

- **MIMO 802.11 he20:**

- LOW CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- HIGH CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- **MIMO 802.11 n40:**

- LOW CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- HIGH CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- **MIMO 802.11 ac40:**

- LOW CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- HIGH CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- **MIMO 802.11 he40:**

- LOW CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- HIGH CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- **MIMO 802.11 ac80:**

- SINGLE CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

- **MIMO 802.11 he80:**

- SINGLE CHANNEL:

- Lower Band Edge. No spurious emissions inside the Restricted Band 4.50-5.15 GHz.
- Upper Band Edge. No spurious emissions inside the Restricted Band 5.35-5.46 GHz.

Measurement Uncertainty (dB) $< \pm 4.6$

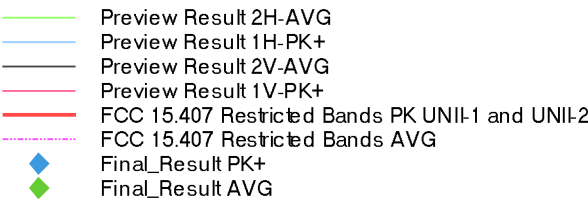
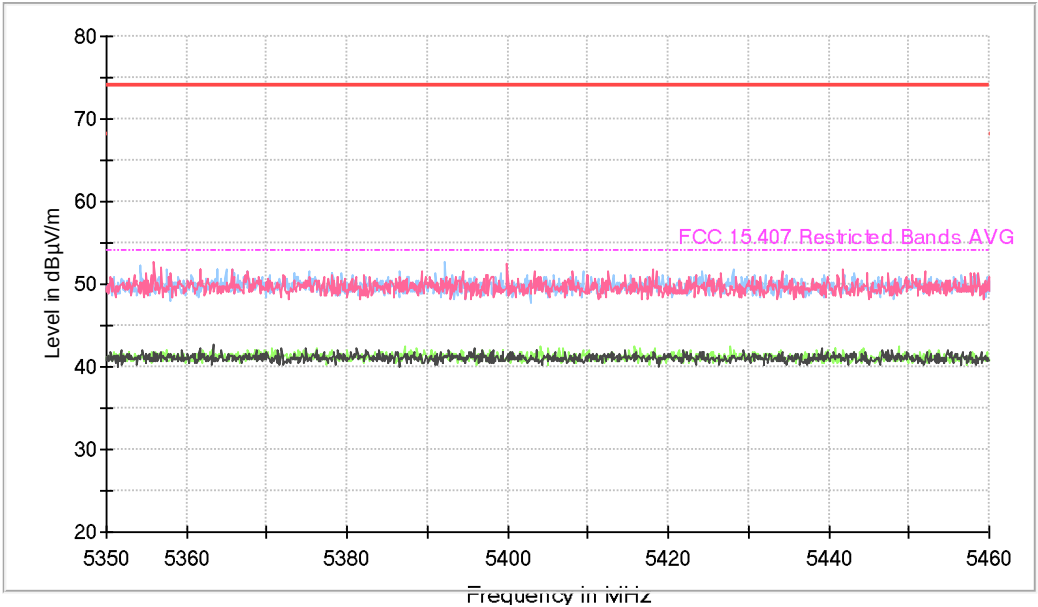
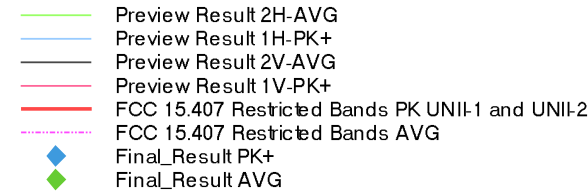
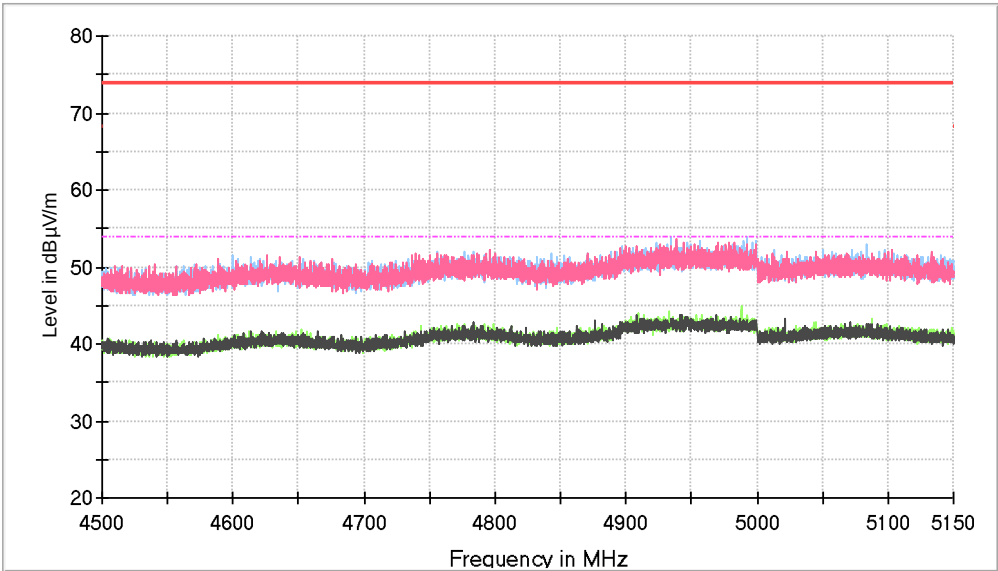
Verdict: PASS

