

Appendix C: Test results for the U-NII-3 Band 5.725 – 5.85 GHz

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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: +0.9 dBi (antenna gain plus antenna cable loss).

Technology Tested:	WLAN (IEEE 802.11 a/n/ac): U-NII-3 band	
Modes:	802.11a: 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 MCS8	
	802.11ac VHT40: MCS0 to MCS9	
	802.11ac VHT80: MCS0 to MCS9	
Setting of cores / ports:	One port.	
Beamforming:	No	
Frequency Range:	5725 MHz to 5850 MHz	
Channel Spacing:	20 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Low: 149	5745
	Middle: 157	5785
	High: 165	5825
Channel Spacing:	40 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Low: 151	5755
	High: 159	5795
Channel Spacing:	80 MHz	
Transmit Channels	Middle: 155	5775

The test set-up was made in accordance to the general provisions of ANSI C63.10: 2013 and FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01 dated 12/14/2017.

The EUT was tested in the following operating mode:

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

The field strength at the band edges was evaluated for each mode individually 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 scripts to configure the EUT. The customer supplied a document containing the setup instructions.

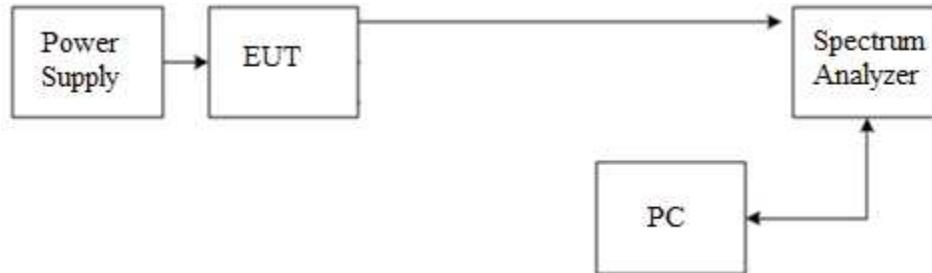
The worst cases for testing were identified for output power and spurious levels at the band edges which were selected based on preliminary testing that correspond to next data rates:

- 802.11a20: 6 Mbit/s
- 802.11n HT20: MCS0
- 802.11n HT40: MCS0
- 802.11ac VHT20: MCS0
- 802.11ac VHT40: MCS0
- 802.11ac VHT80: MCS0

CONDUCTED MEASUREMENTS:

The equipment under test was set up in a shielded room and connected to the 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 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-40 GHz (18 GHz-40 GHz horn antenna).

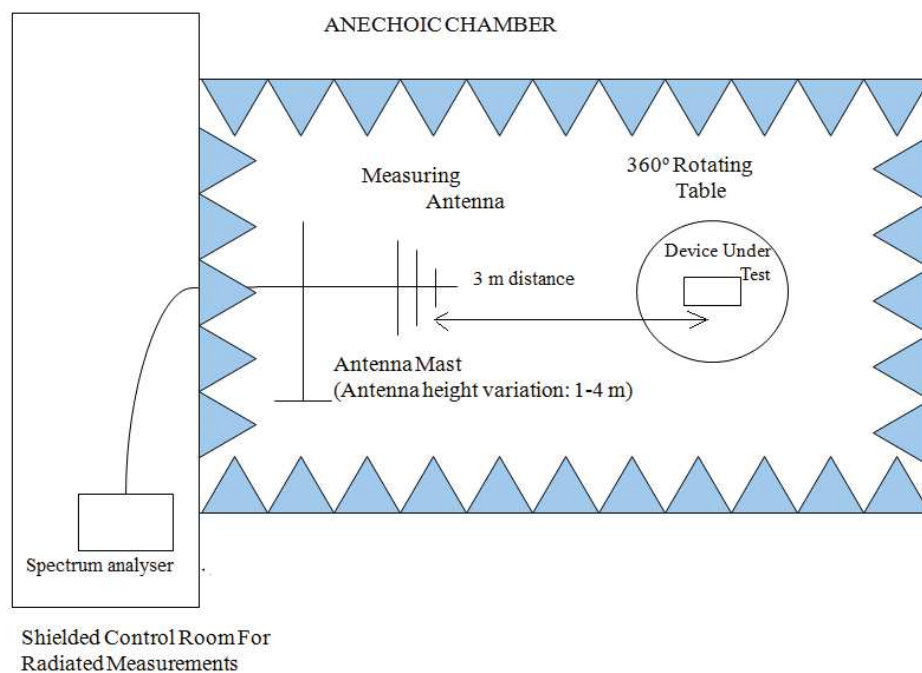
For radiated emissions in the range 17 GHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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.

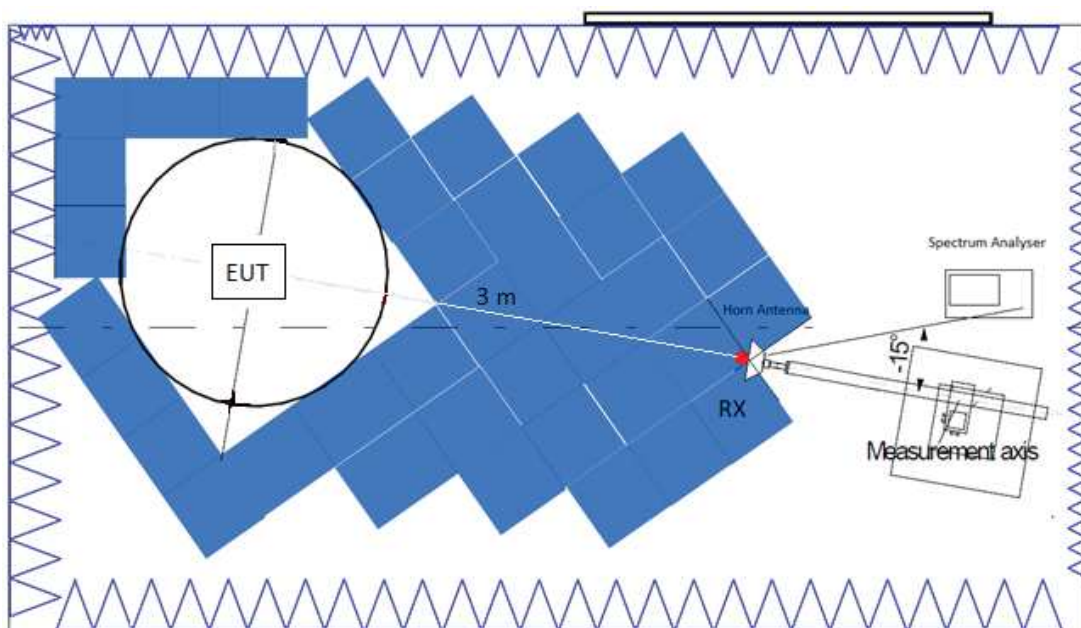
Measurements were made in both horizontal and vertical planes of polarization.

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.

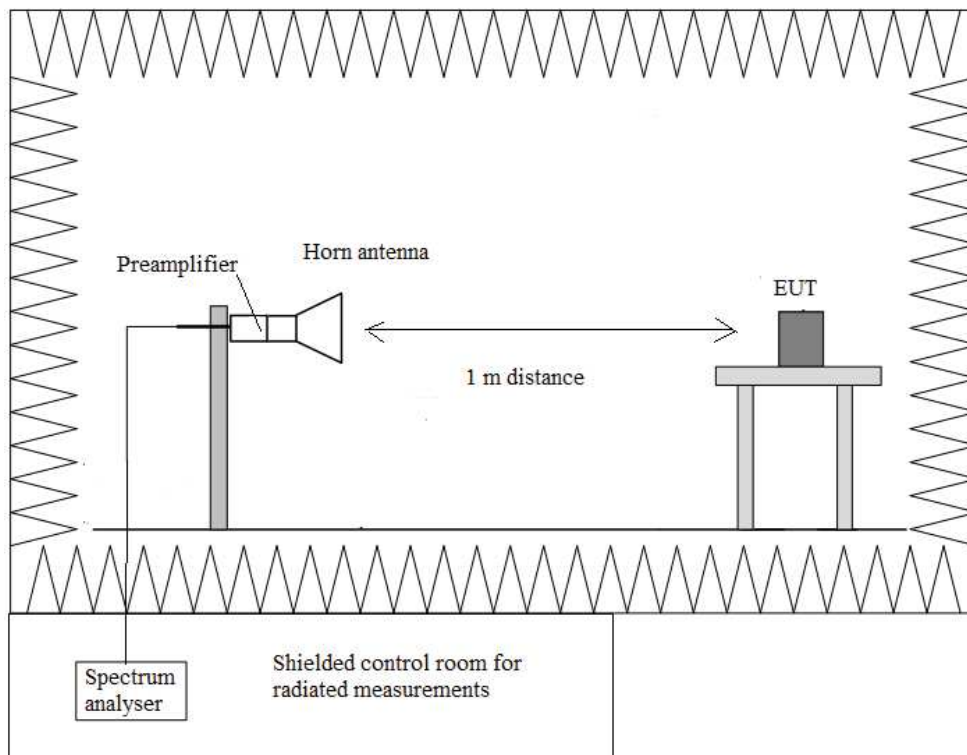
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup $f > 17$ GHz:



FCC 15.247 (e) / RSS-247 6.2.4.1. 6 dB Bandwidth

SPECIFICATION:

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

RESULTS:

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

- 802.11a20: 6 Mbit/s
- 802.11n HT40: MCS0
- 802.11ac VHT20: MCS0
- 802.11ac VHT80: MCS0

Mode 802.11 a20:

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
6 dB Bandwidth (MHz)	16.336	16.327	16.330
Measurement uncertainty (kHz)	<±13.86		

Mode 802.11 n20 (HT20):

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
6 dB Bandwidth (MHz)	17.573	17.567	17.570
Measurement uncertainty (kHz)	<±13.86		

Mode 802.11 ac20 (VHT20):

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
6 dB Bandwidth (MHz)	17.573	17.566	17.562
Measurement uncertainty (kHz)	<±13.86		

Mode 802.11 n40 (HT40):

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
6 dB Bandwidth (MHz)	36.050	36.059
Measurement uncertainty (kHz)	<±16.17	

Mode 802.11 ac40 (VHT40):

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
6 dB Bandwidth (MHz)	36.2869	36.0629
Measurement uncertainty (kHz)	<±16.17	

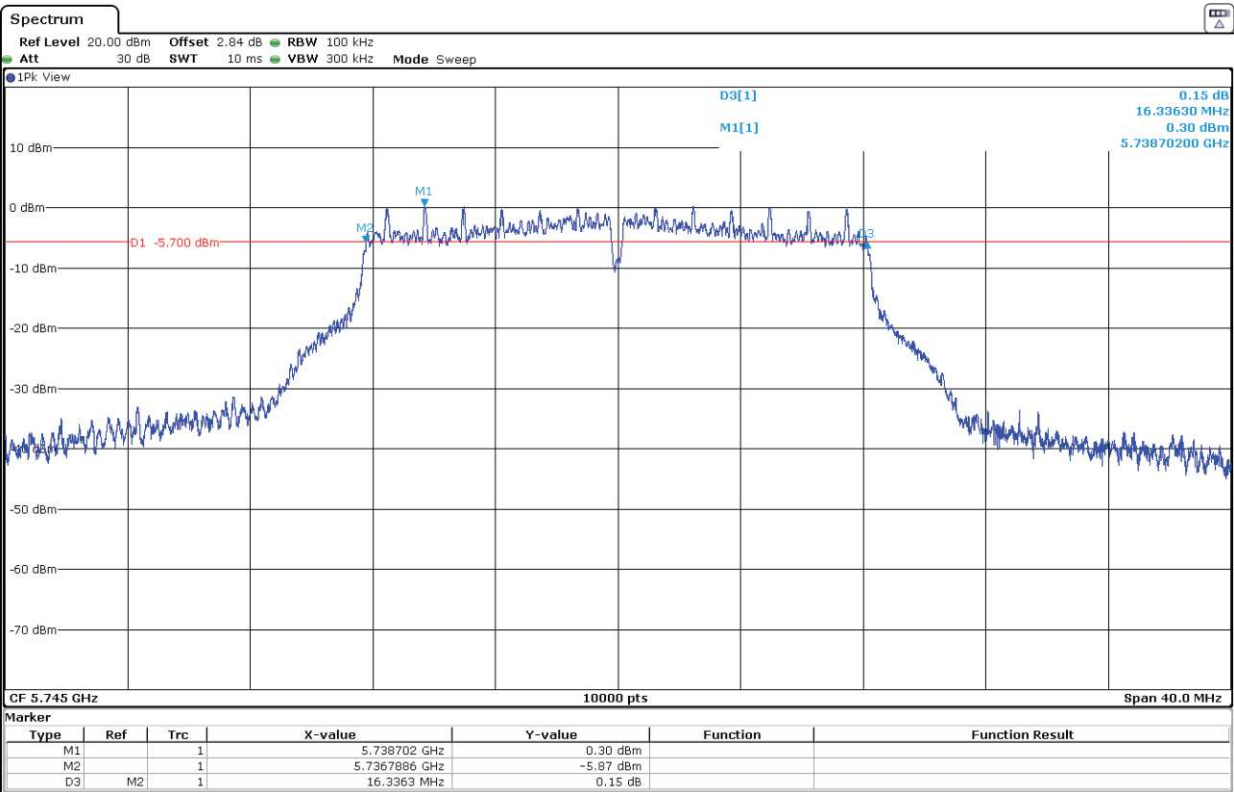
Mode 802.11 ac80 (VHT80):

	Single Channel 155 (5775 MHz)
6 dB bandwidth (MHz)	75.369
Measurement uncertainty (kHz)	<±20.79

