Appendix C: Test result for 5.725GHz – 5.850GHz.

INDEX

TEST CONDITIONS

Power supply (V):

Vnominal = 12.6 Vdc

Type of power supply = External power supply (Battery).

Type of antenna: External antenna.

Declared Gain for WLAN0-Core 0 Antenna RF Port 3 (maximum):

G = + 0.9dBi

Technology Tested:	WLAN (IEEE 802.11 a,n,ac) / U-NII	
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:	WLAN0-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 ANSI C63.10: 2013 and FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01 dated 12/14/2017 and FCC KBD 662911 D01 Multiple Transmitter Output v02r01 dated 10/31/2013.

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:

- 802.11a: 6 Mbit/s / SISO on WLAN0-Core 0 – Antenna RF Port 3
- 802.11n HT20: MCS0 / SISO WLAN0-Core 0 – Antenna RF Port 3
- 802.11n HT40: MCS0 / SISO on WLAN0-Core 0 – Antenna RF Port 3
- 802.11ac VHT80: MCS0x1 / SISO on WLAN0-Core 0 – Antenna RF Port 3

It was necessary to change between CORE 0 with Antenna Port 3.

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

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

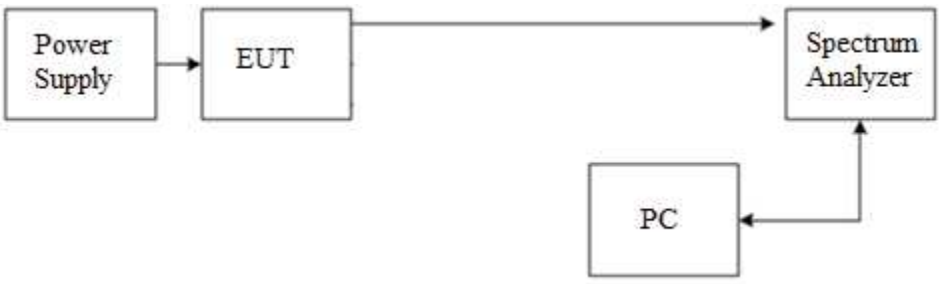
ac80 - Core0

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 is situated at a distance of 1 m for the frequency range 1 GHz-40 GHz (1 GHz-18 GHz Double ridge horn antenna and 18 GHz-40 GHz horn antenna).

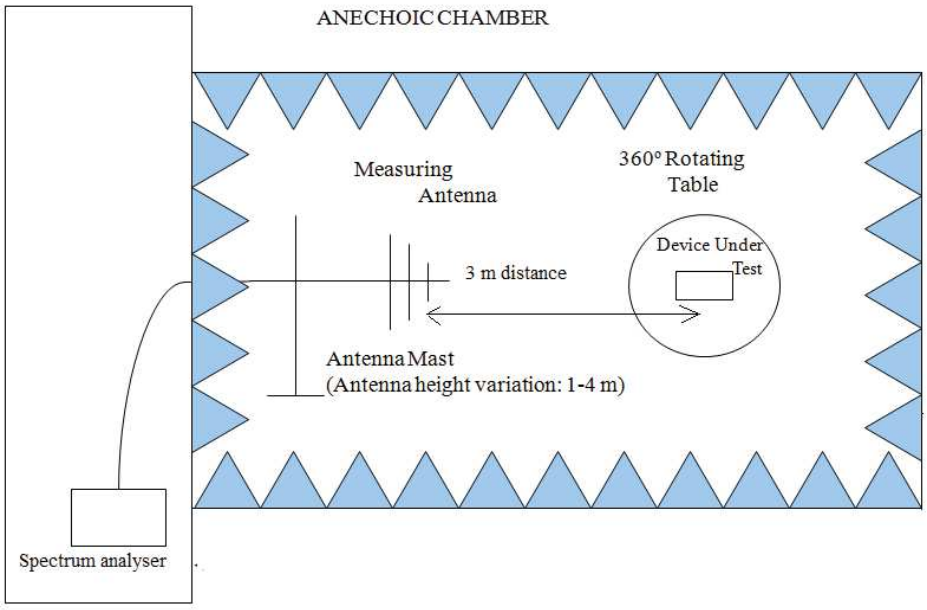
For radiated emissions in the range 1 GHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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 360º 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.

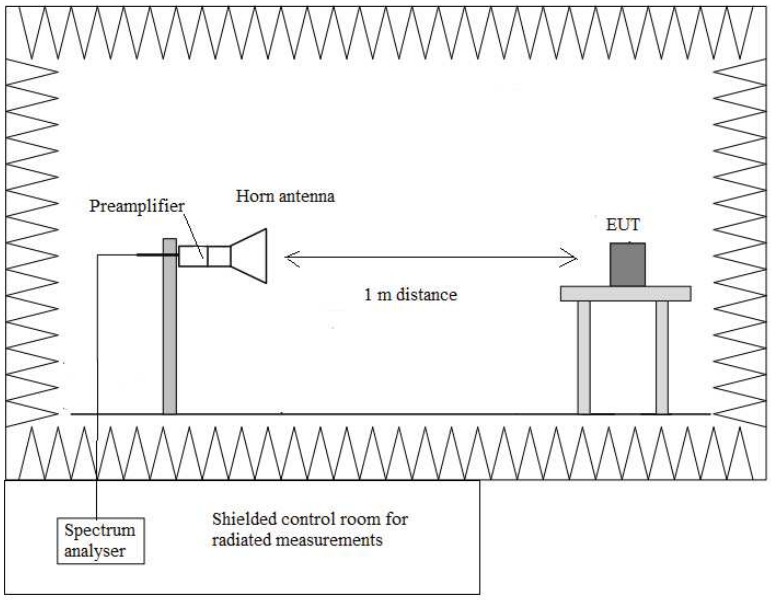
The final measured value, for the given emission, in the tables below incorporates the calibrated antenna factor and cable loss.

Radiated measurements setup f < 1 GHz

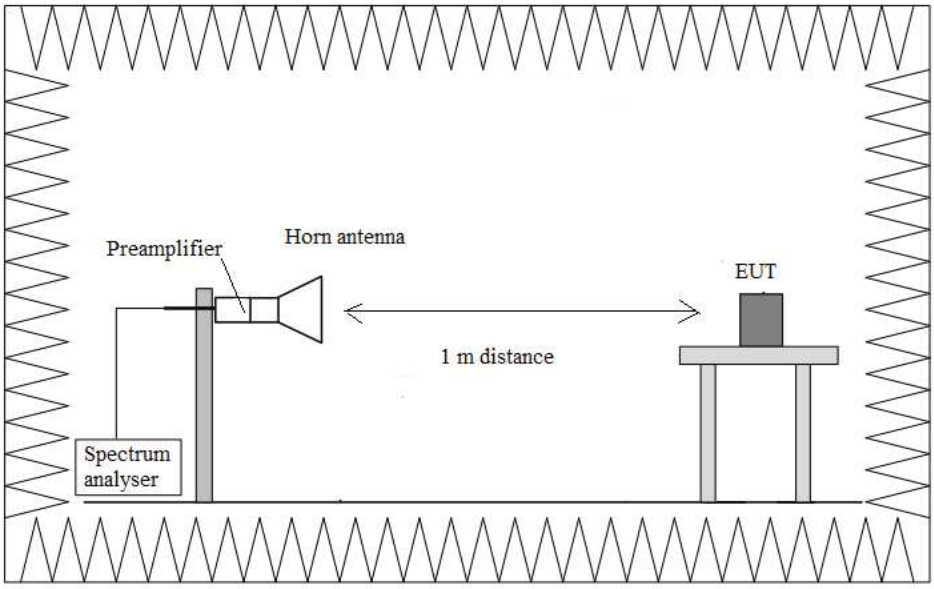


Shielded Control Room For Radiated Measurements

Radiated measurements setup f > 1 GHz up to 18 GHz.



Radiated measurements setup f > 18 GHz up to 40 GHz.



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

SPECIFICATION

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

RESULTS:

6 dB Bandwidth (see next plots).