The setting for each range of frequency is indicated in the following tables:

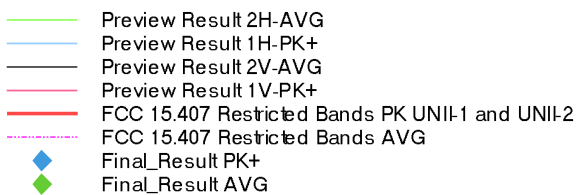
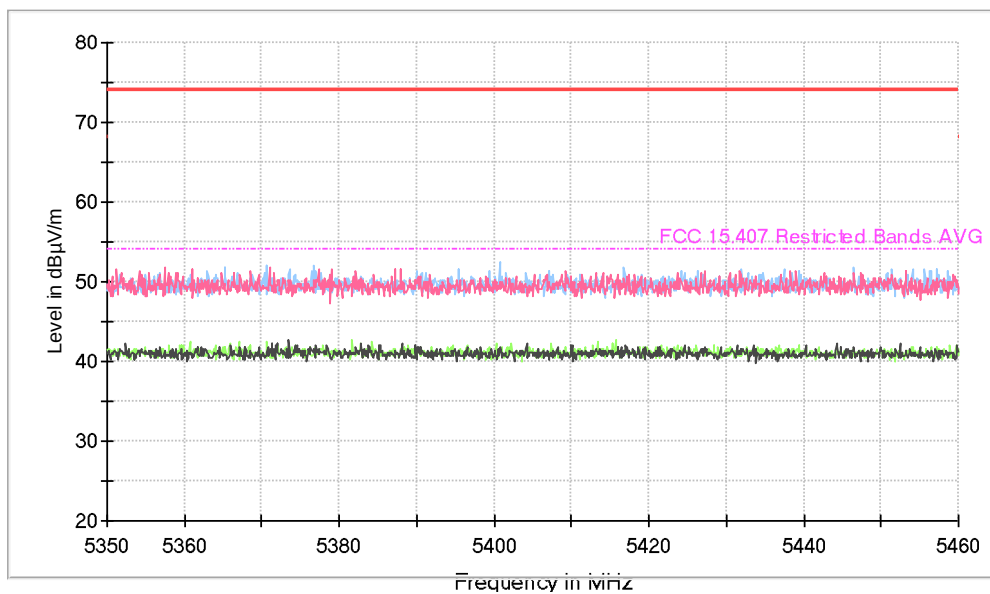
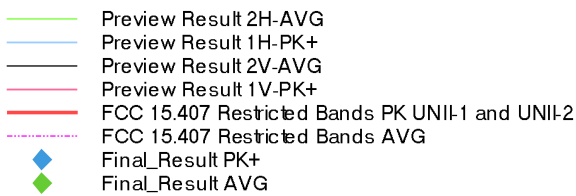
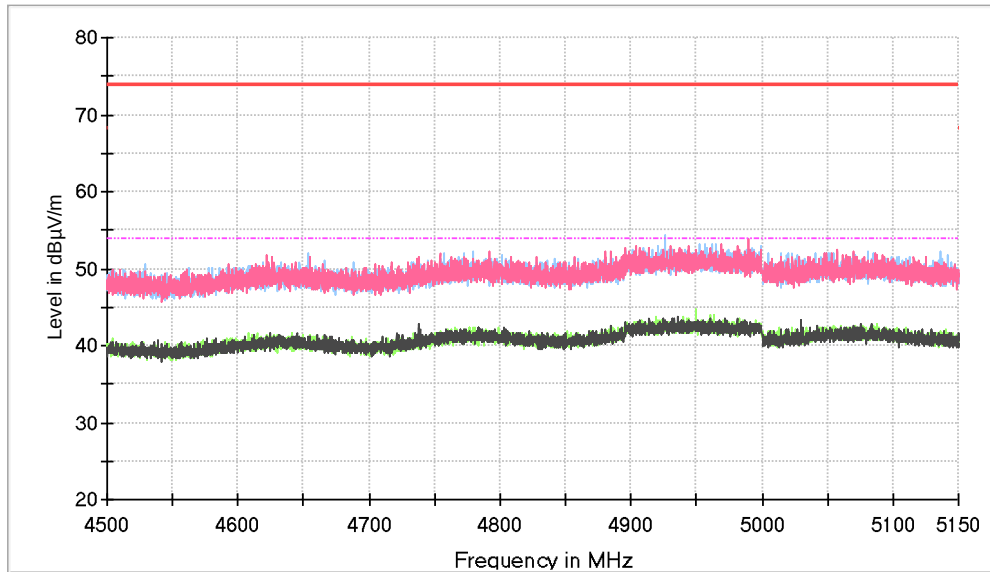
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW44] 1 GHz – 7 GHz	187.5 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

MIMO 802.11 a20:

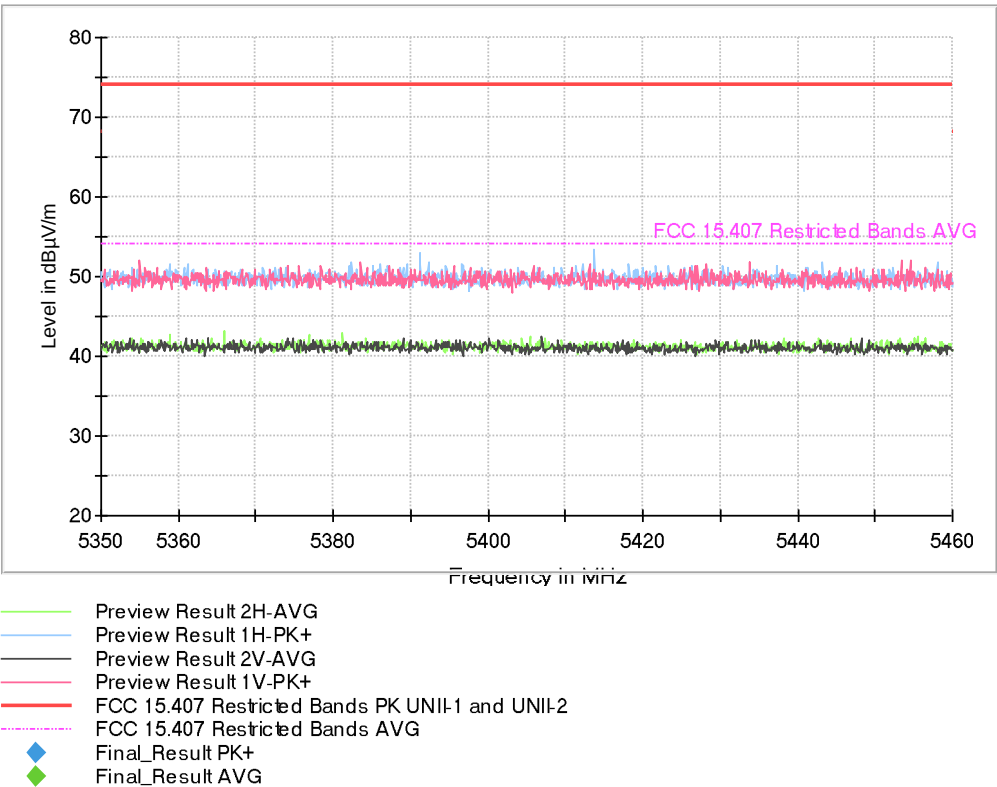
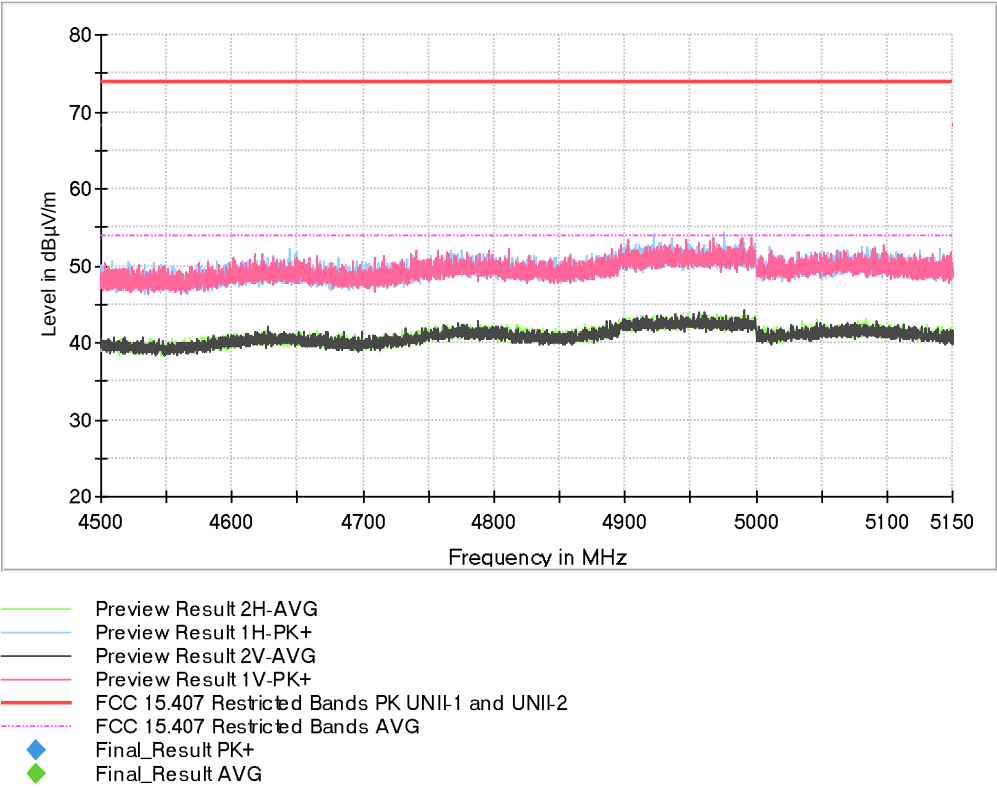
- Lower Band Edge and Upper Band Edge – Low Channel (Restricted Bands)



