

Appendix B: Test result for 5.15GHz – 5.25GHz.

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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 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 MCS23	
	802.11n HT40: MCS0 to MCS23	
	802.11ac VHT20: MCS0 to MCS9	
	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:	5150 MHz to 5250 MHz	
Channel Spacing:	20 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Lowest: 36	5180
	Middle: 40	5200
	Highest: 48	5240
Channel Spacing:	40 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Lowest: 38	5190
	Highest: 46	5230
Channel Spacing:	80 MHz	
Transmit Channels	Middle: 42	5210

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 on the lowest and highest channels at the rated power for the channel under test.

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

The worst cases for testing were identified 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 Mbits / SISO
- 802.11n HT20: MCS0 / SISO
- 802.11n HT40: MCS0 / SISO
- 802.11ac VHT80: MCS0 / SISO

WIFI FCC:

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

a20 - Core0

```
tx_test.sh -a wlan0 36 0 -d x -r 6 20 -c US
```

```
tx_test.sh -a wlan0 40 0 -d x -r 6 20 -c US
```

```
tx_test.sh -a wlan0 48 0 -d x -r 6 20 -c US
```

n20 - Core0

```
tx_test.sh -a wlan0 36 0 -d x -h 0 20 -c US
```

```
tx_test.sh -a wlan0 40 0 -d x -h 0 20 -c US
```

```
tx_test.sh -a wlan0 48 0 -d x -h 0 20 -c US
```

n40 - Core0

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

```
tx_test.sh -a wlan0 48 0 -d x -h 0 40 -c US
```

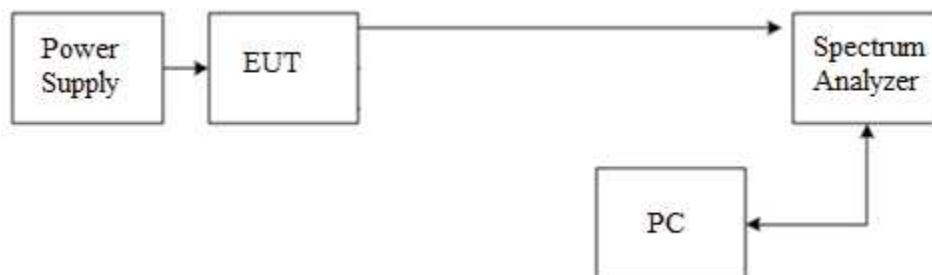
ac80 - Core0

```
tx_test.sh -a wlan0 40 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).

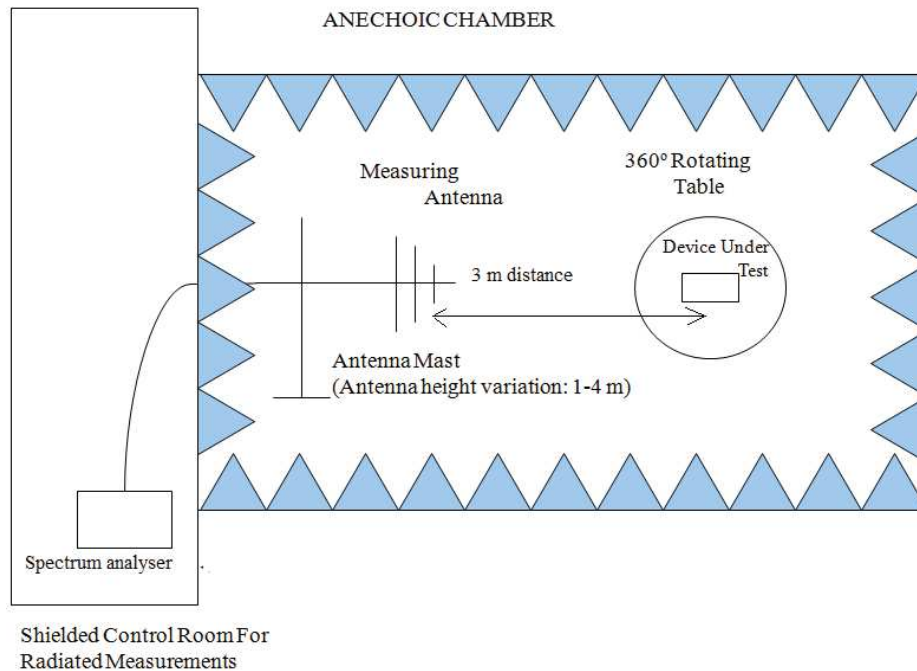
For radiated emissions in the range 1 GHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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 360° and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

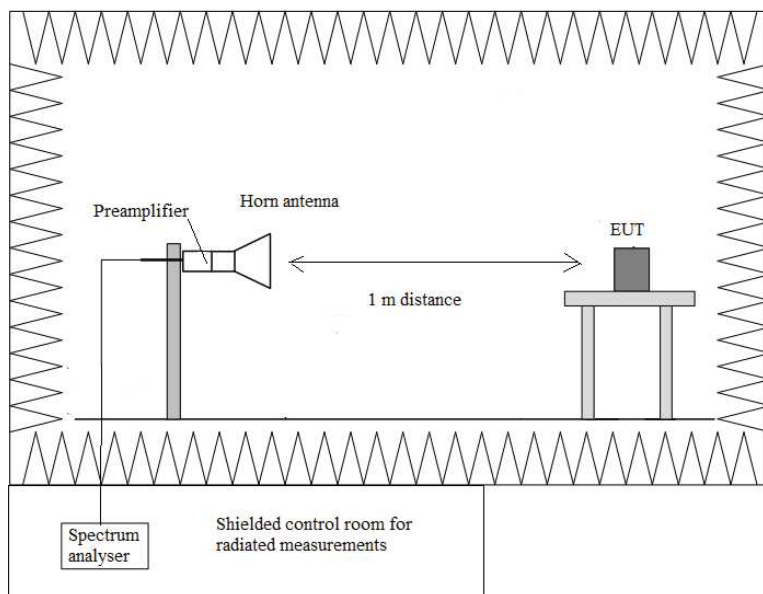
Measurements were made in both horizontal and vertical planes of polarization.

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

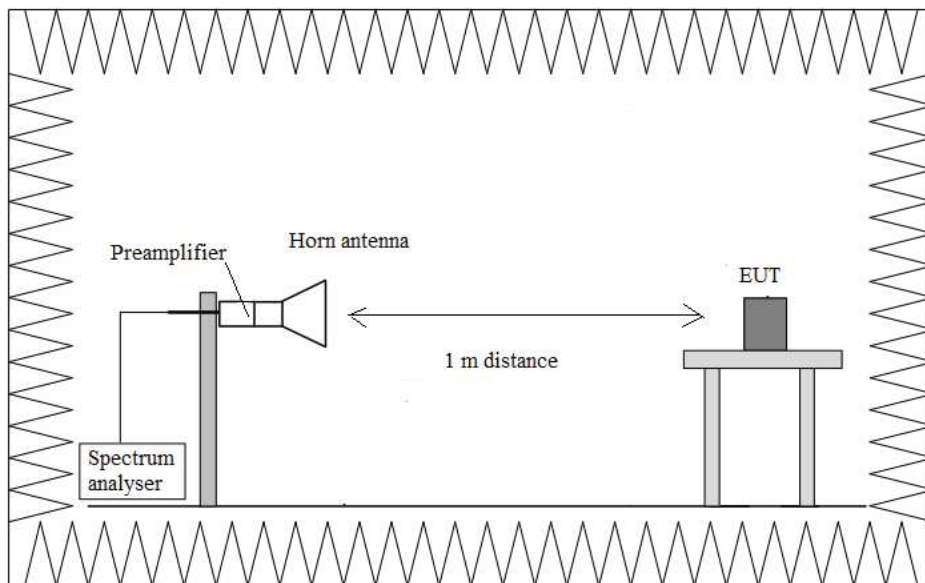
Radiated measurements setup $f < 1$ GHz.



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



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



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

SPECIFICATION

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

RSS-247: The maximum e.i.r.p. shall not exceed 200 mW (23 dBm) or $10 + 10 \log_{10} B$, dBm, whichever power is less. B is the 99% emission bandwidth in MHz.