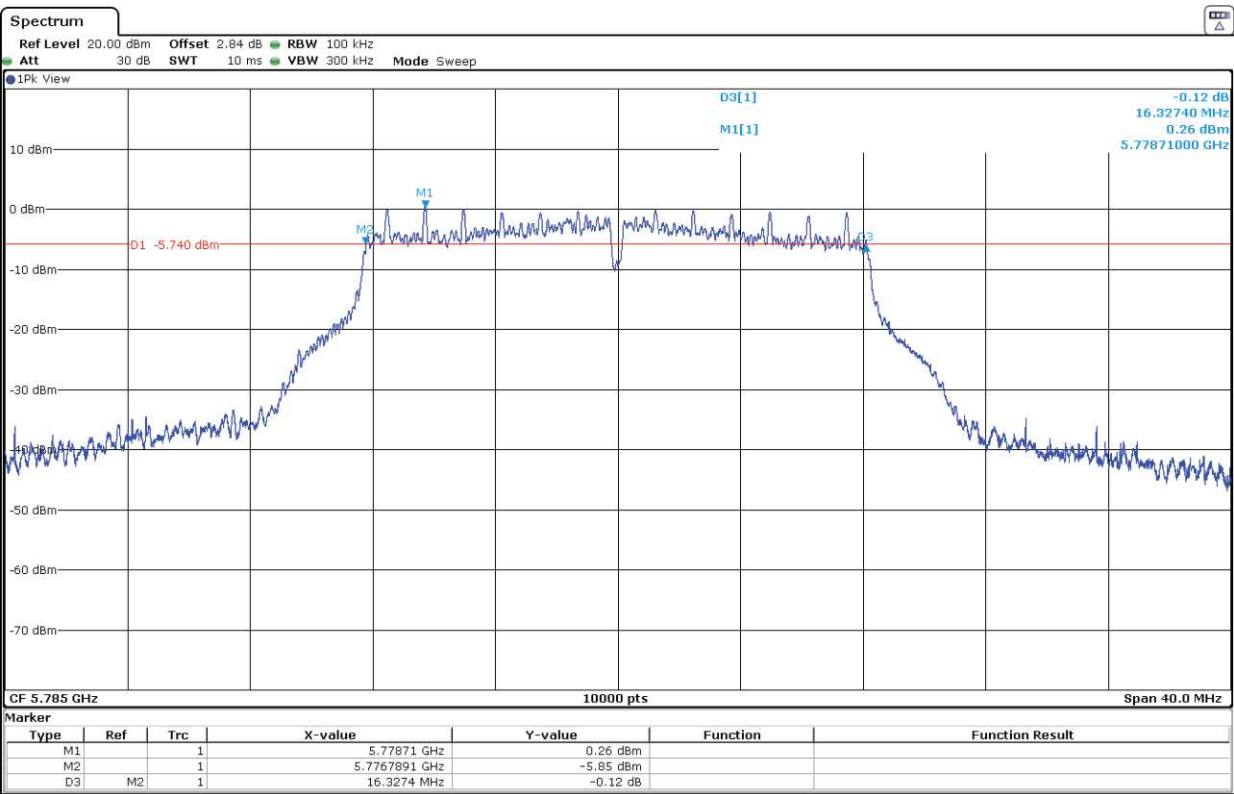
Verdict: PASS

Mode 802.11 a20:

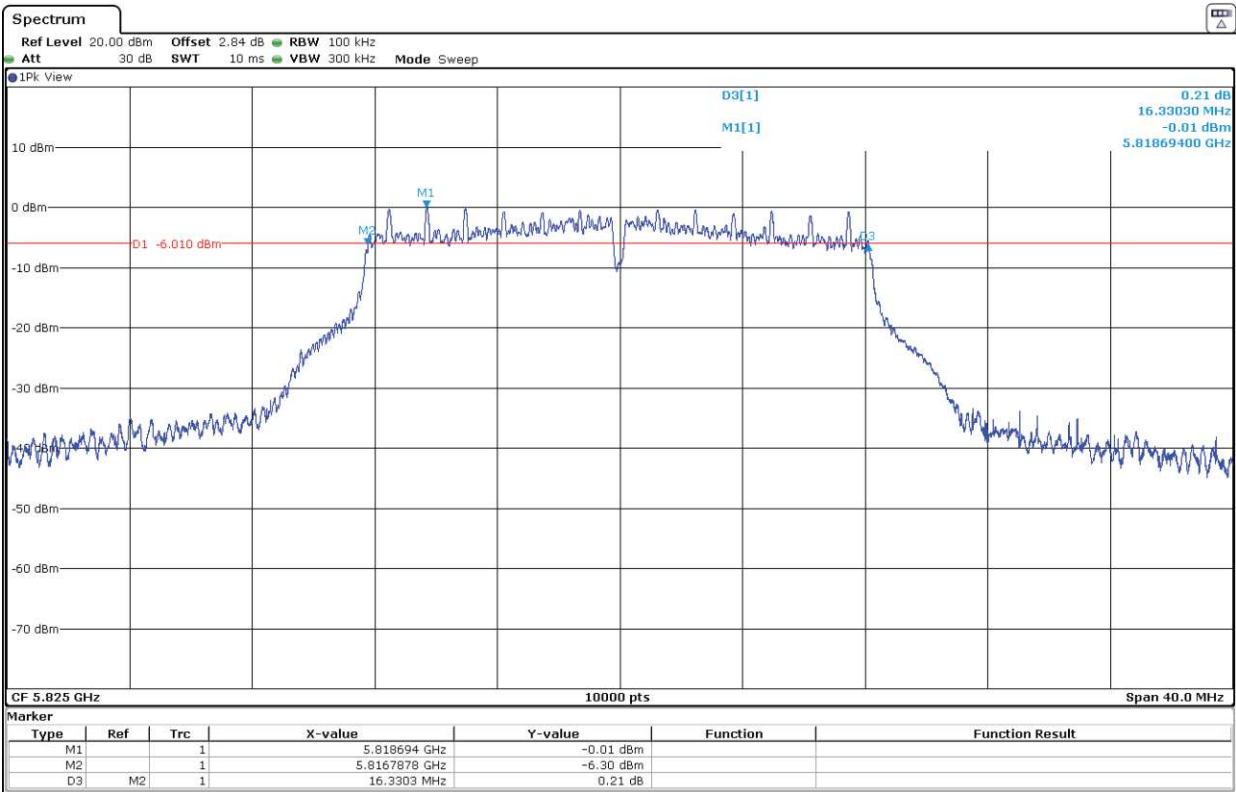
- Low Channel:



- Middle Channel:

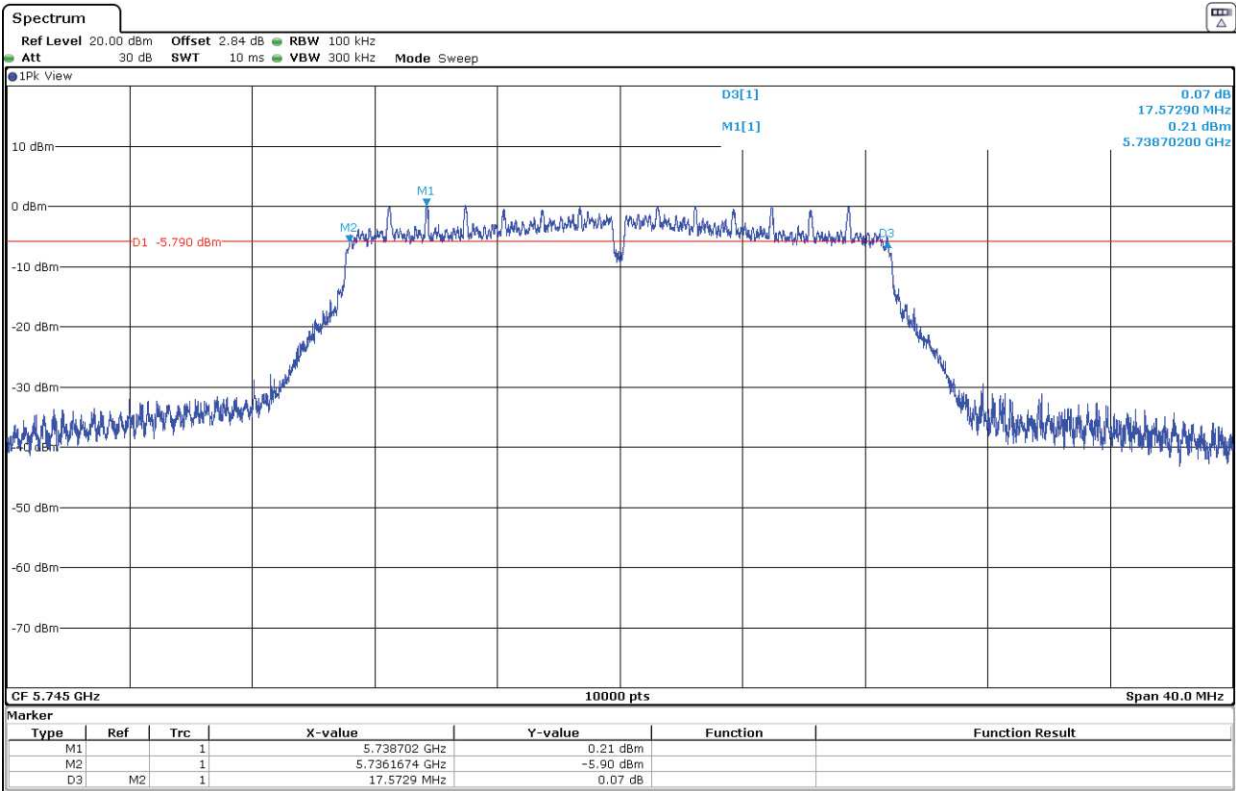


- High Channel:

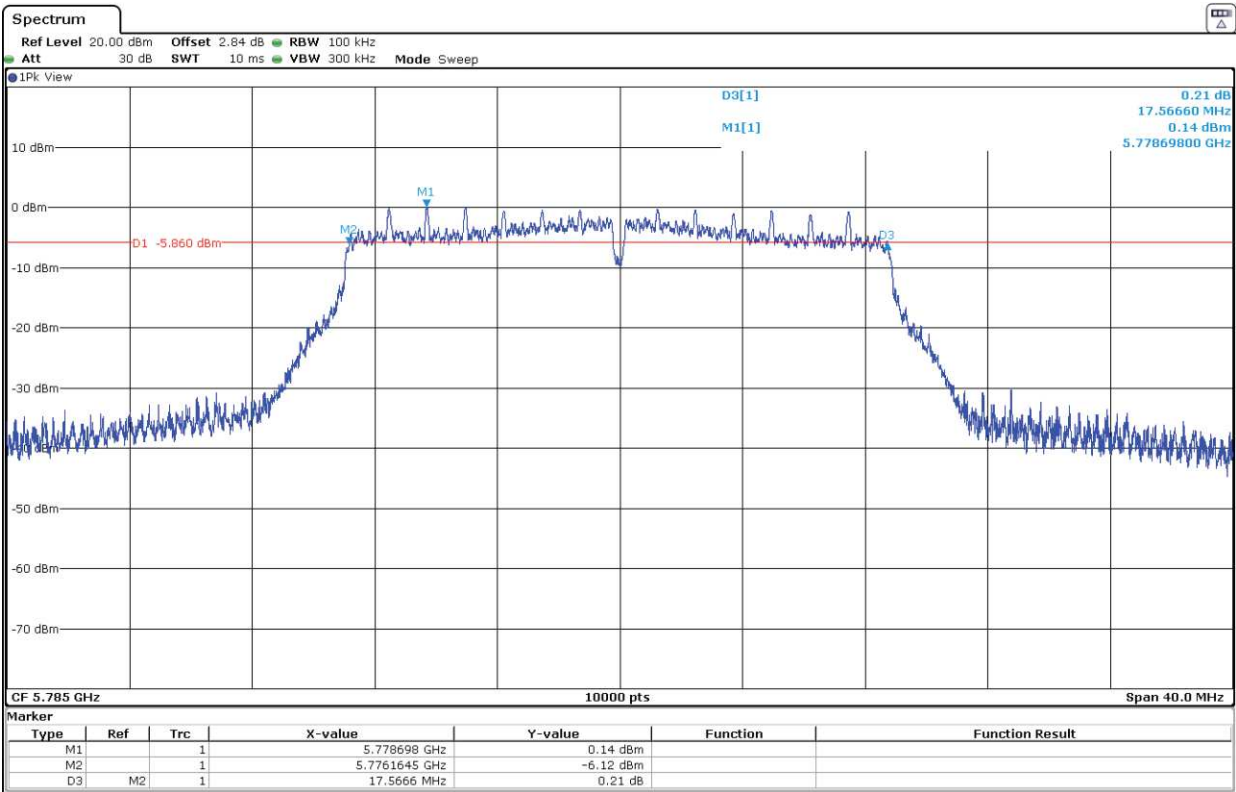


Mode 802.11 n20 (HT20):

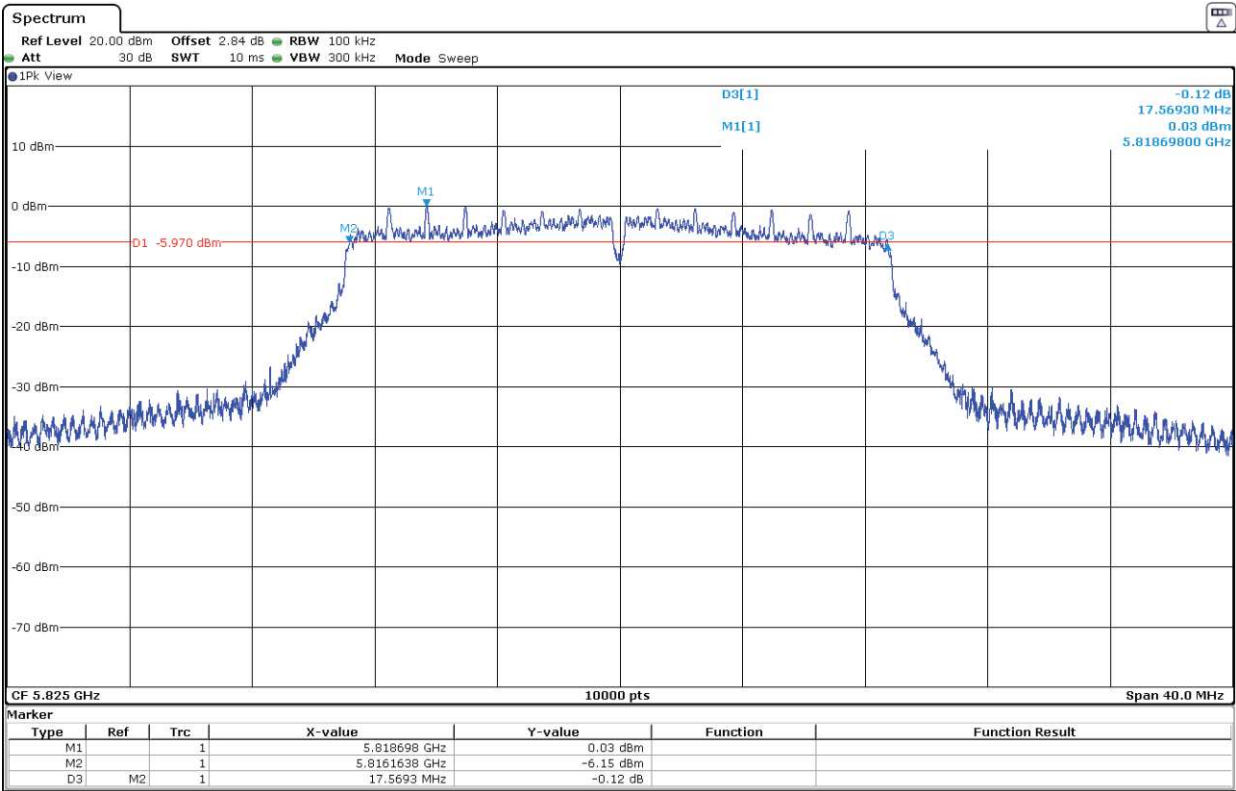
- Low Channel:



- Middle Channel:

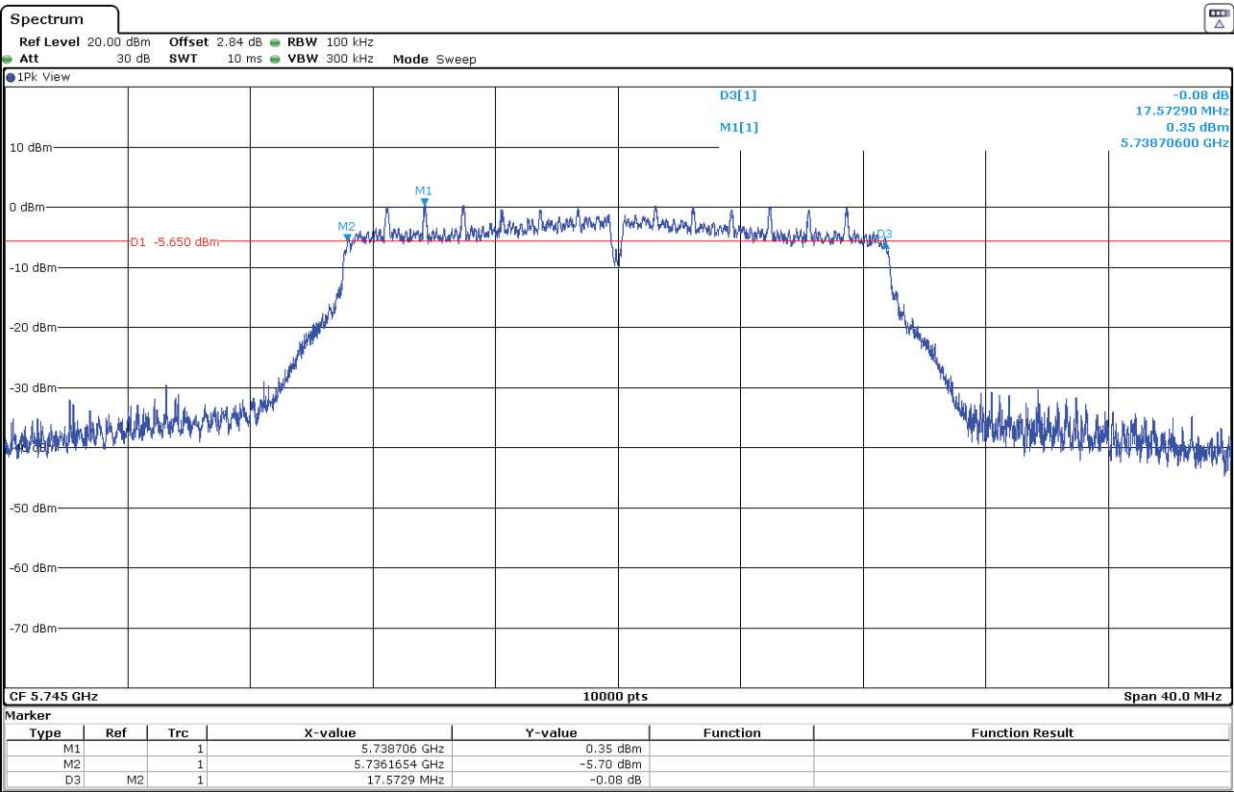


- High Channel:

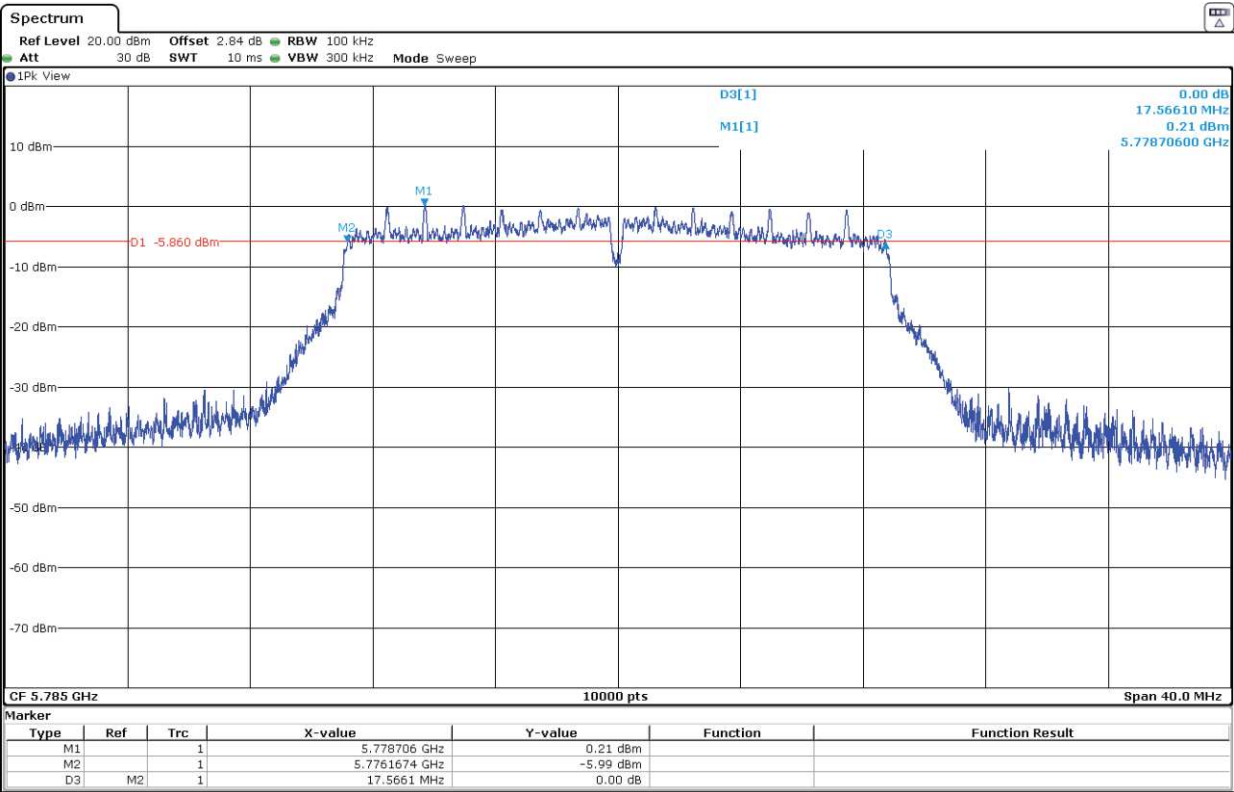


Mode 802.11 ac20 (VHT20):

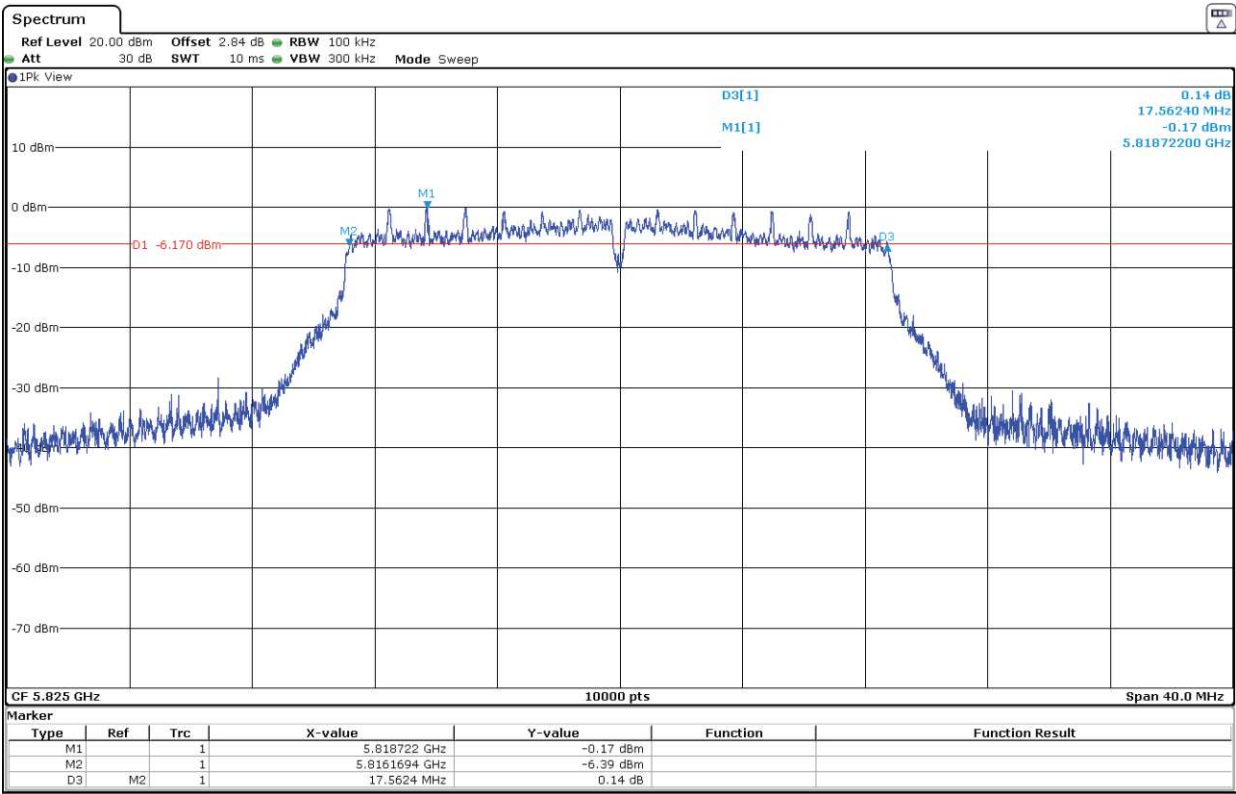
- Low Channel:



- Middle Channel:

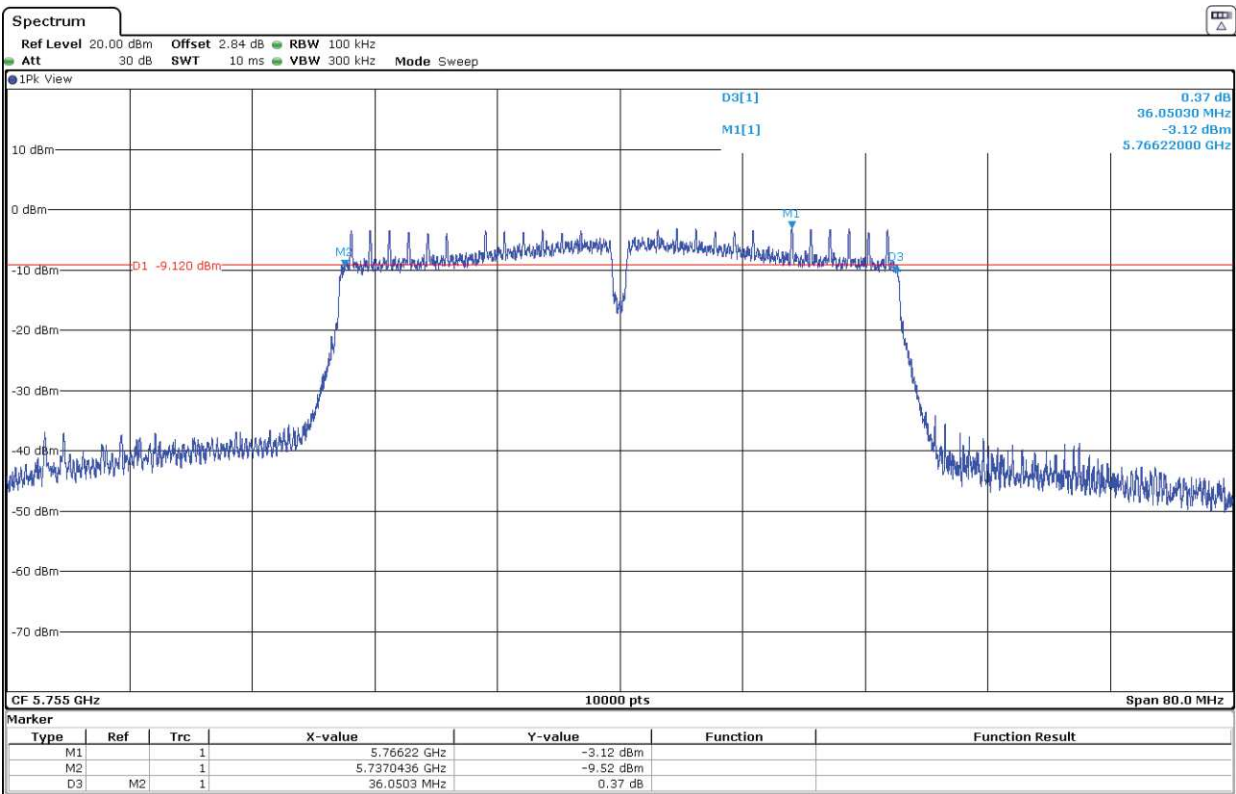


- High Channel:

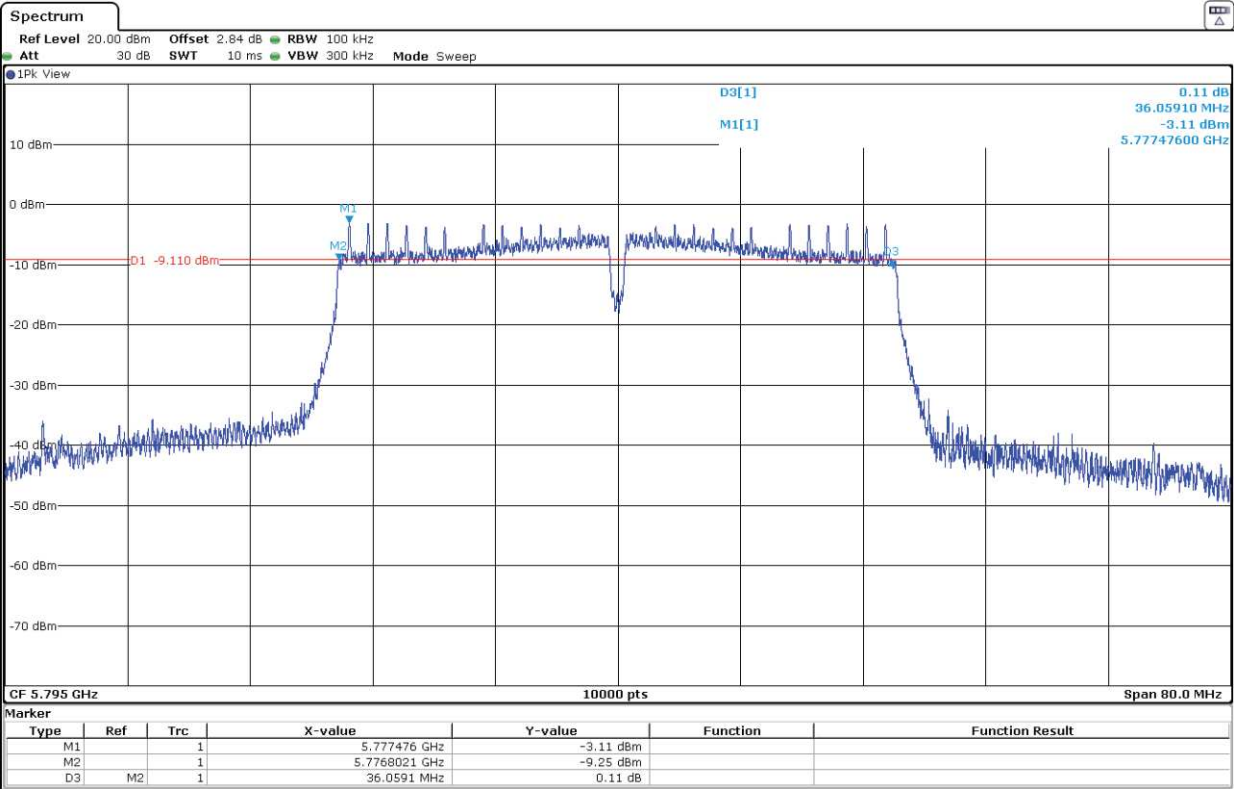


Mode 802.11 n40 (HT40):