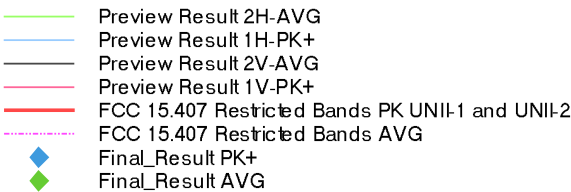
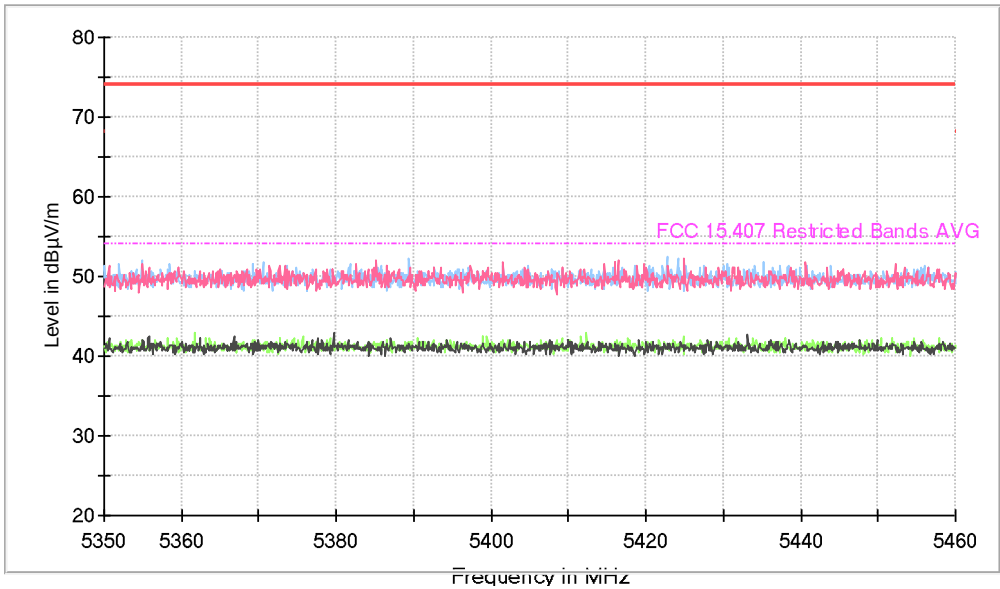
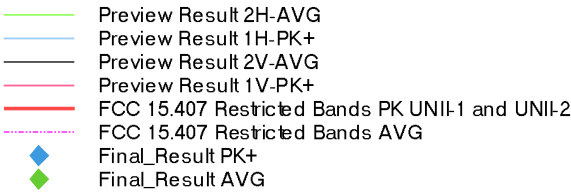
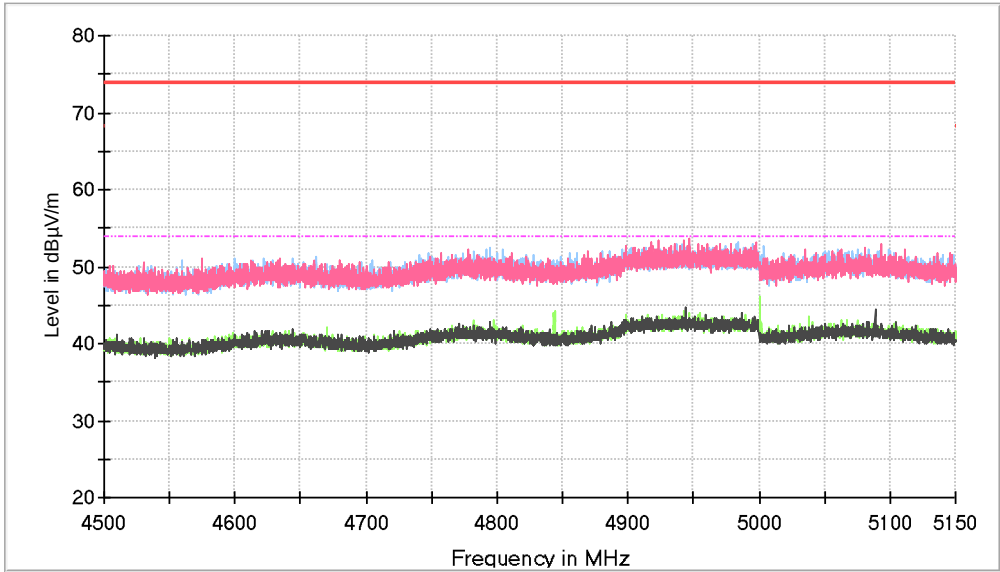
- Lower Band Edge and Upper Band Edge – High Channel (Restricted Bands)



- MIMO 802.11 n20:
 - Lower Band Edge and Upper Band Edge – Low Channel (Restricted Bands)

