# **Appendix B:** Tests results for the U-NII-3 Band 5.725 – 5.85 GHz

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# TEST CONDITIONS

POWER SUPPLY (V):

Vnominal: 12 Vdc
Type of Power Supply: External DC (Vehicle battery).

ANTENNA:

Type of Antenna: External.
Maximum Declared Assembly Antenna Gain: +2.5 dBi

TEST FREQUENCIES:

| | | |
|---|---|---|
| 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) |
| | 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

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).

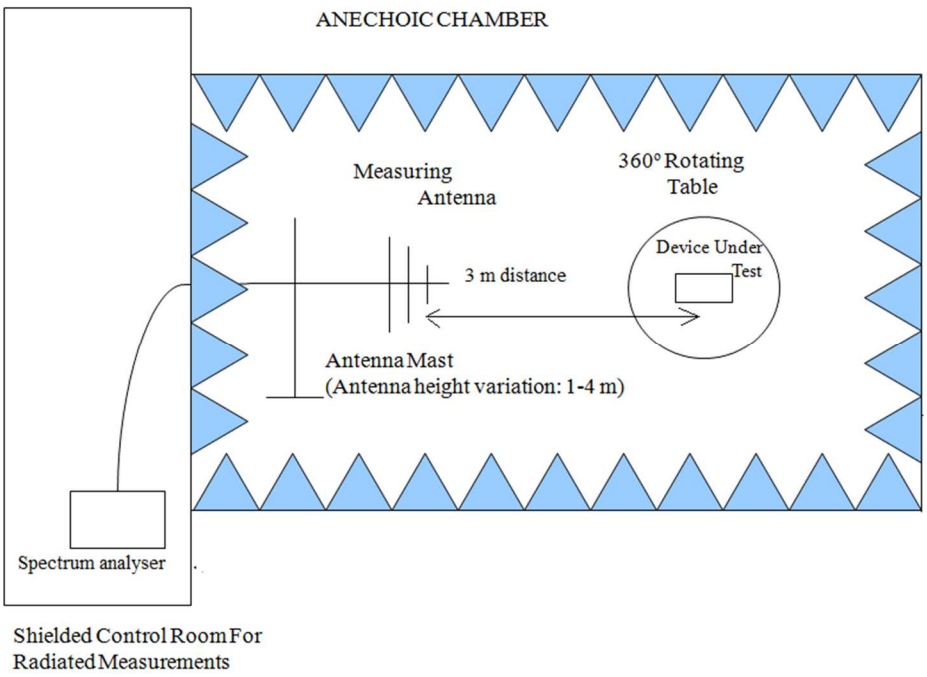
For radiated emissions in the range 1 GHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

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.

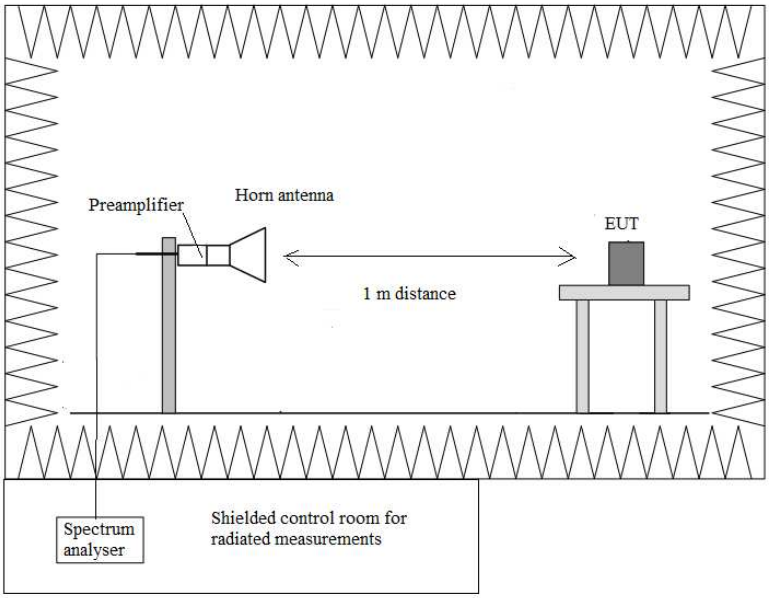
Measurements were made in both horizontal and vertical planes of polarization.

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

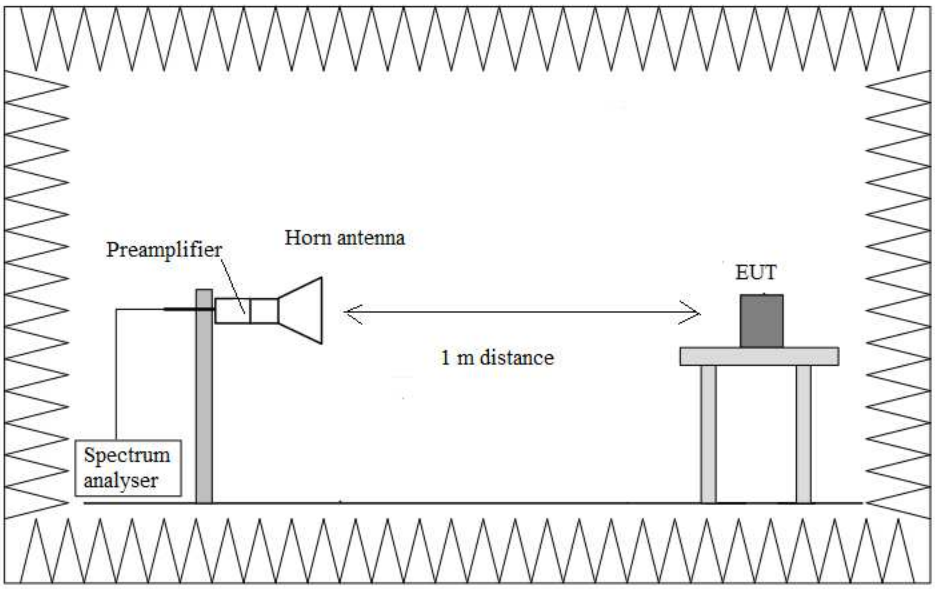
Radiated measurements setup f < 1 GHz



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




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



# FCC 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 34nalyser. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

- Test performed on the worst case: 802.11 ac20 (MSC0).

The worst case was determined by measuring the eirp density (radiated).

**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) at less than 20 dB below the limit:

| Spurious frequency (MHz) | Emission Level (dBµV/m) | Polarization | Detector | Measurement Uncertainty (dB) |
|---|---|---|---|---|
| 47.088 | 39.1 | V | Quasi-Peak | ± 5.08 |
| 125.012 | 39.7 | V | Quasi-Peak | ± 5.08 |
| 250.012 | 31.3 | V | Quasi-Peak | ± 5.08 |
| 375.013 | 29.1 | H | Quasi-Peak | ± 5.08 |

**Frequency range 1 - 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 Low, Middle and High Channels were measured for out-of-band emissions for the worst mode.

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

- **802.11 ac20 (worst case):**

- LOW CHANNEL. Spurious frequencies closest to the limit:

| Spurious frequency (GHz) | Emission Level (dBµV/m) | Polarization | Detector | Measurement Uncertainty (dB) |
|---|---|---|---|---|
| 2.4517 | 44.08 | H | Peak | <±4.11 |
| 2.9411 | 49.59 | V | Peak | <±4.11 |
| 11.4905 | 57.52 | H | Peak | <±5.13 |
| | 48.09 | | Average | <±5.13 |
| 39.32572 | 56.02 | V | Peak | <±5.14 |
| | 44.56 | | Average | <±5.14 |

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

| Spurious frequency (GHz) | Emission Level (dBµV/m) | Polarization | Detector | Measurement Uncertainty (dB) |
|---|---|---|---|---|
| 2.4517 | 44.31 | H | Peak | <±4.11 |
| 5.63554 | 51.15 | H | Peak | <±4.11 |
| 11.56583 | 56 | H | Peak | <±5.13 |
| | 46.62 | | Average | <±5.13 |
| 39.57642 | 54.82 | V | Peak | <±5.14 |
| | 45.05 | | Average | <±5.14 |
| 39.46372 | 55.11 | H | Peak | <±5.14 |
| | 44.59 | | Average | <±5.14 |

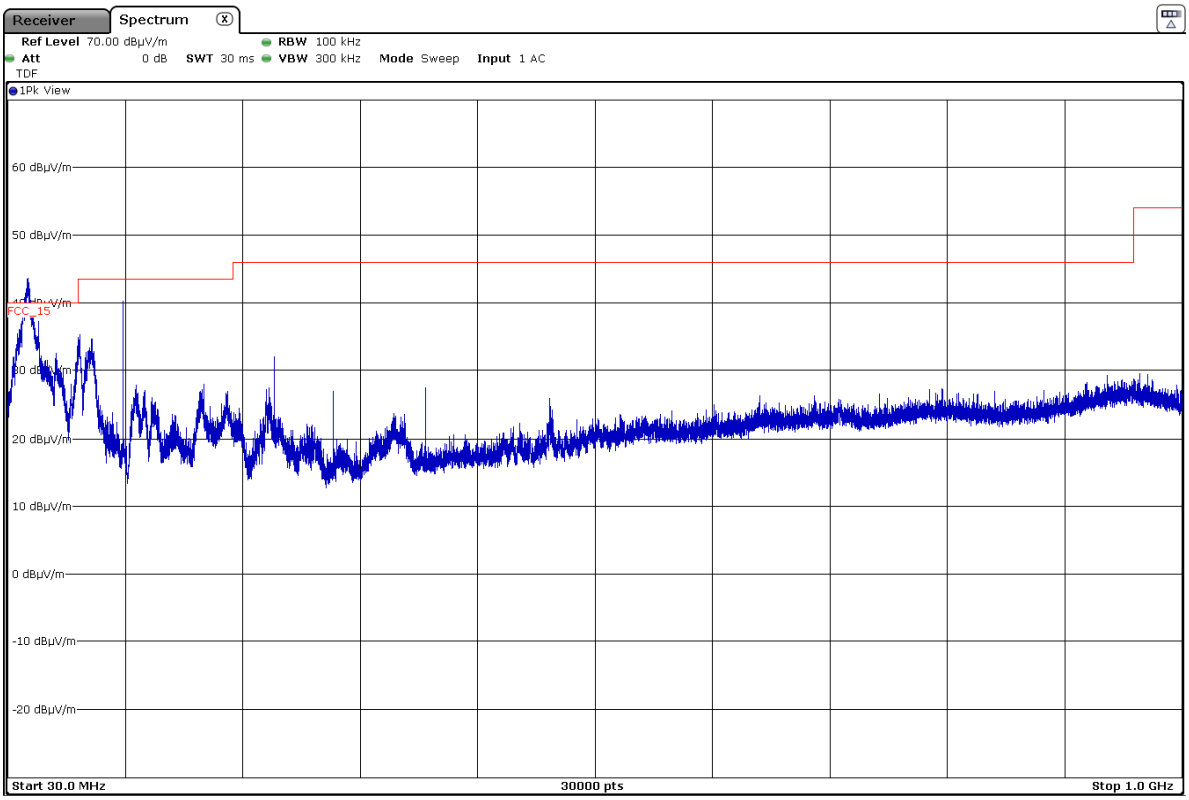
- HIGH CHANNEL. Spurious frequencies closest to the limit:

| Spurious frequency (GHz) | Emission Level (dBµV/m) | Polarization | Detector | Measurement Uncertainty (dB) |
|---|---|---|---|---|
| 5.67489 | 50.81 | V | Peak | <±4.11 |
| 11.65083 | 53.64 | V | Peak | <±5.13 |
| 39.56415 | 55.68 | V | Peak | <±5.14 |
| | 44.54 | | Average | <±5.14 |
| 39.38322 | 54.75 | H | Peak | <±5.14 |
| | 44.53 | | Average | <±5.14 |

Verdict: PASS

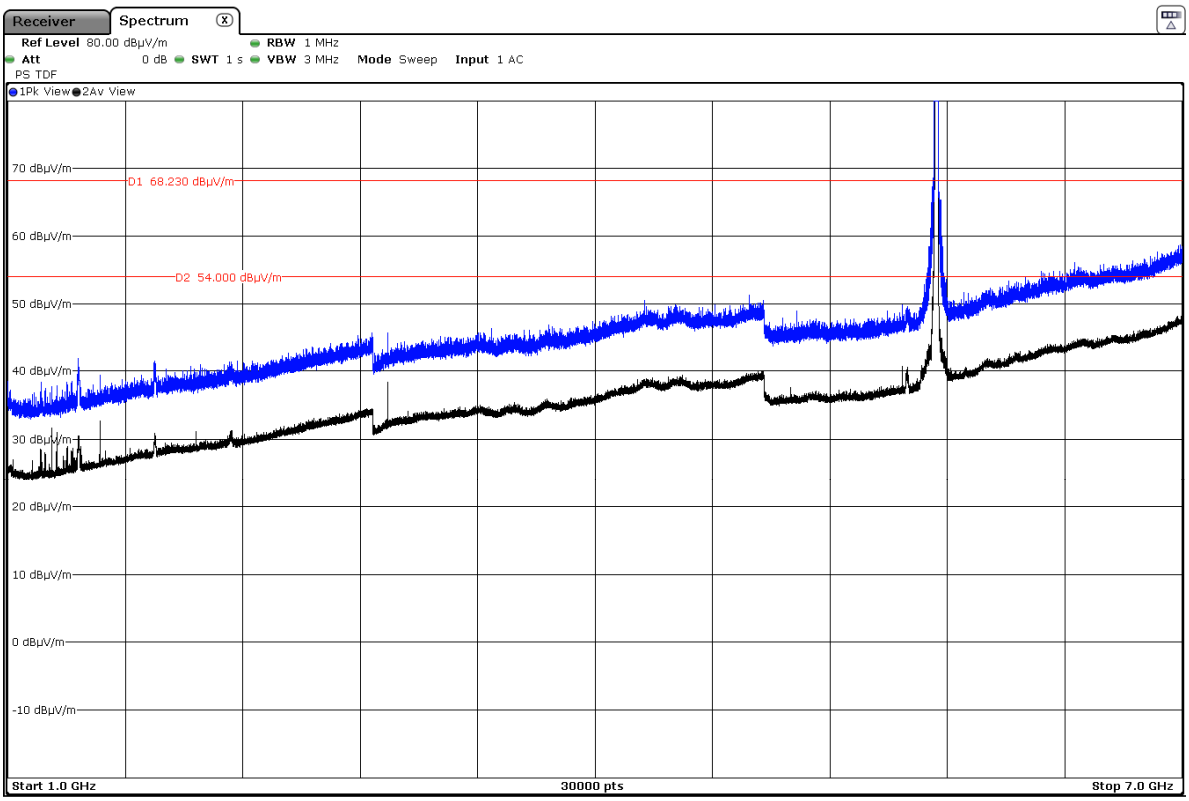
**FREQUENCY RANGE 30 MHz - 1 GHz:**

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



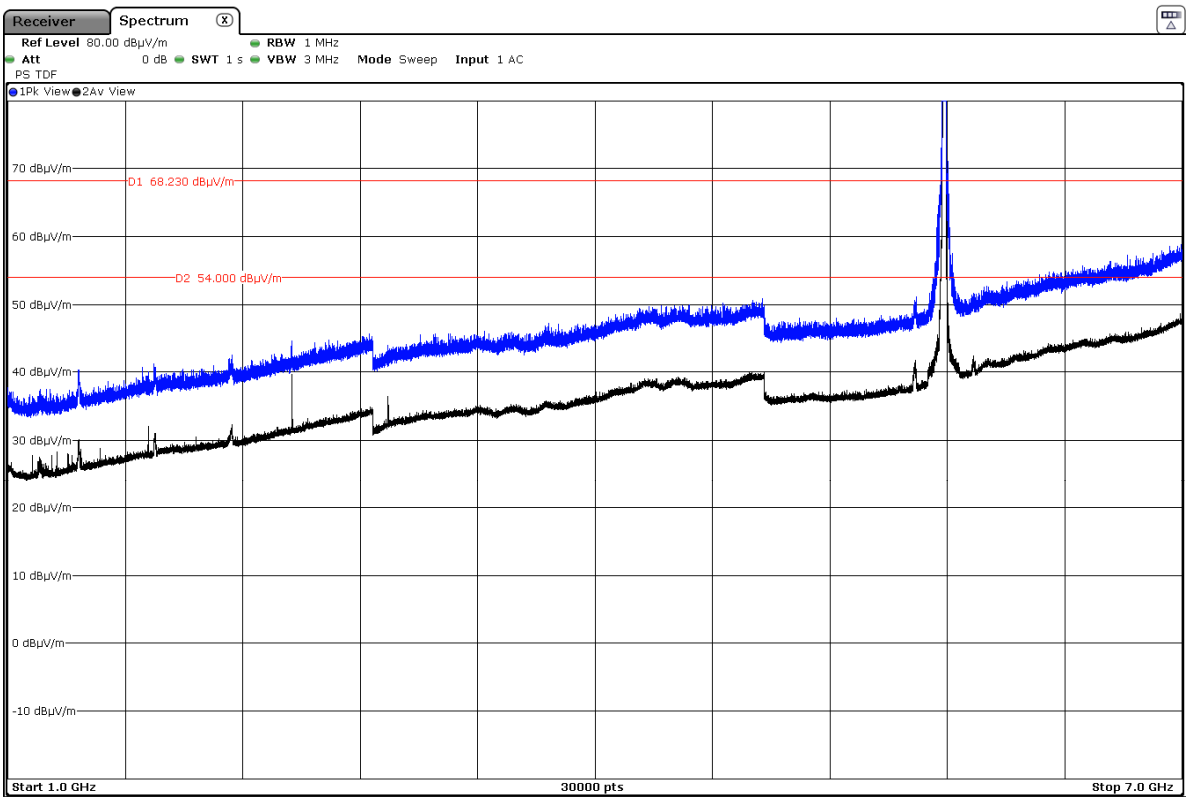
## FREQUENCY RANGE 1 – 7 GHz (worst case):

- Low Channel:



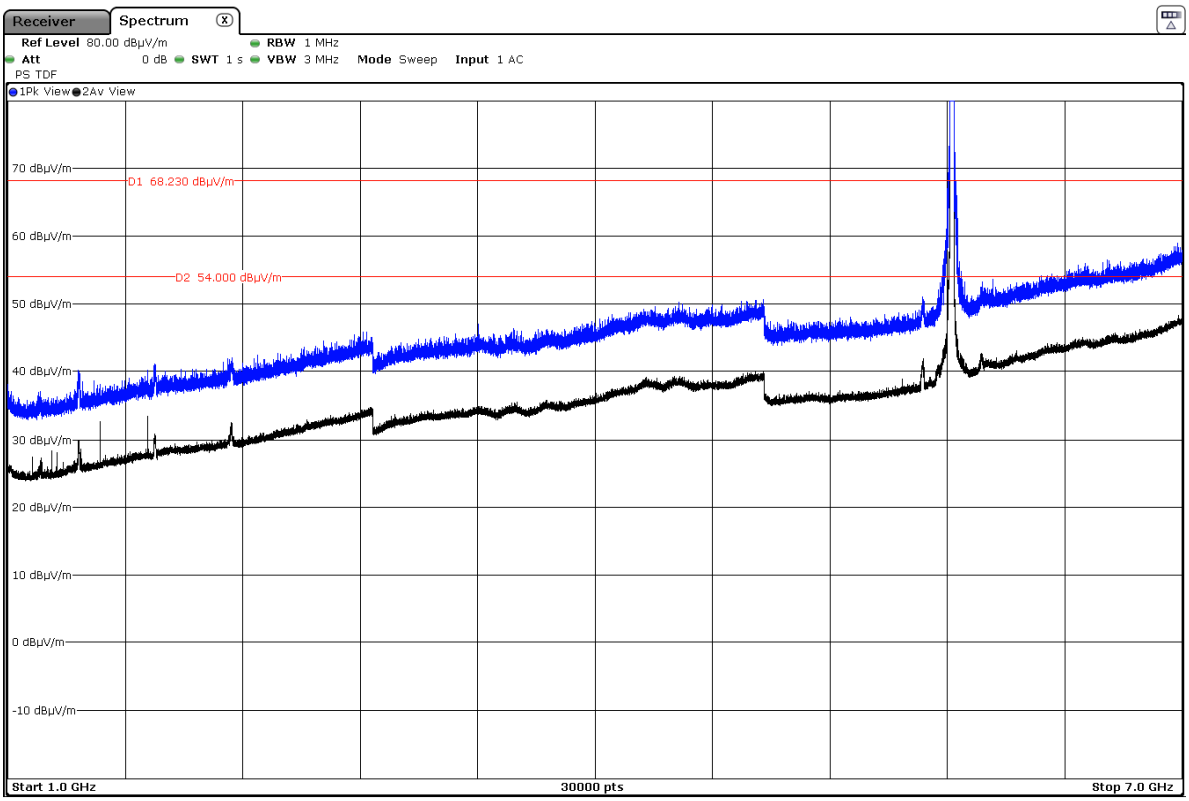

The peak above the limit is the carrier frequency.