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

- 802.11a: 6 Mbit/s / SISO on WLAN0-Core 0 – Antenna RF Port 3
- 802.11n HT20: MCS0 / SISO on WLAN0-Core 0 – Antenna RF Port 3
- 802.11n HT40: MCS0 / SISO on WLAN0-Core 0 – Antenna RF Port 3
- 802.11ac VHT80: MCS0 / SISO on WLAN0-Core 0 – Antenna RF Port 3

Mode : 802.11a - 20MHz

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
6 dB bandwidth (MHz)	16.33	16.33	16.26
Measurement uncertainty (kHz)	<±23.02		

Mode : 802.11n HT20 - 20MHz

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
6 dB bandwidth (MHz)	17.53	17.56	17.58
Measurement uncertainty (kHz)	<±23.02		

Mode : 802.11n HT40 - 40MHz

	Channel 151 5755 MHz	Channel 159 5795 MHz
6 dB bandwidth (MHz)	35.79	36.08
Measurement uncertainty (kHz)	<±53.05	

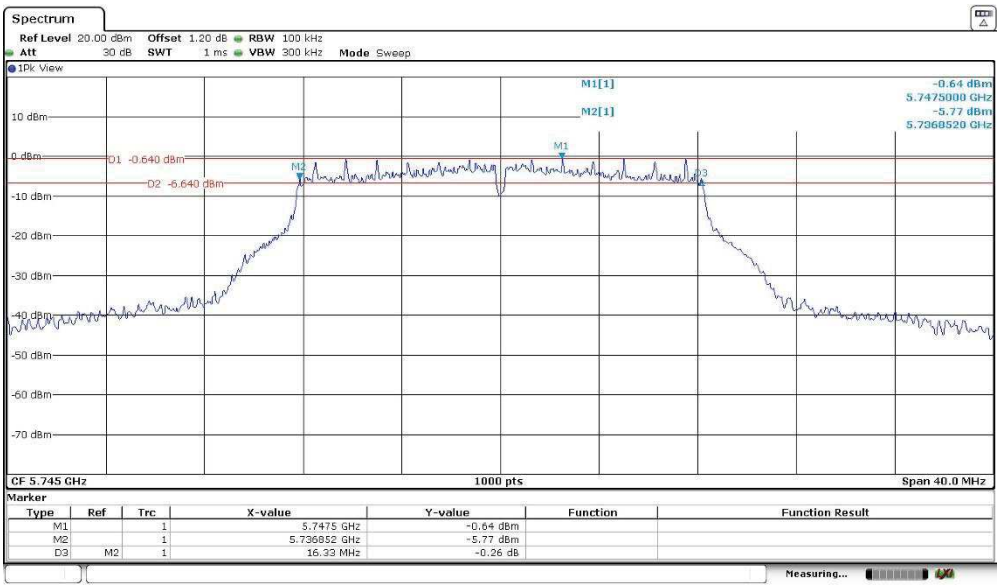
Mode : 802.11ac VHT80 - 80MHz

	Channel 155 5775 MHz
6 dB bandwidth (MHz)	75.64
Measurement uncertainty (kHz)	<±103.10

