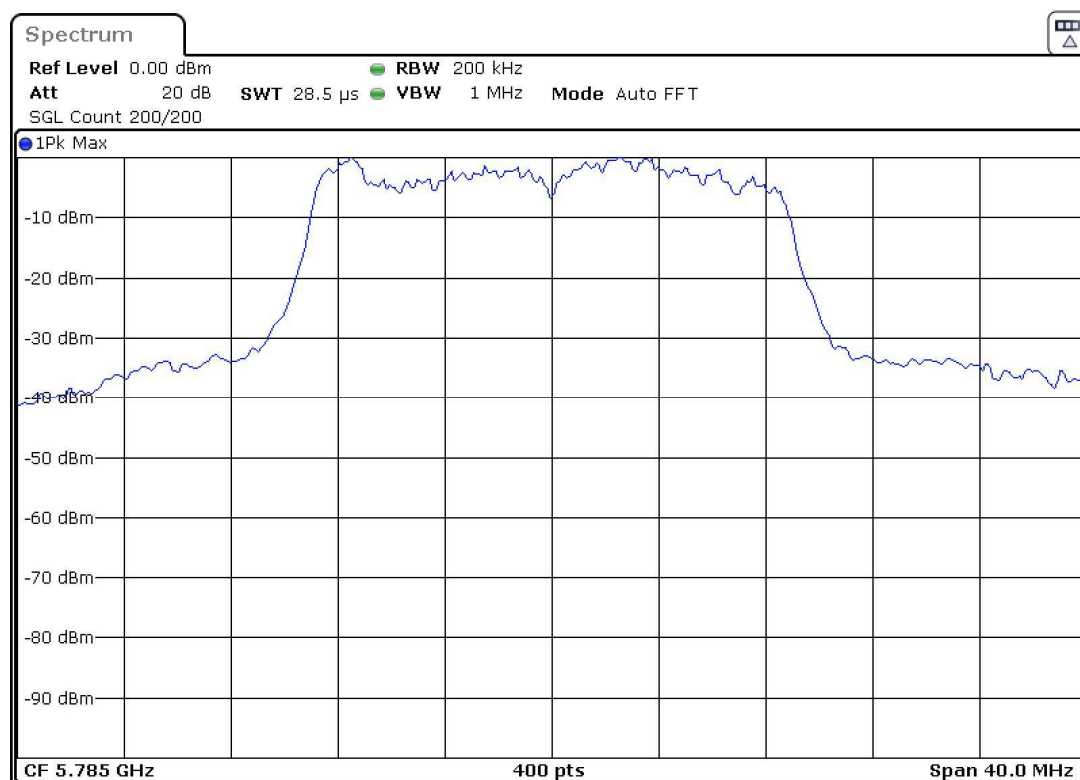
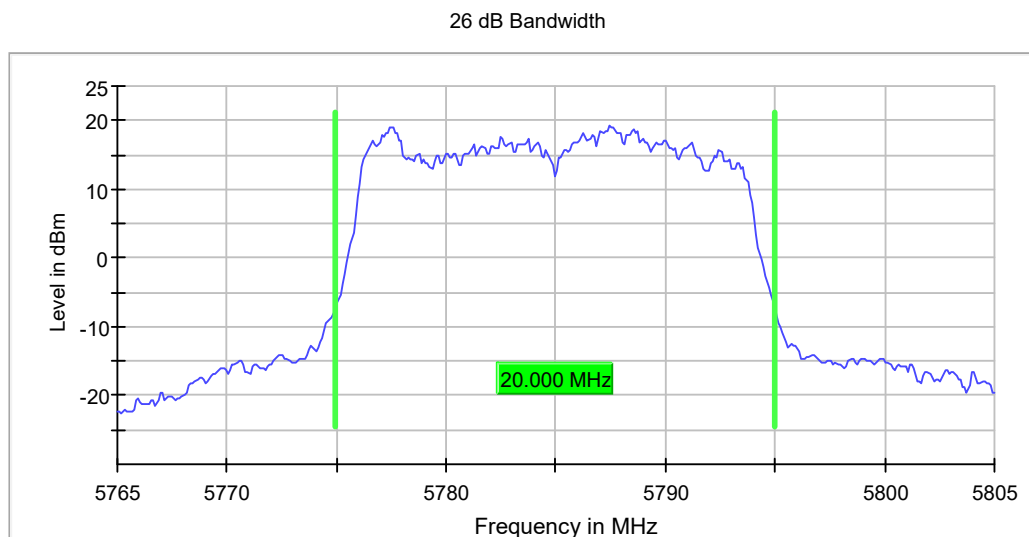


U-NII-3 (5725-5850 MHz)

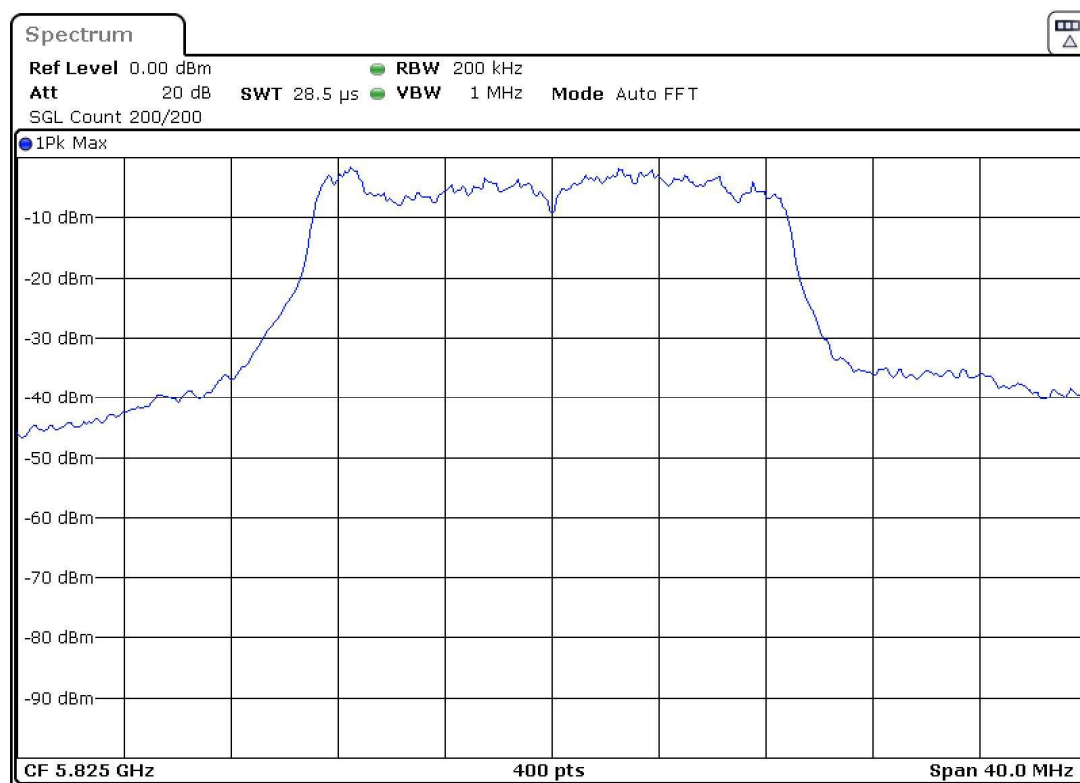
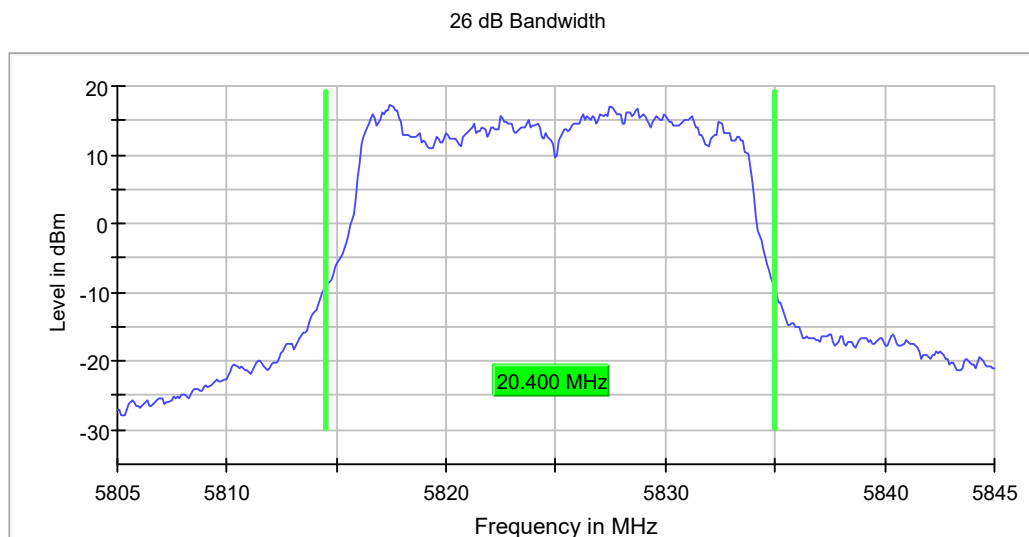
- Low Channel 149 (5745 MHz):



- Middle Channel 157 (5785 MHz):



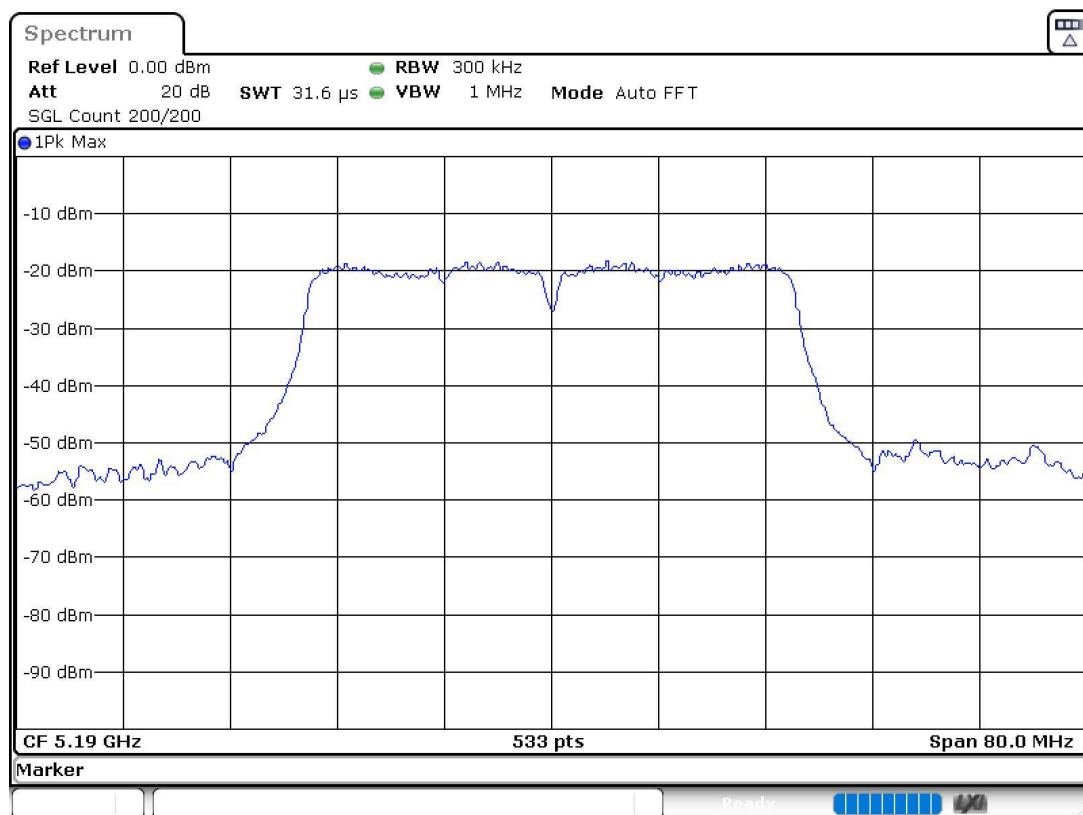
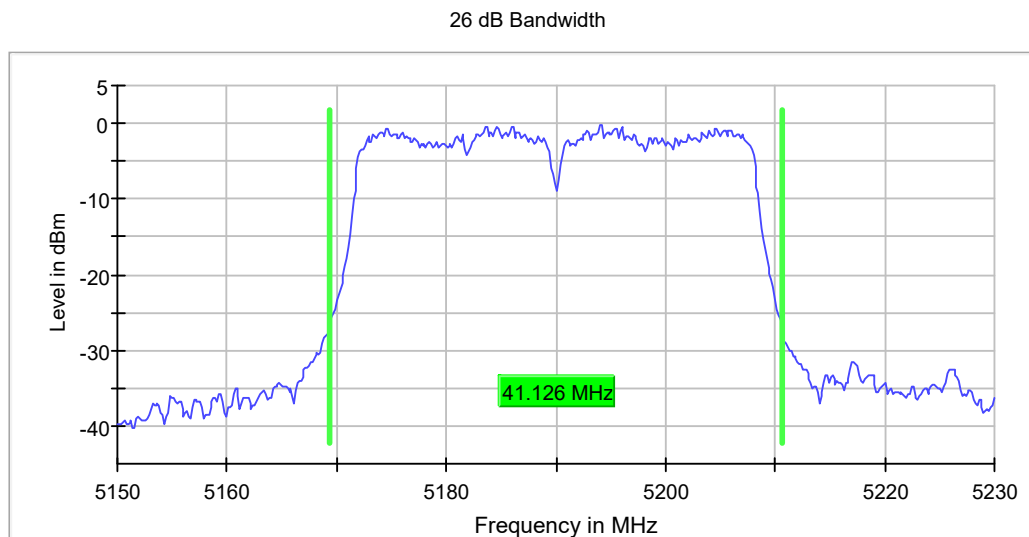
- High Channel 165 (5825 MHz):



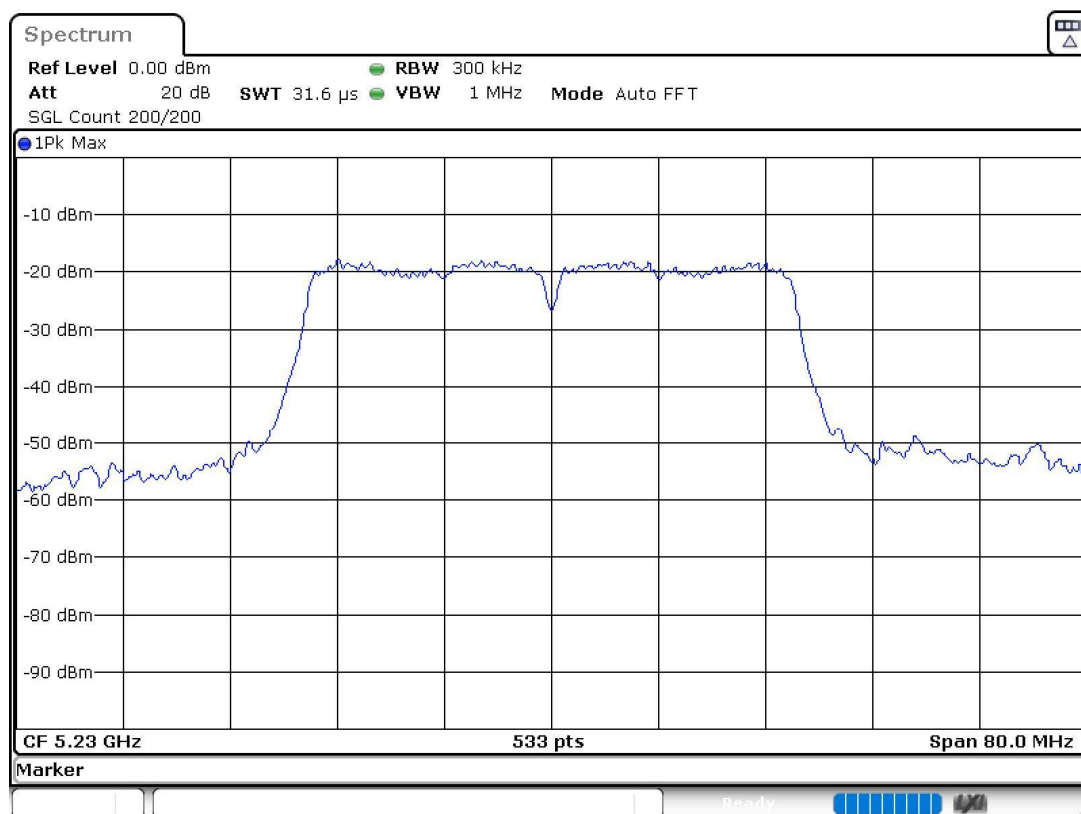
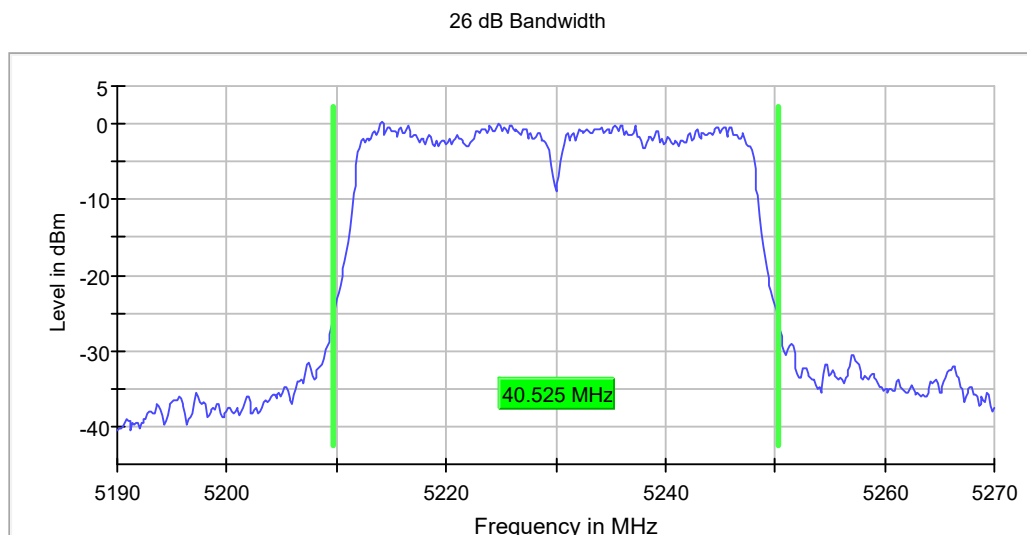
Mode 802.11 n40 (HT40):