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 & Canada power setting

Mode : 802.11a - 20MHz (see next plots)

Antenna gain: +0.9 dBi

	channel 36 5180 MHz	channel 40 5200 MHz	channel 48 5240 MHz
Max. conducted power (dBm)	12.37	11.73	11.53
Duty Cycle Correction Factor (dB)	0.96		
Max. conducted power corrected (dBm)	13.33	12.69	12.49
Max. EIRP power (dBm)	14.23	13.59	13.39
Measurement uncertainty (dB)	<±1.20		

Mode : 802.11n HT20 - 20MHz (see next plots)

Antenna gain: +0.9 dBi

	channel 36 5180 MHz	channel 40 5200 MHz	channel 48 5240 MHz
Max. conducted power (dBm)	12.19	11.58	11.27
Duty Cycle Correction Factor (dB)	1.03		
Max. conducted power corrected (dBm)	13.22	12.61	12.30
Max. EIRP power (dBm)	14.12	13.51	13.20
Measurement uncertainty (dB)	<±1.20		

Mode : 802.11n HT40 - 40MHz (see next plots)

Antenna gain: +0.9 dBi

	channel 38 5190 MHz	channel 46 5230 MHz
Max. conducted power (dBm)	9.42	8.55
Duty Cycle Correction Factor (dB)	1.88	
Max. conducted power corrected (dBm)	11.30	10.43
Max. EIRP power (dBm)	12.20	11.33
Measurement uncertainty (dB)	<±1.20	

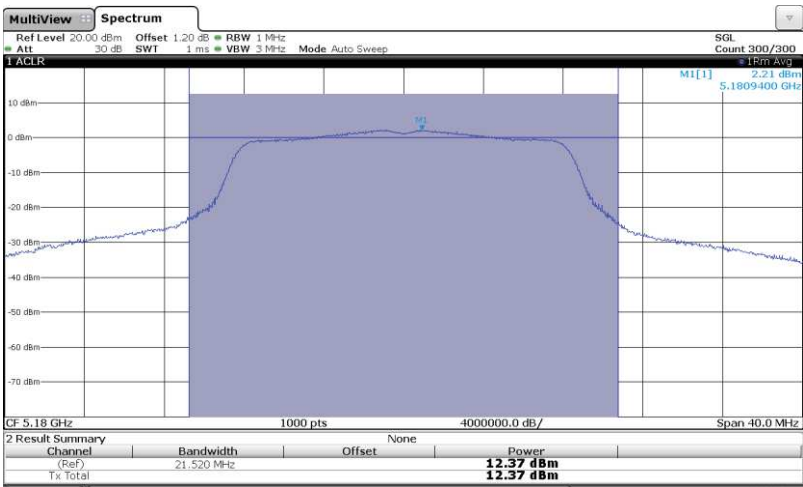
Mode : 802.11ac VHT80 - 80MHz (see next plots)

Antenna gain: +0.9 dBi

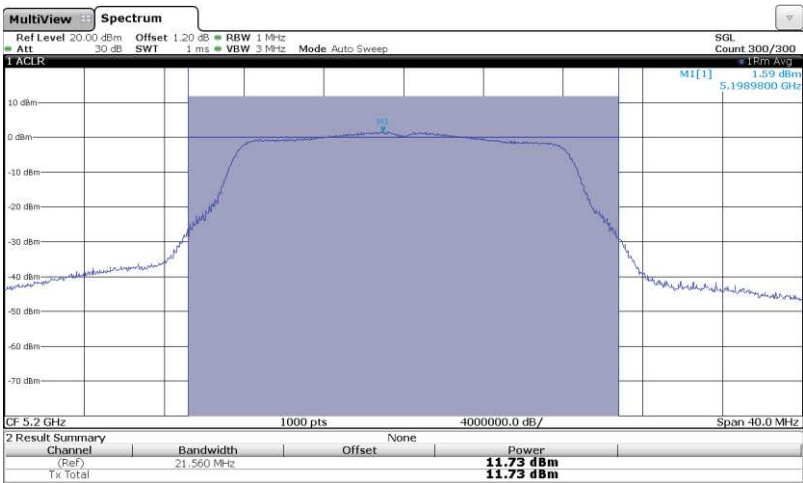
	channel 42 5210 MHz
Max. conducted power (dBm)	8.53
Duty Cycle Correction Factor (dB)	3.18
Max. conducted power corrected (dBm)	11.71
Max. EIRP power (dBm)	12.61
Measurement uncertainty (dB)	<±1.20

Mode : 802.11a - 20MHz

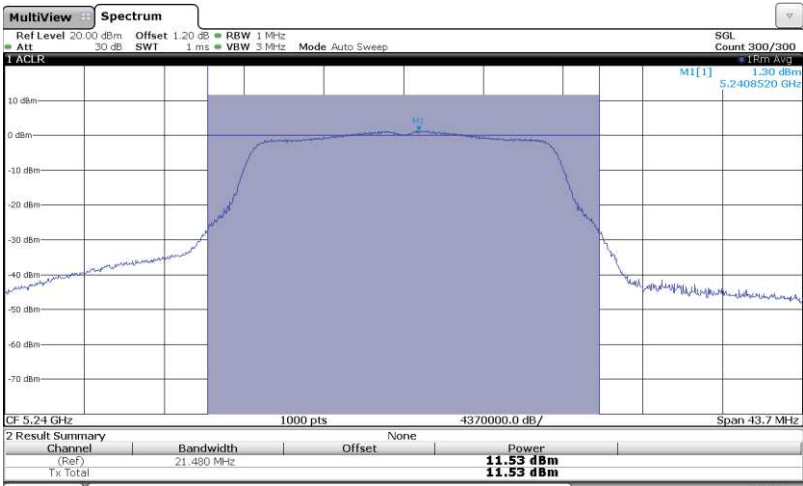
Channel 36



Channel 40

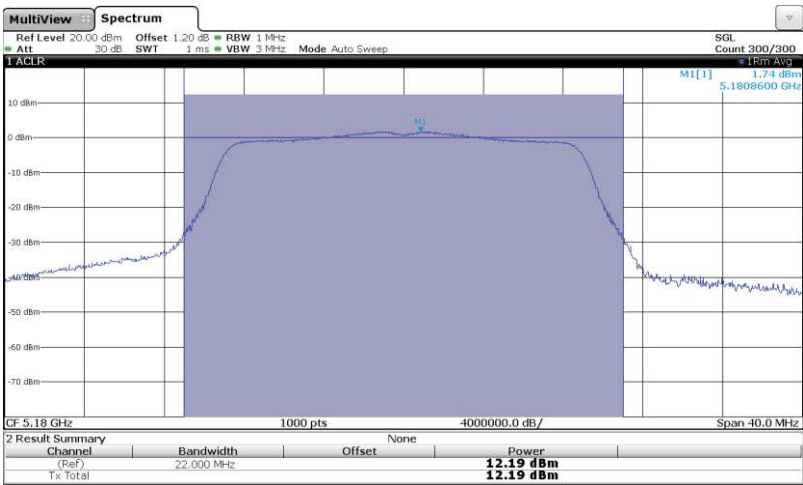


Channel 48

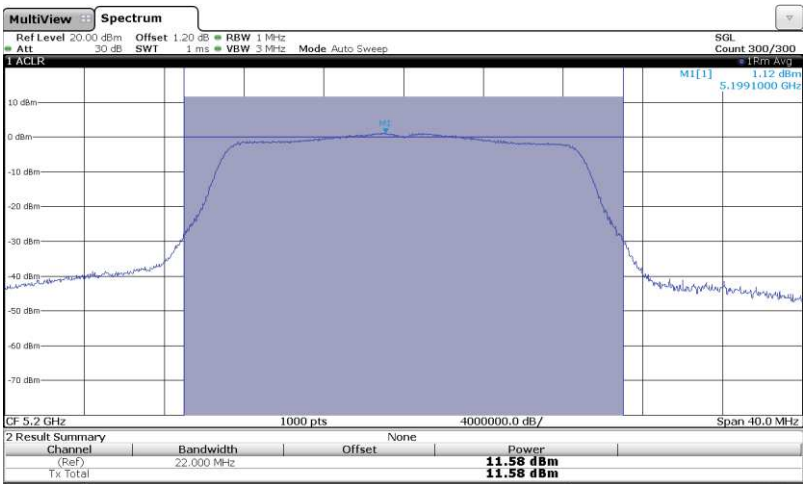


Mode : 802.11n HT20 - 20MHz

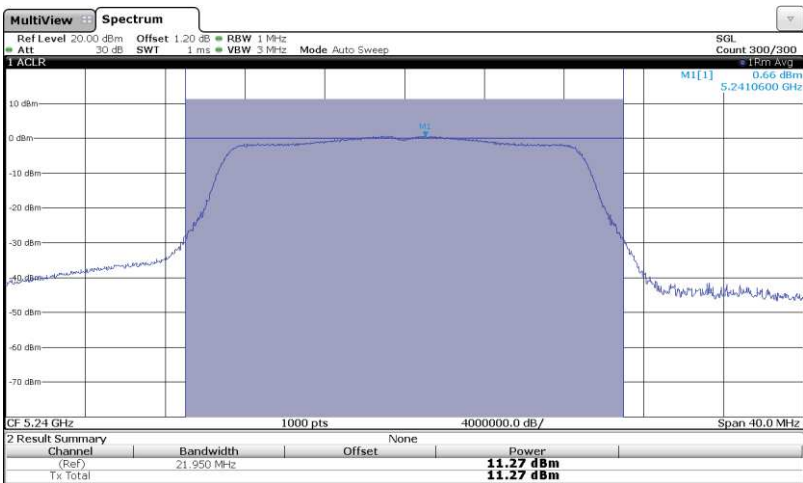
Channel 36



Channel 40

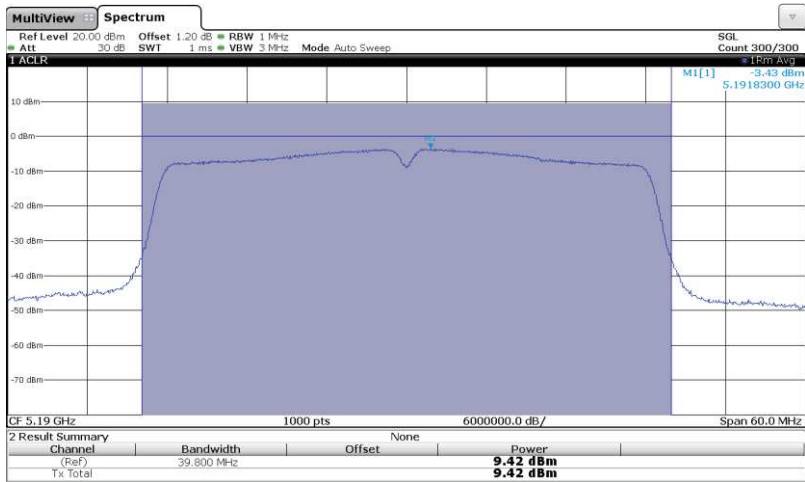


Channel 48

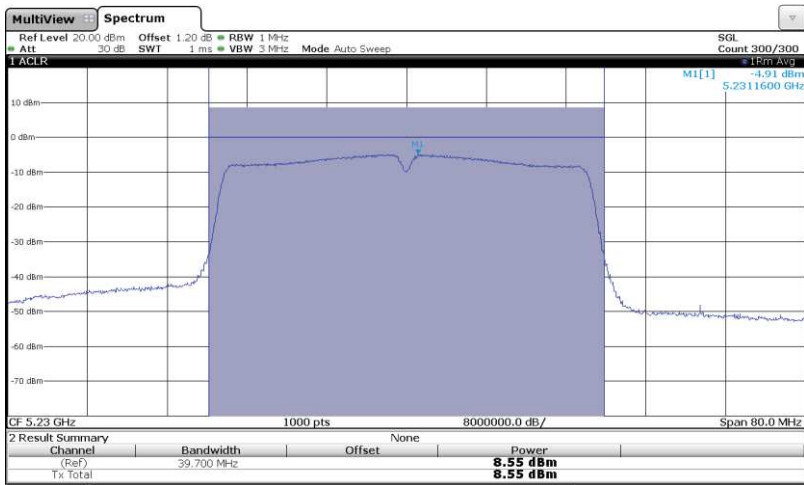


Mode : 802.11n HT40 - 40MHz

Channel 38

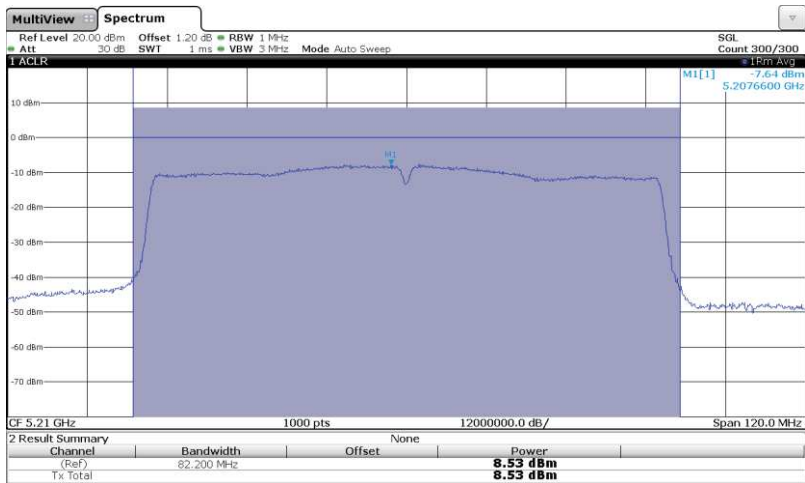


Channel 46



Mode : 802.11ac VHT80 - 80MHz

Channel 42



FCC Section 15.407 Subclause (a) (1) (ii). Transmitter Maximum Power Spectral Density / RSS-247 Clause 6.2.1.1. Transmitter EIRP Spectral Density

FCC 15.407: The maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