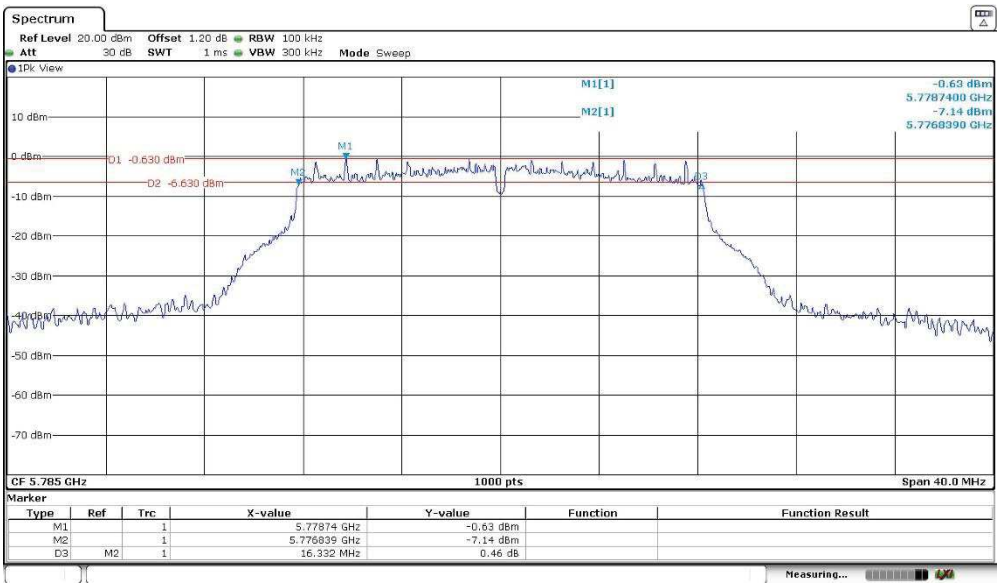
Verdict: PASS

Mode: 802.11a - 20MHz

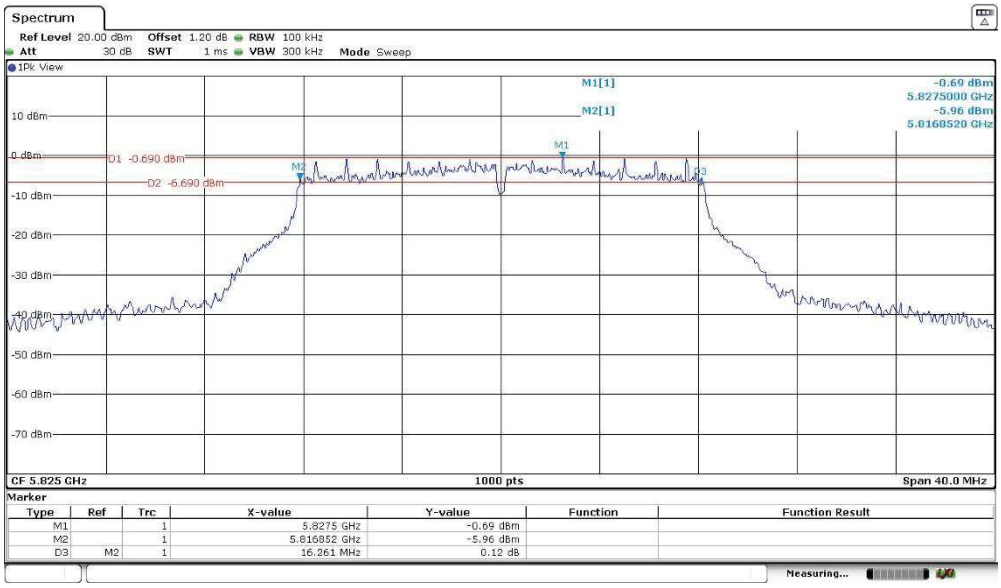
Channel 149



Channel 157

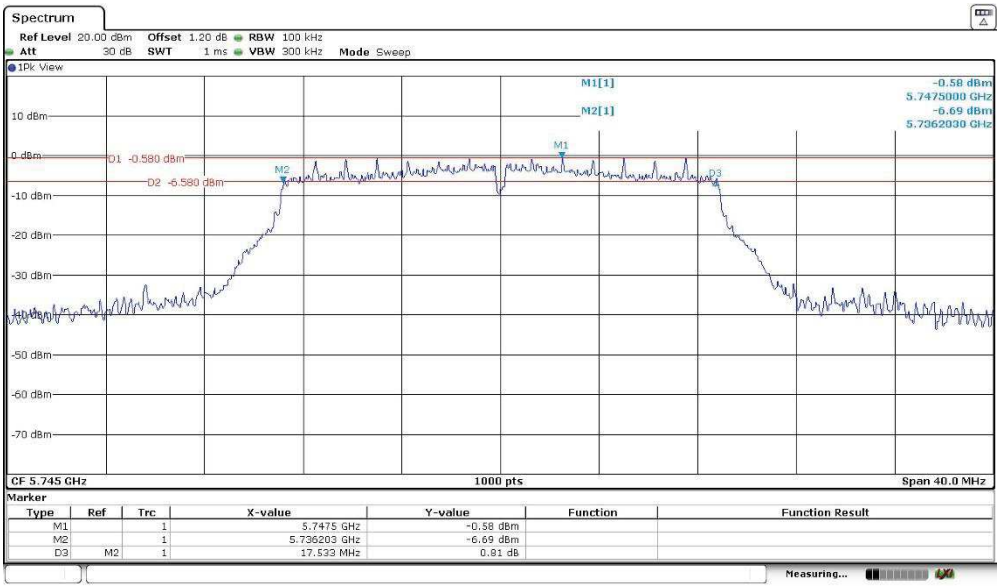


Channel 165

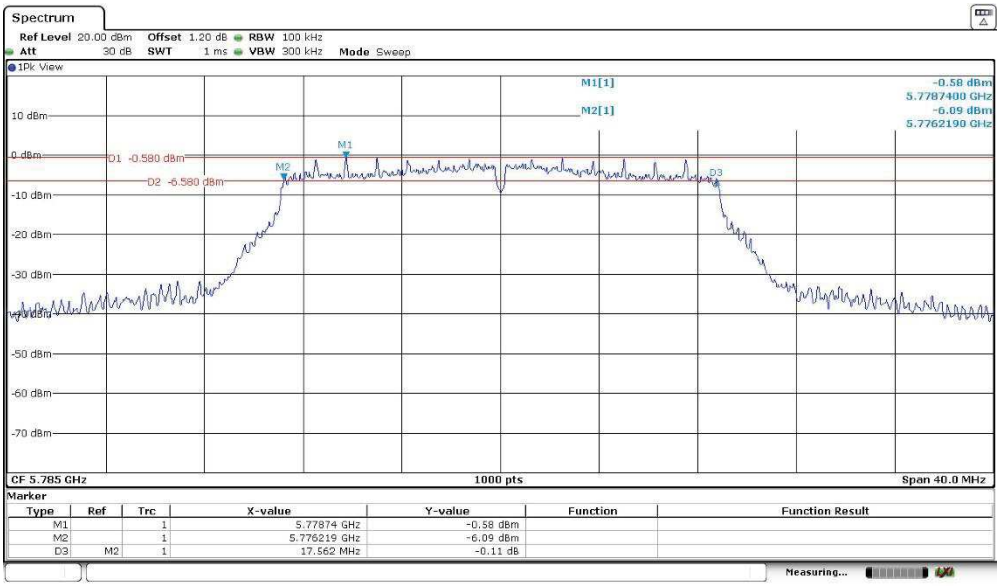


Mode: 802.11n HT20 - 20MHz

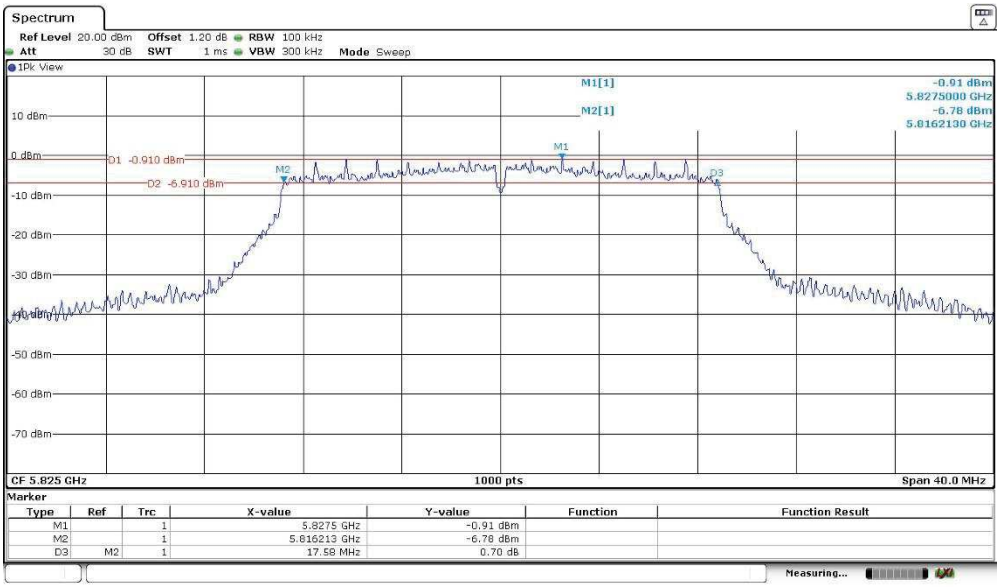
Channel 149



Channel 157

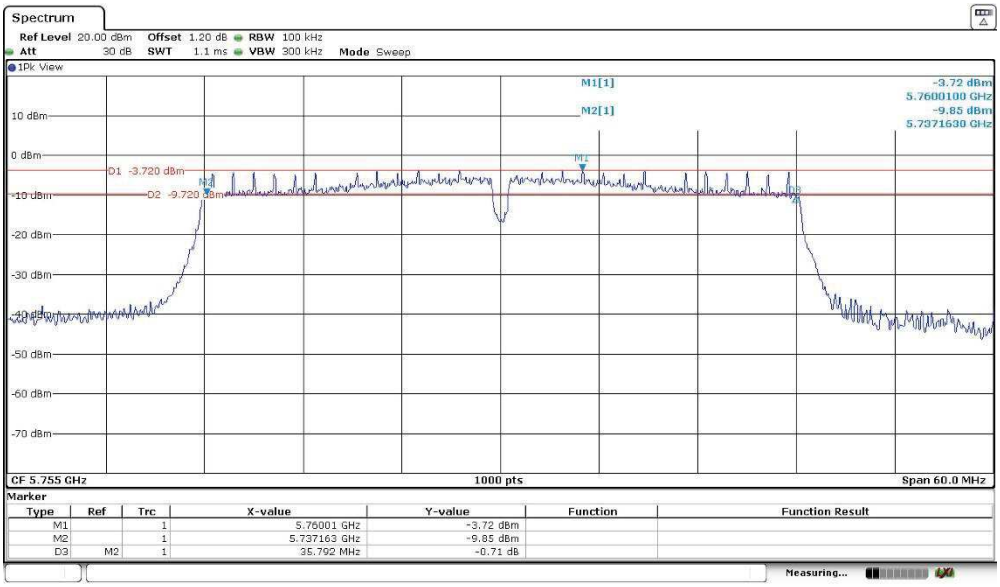


Channel 165

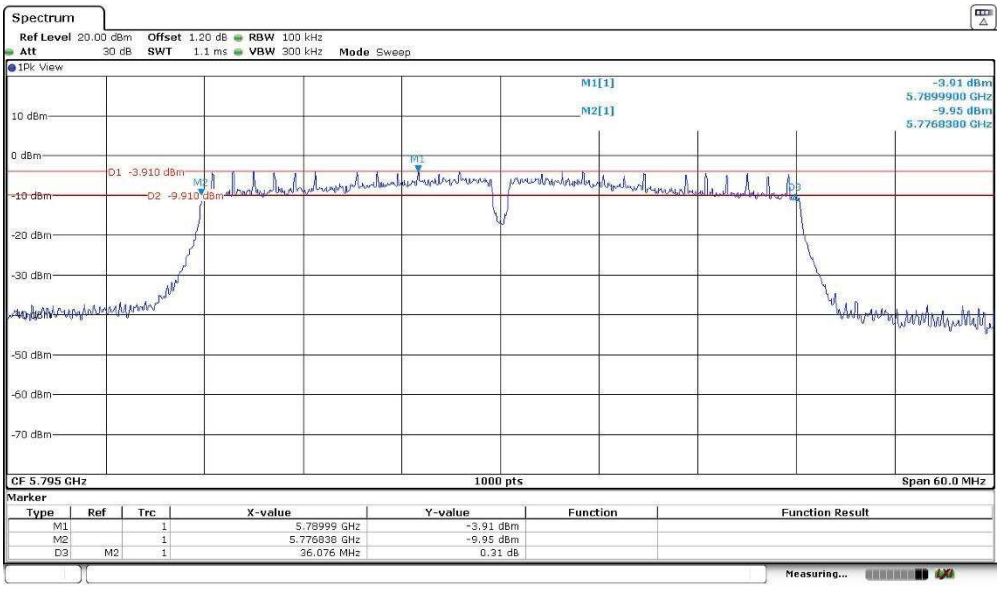


Mode: 802.11n HT40 - 40MHz

Channel 151

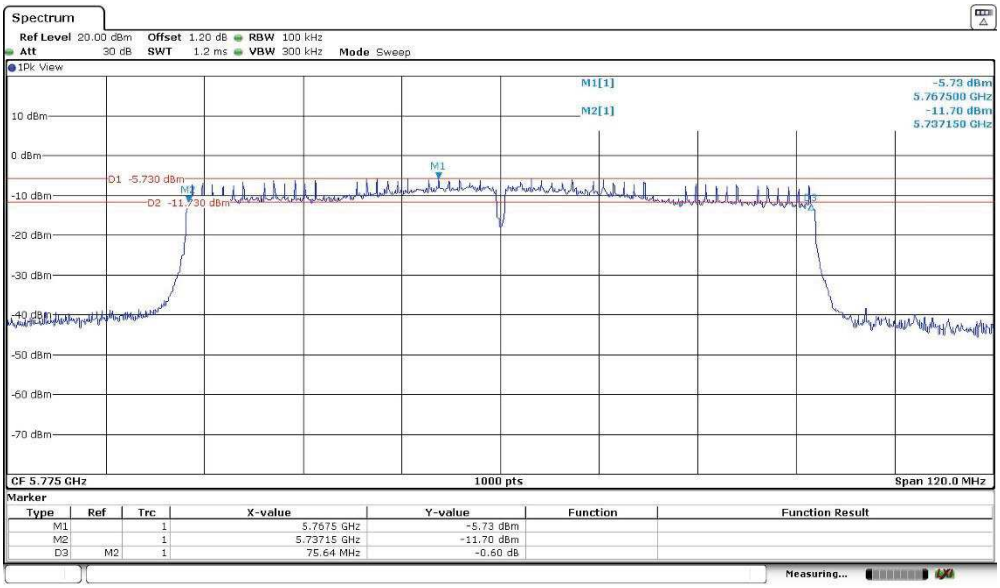


Channel 159



Mode: 802.11ac VHT80 - 80MHz

Channel 155



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

SPECIFICATION

FCC 15.407/ RSS-247: For the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W (30 dBm). In addition, 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 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 SISO modes of operation, the antenna gain is less than 6dBi.