- Middle Channel:




The peak above the limit is the carrier frequency.

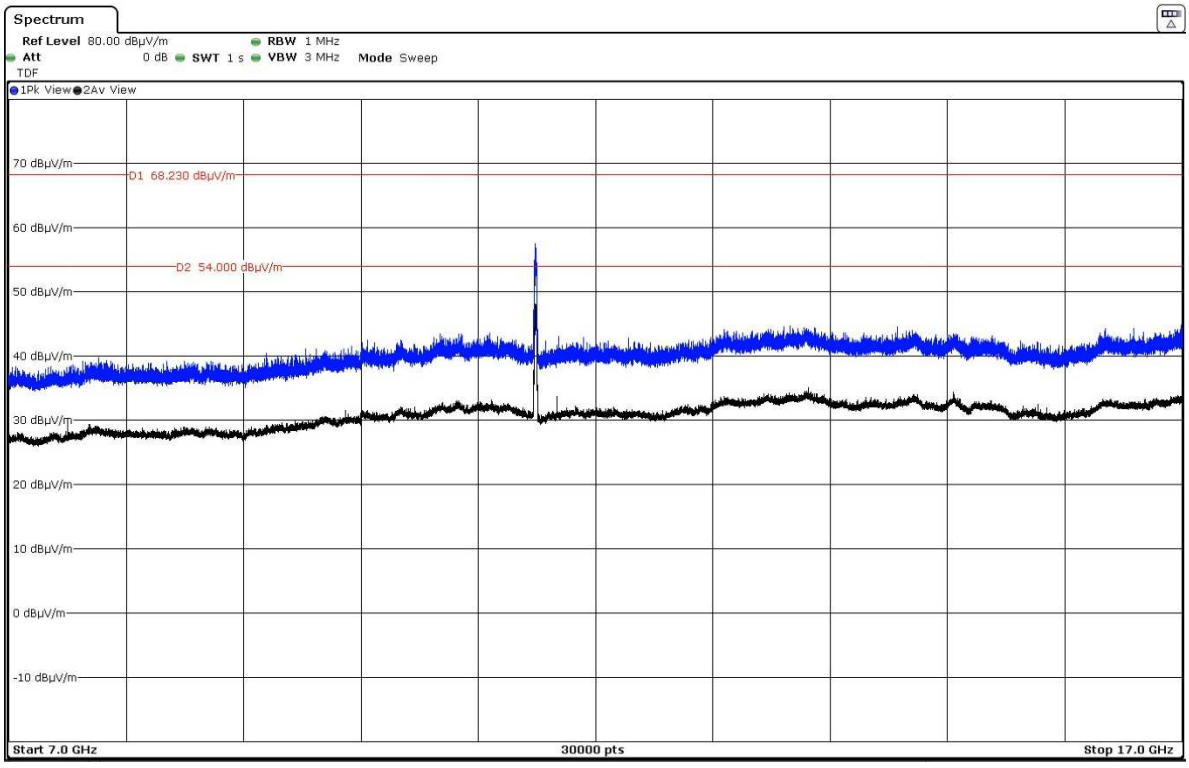
- High Channel:



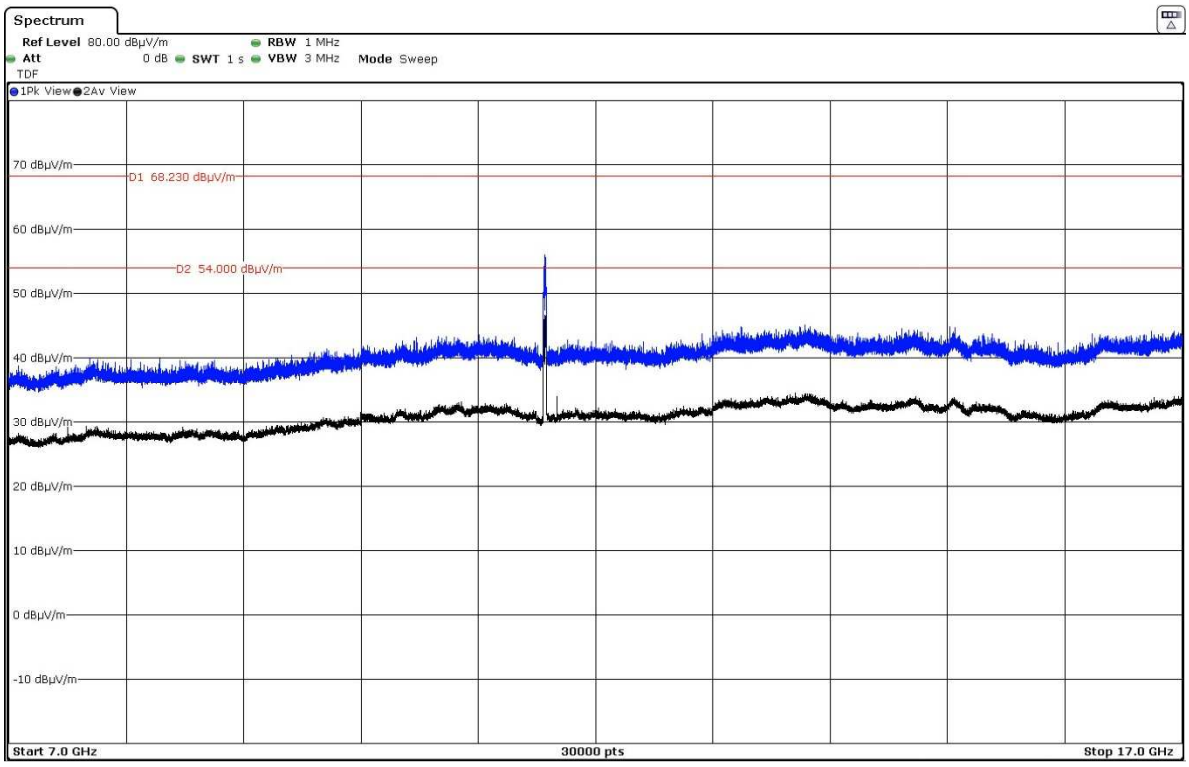

The peak above the limit is the carrier frequency.

**FREQUENCY RANGE 7 - 17 GHz (worst case):**

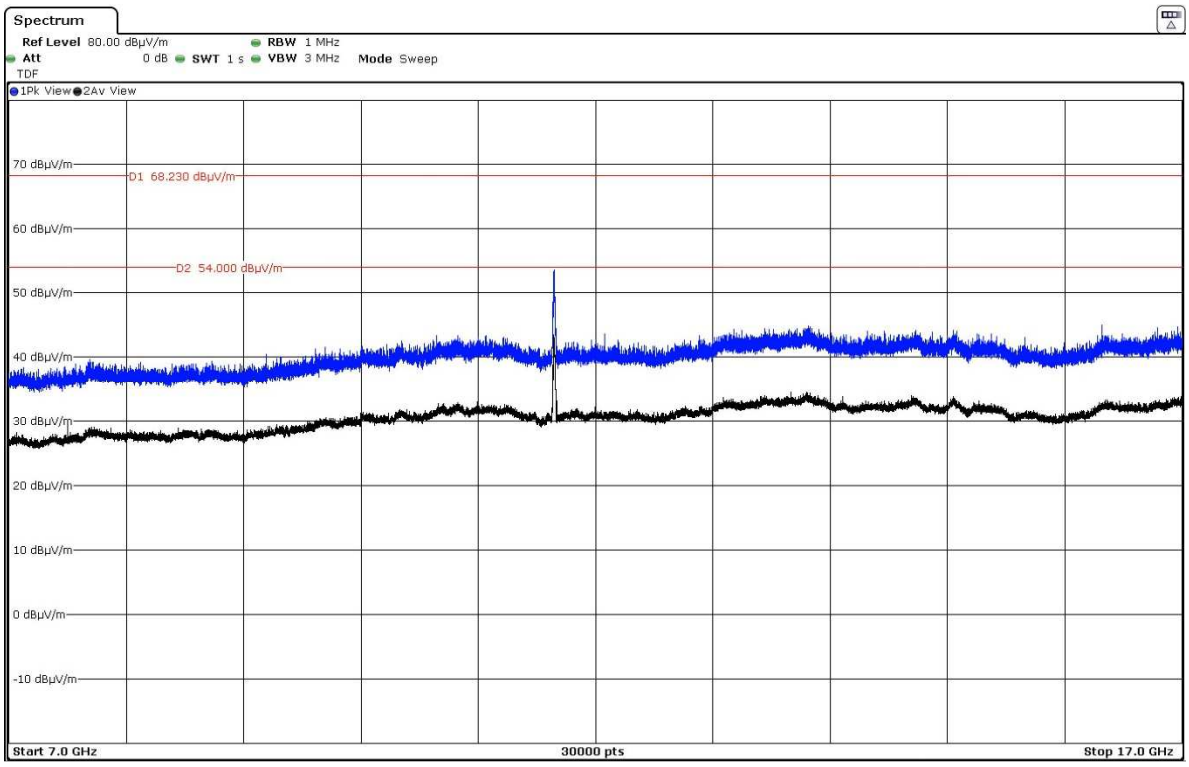
- Low Channel:



- Middle Channel:

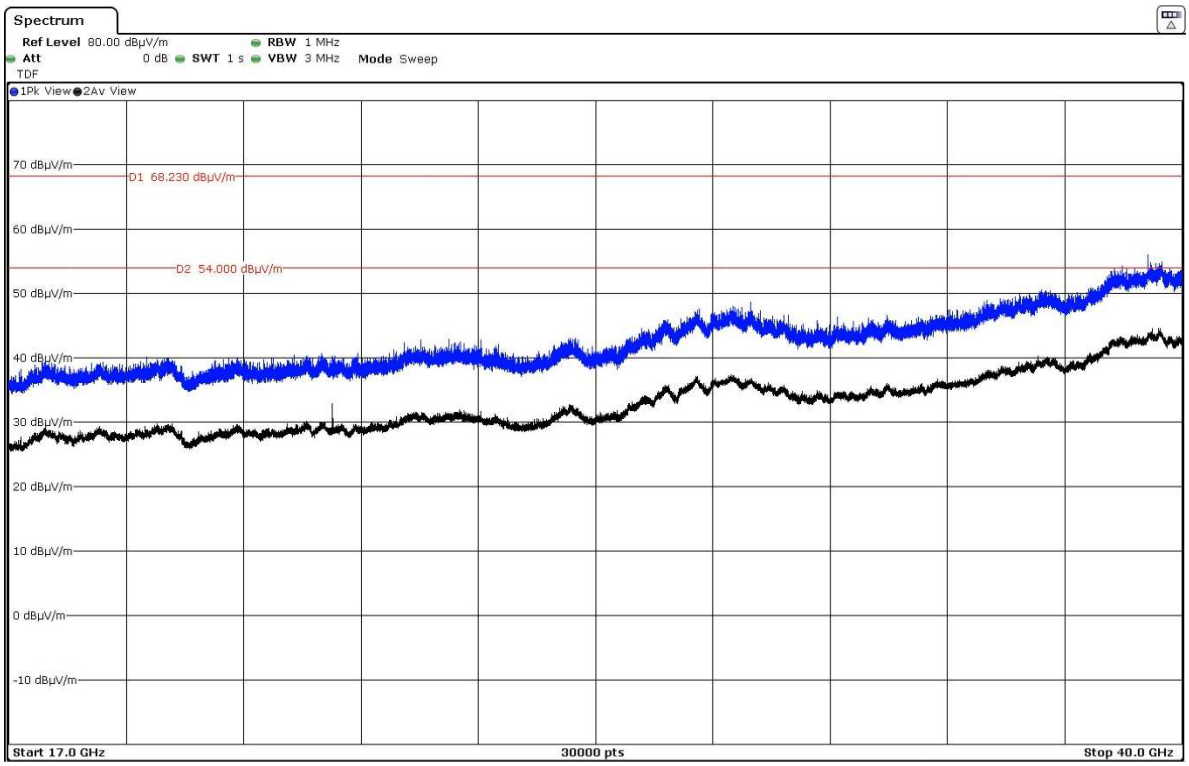



- High Channel:



## FREQUENCY RANGE 17 - 40 GHz

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



# FCC 15.407 (b)(4) / RSS-247 6.2.4.2. 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) |
|---|---|---|---|
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| 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.

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

- 802.11a20: 6 Mbits
- 802.11n HT20: MCS0
- 802.11n HT40: MCS0
- 802.11ac VHT40: MCS0
- 802.11ac VHT80: MCS0

- **802.11 a20:**

Inside band spurious emissions in 5.65-5.925 GHz adjacent band.

- Lower Channel 149 (5745 MHz):

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

- Middle Channel 157 (5785 MHz):

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

- High Channel 165 (5825 MHz):

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

The measurement uncertainly (dB) is <±4.11

- **802.11 n20:**

Inside band spurious emissions in 5.65-5.925 GHz adjacent band.

- Low Channel 149 (5745 MHz):

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

- Middle Channel 157 (5785 MHz):

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

- High Channel 165 (5825 MHz):

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

The measurement uncertainly (dB) is <±4.11

- **802.11 ac20:**

Inside band spurious emissions in 5.65-5.925 GHz adjacent band.

- Low Channel 149 (5745 MHz):

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

- Middle Channel 157 (5785 MHz):

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

- High Channel 165 (5825 MHz):

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

The measurement uncertainly (dB) is <±4.11

- **802.11 n40:**

Inside band spurious emissions in 5.65-5.925 GHz adjacent band.

- Low Channel 151 (5755 MHz):

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

- High Channel 159 (5795 MHz):

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

The measurement uncertainly (dB) is <±4.11

- **802.11 ac40:**

Inside band spurious emissions in 5.65-5.925 GHz adjacent band.

- Low Channel 151 (5755 MHz):

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

- High Channel 159 (5795 MHz):

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

The measurement uncertainly (dB) is <±4.11

- **802.11 ac80:**

Inside band spurious emissions in 5.65-5.925 GHz adjacent band.

- Middle Channel 155 (5775 MHz):

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

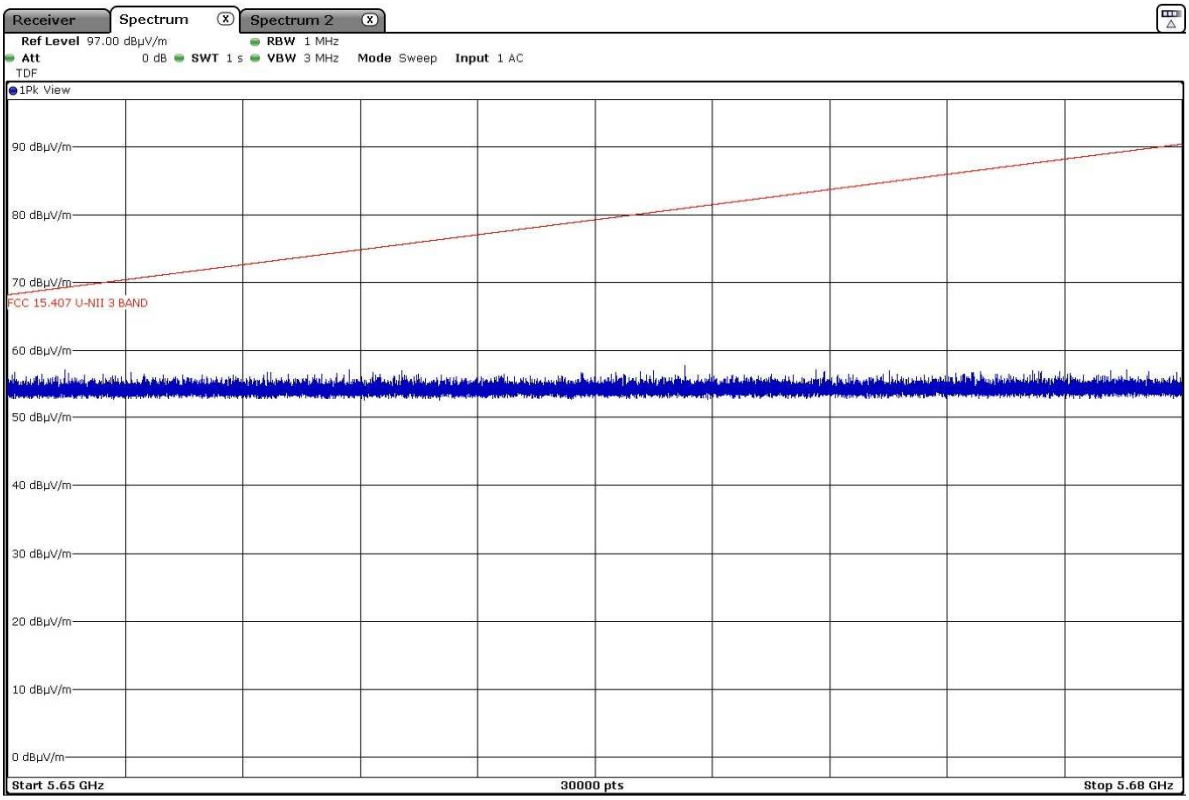
The measurement uncertainly (dB) is <±4.11

Verdict: PASS

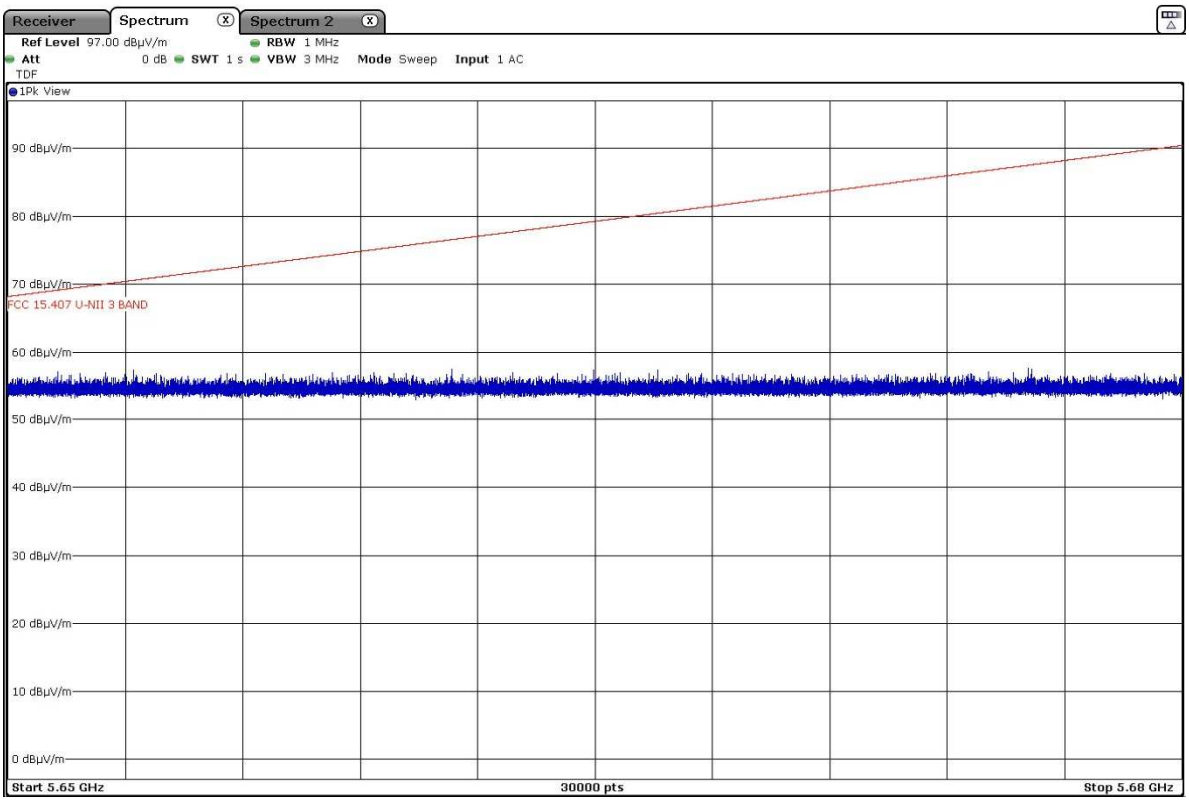
- **802.11 a20:**

**Radiated spurious emissions at band-edges and inside adjacent band 5.65 – 5.68 GHz**

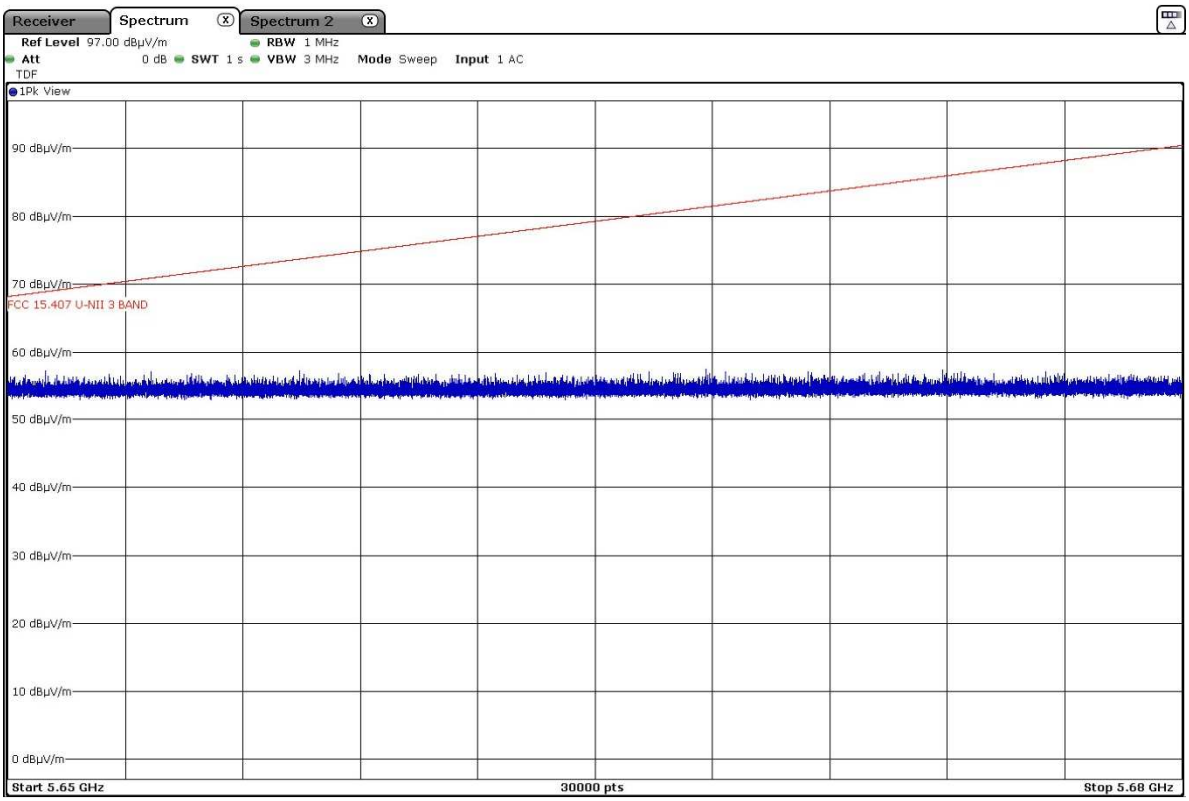
- Low Channel 149 (5745 MHz):




