

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

SPECIFICATION:

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
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 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.

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

All emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27dBm/MHz. There are restricted bands of operation below band edge at 4.50-5.15 GHz also above the upper band edge at 5.35-5.46 GHz therefore the provision of FCC Part 15.205 apply.

Field strength measurements using peak and average detector performed in the restricted bands below 5.15 GHz and above 5.35 GHz.

Test performed on the following worst cases modes in all relevant tests channels:

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

BAND EDGE EMISSIONS: For U-NII-1 band edge spurious emissions inside of the Restricted Bands 4.50-5.15 GHz and 5.35-5.46 GHz.

The Lower Band Edge Channel and the Upper Band Edge Channel were tested for all modes.

- **802.11 a20:**

- Lower Band Edge Channel 36 (5180 MHz). Spurious emissions inside the Restricted Band 4.50-5.15 GHz:

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.1484	50.99	H	Peak	<± 4.6
	37.94		Average	<± 4.6

- Upper Band Edge Channel 48 (5240 MHz). Spurious emissions inside the Restricted Band 5.35-5.46 GHz:

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

- **802.11 n20:**

- Lower Band Edge Channel 36 (5180 MHz). Spurious emissions inside the Restricted Band 4.50-5.15 GHz:

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

- Upper Band Edge Channel 48 (5240 MHz). Spurious emissions inside the Restricted Band 5.35-5.46 GHz:

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

- **802.11 ac20:**

- Lower Band Edge Channel 36 (5180 MHz). Spurious emissions inside the Restricted Band 4.50-5.15 GHz:

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

- Upper Band Edge Channel 48 (5240 MHz). Spurious emissions inside the Restricted Band 5.35-5.46 GHz:

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

- **802.11 n40:**

- Lower Band Edge Channel 38 (5190 MHz). Spurious emissions inside the Restricted Band 4.50-5.15 GHz:

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

- Upper Band Edge Channel 46 (5230 MHz). Spurious emissions inside the Restricted Band 5.35-5.46 GHz:

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

- **802.11 ac40:**

- Lower Band Edge Channel 38 (5190 MHz). Spurious emissions inside the Restricted Band 4.50-5.15 GHz:

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

- Upper Band Edge Channel 46 (5230 MHz). Spurious emissions inside the Restricted Band 5.35-5.46 GHz:

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

- **802.11 ac80:**

- Lower Band Edge Channel 42 (5210 MHz). Spurious emissions inside the Restricted Band 4.50-5.15 GHz:

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.135200000	57.15	H	Peak	<± 4.6
	41.54		Average	<± 4.6

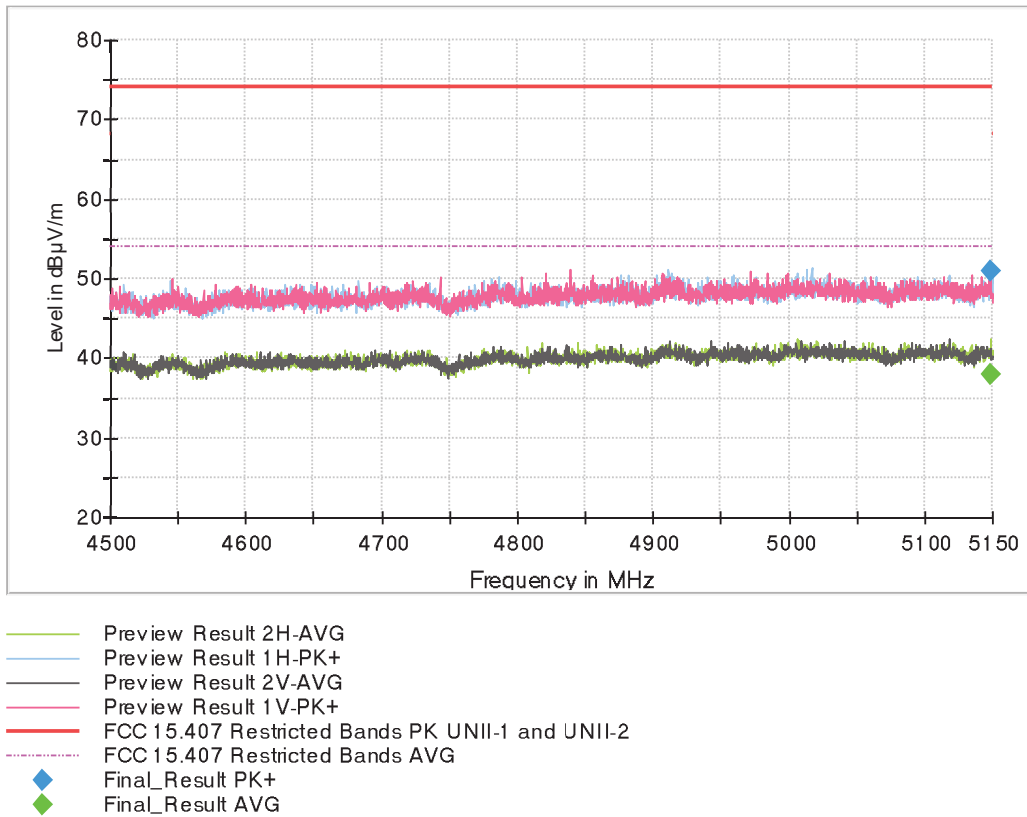
- Upper Band Edge Channel 42 (5210 MHz). Spurious emissions inside the Restricted Band 5.35-5.46 GHz:

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

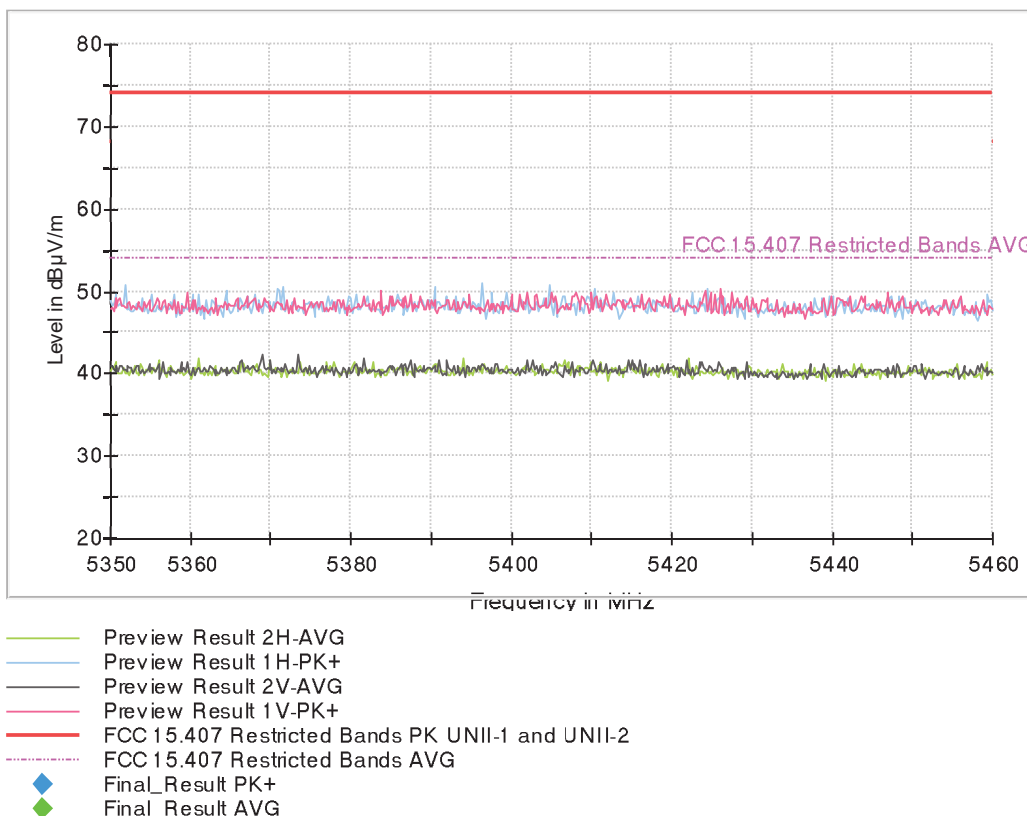
Verdict: PASS

• **802.11 a20:**

- Lower Band Edge Channel 36 (Restricted Band 4.50-5.15 GHz)

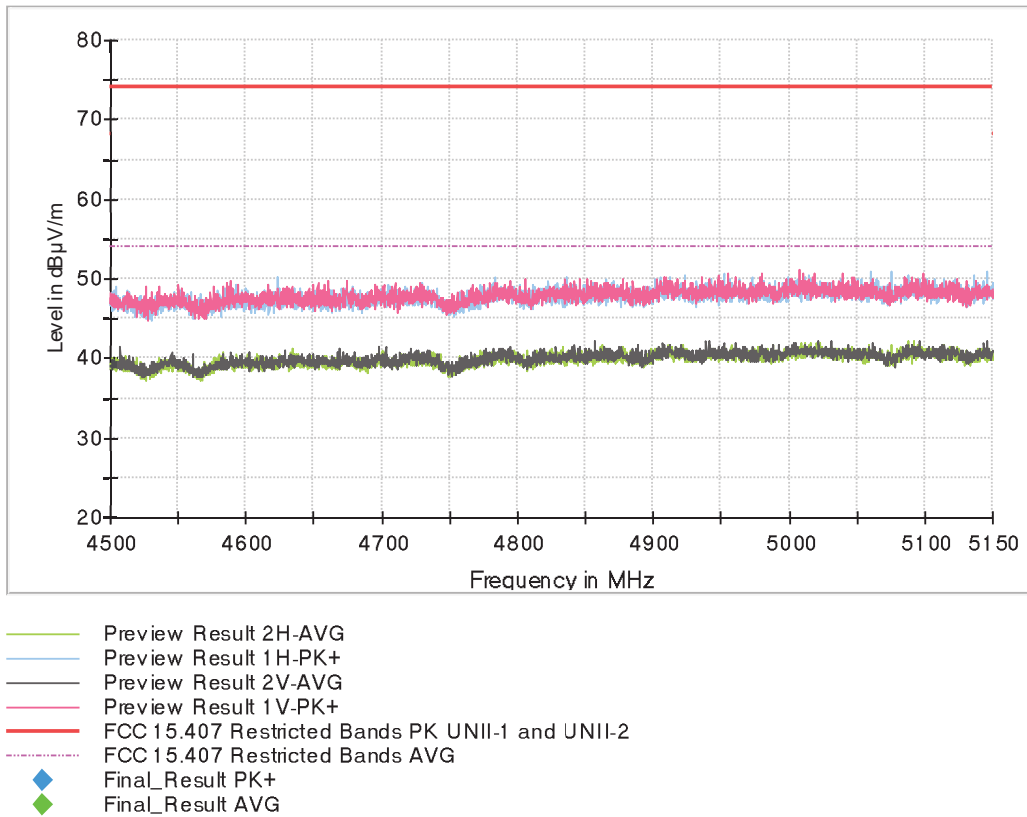


- Upper Band Edge Channel 48 (Restricted Band 5.35-5.46 GHz)

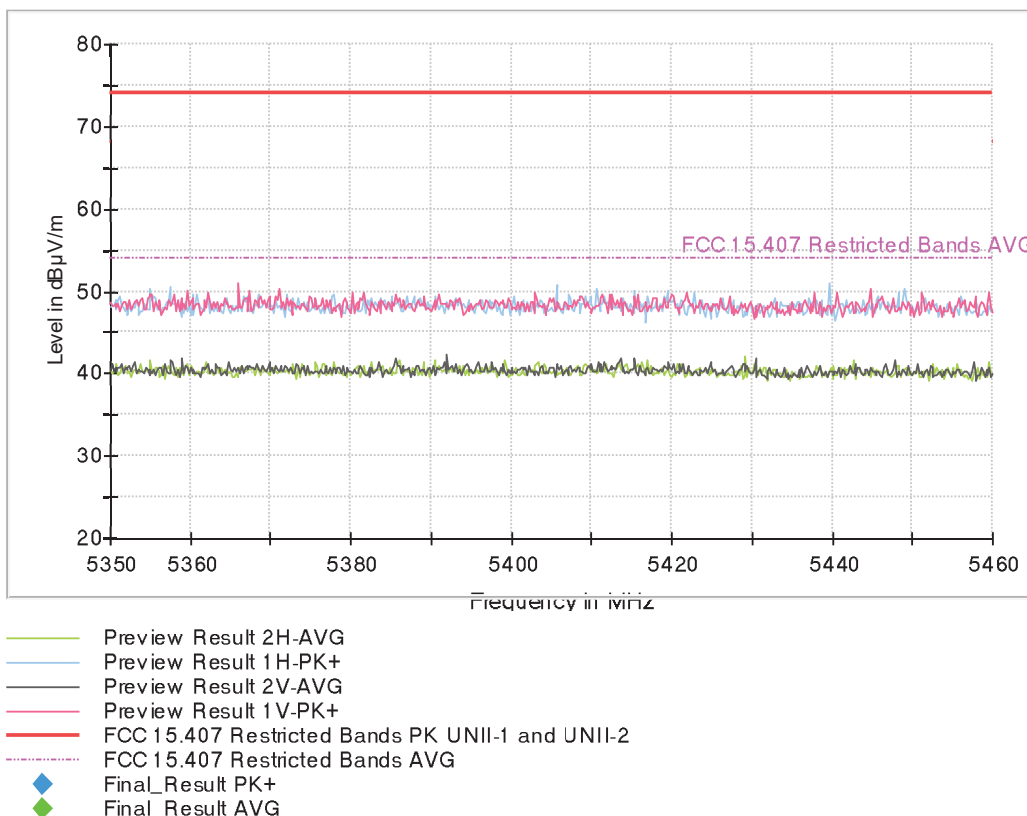


• **802.11 n20:**

- Lower Band Edge Channel 36 (Restricted Band 4.50-5.15 GHz)

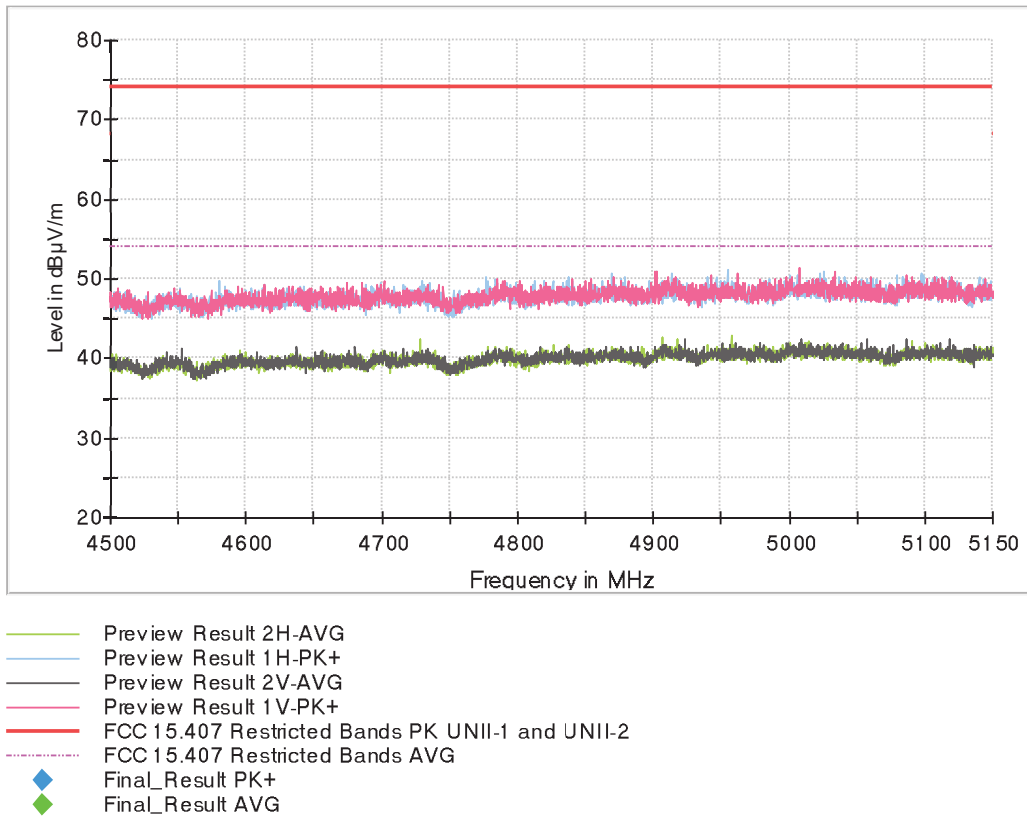


- Upper Band Edge Channel 48 (Restricted Band 5.35-5.46 GHz)