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

FCC and Canada power setting

Mode: 802.11a - 20MHz

Declared antenna gain: +0.9 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
Max. conducted power (dBm)	9.27	9.94	9.30
Duty Cycle Correction Factor (dB)	0.96		
Max. conducted power corrected (dBm)	10.23	10.90	10.26
Maximum EIRP power (dBm)	11.13	11.80	11.16
Measurement uncertainty (dB)	<±1.20		

Mode: 802.11n HT20 - 20MHz

Declared antenna gain: +0.9 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
Max. conducted power (dBm)	9.48	9.86	9.21
Duty Cycle Correction Factor (dB)	1.03		
Max. conducted power corrected (dBm)	10.51	10.89	10.24
Maximum EIRP power (dBm)	11.41	11.79	11.14
Measurement uncertainty (dB)	<±1.20		

Mode: 802.11n HT40 - 40MHz

Declared antenna gain: +0.9 dBi

	Channel 151 5755 MHz	Channel 159 5795 MHz
Max. conducted power (dBm)	8.25	8.42
Duty Cycle Correction Factor (dB)	1.88	
Max. conducted power corrected (dBm)	10.13	10.30
Maximum EIRP power (dBm)	11.03	11.20
Measurement uncertainty (dB)	<±1.20	

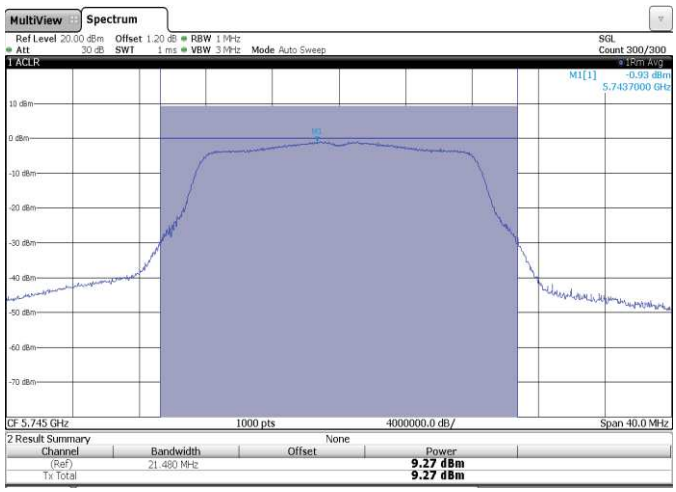
Mode : 802.11ac VHT80 - 80MHz

Declared antenna gain: +0.9 dBi

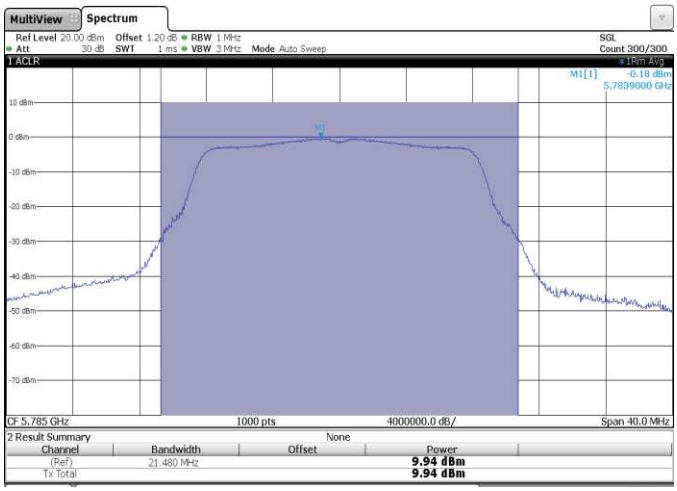
	channel 155 5775 MHz
Max. conducted power (dBm)	7.46
Duty Cycle Correction Factor (dB)	3.18
Max. conducted power corrected (dBm)	10.64
Maximum EIRP power (dBm)	11.54
Measurement uncertainty (dB)	<±1.20