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

RESULTS

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

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 marker 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 36 5180 MHz	channel 40 5200 MHz	channel 48 5240 MHz
PSD (dBm/MHz)	2.21	1.59	1.3
Duty Cycle Correction Factor (dB)	0.96		
PSD Corrected (dBm/MHz)	3.17	2.55	2.26
e.i.r.p PSD (dBm/MHz)	4.07	3.45	3.16
Measurement uncertainty (dB)	<±1.20		

Mode: 802.11n HT20 - 20MHz

Declared antenna gain: +0.9 dBi

	channel 36 5180 MHz	channel 40 5200 MHz	channel 48 5240 MHz
PSD (dBm/MHz)	1.74	1.12	0.66
Duty Cycle Correction Factor (dB)	1.03		
PSD Corrected (dBm/MHz)	2.77	2.15	1.69
e.i.r.p PSD (dBm/MHz)	3.67	3.05	2.59
Measurement uncertainty (dB)	<±1.20		

Mode: 802.11n HT40 - 40MHz

Declared antenna gain: +0.9 dBi

	channel 38 5190 MHz	channel 46 5230 MHz
PSD (dBm/MHz)	-3.43	-4.91
Duty Cycle Correction Factor (dB)	1.88	
PSD Corrected (dBm/MHz)	-1.55	-3.03
e.i.r.p PSD (dBm/MHz)	-0.65	-2.13
Measurement uncertainty (dB)	<±1.20	

Mode: 802.11ac VHT80 - 80MHz

Declared antenna gain: +0.9 dBi

	channel 42 5210 MHz
PSD (dBm/MHz)	-7.64
Duty Cycle Correction Factor (dB)	3.18
PSD Corrected (dBm/MHz)	-4.46
e.i.r.p PSD (dBm/MHz)	-3.56
Measurement uncertainty (dB)	<±1.20

FCC Section 15.407(b)(1)(6) /RSS-247 6.2.1.2. Transmitter Out of Band 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 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 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)
39.520	Vertical	Quasi-Peak	26.7	40	13.3	± 3.88
786.487	Vertical	Quasi-Peak	29.3	46	16.7	± 3.88
860.207	Horizontal	Quasi-Peak	29.6	46	16.4	± 3.88
884.780	Horizontal	Quasi-Peak	36.9	46	9.1	± 3.88
890.245	Horizontal	Quasi-Peak	34.3	46	11.7	± 3.88

Frequency range 1 GHz-40 GHz

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

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 36 (5180MHz): Out-of-band spurious emissions in the 1-40 GHz range.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
10.36417	Horizontal	Peak	60.17	68.23	8.06	± 3.70

Channel 40 (5200MHz): Out-of-band spurious emissions in the 1-40 GHz range.