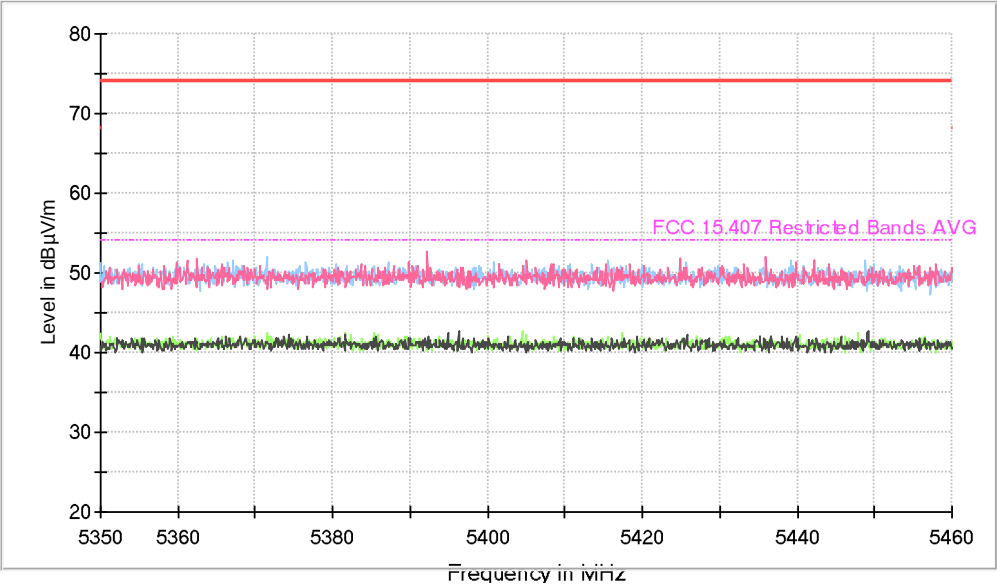
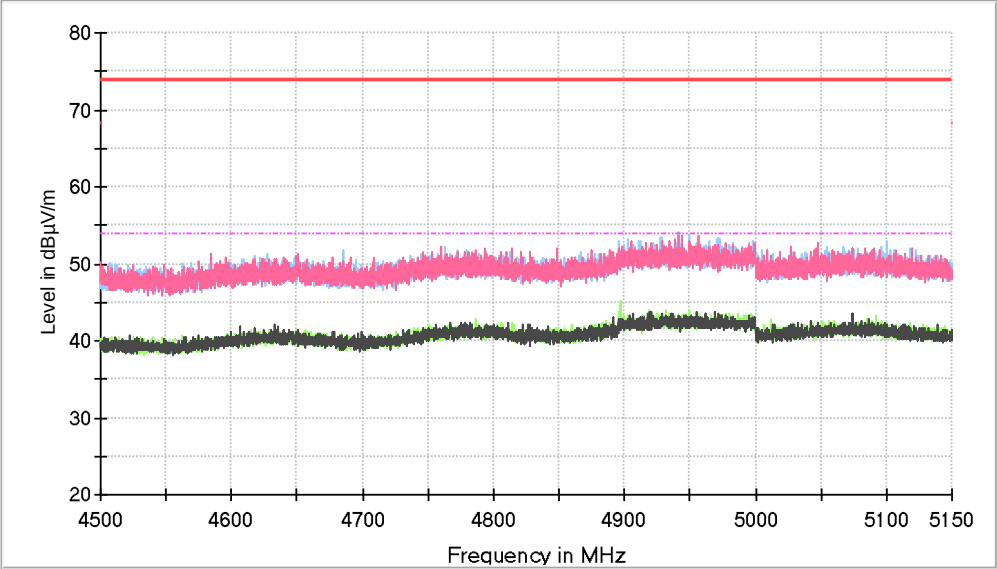


- Lower Band Edge and Upper Band Edge – High Channel (Restricted Bands)

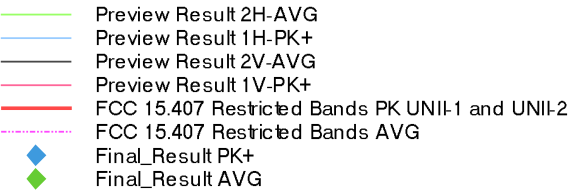
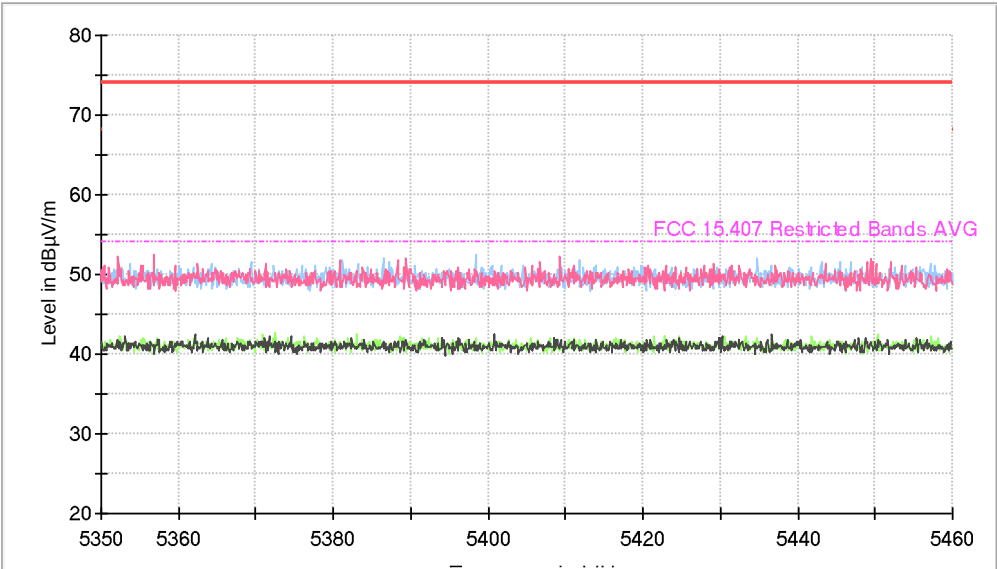
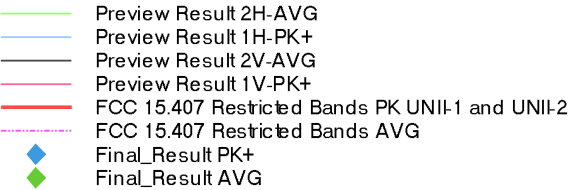
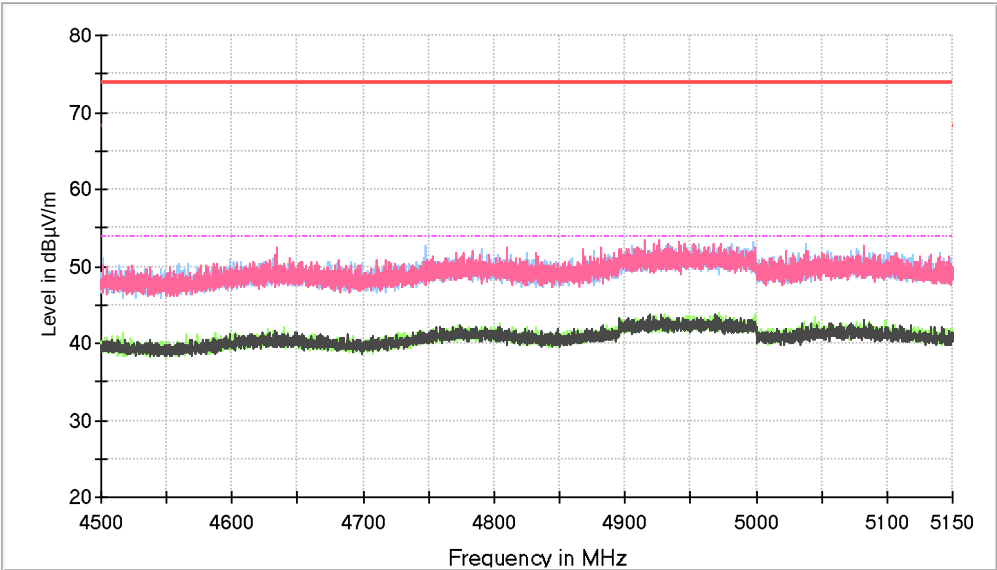