- Low Channel:

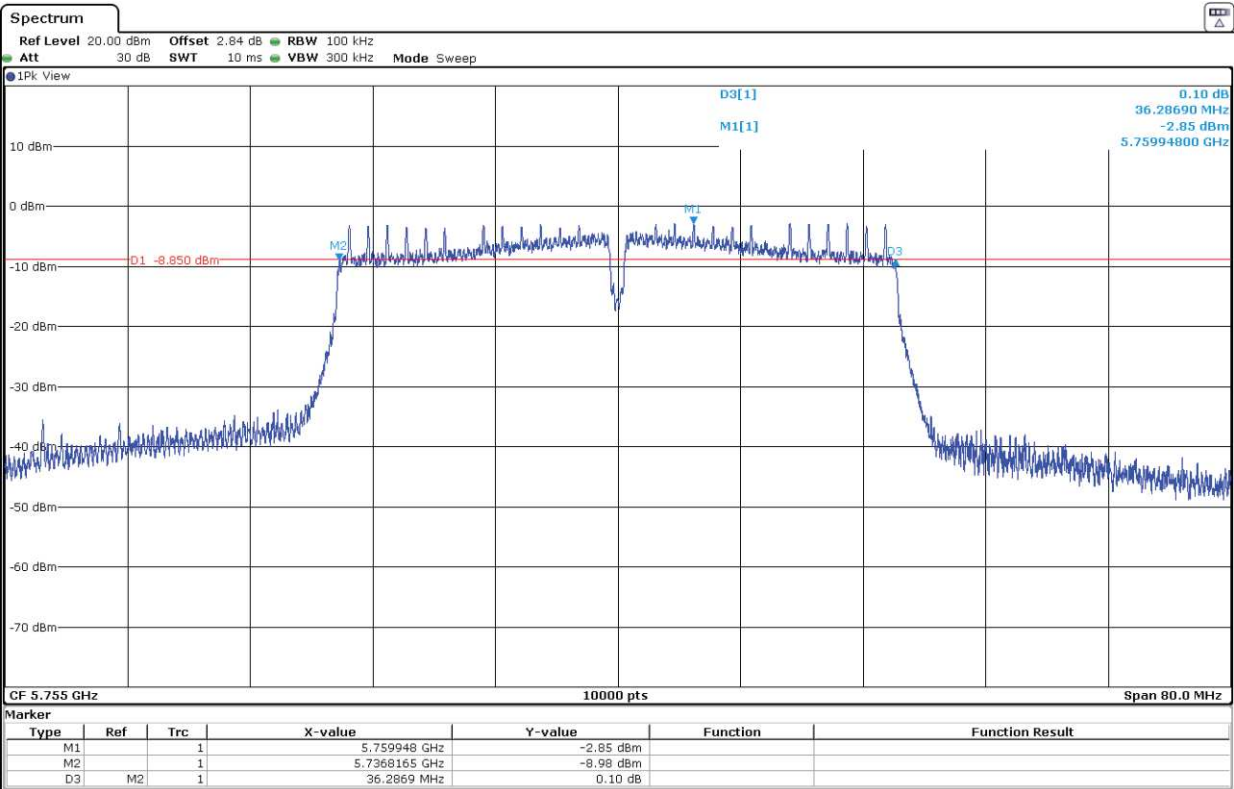


- High Channel:

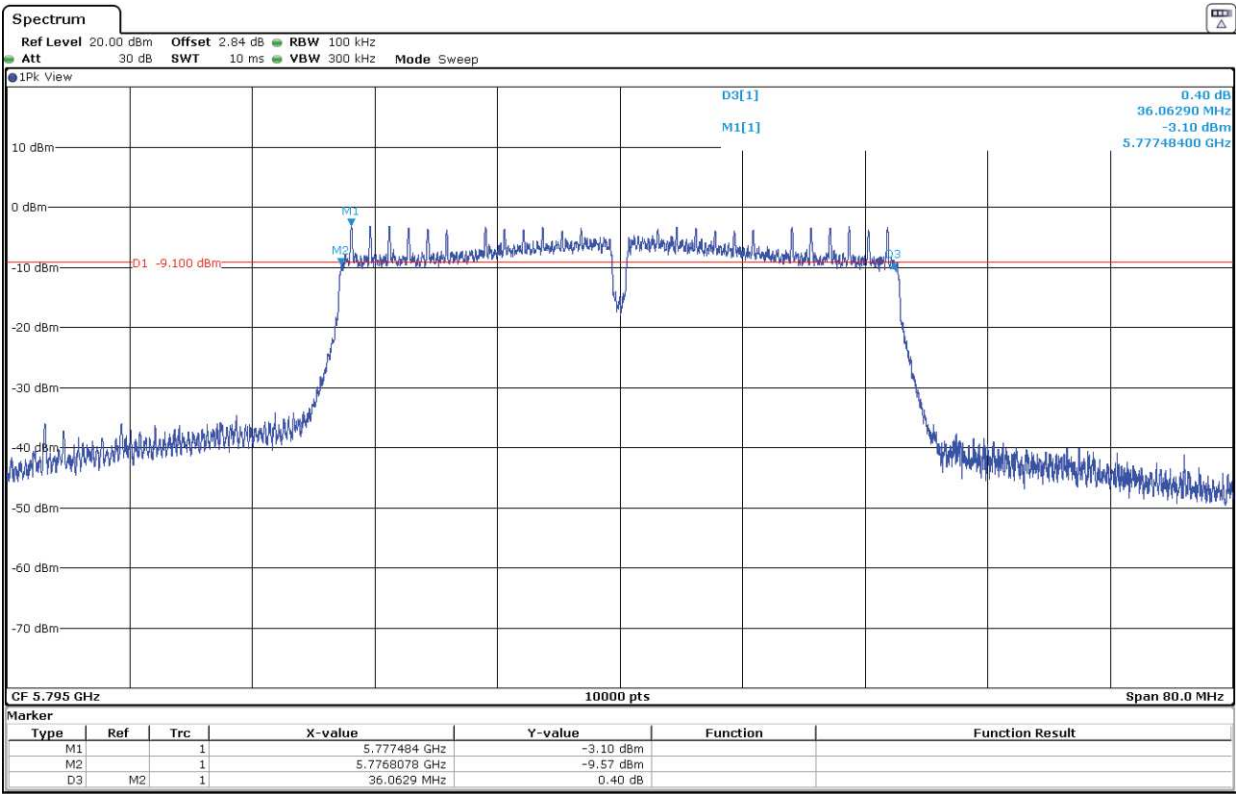


Mode 802.11 ac40 (VHT40):

- Low Channel:

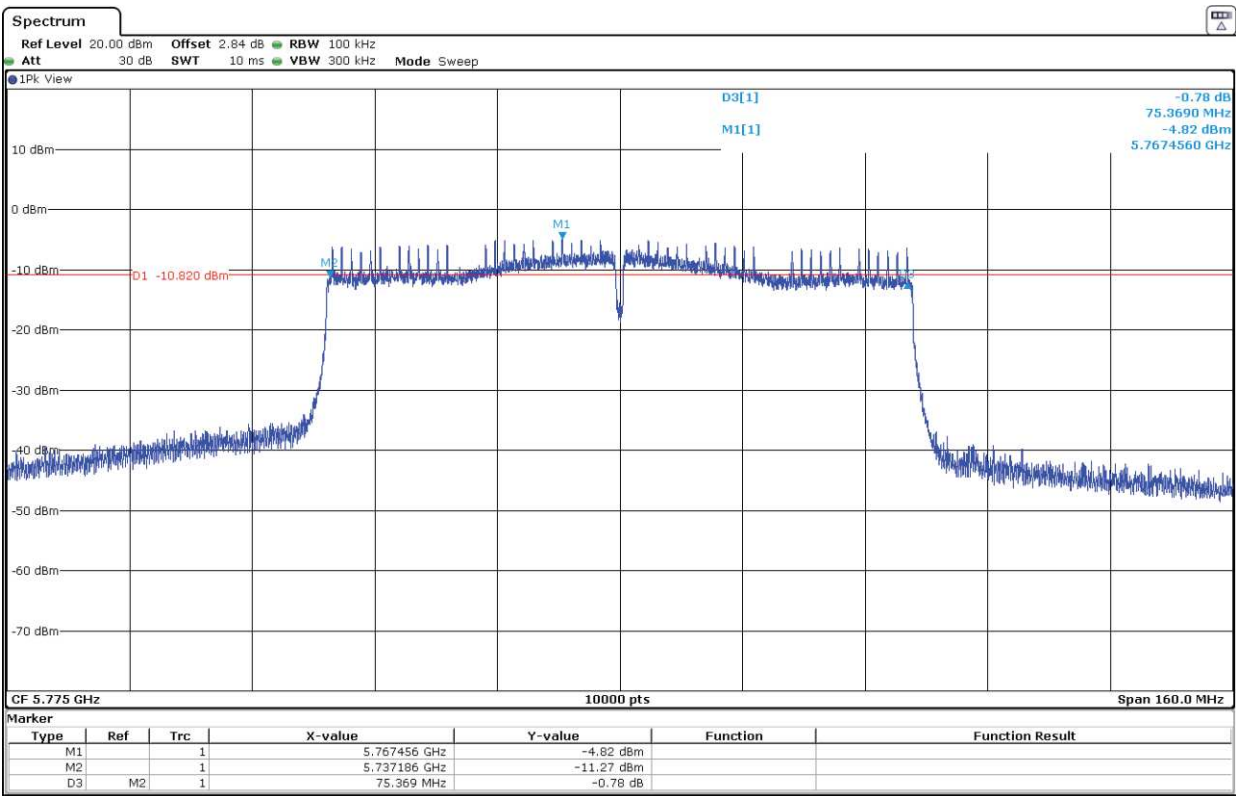


- High Channel:



Mode 802.11 ac80 (VHT80):

- Single Channel:



FCC 15.407 (a)(3) / RSS-247 6.2.4.1. Transmitter Maximum Conducted Output Power

SPECIFICATION:

For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1W (30 dBm). 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.

RESULTS:

The maximum conducted output power was measured using the channel power integration method according to point E) 2) b) (Method SA-1) of 789033 D02 General UNII Test Procedures New Rules v02r01 when the duty cycle is >98% and the channel power integration method according to point E) 2) d) (Method SA-2) of 789033 D02 General UNII Test Procedures New Rules v02r01 when the duty cycle is <98%.

For data rates where the EUT was transmitting at <98% duty cycle, the duty calculated in Appendix A was added to the measured power in order to calculate the total average power during the actual transmission time.

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

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

Maximum Declared Antenna Gain: +0.9 dBi

Mode 802.11 a20:

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
Max. Conducted Power (dBm)	10.45	10.52	9.96
Duty Cycle Correction Factor (dB)	0.943		
Max. Conducted Power Corrected (dBm)	11.393	11.463	10.903
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 n20 (HT20):

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
Max. Conducted Power (dBm)	10.3	10.42	9.8
Duty Cycle Correction Factor (dB)	1.017		
Max. Conducted Power Corrected (dBm)	11.317	11.437	10.817
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 ac20 (VHT20):

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
Max. Conducted Power (dBm)	10.55	10.41	9.95
Duty Cycle Correction Factor (dB)	1.009		
Max. Conducted Power Corrected (dBm)	11.559	11.419	10.959
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 n40 (HT40):

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
Max. Conducted Power (dBm)	8.81	8.93
Duty Cycle Correction Factor (dB)	1.850	
Max. Conducted Power Corrected (dBm)	10.660	10.780
Measurement uncertainty (dB)	<±2.00	

Mode 802.11 ac40 (VHT40):

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
Max. Conducted Power (dBm)	8.72	8.71
Duty Cycle Correction Factor (dB)	1.842	
Max. Conducted Power Corrected (dBm)	10.562	10.552
Measurement uncertainty (dB)	<±2.00	

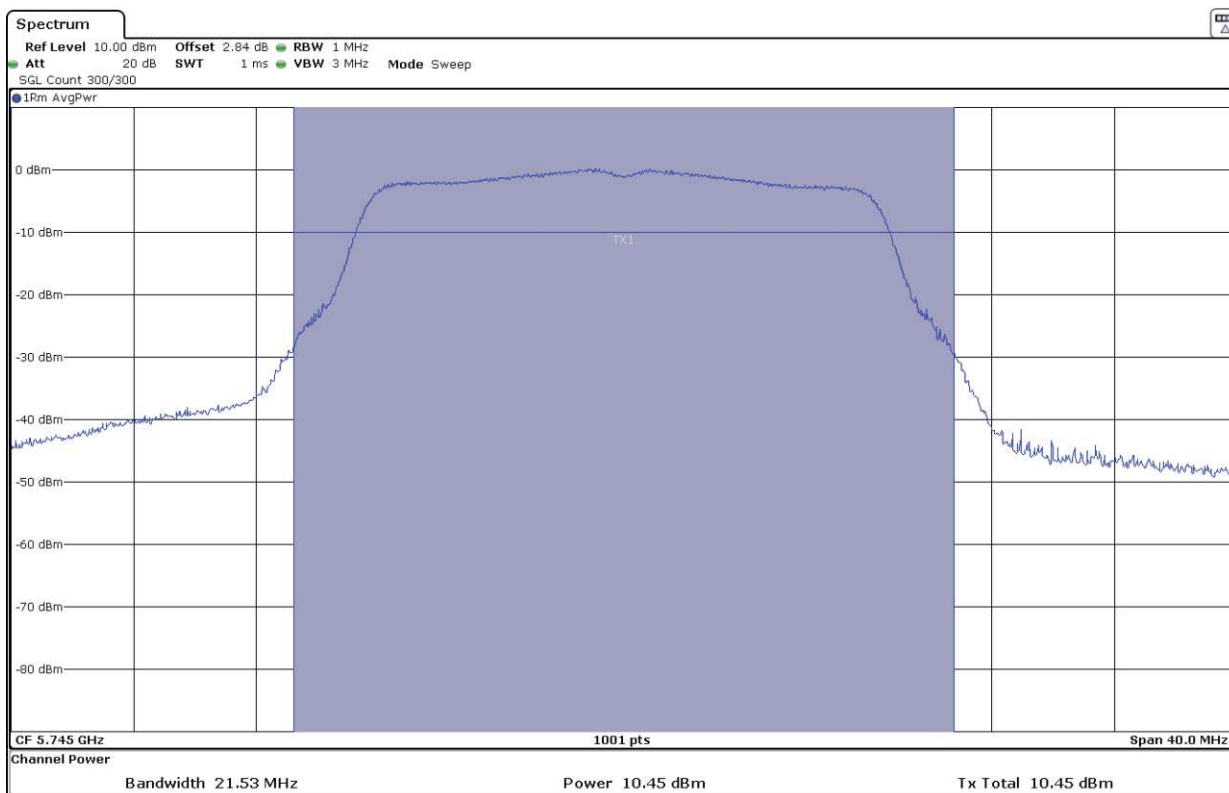
Mode 802.11 ac80 (VHT80):