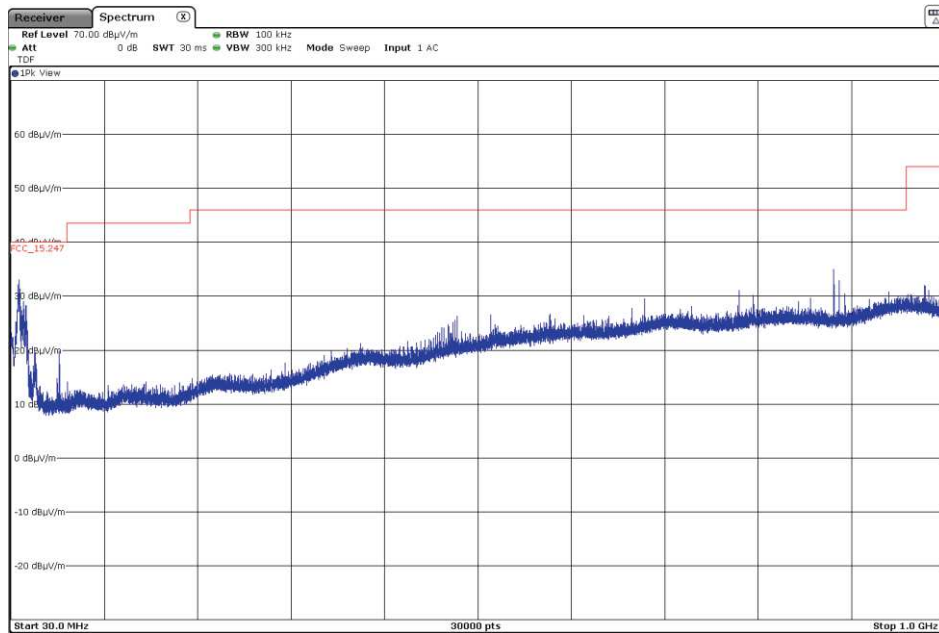
Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
10.3995	Vertical	Peak	59.12	68.23	9.11	± 3.70

Channel 48 (5240MHz): Out-of-band spurious emissions in the 1-40 GHz range.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Measurement Uncertainty (dB)
10.48117	Vertical	Peak	62.02	68.23	6.21	± 3.70

Verdict: PASS

FREQUENCY RANGE 30 MHz-1000 MHz.

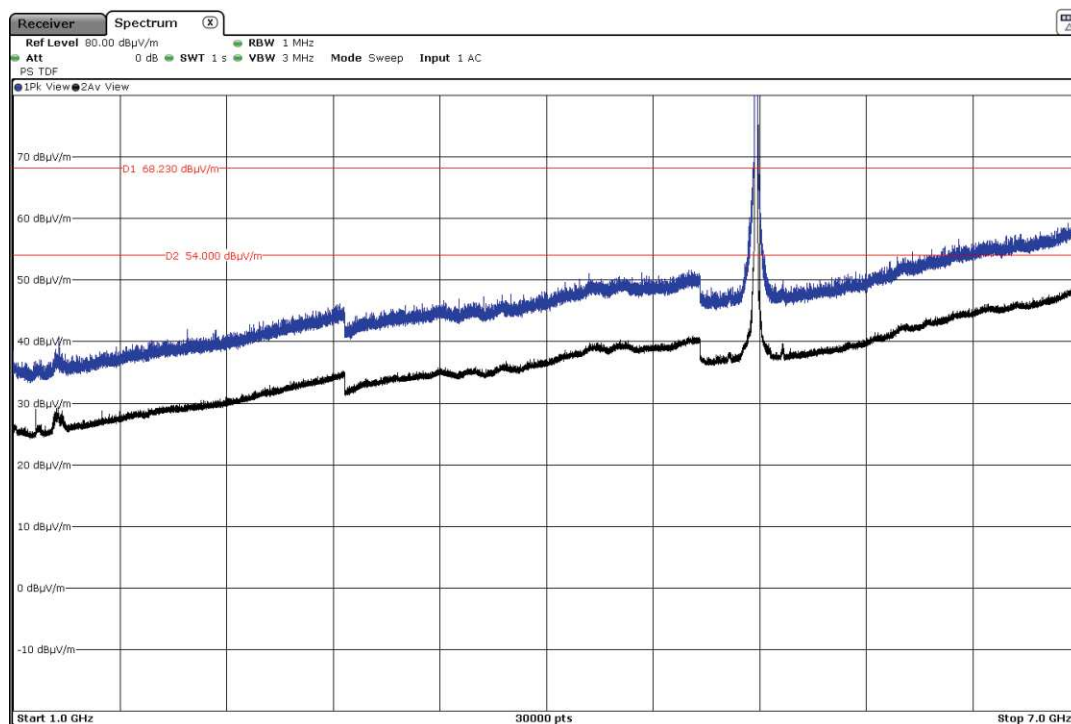


Note: This plot is valid for all channels and all modulation modes.

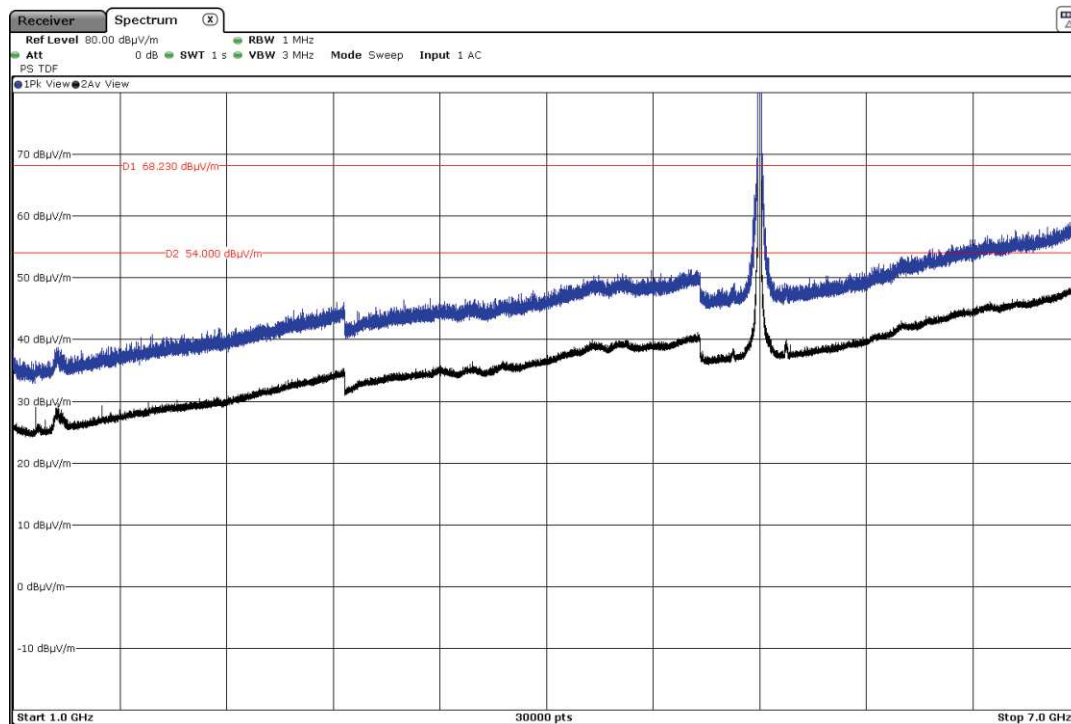
FREQUENCY RANGE 1 GHz to 7 GHz. (worst case)

Mode: 802.11n HT20 – 20MHz

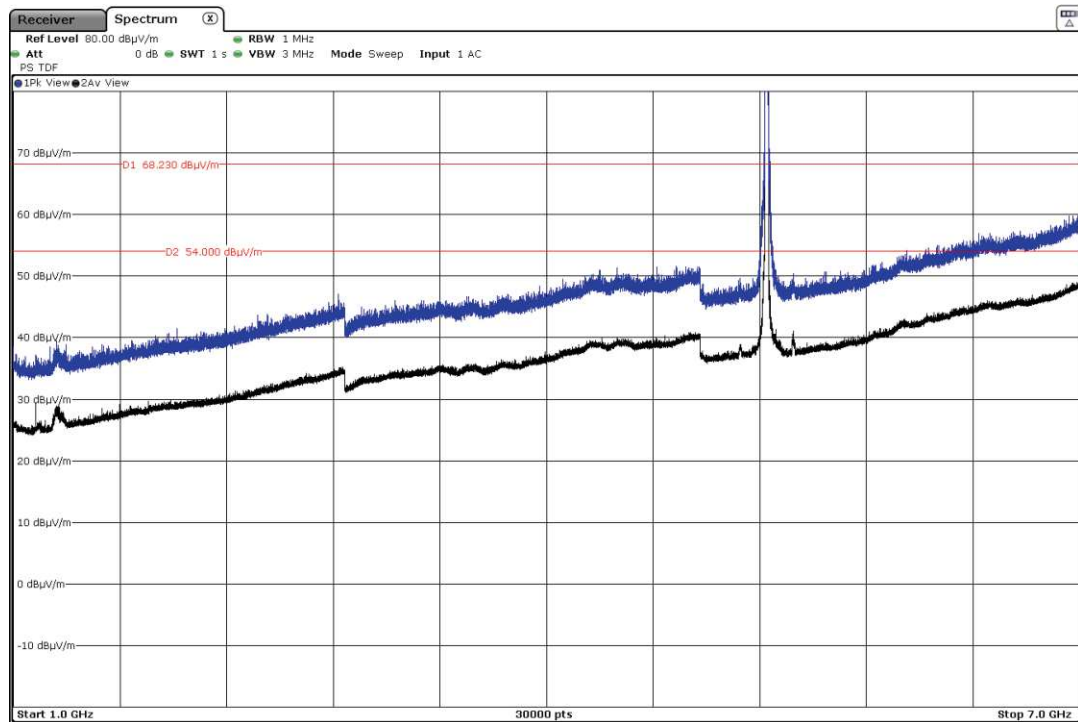
Channel 36 (5180MHz):



Channel 40 (5200MHz):



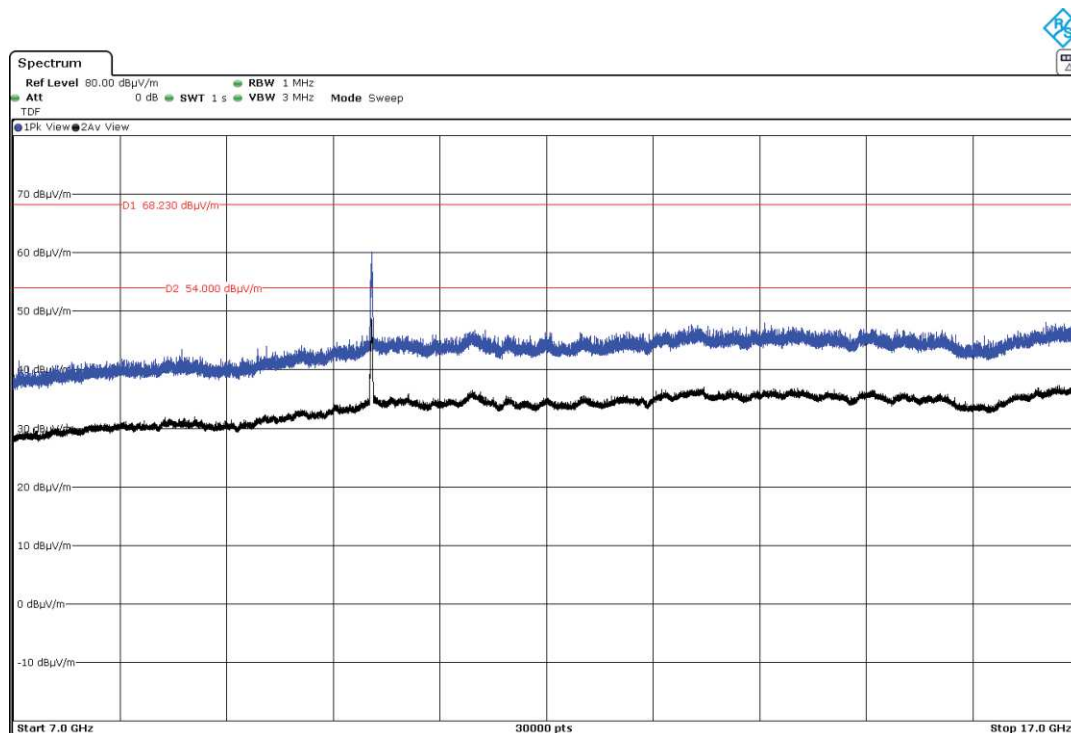
Channel 48 (5240MHz):



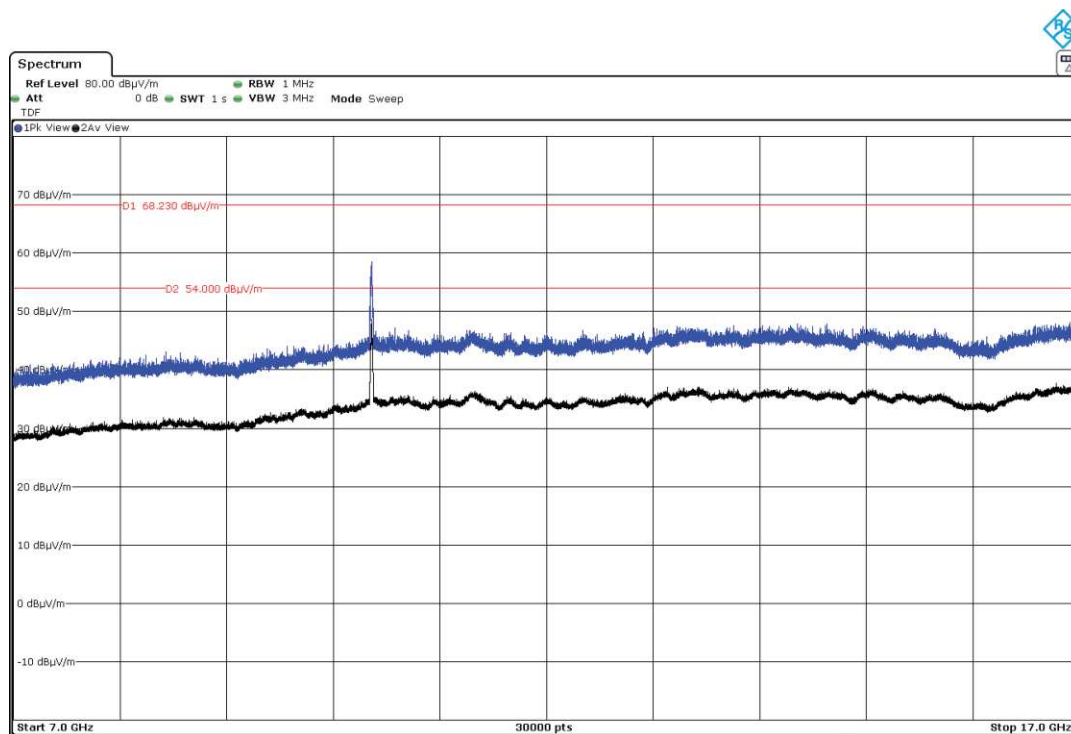
FREQUENCY RANGE 7 GHz to 17 GHz. (worst case)

Mode: 802.11n HT20 – 20MHz

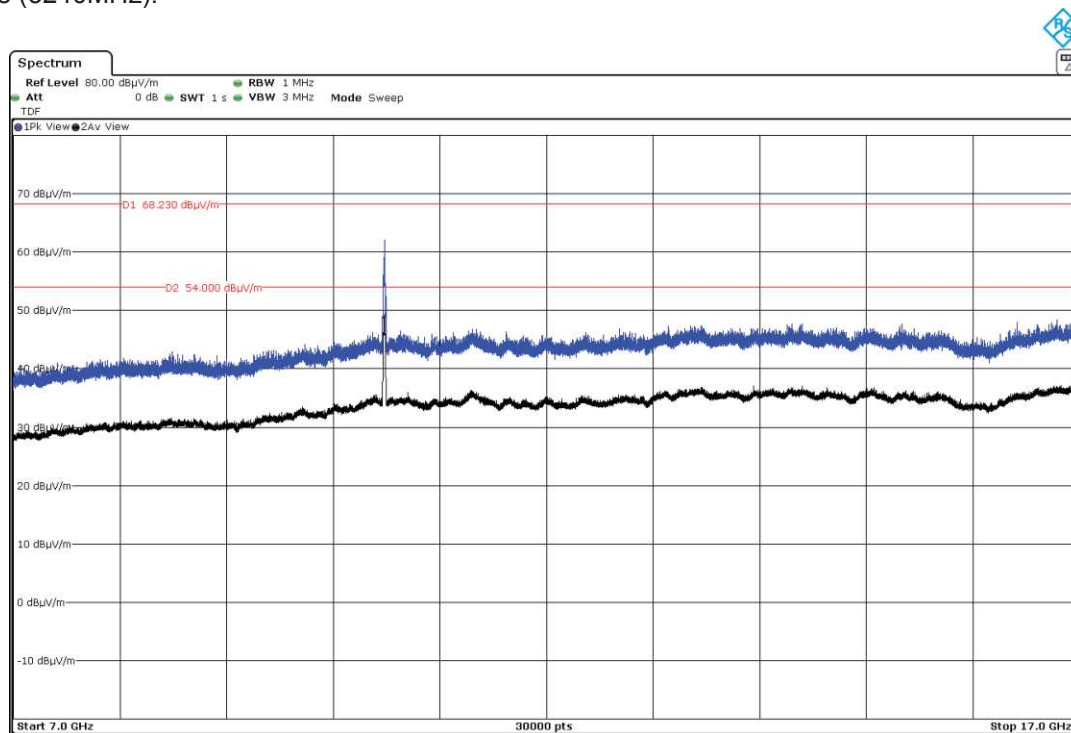
Channel 36 (5180MHz):



Channel 40 (5200MHz):



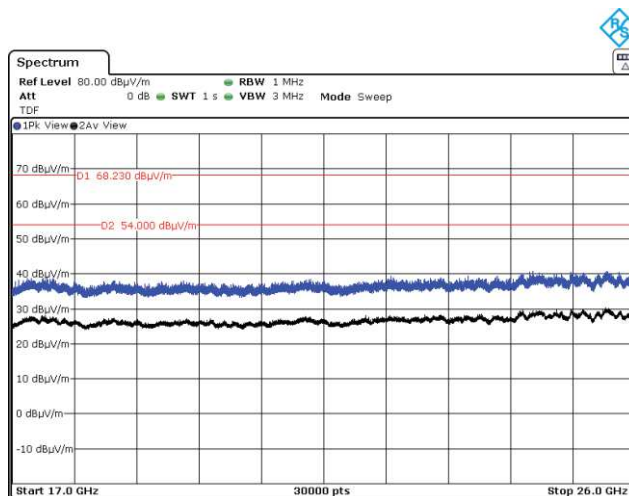
Channel 48 (5240MHz):



FREQUENCY RANGE 17 GHz to 26 GHz.

Mode: 802.11n HT20 – 20MHz

Channel 40 (5200MHz):