- Middle Channel 157 (5785 MHz):

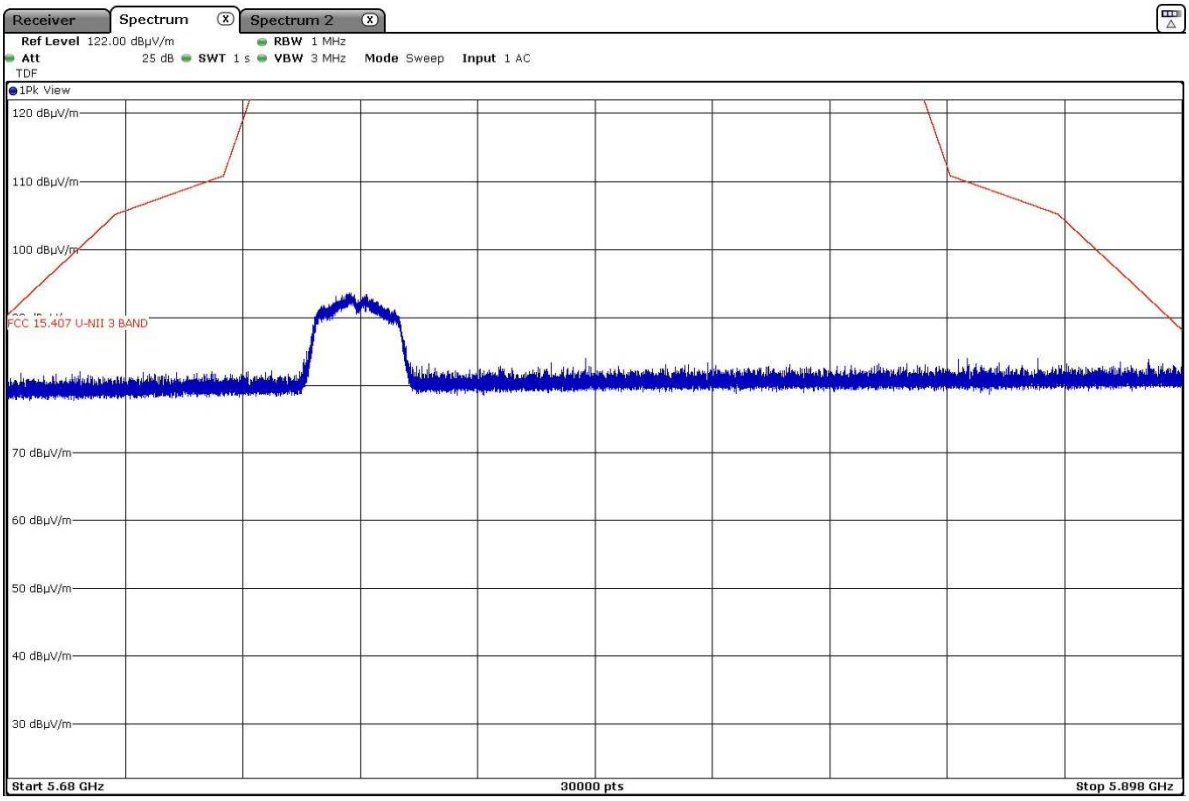


- High Channel 165 (5825 MHz):

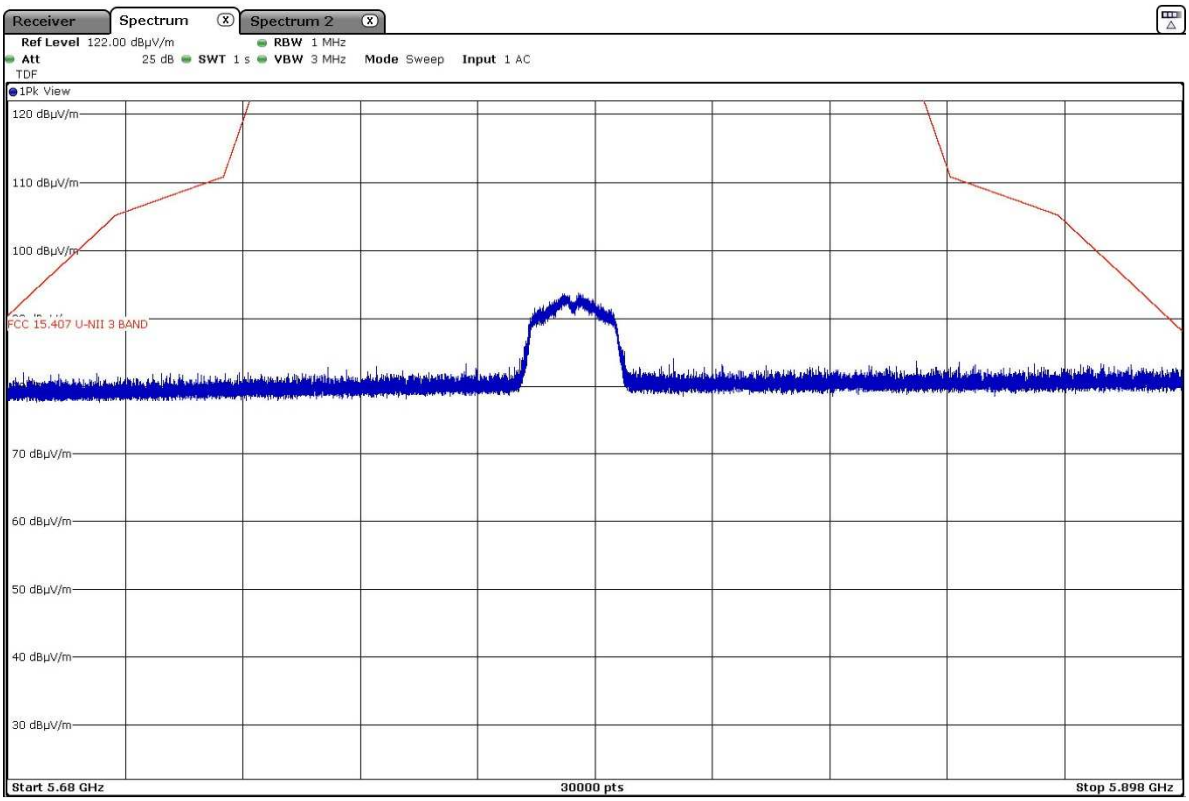



**Radiated spurious emissions at band-edges and inside adjacent band 5.68 – 5.898 GHz**

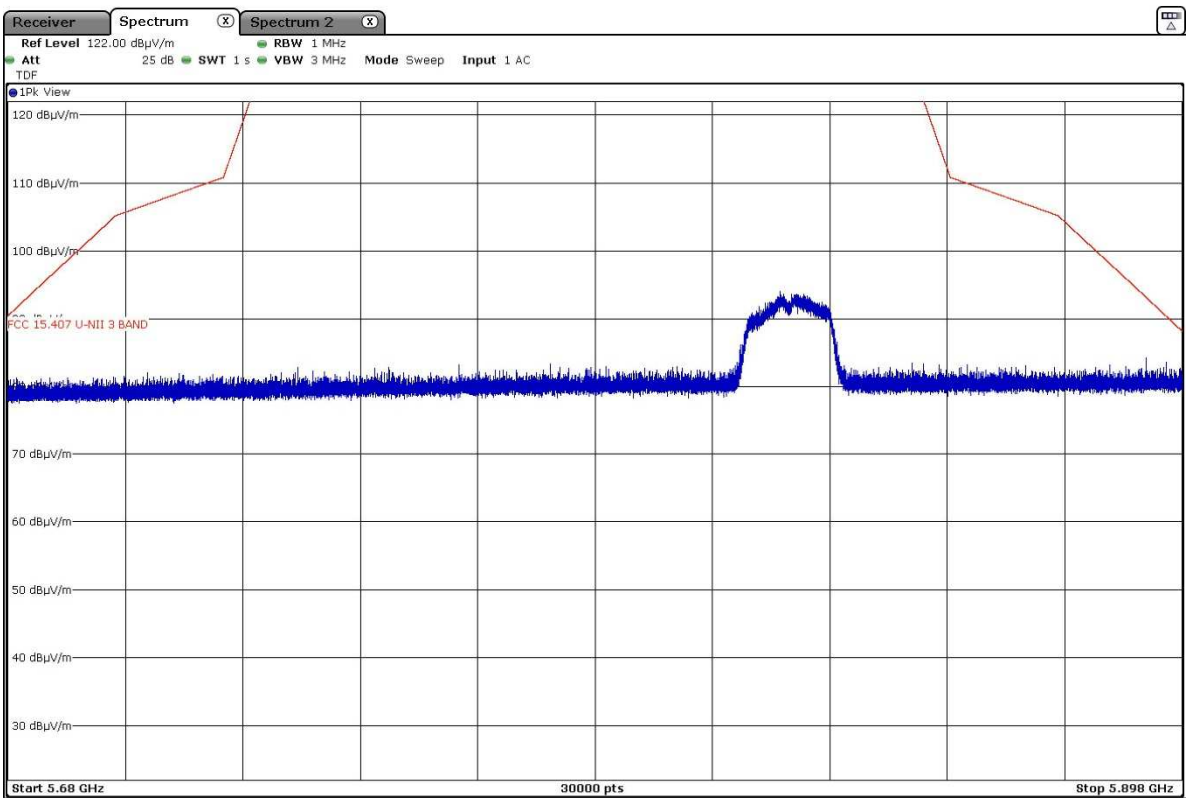
- Low Channel 149 (5745 MHz):



- Middle Channel 157 (5785 MHz):

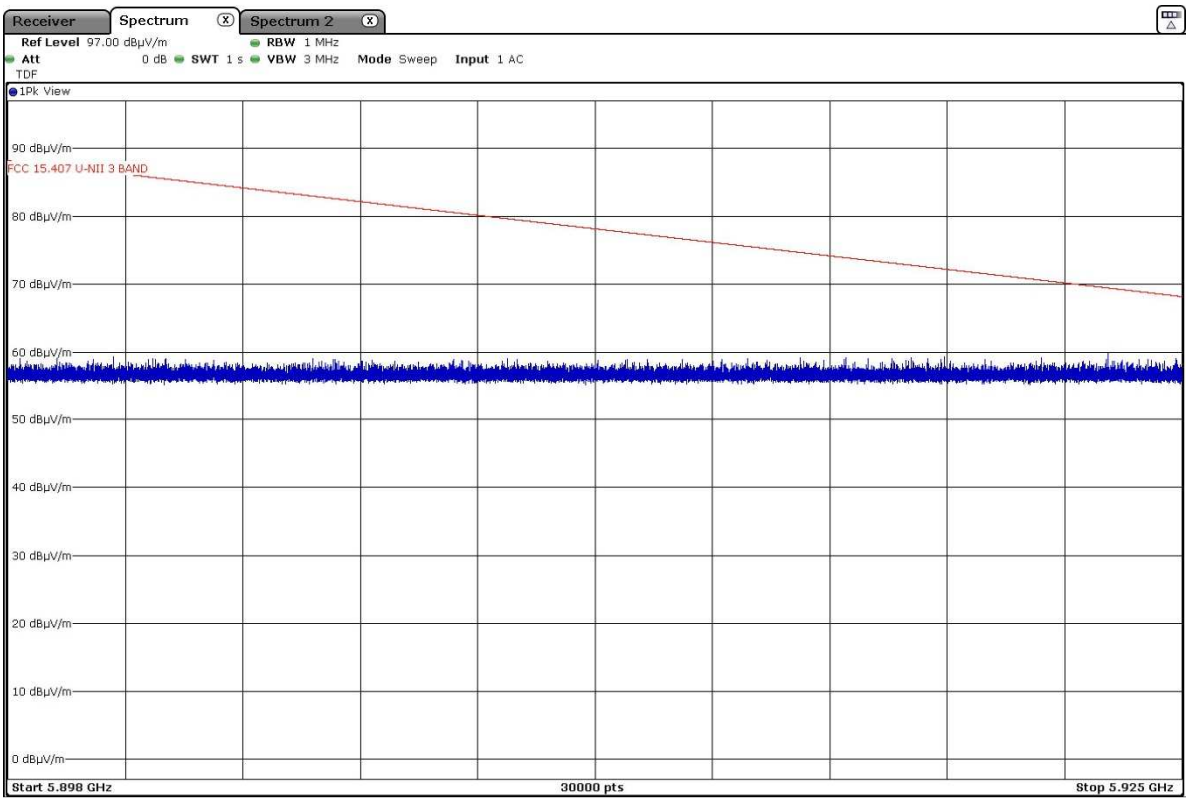



- High Channel 165 (5825 MHz):

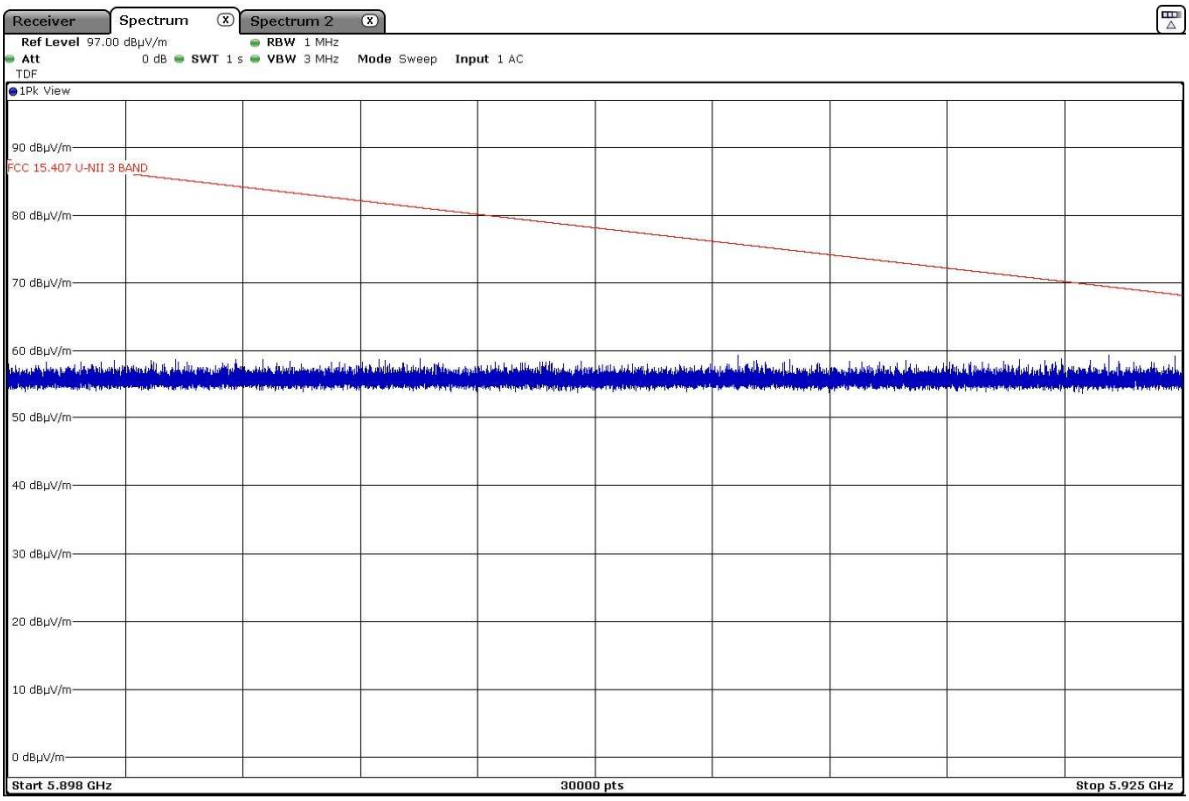


## Radiated spurious emissions at band-edges and inside adjacent band 5.898 – 5.925 GHz

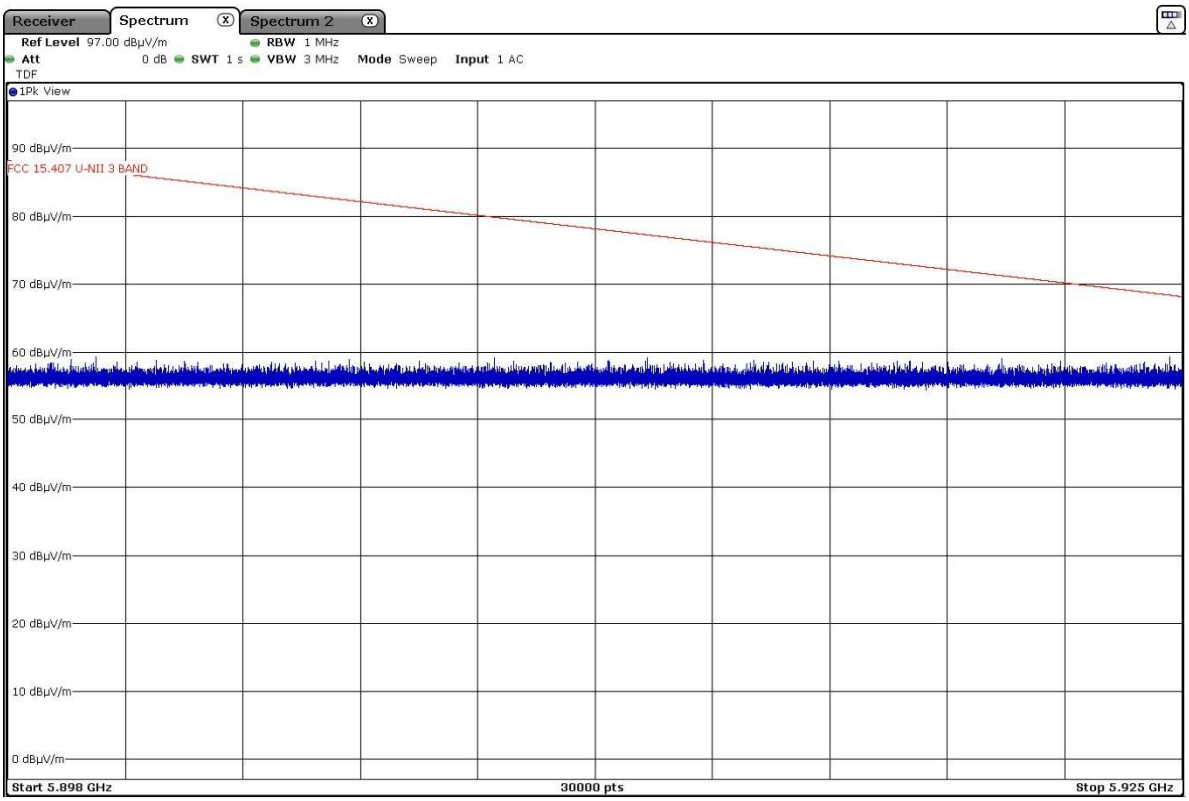
- Low Channel 149 (5745 MHz):