U-NII-1 (5150-5250 MHz)

- Low Channel 38 (5190 MHz):

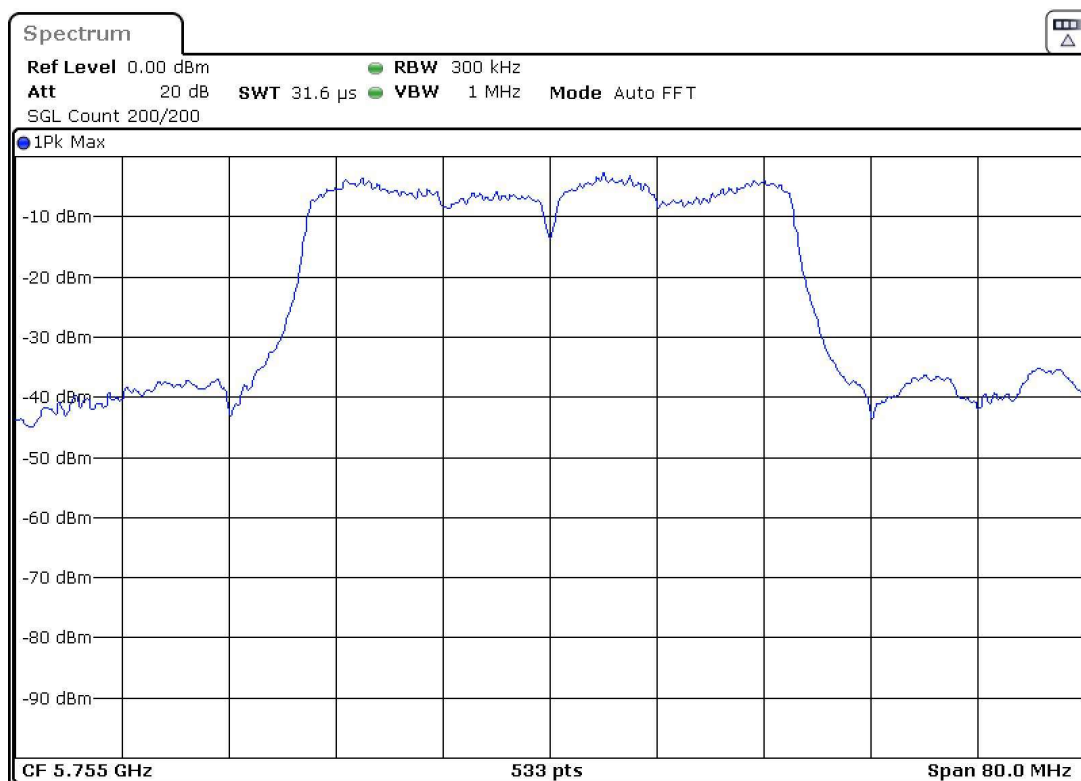
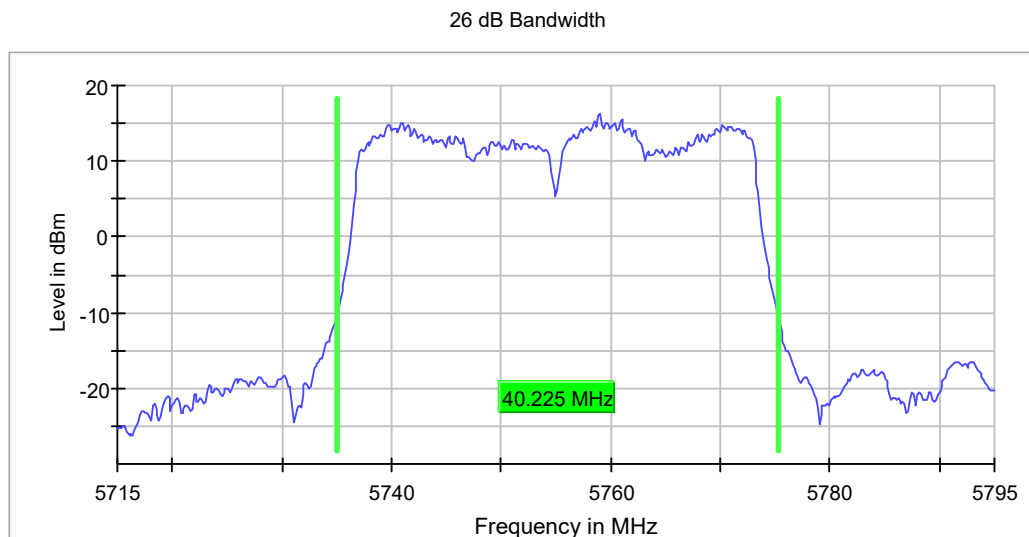


- High Channel 46 (5230 MHz):

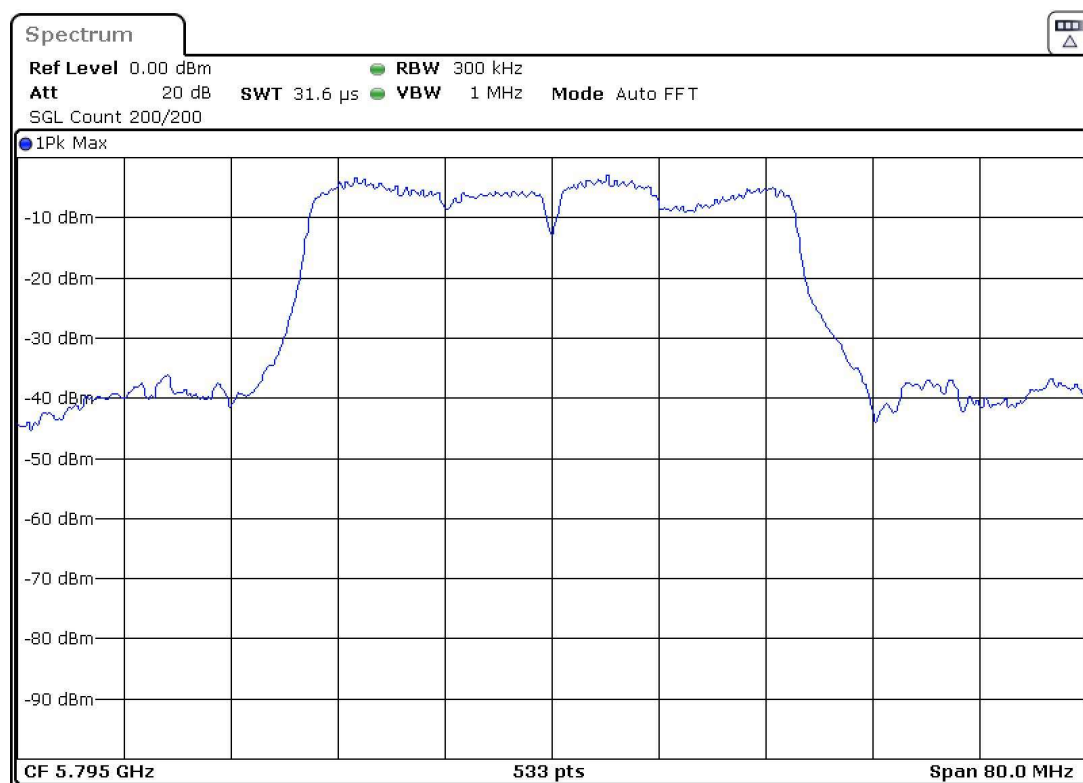
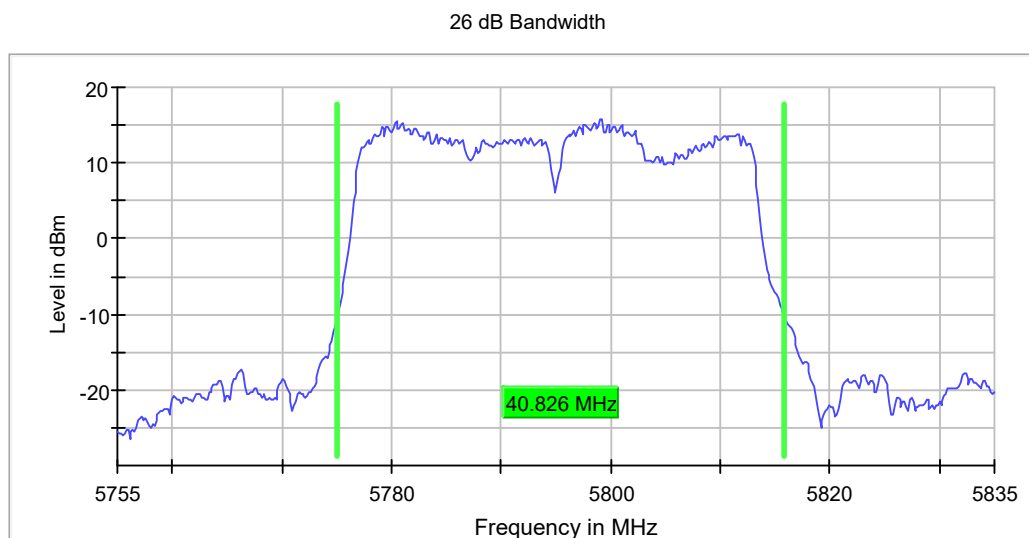


U-NII-3 (5725-5850 MHz)

- Low Channel 151 (5755 MHz):



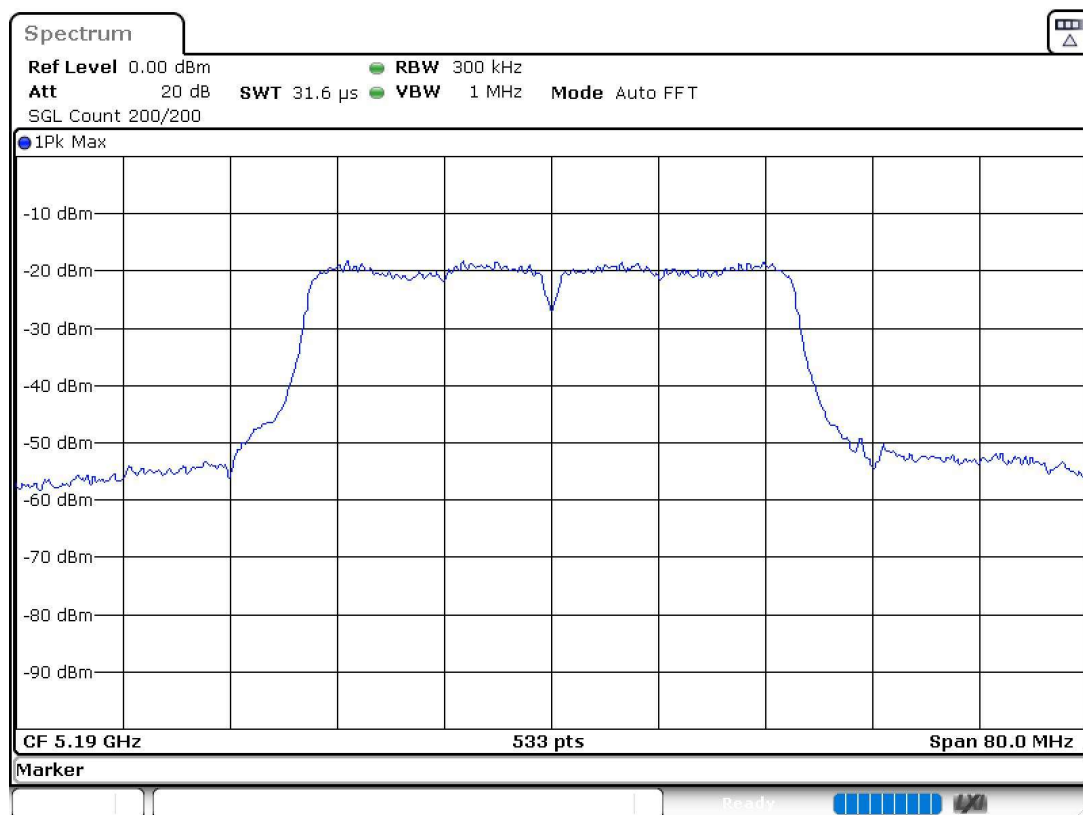
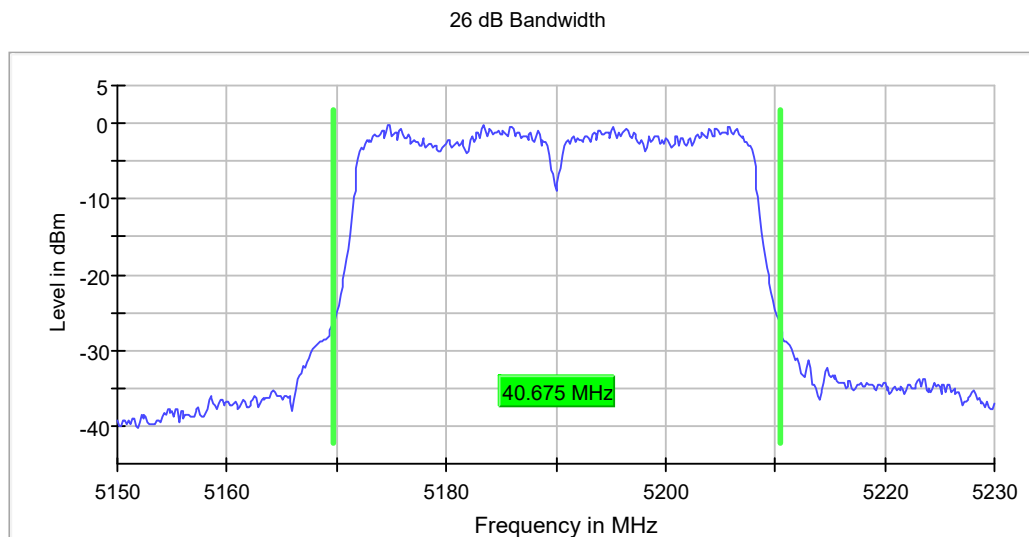
- High Channel 159 (5795 MHz):



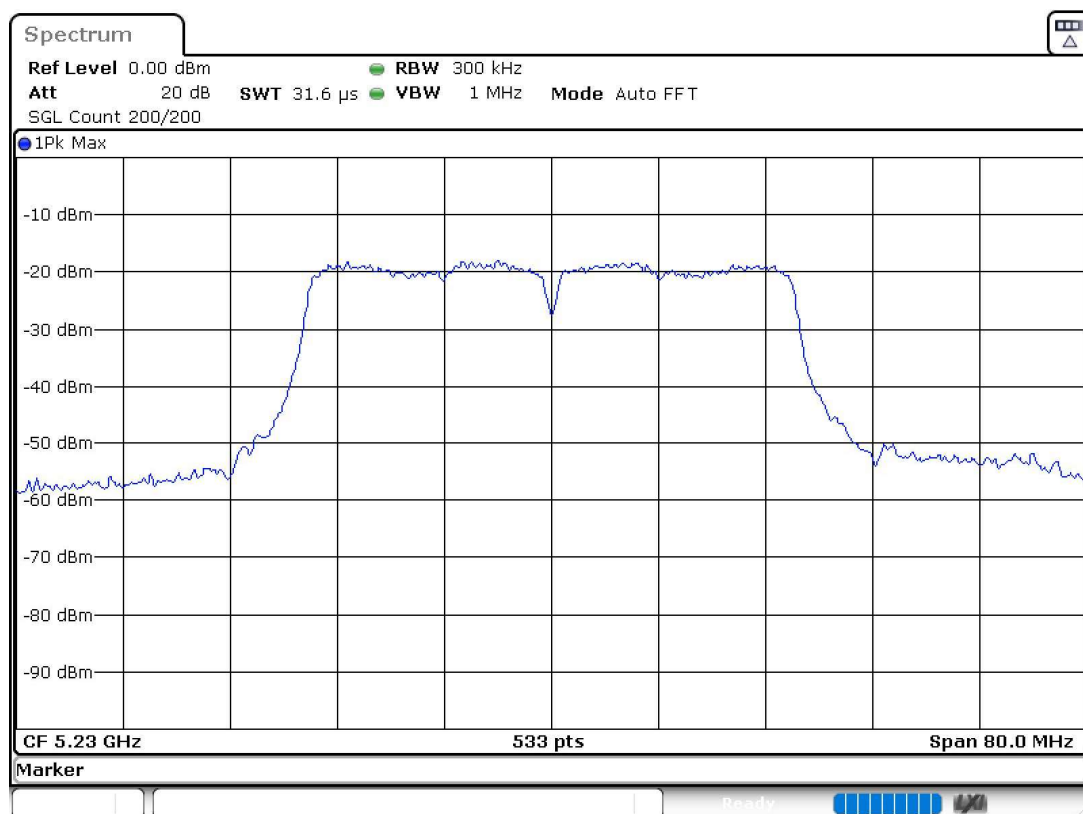
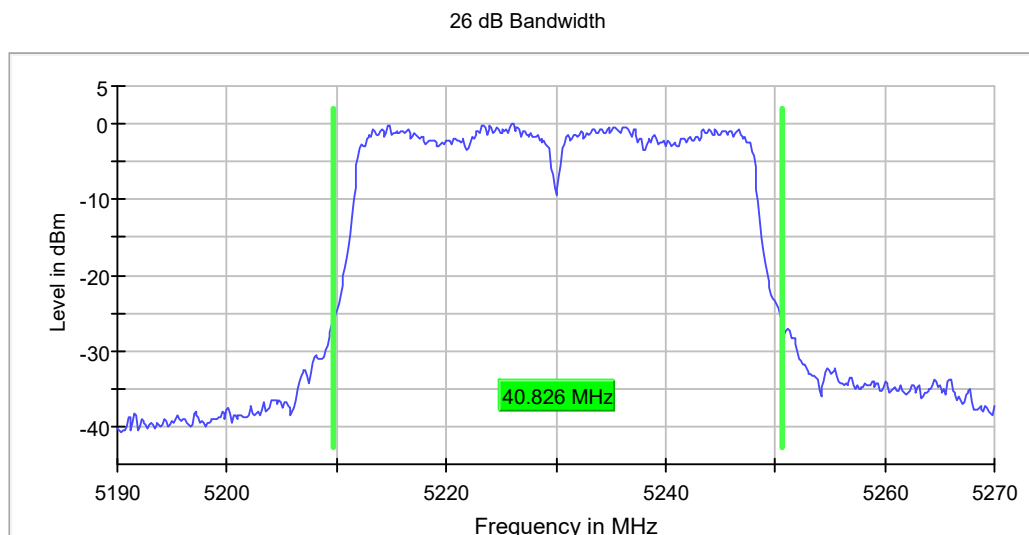
Mode 802.11 ac40 (VHT40):