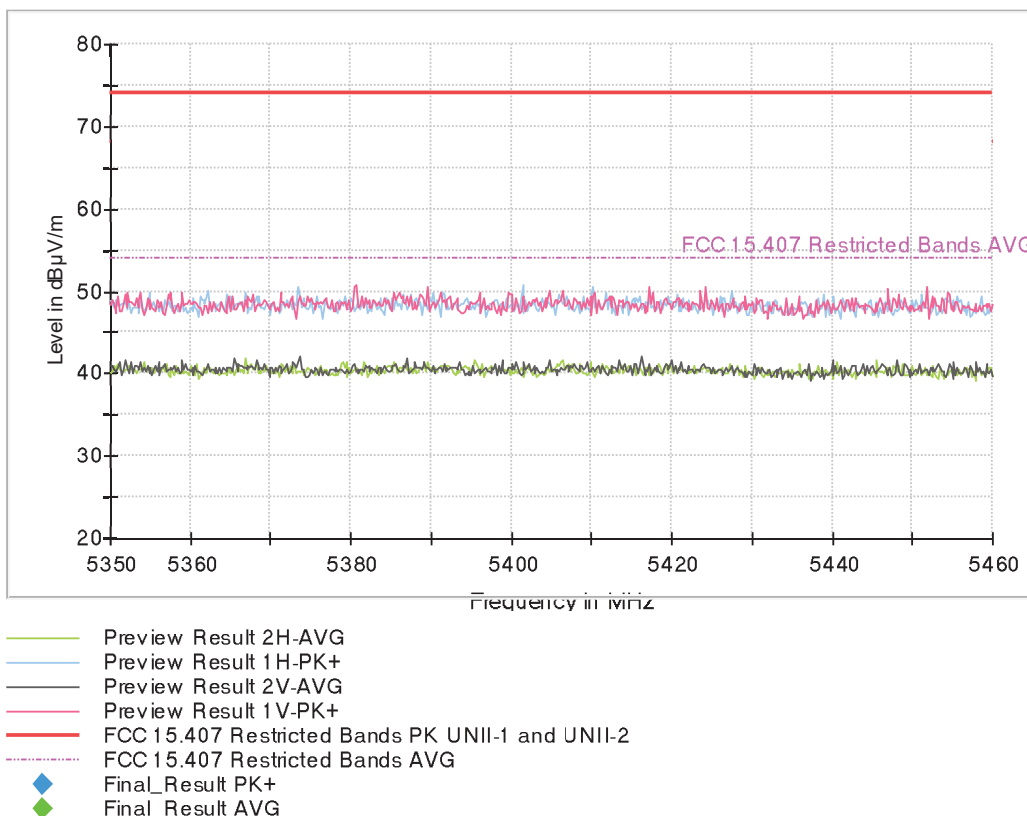


• **802.11 ac20:**

- Lower Band Edge Channel 36 (Restricted Band 4.50-5.15 GHz)

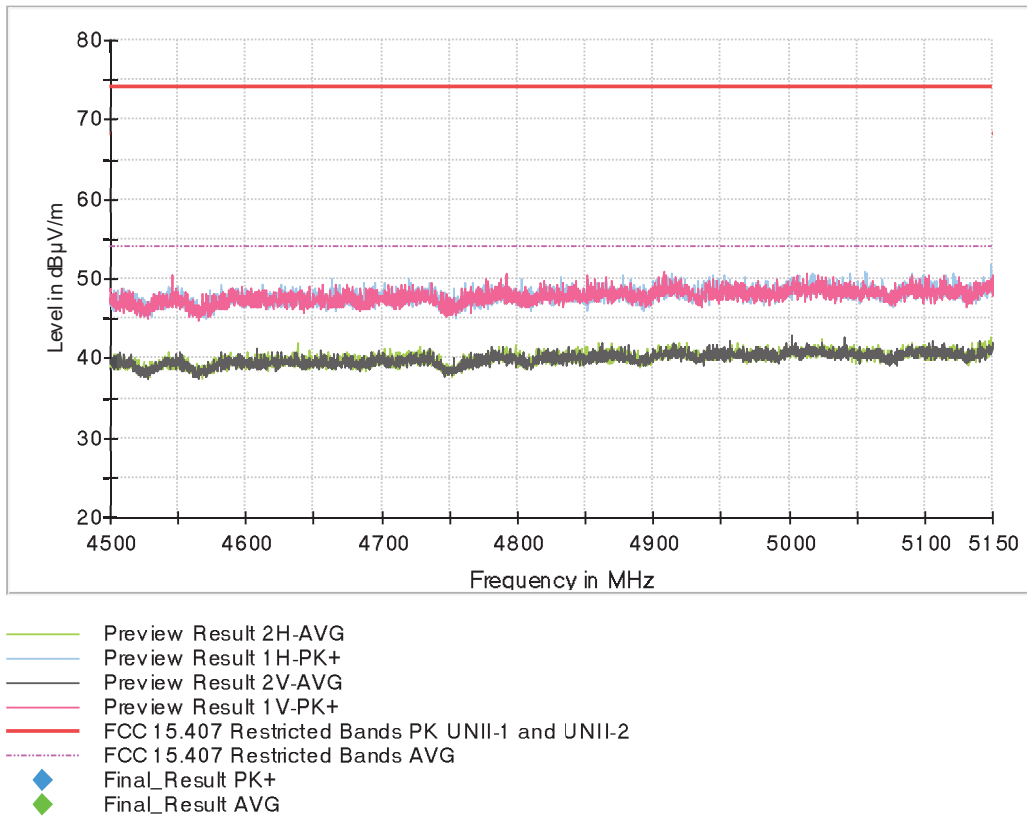


- Upper Band Edge Channel 48 (Restricted Band 5.35-5.46 GHz)

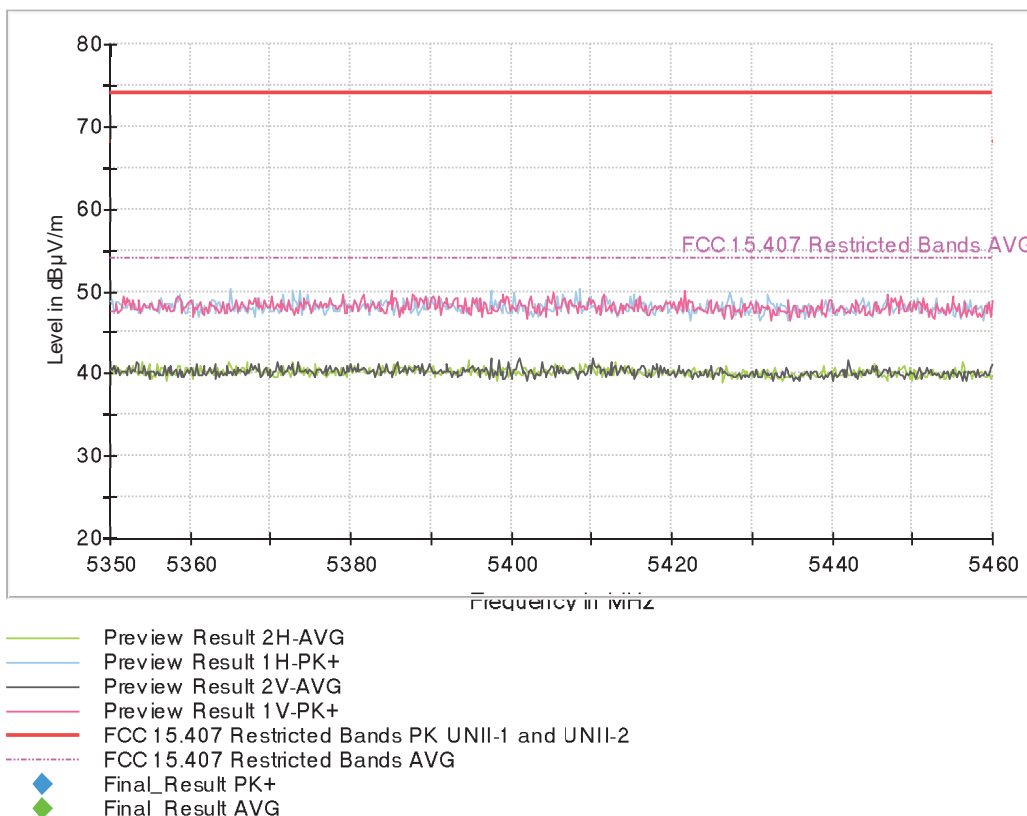


• **802.11 n40:**

- Lower Band Edge Channel 38 (Restricted Band 4.50-5.15 GHz)

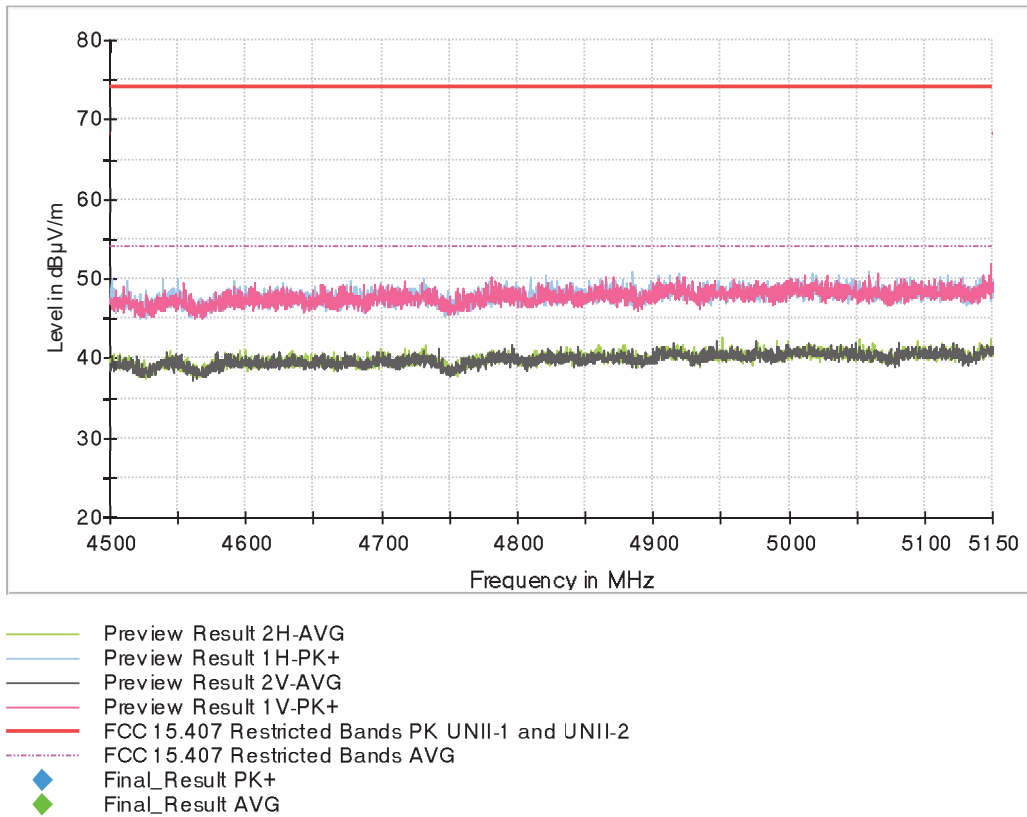


- Upper Band Edge Channel 46 (Restricted Band 5.35-5.46 GHz)

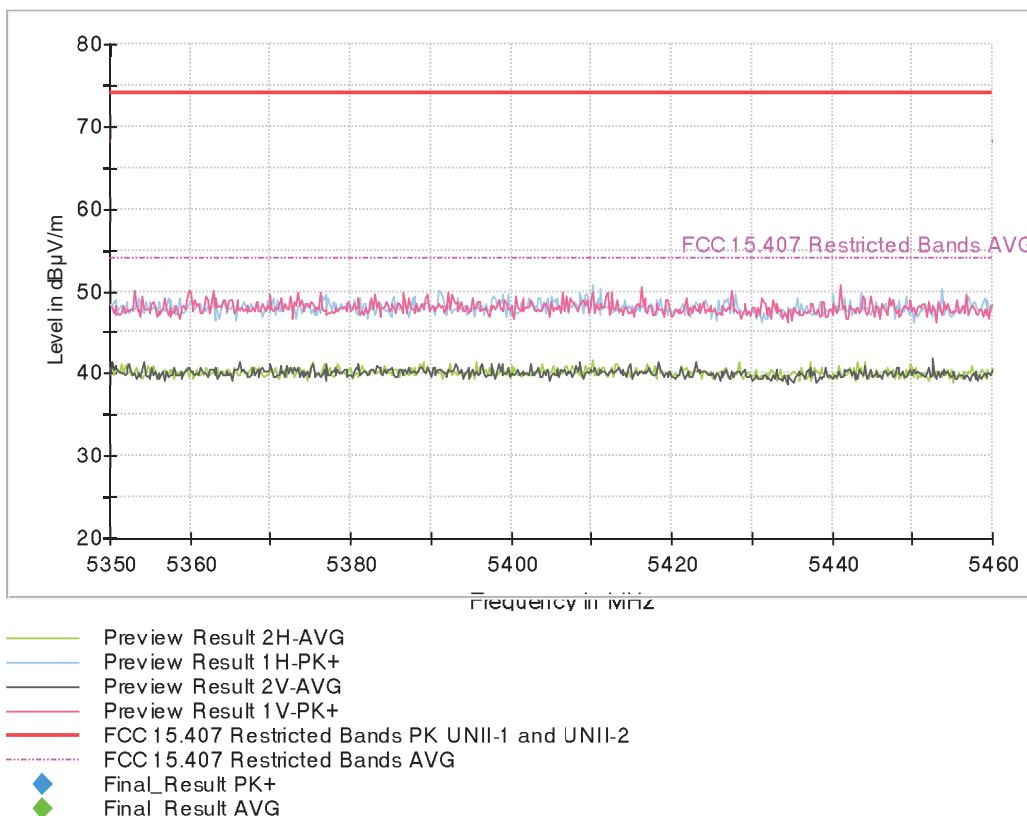


• **802.11 ac40:**

- Lower Band Edge Channel 38 (Restricted Band 4.50-5.15 GHz)

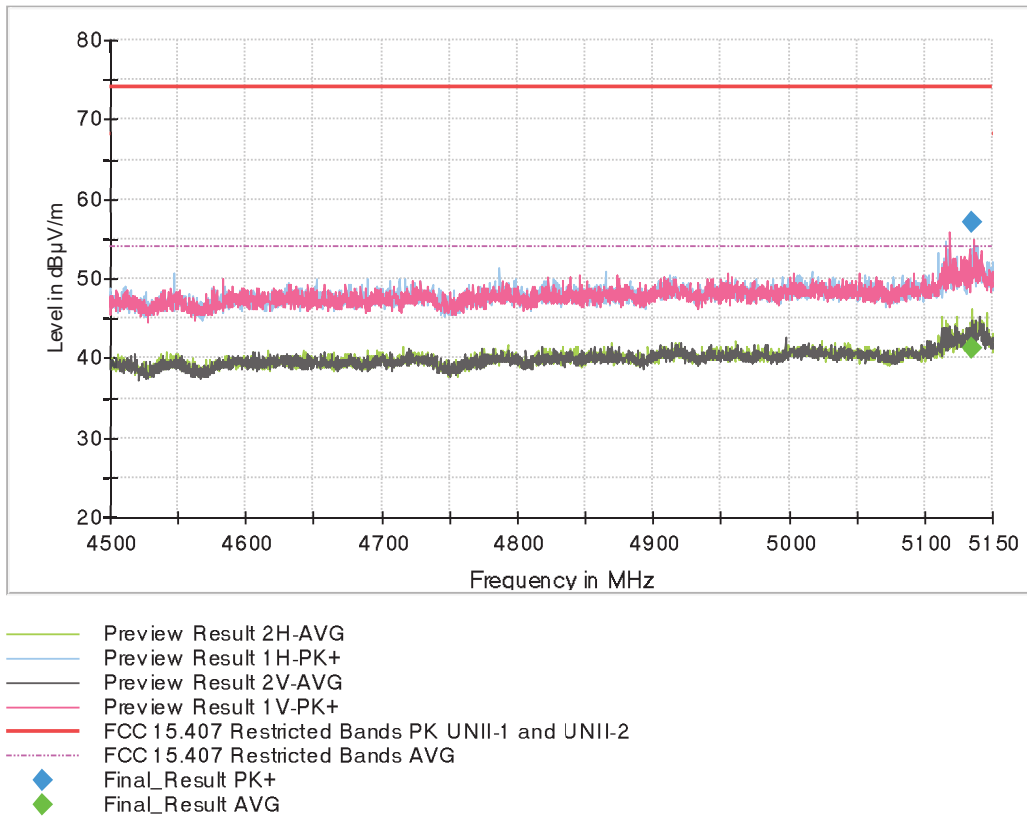


- Upper Band Edge Channel 46 (Restricted Band 5.35-5.46 GHz)

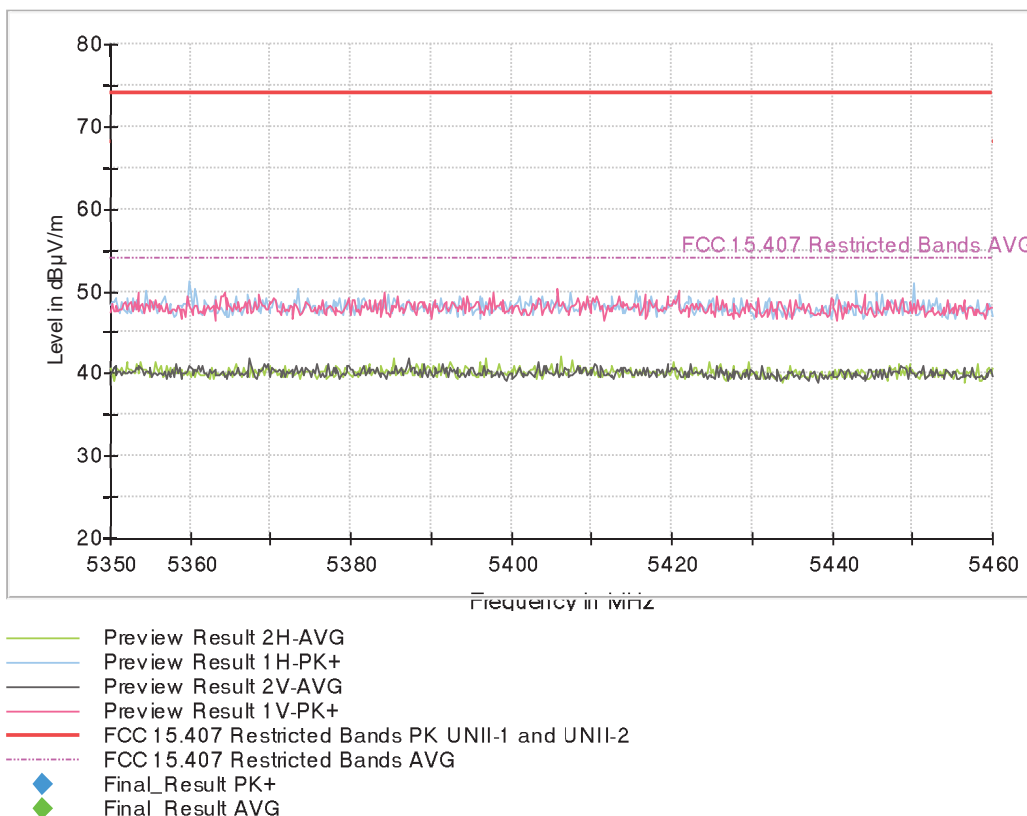


• 802.11 ac80:

- Lower Band Edge Channel 42 (Restricted Band 4.50-5.15 GHz)



- Upper Band Edge Channel 42 (Restricted Band 5.35-5.46 GHz)



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

INDEX

TEST CONDITIONS	76
FCC 15.247 (e) / RSS-247 6.2.4.1. 6 dB Bandwidth	81
FCC 15.407 (a)(3) / RSS-247 6.2.4.1. Transmitter Maximum Conducted Output Power	90
FCC 15.407 (a)(3) / RSS-247 6.2.4.1. Transmitter Maximum Power Spectral Density	100
FCC 15.407 (b)(4)(6) / RSS-247 6.2.4.2. Transmitter Out of Band Radiated Emissions.....	102
FCC 15.407 (b)(4) / RSS-247 6.2.4.2. Transmitter Band Edge Radiated Emissions.	110

TEST CONDITIONS

POWER SUPPLY (V):

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

ANTENNA:

Type of Antenna: Internal.
Maximum Declared Antenna Gain: +3 dBi

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.

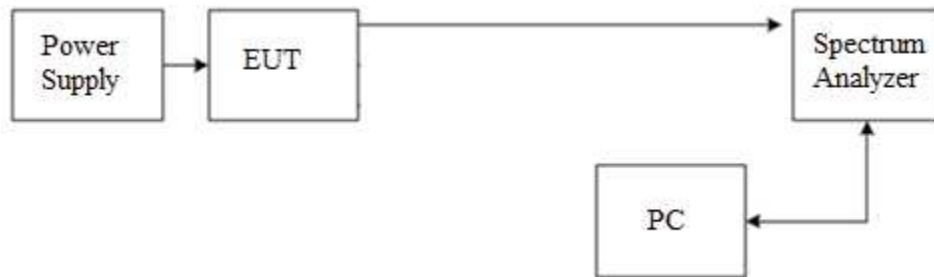
The worst cases for testing were identified for output power and spurious levels at the band edges which were selected based on preliminary testing that correspond to next data rates:

- 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).

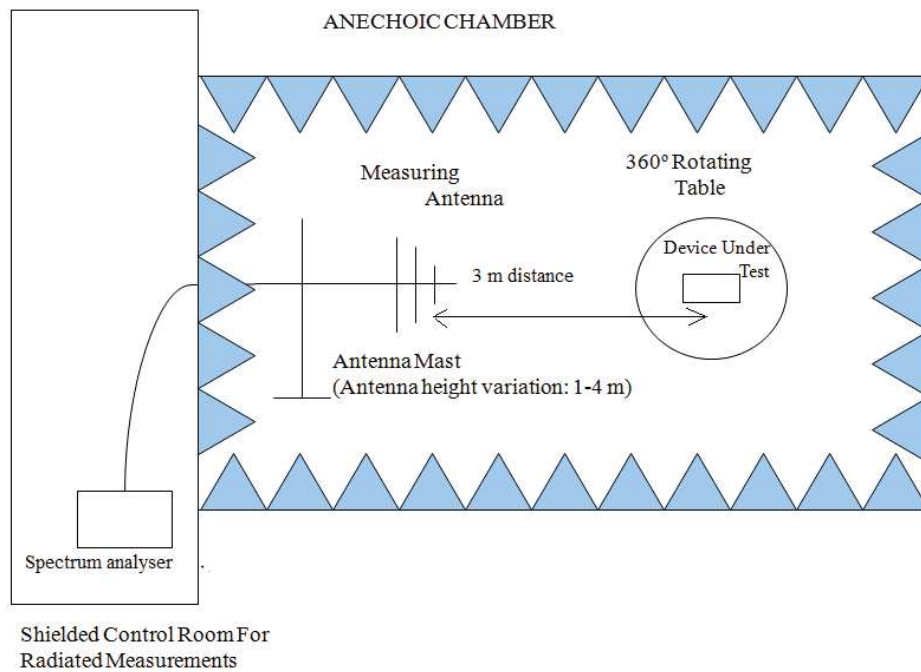
For radiated emissions in the range 17 GHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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.

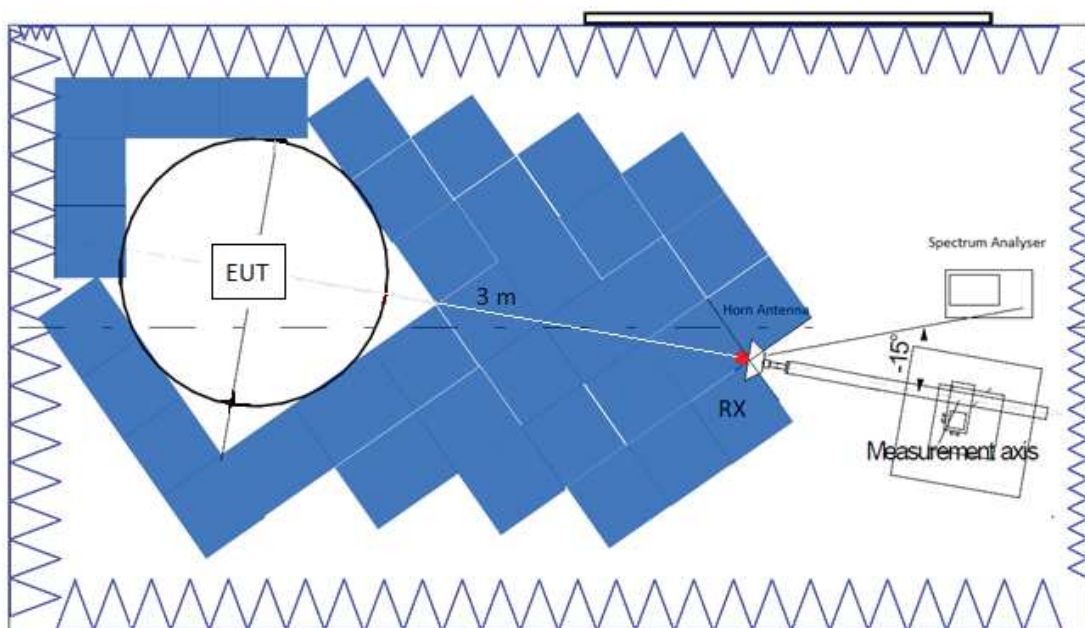
Measurements were made in both horizontal and vertical planes of polarization.

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.

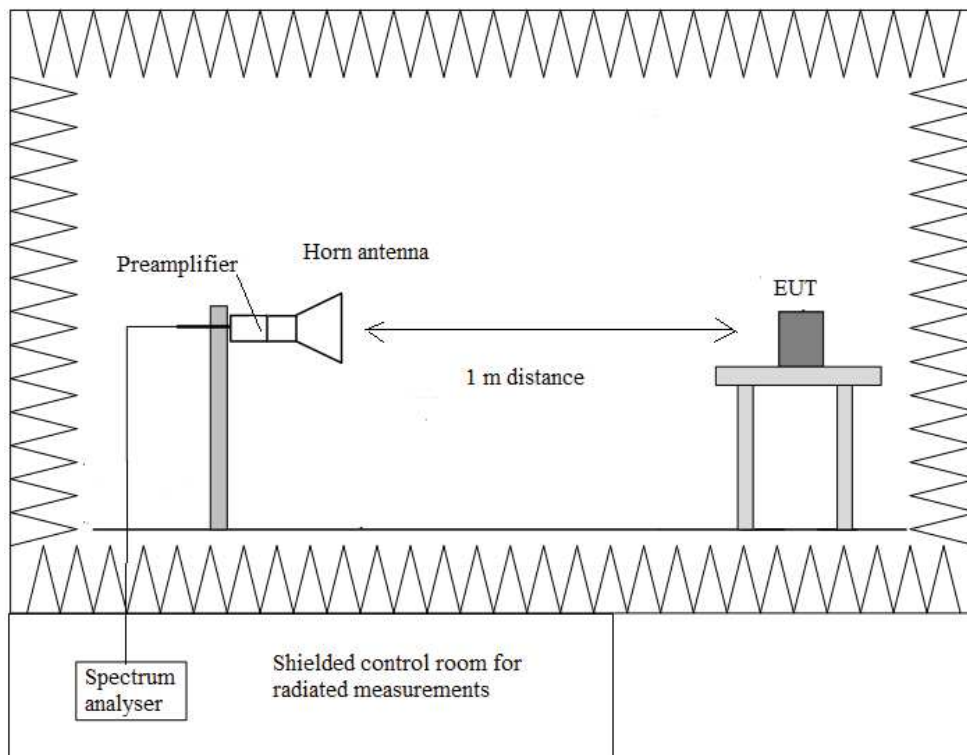
Radiated measurements setup from 30 MHz to 1 GHz:



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)	16.360	16.360	16.372
Measurement uncertainty (kHz)	<±19.25		

Mode 802.11 n20 (HT20):

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
6 dB Bandwidth (MHz)	17.307	17.560	17.560
Measurement uncertainty (kHz)	<±19.25		

Mode 802.11 ac20 (VHT20):

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
6 dB Bandwidth (MHz)	17.120	17.547	17.373
Measurement uncertainty (kHz)	<±19.25		

Mode 802.11 n40 (HT40):

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
6 dB Bandwidth (MHz)	35.386	35.693
Measurement uncertainty (kHz)	<±26.95	

Mode 802.11 ac40 (VHT40):

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
6 dB Bandwidth (MHz)	35.439	35.613
Measurement uncertainty (kHz)	<±26.95	

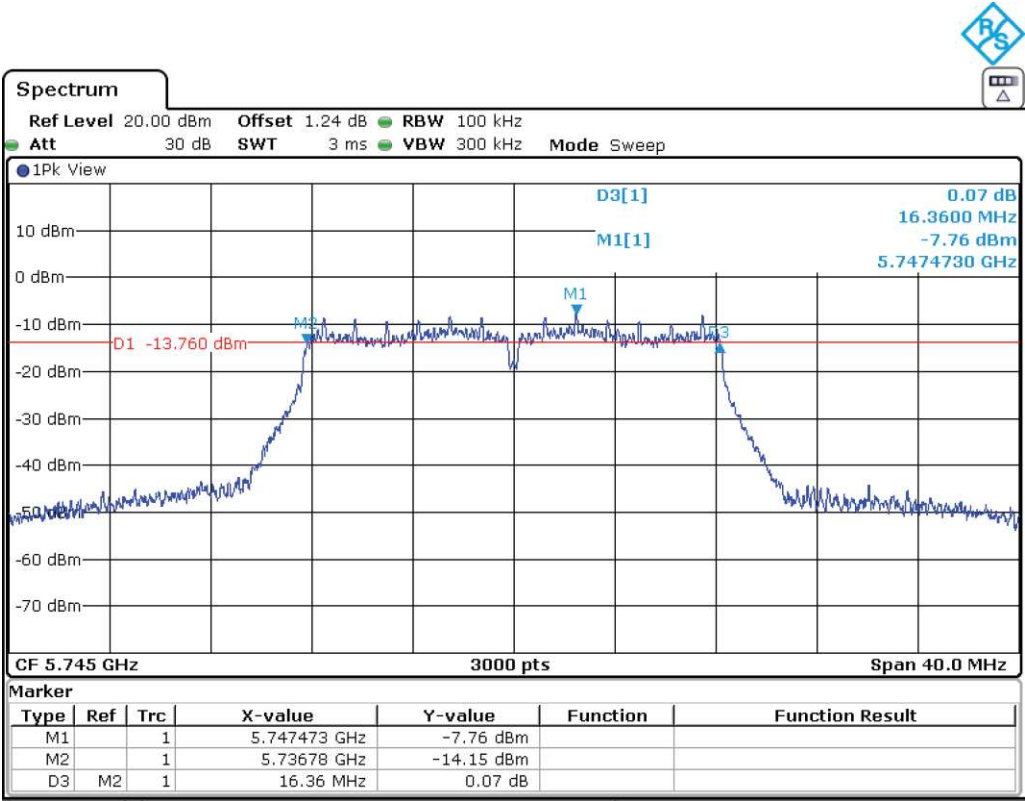
Mode 802.11 ac80 (VHT80):

	Single Channel 155 (5775 MHz)
6 dB bandwidth (MHz)	76.387
Measurement uncertainty (kHz)	<±42.35

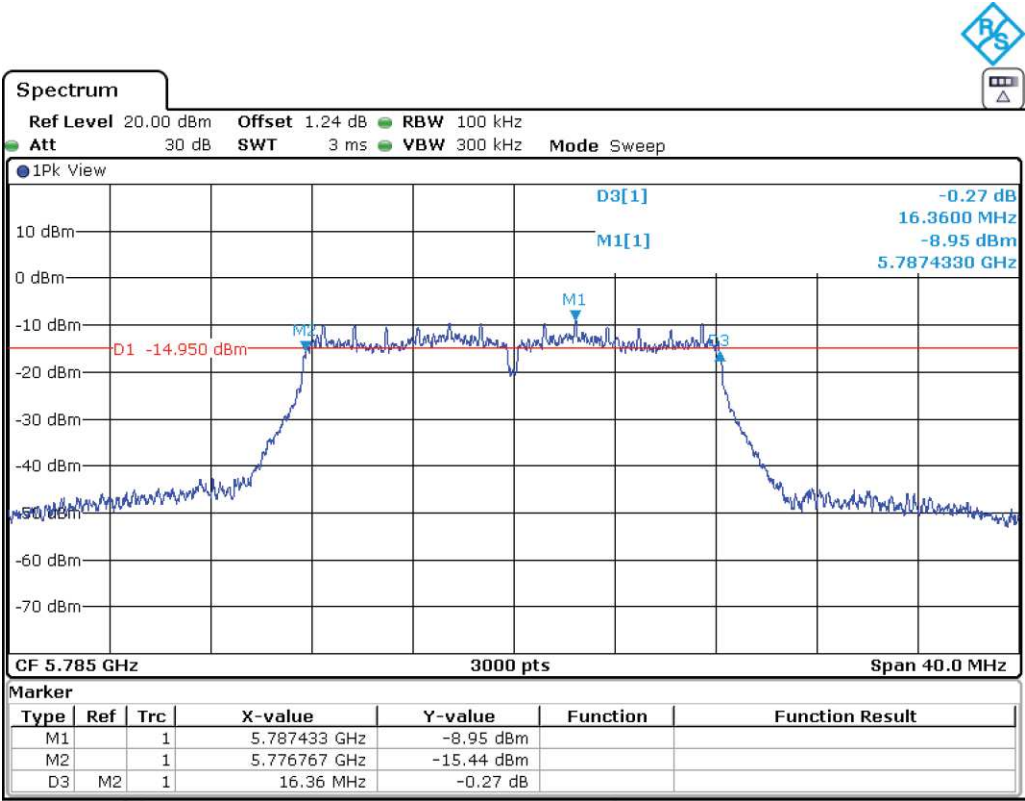
Verdict: PASS

Mode 802.11 a20:

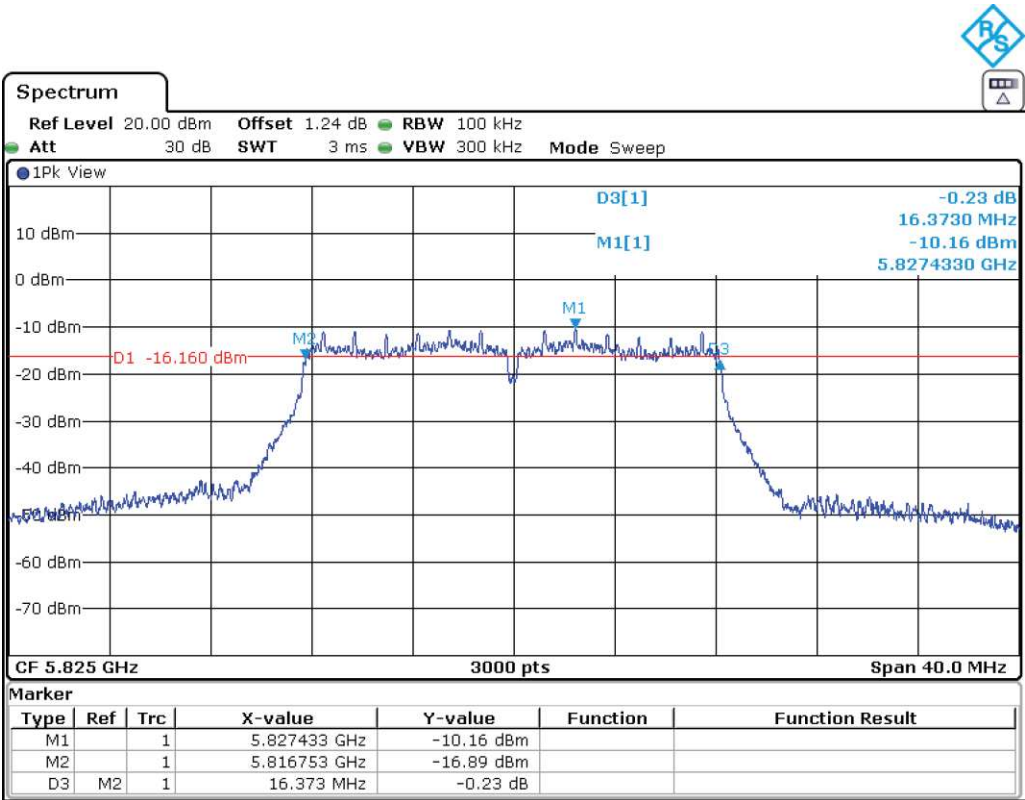
- Low Channel:



- Middle Channel:

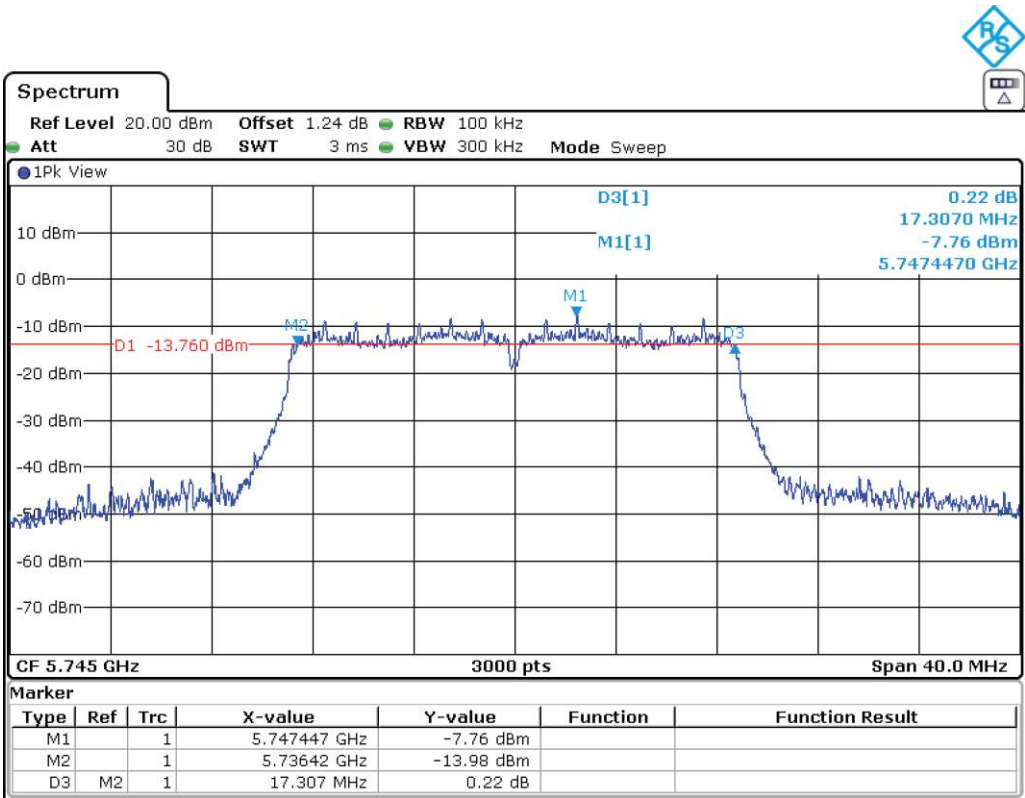


- High Channel:

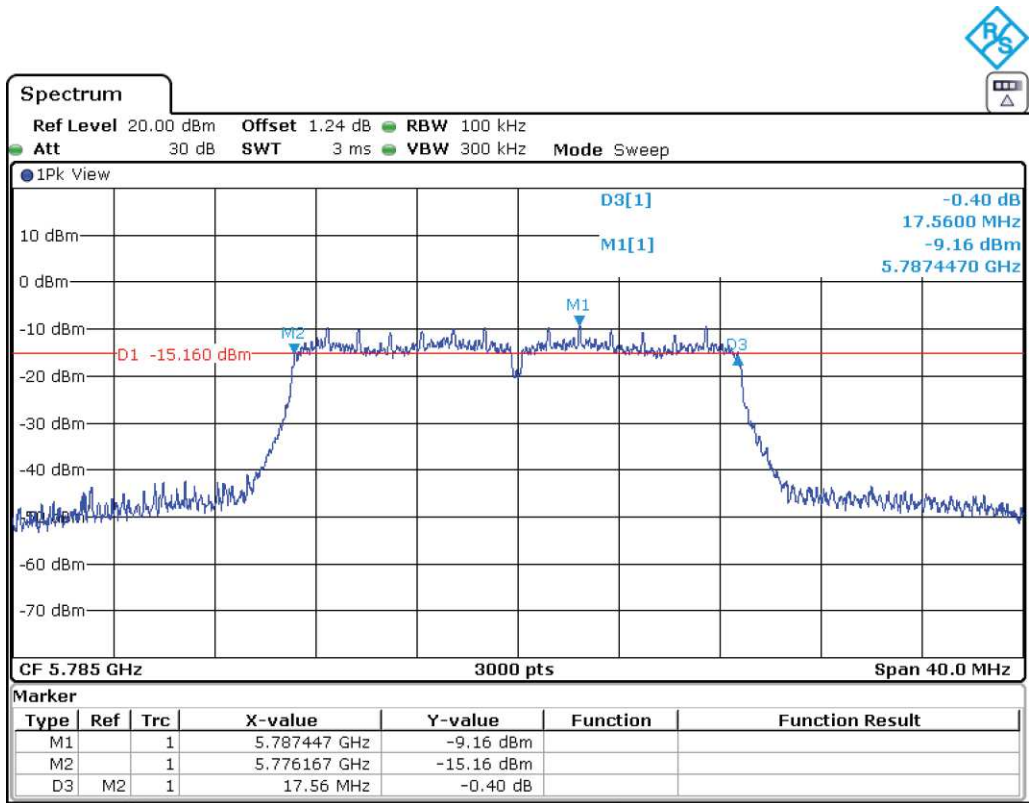


Mode 802.11 n20 (HT20):

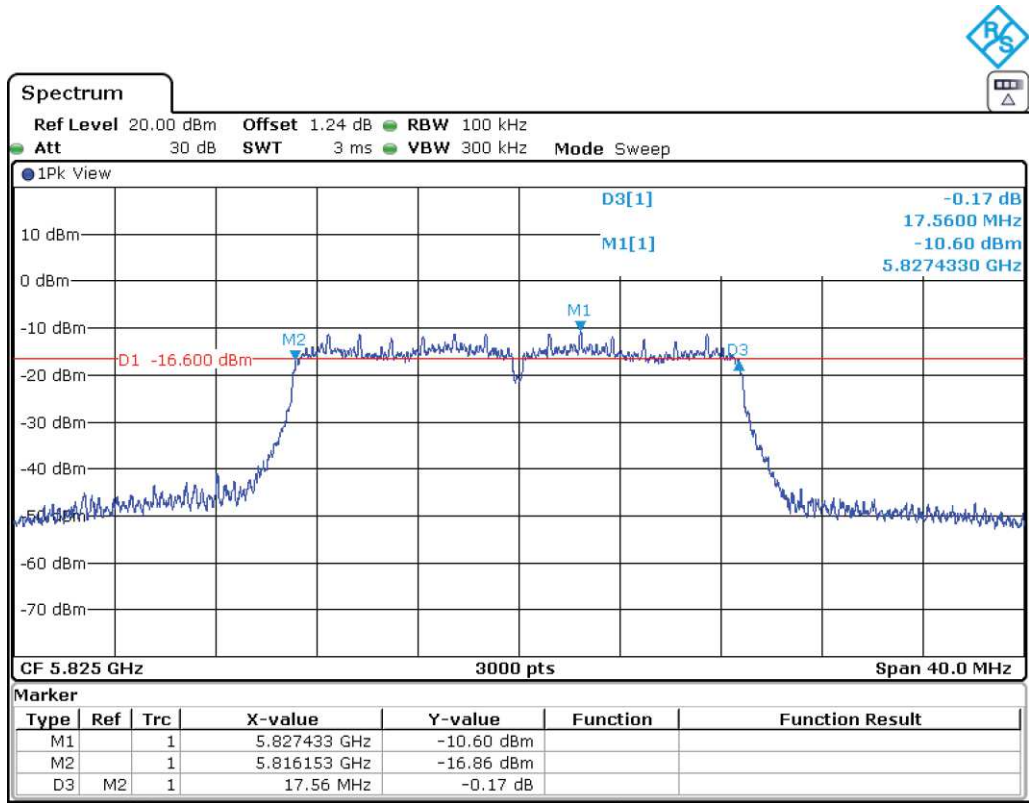
- Low Channel:



- Middle Channel:

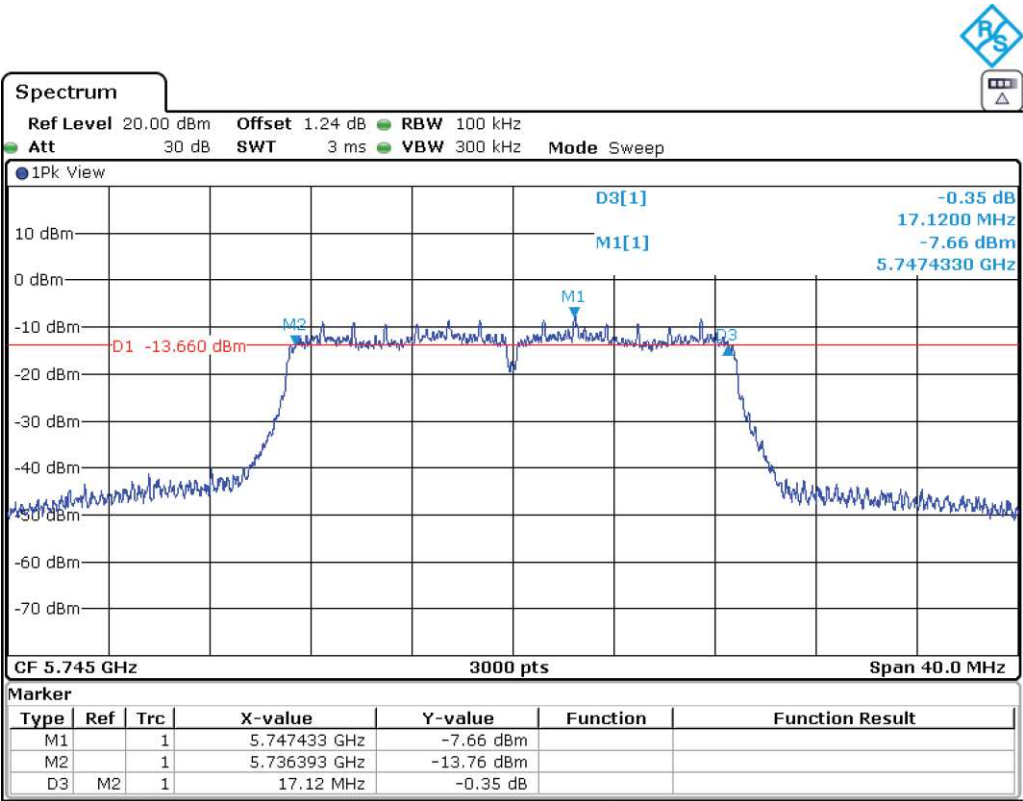


- High Channel:

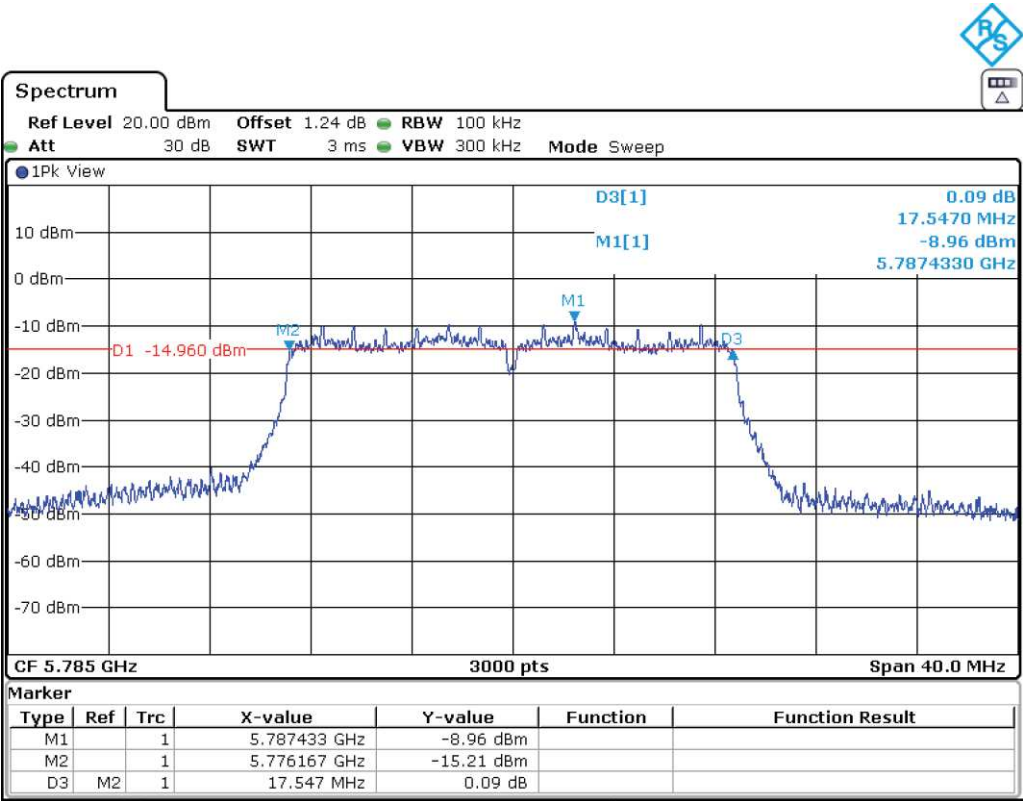


Mode 802.11 ac20 (VHT20):

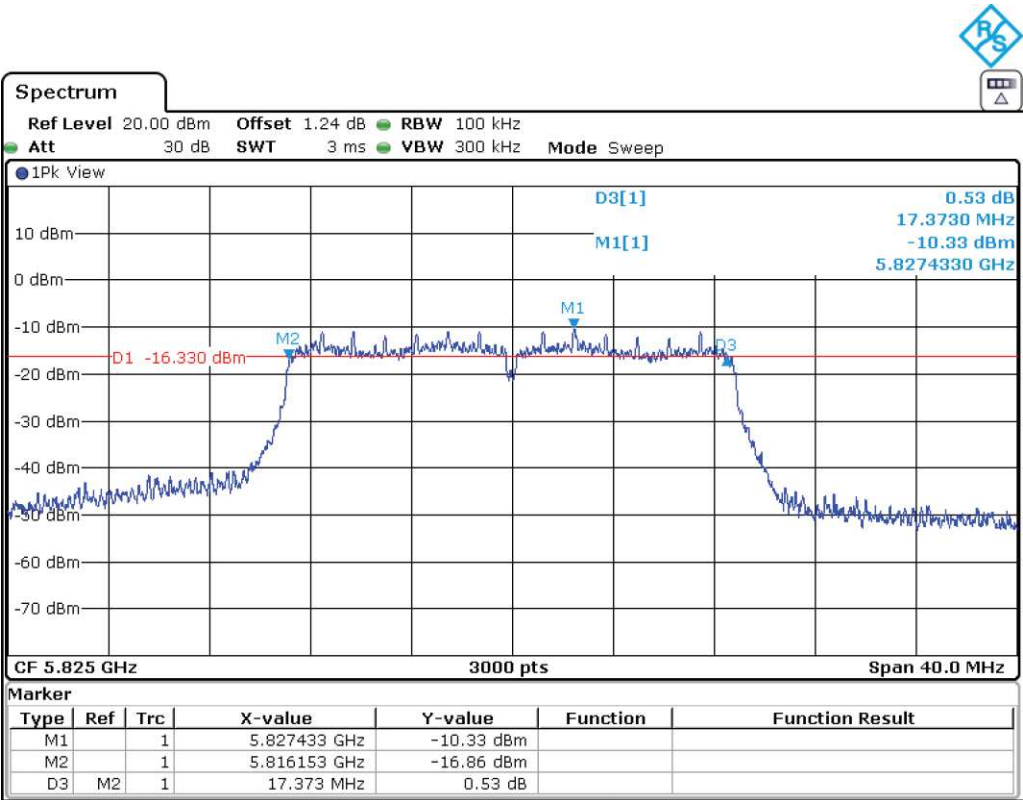
- Low Channel:



- Middle Channel:

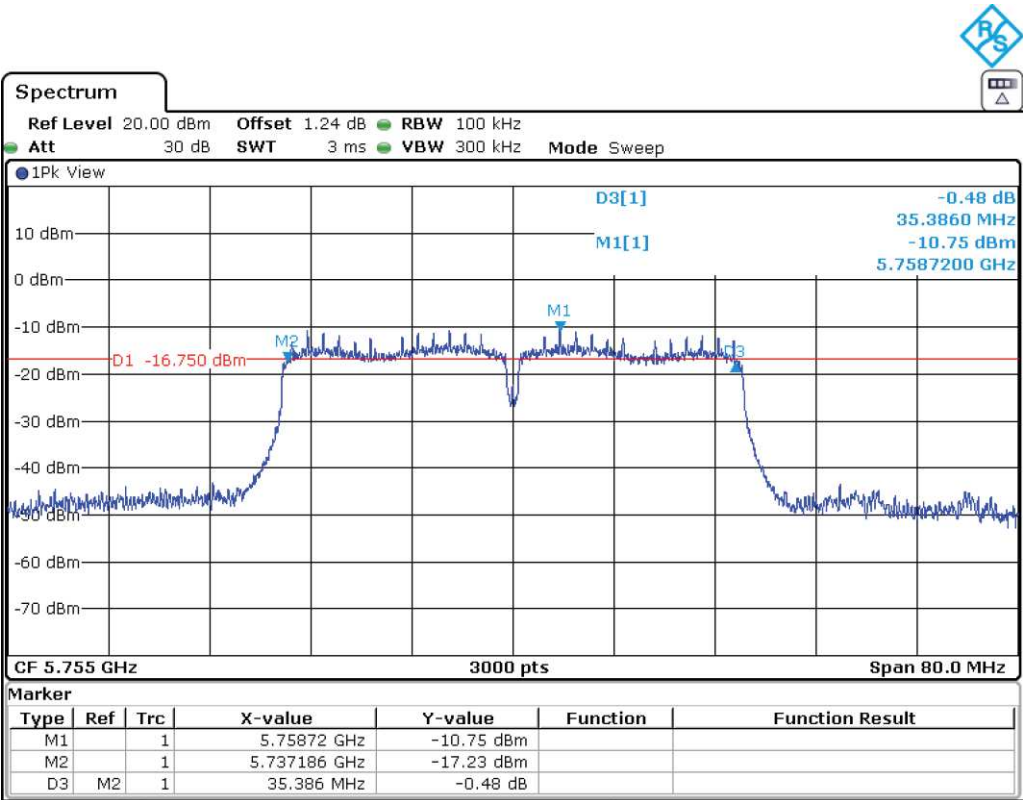


- High Channel:

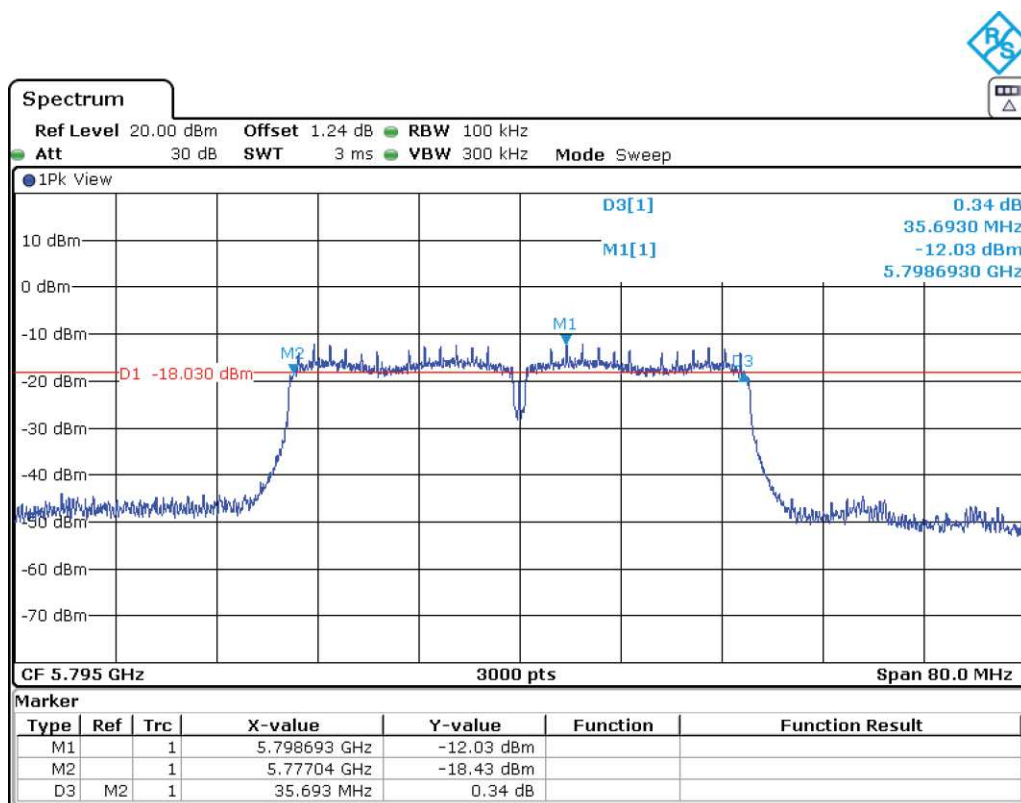


Mode 802.11 n40 (HT40):

- Low Channel:

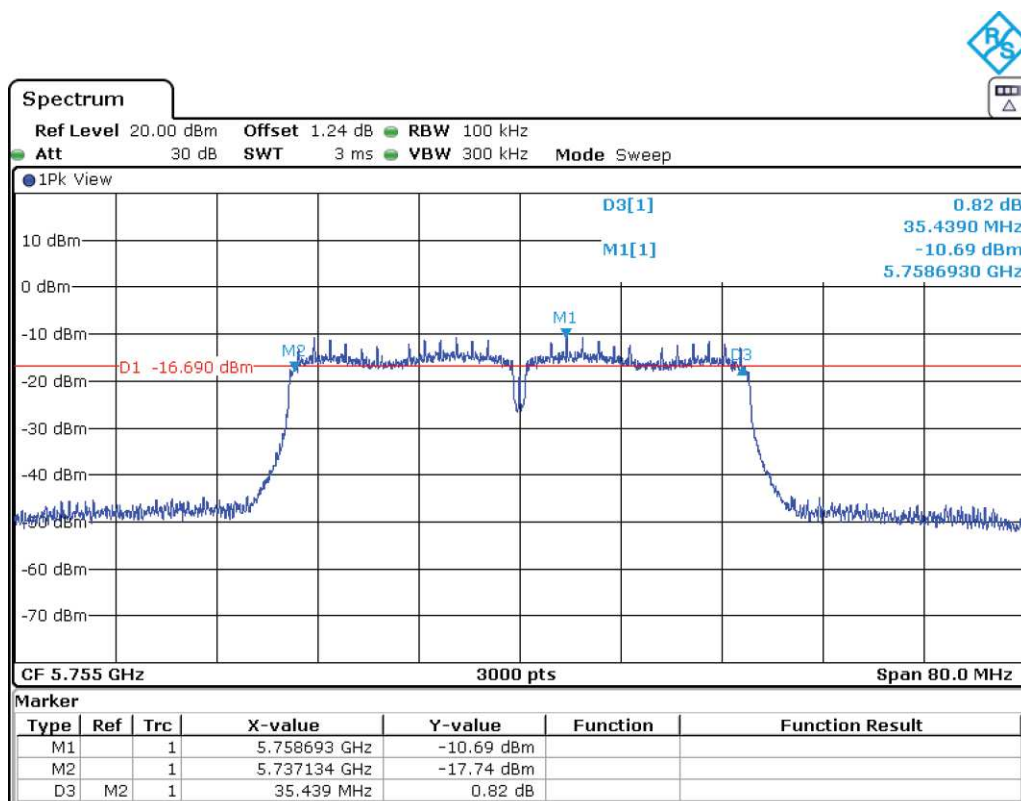


- High Channel:

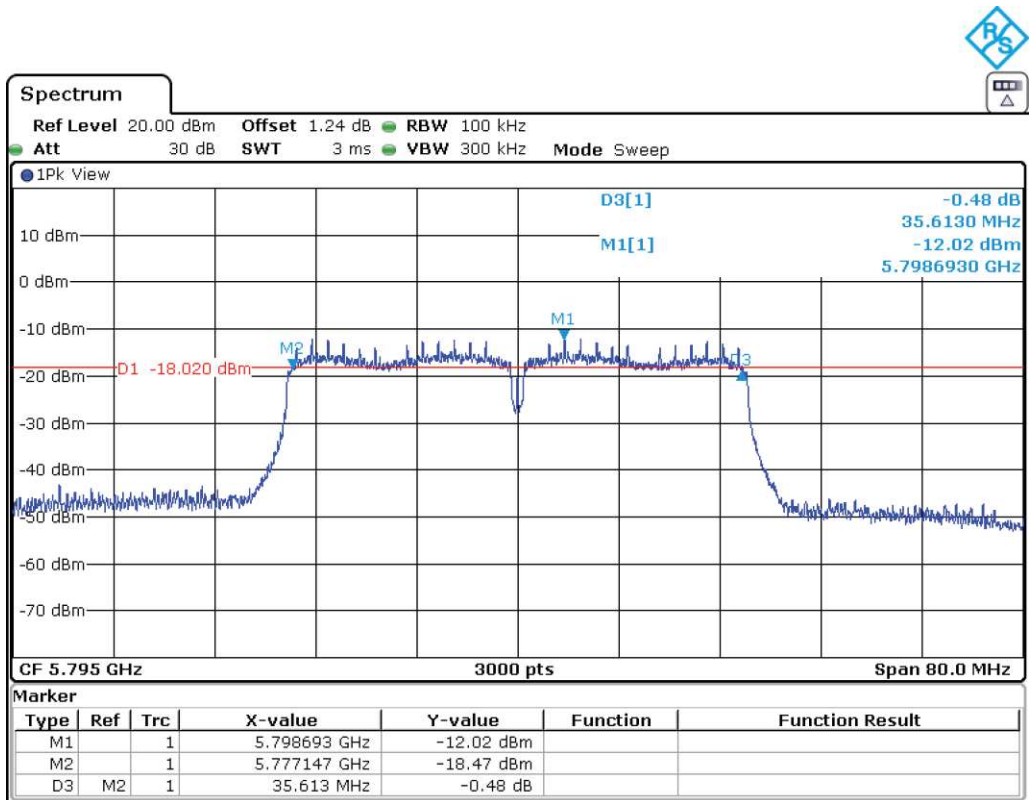


Mode 802.11 ac40 (VHT40):

- Low Channel:

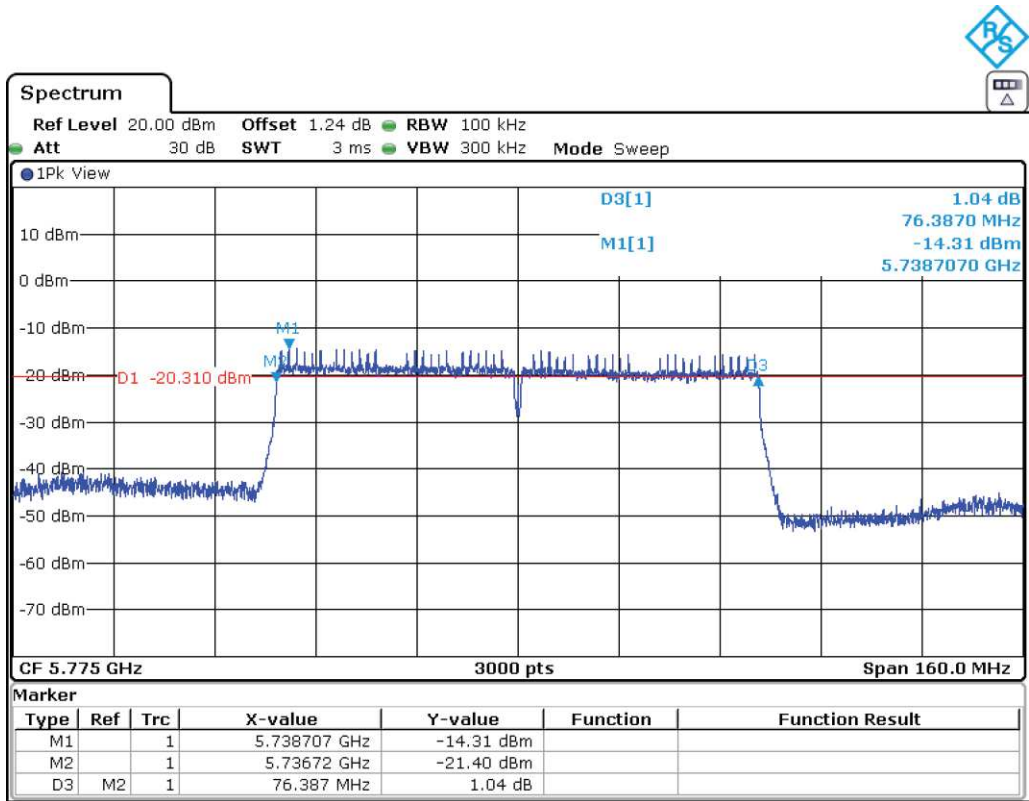


- High Channel:



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: +3 dBi

Mode 802.11 a20:

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
Max. Conducted Power (dBm)	2.1	2.1	3.4
Maximum EIRP power (dBm)	5.1	5.1	6.4
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)	1.93	1.65	3.44
Maximum EIRP power (dBm)	4.93	4.65	6.44
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)	2.08	1.59	3.11
Maximum EIRP power (dBm)	5.08	4.59	6.11
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 n40 (HT40):

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
Max. Conducted Power (dBm)	1.99	2.35
Duty Cycle Correction Factor (dB)	0.140	
Max. Conducted Power Corrected (dBm)	2.129	2.490
Maximum EIRP power Corrected (dBm)	5.129	5.490
Measurement uncertainty (dB)	<±2.00	

Mode 802.11 ac40 (VHT40):

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
Max. Conducted Power (dBm)	1.91	2.31
Duty Cycle Correction Factor (dB)	0.137	
Max. Conducted Power Corrected (dBm)	2.047	2.447
Maximum EIRP power Corrected (dBm)	5.047	5.447
Measurement uncertainty (dB)	<±2.00	

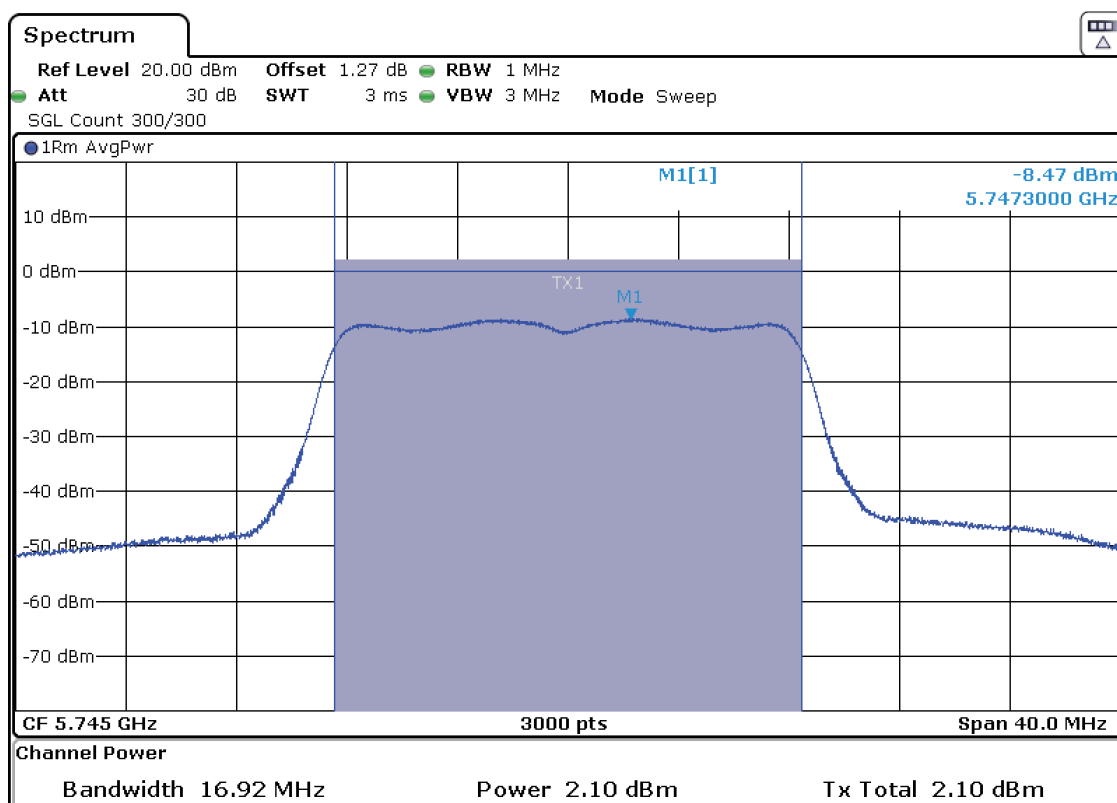
Mode 802.11 ac80 (VHT80):

	Low Channel 155 (5775 MHz)
Max. Conducted Power (dBm)	2.41
Duty Cycle Correction Factor (dB)	0.274
Max. Conducted Power Corrected (dBm)	2.684
Maximum EIRP power Corrected (dBm)	5.684
Measurement uncertainty (dB)	<±2.00

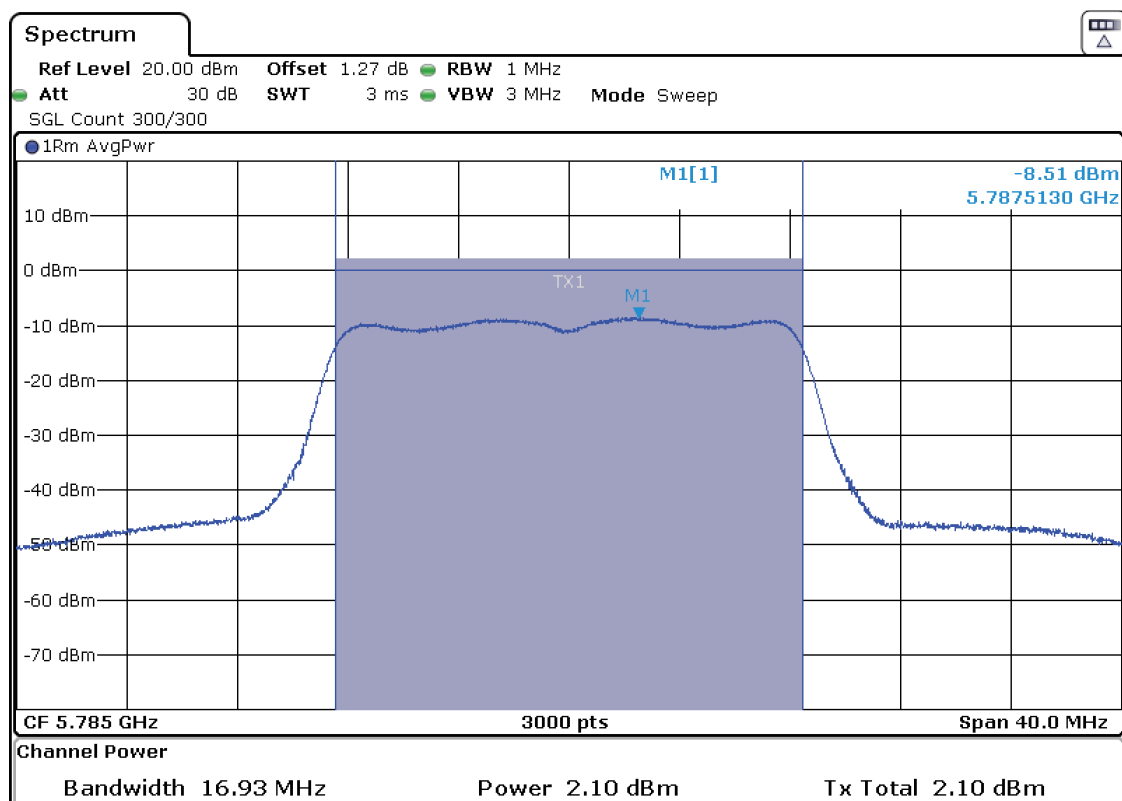
Verdict: PASS

Mode 802.11 a20:

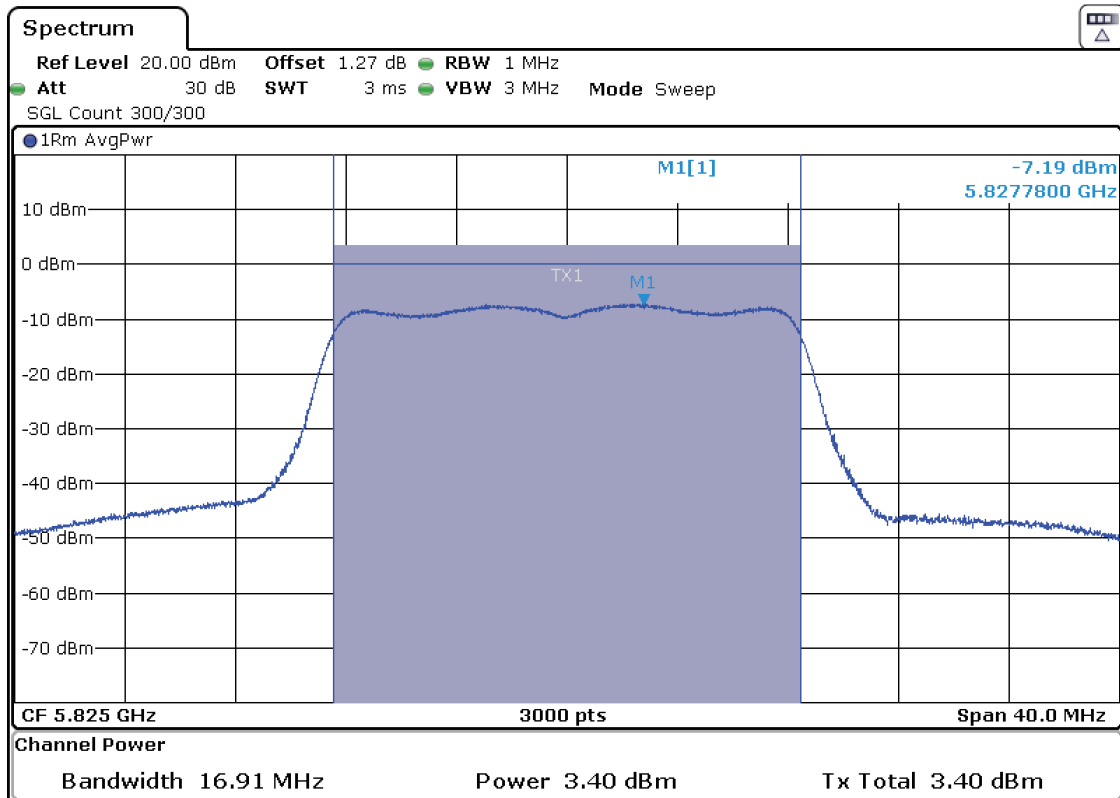
- Low Channel:



- Middle Channel:

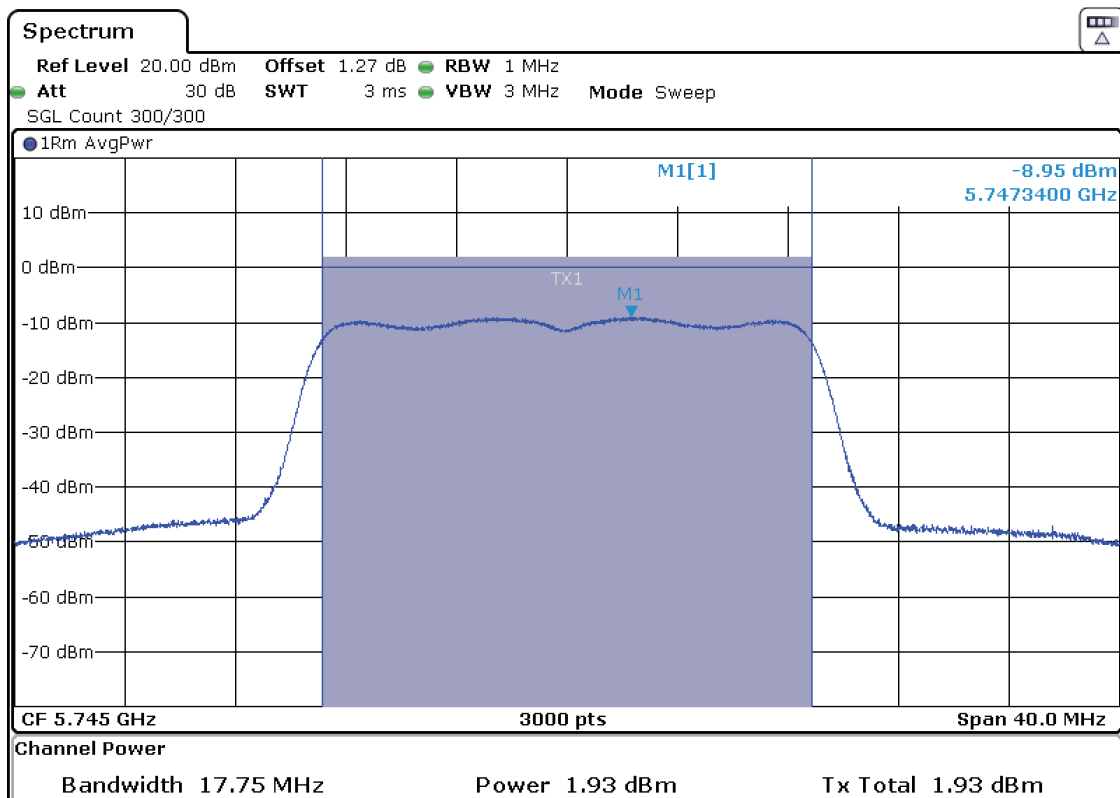


- High Channel:

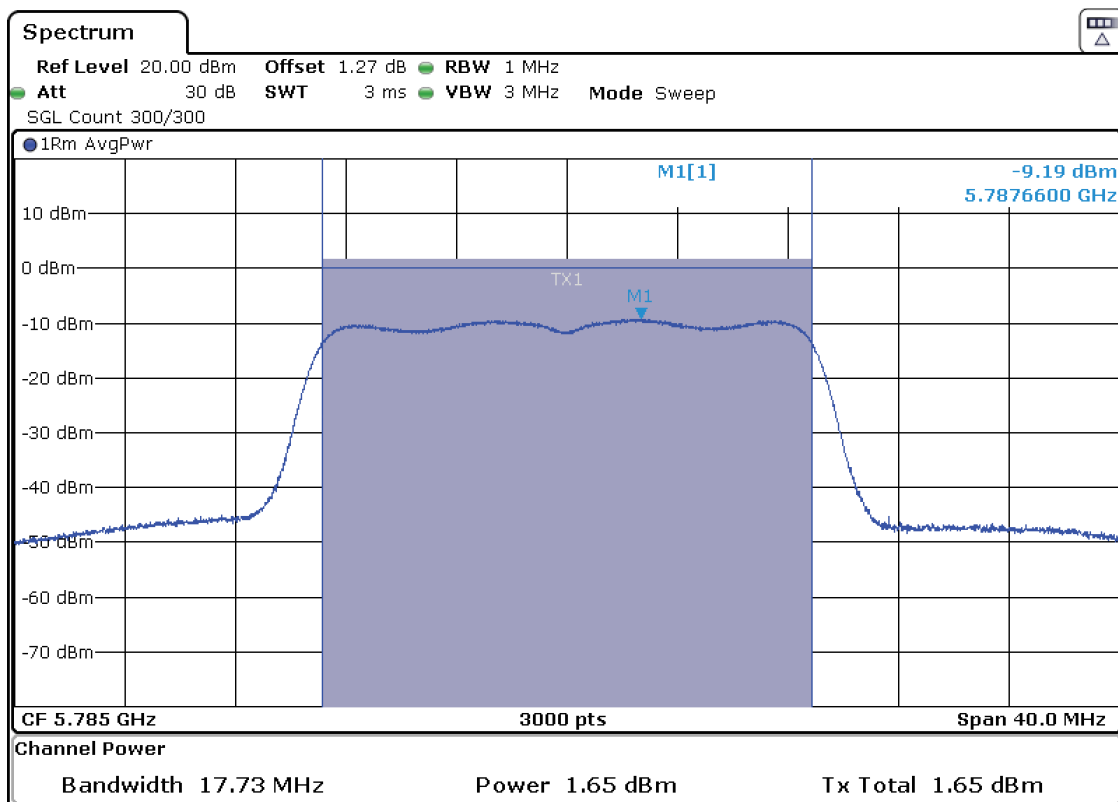


Mode 802.11 n20 (HT20):

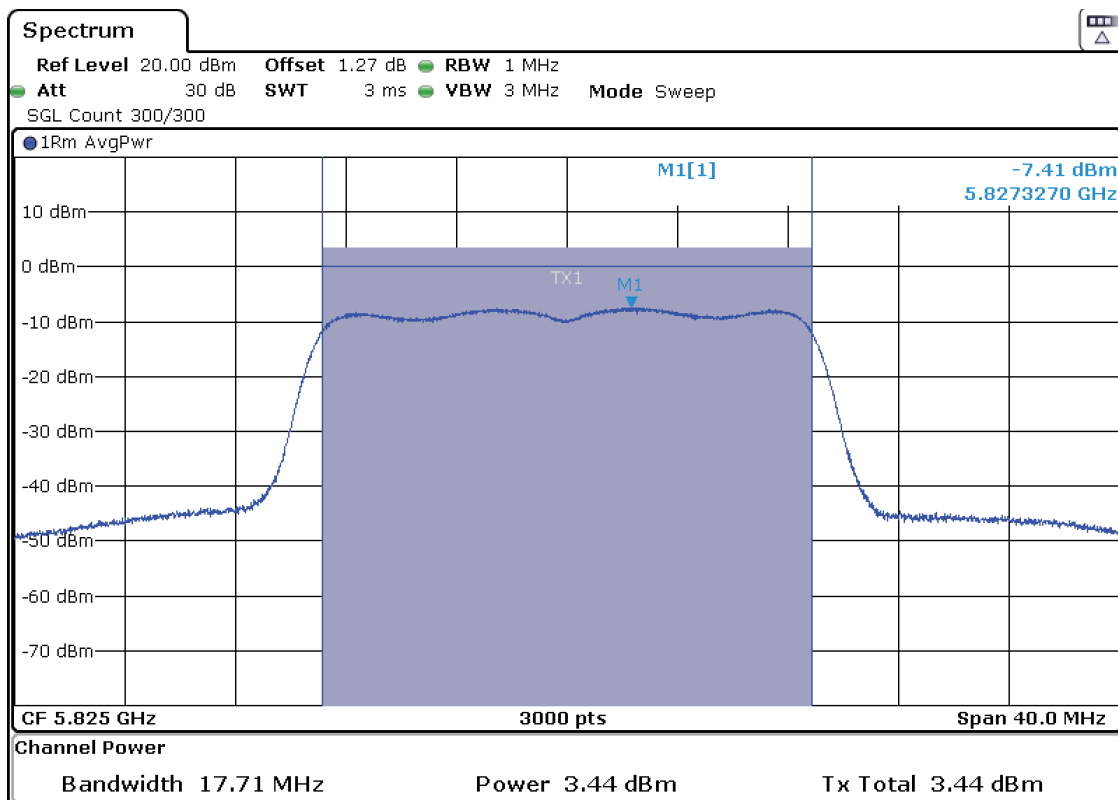
- Low Channel:



- Middle Channel:

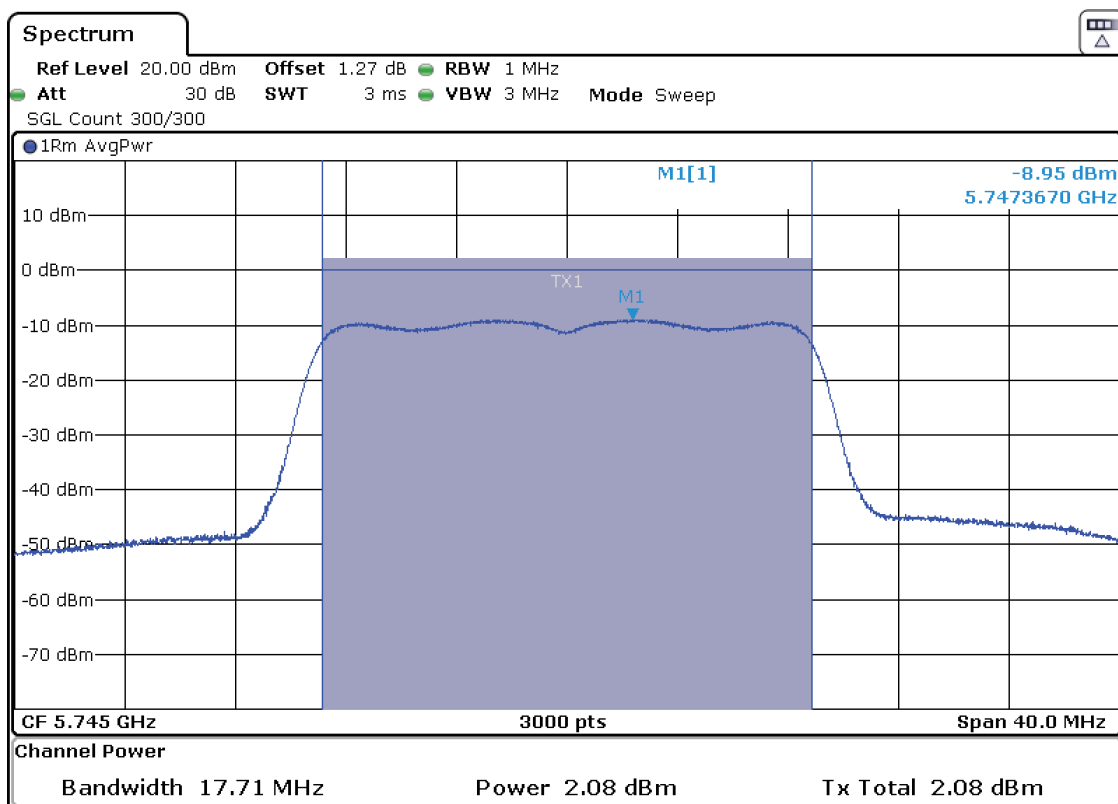


- High Channel:

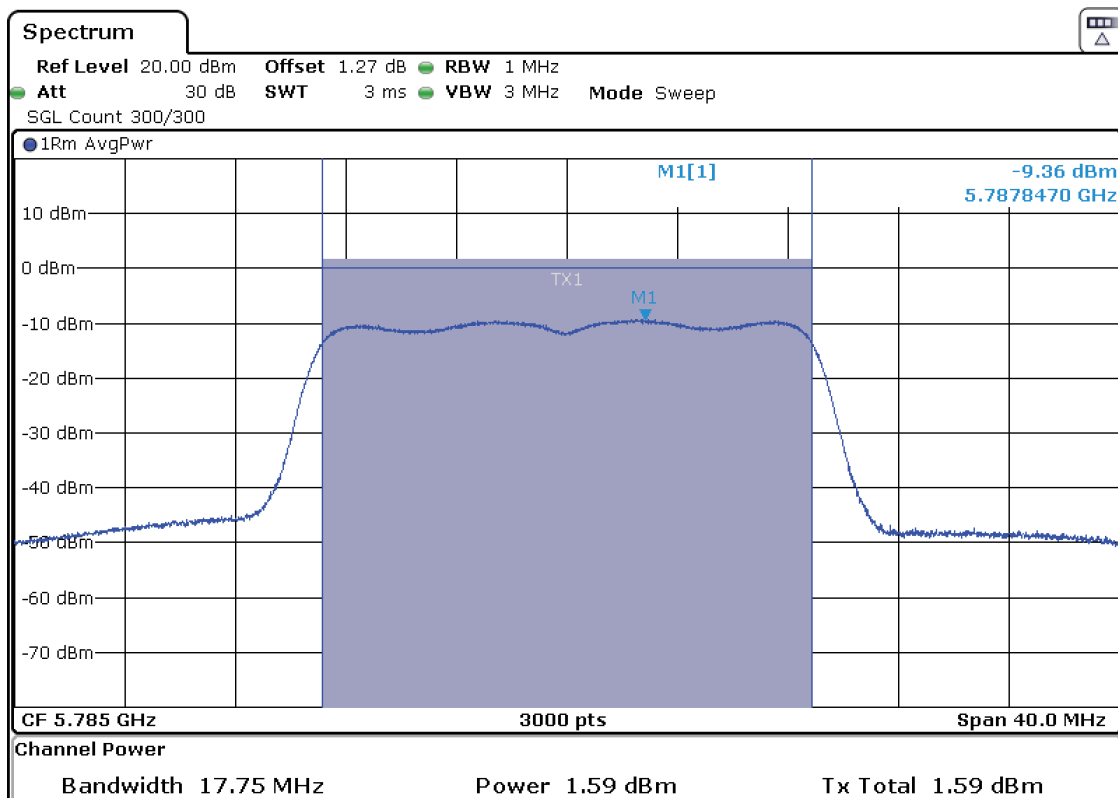


Mode 802.11 ac20 (VHT20):

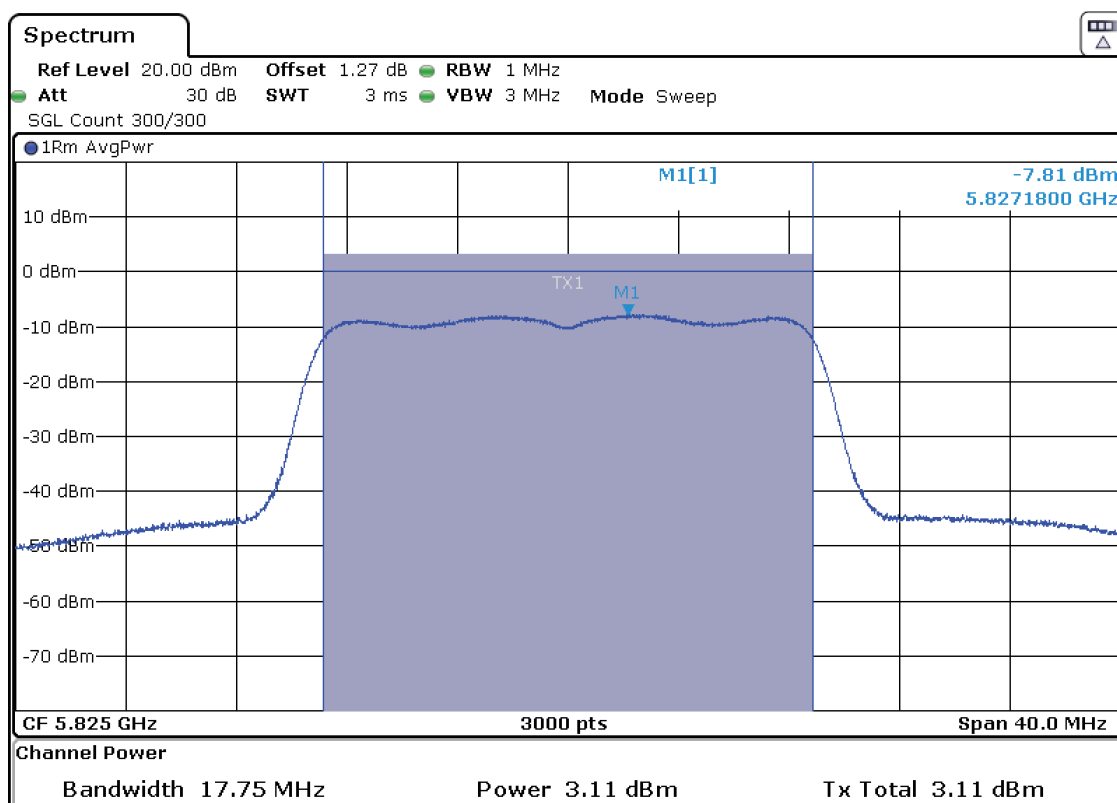
- Low Channel:



- Middle Channel:

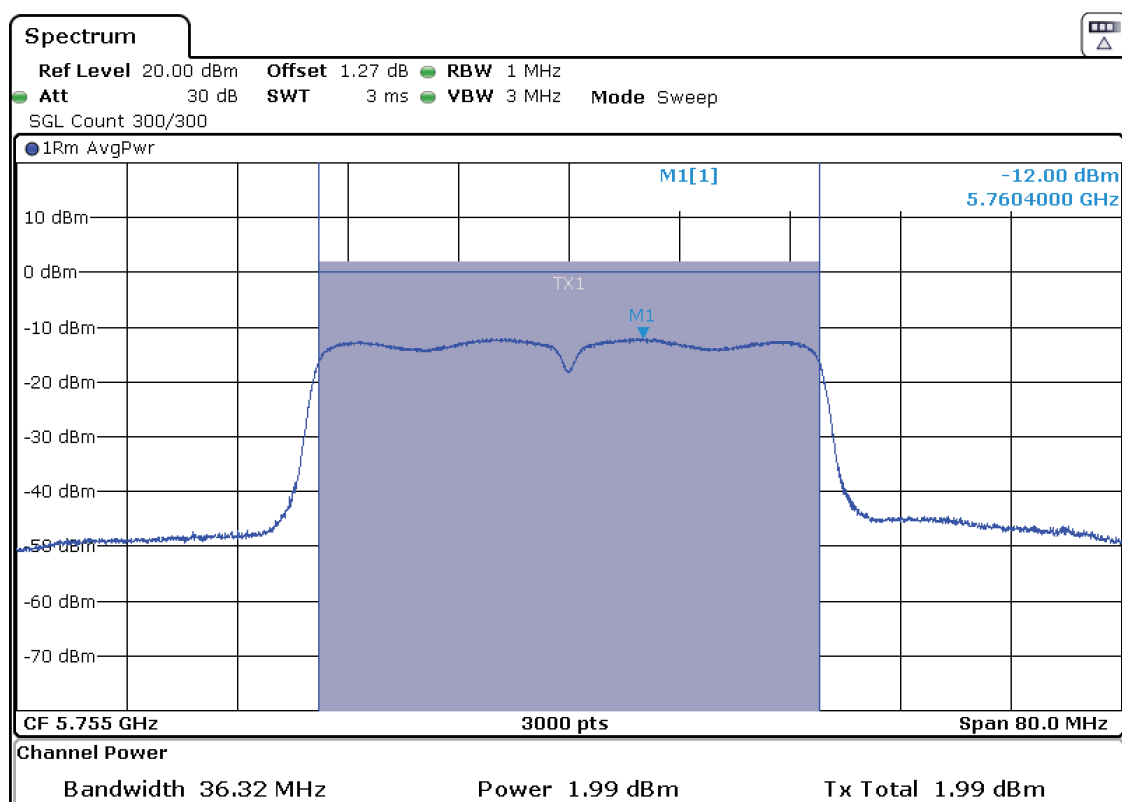


- High Channel:

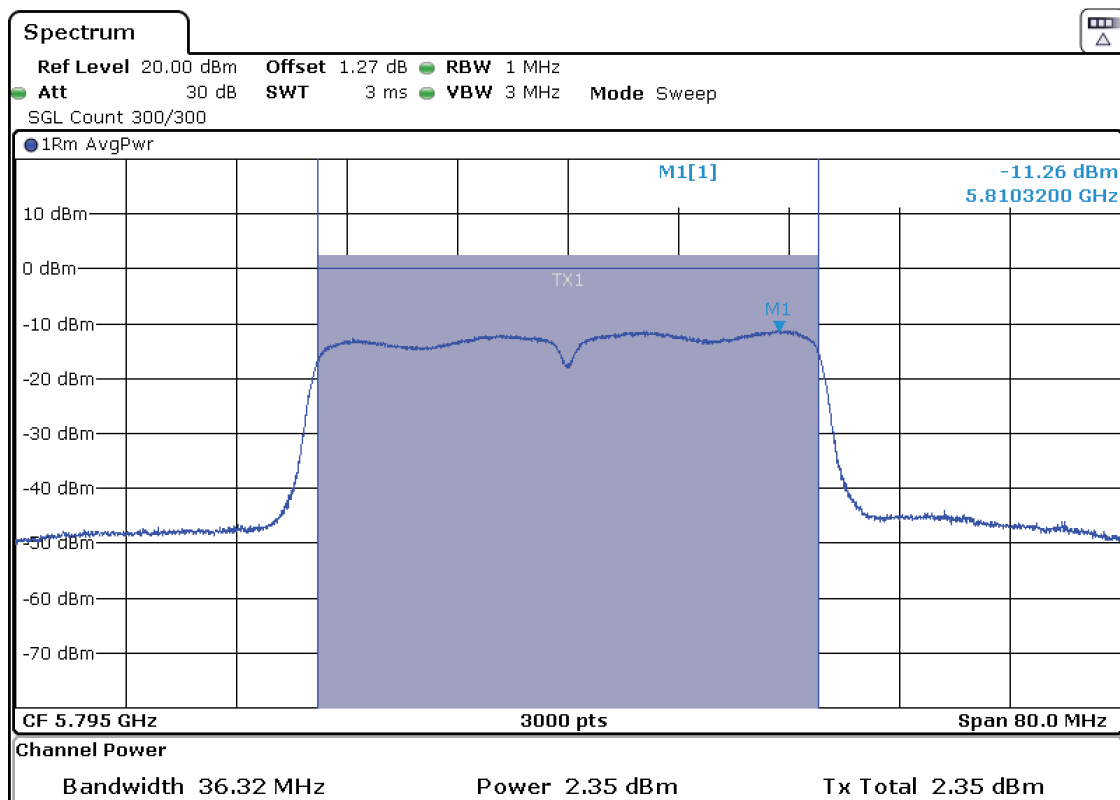


Mode 802.11 n40 (HT40):

- Low Channel:

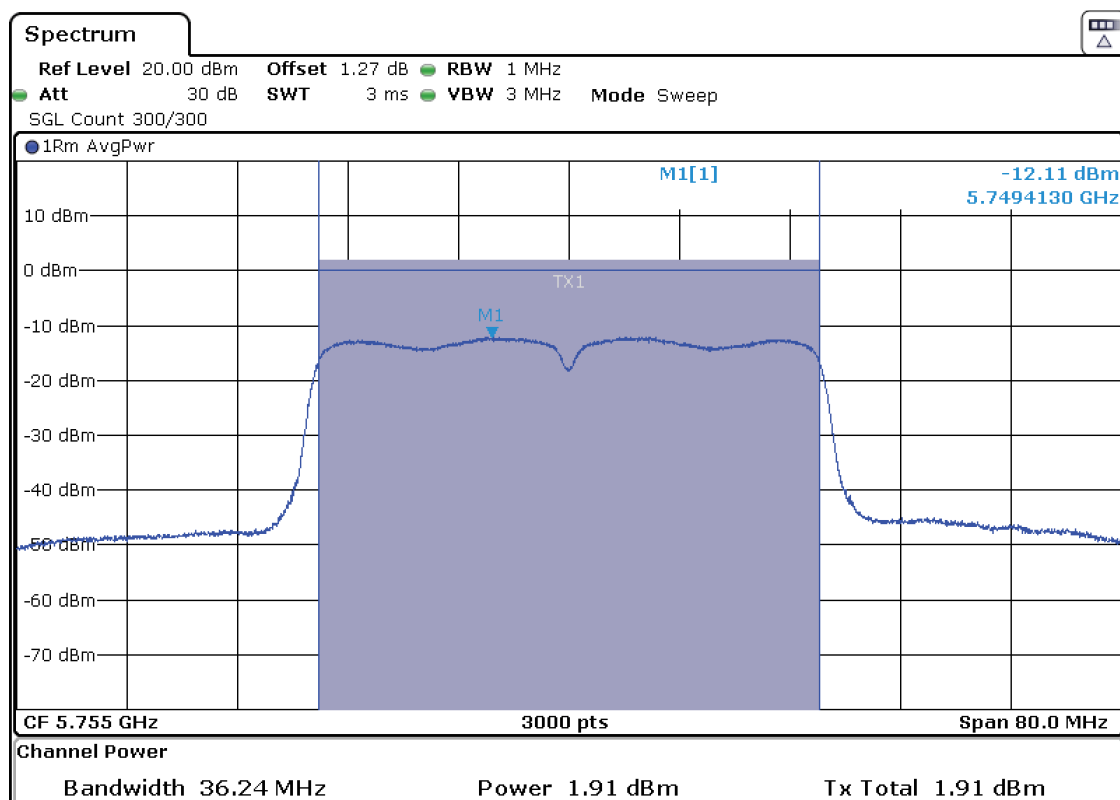


- High Channel:

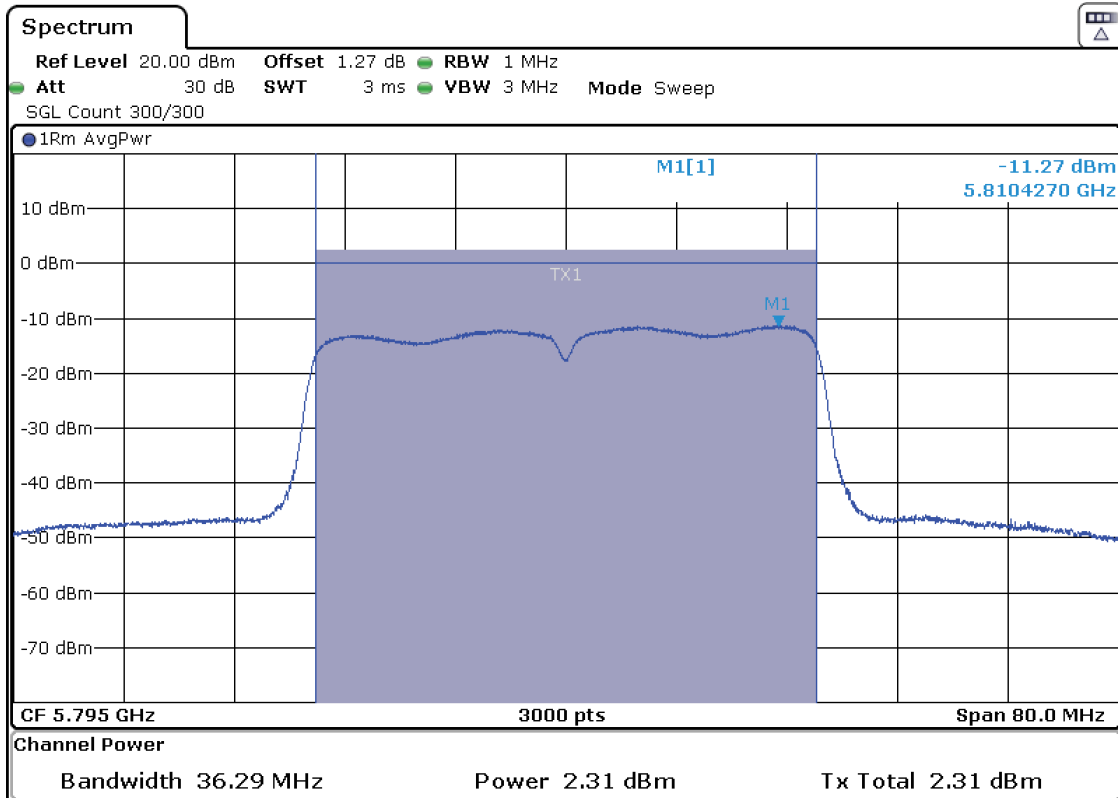


Mode 802.11 ac40 (VHT40):

- Low Channel:

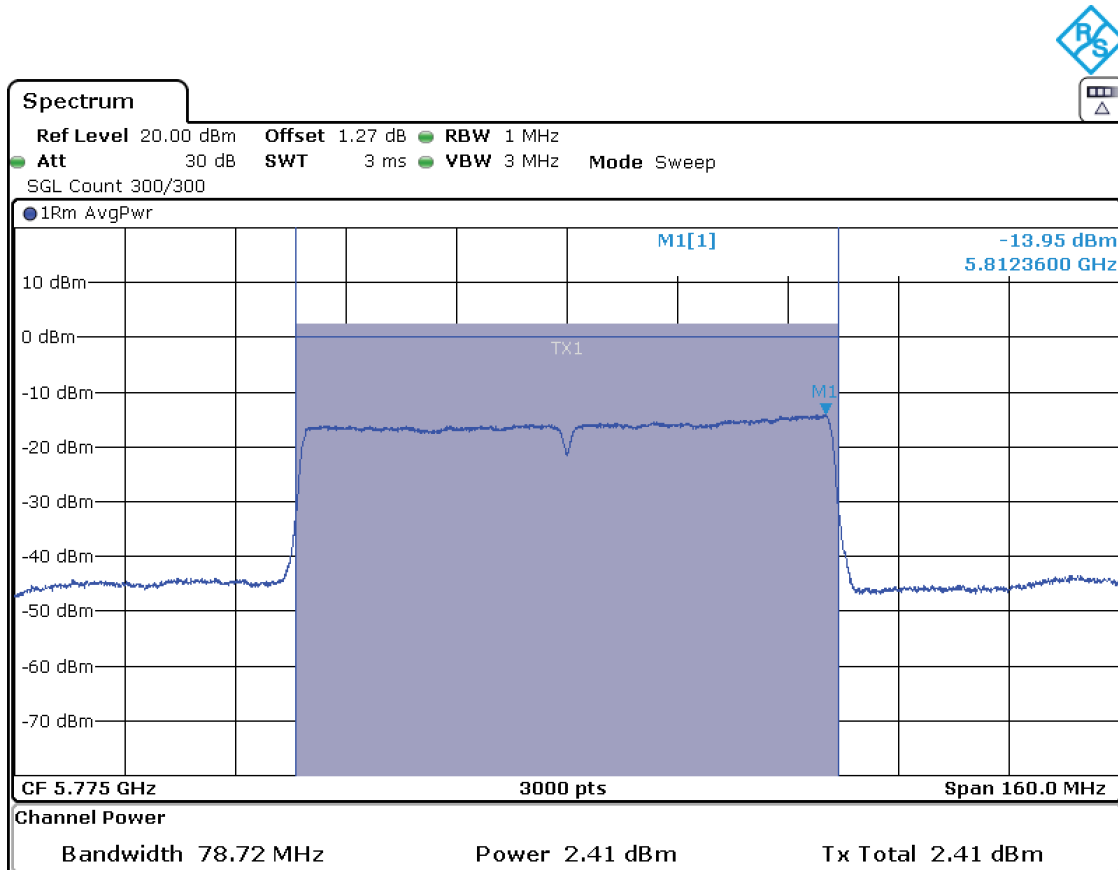


- High Channel:



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: +3 dBi

Mode 802.11 a20:

	Low Channel	Middle Channel	High Channel
Maximum Average PSD (dBm/MHz)	-8.47	-8.51	-7.19
Maximum EIRP PSD (dBm/MHz)	-5.47	-5.51	-4.19
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 n20 (HT20):

	Low Channel	Middle Channel	High Channel
Maximum Average PSD (dBm/MHz)	-8.95	-9.19	-7.41
Maximum EIRP PSD (dBm/MHz)	-5.95	-6.19	-4.41
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 ac20 (VHT20):

	Low Channel	Middle Channel	High Channel
Maximum Average PSD (dBm/MHz)	-8.95	-9.36	-7.81
Maximum EIRP PSD (dBm/MHz)	-5.95	-6.36	-4.81
Measurement uncertainty (dB)	<±2.00		

Mode 802.11 n40 (HT40):

	Low Channel	High Channel
Maximum Average PSD (dBm/MHz)	-12	-11.26
Duty Cycle Correction Factor (dB)	0.139	
Maximum Average PSD Corrected (dBm/MHz)	-11.861	-11.121
Maximum EIRP PSD Corrected (dBm/MHz)	-8.861	-8.121
Measurement uncertainty (dB)	<±2.00	

Mode 802.11 ac40 (VHT40):

	Low Channel	High Channel
Maximum Average PSD (dBm/MHz)	-12.11	-11.27
Duty Cycle Correction Factor (dB)	0.137	
Maximum Average PSD Corrected (dBm/MHz)	-11.973	-11.133
Maximum EIRP PSD Corrected (dBm/MHz)	-8.973	-8.133
Measurement uncertainty (dB)	<±2.00	

Mode 802.11 ac80 (VHT80):

	Low Channel
Maximum Average PSD (dBm/MHz)	-13.95
Duty Cycle Correction Factor (dB)	0.274
Maximum Average PSD Corrected (dBm/MHz)	-13.676
Maximum EIRP PSD Corrected (dBm/MHz)	-10.676
Measurement uncertainty (dB)	<±2.00

Verdict: PASS