Mode: 802.11a - 20MHz

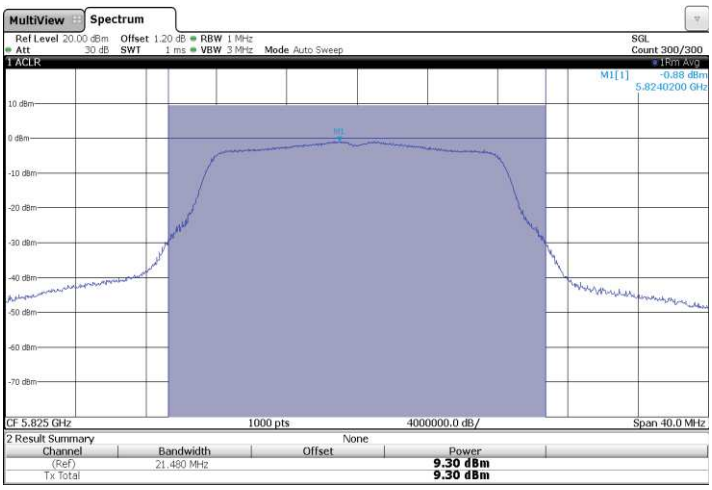
Channel 149



Channel 157

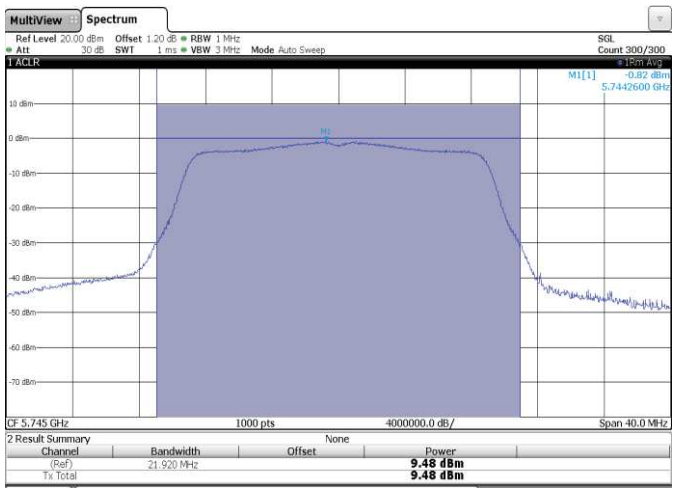


Channel 165

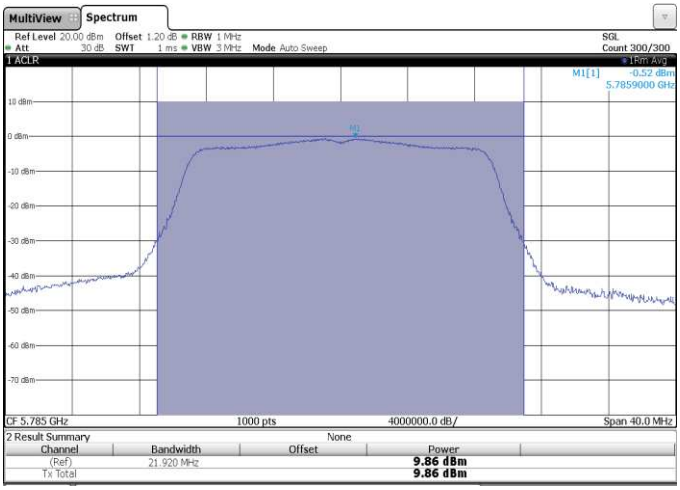


Mode: 802.11n HT20 - 20MHz

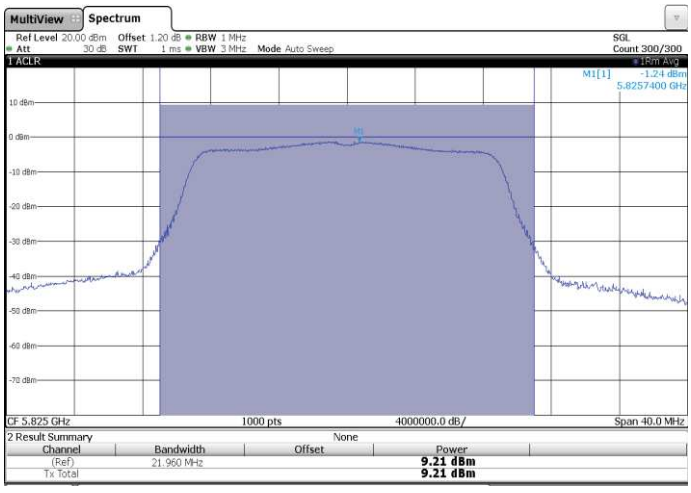
Channel 149



Channel 157

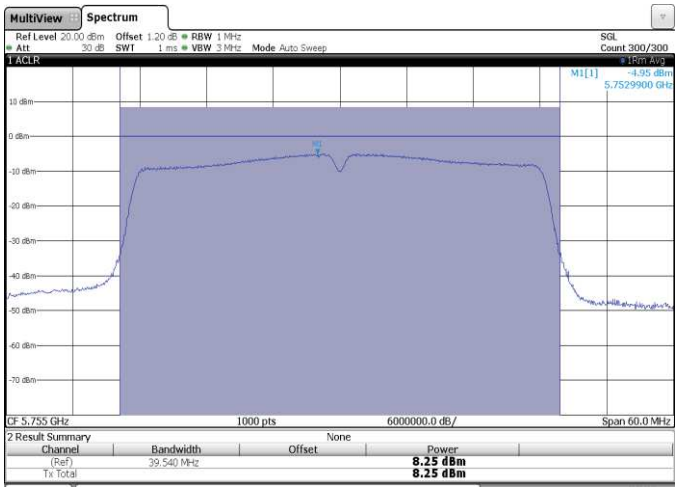


Channel 165

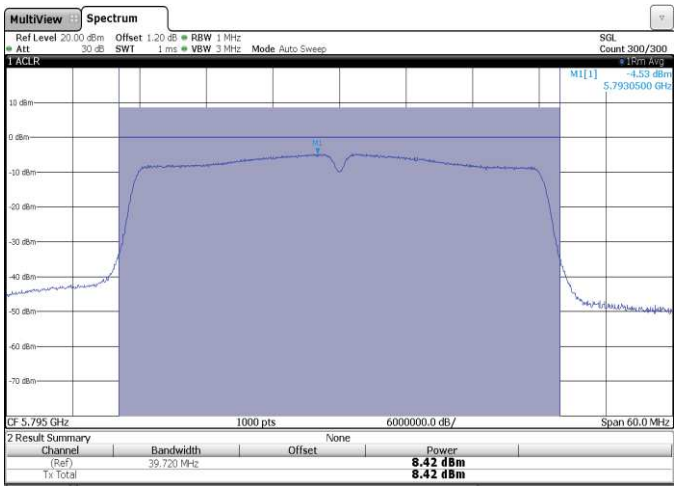


Mode: 802.11n HT40 - 40MHz

Channel 151

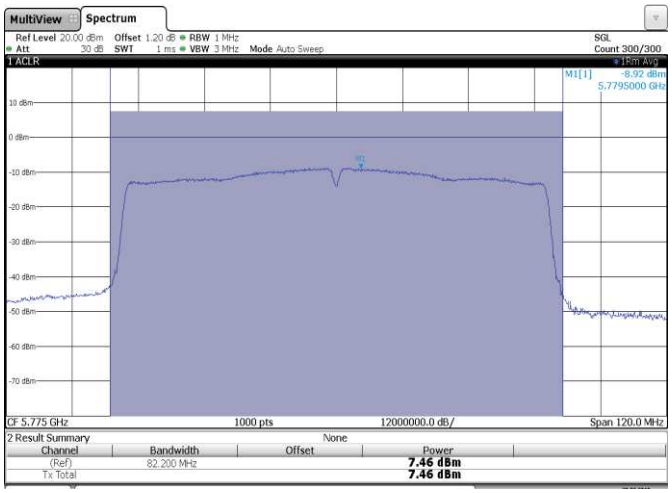


Channel 159



Mode: 802.11ac VHT80 - 80MHz

Channel 155



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

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 showns using a 1 MHz resolution bandwidth. This was deemed worst case.

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

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

FCC & Canada power setting

Mode : 802.11a - 20MHz

Declared antenna gain: +0.9 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
PSD (dBm/MHz)	-0.93	-0.18	-0.88
Duty Cycle Correction Factor (dB)	0.96		
PSD Corrected (dBm/MHz)	0.03	0.78	0.08
e.i.r.p PSD (dBm/MHz)	0.93	1.68	0.98
Measurement uncertainty (dB)	<±1.20		

Mode : 802.11n HT20 - 20MHz

Declared antenna gain: +0.9 dBi

	Channel 149 5745 MHz	Channel 157 5785 MHz	Channel 165 5825 MHz
PSD (dBm/MHz)	-0.82	-0.52	-1.24
Duty Cycle Correction Factor (dB)	1.03		
PSD Corrected (dBm/MHz)	0.21	0.51	-0.21
e.i.r.p PSD (dBm/MHz)	1.11	1.41	0.69
Measurement uncertainty (dB)	<±1.20		

Mode : 802.11n HT40 - 40MHz

Declared antenna gain: +0.9 dBi

	Channel 151 5755 MHz	Channel 159 5795 MHz
PSD (dBm/MHz)	-4.95	-4.53
Duty Cycle Correction Factor (dB)	1.88	
PSD Corrected (dBm/MHz)	-3.07	-2.65
e.i.r.p PSD (dBm/MHz)	-2.17	-1.75
Measurement uncertainty (dB)	<±1.20	

Mode : 802.11ac VHT80 - 80MHz

Declared antenna gain: +0.9 dBi

	Channel 155 5775 MHz
PSD (dBm/MHz)	-8.92
Duty Cycle Correction Factor (dB)	3.18
PSD Corrected (dBm/MHz)	-5.74
e.i.r.p PSD (dBm/MHz)	-4.84
Measurement uncertainty (dB)	<±1.20

FCC Section 15.407(b)(4)(6) /RSS-247 6.2.4.2. Transmitter Out of Band 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 360º 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 analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

Frequency range 30 MHz-1000 MHz.

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

Spurious levels operating (radiated) closest to limit.

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
42.206	Vertical	Quasi-Peak	25.60	40	14.40	± 3.88
688.161	Horizontal	Quasi-Peak	27	46	19	± 3.88
786.455	Horizontal	Quasi-Peak	33.50	46	12.50	± 3.88
884.748	Horizontal	Quasi-Peak	36.40	46	9.60	± 3.88
890.227	Horizontal	Quasi-Peak	30.90	46	15.10	± 3.88

Frequency range 1 GHz-40 GHz

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.

The lowest, middle and highest channels were measured for out-of-band emissions for the worst mode.

Spurious signals 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.

Mode: 802.11n HT20 – 20MHz (worst case)

Channel 149 (5745MHz):

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
11.48983	Horizontal	Peak	48.28	68.23	19.95	± 3.70
		Average	38.33	54	15.67	± 3.70

Channel 157 (5785MHz):

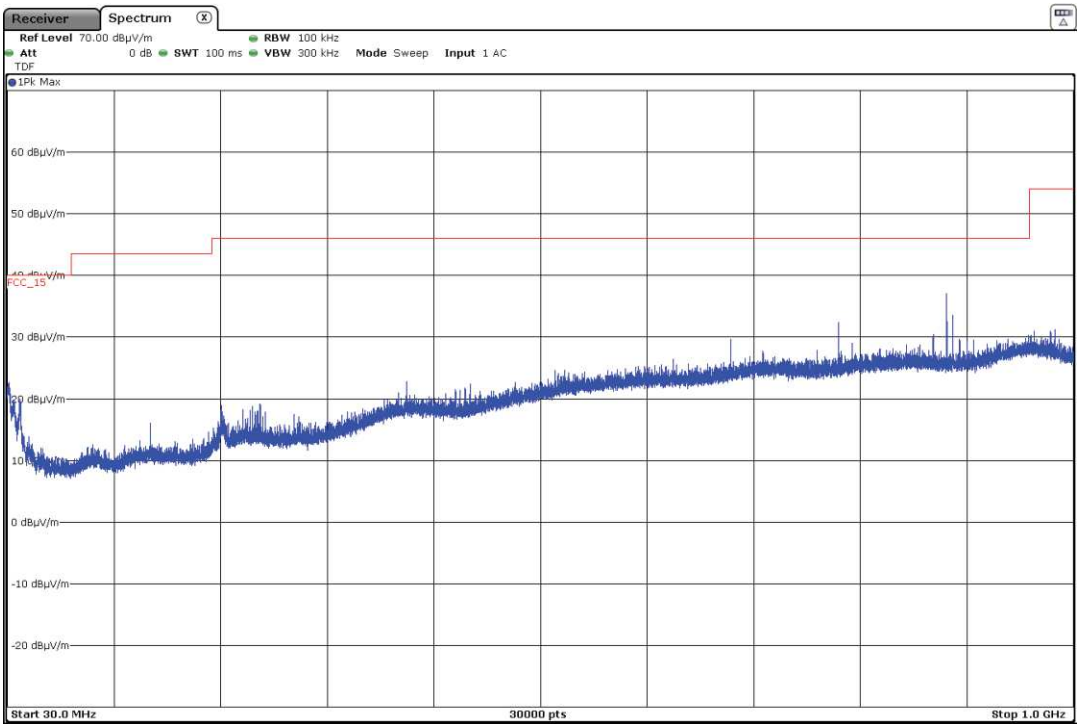
Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
11.57183	Vertical	Peak	46.31	68.23	21.92	± 3.70
		Average	37.27	54	16.73	± 3.70

Channel 165 (5825MHz):

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
11.65017	Horizontal	Peak	46.18	68.23	22.05	± 3.70
		Average	37.36	54	16.64	± 3.70

Verdict: PASS

FREQUENCY RANGE 30 MHz-1000 MHz.

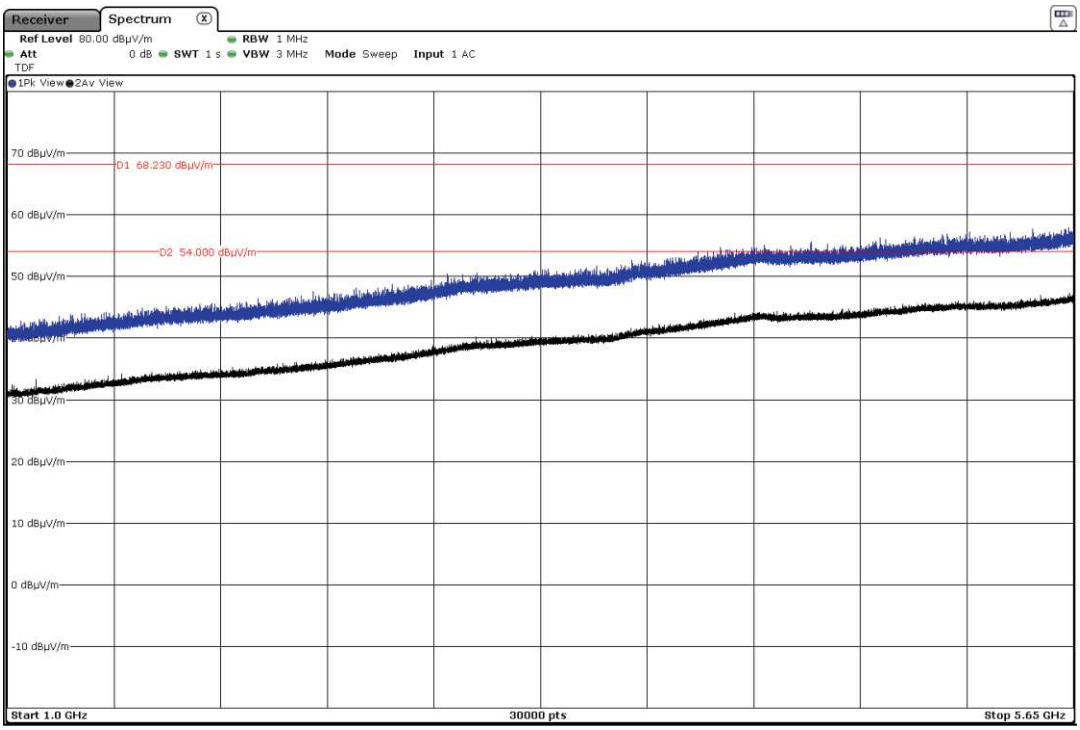


Note: This plot is valid for all channels and all modulation modes.