• MIMO 802.11 ac20:

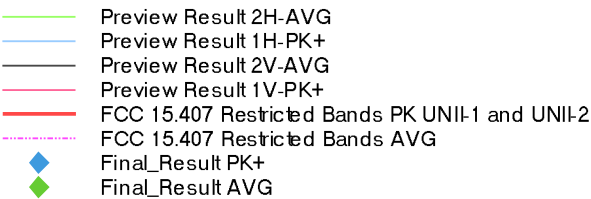
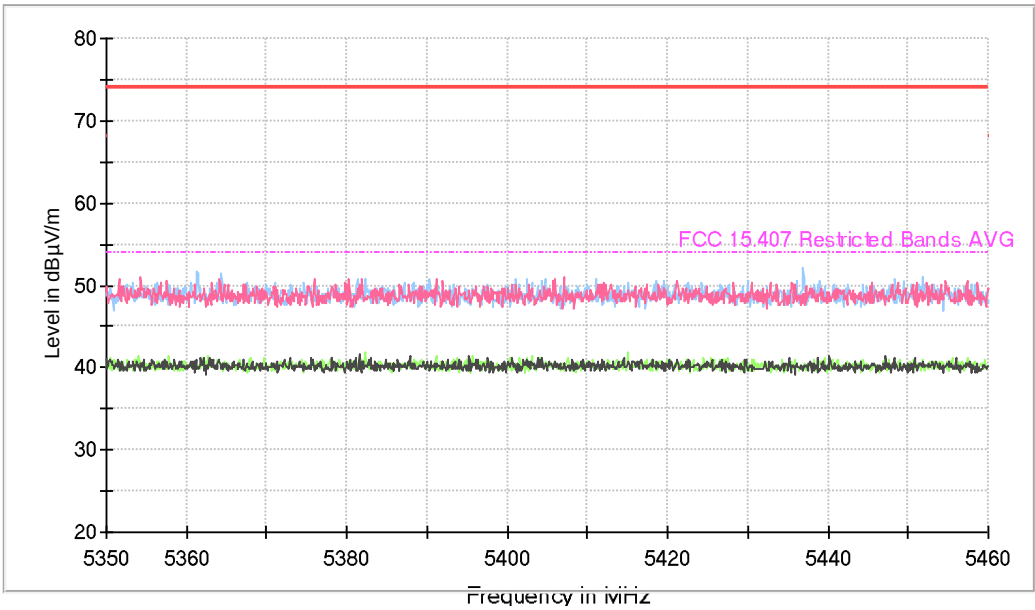
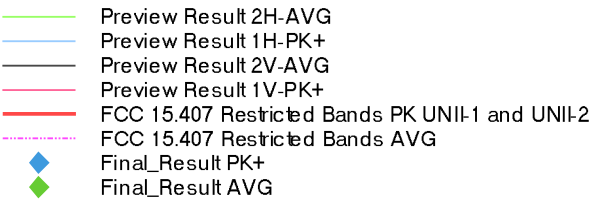
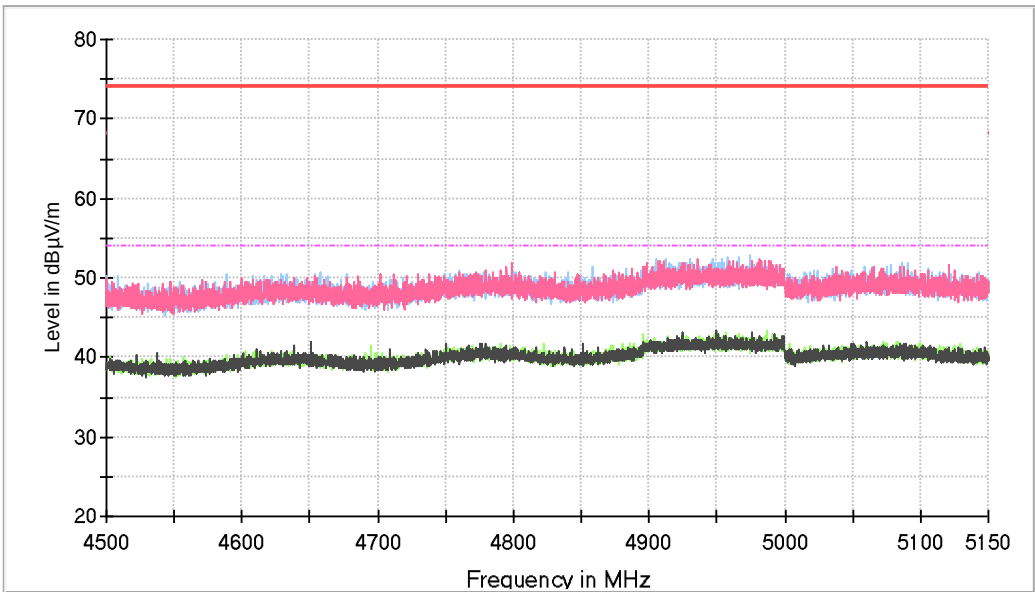
- Lower Band Edge and Upper Band Edge – Low Channel (Restricted Bands)