- Middle Channel 157 (5785 MHz):



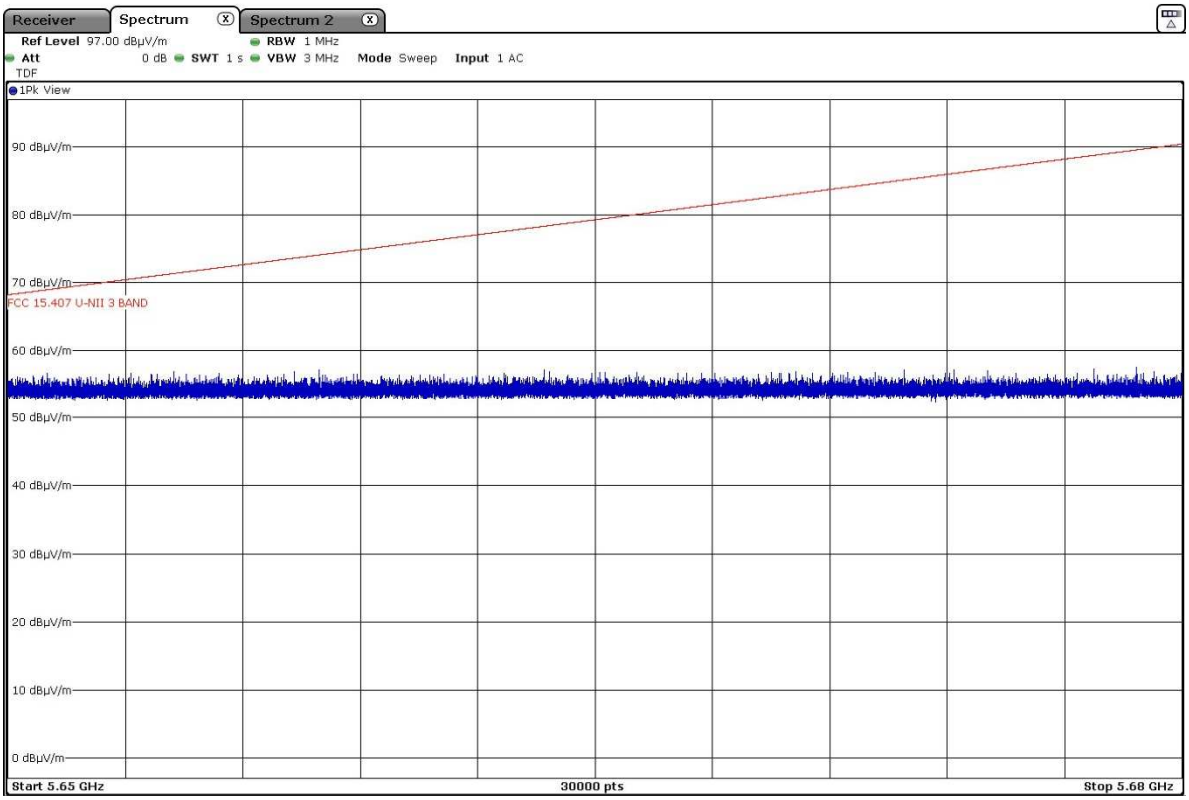
- High Channel 165 (5825 MHz):



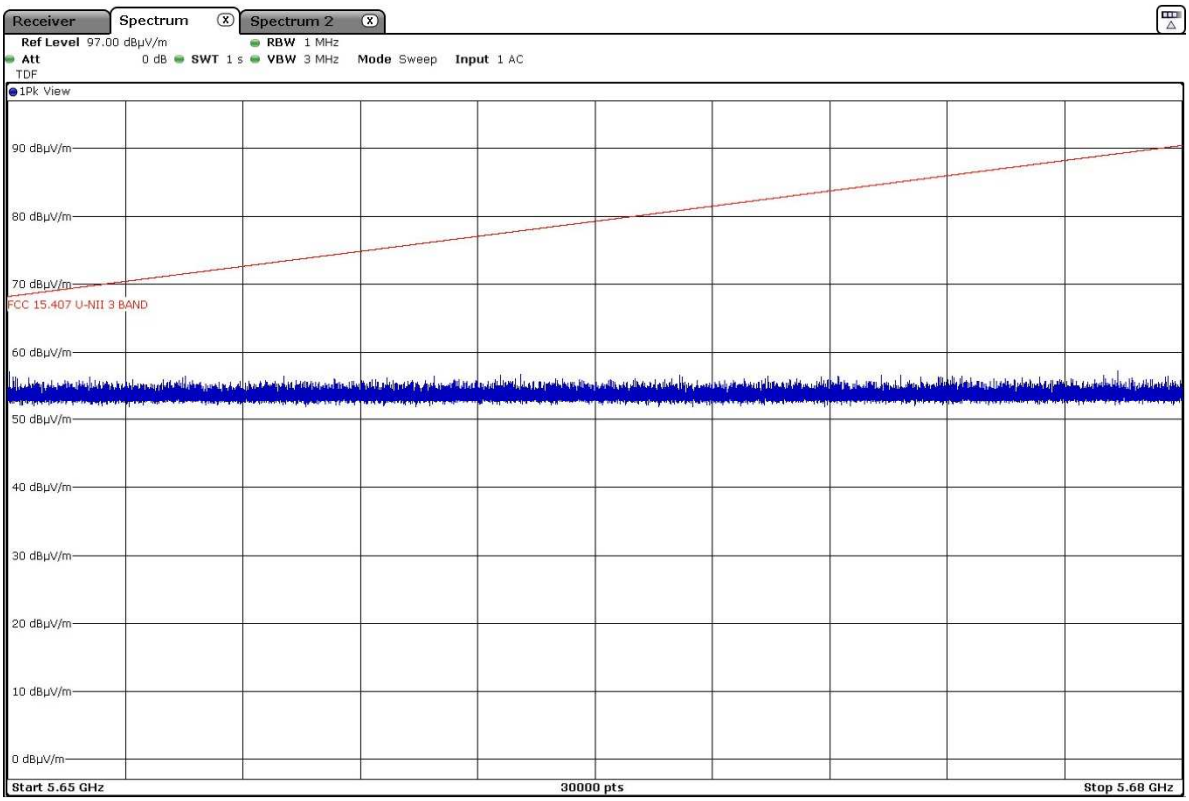

- **802.11 n20:**

**Radiated spurious emissions at band-edges and inside adjacent band 5.65 – 5.68 GHz**

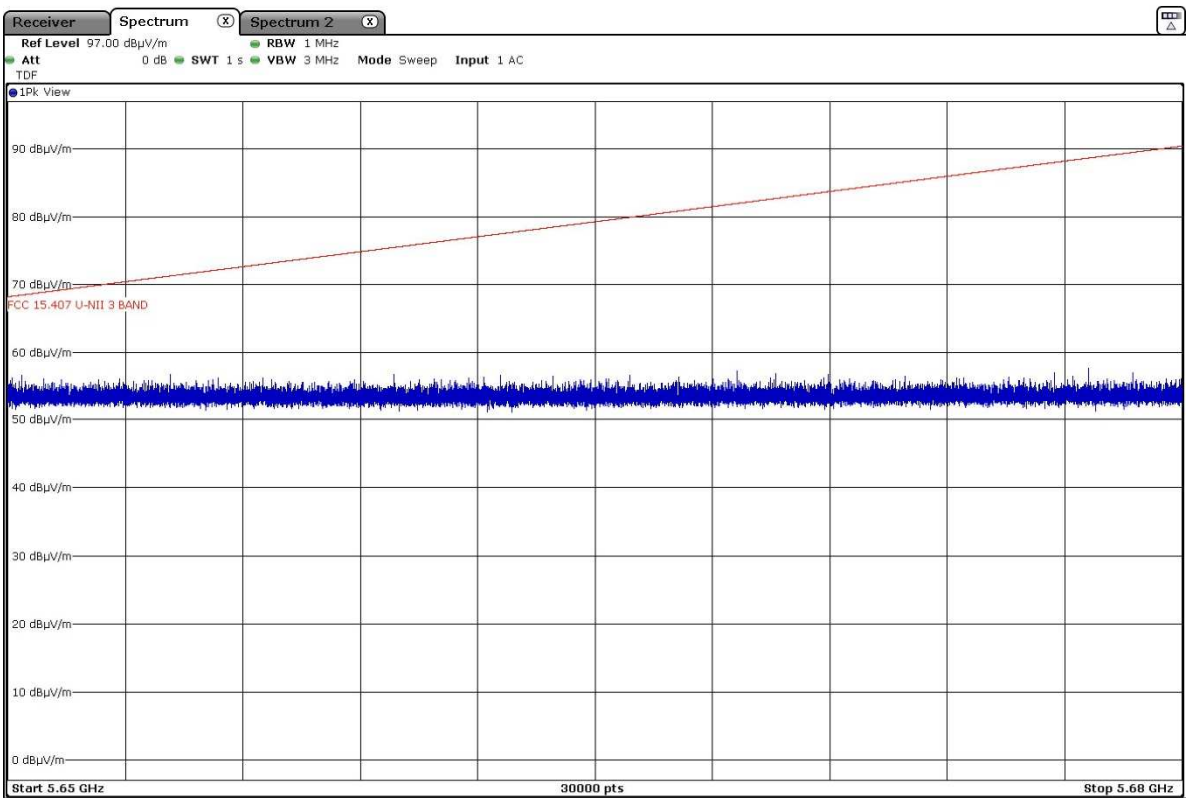
- Low Channel 149 (5745 MHz):



- Middle Channel 157 (5785 MHz):

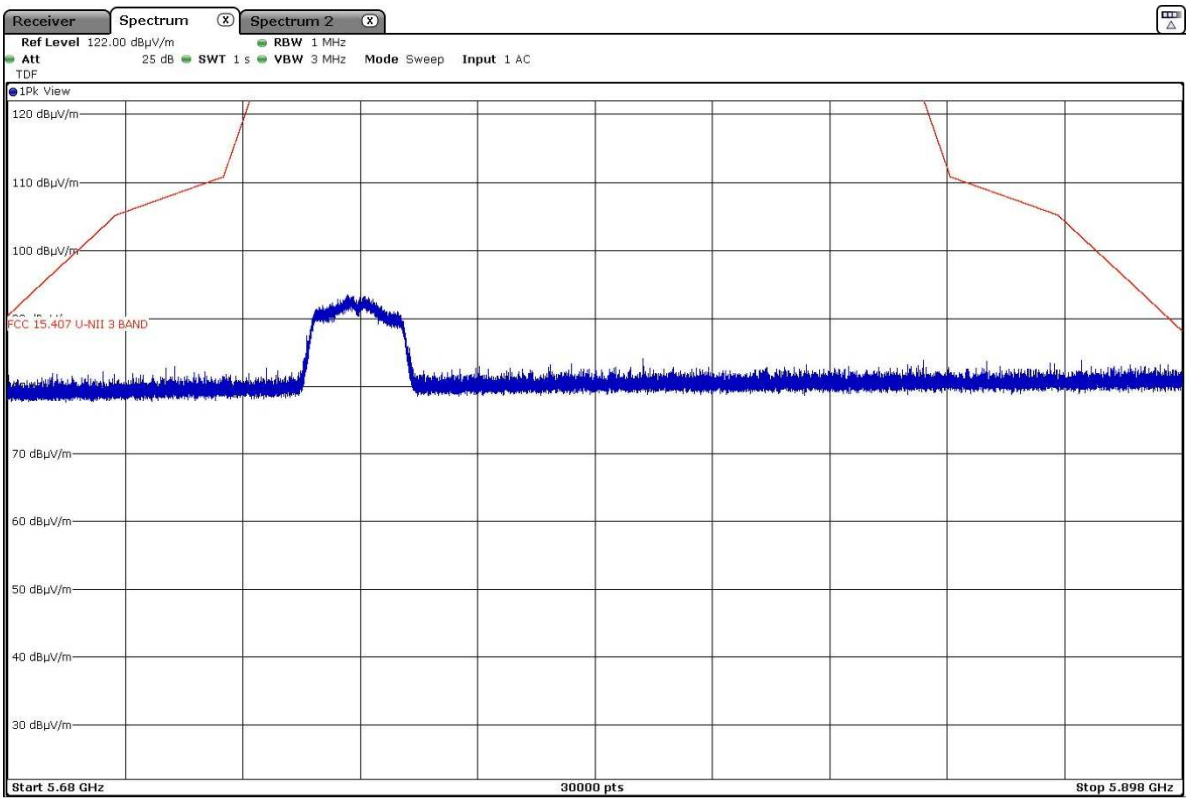



- High Channel 165 (5825 MHz):

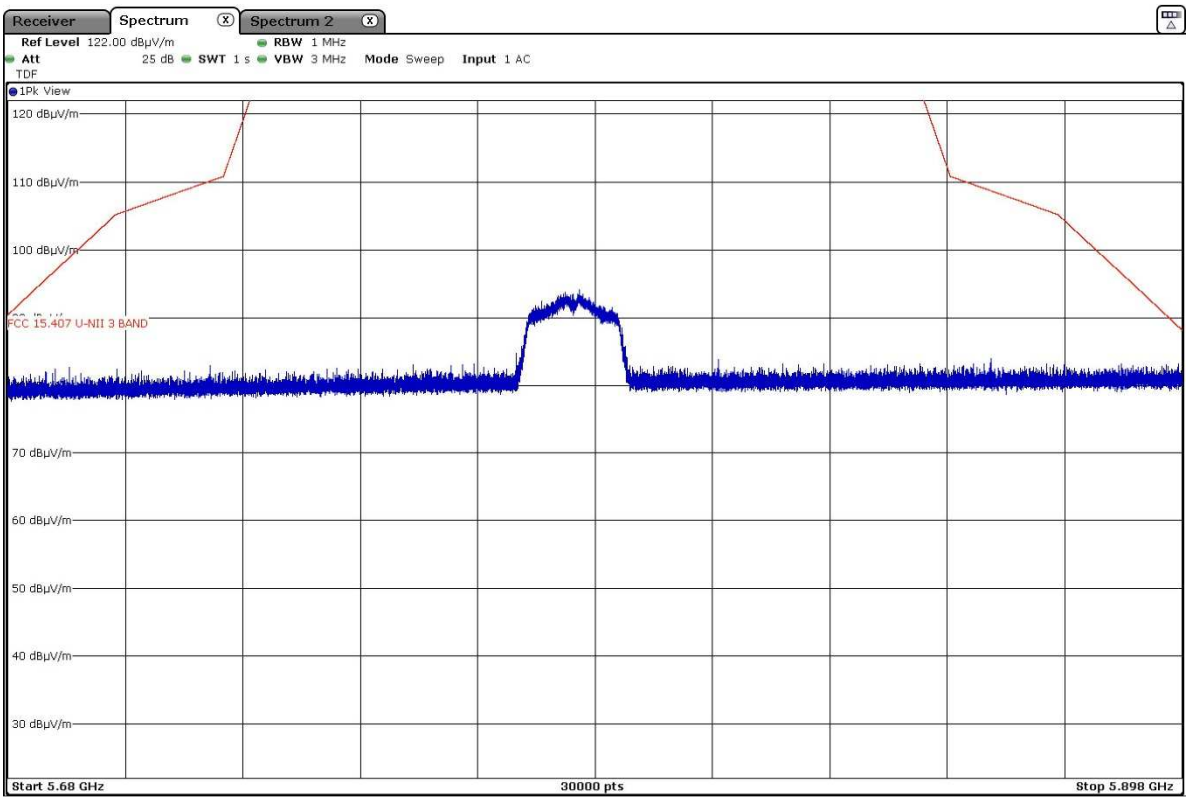


**Radiated spurious emissions at band-edges and inside adjacent band 5.68 – 5.898 GHz**

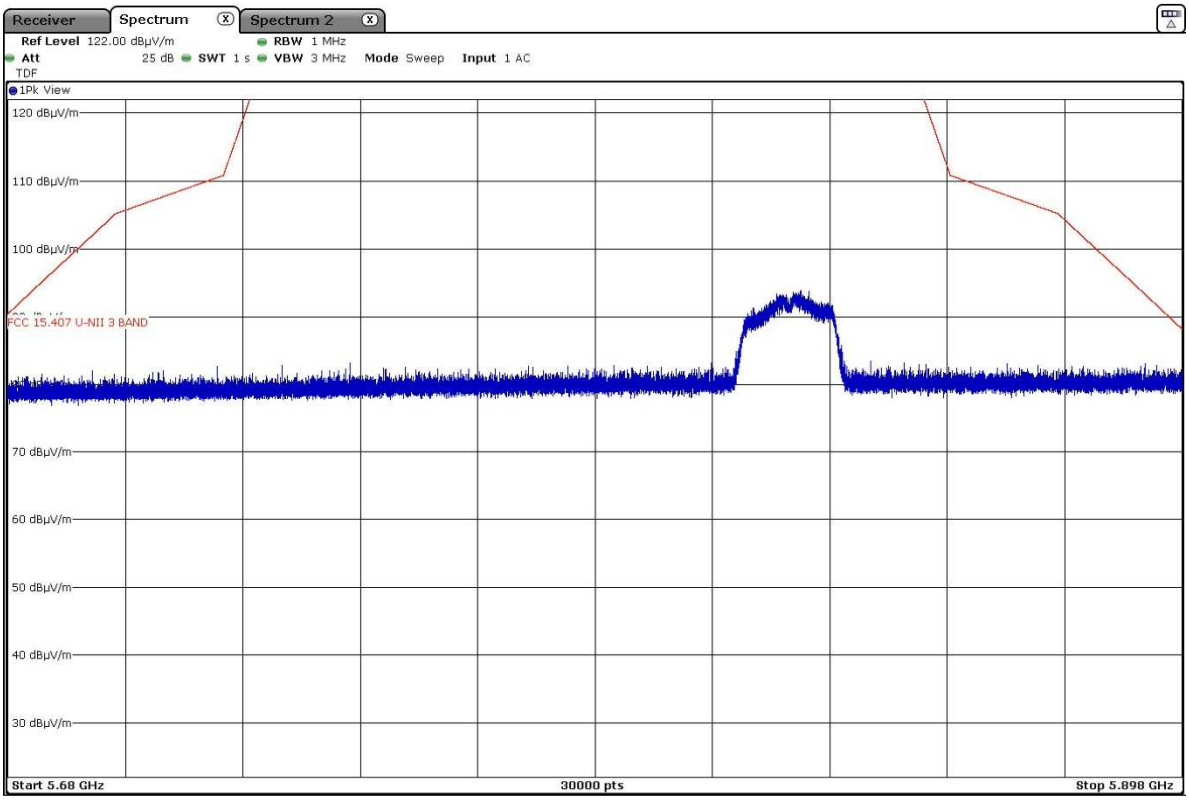
- Low Channel 149 (5745 MHz):




- Middle Channel 157 (5785 MHz):