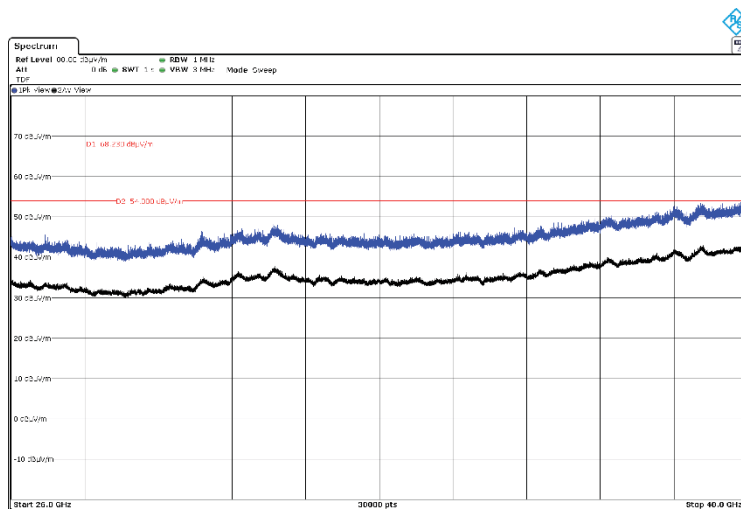


Note: This plot is valid for all channels and all modulation modes.

FREQUENCY RANGE 26 GHz to 40 GHz.

Mode: 802.11n HT20 – 20MHz

Channel 40 (5200MHz):



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

FCC Section 15.407 Subclause (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 (68.20 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.

All emissions outside of the 5.15-5.35GHz band shall not exceed an EIRP of -27dBm/MHz. There are restricted bands of operation below band edge at 4.5-5.15 GHz also above the upper band edge at 5.35-5.46GHz therefore the provision of FCC Part 15.205 apply.

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

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

- 802.11a: 6 Mbit/s / SISO on WLAN0 CORE0 – Antenna Port 3
- 802.11n HT20: MCS0 / SISO on WLAN0 CORE0 – Antenna Port 3
- 802.11n HT40: MCS0 / SISO on WLAN0 CORE0 – Antenna Port 3
- 802.11ac VHT80: MCS0 / SISO on WLAN0 CORE0 – Antenna Port 3

Mode: 802.11a - 20MHz

Channel 36 (5180MHz): Inside band spurious emissions in 4.50-5.15 GHz adjacent band.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Measurement Uncertainty (dB)
5.14729	Horizontal	Peak	55.13	74	18.87	± 3.05
4.86389		Average	40.19	54	13.81	± 3.05

Channel 48 (5240MHz): Inside band spurious emissions in 5.35-5.46 GHz adjacent band.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

Mode: 802.11n HT20 – 20MHz

Channel 36 (5180MHz): Inside band spurious emissions in 4.50-5.15 GHz adjacent band.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Measurement Uncertainty (dB)
5.14946	Horizontal	Peak	57.51	74	16.49	± 3.05
5.16600		Average	40.94	54	13.06	± 3.05

Channel 48 (5240MHz): Inside band spurious emissions in 5.35-5.46 GHz adjacent band.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

Mode: 802.11n HT40 – 40MHz

Channel 38 (5190MHz): Inside band spurious emissions in 4.50-5.15 GHz adjacent band.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Measurement Uncertainty (dB)
5.14989	Vertical	Peak	53.24	74	20.76	± 3.05
4.84699		Average	40.31	54	13.69	± 3.05

Channel 46 (5230MHz): Inside band spurious emissions in 5.35-5.46 GHz adjacent band.

No radiated spurious signals were detected at less than 20 dB respect to the limit.