	Low Channel 155 (5775 MHz)
Max. Conducted Power (dBm)	8.39
Duty Cycle Correction Factor (dB)	3.231
Max. Conducted Power Corrected (dBm)	11.621
Measurement uncertainty (dB)	<±2.00

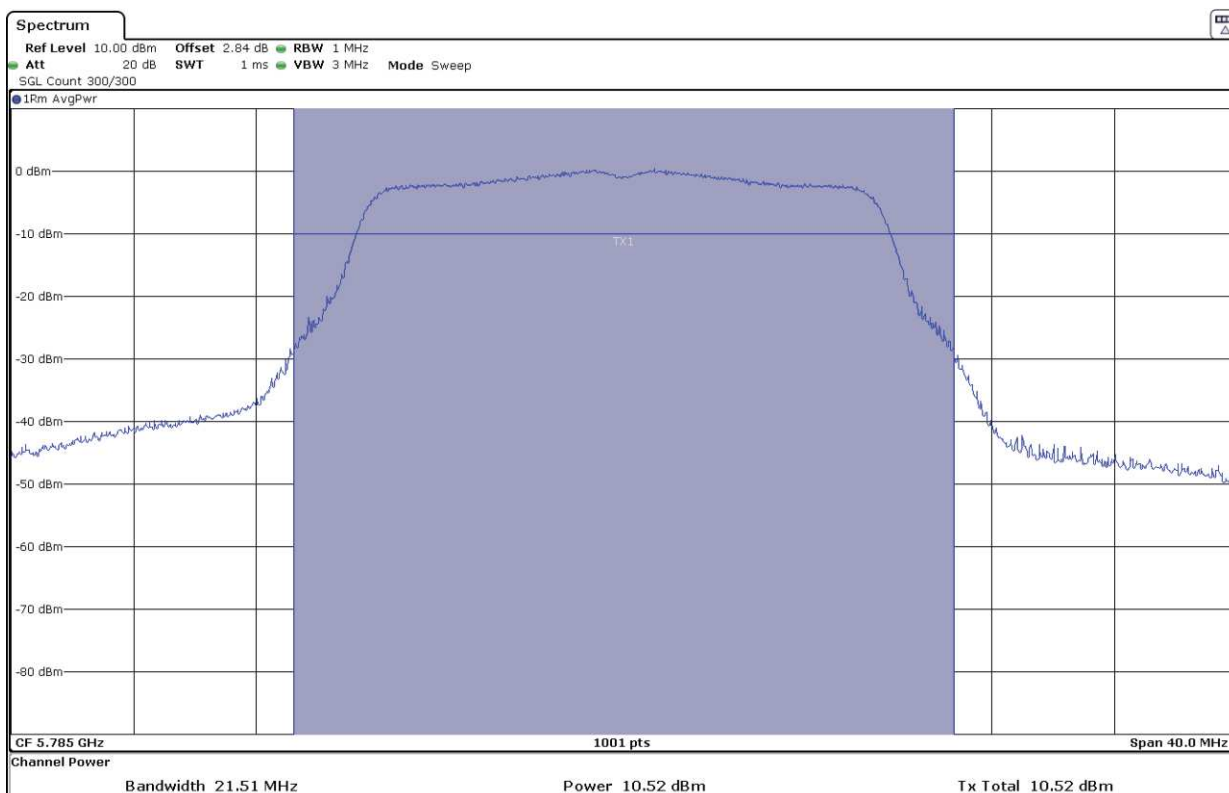
Verdict: PASS

Mode 802.11 a20:

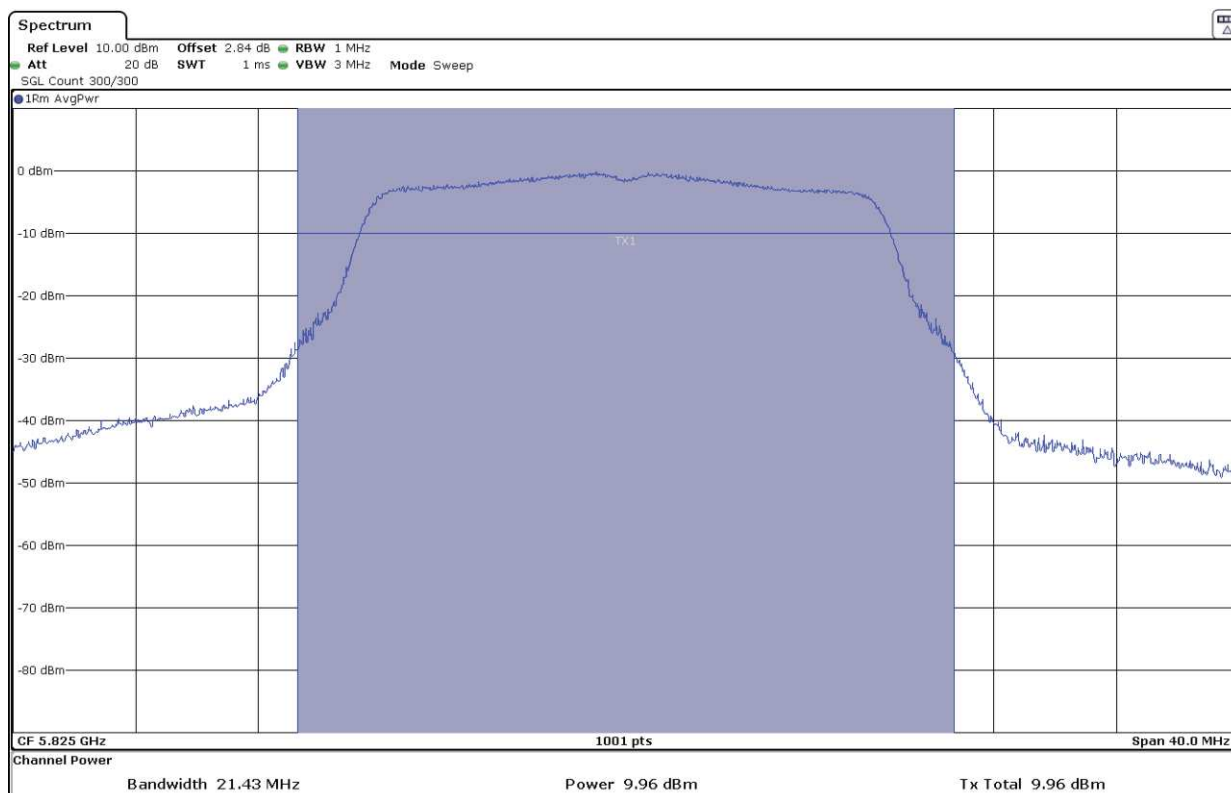
- Low Channel:



- Middle Channel:

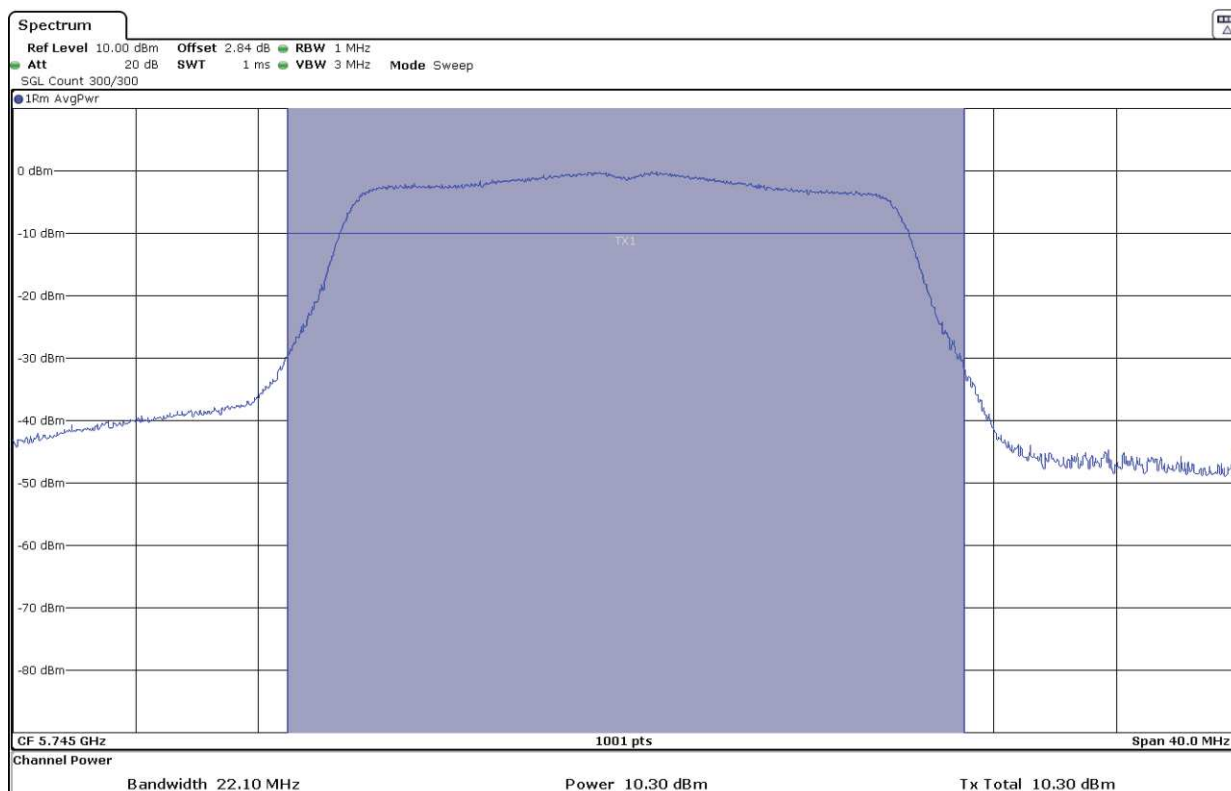


- High Channel:

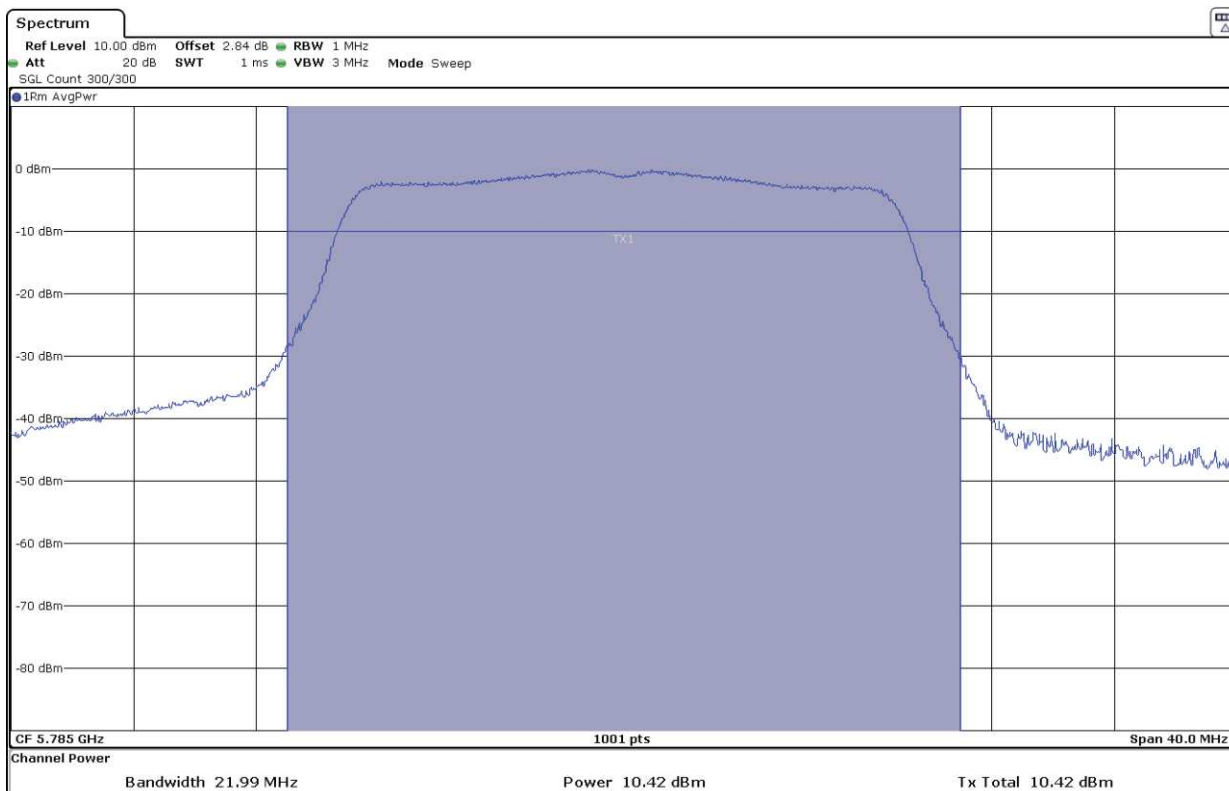


Mode 802.11 n20 (HT20):

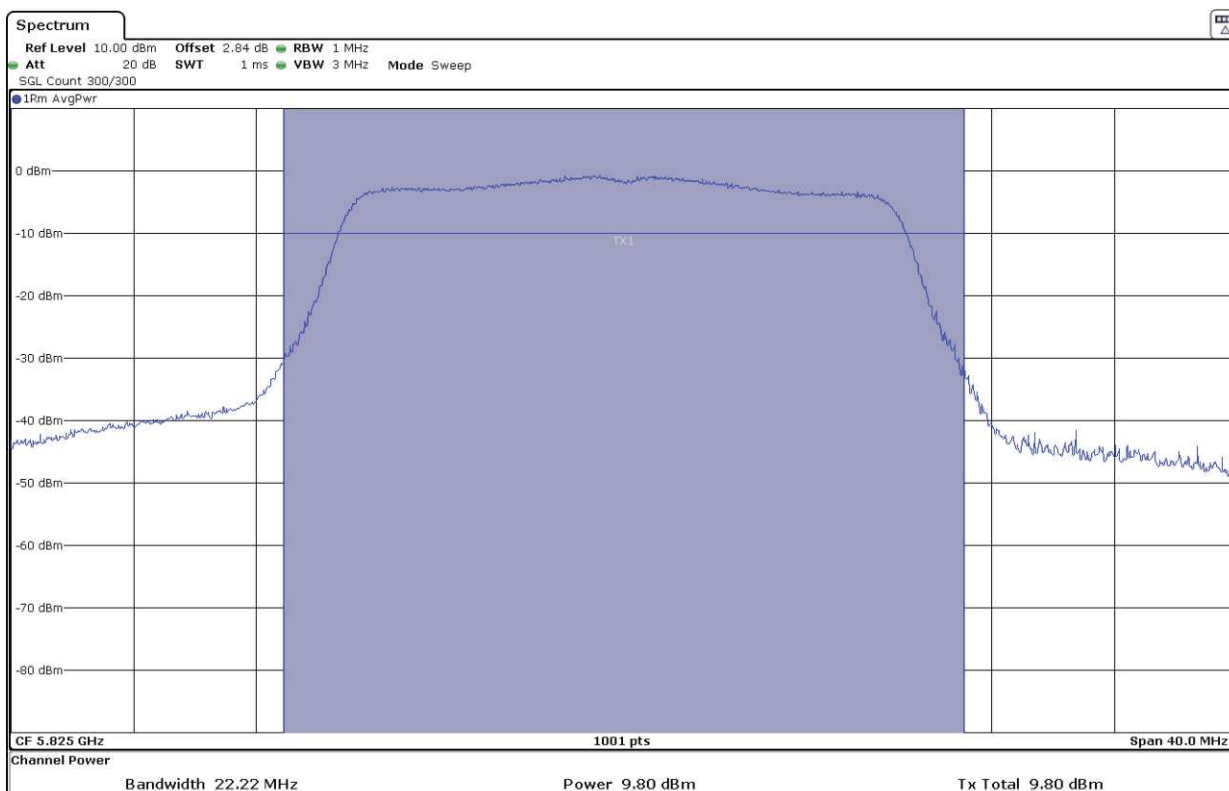
- Low Channel:



- Middle Channel:

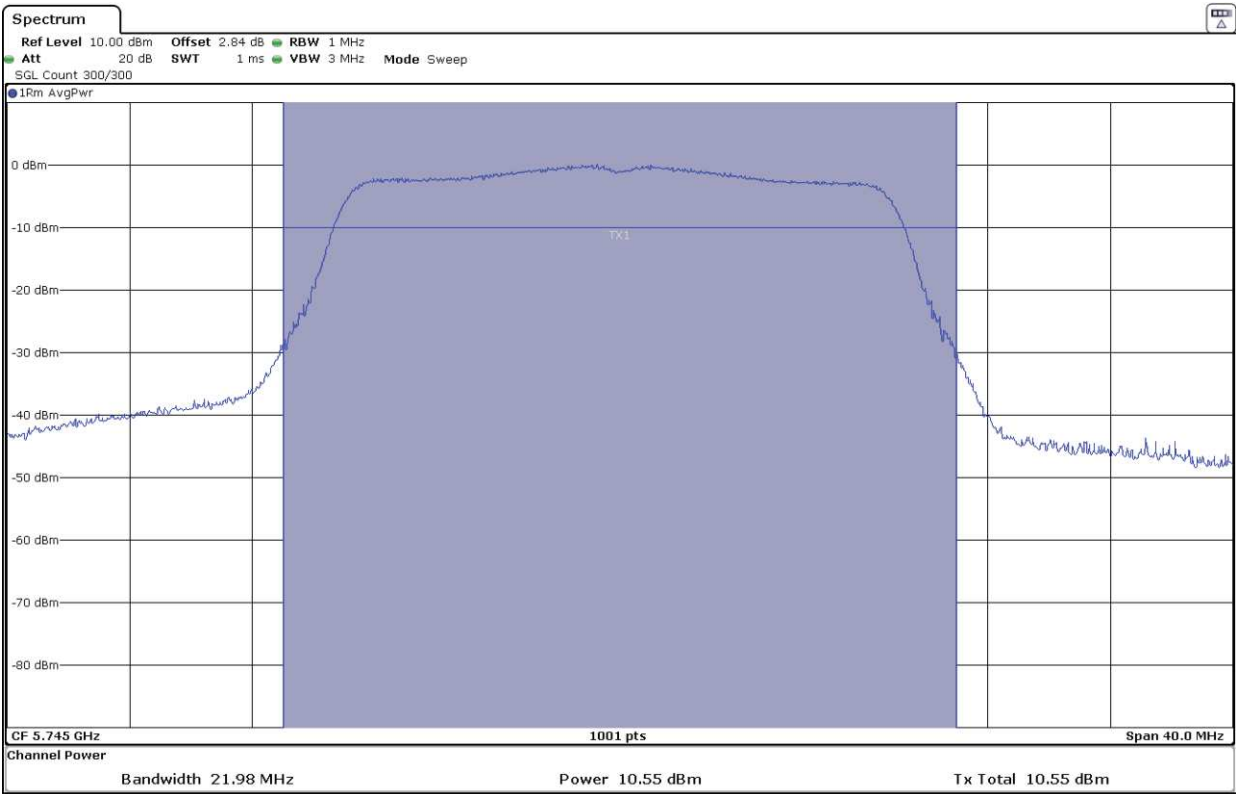


- High Channel:

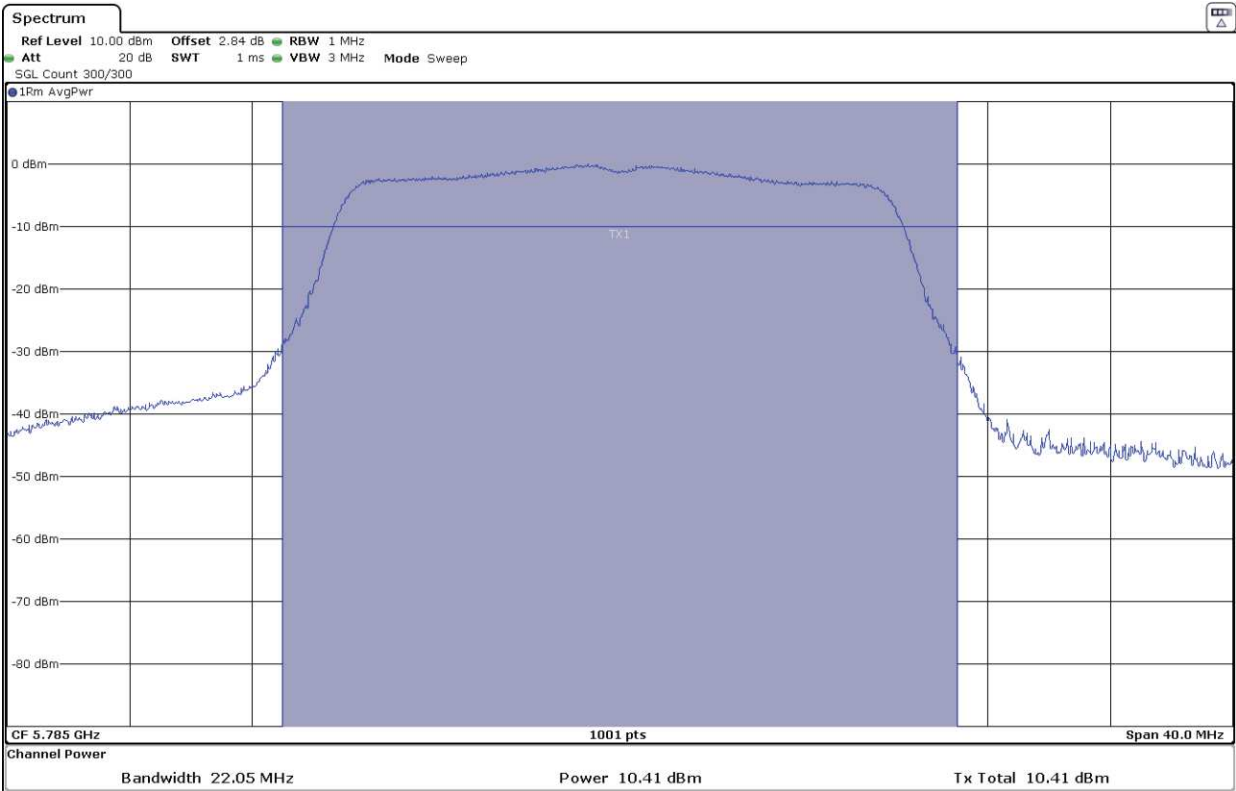


Mode 802.11 ac20 (VHT20):

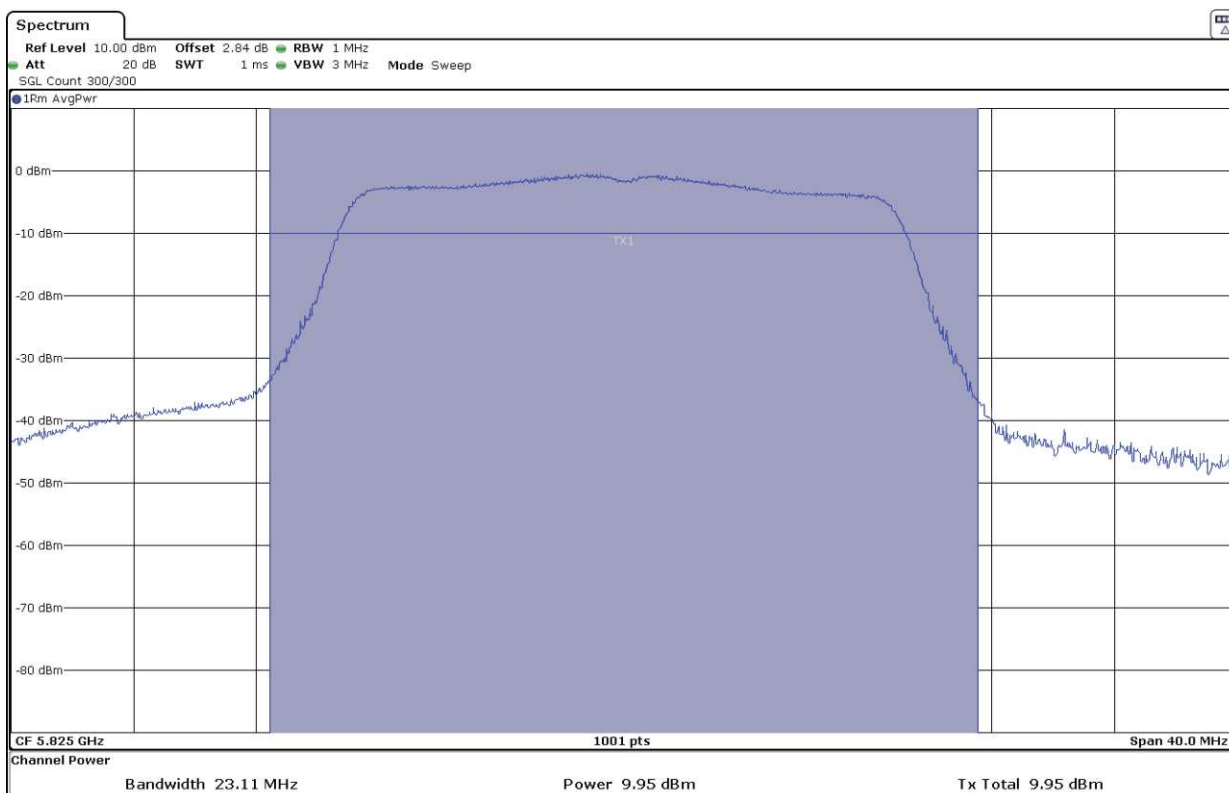
- Low Channel:



- Middle Channel:

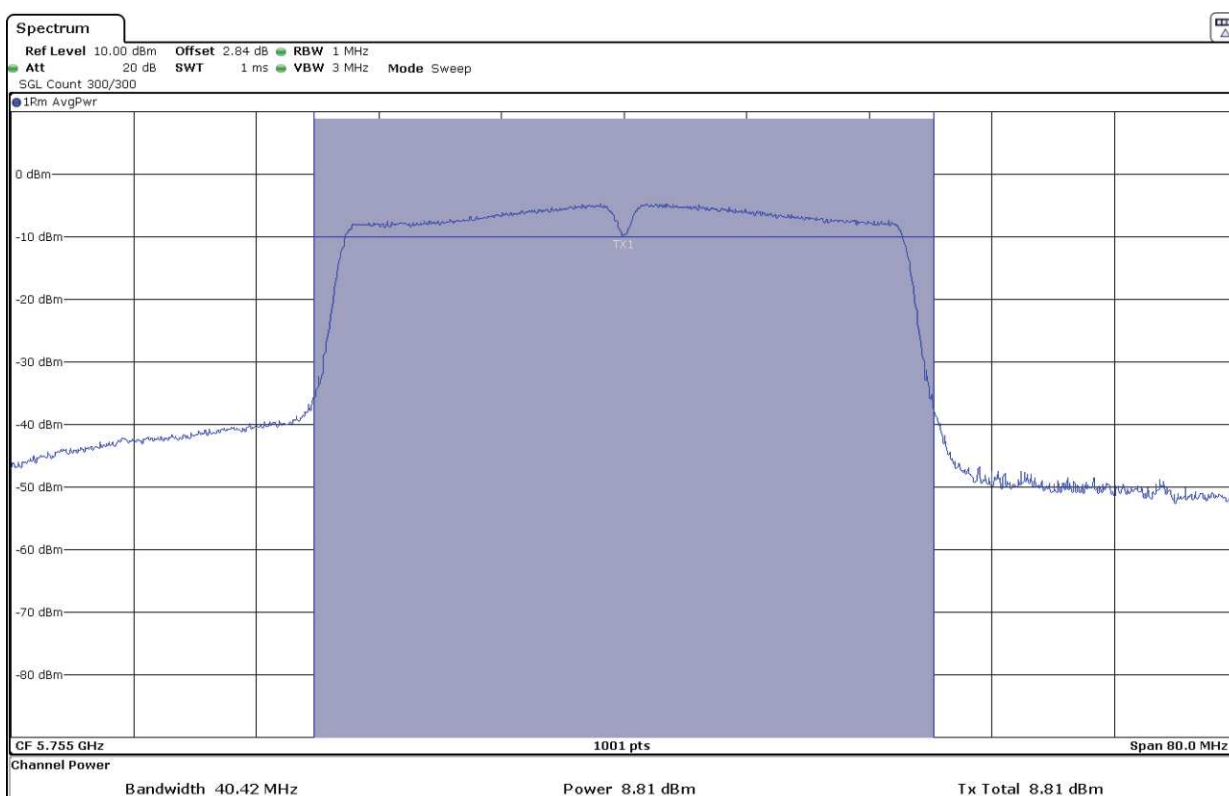


- High Channel:

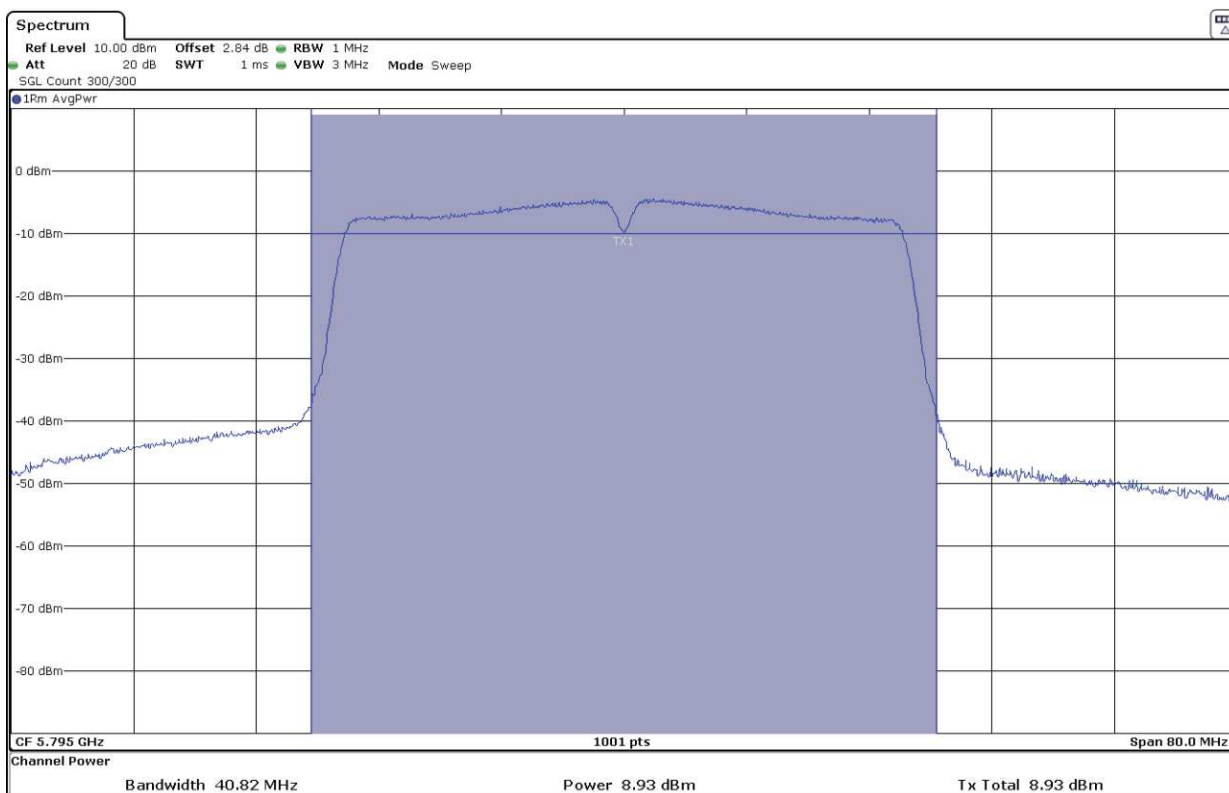


Mode 802.11 n40 (HT40):