U-NII-1 (5150-5250 MHz)

- Low Channel 38 (5190 MHz):

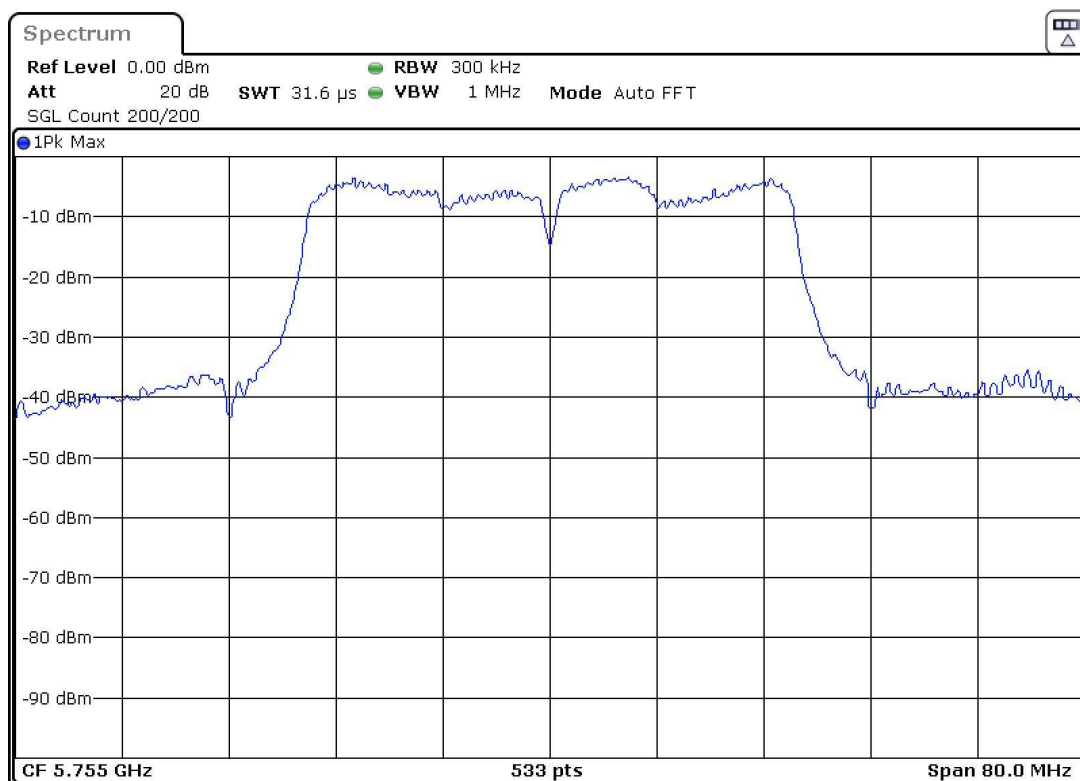
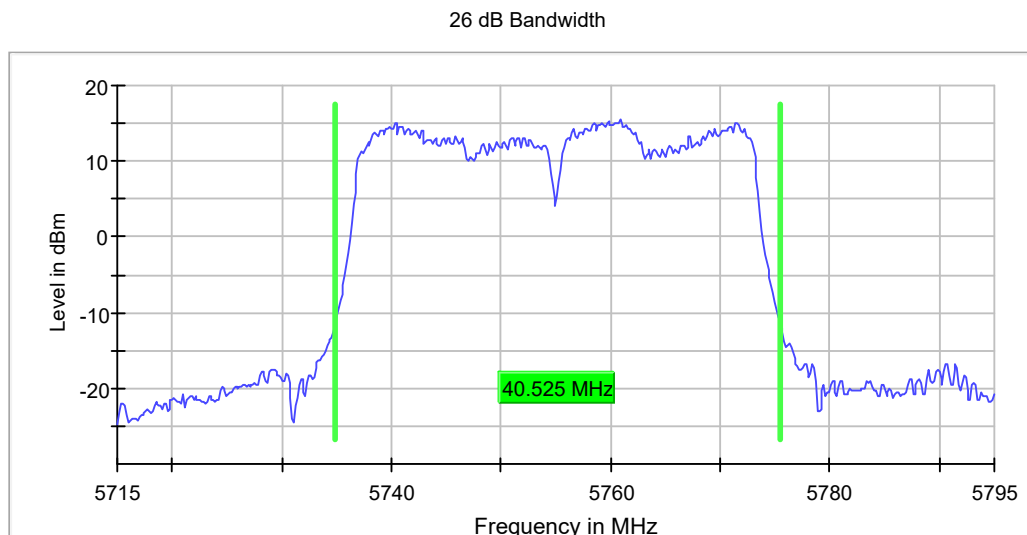


- High Channel 46 (5230 MHz):

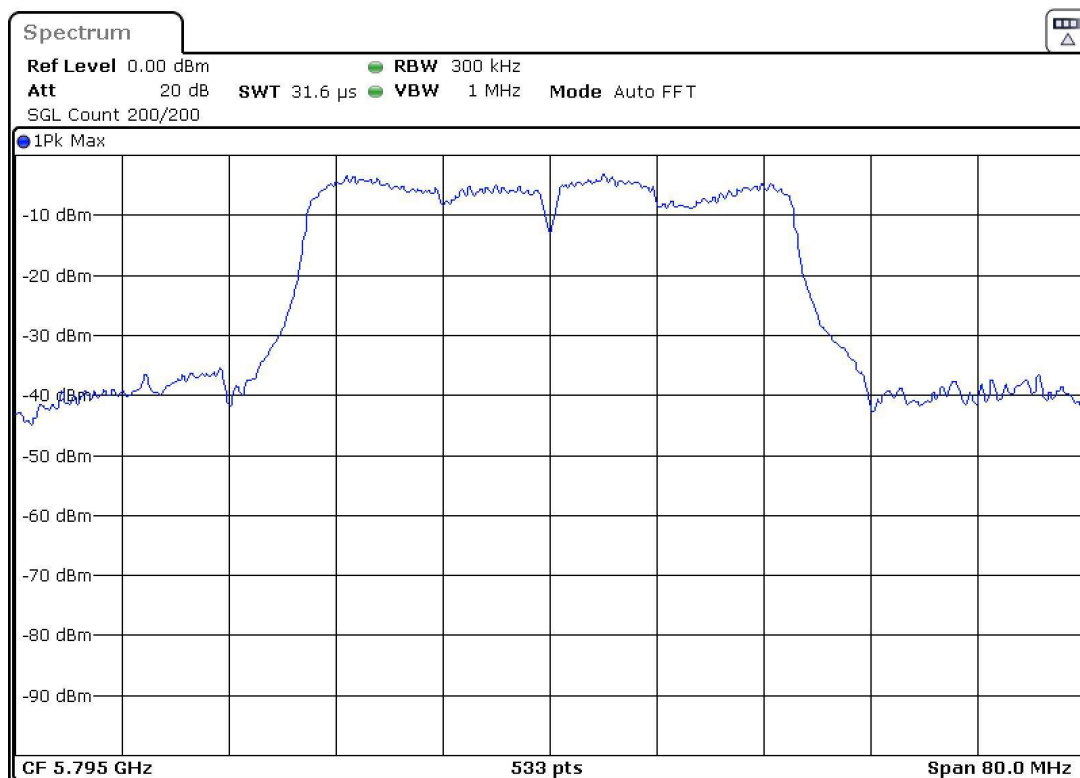
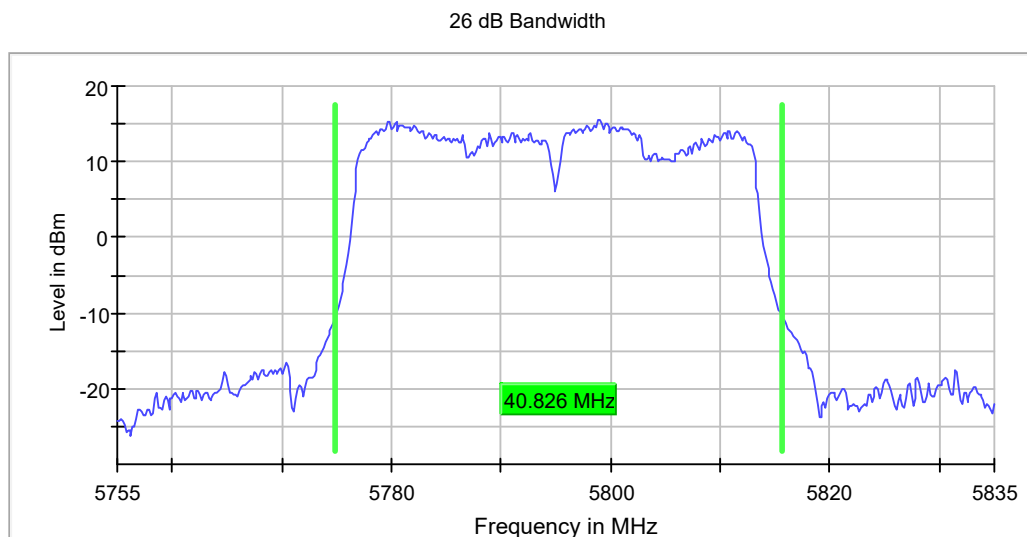


U-NII-3 (5725-5850 MHz)

- Low Channel 151 (5755 MHz):



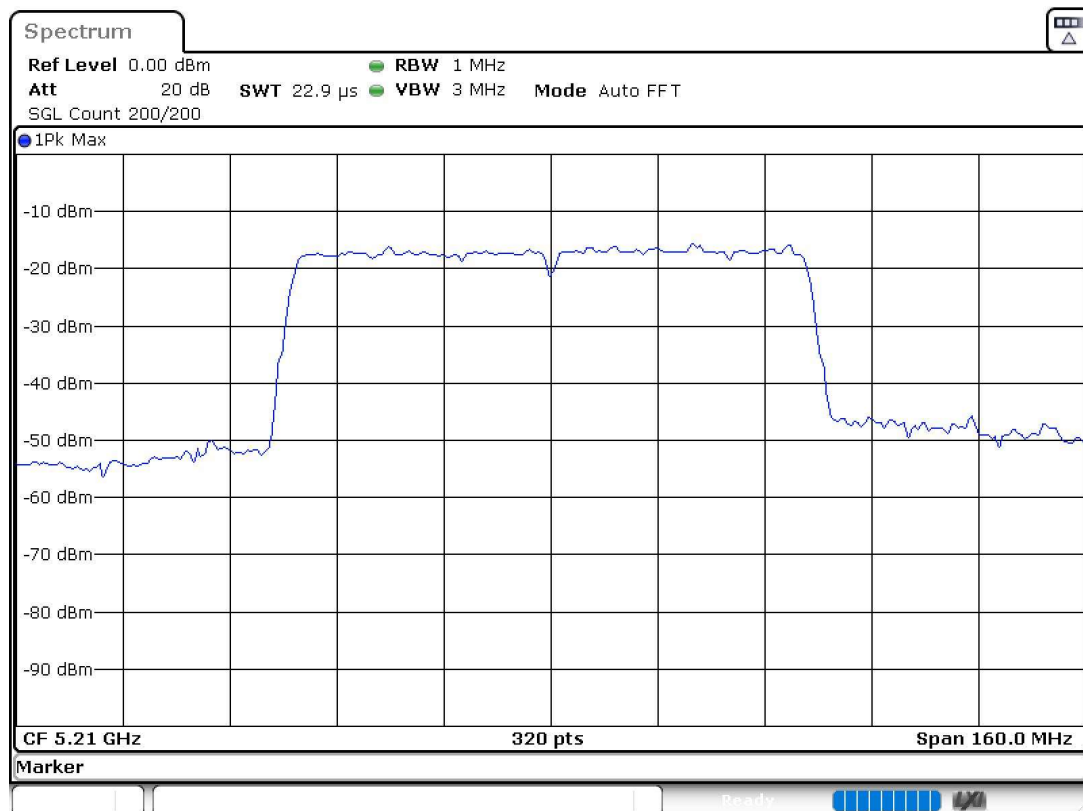
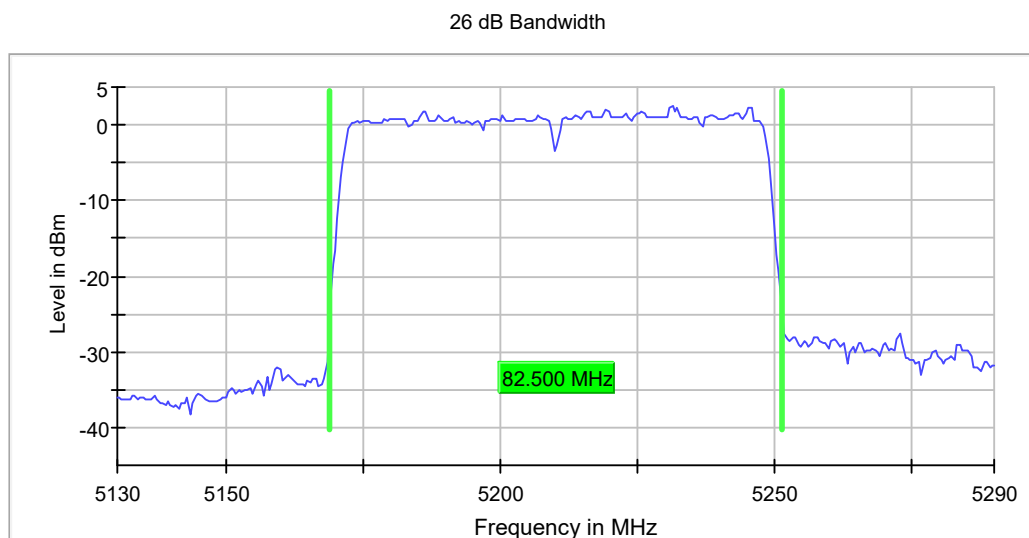
- High Channel 159 (5795 MHz):



Mode 802.11 ac80 (VHT80):

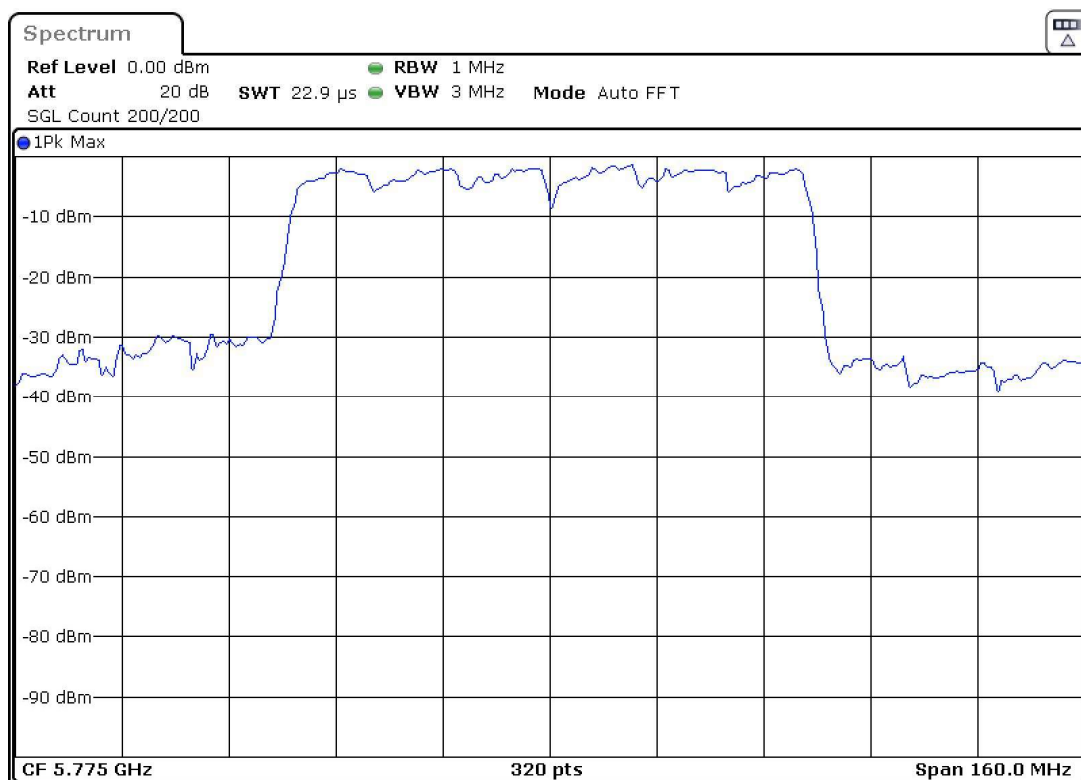
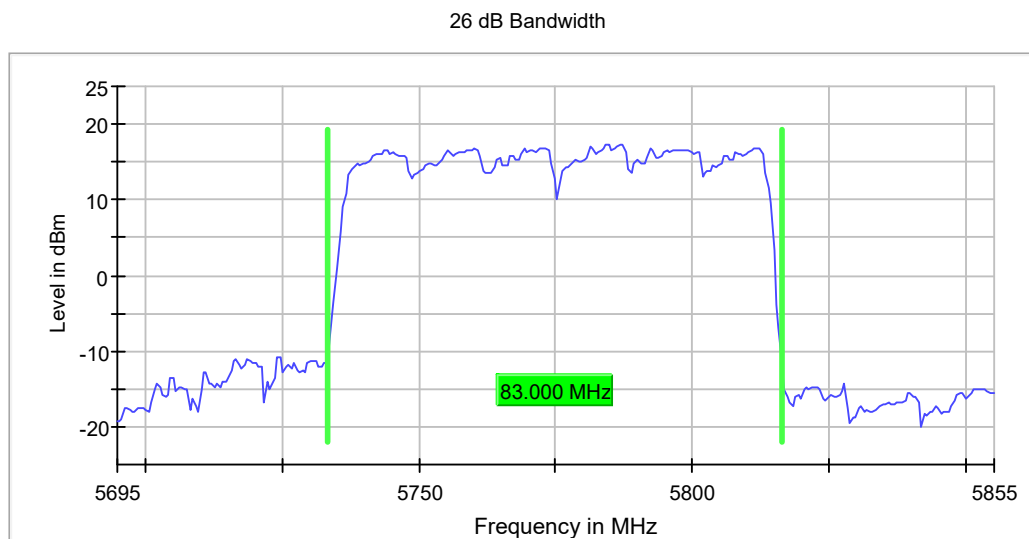
U-NII-1 (5150-5250 MHz)