Mode : 802.11ac VHT80 – 80MHz

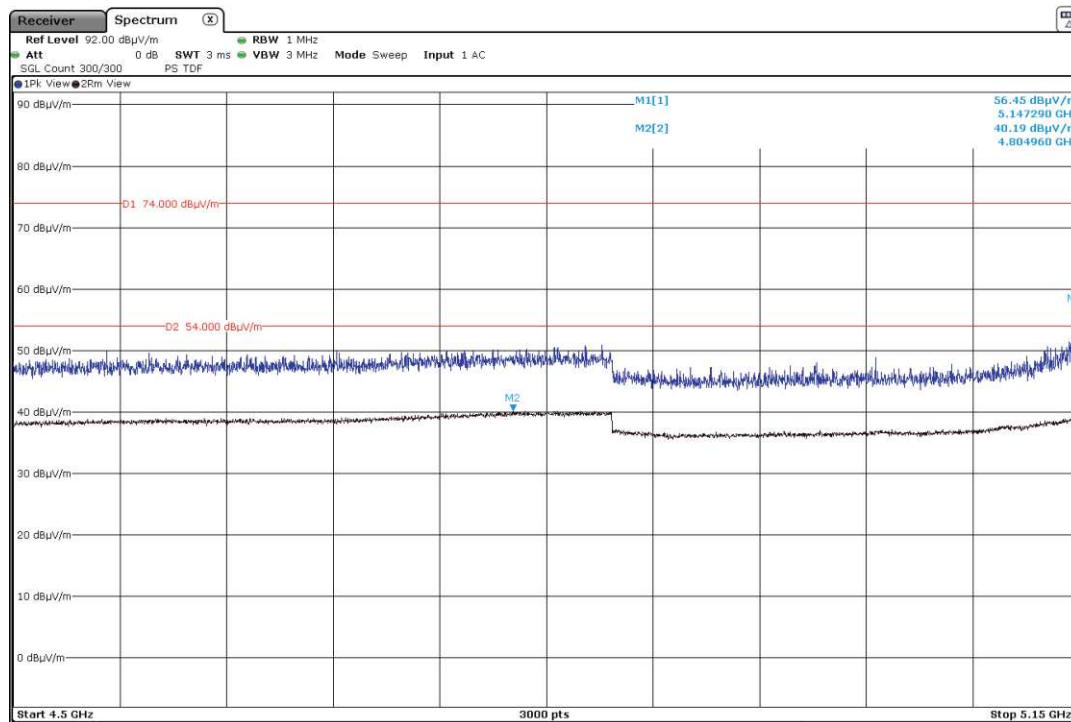
Channel 42 (5240MHz): Inside band spurious emissions in 4.50-5.15 GHz and 5.35-5.46 GHz adjacent band.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Measurement Uncertainty (dB)
5.14014	Horizontal	Peak	55	74	19	± 3.05
5.14989		Average	42.22	54	11.78	± 3.05

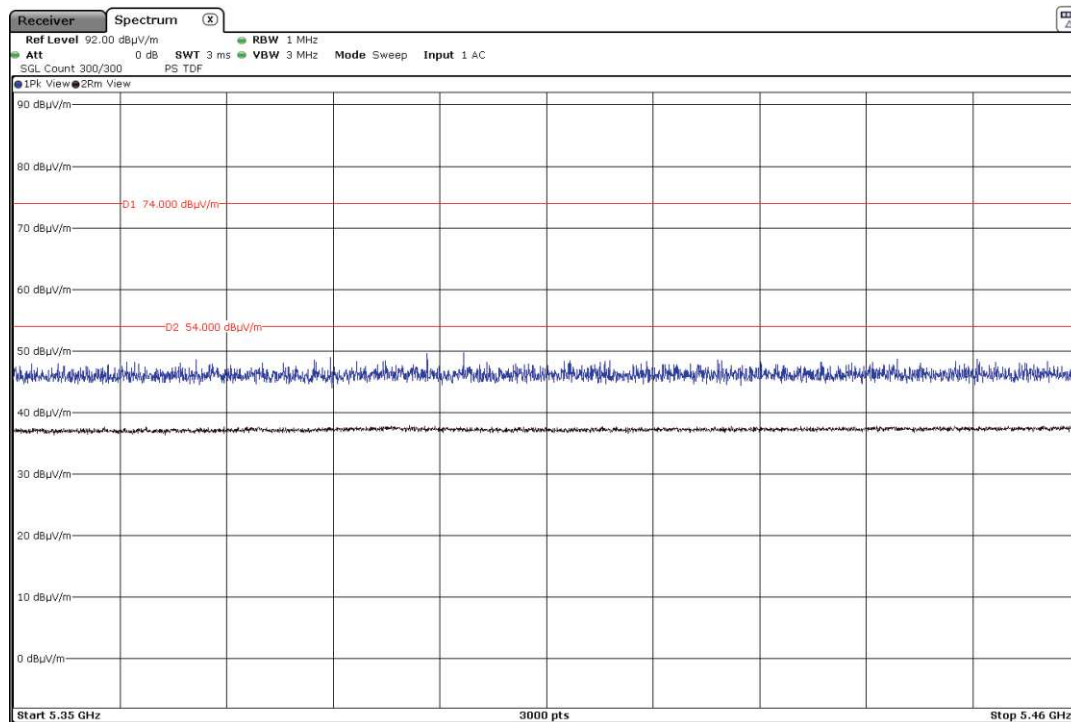
Verdict: PASS

Mode: 802.11a - 20MHz

4500 MHz to 5150 MHz Lower Band Edge Channel 36

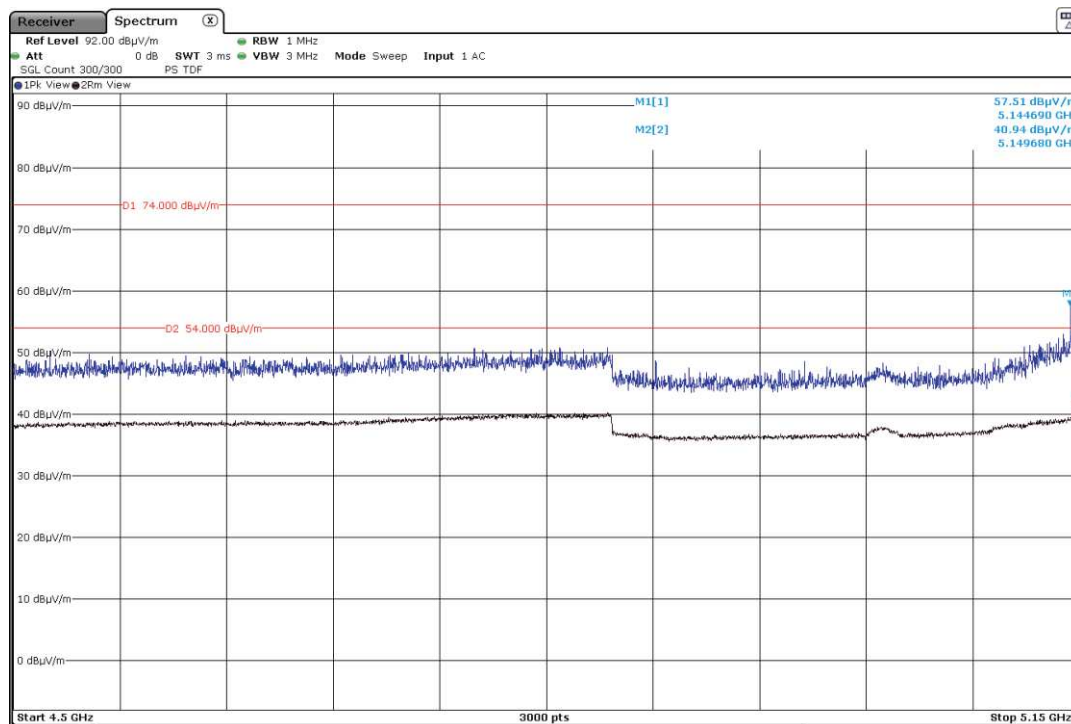


5350 MHz to 5460 MHz Upper Band Edge Channel 48