- Low Channel:

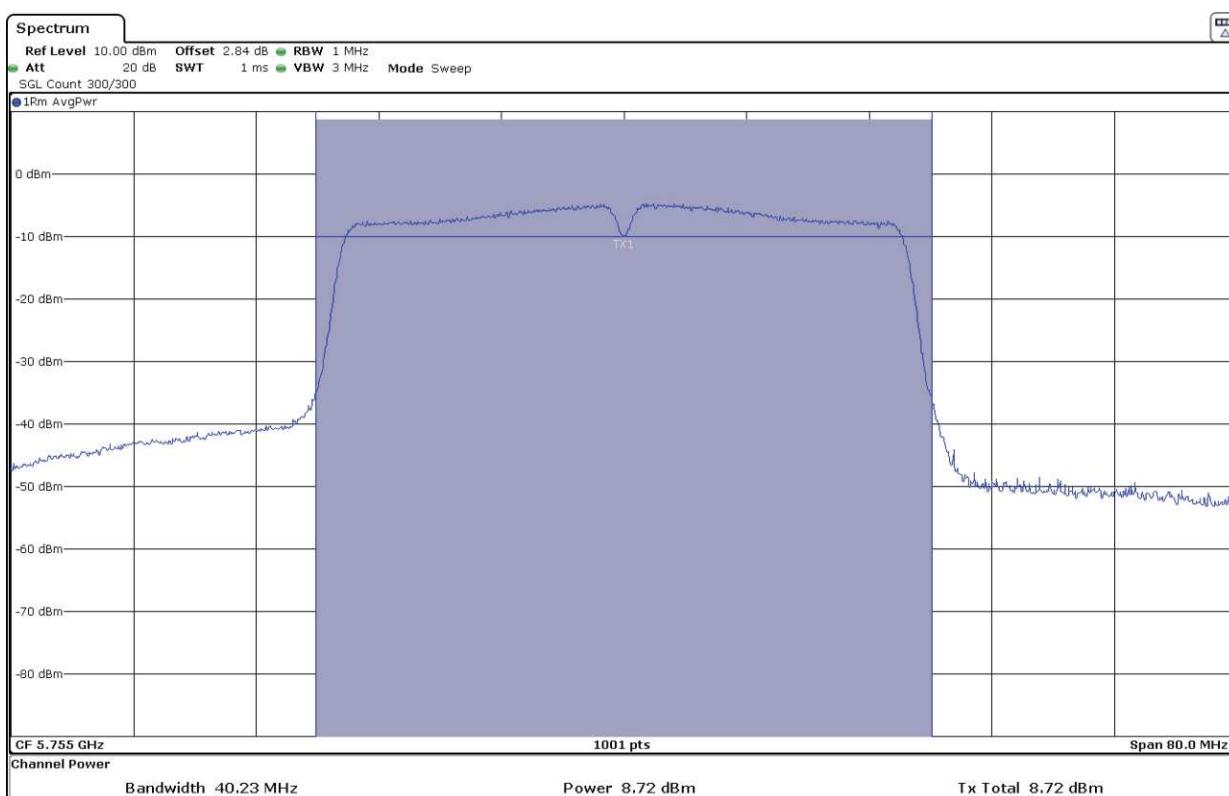


- High Channel:

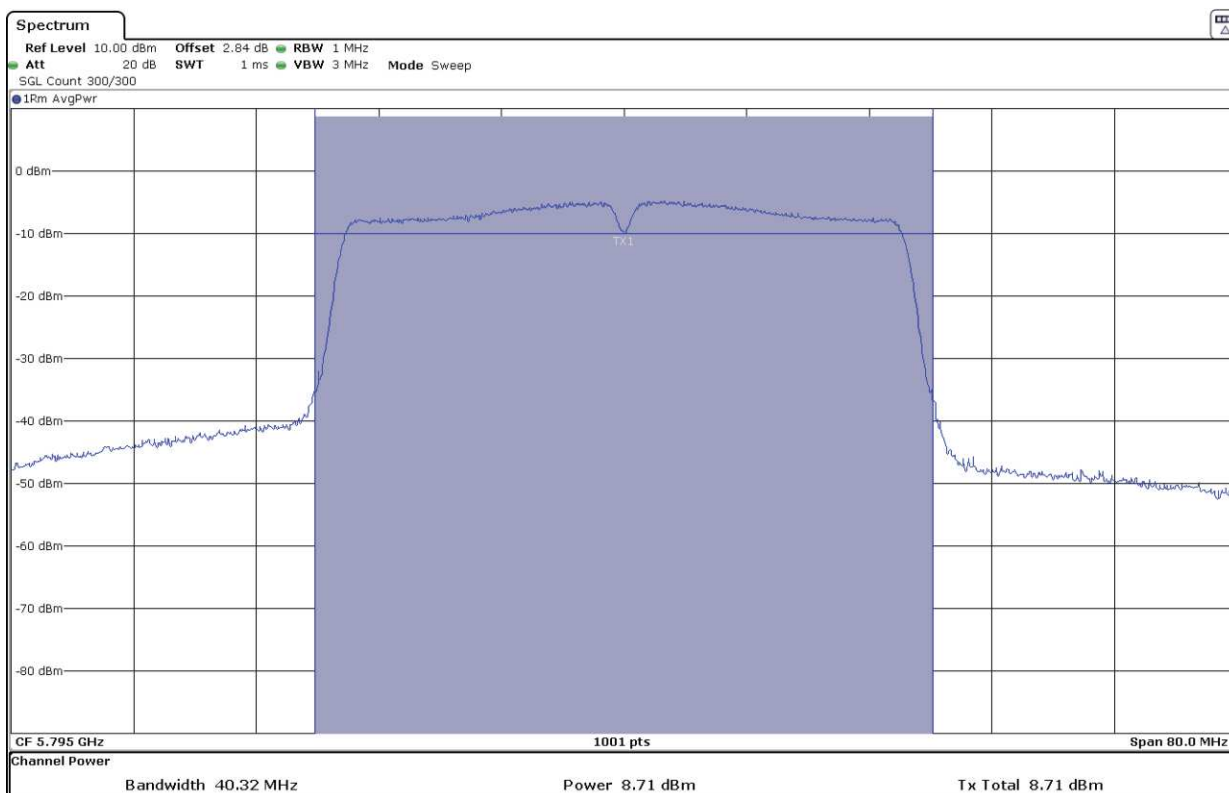


Mode 802.11 ac40 (VHT40):

- Low Channel:

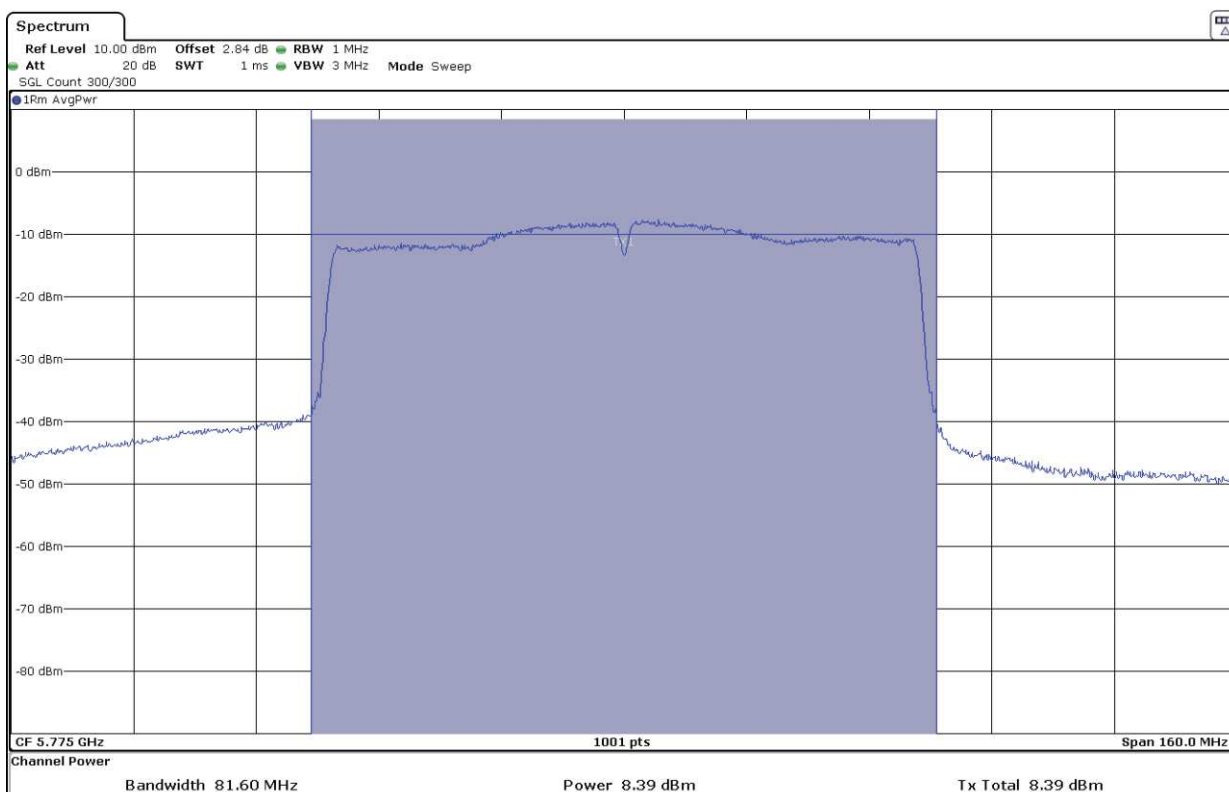


- High Channel:



Mode 802.11 ac80 (VHT80):

- Single Channel:



FCC 15.407 (a)(3) / RSS-247 6.2.4.1. Transmitter Maximum Power Spectral Density

SPECIFICATION:

The maximum power spectral density shall not exceed 30 dBm in any 500-kHz 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.

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.

In accordance with ANSI C63.10 Section 4.1.4.1, use of bandwidths greater than those specified can produce higher readings. Compliance against the applicable limits is shown using a 1 MHz resolution bandwidth. This was deemed worst case.

The PSD test uses the same setup than the transmitter maximum conducted output power test. The result of the Peak PSD was measured by collocation a marker on the peak of the signal and the results are in the tables below.

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

Maximum Declared Antenna Gain: +0.9 dBi

Mode 802.11 a20:

	Low Channel	Middle Channel	High Channel
Maximum Average PSD (dBm/MHz)	-0.26	0.44	0.42
Duty Cycle Correction Factor (dB)	0.943		
Maximum Average PSD Corrected (dBm/MHz)	0.683	1.382843135	1.362843135
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 n20 (HT20):

	Low Channel	Middle Channel	High Channel
Maximum Average PSD (dBm/MHz)	-0.39	0.03	-0.51
Duty Cycle Correction Factor (dB)	1.017		
Maximum Average PSD Corrected (dBm/MHz)	0.627	1.047	0.507
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 ac20 (VHT20):

	Low Channel	Middle Channel	High Channel
Maximum Average PSD (dBm/MHz)	-0.24	-0.03	-0.35
Duty Cycle Correction Factor (dB)	1.009		
Maximum Average PSD Corrected (dBm/MHz)	0.769	0.979	0.659
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 n40 (HT40):

	Low Channel	High Channel
Maximum Average PSD (dBm/MHz)	-4.27	-4.64
Duty Cycle Correction Factor (dB)	1.850	
Maximum Average PSD Corrected (dBm/MHz)	-2.390	-2.790
Measurement uncertainty (dB)	<±2.00	

Mode 802.11 ac40 (VHT40):

	Low Channel	High Channel
Maximum Average PSD (dBm/MHz)	-4.51	-4.41
Duty Cycle Correction Factor (dB)	1.842	
Maximum Average PSD Corrected (dBm/MHz)	-2.668	-2.568
Measurement uncertainty (dB)	<±2.00	

Mode 802.11 ac80 (VHT80):

	Low Channel
Maximum Average PSD (dBm/MHz)	-8.08
Duty Cycle Correction Factor (dB)	3.231
Maximum Average PSD Corrected (dBm/MHz)	-4.849
Measurement uncertainty (dB)	<±2.00

Verdict: PASS

FCC 15.407 (b)(4)(6) / RSS-247 6.2.4.2. Transmitter Out of Band Radiated Emissions and Transmitter Band Edge Radiated Emissions

SPECIFICATION:

For transmitters operating in the 5.725–5.85 GHz band:

All emissions shall be limited to a level of –27 dBm/MHz (68.23 dBμV/m at 3 m distance) at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

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
960 – 40000	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 1m for the frequency range 1 GHz-40 GHz and a distance of 3m for frequency range 30MHz-1GHz.

The field strength is calculated by adding correction factor to the measured level from the spectrum 104analyser. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

OUT OF BAND EMISSIONS: For spurious emissions outside of the U-NII-3 band edge mask of 5.65-5.925 GHz, the OFDM worst mode case was determined after preliminary measurements of the E.I.R.P. density (radiated). The Low, Middle and High Channels were tested.

- **Worst case:** 802.11 a20 (6 Mbps).

Frequency range 30 MHz - 1 GHz (worst case):

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

Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
688.145000	26.39	V	Quasi-Peak	<± 5.08
786.454500	29.41	H	Quasi-Peak	<± 5.08
884.764000	32.66	V	Quasi-Peak	<± 5.08

Frequency range 1 - 40 GHz (worst case):

The results in the next tables show the maximum measured levels in the 1-40 GHz range except the 5.65-5.725 GHz and 5.85-5.925GHz adjacent bands. The results in the adjacent bands was evaluated on the next section.

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

- LOW CHANNEL. No spurious frequencies at less than 20 dB below the limit.