- Single Channel 42 (5210 MHz):



U-NII-3 (5725-5850 MHz)

- Single Channel 155 (5775 MHz):



Appendix B: Tests results for the U-NII-1 Band 5.15 – 5.25 GHz

INDEX

TEST CONDITIONS	84
FCC 15.407 (a)(1)(iv). Transmitter Maximum Conducted Output Power / RSS-247 6.2.1.1. Transmitter Maximum Equivalent Isotropically Radiated Power	89
FCC 15.407 (a)(1)(iv). Transmitter Maximum Power Spectral Density / RSS-247 6.2.1.1. Transmitter EIRP Spectral Density	91
FCC 15.407 (b)(1) / RSS-247 6.2.1.2. Transmitter Out of Band Radiated Emissions	107
FCC 15.407 (b)(1) / RSS-247 6.2.1.2. Transmitter Band Edge Radiated Emissions	116

TEST CONDITIONS

(*) Data provided by the Applicant

POWER SUPPLY:

Vnominal: 13.2 Vdc.
Type of Power Supply (*): DC External (Car Battery).

ANTENNA:

Type of Antenna: External.
Maximum Declared Antenna Gain (*): -2.8 dBi

TEST FREQUENCIES:

Technology Tested:	WLAN (IEEE 802.11 a,n,ac) / U-NII-1	
Modes:	802.11a20: 6, 9, 12, 18, 24, 36, 48 & 54 Mbps	
	802.11n HT20: MCS0 to MCS7	
	802.11n HT40: MCS0 to MCS7	
	802.11ac VHT20: MCS0 to MCS9	
	802.11ac VHT40: MCS0 to MCS9	
	802.11ac VHT80: MCS0 to MCS9	
Setting of cores / ports:	One port.	
Beamforming:	No.	
Frequency Range:	5150 MHz to 5250 MHz	
Channel Bandwidth:	20 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Low: 36	5180
	Middle: 40	5200
	High: 48	5240
Channel Bandwidth:	40 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Low: 38	5190
	High: 46	5230
Channel Bandwidth:	80 MHz	
Transmit Channels	Middle: 42	5210

The test set-up was made in accordance with the general provisions of FCC Unlicensed National Information Infrastructure (U-NII) Devices 789033 D02 General U-NII Test Procedures New Rules v02r01 dated Dec 14, 2017.

The EUT was tested in the following operating mode:

- Continuously transmitting with a modulated carrier at maximum power on all required channels using the supported data rates/modulations types.

The field strength at the band edges was evaluated for each mode on the lowest and highest channels at the rated power for the channel under test.

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

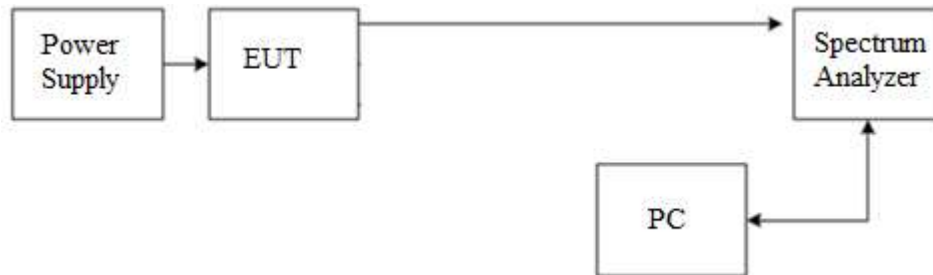
The worst cases for testing were identified based on output power and spurious levels at the band edges. Preliminary testing determined the following data rates as the worst-case modes:

802.11 a20:	6 Mbps
802.11 n HT20:	MCS0
802.11 n HT40:	MCS0
802.11 ac VHT20:	MCS0
802.11 ac VHT40:	MCS0
802.11 ac VHT80:	MCS0

CONDUCTED MEASUREMENTS:

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

For all modes:



The DC supply voltage is applied using an external power supply.

RADIATED MEASUREMENTS:

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range from 30 MHz to 1000 MHz and 1 GHz-17 GHz Double ridge horn antenna) is situated at a distance of 3 m and a distance of 1.5m for the frequency range 17 GHz-40 GHz (18 GHz-40 GHz horn antenna).

For radiated emissions in the range 17 GHz-40 GHz 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.

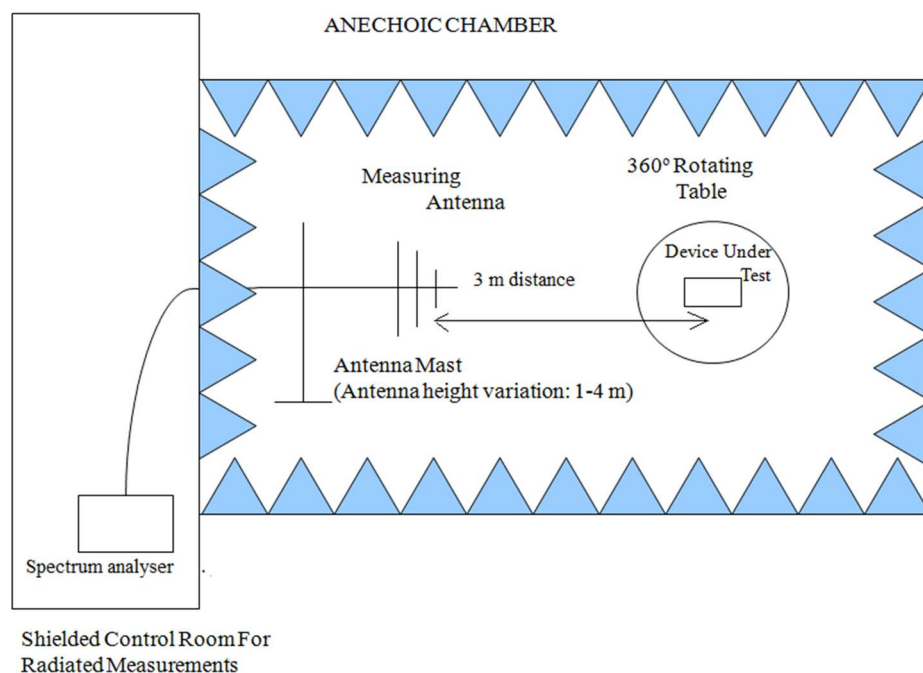
The equipment under test was set up on a non-conductive platform above the ground plane and its situation and orientation were varied to find the maximum radiated emission. It was also rotated 360° and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find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

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

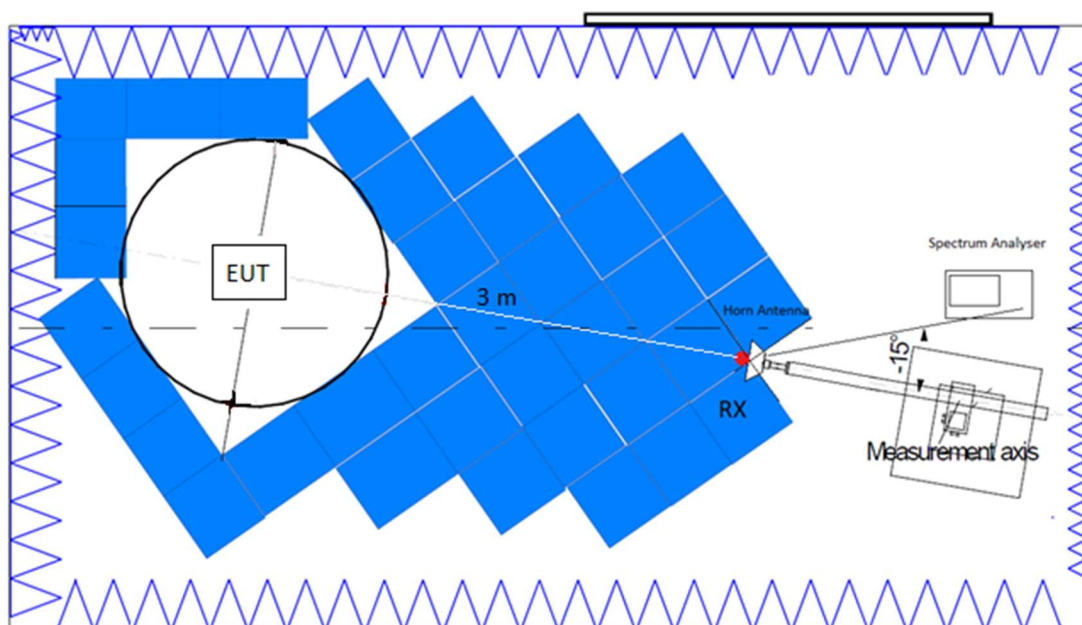
The final measured value, for the given emission, incorporates the calibrated antenna factor and cable loss.

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.

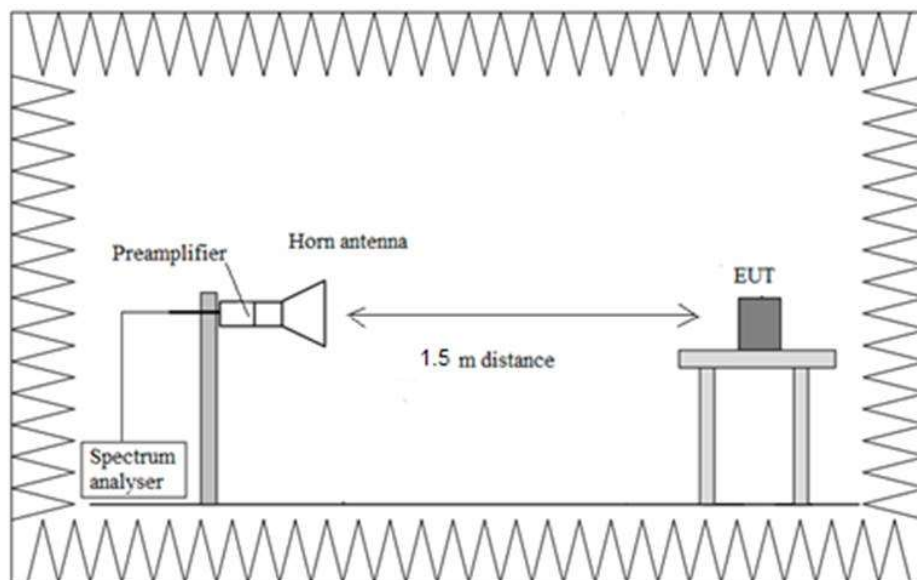
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup $f > 17$ GHz:



FCC 15.407 (a)(1)(iv). Transmitter Maximum Conducted Output Power / RSS-247 6.2.1.1. Transmitter Maximum Equivalent Isotropically Radiated Power

Limits

FCC 15.407: For client devices in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW (24 dBm) provided the maximum antenna gain does not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247: For OEM devices installed in vehicles, the maximum e.i.r.p. shall not exceed 30 mW or $1.76 + 10 \log_{10} B$, dBm, whichever is less. Devices shall implement transmitter power control (TPC) in order to have the capability to operate at least 3 dB below the maximum permitted e.i.r.p. of 30 mW.

Results

The maximum conducted output power was measured according to ANSI C63.10-2013 clause 11.9.2.3.2 and clause E.3.b) of Guidance 789033 D02 General UNII Test Procedures New Rules v02r01 (Method AVGPM-G). A gated RF average power meter was used; therefore, no duty cycle correction factor is applicable to the measured results.

The e.i.r.p. levels are calculated by adding the declared maximum antenna gain (dBi).

For all modes of operation, the antenna gain is less than 6 dBi.

Maximum Declared Antenna Gain: -2.8 dBi

Mode 802.11 a20:

	Low Channel 36 (5180 MHz)	Middle Channel 44 (5220 MHz)	High Channel 48 (5240 MHz)
Max. Conducted Power (dBm)	12.284	12.786	12.791
Max. Power E.I.R.P (dBm)	9.484	9.986	9.991

Mode 802.11 n20 (HT20):

	Low Channel 36 (5180 MHz)	Middle Channel 44 (5220 MHz)	High Channel 48 (5240 MHz)
Max. Conducted Power (dBm)	12.293	12.783	12.834
Max. Power E.I.R.P (dBm)	9.493	9.983	10.034

Mode 802.11 ac20 (VHT20):

	Low Channel 36 (5180 MHz)	Middle Channel 44 (5220 MHz)	High Channel 48 (5240 MHz)
Max. Conducted Power (dBm)	12.282	12.837	12.831
Max. Power E.I.R.P (dBm)	9.482	10.037	10.031

Mode 802.11 n40 (HT40):

	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
Max. Conducted Power (dBm)	11.322	11.735
Max. Power E.I.R.P (dBm)	8.522	8.935

Mode 802.11 ac40 (VHT40):

	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
Max. Conducted Power (dBm)	11.326	11.740
Max. Power E.I.R.P (dBm)	8.526	8.940

Mode 802.11 ac80 (VHT80):

	Single Channel 42 (5210 MHz)
Max. Conducted Power (dBm)	11.648
Max. Power E.I.R.P (dBm)	8.848

Verdict

Pass

FCC 15.407 (a)(1)(iv). Transmitter Maximum Power Spectral Density / RSS-247 6.2.1.1. Transmitter EIRP Spectral Density

Limits

FCC 15.407: The maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247: The e.i.r.p. spectral density shall not exceed 10 dBm in any 1.0 MHz band.

Results

The maximum power spectral density (PSD) was measured using the method according to point F) referencing E.2.b) (Method SA-1) and E.2.b) (Method SA-2) of Guidance 789033 D02 General UNII Test Procedures New Rules v02r01.

An average of 100 traces was performed using rms detector. The maximum PSD is determined by using the peak marker function to find the maximum amplitude level. For the modes with an associated duty cycle < 98 % the applicable duty cycle correction factor is added to the measured PSD value in order to compute the PSD during the actual transmission times.

Both the measured and the corrected PSD values are reported in the tables below.

For all modes of operation, the antenna gain is lower than 6 dBi. Therefore no reduction is applicable to the measured results.