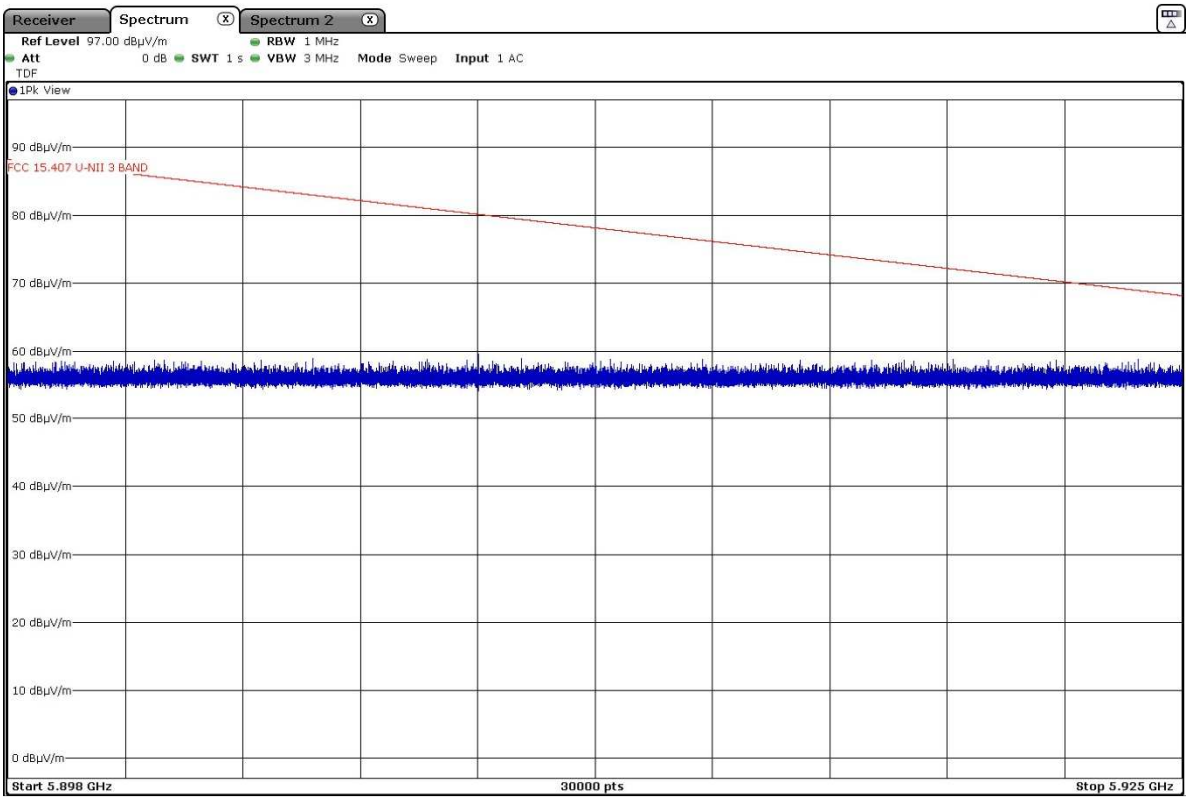


- High Channel 165 (5825 MHz):

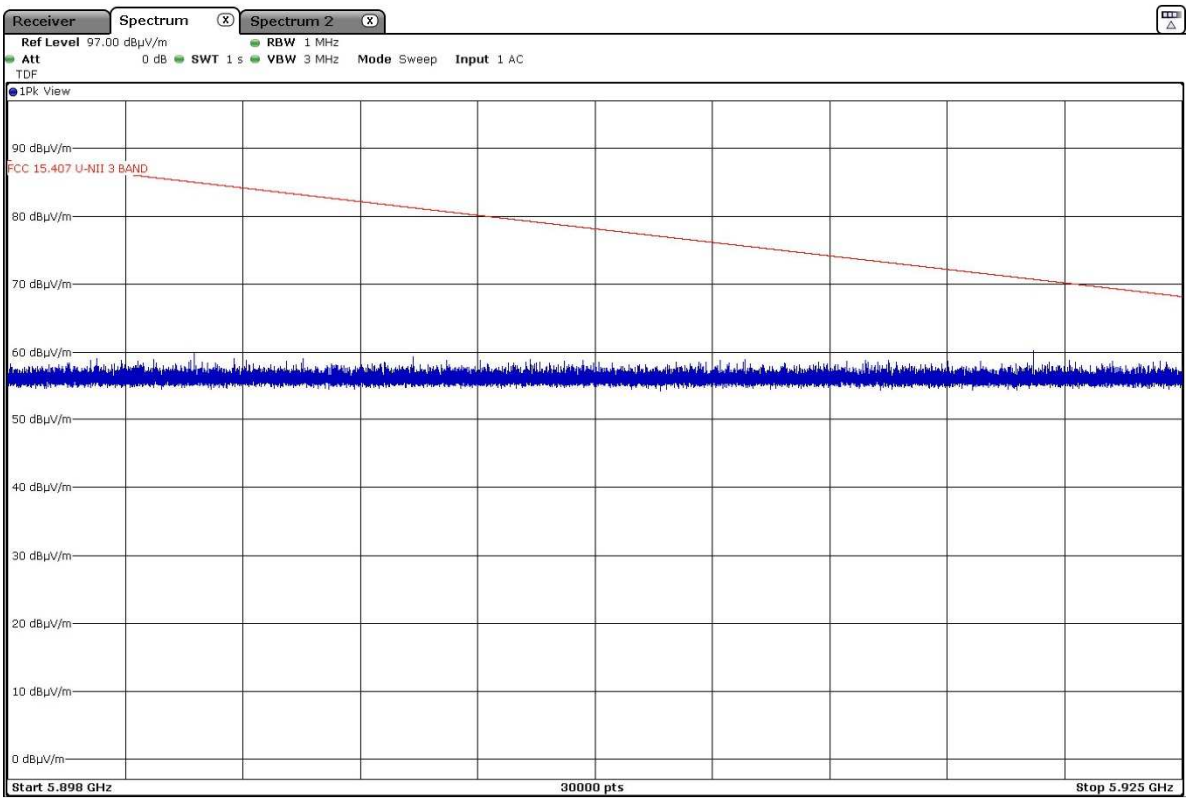



**Radiated spurious emissions at band-edges and inside adjacent band 5.898 – 5.925 GHz**

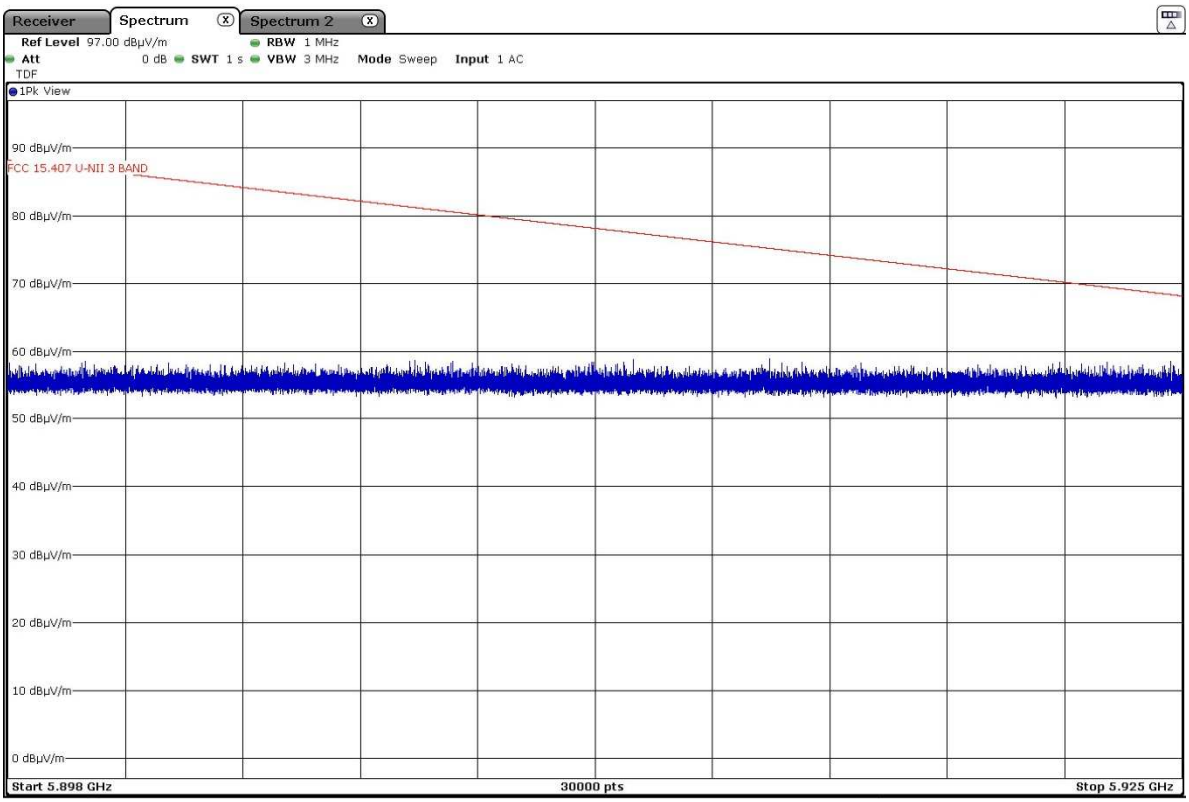
- Low Channel 149 (5745 MHz):



- Middle Channel 157 (5785 MHz):



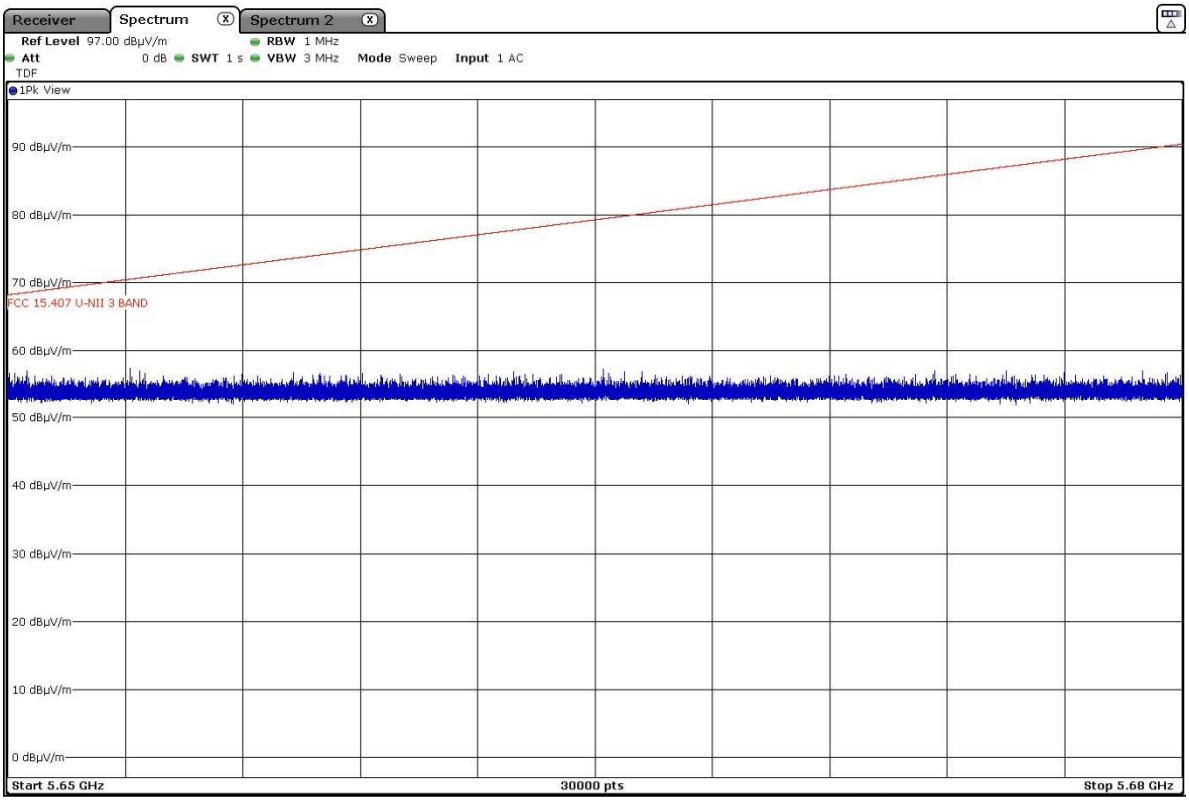

- High Channel 165 (5825 MHz):



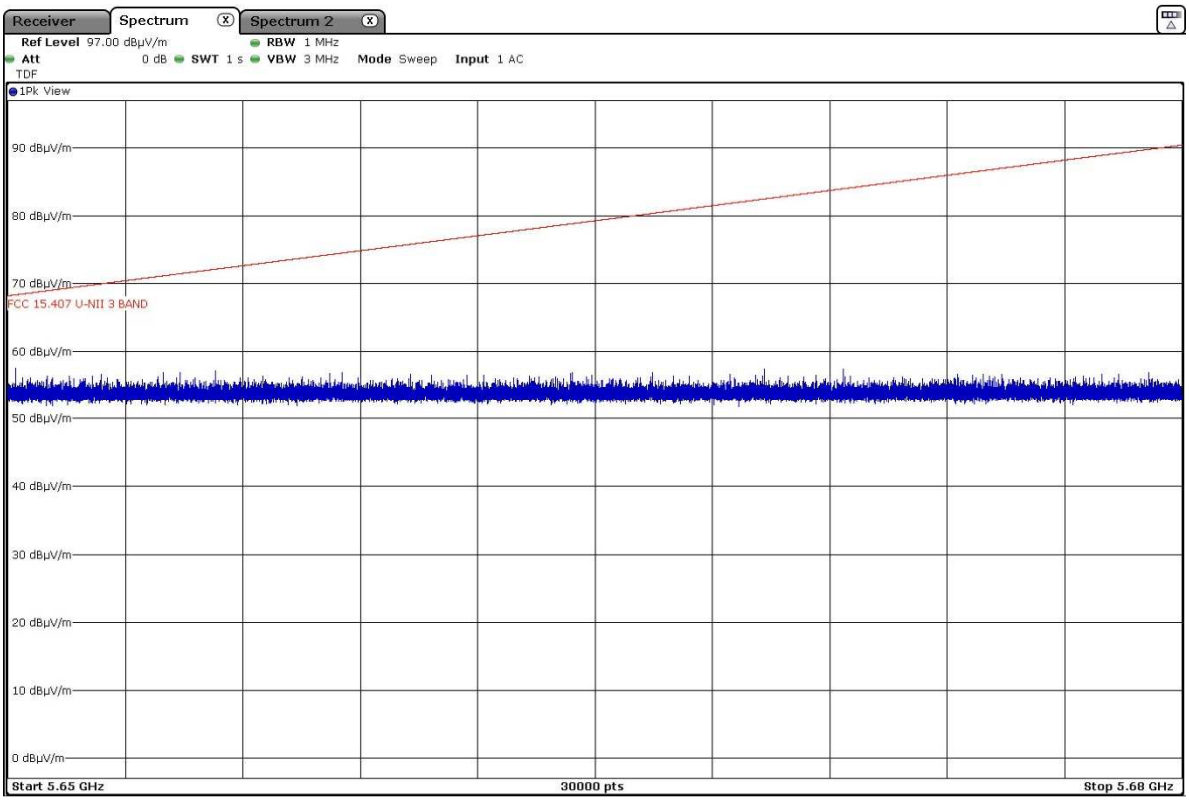
- **802.11 ac20:**

**Radiated spurious emissions at band-edges and inside adjacent band 5.65 – 5.68 GHz**

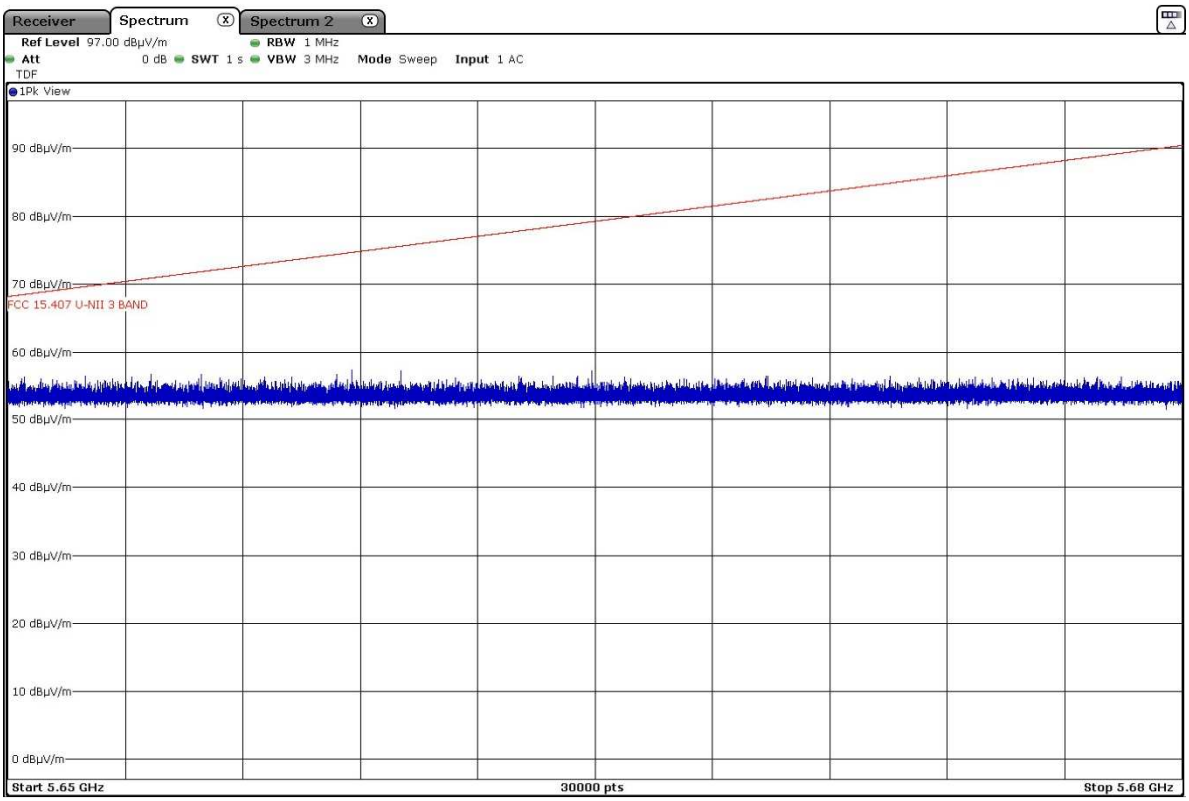
- Low Channel 149 (5745 MHz):




- Middle Channel 157 (5785 MHz):

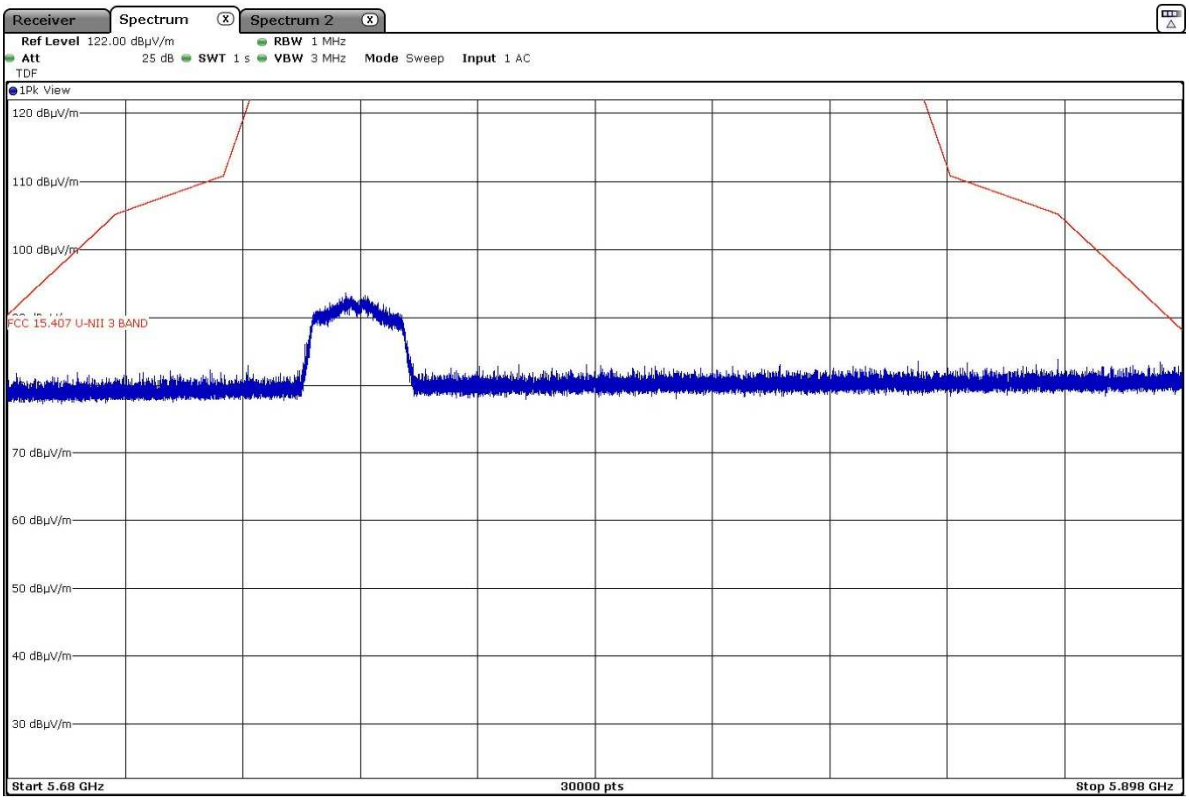


- High Channel 165 (5825 MHz):