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

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.3742	51.91	V	Peak	<± 5.13

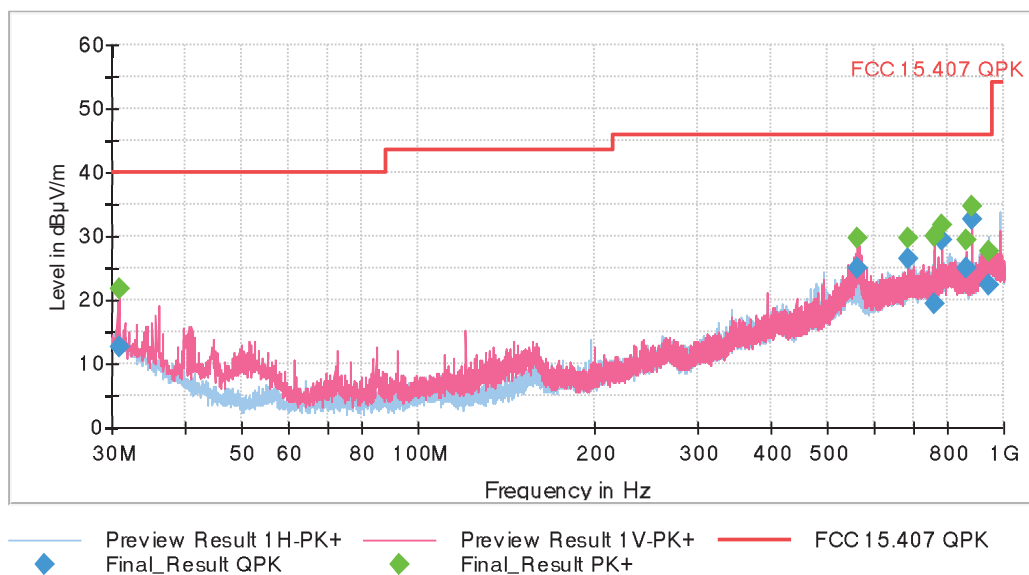
- HIGH CHANNEL. No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB):
1 GHz - 17 GHz <± 5.13
17 GHz - 26.5 GHz <± 4.82
26.5 GHz - 40 GHz <± 5.14

Verdict: PASS

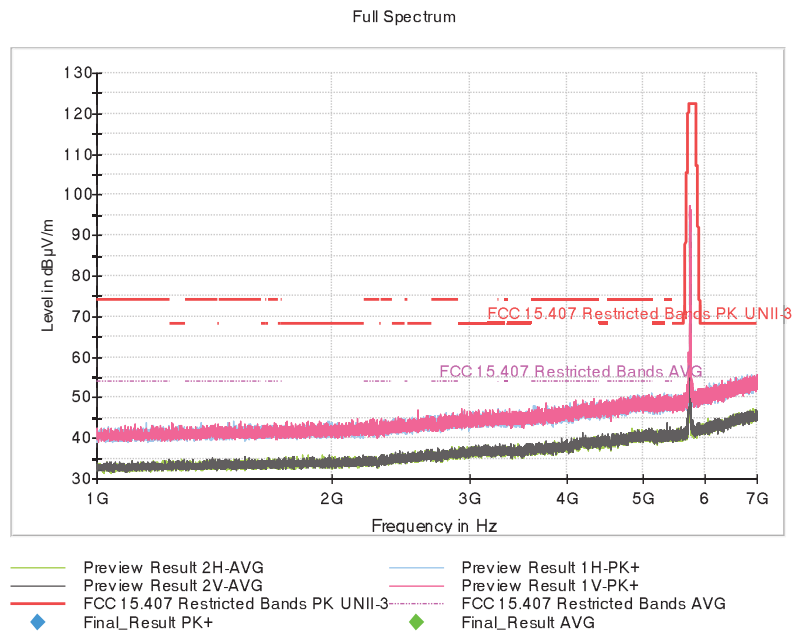
FREQUENCY RANGE 30 MHz - 1 GHz (worst case):

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



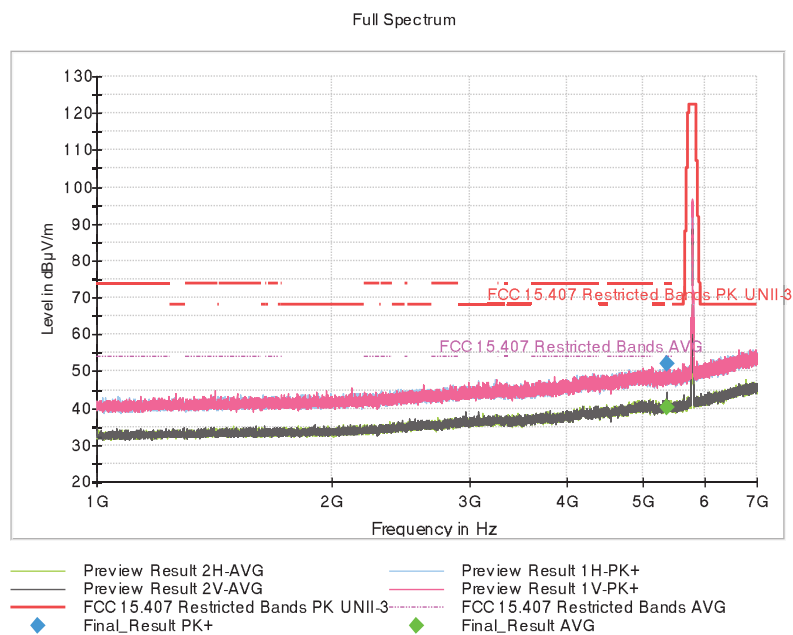
FREQUENCY RANGE 1 - 7 GHz (worst case):

- Low Channel:



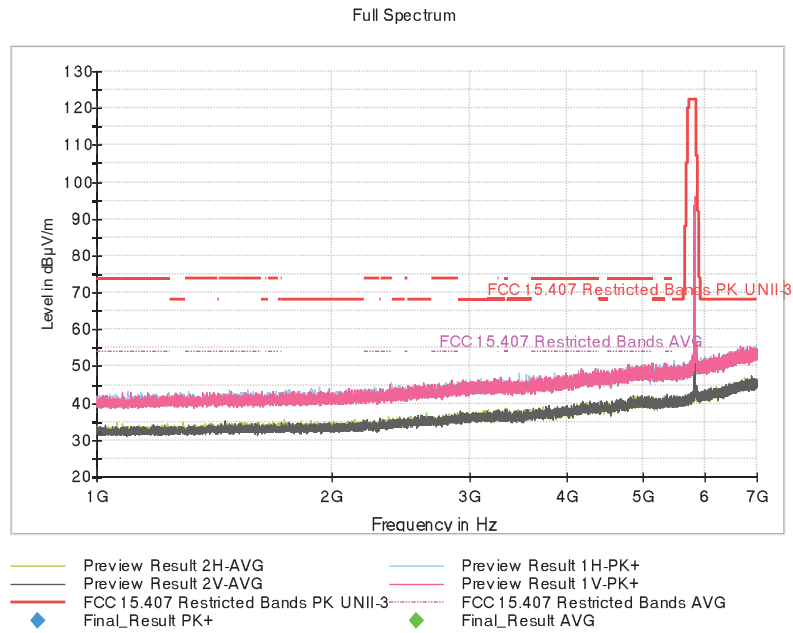
The peak above the limit is the carrier frequency.

- Middle Channel:



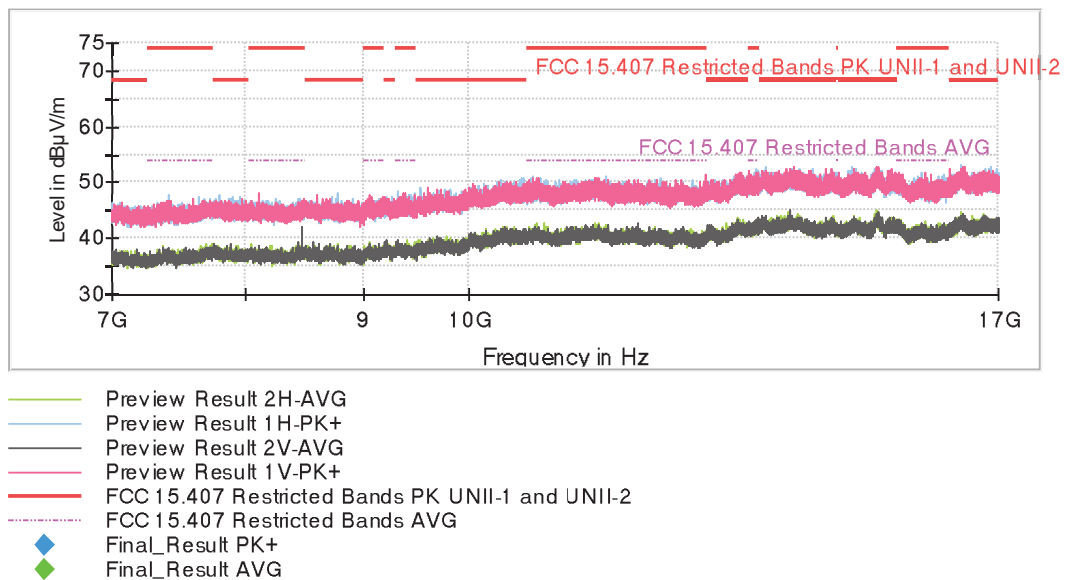
The peak above the limit is the carrier frequency.

- High Channel:

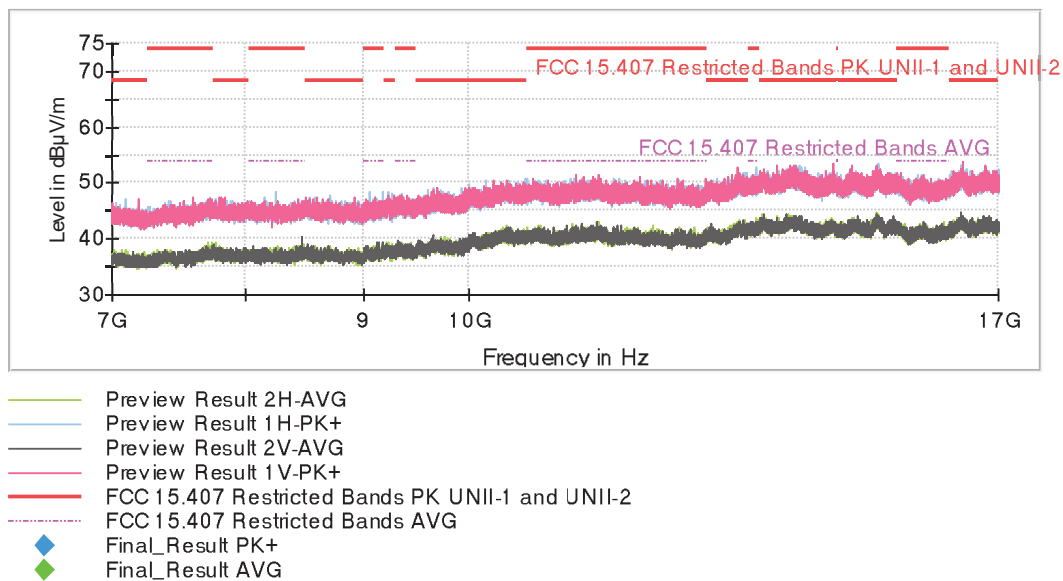


FREQUENCY RANGE 7 - 17 GHz (worst case):

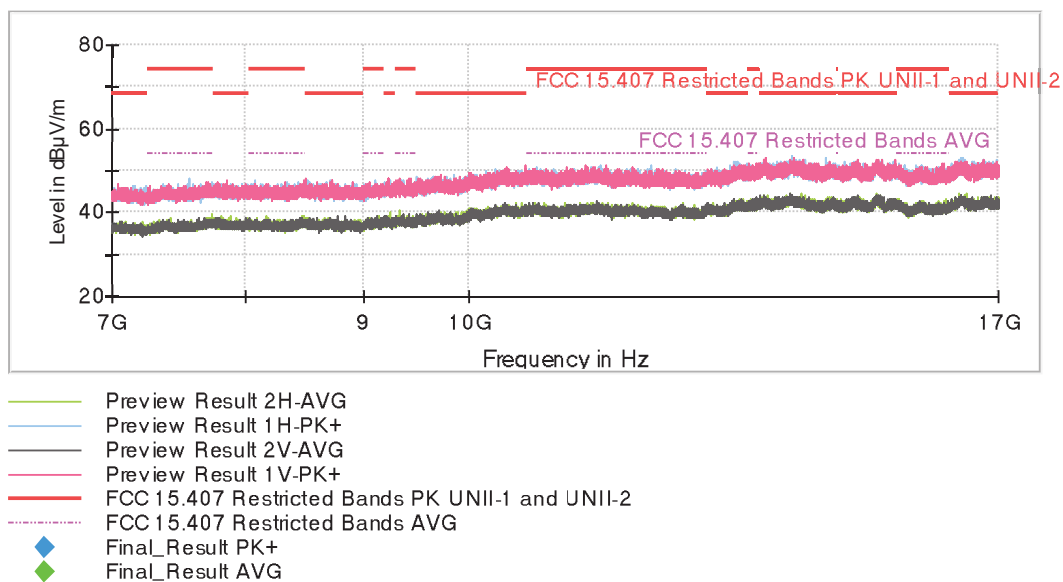
- Low Channel:



- Middle Channel:

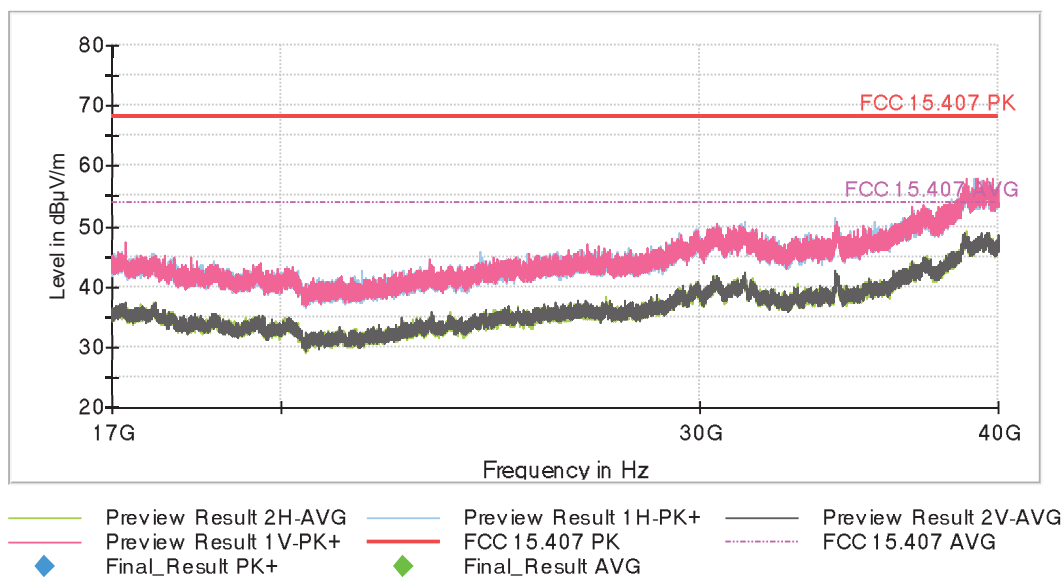


- High Channel:



FREQUENCY RANGE 17 - 40 GHz (worst case):

- Low Channel:



- Middle Channel:

