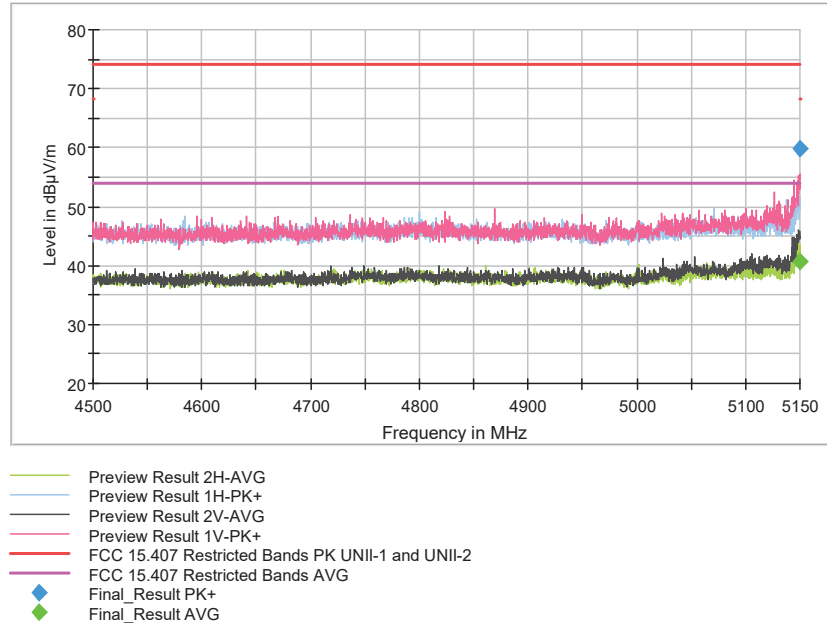


• **Mode 802.11 n40 (HT40)**

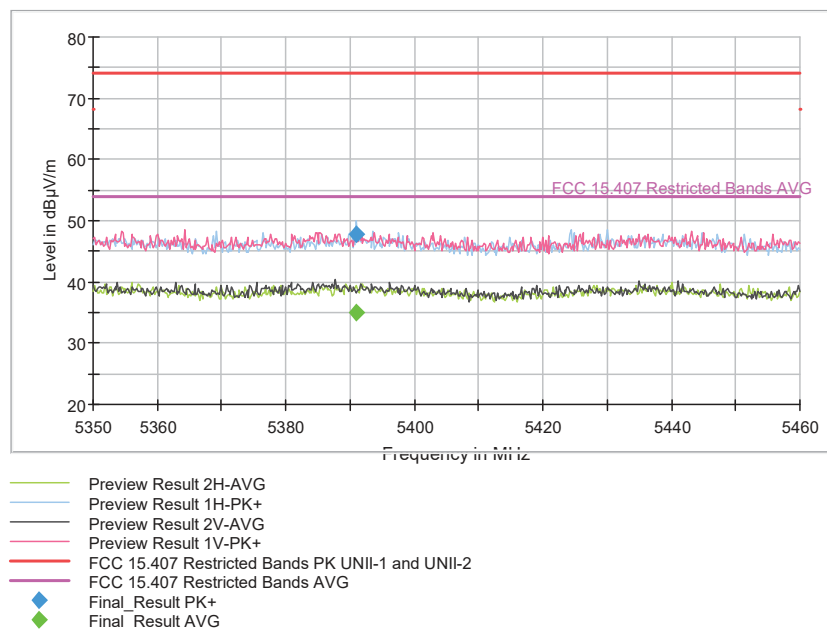
Radiated spurious emissions at band-edges and inside adjacent band 4.50 - 5.15 GHz

- Lower Band Edge Channel 38 (4500 to 5150 MHz)



Radiated spurious emissions at band-edges and inside adjacent band 5.35 - 5.46 GHz

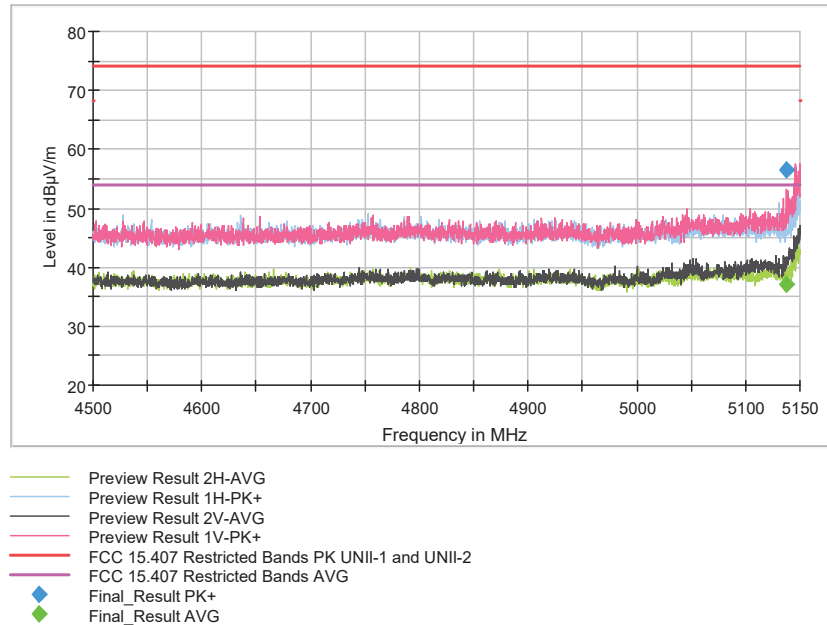
- Upper Band Edge Channel 46 (5350 to 5460 MHz)



• **Mode 802.11 ac40 (VHT40)**

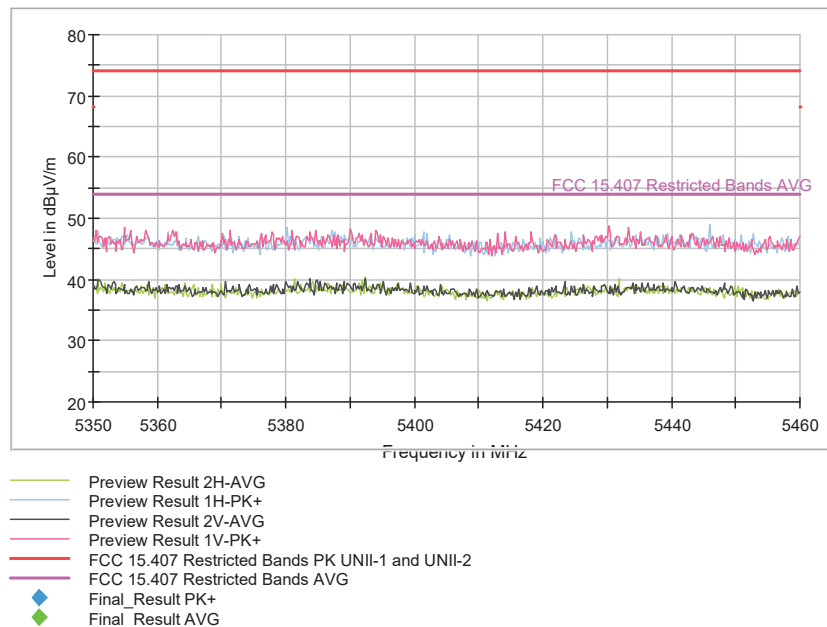
Radiated spurious emissions at band-edges and inside adjacent band 4.50 - 5.15 GHz

- Lower Band Edge Channel 38 (4500 to 5150 MHz)



Radiated spurious emissions at band-edges and inside adjacent band 5.35 - 5.46 GHz

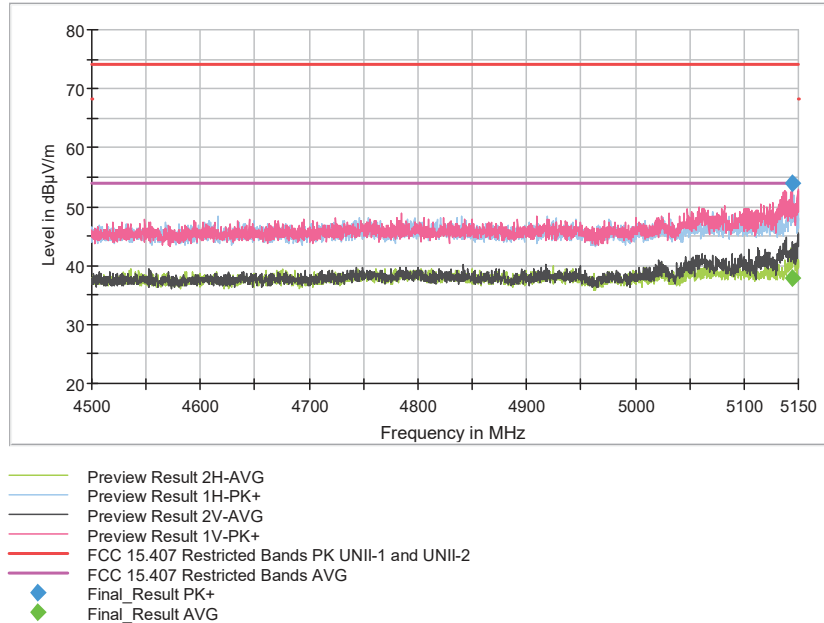
- Upper Band Edge Channel 46 (5350 to 5460 MHz)



- **Mode 802.11 ac80 (VHT80)**

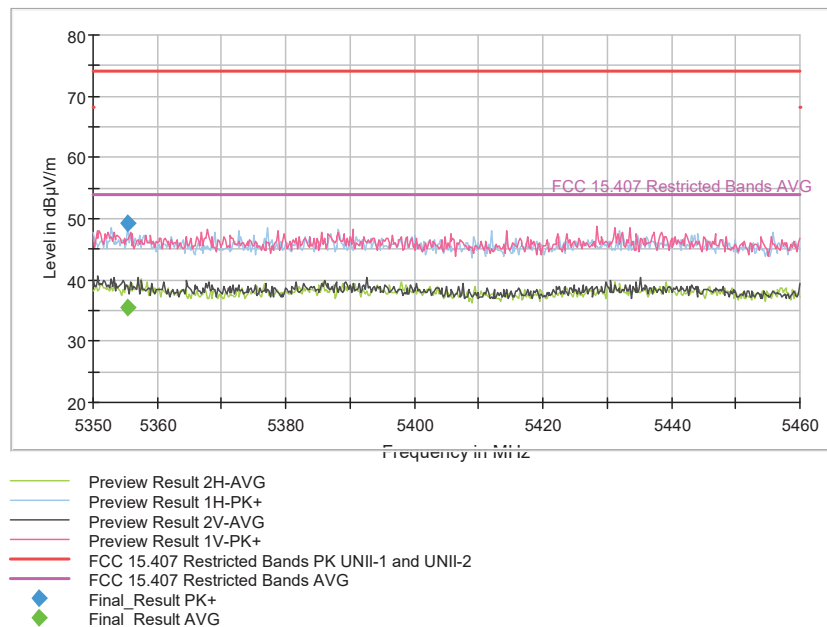
Radiated spurious emissions at band-edges and inside adjacent band 4.50 - 5.15 GHz

- Lower Band Edge Channel 42 (4500 to 5150 MHz)



Radiated spurious emissions at band-edges and inside adjacent band 5.35 - 5.46 GHz

- Upper Band Edge Channel 42 (5350 to 5460 MHz)



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

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Band Edge Radiated Emissions.96

TEST CONDITIONS

POWER SUPPLY (V):

V nominal: 12 Vdc
Type of Power Supply: DC voltage from external power supply (car battery).

ANTENNAS:

Type of Antenna: External.
Antennas Gain:

- SISO – CORE-0_Port3 Antenna – Declared Maximum Antenna Gain: +2.5 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:	Core 0 / Port 3.	
Beamforming:	No	
Frequency Range:	5725 MHz to 5850 MHz	
Channel Spacing:	20 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Lowest: 149	5745
	Middle: 157	5785
	Highest: 165	5825
Channel Spacing:	40 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Lowest: 151	5755
	Highest: 159	5795
Channel Spacing:	80 MHz	
Transmit Channels	Middle: 155	5775

The test set-up was made in accordance to 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 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 Mbits
- 802.11n HT20: MCS0
- 802.11n HT40: MCS0
- 802.11ac VHT20: MCS0
- 802.11ac VHT40: MCS0
- 802.11ac VHT80: MCS0

WIFI FCC:

```
tx_test.sh -a wlan0 stop
```

a20 - Core0

```
tx_test.sh -a wlan0 149 0 -d x -r 6 20 -c US
```

```
tx_test.sh -a wlan0 157 0 -d x -r 6 20 -c US
```

```
tx_test.sh -a wlan0 165 0 -d x -r 6 20 -c US
```

n20 - Core0

```
tx_test.sh -a wlan0 149 0 -d x -h 0 20 -c US
```

```
tx_test.sh -a wlan0 157 0 -d x -h 0 20 -c US
```

```
tx_test.sh -a wlan0 165 0 -d x -h 0 20 -c US
```

ac20 - Core0

```
tx_test.sh -a wlan0 149 0 -d x -v 0 20 -c US
```

```
tx_test.sh -a wlan0 157 0 -d x -v 0 20 -c US
```

```
tx_test.sh -a wlan0 165 0 -d x -v 0 20 -c US
```

n40 - Core0

```
tx_test.sh -a wlan0 153 0 -d x -h 0 40 -c US
```

```
tx_test.sh -a wlan0 161 0 -d x -h 0 40 -c US
```

ac40 - Core0

```
tx_test.sh -a wlan0 153 0 -d x -v 0 40 -c US
```

```
tx_test.sh -a wlan0 161 0 -d x -v 0 40 -c US
```

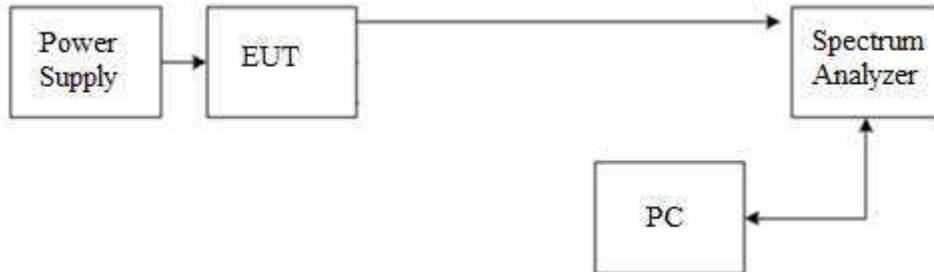
ac80 - Core0

```
tx_test.sh -a wlan0 161 0 -d x -v 0 80 -c US
```

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 1 GHz and 1 GHz-17 GHz Double ridge horn antenna) is situated at a distance of 3 and at a distance of 1m for the frequency range 17 GHz-40 GHz (17 GHz-40 GHz horn antenna).

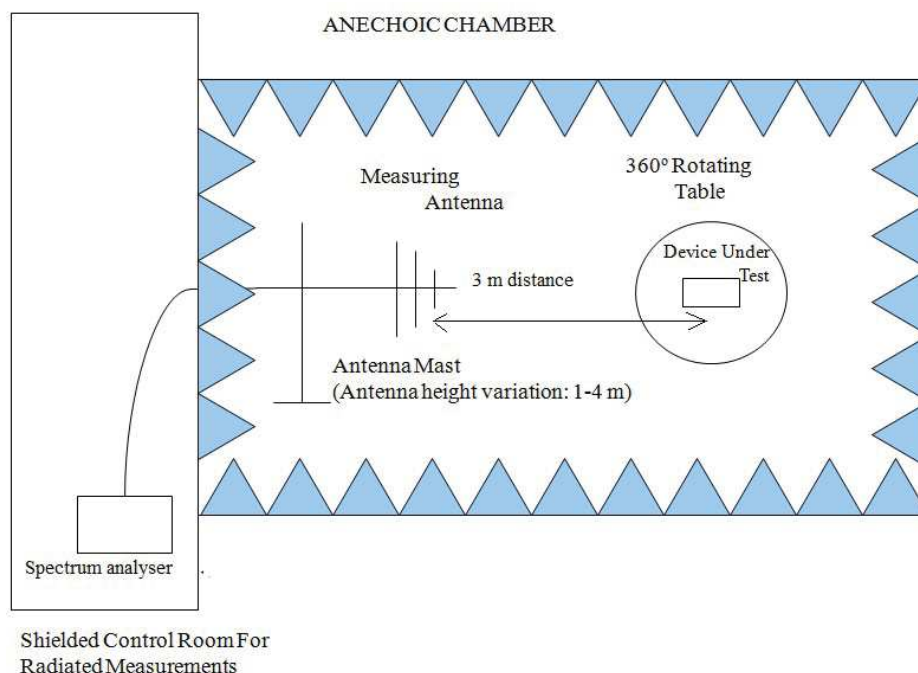
For radiated emissions in the range 17 GHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The EUT was placed at a height of 80 cm above the reference ground plane in the center of the chamber turntable to perform the measurements below 1GHz and the EUT was placed at a height of 1.5 meters above the test chamber floor in the center of the chamber turntable to perform the measurements above 1GHz. It was also rotated 360° and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

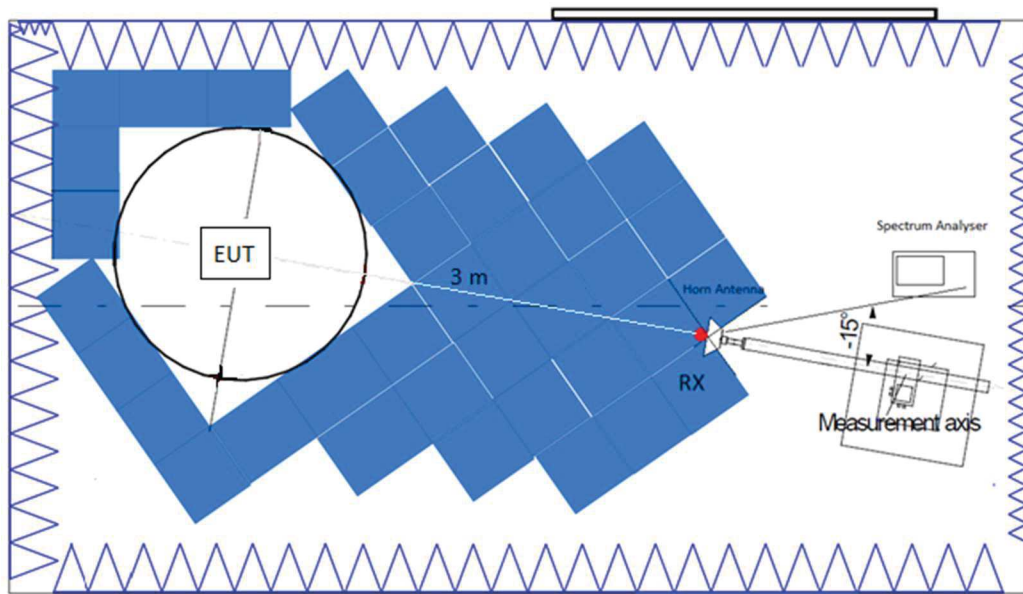
Measurements were made in both horizontal and vertical planes of polarization.

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

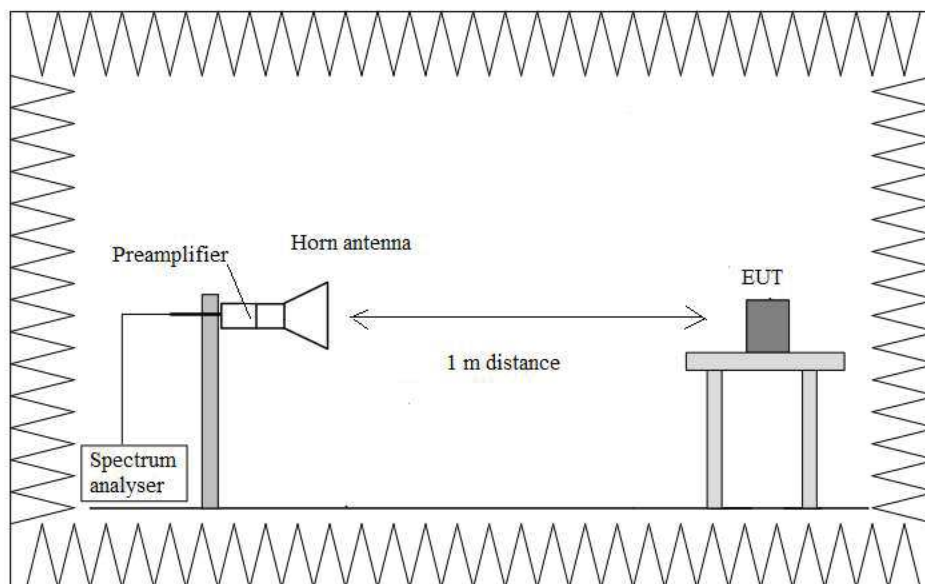
Radiated measurements setup $f < 1$ GHz



Radiated measurements setup $f > 1$ GHz up to 17 GHz.



Radiated measurements setup $f > 17$ GHz up to 40 GHz.



FCC 15.407 (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 Mbps
- 802.11n HT20: MCS0
- 802.11ac VHT40: MCS0
- 802.11ac VHT80: MCS0

SISO CORE-0_Port3

Mode 802.11 a20

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
6 dB Bandwidth (MHz)	16.329	16.335	16.349
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)	17.563	17.579	17.575
Measurement uncertainty (kHz)	<±19.25		

Mode 802.11 ac40 (VHT40)

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
6 dB Bandwidth (MHz)	35.813	35.863
Measurement uncertainty (kHz)	<±53.05	

Mode 802.11 ac80 (VHT80)

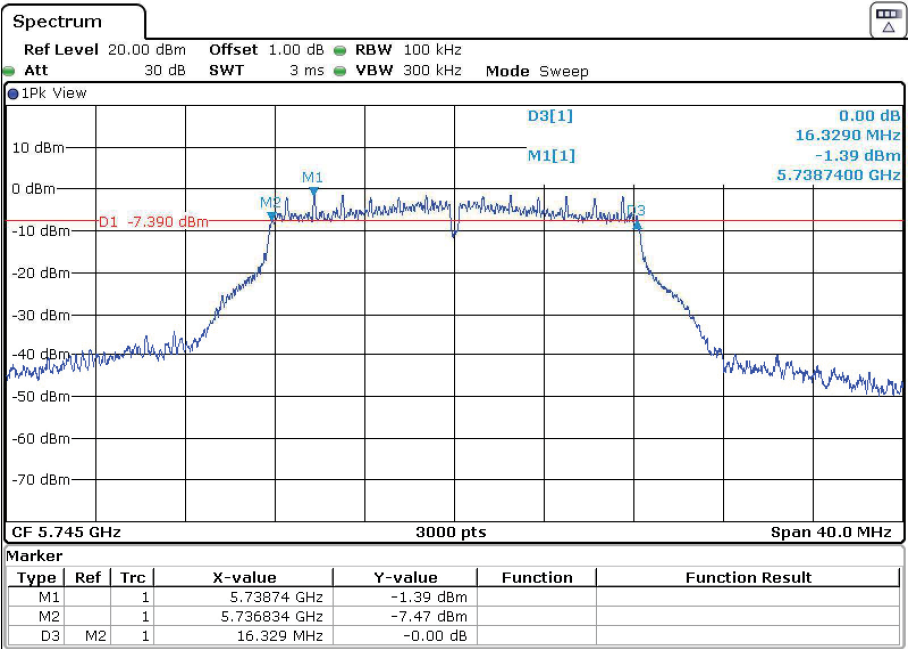
	Single Channel 155 (5775 MHz)
6 dB bandwidth (MHz)	75.744
Measurement uncertainty (kHz)	<±42.35

Verdict: PASS

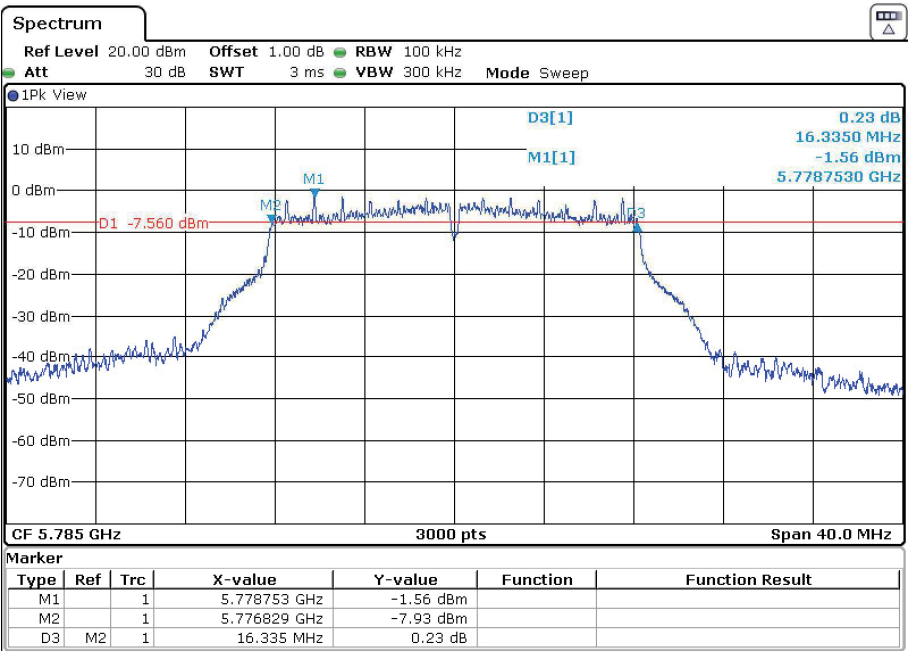
SISO CORE-0_Port3

Mode 802.11 a20

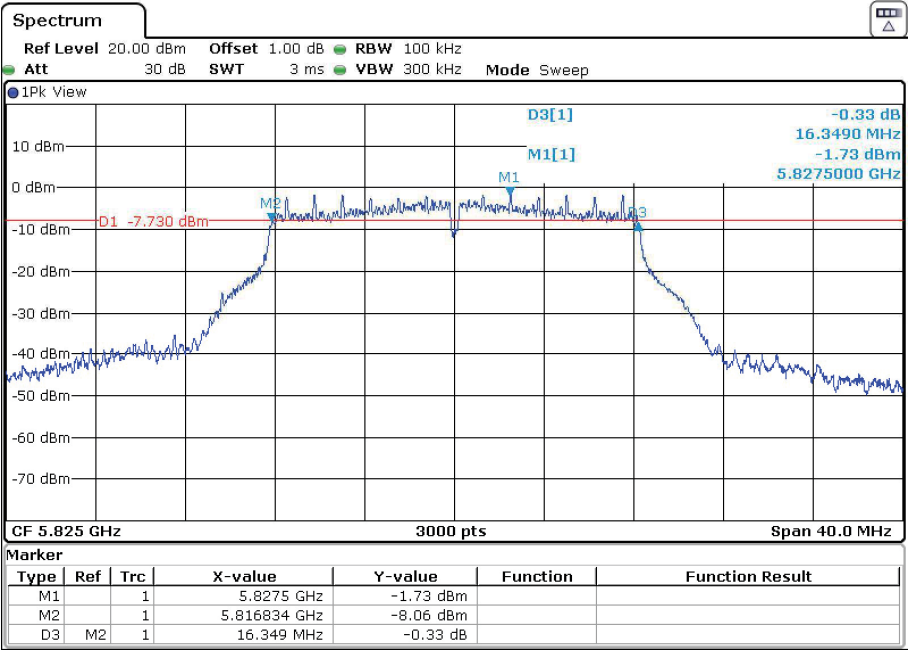
- Low Channel 149:



- Middle Channel 157:

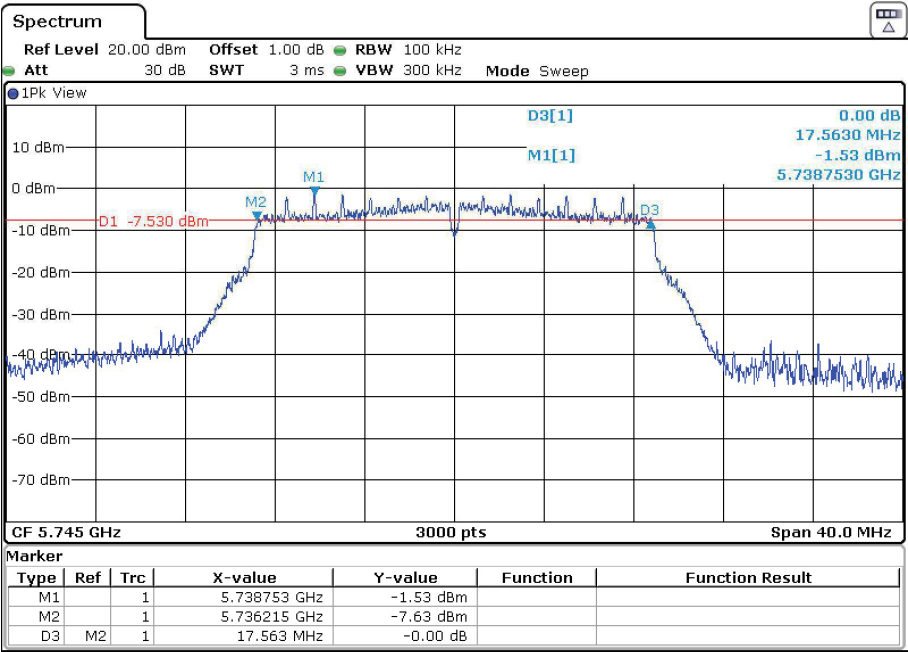


- High Channel 165:

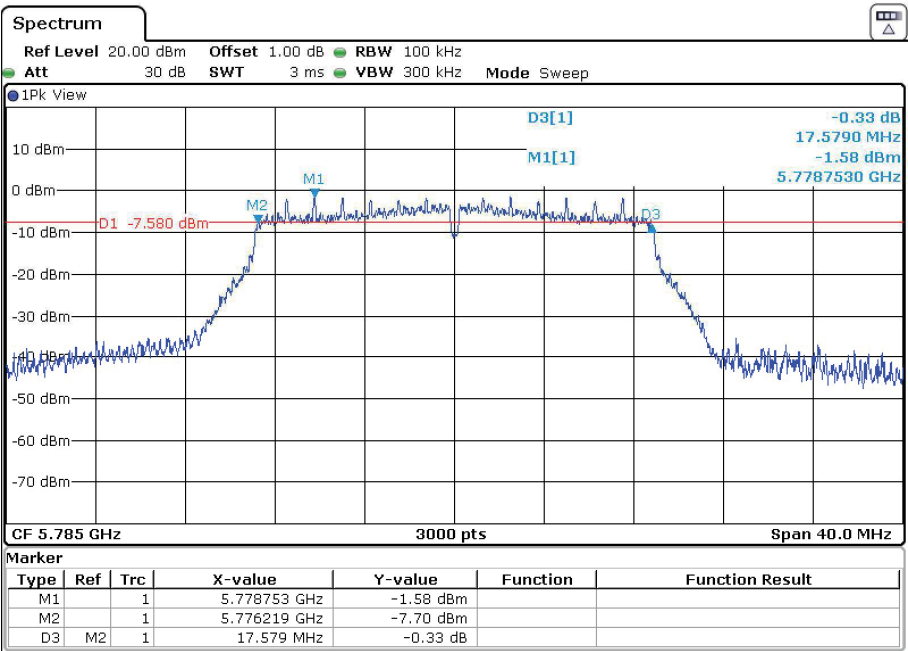


Mode 802.11 n20 (HT20)

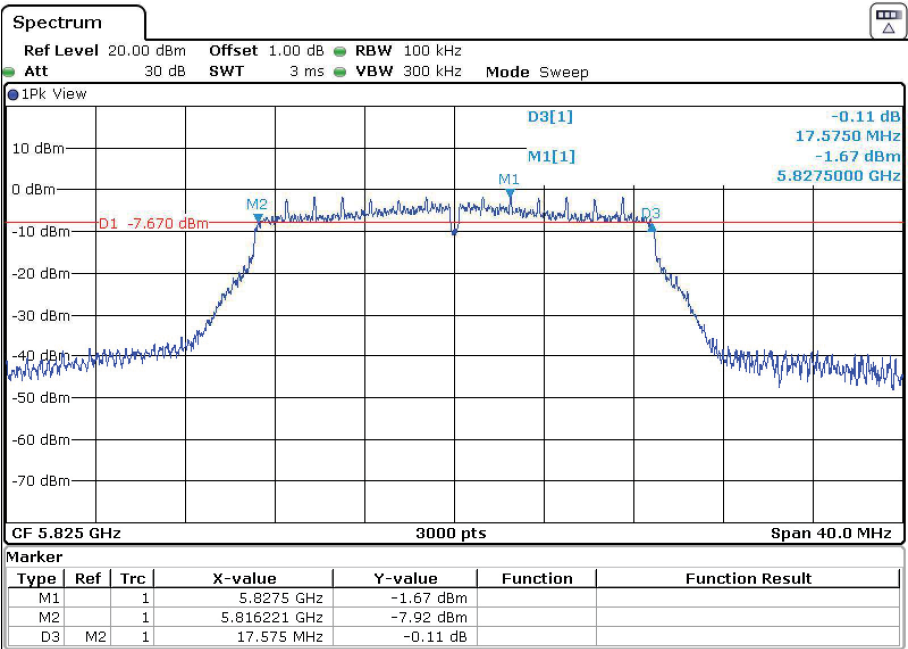
- Low Channel 149:



- Middle Channel 157:

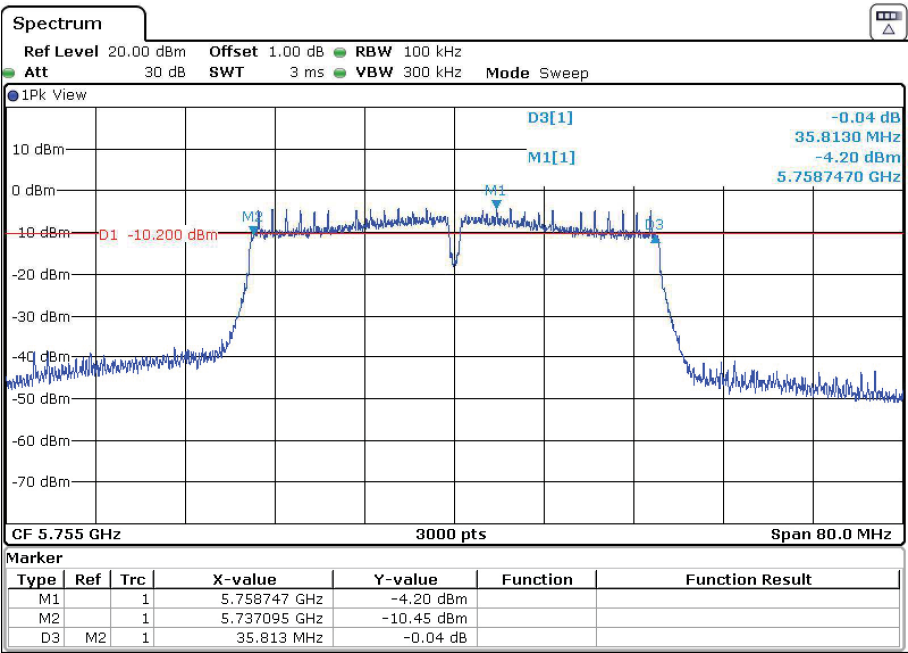


- High Channel 165:

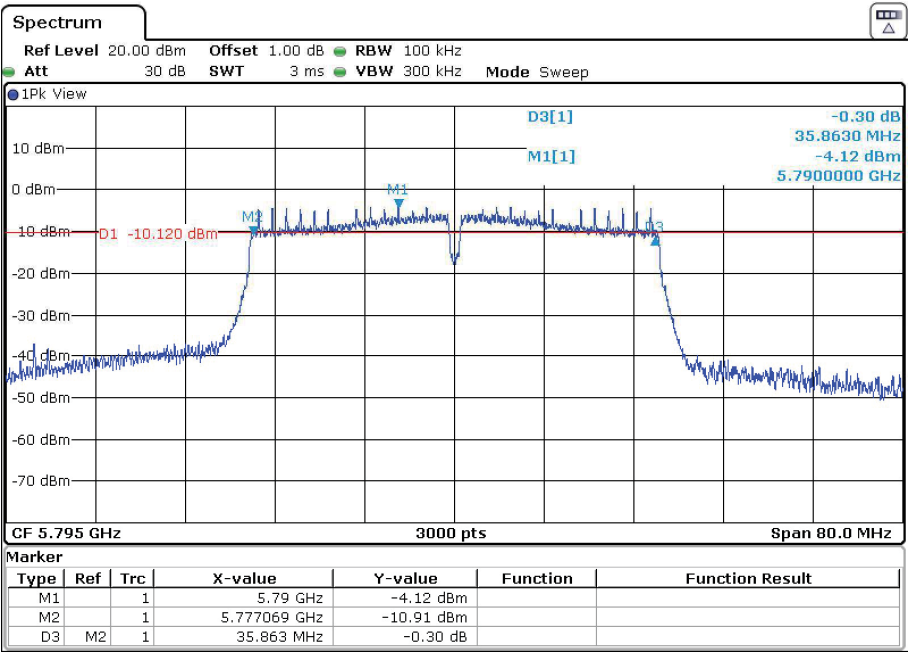


Mode 802.11 ac40 (VHT40)

- Low Channel 151:

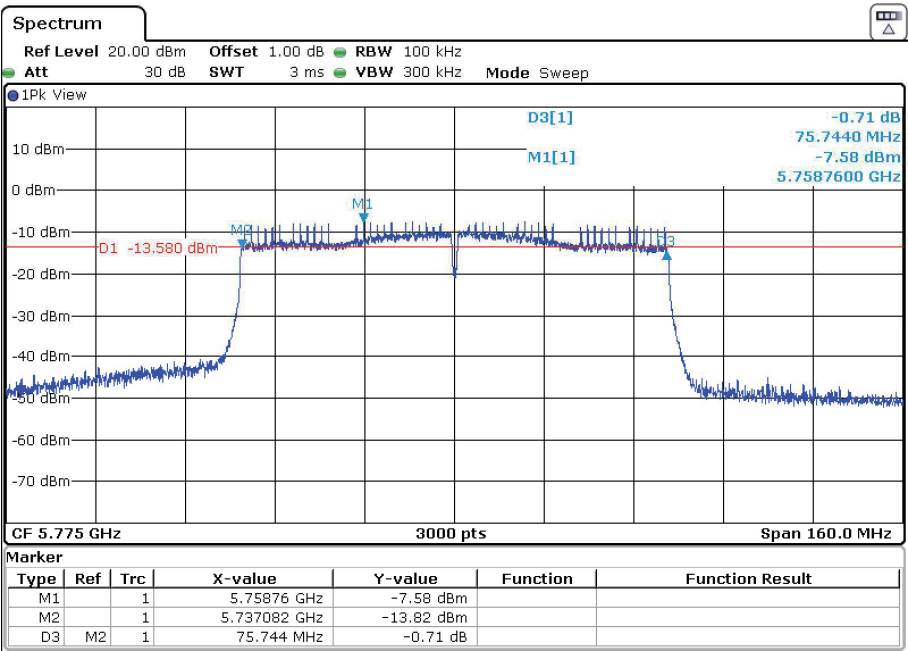


- High Channel 159:



Mode 802.11 ac80 (VHT80)

- Single Channel 155:



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

SPECIFICATION:

FCC 15.407 / RSS-247: For the band 5.725-5.850 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W (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.

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

Preliminary tests determined the SISO worst case is CORE-0_Port3 Antenna.

- SISO – CORE-0_Port3 Antenna – Declared Maximum Antenna Gain: +2.5 dBi

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

SISO – CORE-0_Port3 Antenna:

Mode 802.11 a20

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
Max. Conducted Power (dBm)	9.42	9.15	9.26
Duty Cycle Correction Factor (dB)	1.018		
Max. Conducted Power Corrected (dBm)	10.438	10.168	10.278
Measurement uncertainty (dB)	<±2.57		

Mode 802.11 n20 (HT20)

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
Max. Conducted Power (dBm)	9.08	9.07	9.13
Duty Cycle Correction Factor (dB)	1.060		
Max. Conducted Power Corrected (dBm)	10.140	10.130	10.190
Measurement uncertainty (dB)	<±2.57		

Mode 802.11 ac40 (VHT40)

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
Max. Conducted Power (dBm)	8.11	8.06
Duty Cycle Correction Factor (dB)	1.968	
Max. Conducted Power Corrected (dBm)	10.078	10.028
Measurement uncertainty (dB)	<±2.57	

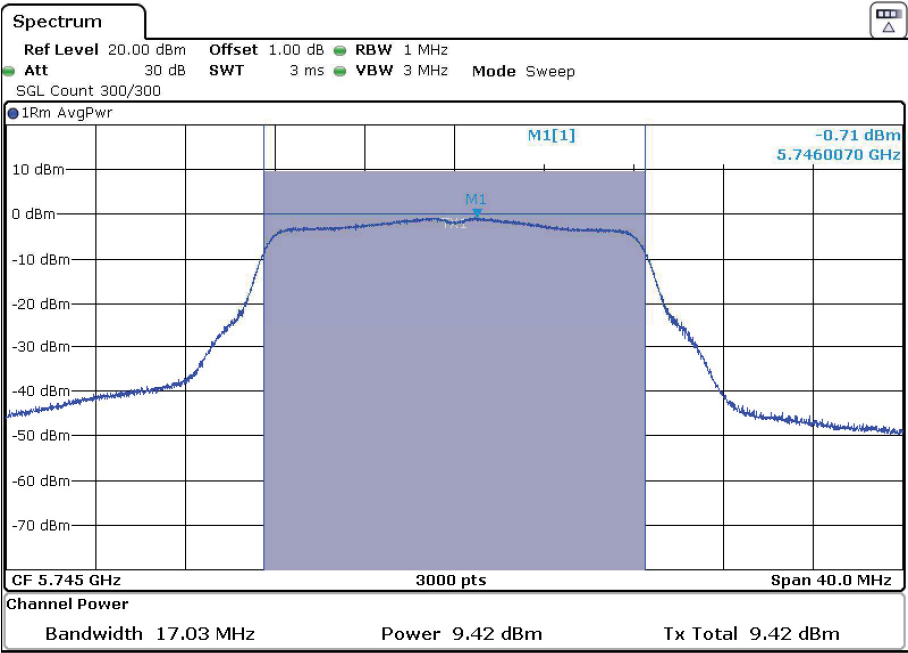
Mode 802.11 ac80 (VHT80)

	Single Channel 155 (5775 MHz)
Max. Conducted Power (dBm)	6.31
Duty Cycle Correction Factor (dB)	3.415
Max. Conducted Power Corrected (dBm)	9.725
Measurement uncertainty (dB)	<±2.57

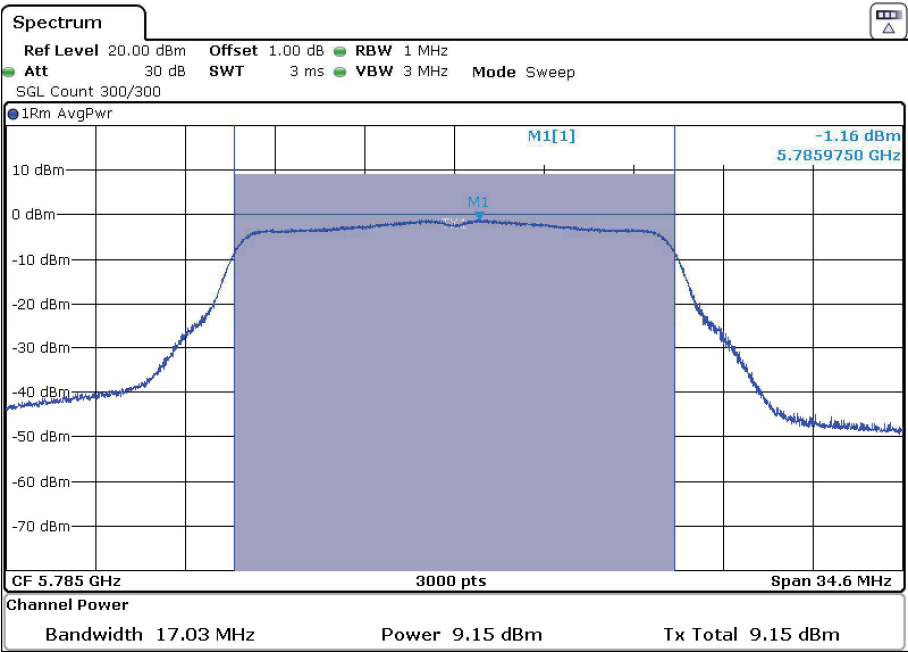
Verdict: PASS

Mode 802.11 a20

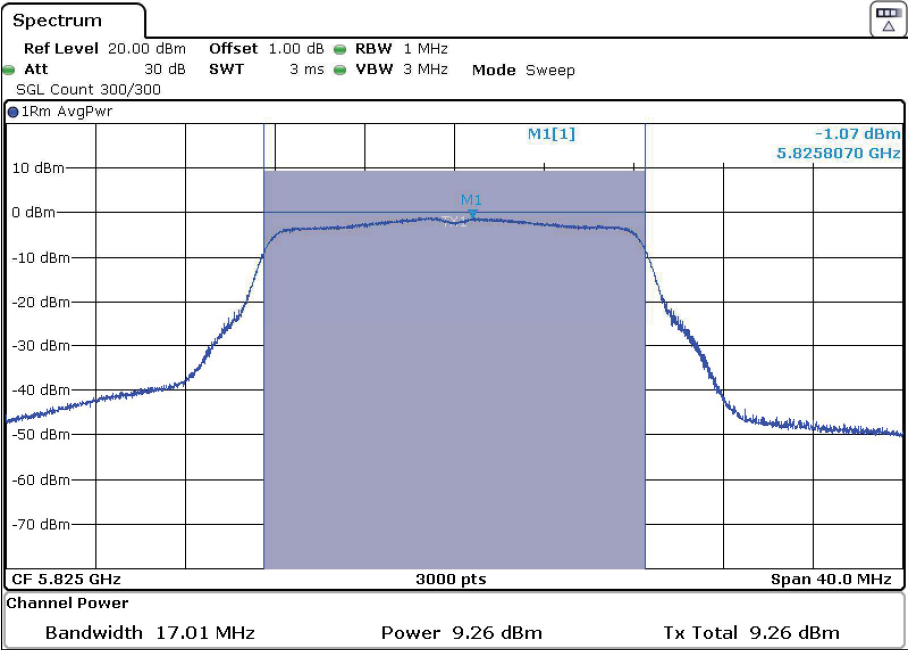
- Low Channel 149:



- Middle Channel 157:

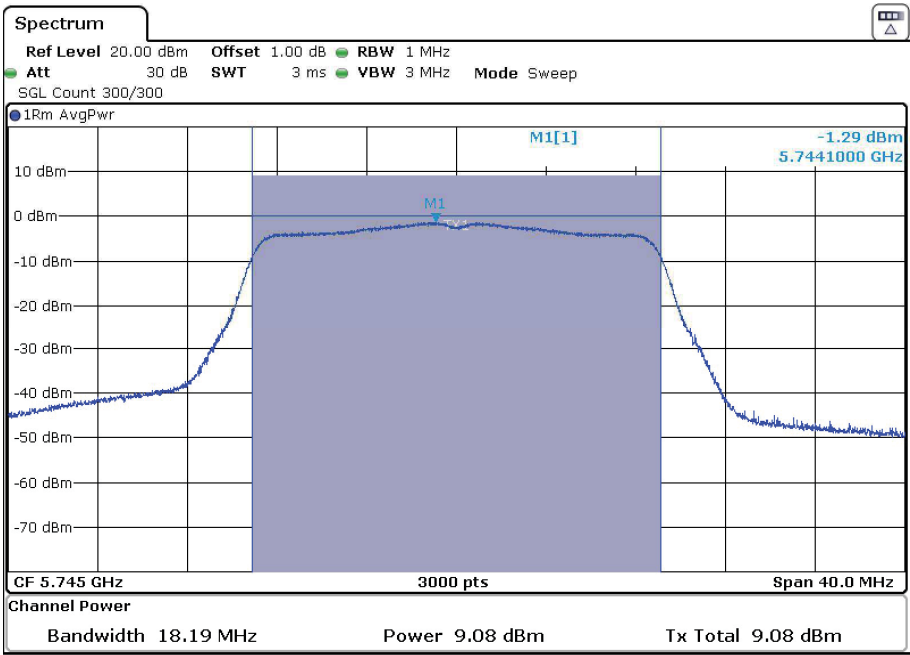


- High Channel 165:

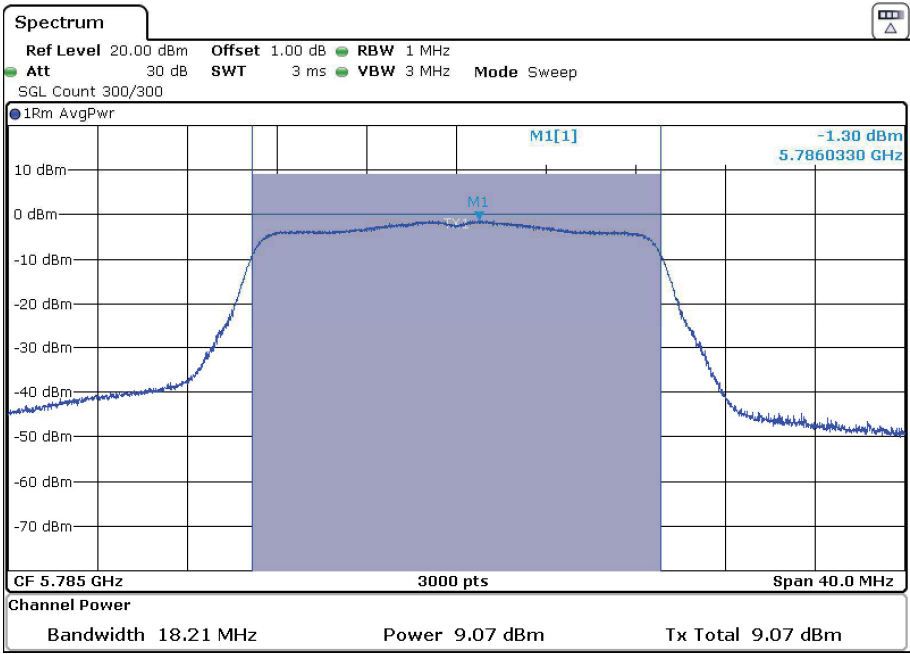


Mode 802.11 n20 (HT20)

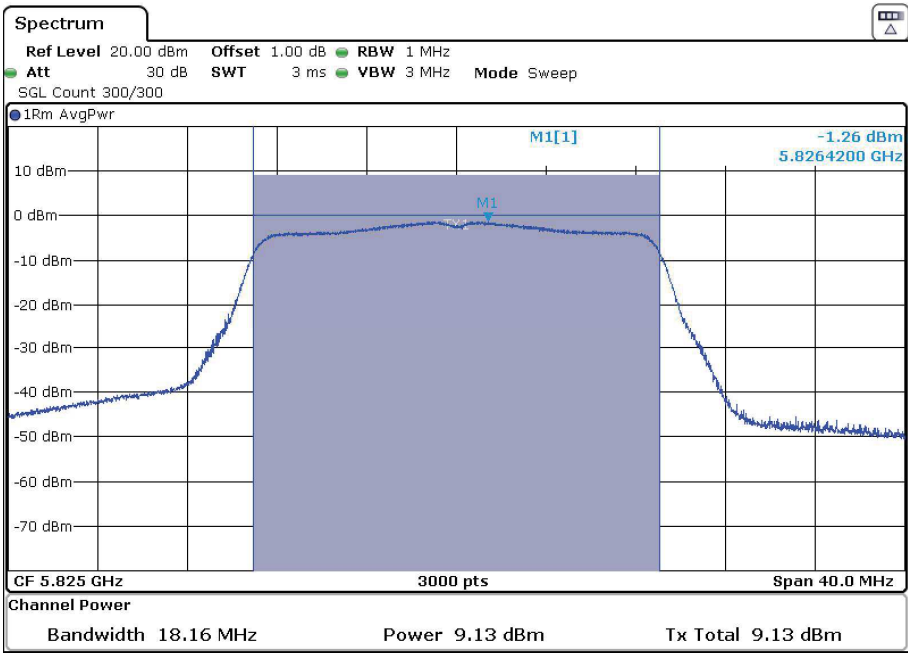
- Low Channel 149:



- Middle Channel 157:

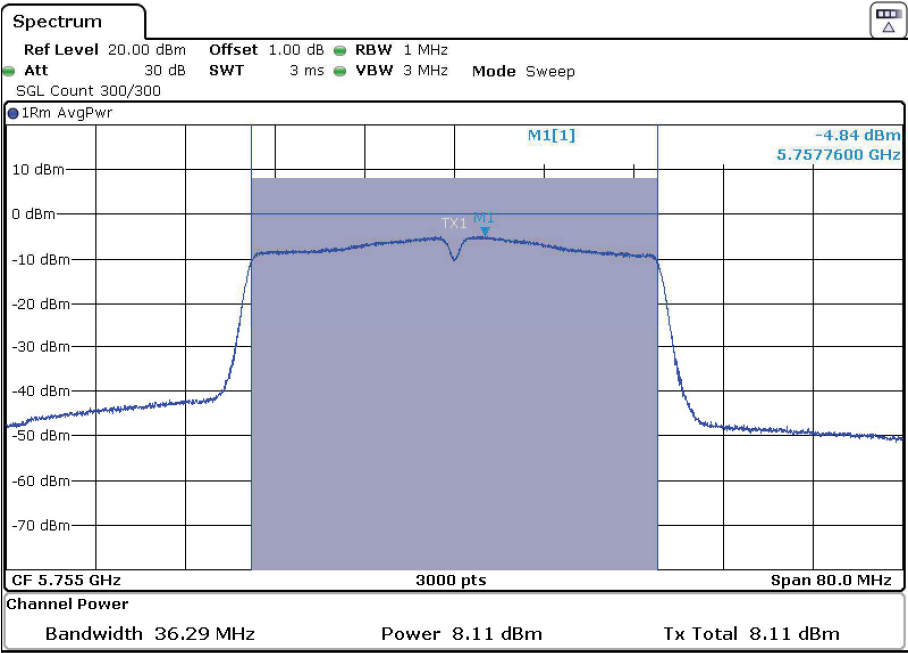


- High Channel 165:

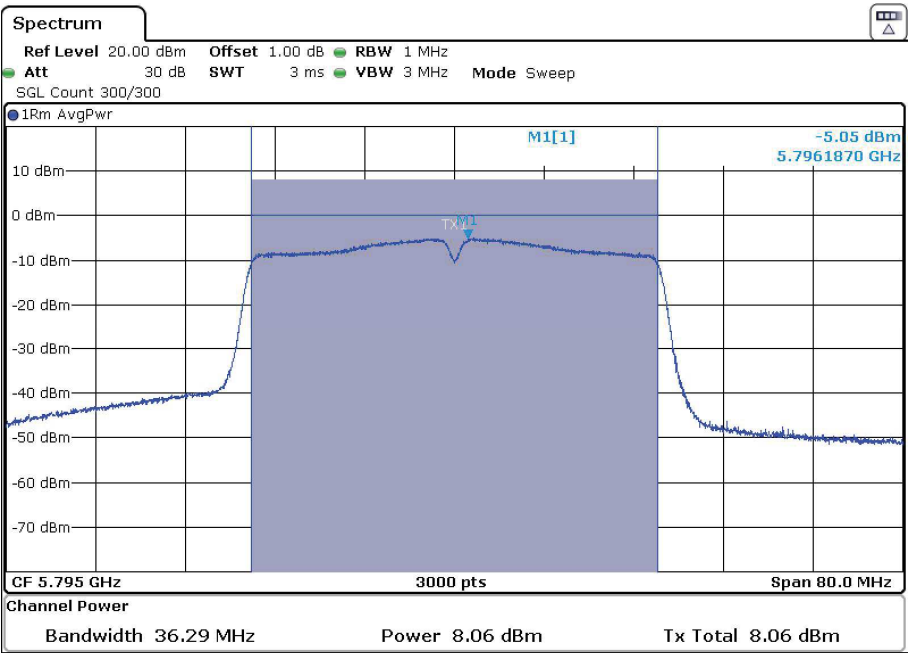


Mode 802.11 ac40 (VHT40)

- Low Channel 151:

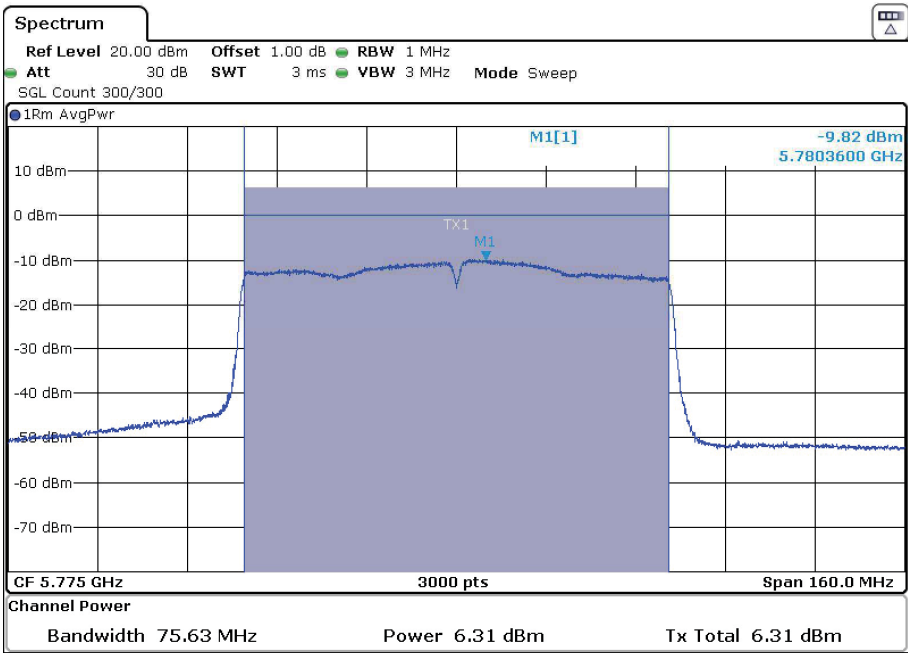


- High Channel 159:



Mode 802.11 ac80 (VHT80)

- Single Channel 155:



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

SPECIFICATION:

FCC 15.407 / RSS-247: 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 as the transmitter maximum conducted output power test. The result of the Peak PSD was measured by collocation a meter on the peak of the signal and the results are in the tables below.

SISO – CORE-0_Port3 – Antenna:

Mode 802.11 a20

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
Maximum Average PSD (dBm/MHz)	-0.71	-1.16	-1.07
Duty Cycle Correction Factor (dB)	1.018		
Maximum Average PSD Corrected (dBm/MHz)	0.308	-0.142	-0.052
Measurement uncertainty (dB)	<±2.57		

Mode 802.11 n20 (HT20)

	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
Maximum Average PSD (dBm/MHz)	-1.29	-1.30	-1.26
Duty Cycle Correction Factor (dB)	1.060		
Maximum Average PSD Corrected (dBm/MHz)	-0.23	-0.24	-0.20
Measurement uncertainty (dB)	<±2.57		

Mode 802.11 ac40 (VHT40)

	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
Maximum Average PSD (dBm/MHz)	-4.84	-5.05
Duty Cycle Correction Factor (dB)	1.968	
Maximum Average PSD Corrected (dBm/MHz)	-2.872	-3.082
Measurement uncertainty (dB)	<±2.57	

Mode 802.11 ac80 (VHT80)

	Low Channel 155 (5775 MHz)
Maximum Average PSD (dBm/MHz)	-9.82
Duty Cycle Correction Factor (dB)	3.415
Maximum Average PSD Corrected (dBm/MHz)	-6.406
Measurement uncertainty (dB)	<±2.57

Verdict: PASS

FCC Section 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 17 – 40 GHz and a distance of 3m for frequency range 30 MHz – 17 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.

Test performed on the following worst case: 802.11n20: MCS0. The worst case was determined by measuring the eirp density (radiated).

SISO – CORE-0_Port3 Antenna:

Frequency range 30 MHz - 1 GHz

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

Spurious frequencies operating (radiated) detected at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dB μ V/m)	Polarization	Detector	Measurement Uncertainty (dB)
31.9400	18.01	V	Quasi-Peak	± 4.99
67.0055	19.70	V	Quasi-Peak	± 4.99
500.0135	31.07	V	Quasi-Peak	± 4.99
781.1680	23.72	V	Quasi-Peak	± 4.99

Frequency range 1 - 40 GHz

The results in the next tables show the maximum measured levels in the 1-40 GHz range including the 5.650 - 5.725 GHz and 5.850 - 5.925 GHz adjacent bands (see following plots).

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

OUT OF BAND EMISSIONS: For outside emissions of the band 5.65 - 5.925 GHz only the OFDM worst mode case determined after preliminary measurements was tested in the Low, Middle and High Channels.

BAND EDGES EMISSIONS: For band edge emissions of the band 5.65 – 5.725 and 5.850 - 5.925 GHz all modes were tested in the Low Middle and High Channels.

• **Mode 802.11 n20** (worst mode case)

OUT OF BAND EMISSIONS. Spurious emissions out of the band 5.65 - 5.925 GHz:

- Low Channel:

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.5624	45.52	H	Peak	± 4.98
11.4900	58.25	V	Peak	± 4.98
	43.29		Average	

- Middle Channel:

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.5974	41.89	H	Peak	± 4.98
11.5734	59.83	V	Peak	± 4.98
	43.78		Average	

- High Channel:

Spurious frequency (GHz)	Emission Level (dBμV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.5986	51.55	H	Peak	± 4.98
11.6509	57.08	V	Peak	± 4.98
	41.82		Average	

Verdict: PASS

BAND EDGES EMISSIONS. Spurious band edge emissions within 5.65 – 5.725 and 5.850 - 5.925 GHz:

- Low Channel 149 (5745 MHz): Inside band 5.65-5.68 GHz.

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

- Middle Channel 157 (5785 MHz): Inside band 5.898-5.925 GHz.

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

- High Channel 165 (5825 MHz): Inside band 5.898-5.925 GHz.

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

- **Mode 802.11 a20 (HT20)**

BAND EDGES EMISSIONS. Spurious band edge emissions within 5.65 - 5.925 GHz:

- Low Channel 149 (5745 MHz): Inside band 5.65-5.68 GHz.

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

- Middle Channel 157 (5785 MHz): Inside band 5.898-5.925 GHz.

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

- High Channel 165 (5825 MHz): Inside band 5.898-5.925 GHz.

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

- **Mode 802.11 ac20 (VHT20)**

BAND EDGES EMISSIONS. Spurious band edge emissions within 5.65 - 5.925 GHz:

- Low Channel 149 (5745 MHz): Inside band 5.65-5.68 GHz.

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

- Middle Channel 157 (5785 MHz): Inside band 5.898-5.925 GHz.

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

- High Channel 165 (5825 MHz): Inside band 5.898-5.925 GHz.

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

- **Mode 802.11 n40 (HT40)**

BAND EDGES EMISSIONS. Spurious band edge emissions within 5.65 - 5.925 GHz:

- Low Channel 151 (5755 MHz): Inside band 5.65-5.68 GHz.

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

- High Channel 159 (5795 MHz): Inside band 5.898-5.925 GHz.

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

- **Mode 802.11 ac40 (VHT40)**

BAND EDGES EMISSIONS. Spurious band edge emissions within 5.65 - 5.925 GHz:

- Low Channel 151 (5755 MHz): Inside band 5.65-5.68 GHz.

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

- High Channel 159 (5795 MHz): Inside band 5.898-5.925 GHz.

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

- **Mode 802.11 ac80 (VHT80)**

BAND EDGES EMISSIONS. Spurious band edge emissions within 5.65 - 5.925 GHz:

- Single Channel 155 (5775 MHz): Inside band 5.65-5.68 GHz and 5.898-5.925 GHz.

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

Verdict: PASS