Mode 802.11 a20:

	Low Channel 36 (5180 MHz)	Middle Channel 44 (5220 MHz)	High Channel 48 (5240 MHz)
Maximum Average PSD (dBm/MHz)	0.486	1.182	1.079
Duty Cycle Correction Factor (dB)	0.12		
Maximum Average PSD Corrected (dBm/MHz)	0.606	1.302	1.199
Maximum Average PSD Corrected E.I.R.P (dBm/MHz)	-2.194	-1.498	-1.601

Mode 802.11 n20 (HT20):

	Low Channel 36 (5180 MHz)	Middle Channel 44 (5220 MHz)	High Channel 48 (5240 MHz)
Maximum Average PSD (dBm/MHz)	0.259	0.951	0.809
Duty Cycle Correction Factor (dB)	0.18		
Maximum Average PSD Corrected (dBm/MHz)	0.439	1.131	0.989
Maximum Average PSD Corrected E.I.R.P (dBm/MHz)	-2.361	-1.669	-1.811

Mode 802.11 ac20 (VHT20):

	Low Channel 36 (5180 MHz)	Middle Channel 44 (5220 MHz)	High Channel 48 (5240 MHz)
Maximum Average PSD (dBm/MHz)	0.261	0.894	0.843
Duty Cycle Correction Factor (dB)	0.11		
Maximum Average PSD Corrected (dBm/MHz)	0.371	1.004	0.953
Maximum Average PSD Corrected E.I.R.P (dBm/MHz)	-2.429	-1.796	-1.847

Mode 802.11 n40 (HT40):

	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
Maximum Average PSD (dBm/MHz)	-3.699	-3.099
Duty Cycle Correction Factor (dB)	0.11	
Maximum Average PSD Corrected (dBm/MHz)	-3.589	-2.989
Maximum Average PSD Corrected E.I.R.P (dBm/MHz)	-6.389	-5.789

Mode 802.11 ac40 (VHT40):

	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
Maximum Average PSD (dBm/MHz)	-3.637	-3.154
Duty Cycle Correction Factor (dB)	0.22	
Maximum Average PSD Corrected (dBm/MHz)	-3.417	-2.934
Maximum Average PSD Corrected E.I.R.P (dBm/MHz)	-6.217	-5.734

Mode 802.11 ac80 (VHT80):

	Single Channel 42 (5210 MHz)
Maximum Average PSD (dBm/MHz)	-6.869
Duty Cycle Correction Factor (dB)	0.22
Maximum Average PSD Corrected (dBm/MHz)	-6.649
Maximum Average PSD Corrected E.I.R.P (dBm/MHz)	-9.449

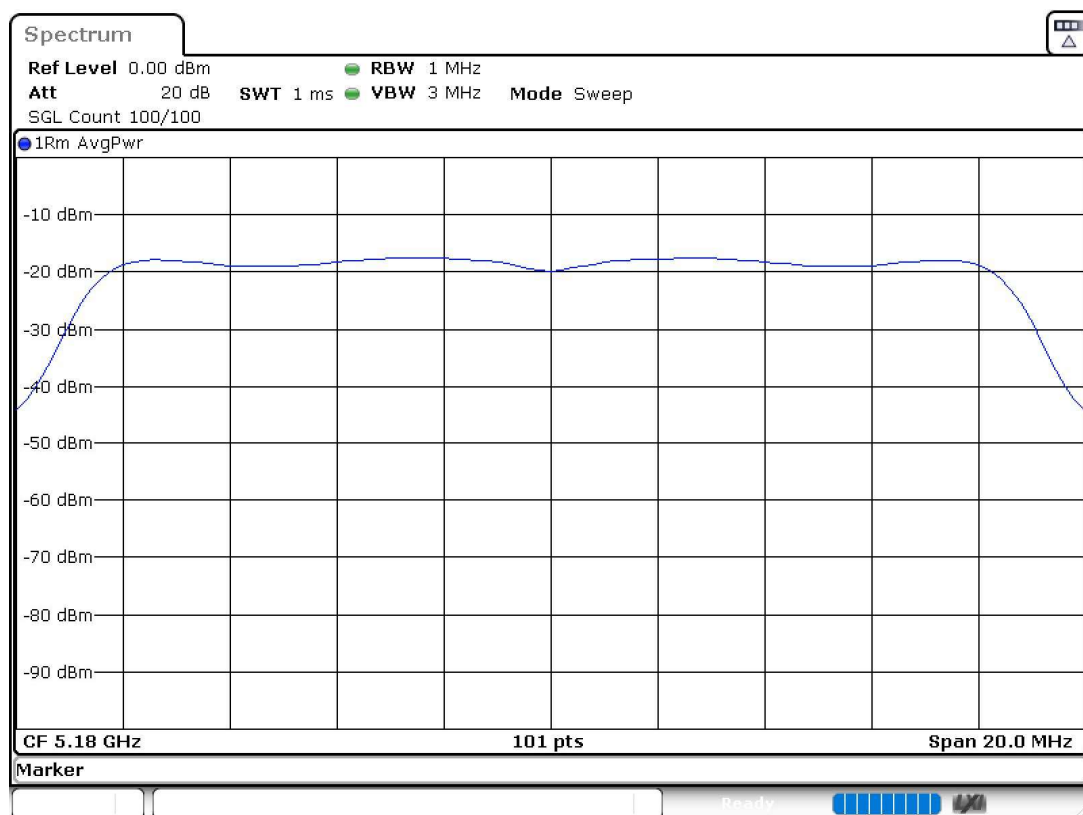
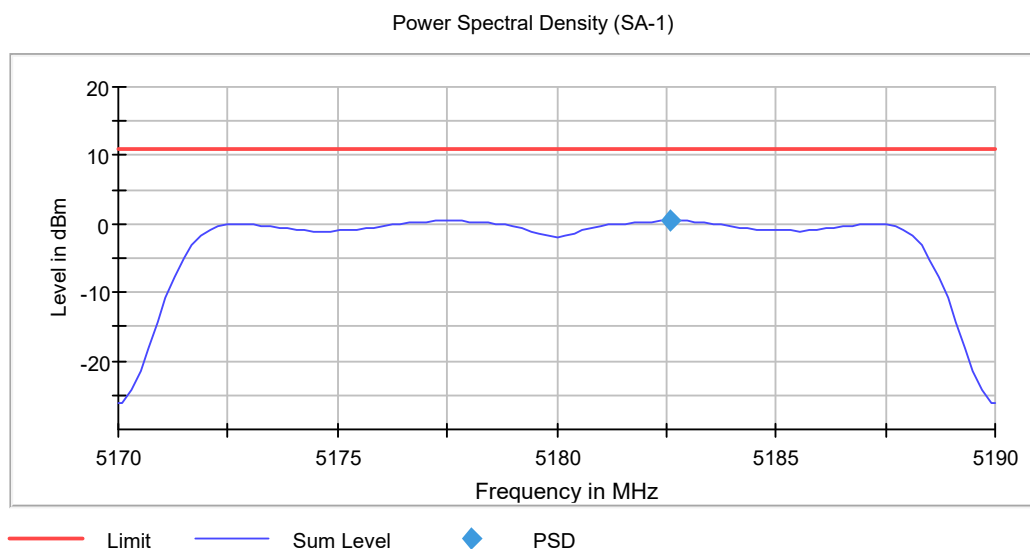
Verdict

Pass

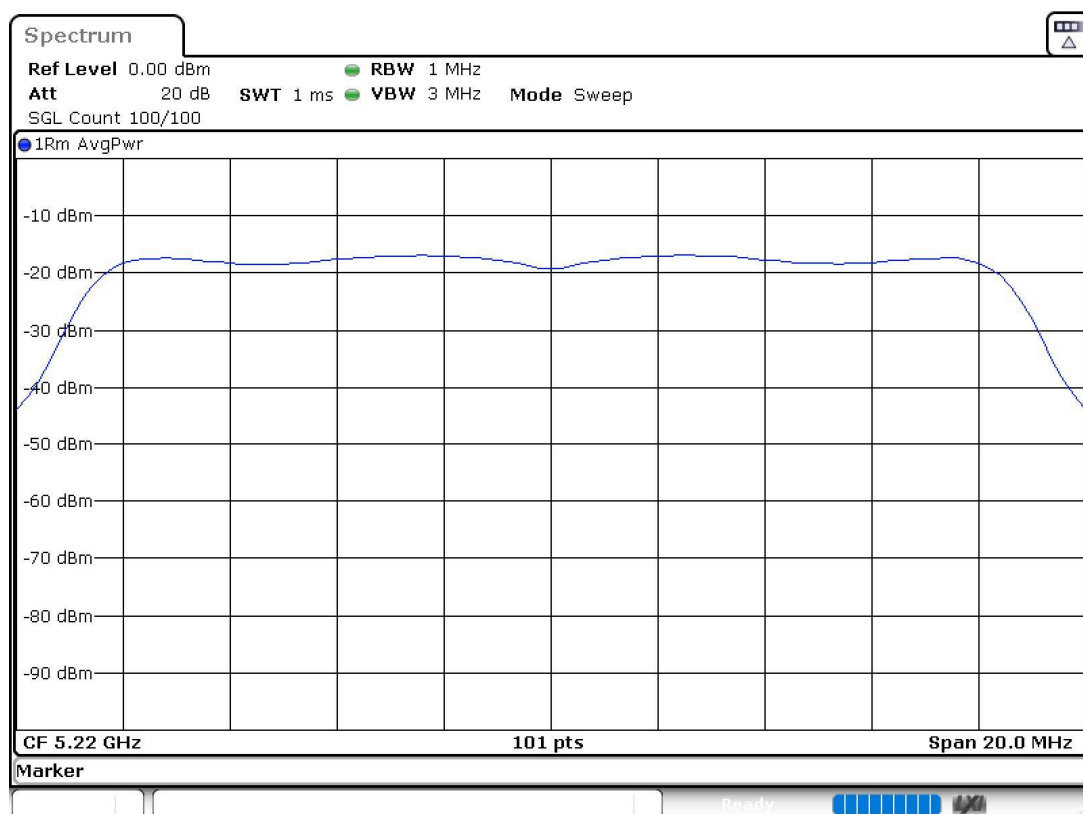
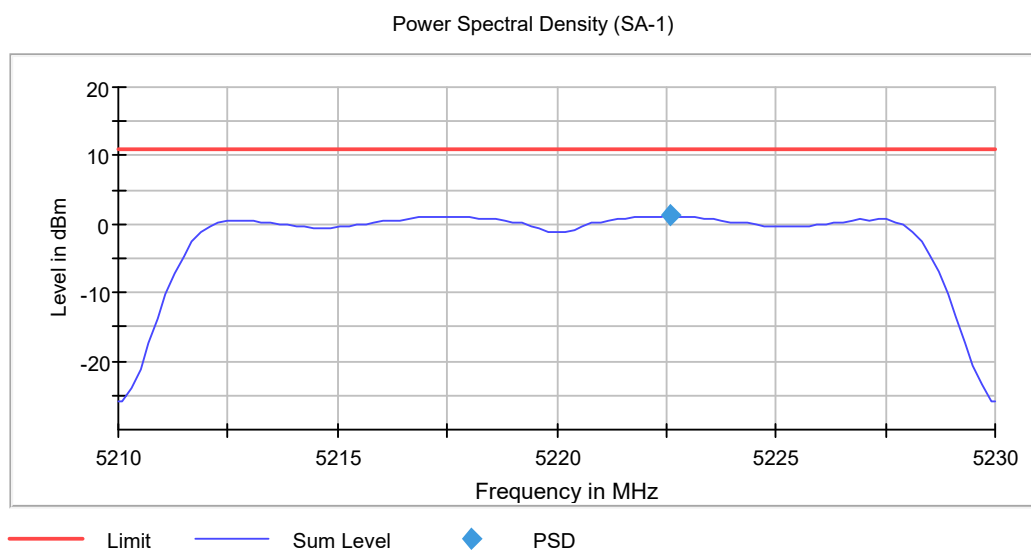
Attachments

Mode 802.11 a20:

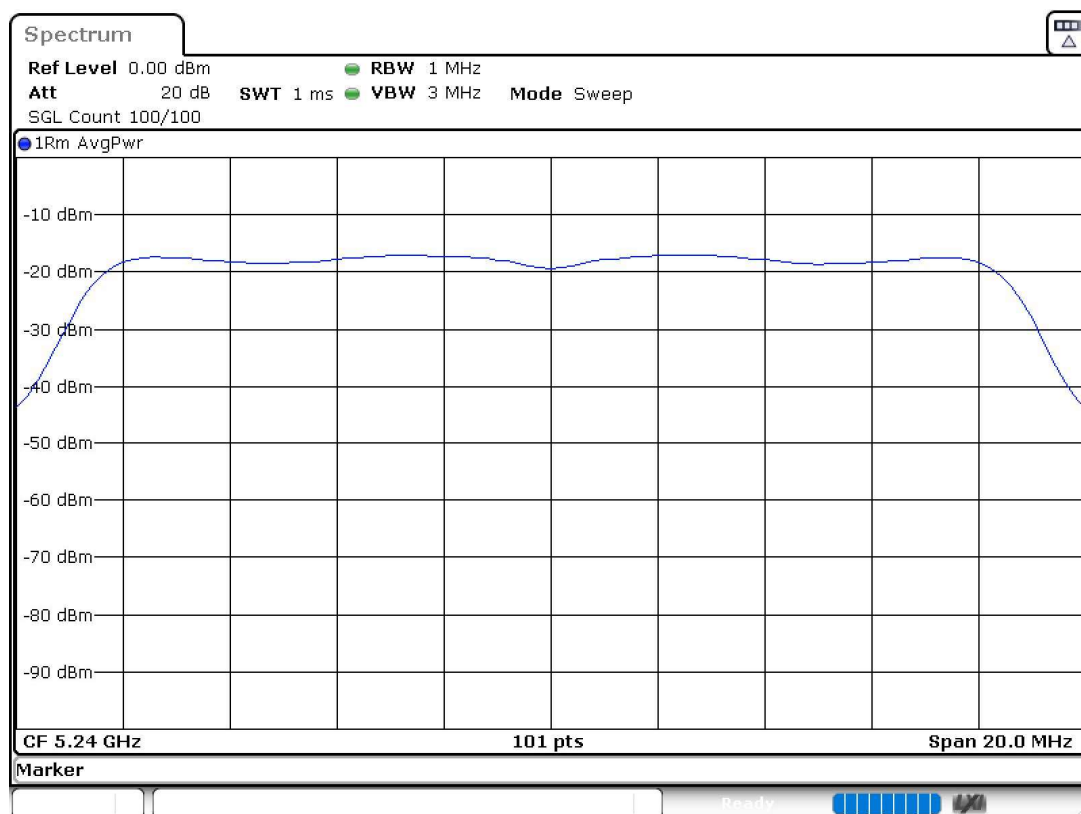
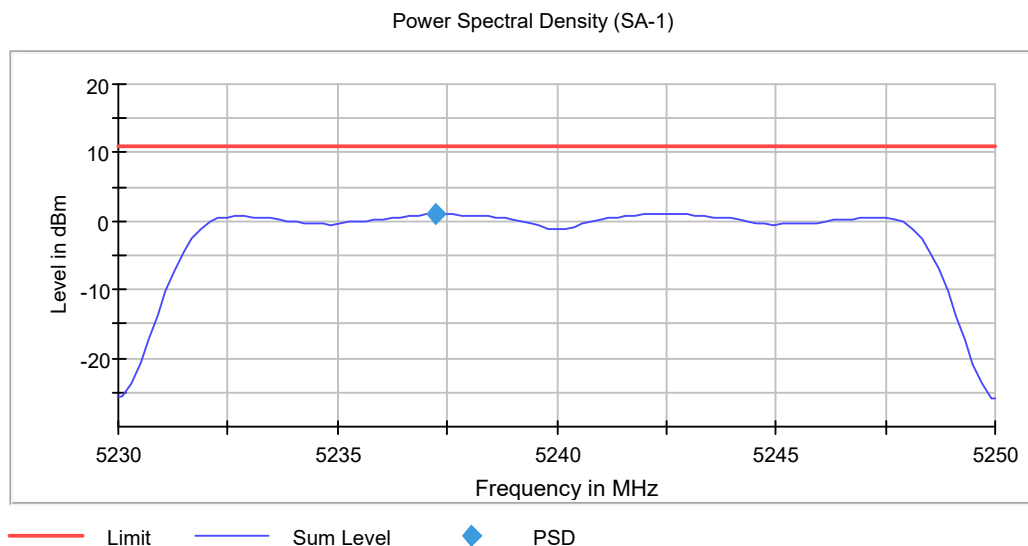
- Low Channel:



- Middle Channel:

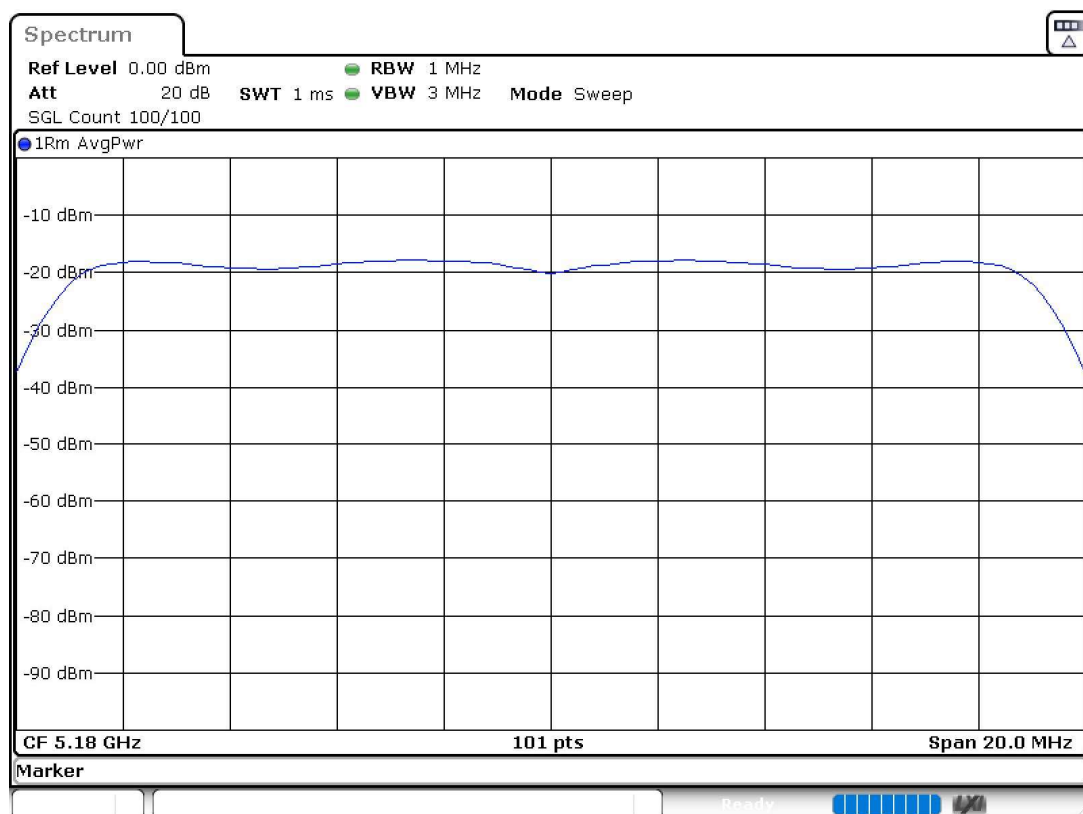
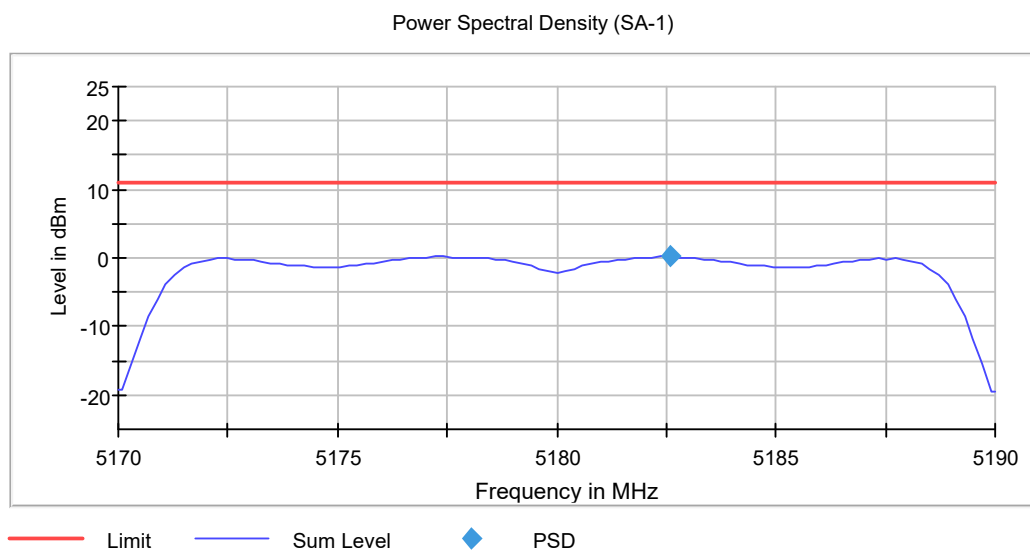


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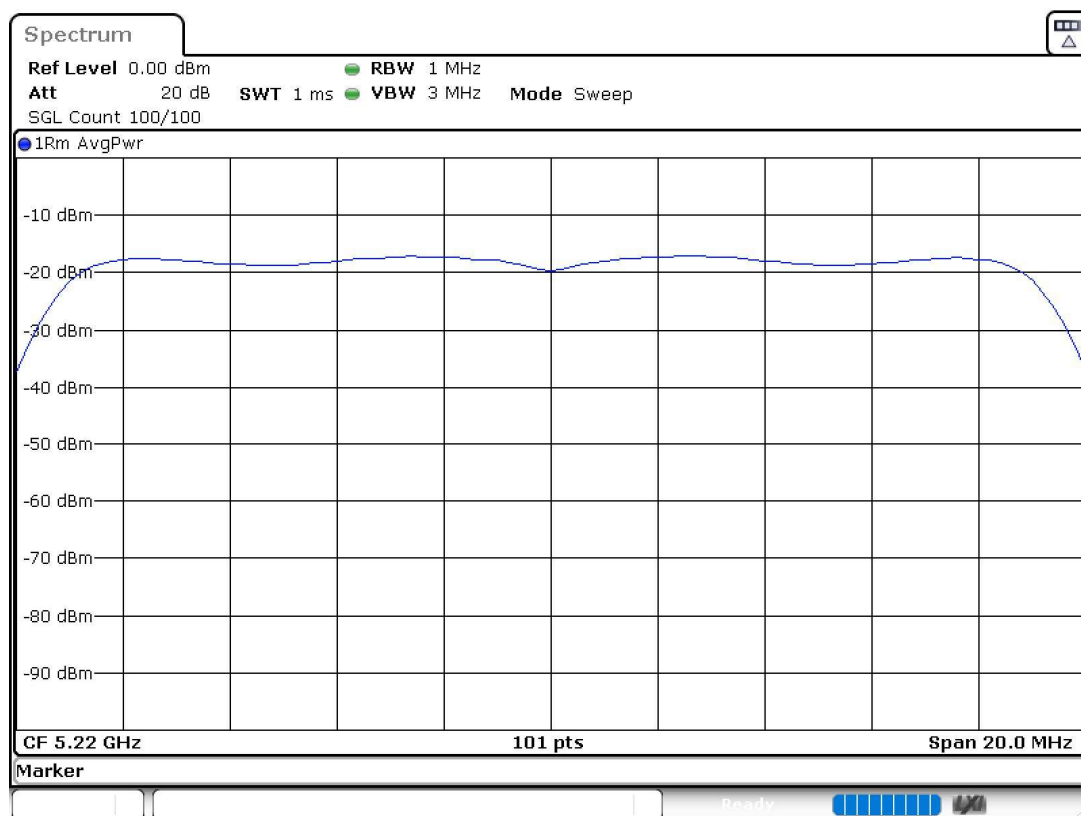
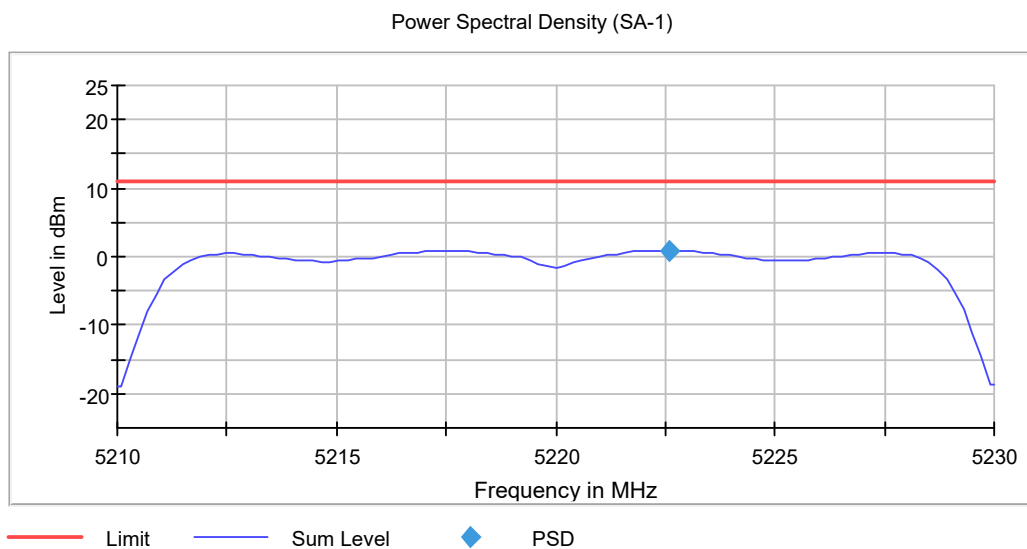


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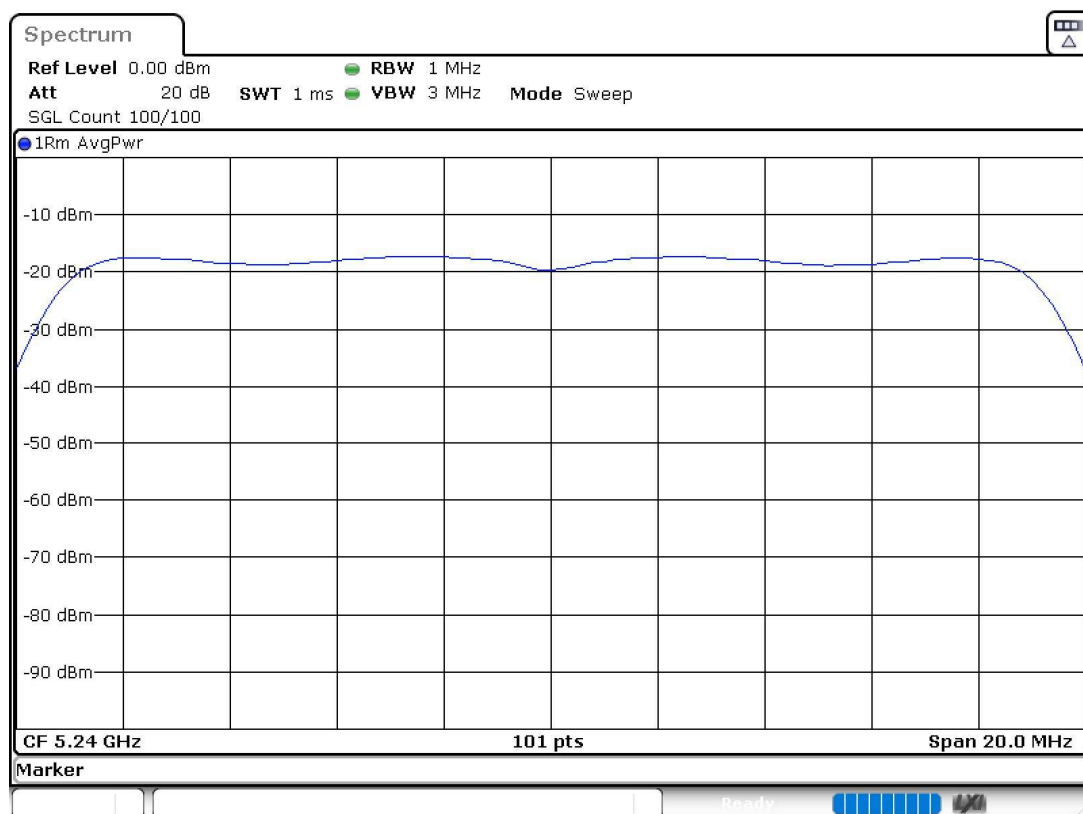
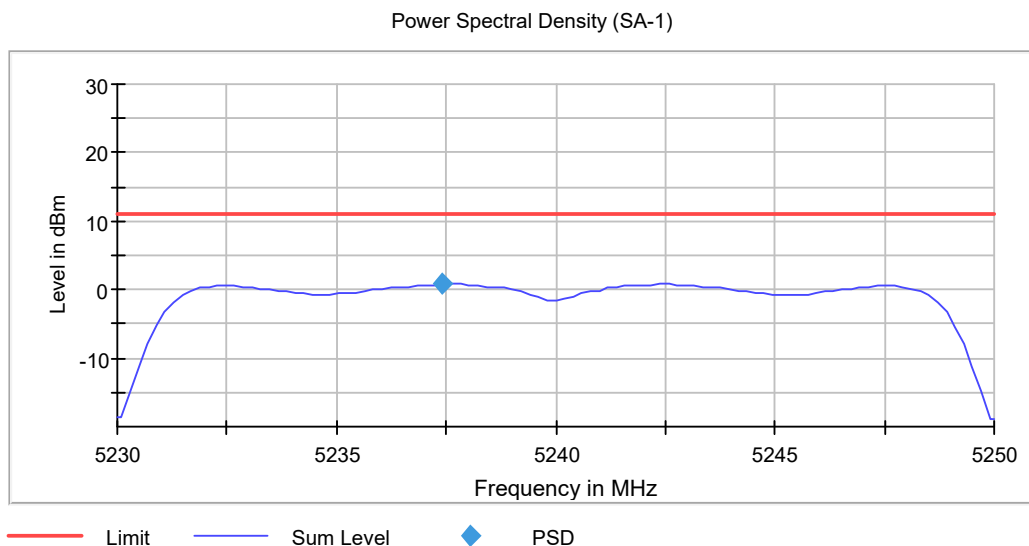
- Low Channel:



- Middle Channel:

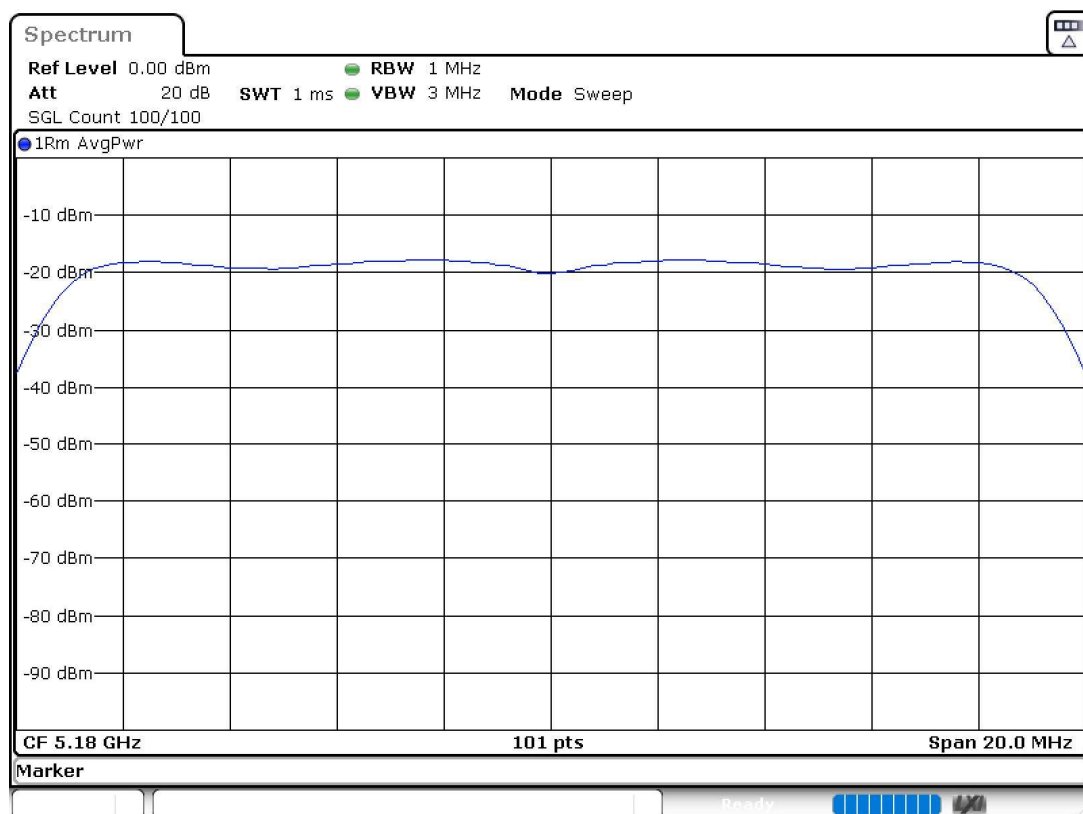
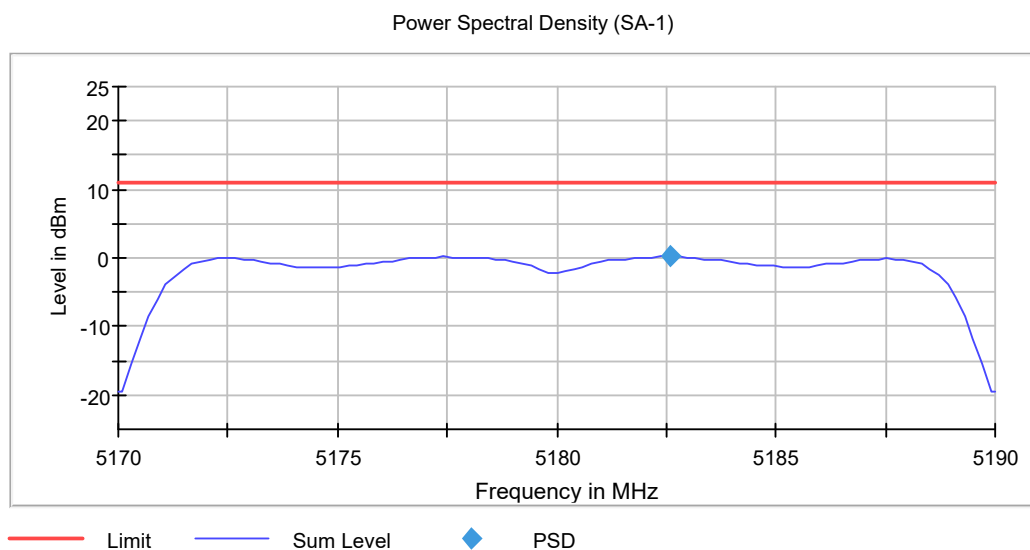


- High Channel:

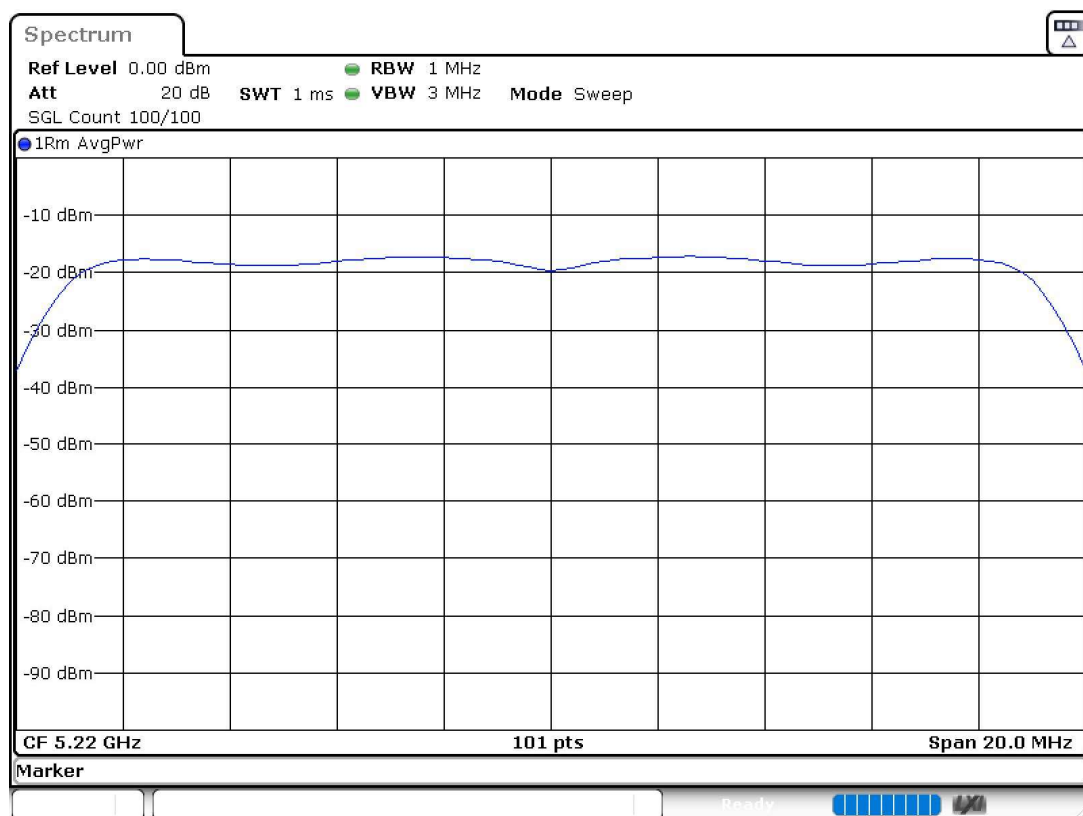
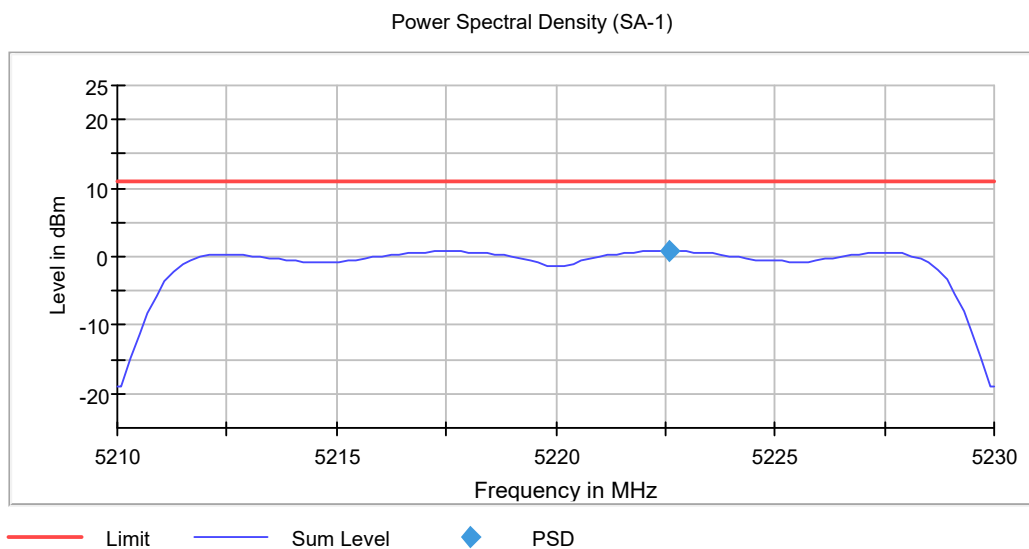


Mode 802.11 ac20 (VHT20):

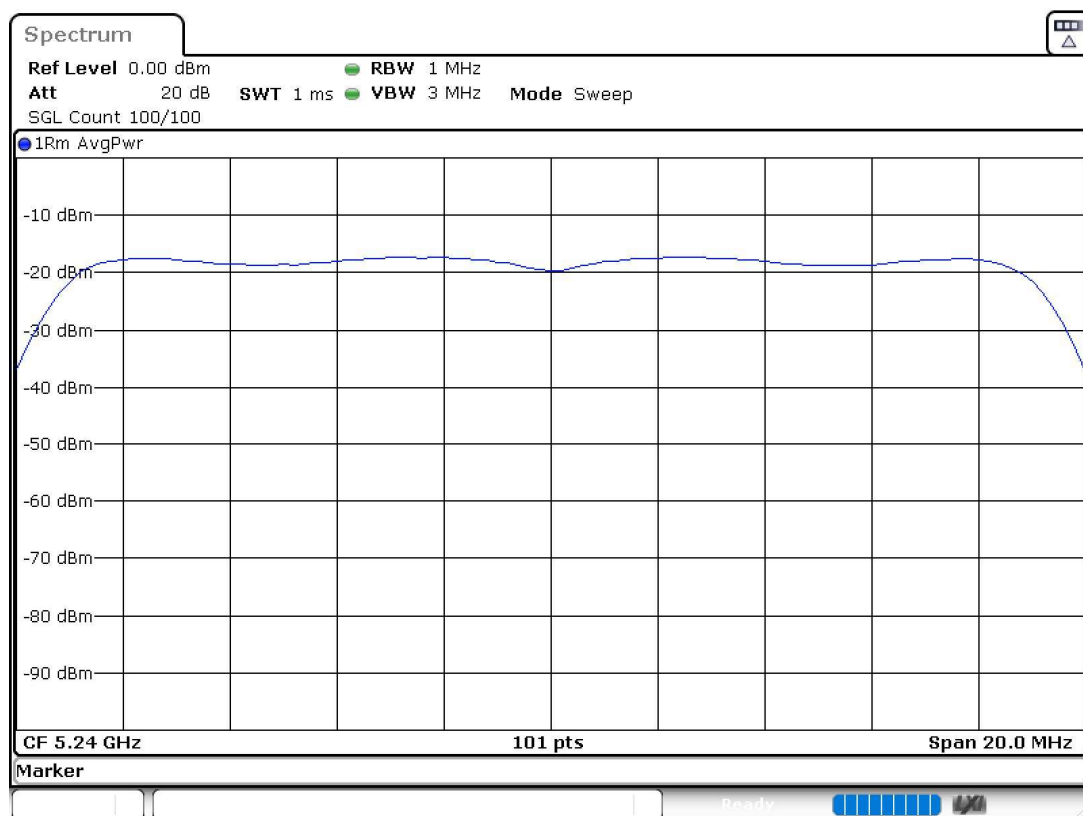
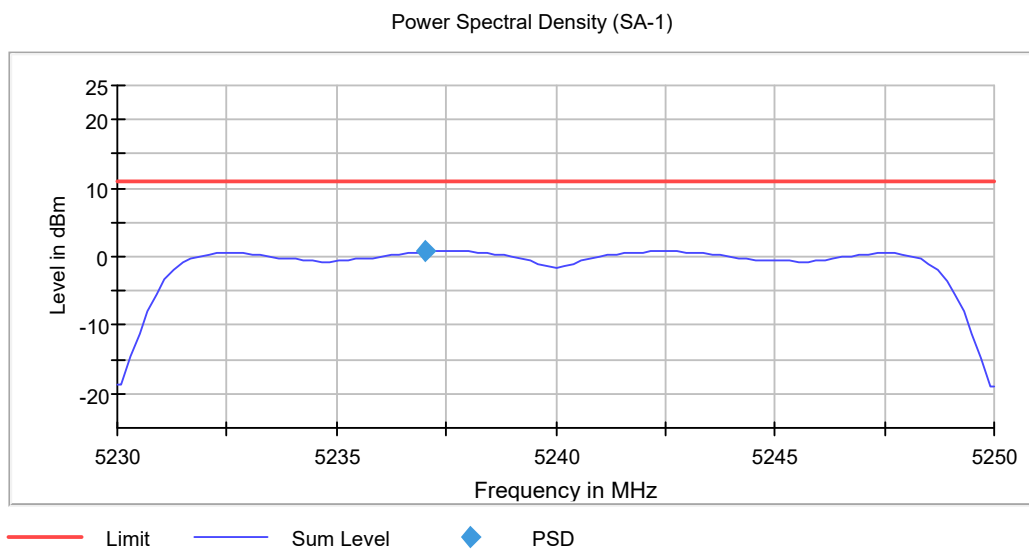
- Low Channel:



- Middle Channel:

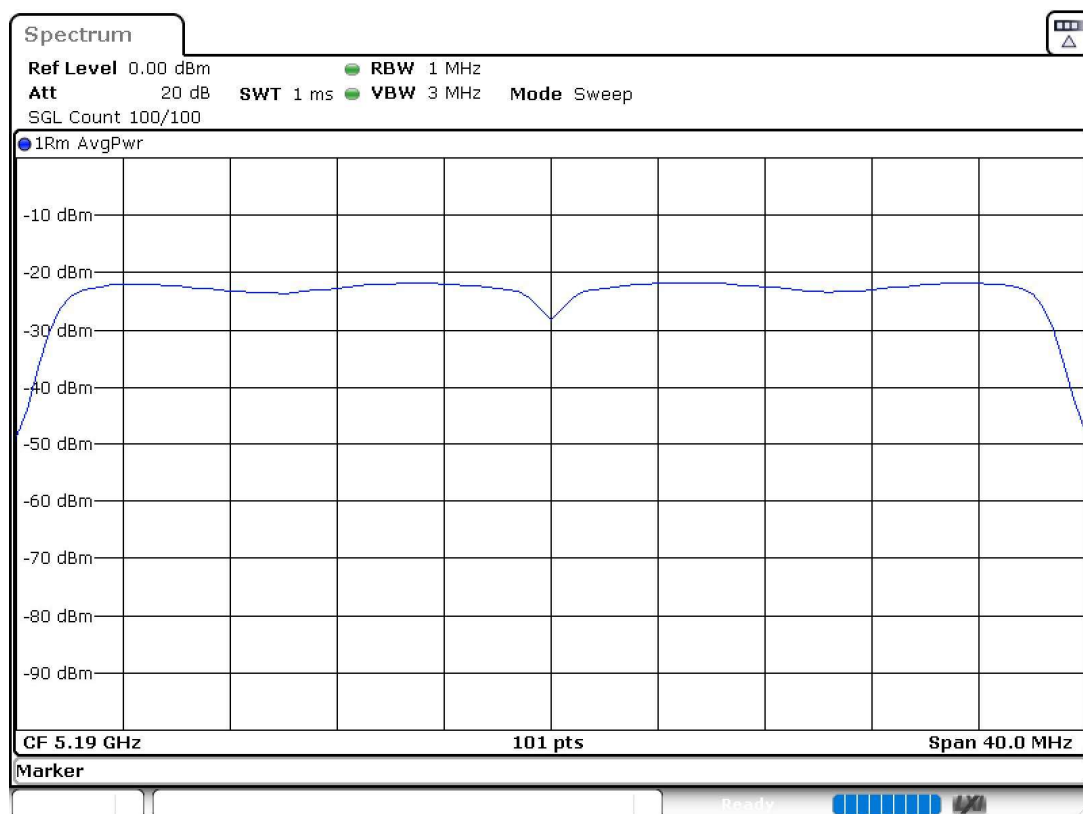
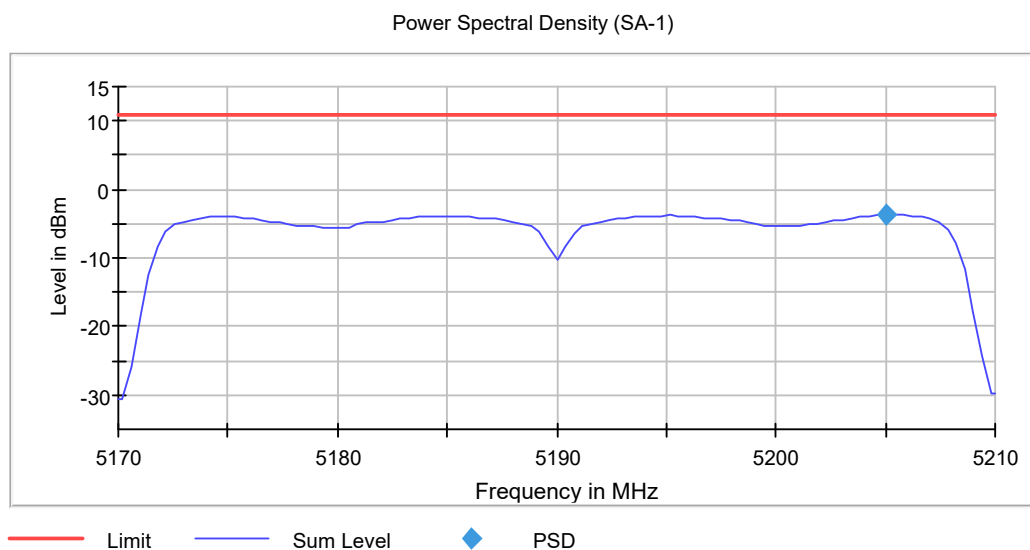


- High Channel:

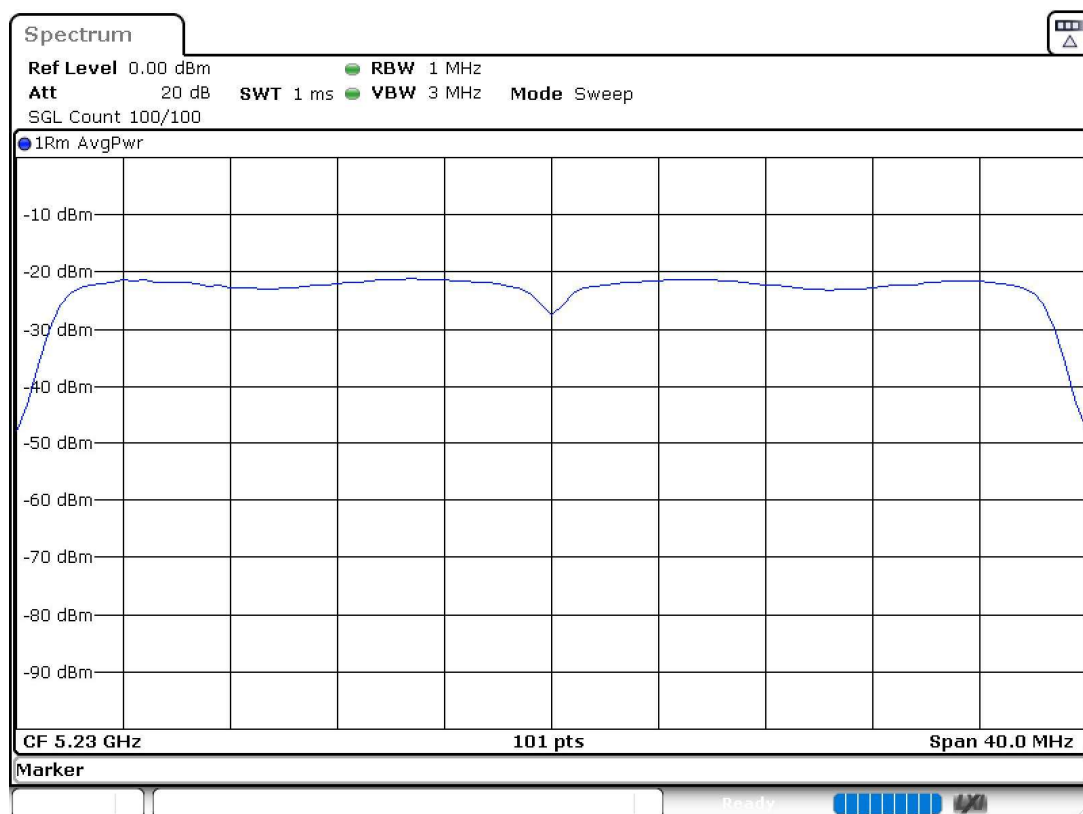
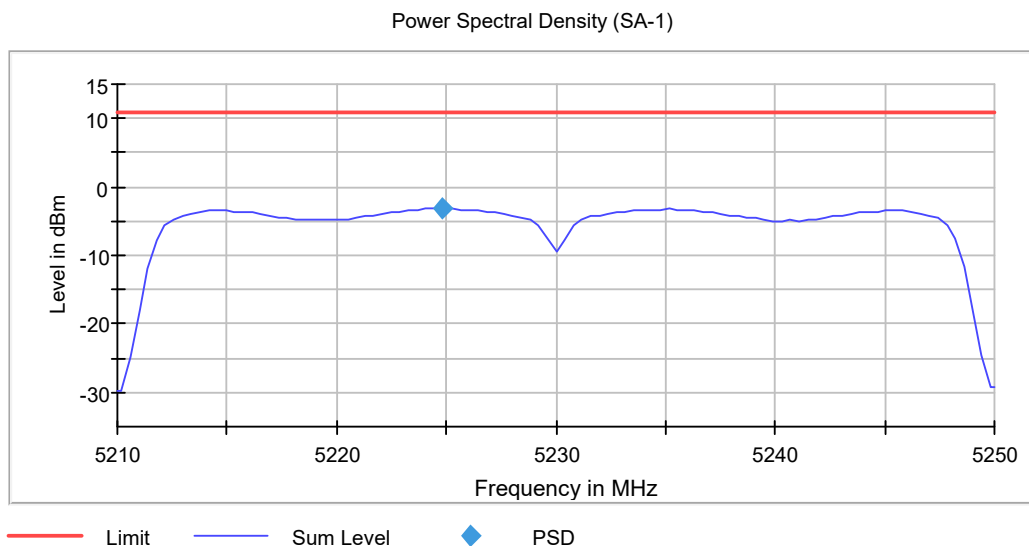


Mode 802.11 n40 (HT40):

- Low Channel:

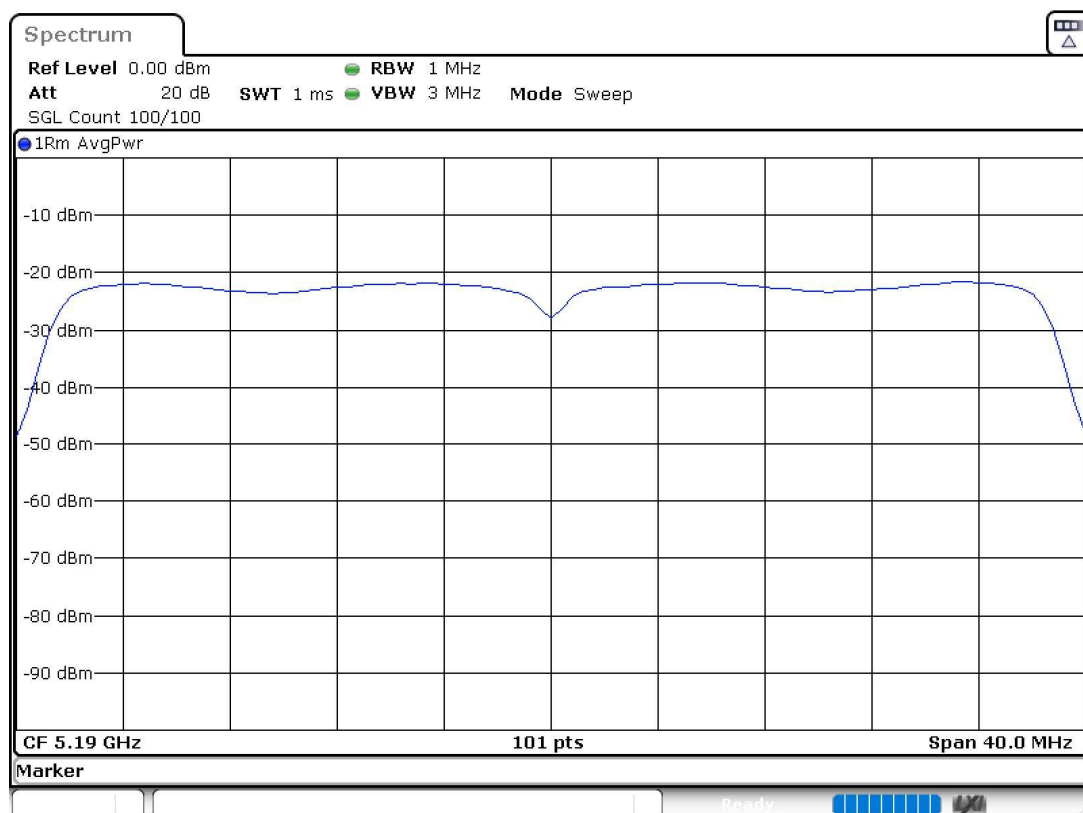
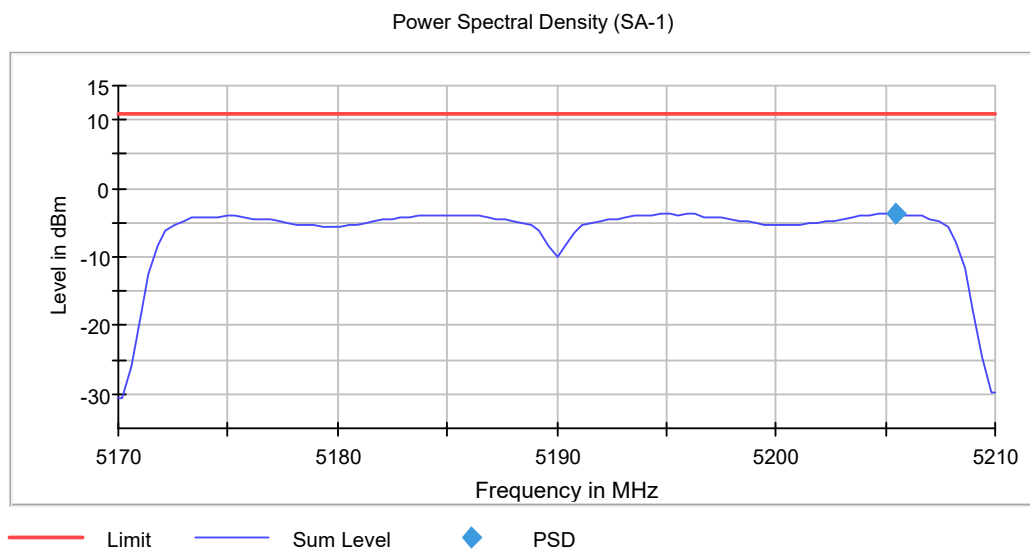


- High Channel:

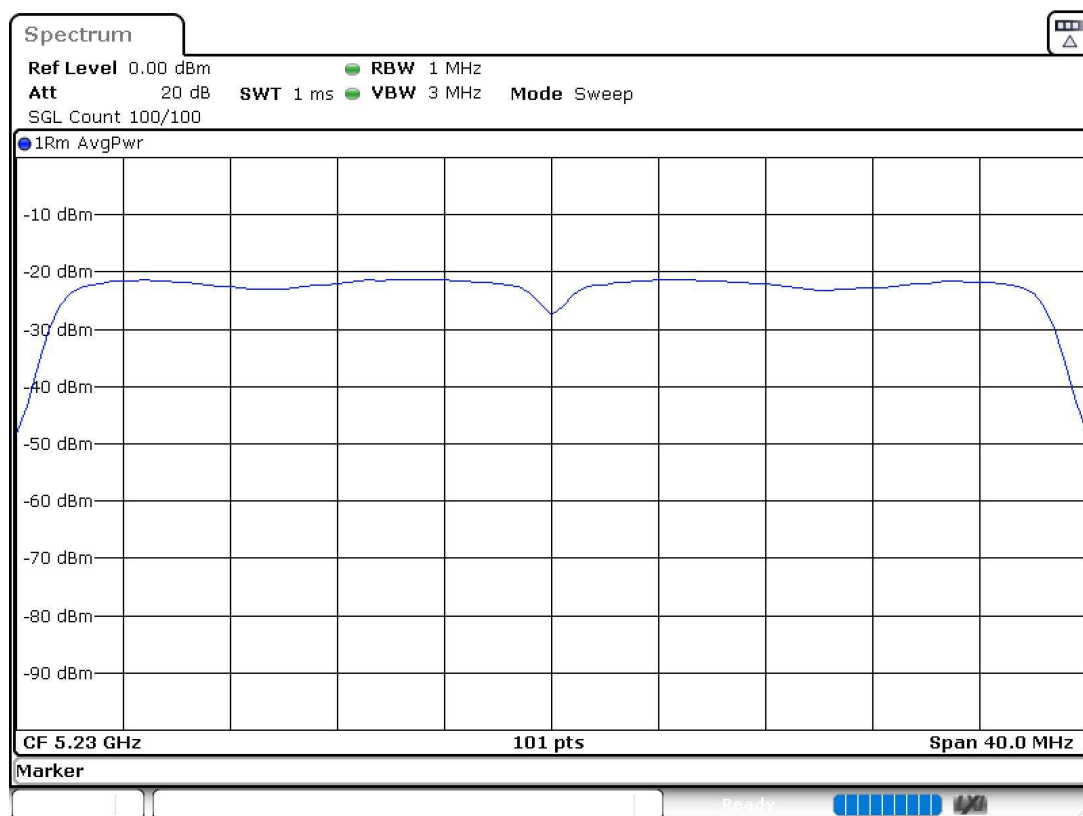
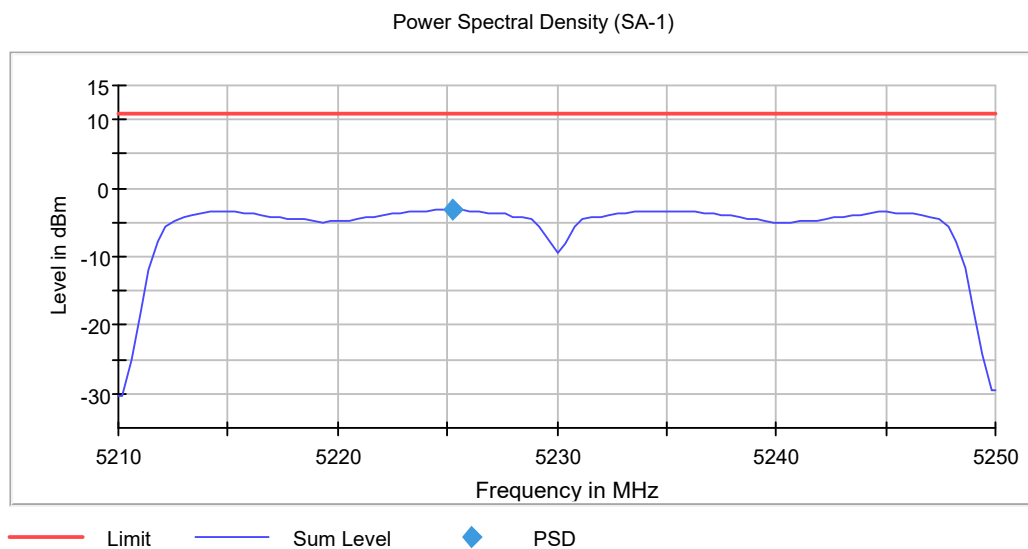


Mode 802.11 ac40 (VHT40):

- Low Channel:

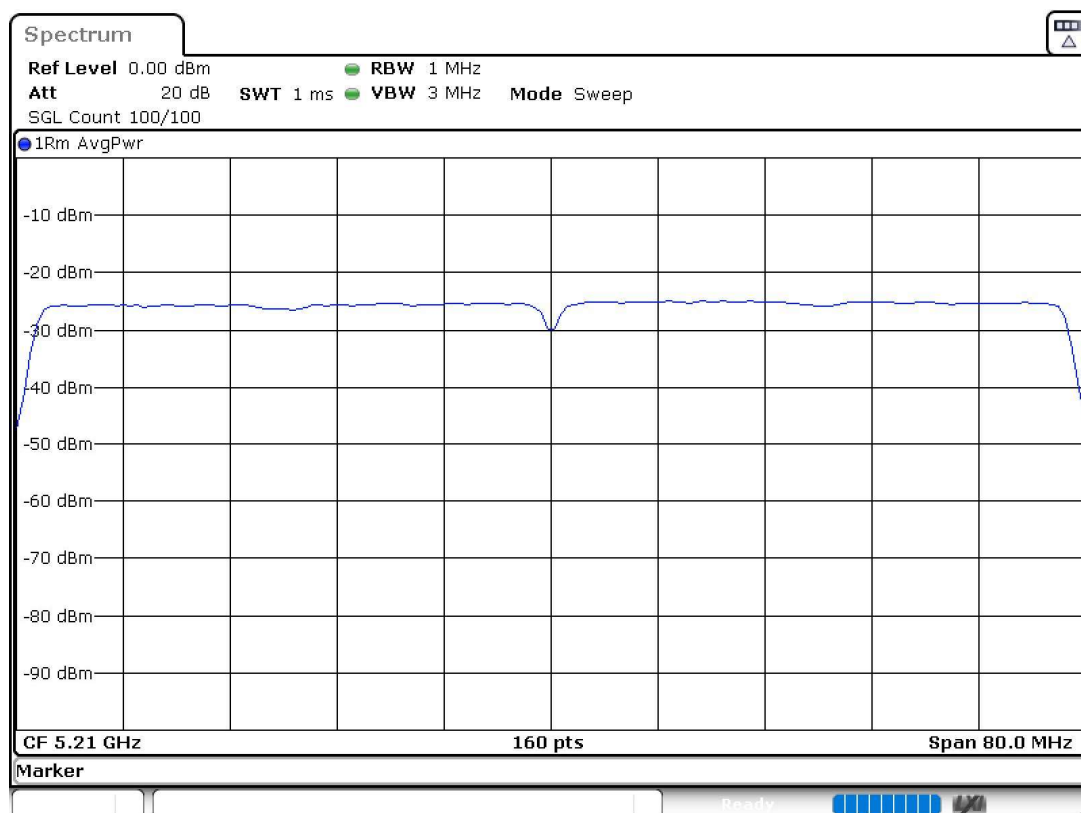
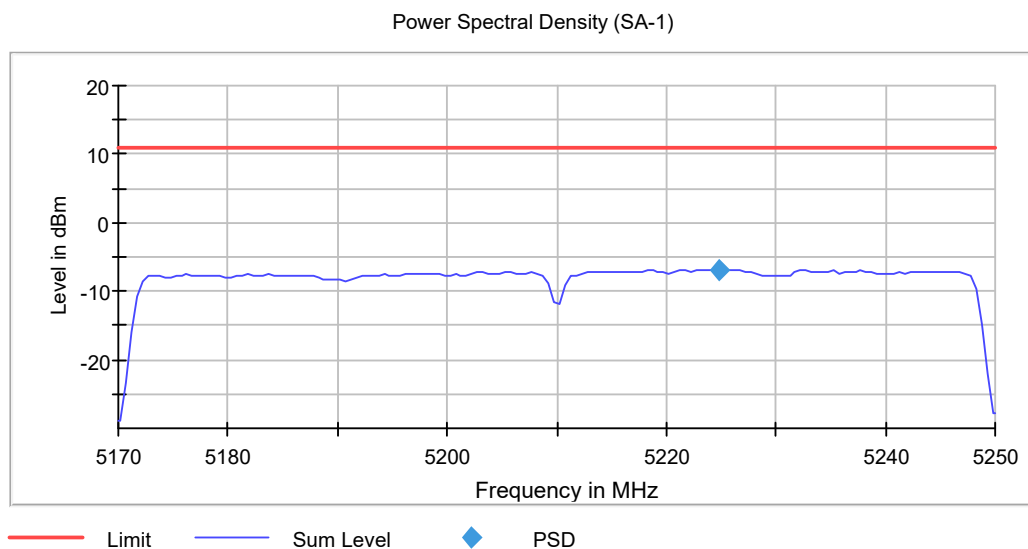


- High Channel:



Mode 802.11 ac80 (VHT80):

- Single Channel:



FCC 15.407 (b)(1) / RSS-247 6.2.1.2. Transmitter Out of Band Radiated Emissions

Limits

For transmitters operating in the 5.15–5.25 GHz band: all emissions outside of the 5.15–5.35 GHz band shall not exceed an EIRP of –27 dBm/MHz (68.23 dBμV/m at 3 m distance).

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)):

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)	-	300
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
Above 960	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, specified when measuring with peak detector function.

Any unwanted emissions that fall into the band 5250-5350 MHz shall be attenuated below the channel power by at least 26 dB, when measured using a resolution bandwidth between 1 and 5% of the occupied bandwidth (i.e. 99% bandwidth), above 5250 MHz.

Equipment certified under this standard is required to comply with the provisions in RSS-Gen with respect to emissions falling within restricted frequency bands.

Results

The field strength is calculated by adding a correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain. For measurements above 17 GHz performed at a reduced distance, this factor also includes an inverse proportionality factor of 20 dB per decade to normalize the measured data.

Band edge emissions in the restricted band adjacent to the U-NII-1 band, i.e. 4.5-5.15 and 5.35-5.46 GHz, are reported in the next section of this test report.

Test performed on the following modulations and data rates:

802.11 a20:	6 Mbps
802.11 n HT20:	MCS0
802.11 n HT40:	MCS0
802.11 ac VHT20:	MCS0
802.11 ac VHT40:	MCS0
802.11 ac VHT80:	MCS0

OUT OF BAND EMISSIONS:

For spurious emissions outside of the U-NII-1 band, the worst-case mode was determined among all modulations after preliminary measurements of the radiated power spectral density.

The Low, Middle and High Channels were tested for the determined worst case.

- **Worst case:** **802.11 n HT20 MCS0**

Frequency range 30 MHz - 1 GHz

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

No spurious frequencies detected at less than 20 dB below the limit.

Frequency range 1 - 40 GHz

The results in the next tables show the maximum measured levels in the 1 – 40 GHz frequency range.

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

- LOW CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBμV/m)	Polarization	Detector
9966.2647	52.34	V	Peak

- MIDDLE CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBμV/m)	Polarization	Detector
9926.7000	52.27	V	Peak

- HIGH CHANNEL. Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBμV/m)	Polarization	Detector
9974.4000	51.93	V	Peak

Verdict

Pass

Attachments

The setting for each range of frequency is indicated in the following tables:

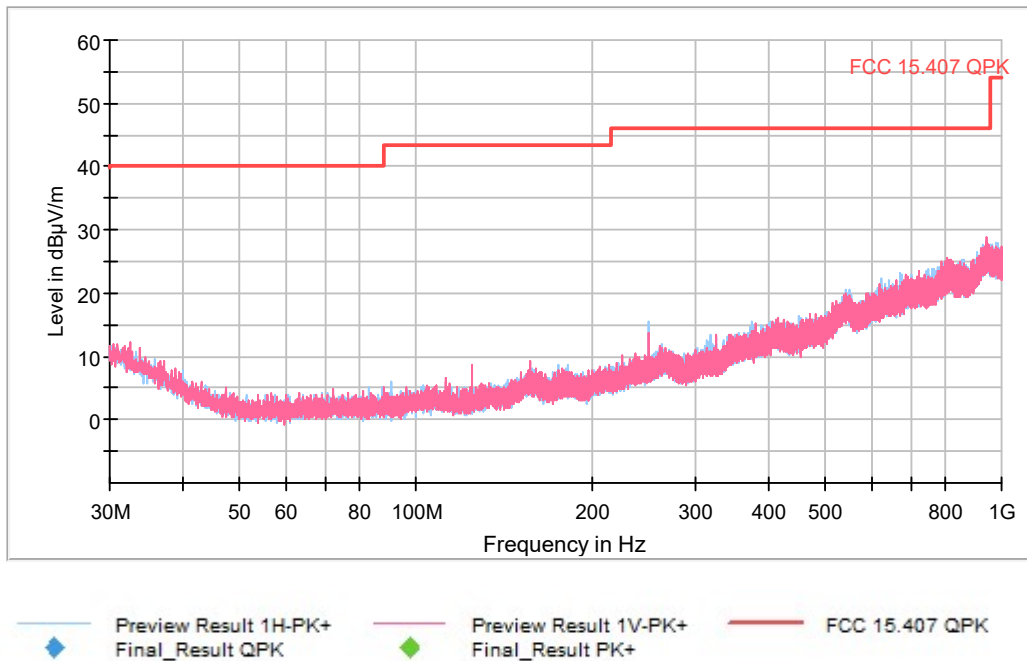
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESR 7] 30 MHz - 1 GHz	9,7 kHz	PK+	100 kHz	1 s	0 dB

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESR 7] 1 GHz - 7 GHz	187,5 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [FSW 50] 7 GHz - 17 GHz	100 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [FSW 50] 17 GHz - 40 GHz	230 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

FREQUENCY RANGE 30 MHz - 1 GHz



This plot is valid for Low, Middle and High Channels and all modulations.