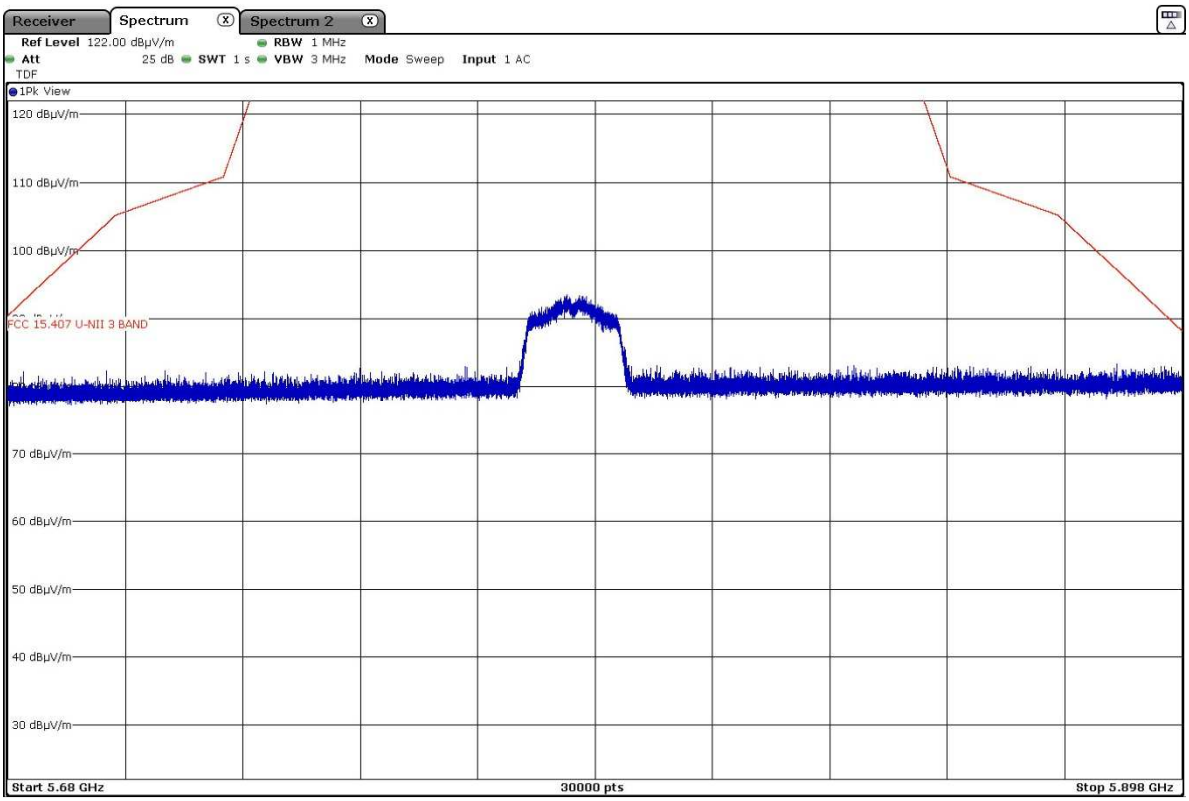



**Radiated spurious emissions at band-edges and inside adjacent band 5.68 – 5.898 GHz**

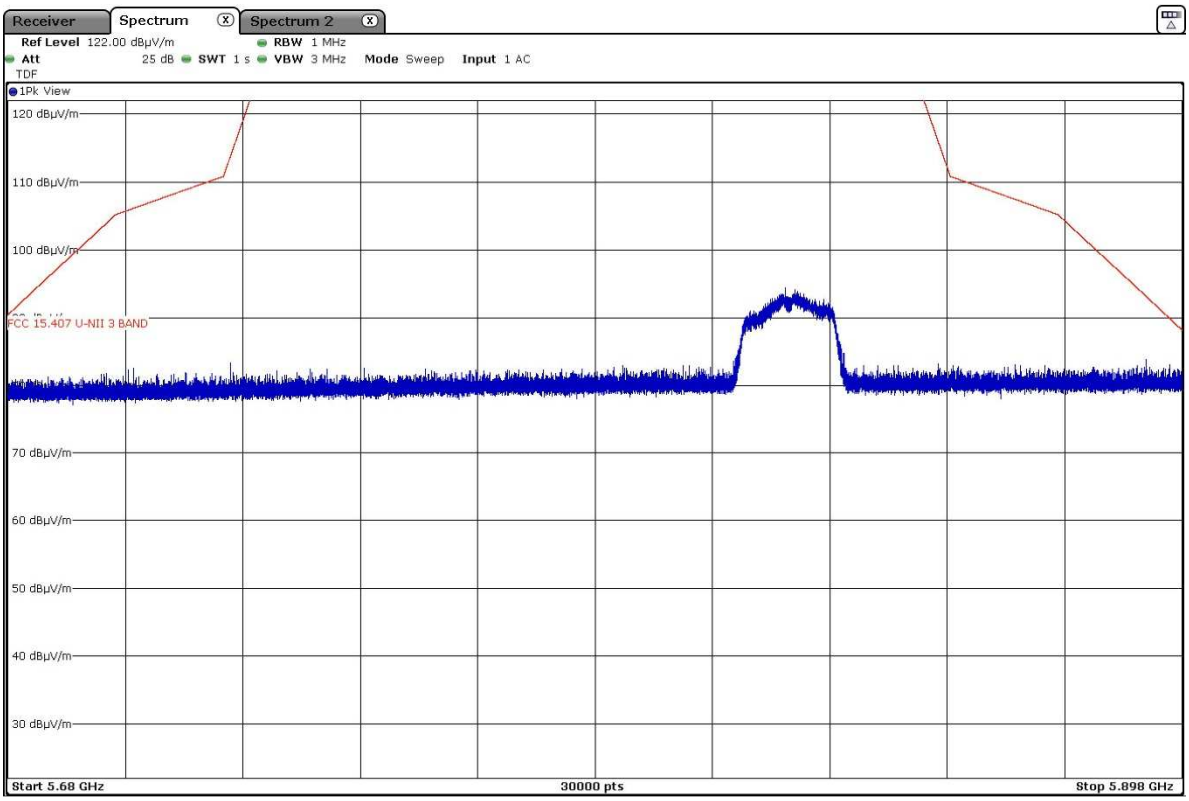
- Low Channel 149 (5745MHz):



- Middle Channel 157 (5785MHz):

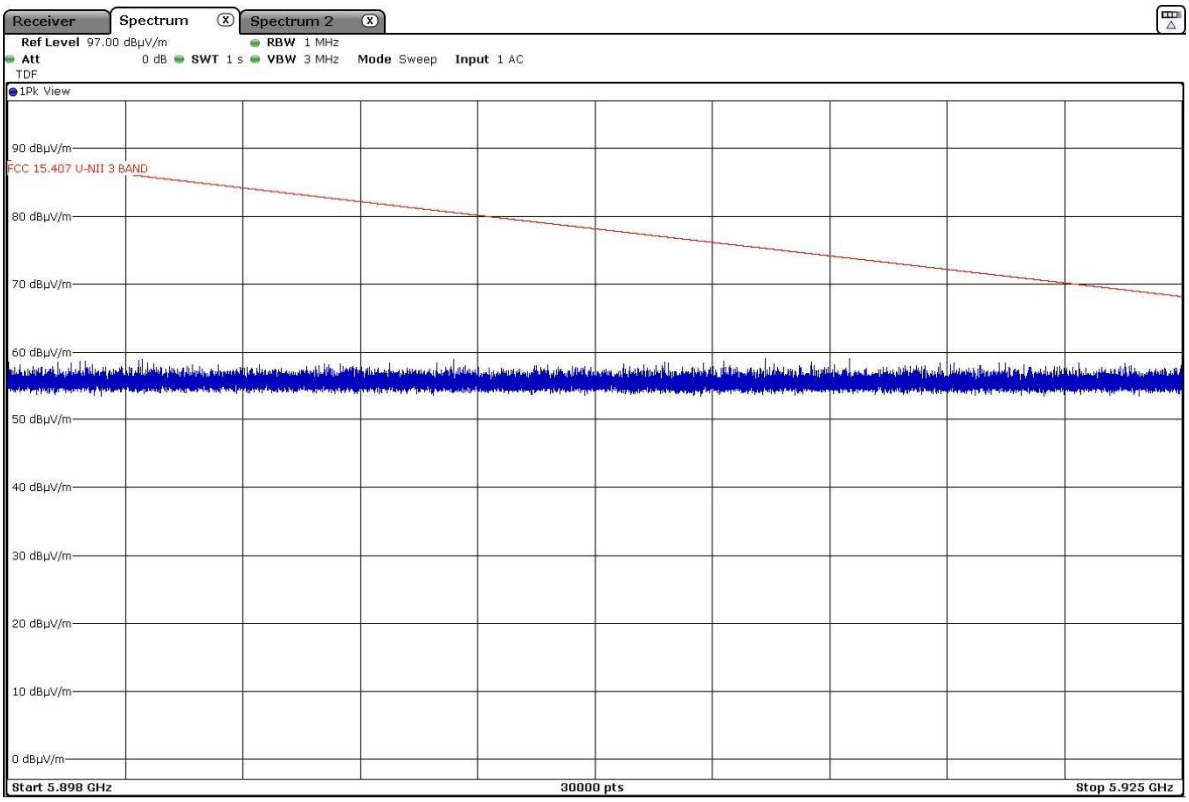



- High Channel 165 (5825MHz):

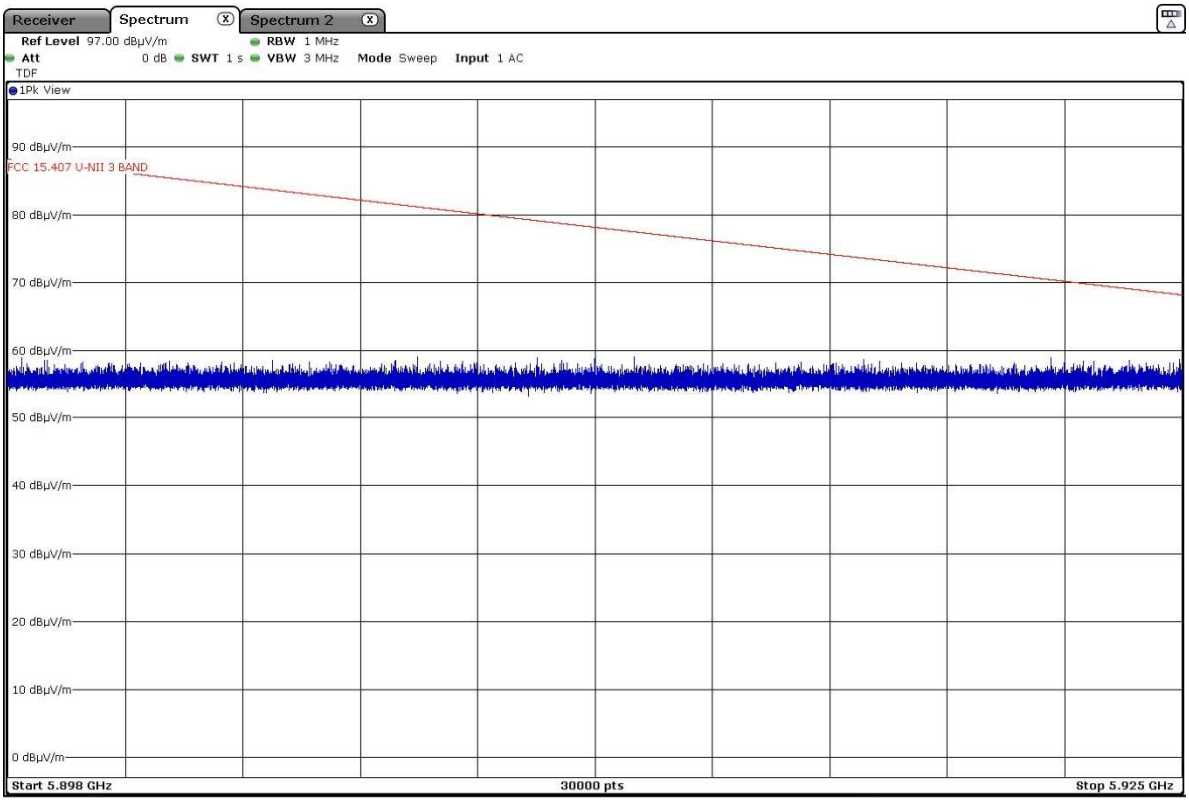


## Radiated spurious emissions at band-edges and inside adjacent band 5.898 – 5.925 GHz

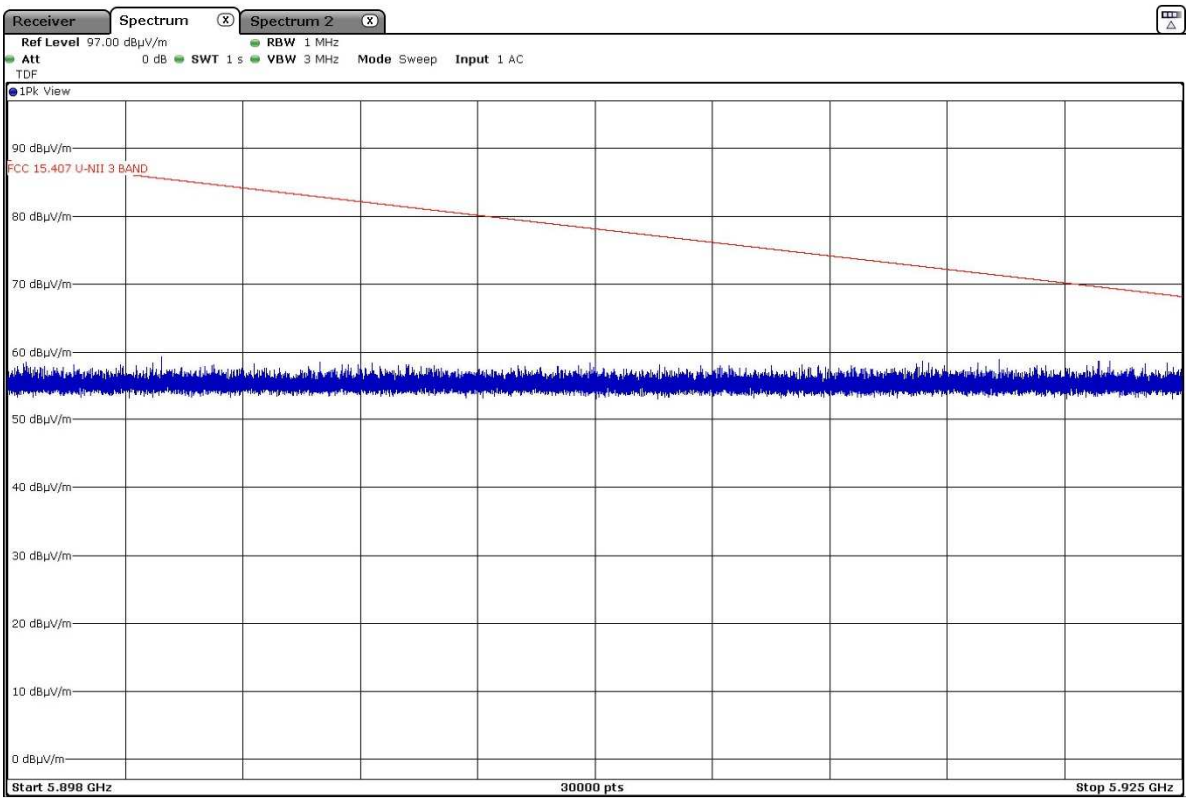
- Low Channel 149 (5745 MHz):




- Middle Channel 157 (5785 MHz):



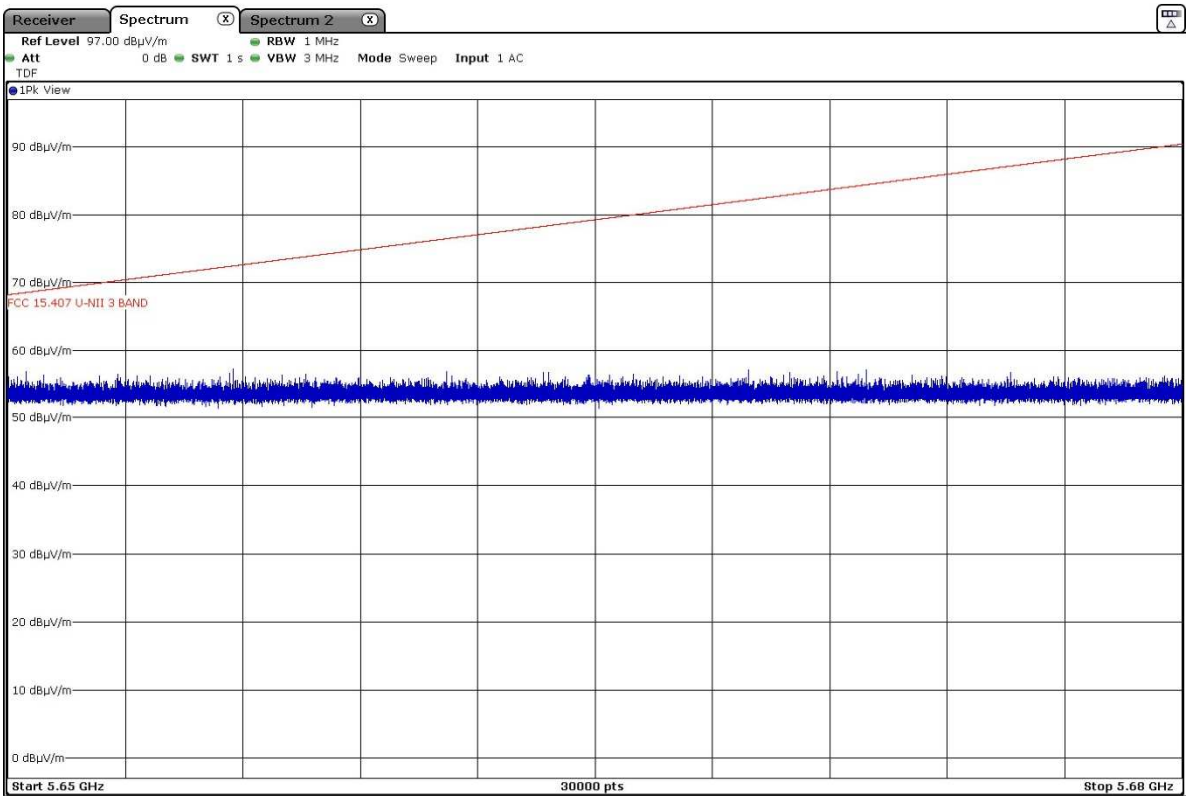
- High Channel 165 (5825 MHz):



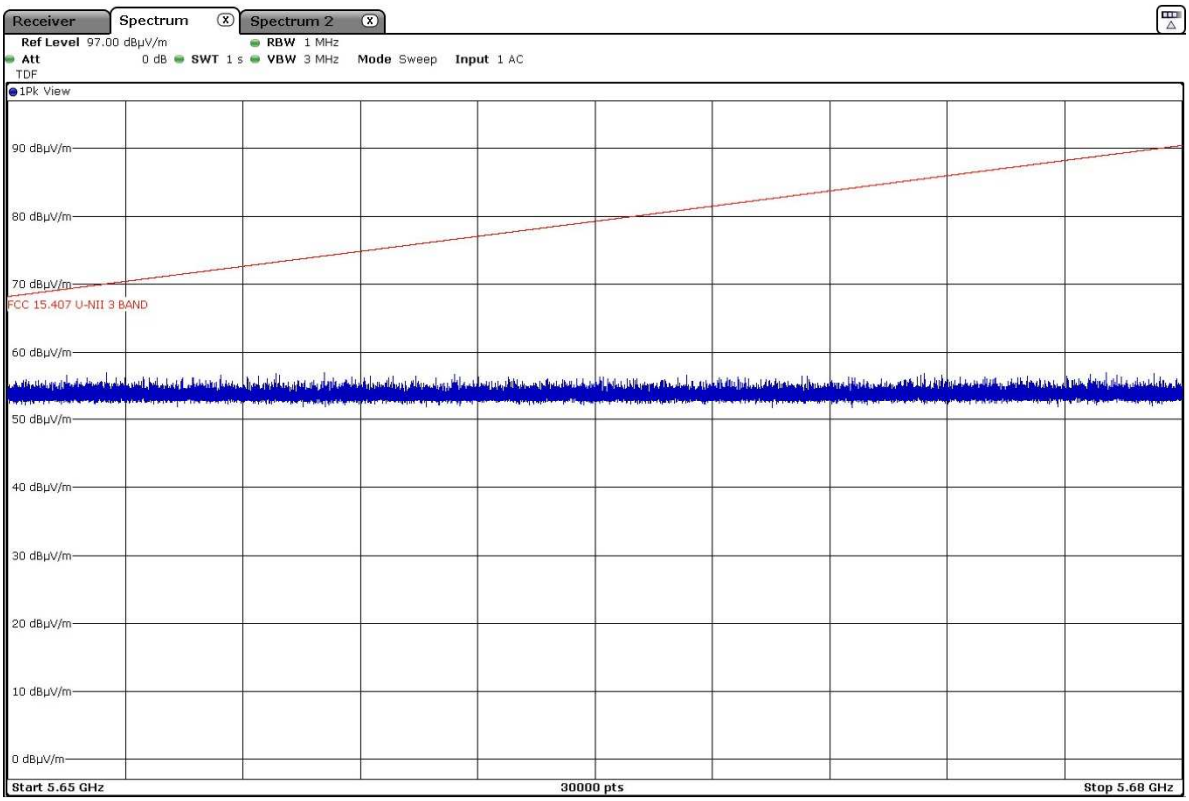

- **802.11 n40:**

**Radiated spurious emissions at band-edges and inside adjacent band 5.65 – 5.68 GHz**

- Low Channel 151 (5755 MHz):