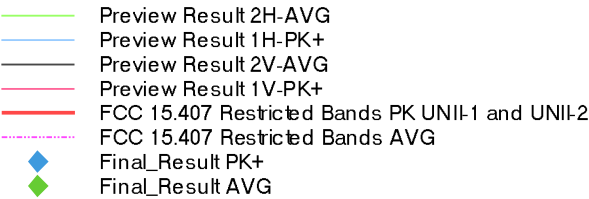
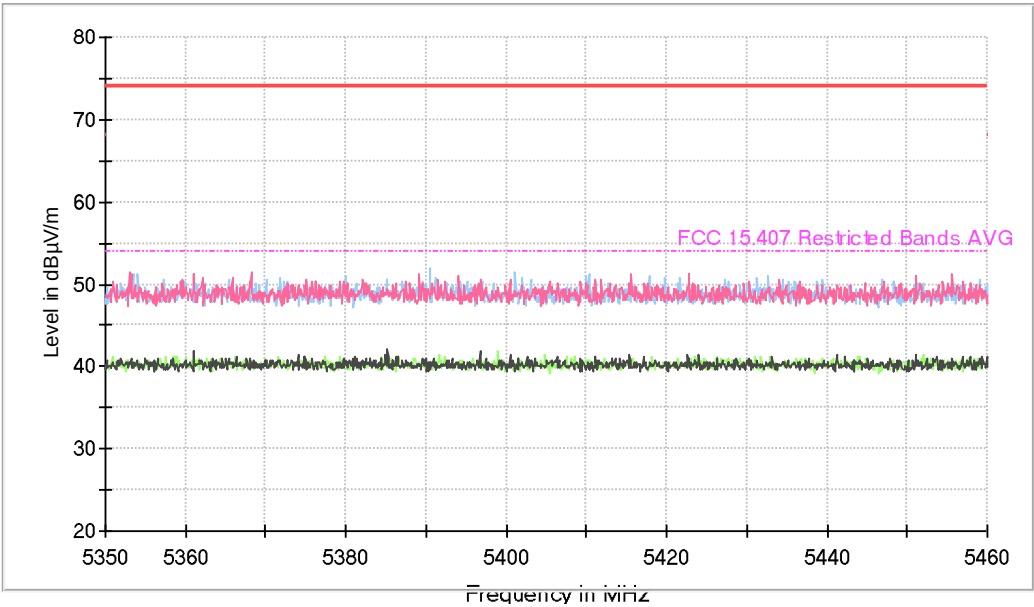
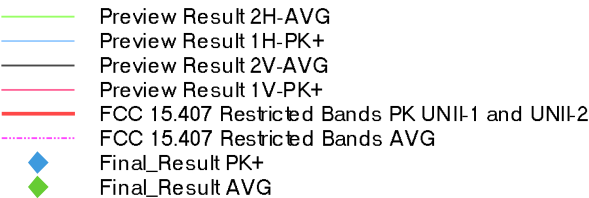
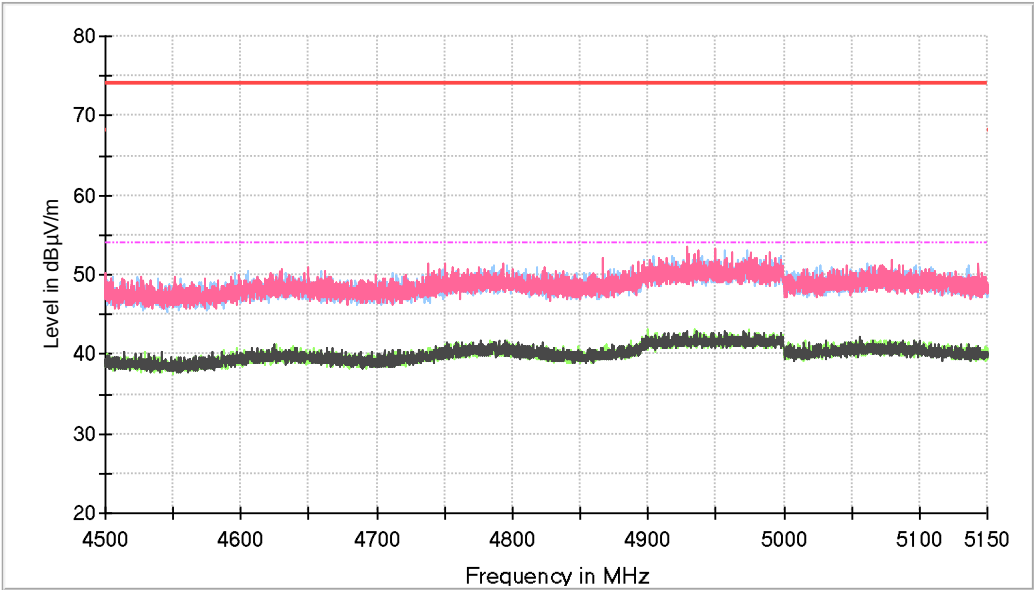
- Lower Band Edge and Upper Band Edge – High Channel (Restricted Bands)