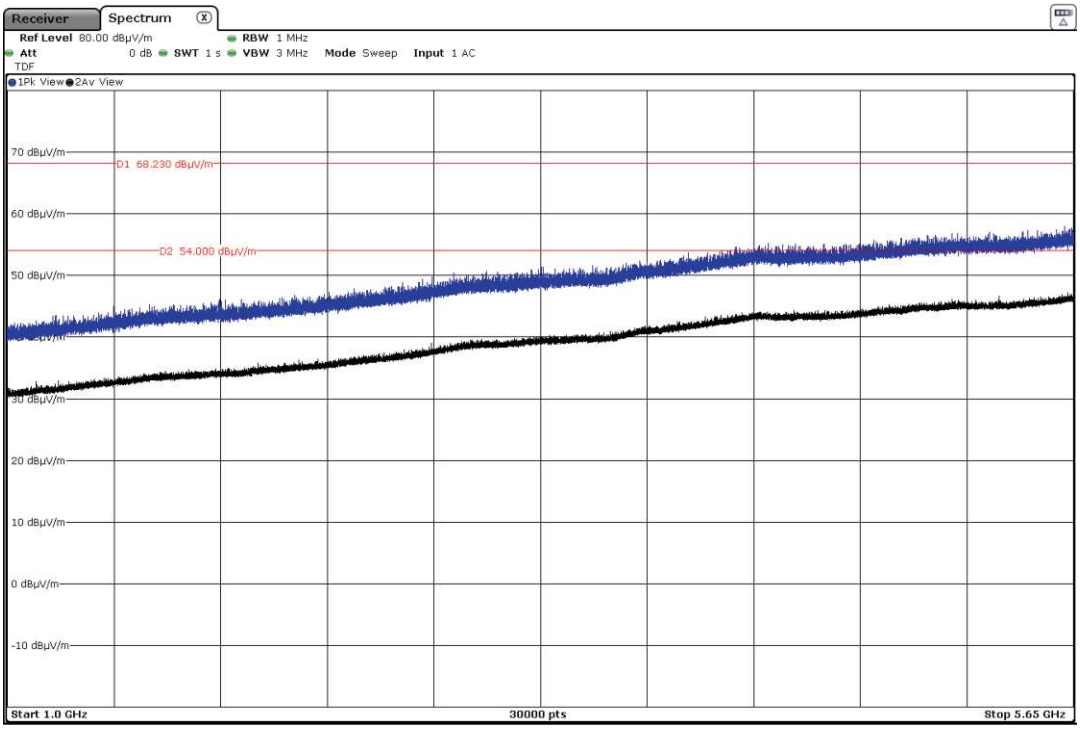
Mode: 802.11n HT20 – 20MHz (worst case)

FREQUENCY RANGE 1 GHz to 5.65 GHz.

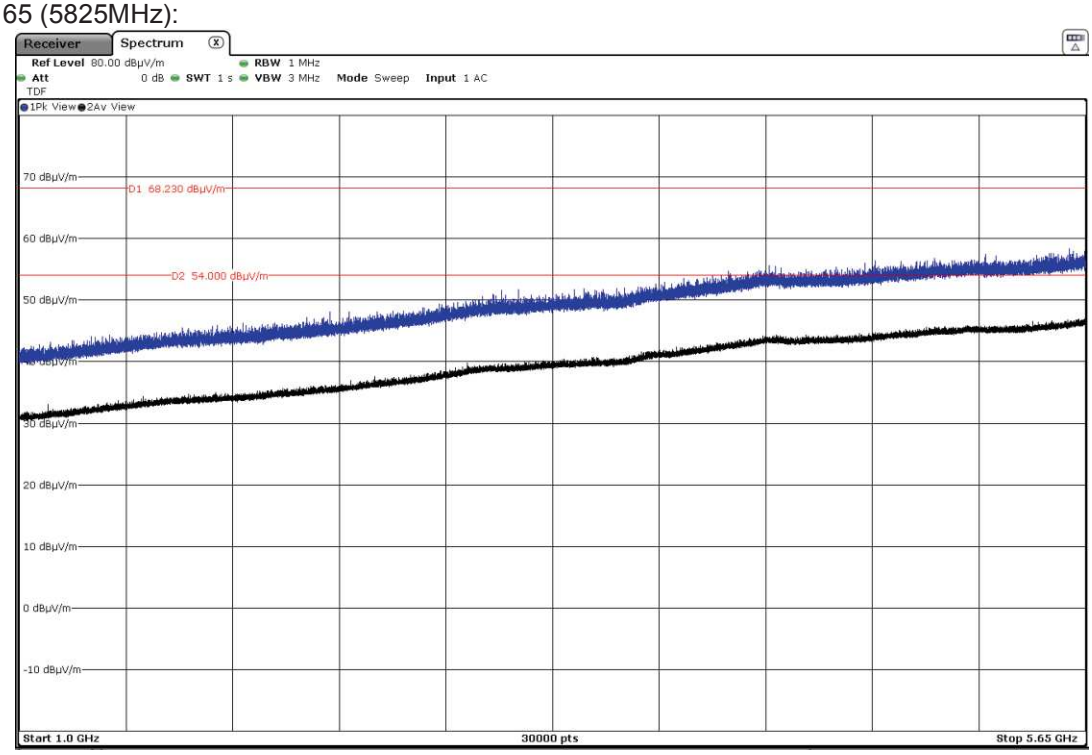
Channel 149 (5745MHz):



Channel 157 (5785MHz):

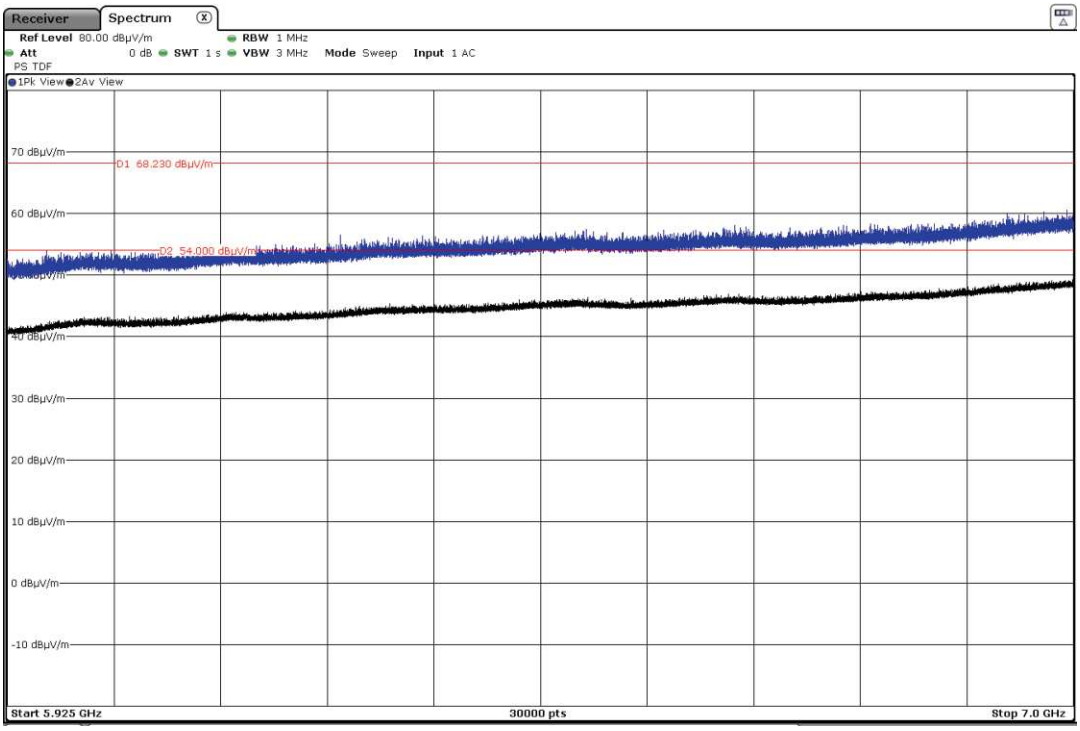


Channel 165 (5825MHz):