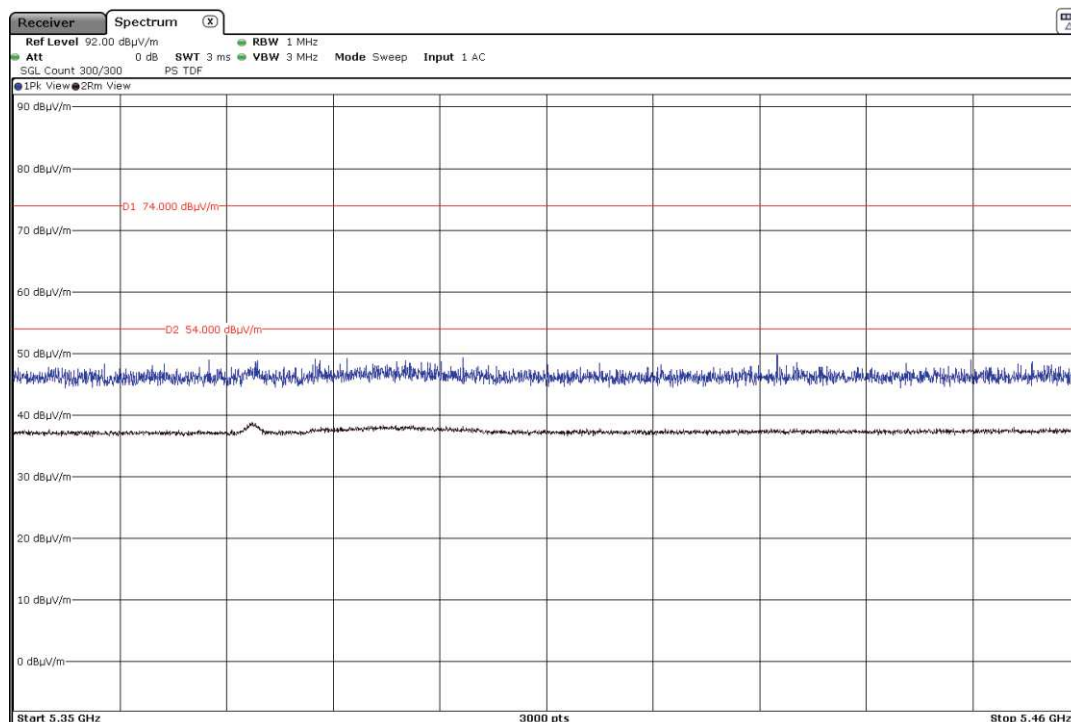


Mode: 802.11n HT20 – 20MHz

4500 MHz to 5150 MHz Lower Band Edge Channel 36

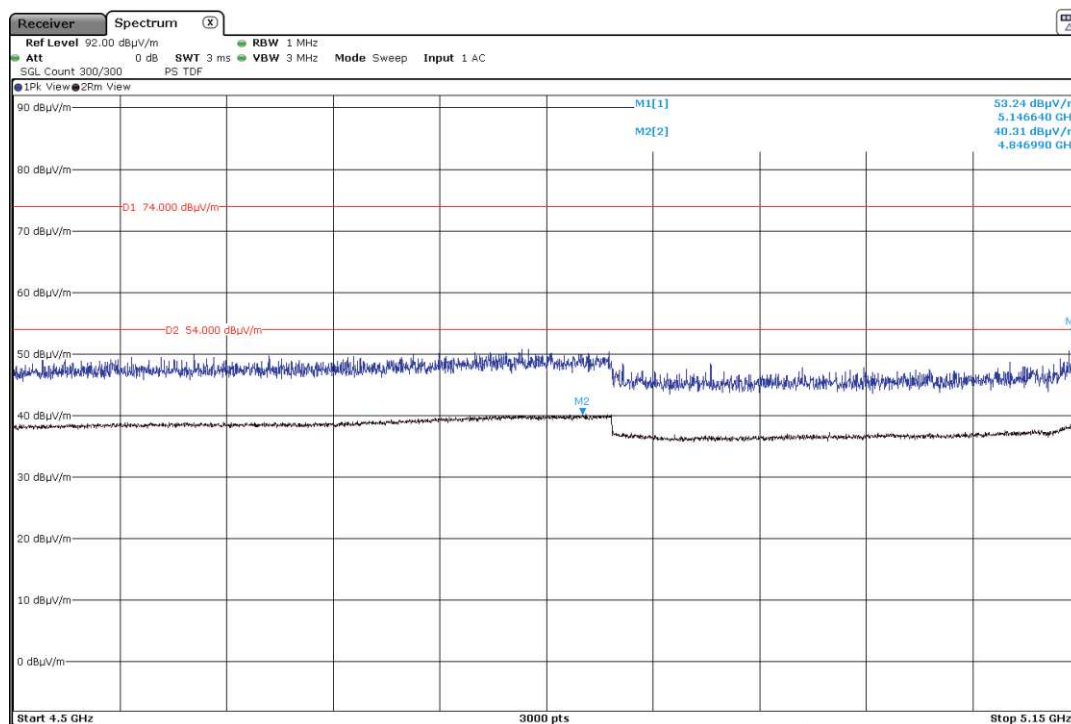


5350 MHz to 5460 MHz Upper Band Edge Channel 48

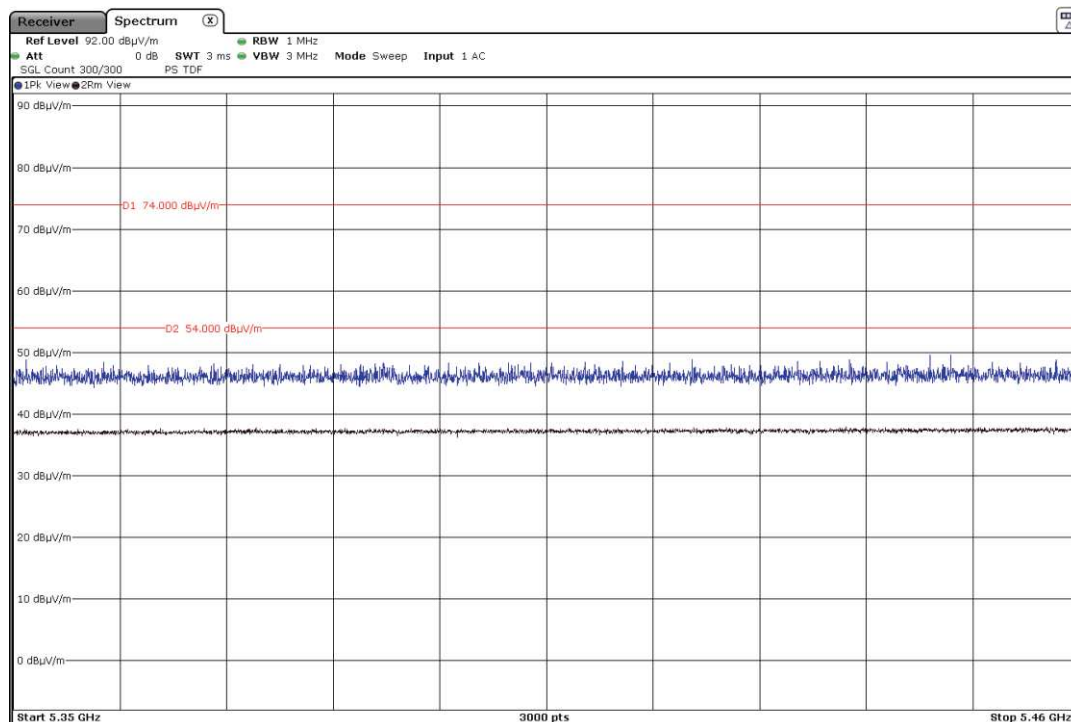


Mode: 802.11n HT40 – 40MHz

4500 MHz to 5150 MHz Lower Band Edge Channel 38

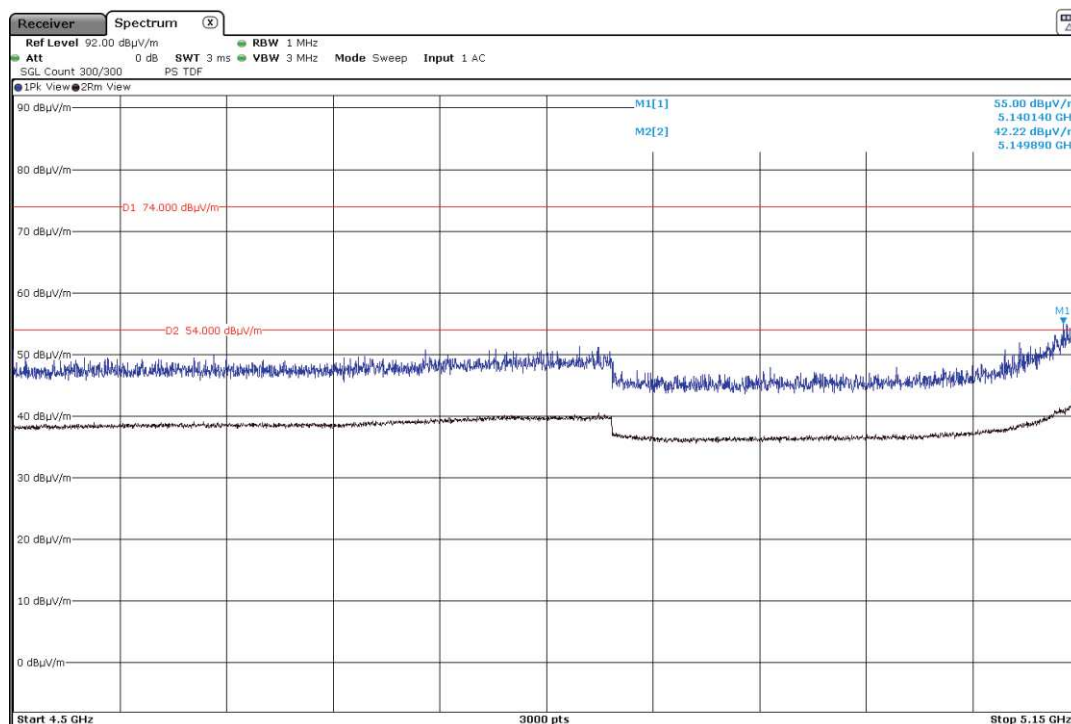


5350 MHz to 5460 MHz Upper Band Edge Channel 46



Mode: 802.11ac VHT80 – 80MHz

4500 MHz to 5150 MHz Lower Band Edge Channel 42



5350 MHz to 5460 MHz Upper Band Edge Channel 42