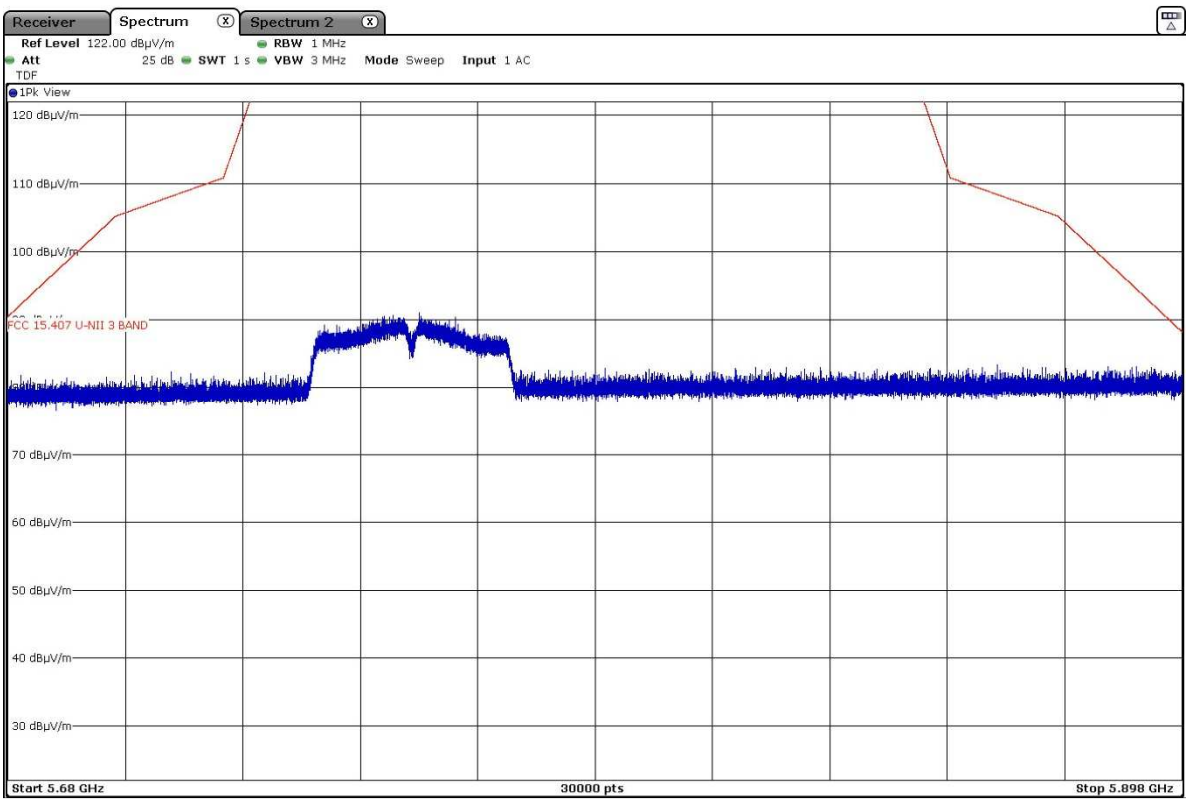


- High Channel 159 (5795 MHz):

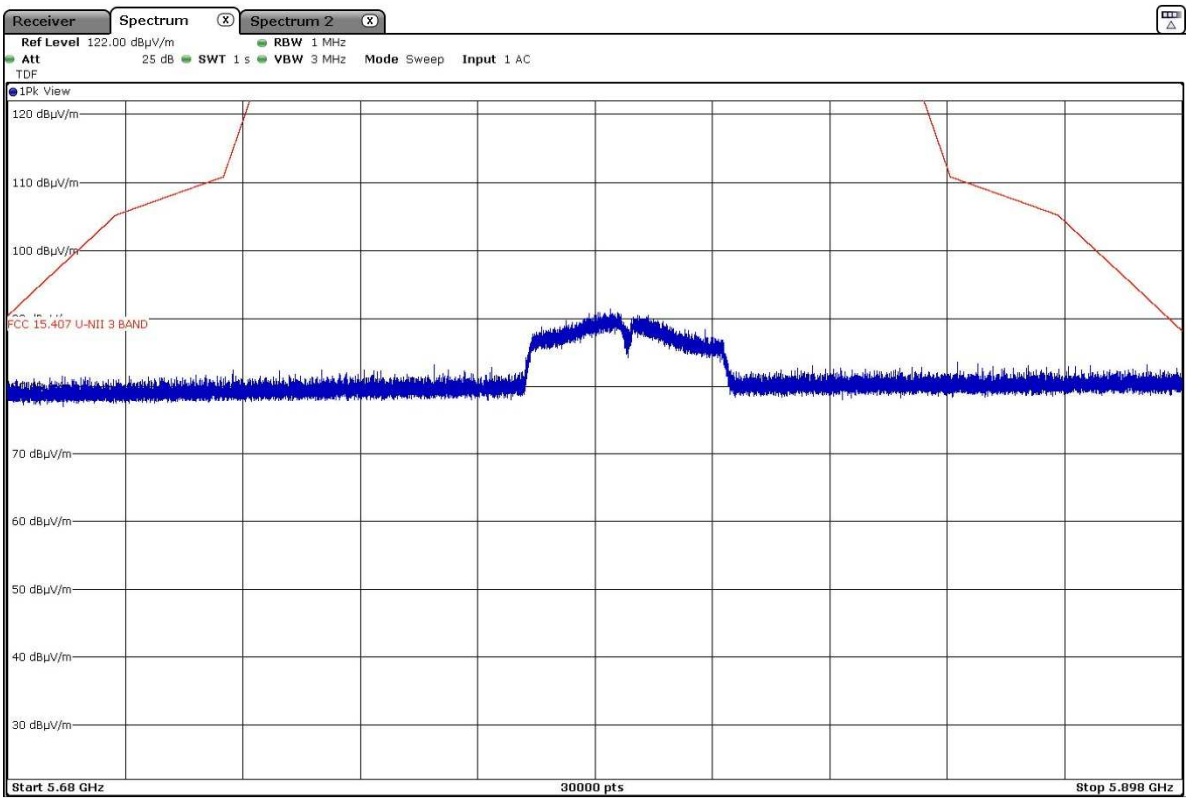



**Radiated spurious emissions at band-edges and inside adjacent band 5.68 – 5.898 GHz**

- Low Channel 151 (5755 MHz):

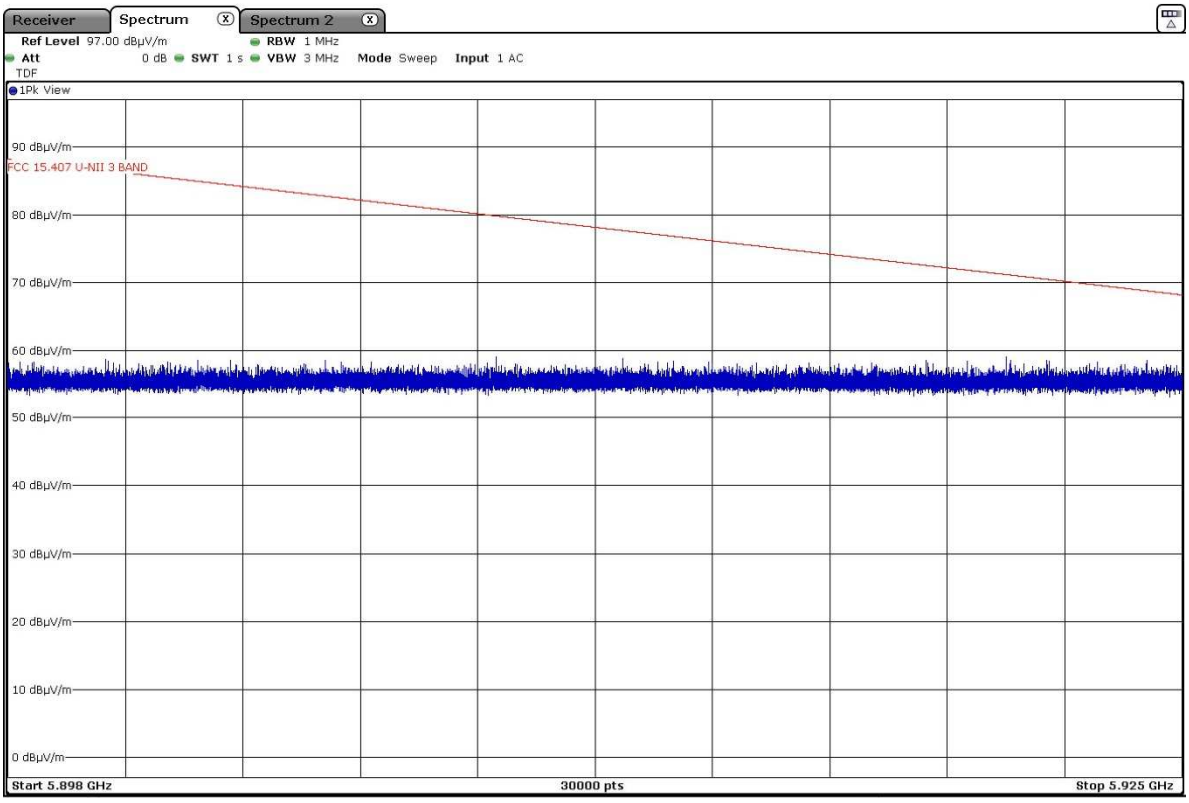


- High Channel 159 (5795 MHz):

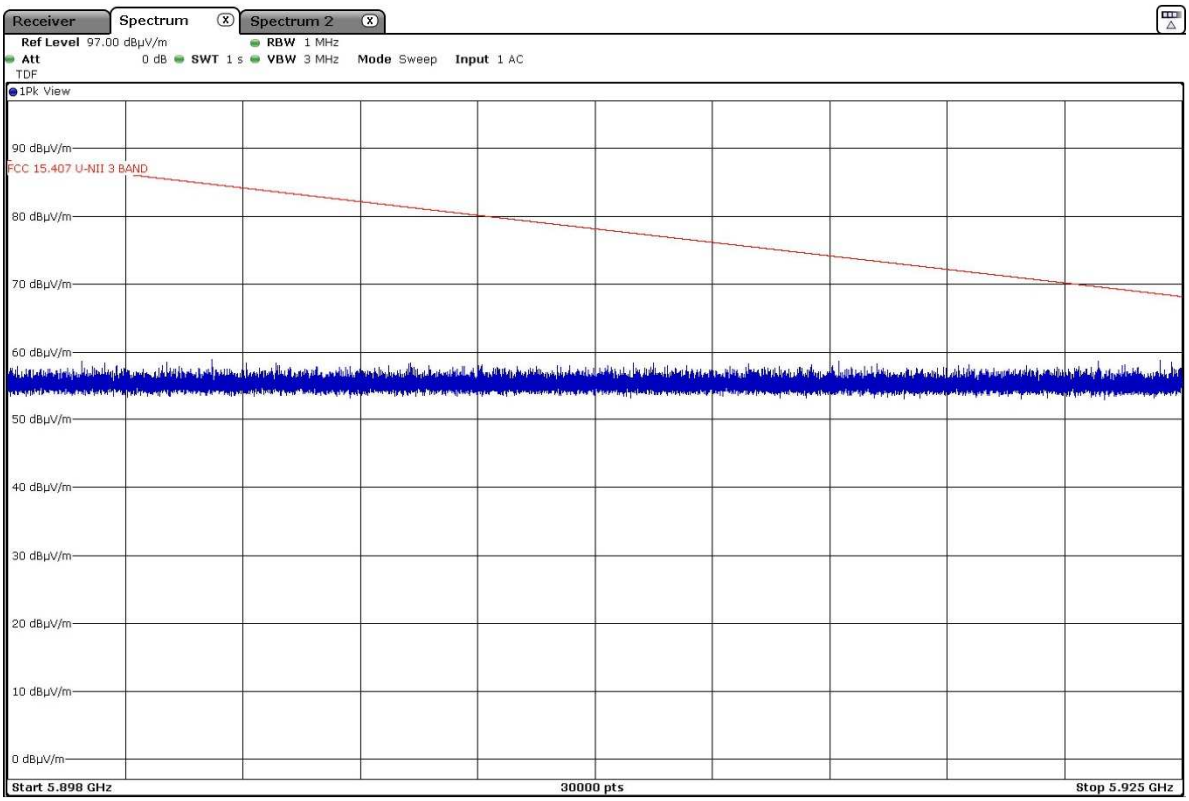



**Radiated spurious emissions at band-edges and inside adjacent band 5.898 – 5.925 GHz**

- Low Channel 151 (5755 MHz):



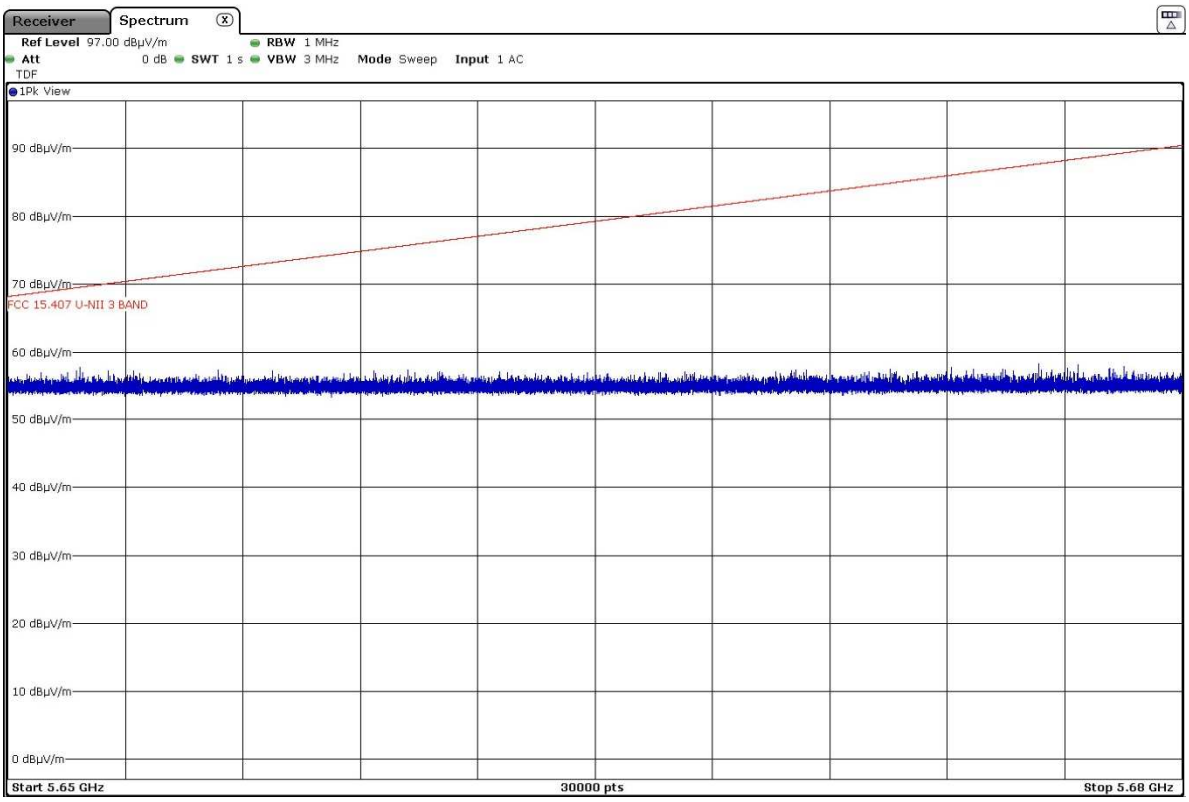
- High Channel 159 (5795 MHz):



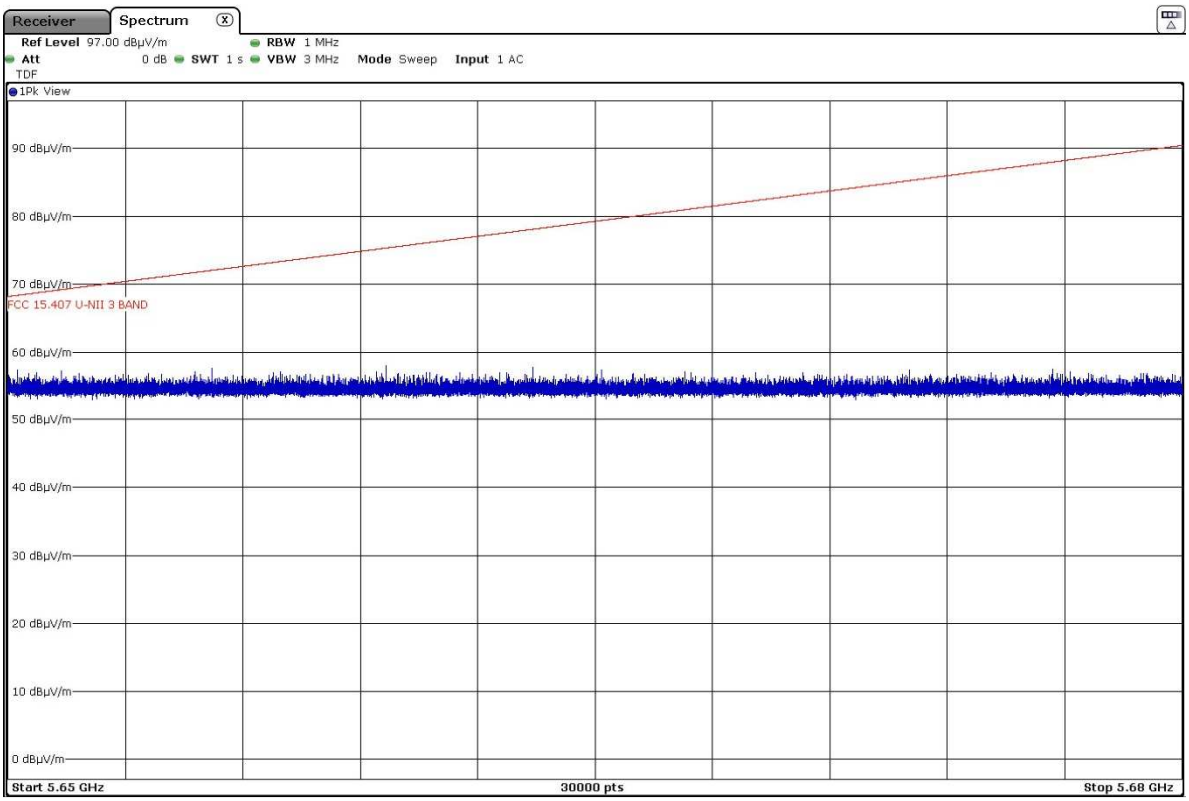

- **802.11 ac40:**

**Radiated spurious emissions at band-edges and inside adjacent band 5.65 – 5.68 GHz**

- Low Channel 149 (5745 MHz):

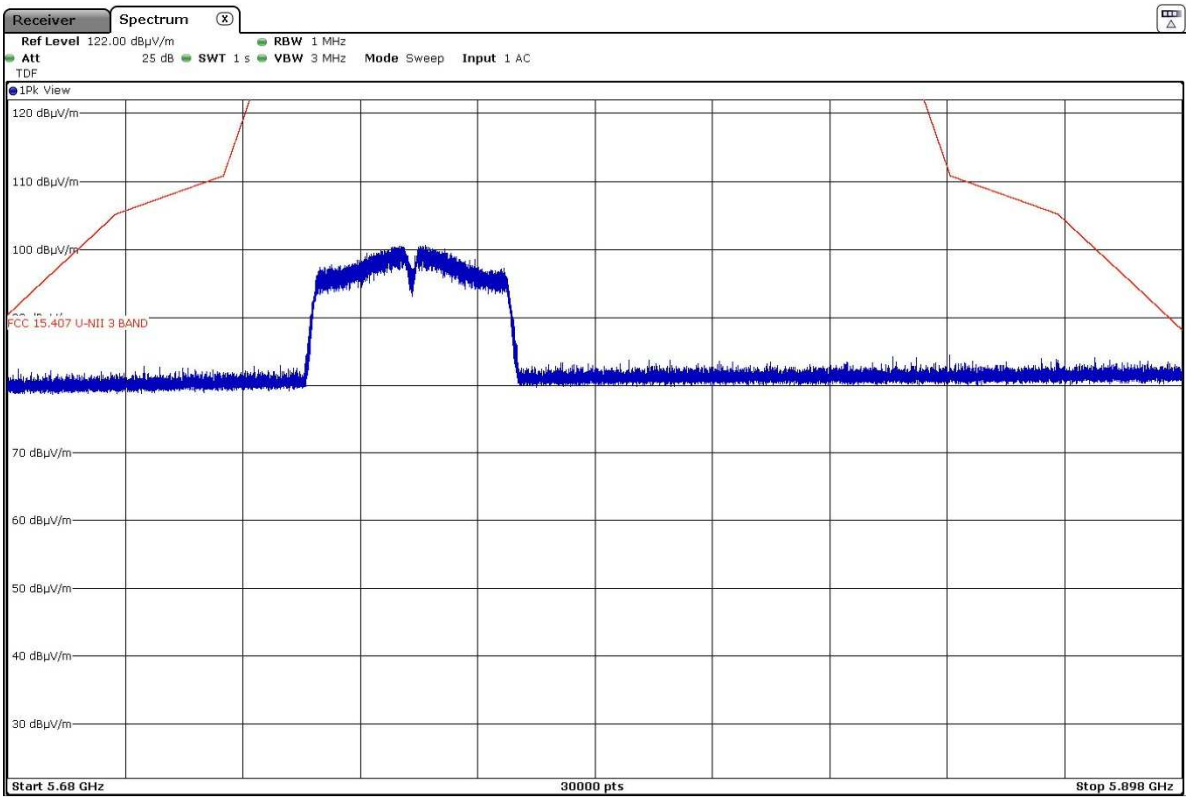


- High Channel 165 (5825 MHz):

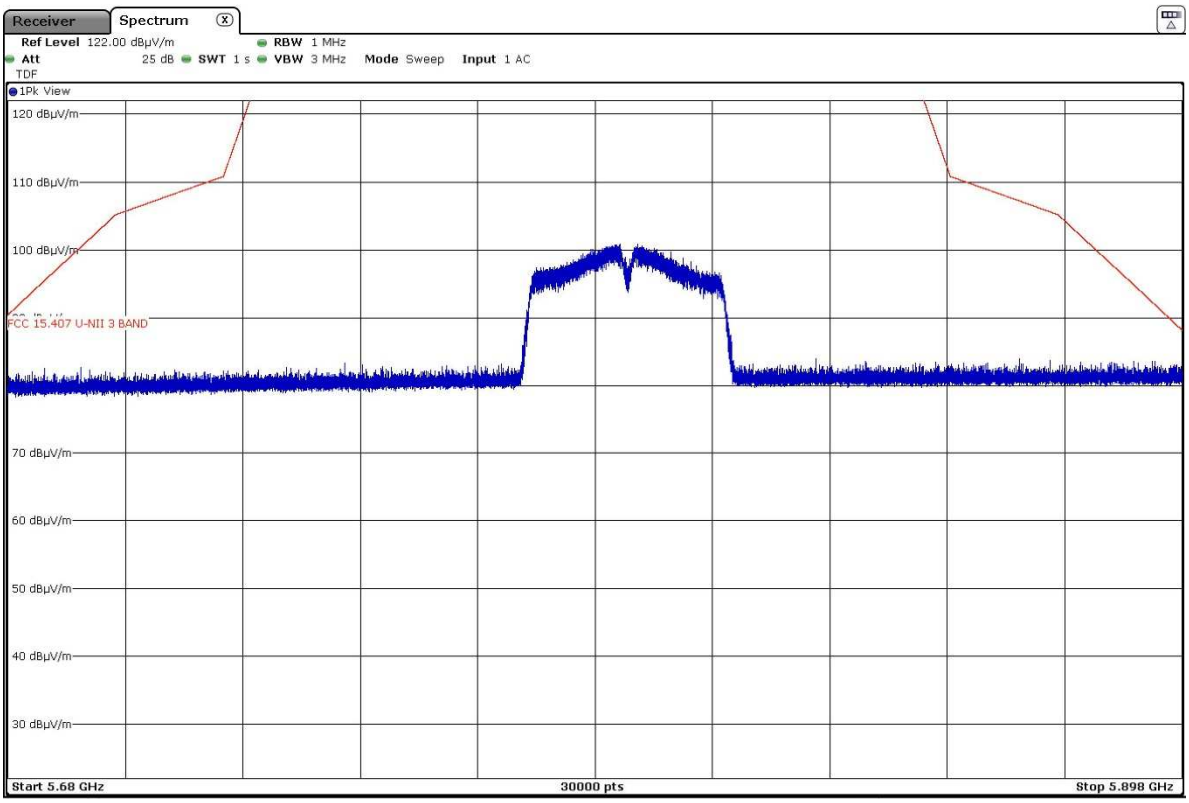



**Radiated spurious emissions at band-edges and inside adjacent band 5.68 – 5.898 GHz**

- Low Channel 149 (5745 MHz):

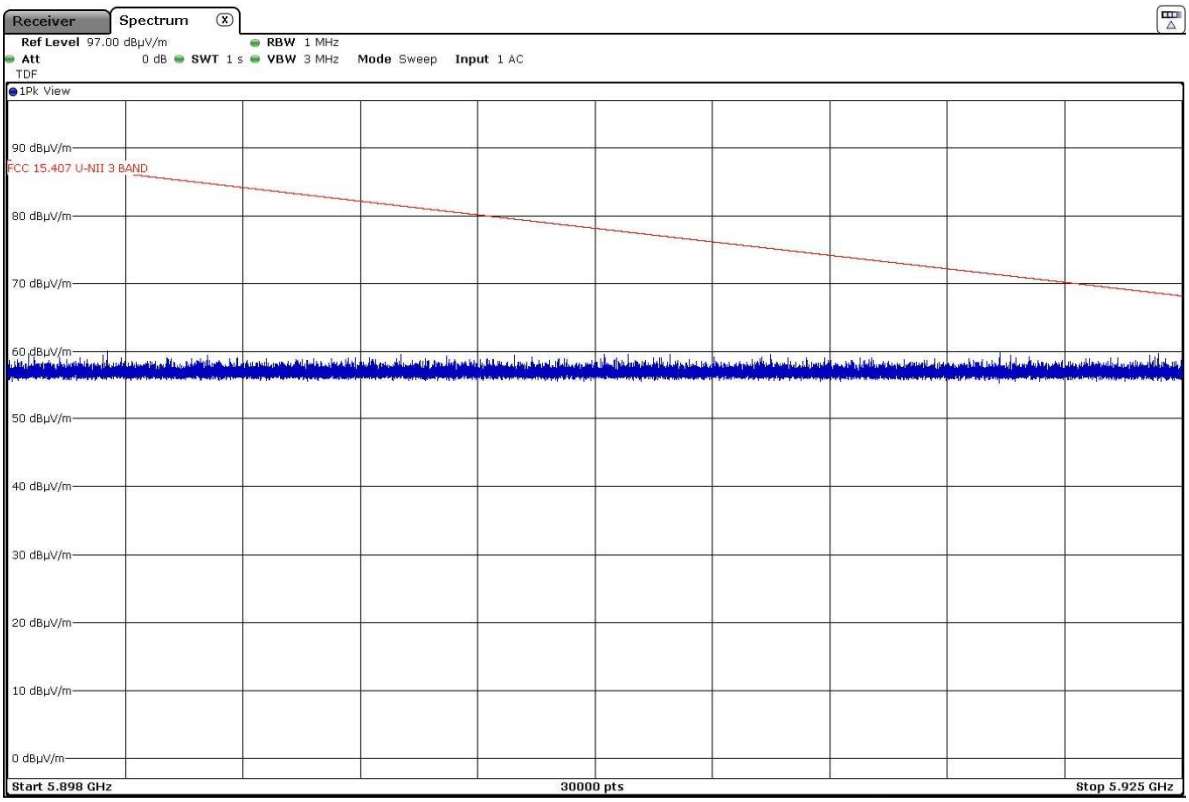


- High Channel 165 (5825MHz):

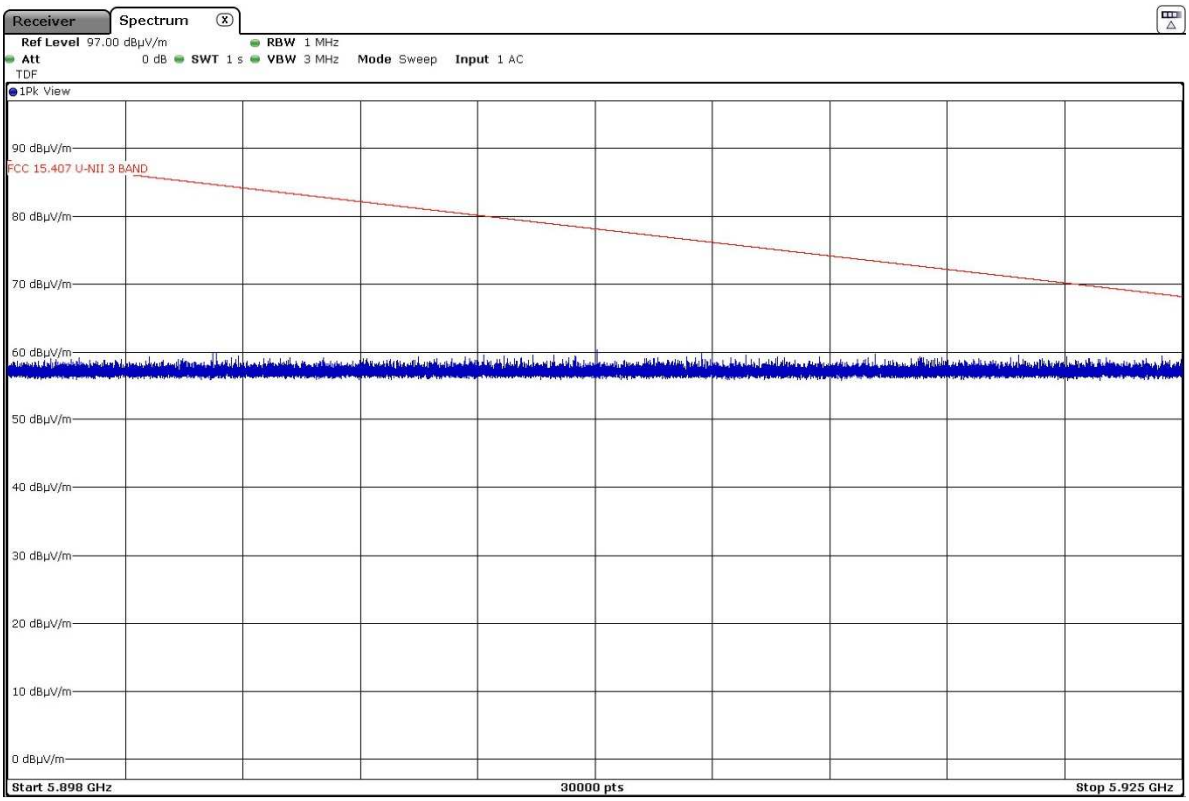



**Radiated spurious emissions at band-edges and inside adjacent band 5.898 – 5.925 GHz**

- Low Channel 149 (5745 MHz):



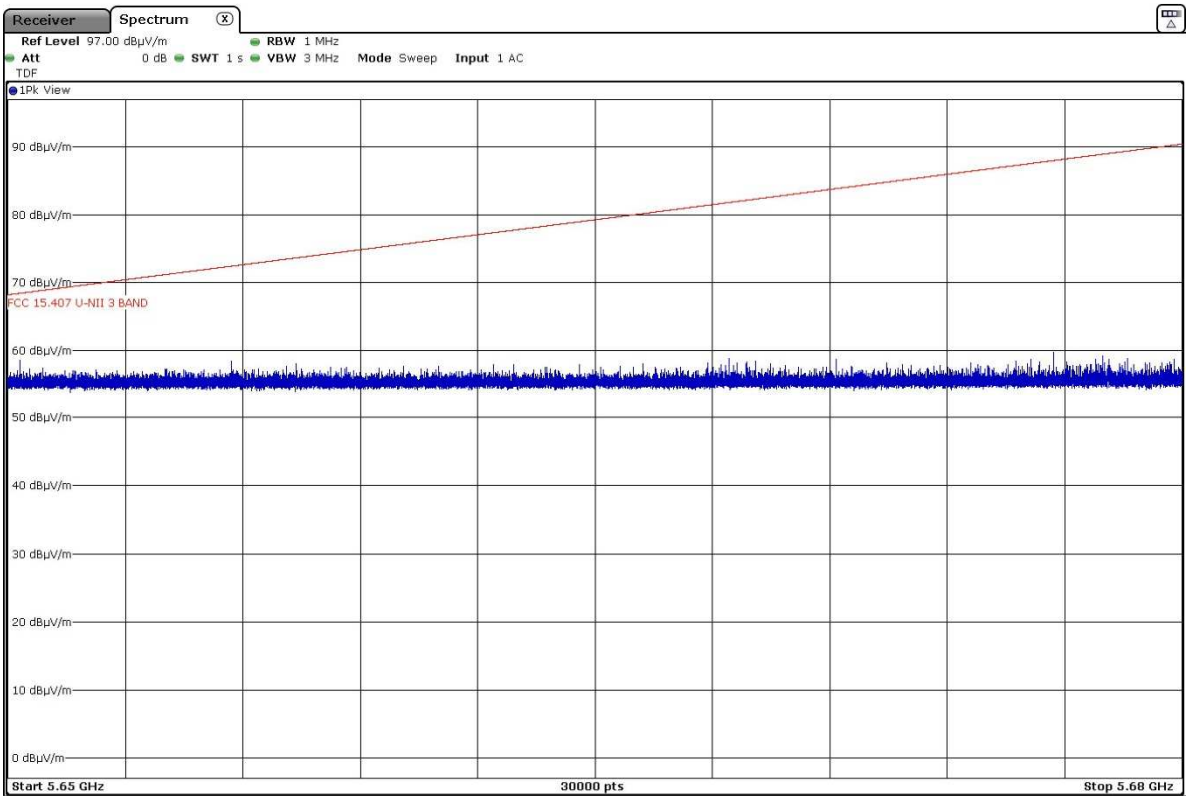
- High Channel 165 (5825 MHz):




- **802.11 ac80:**

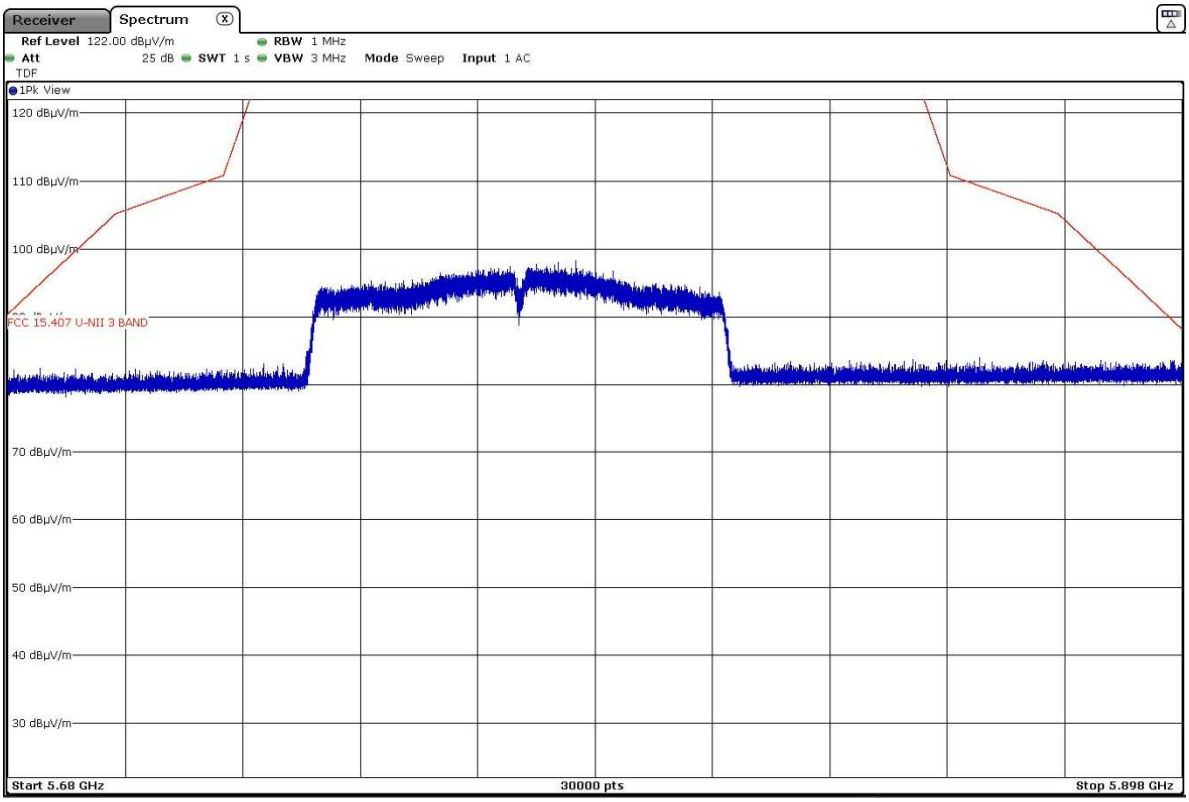
**Radiated spurious emissions at band-edges and inside adjacent band 5.65 – 5.68 GHz**

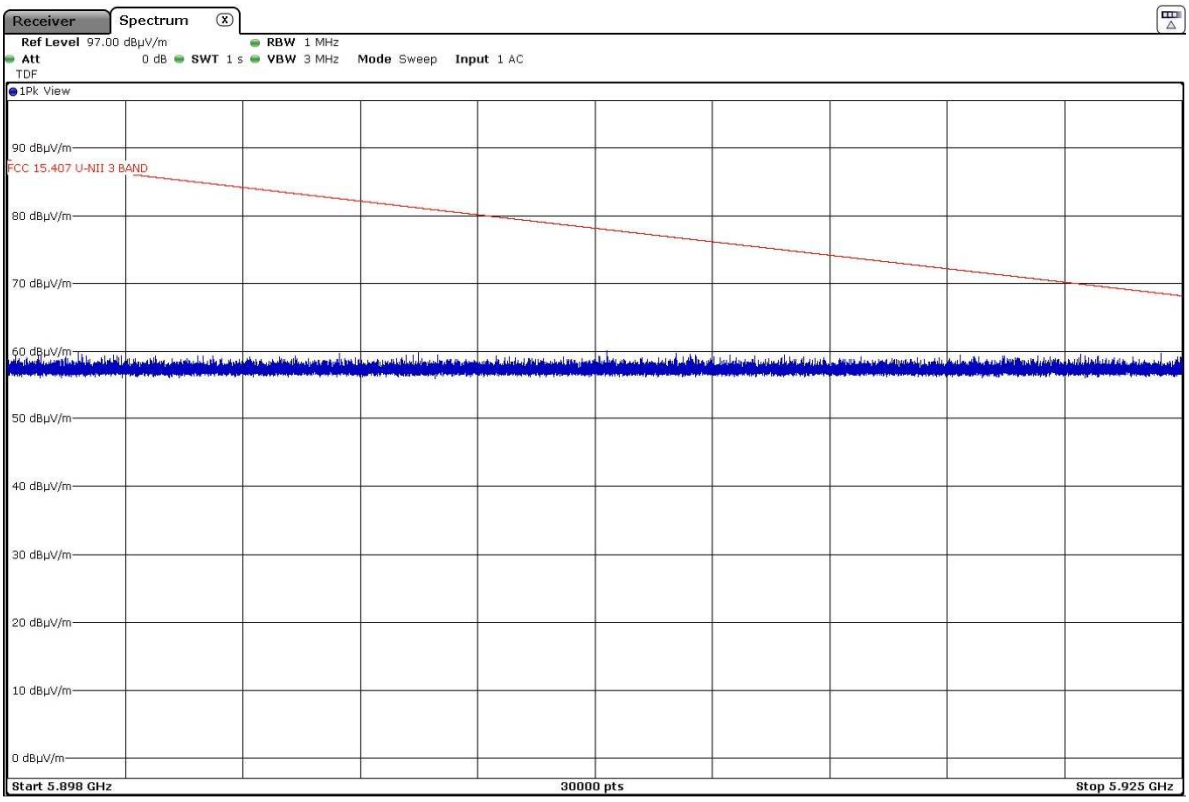
- Middle Channel 155 (5775 MHz):



**Radiated spurious emissions at band-edges and inside adjacent band 5.68 – 5.898 GHz**

- Middle Channel 155 (5775 MHz):




**Radiated spurious emissions at band-edges and inside adjacent band 5.898 – 5.925 GHz**

- Middle Channel 155 (5775 MHz):