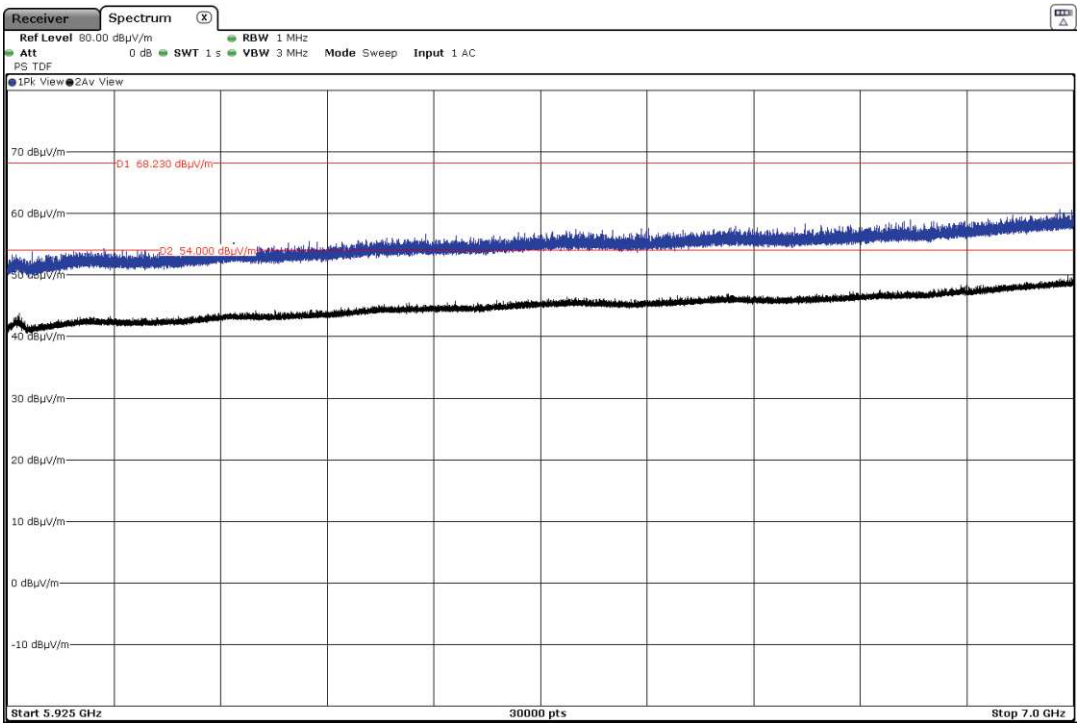


FREQUENCY RANGE 5.925 GHz to 7 GHz.

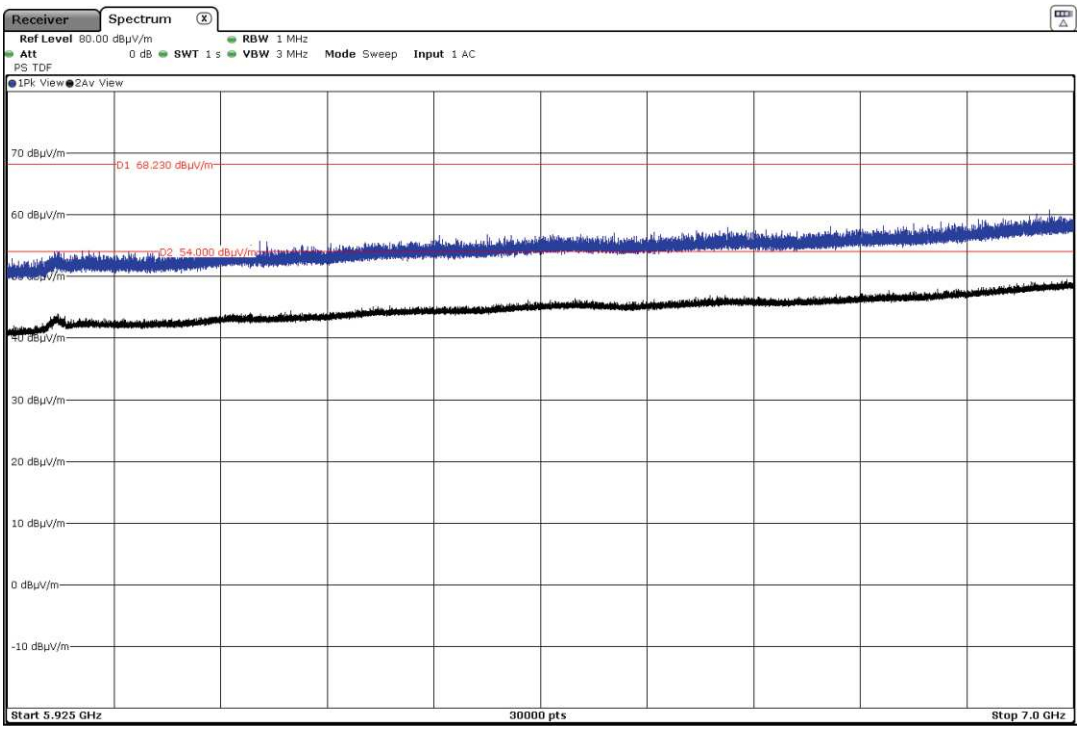
Channel 149 (5745MHz):



Channel 157 (5785MHz):



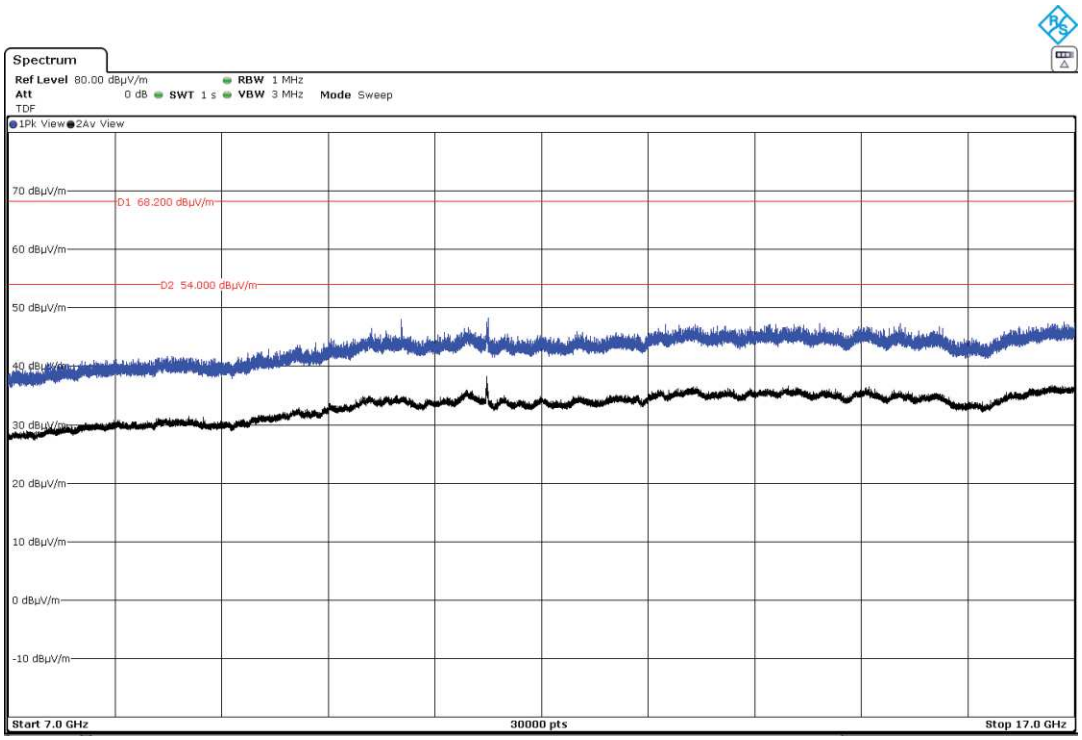
Channel 165 (5825MHz):



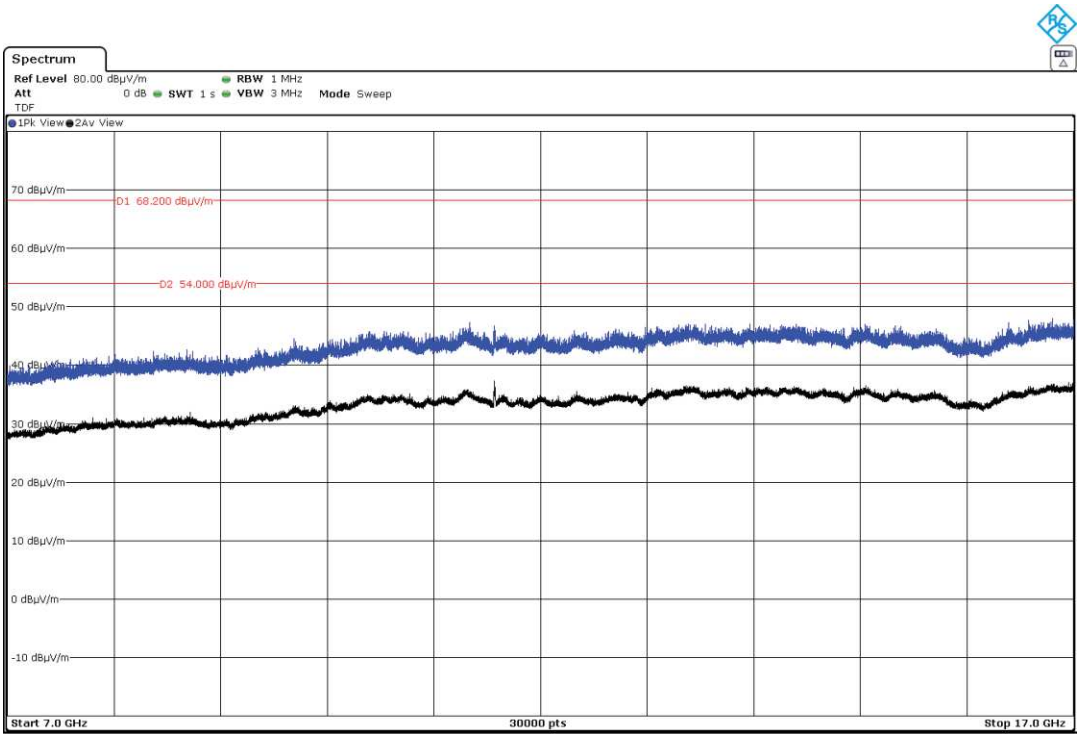
FREQUENCY RANGE 7 GHz to 17 GHz.

Mode: 802.11n HT20 – 20MHz

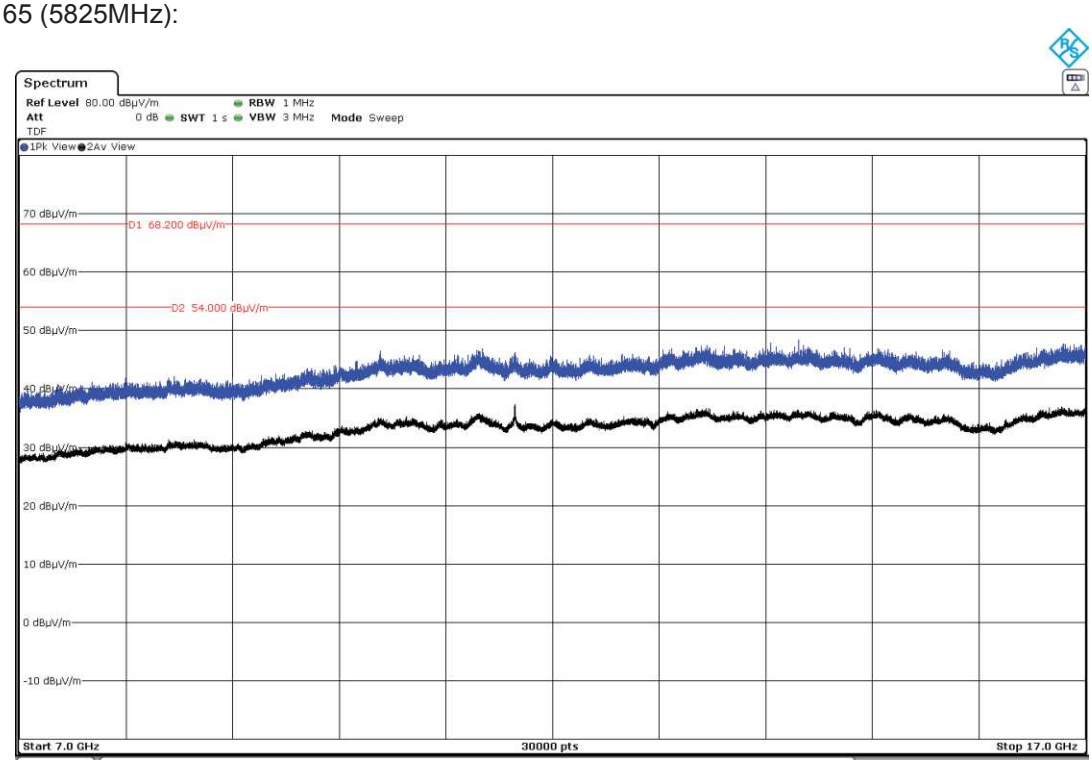
Channel 149 (5745MHz):



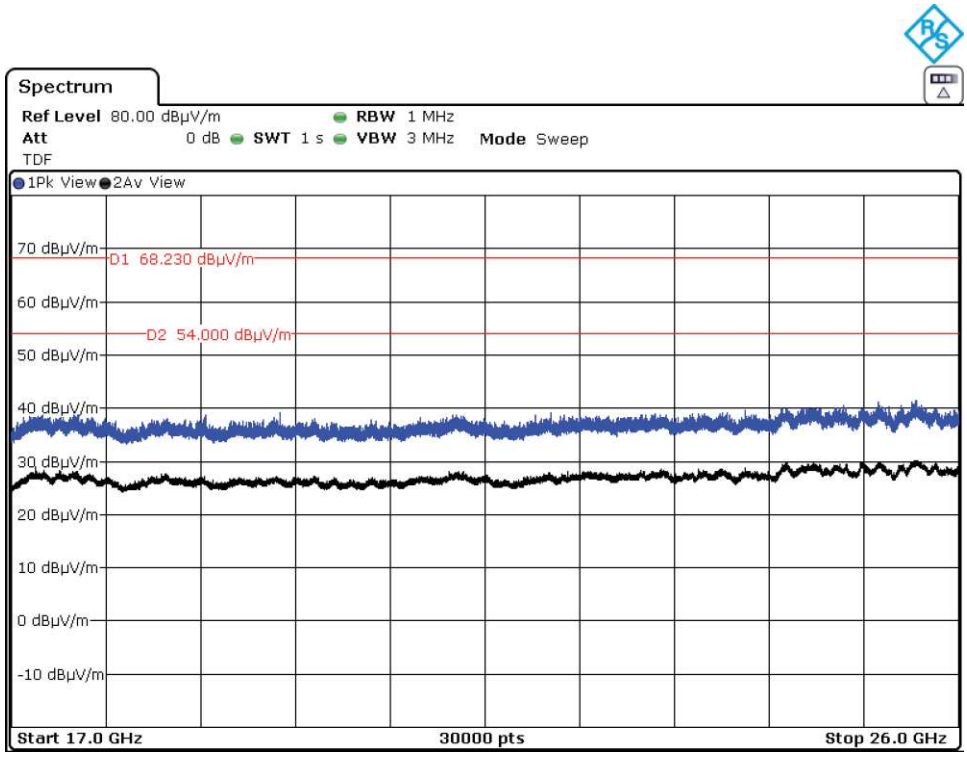
Channel 157 (5785MHz):



Channel 165 (5825MHz):

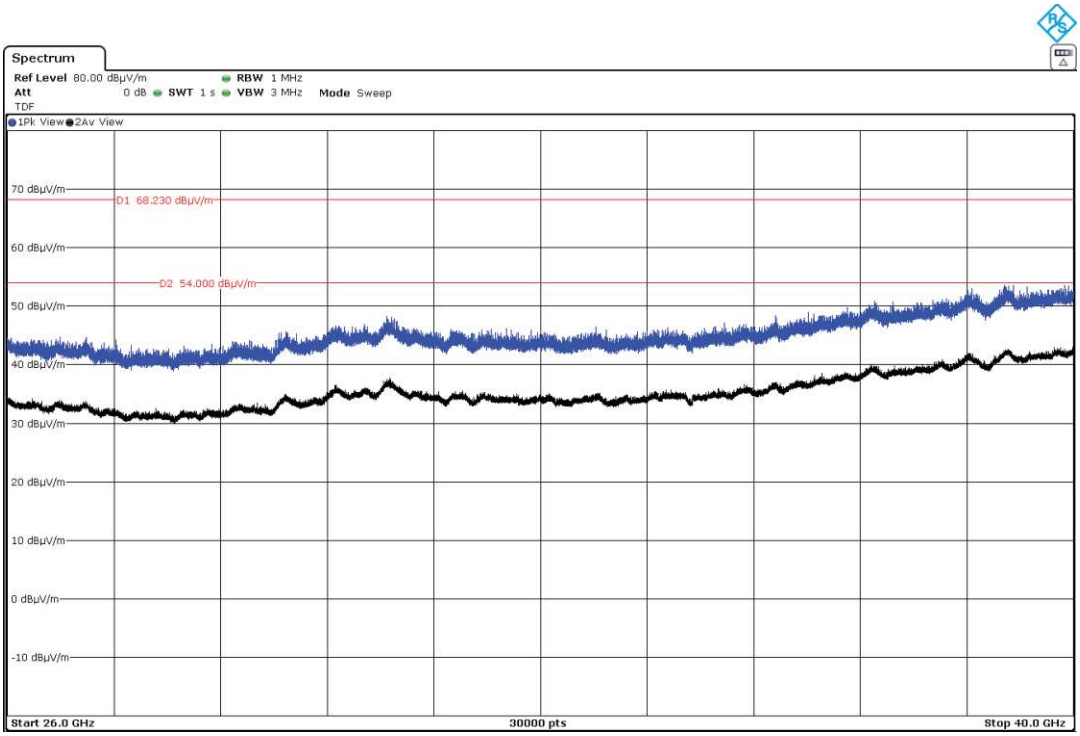


FREQUENCY RANGE 17 GHz to 26 GHz.



No spurious signals were found in all channels tested.

FREQUENCY RANGE 26 GHz to 40 GHz.



No spurious signals were found in all channels tested.