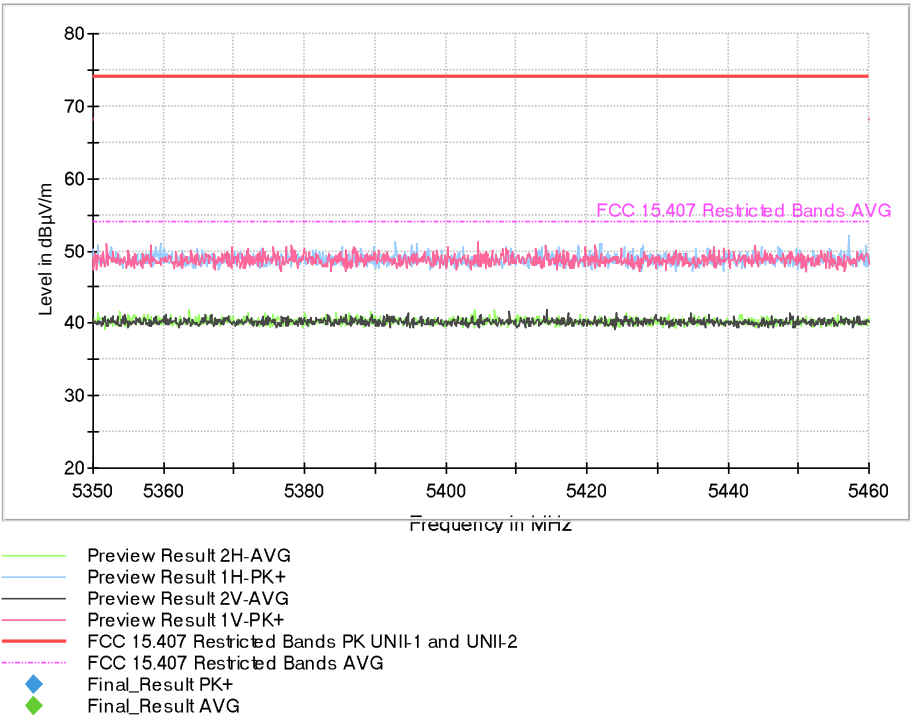
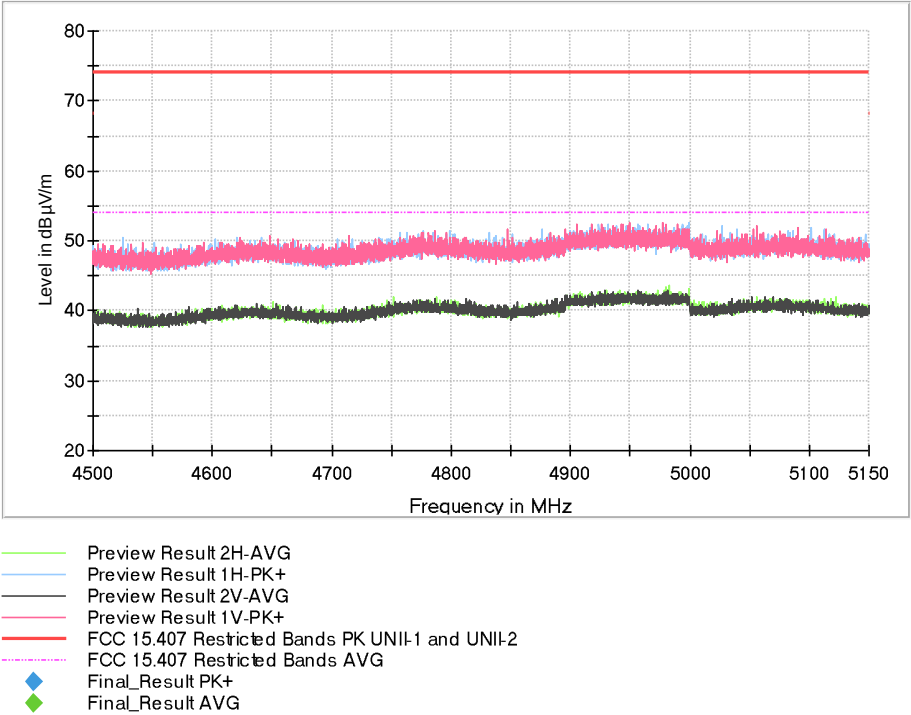
- MIMO 802.11 he20 SU Full-channel allocation:
 - Lower Band Edge and Upper Band Edge – Low Channel (Restricted Bands)



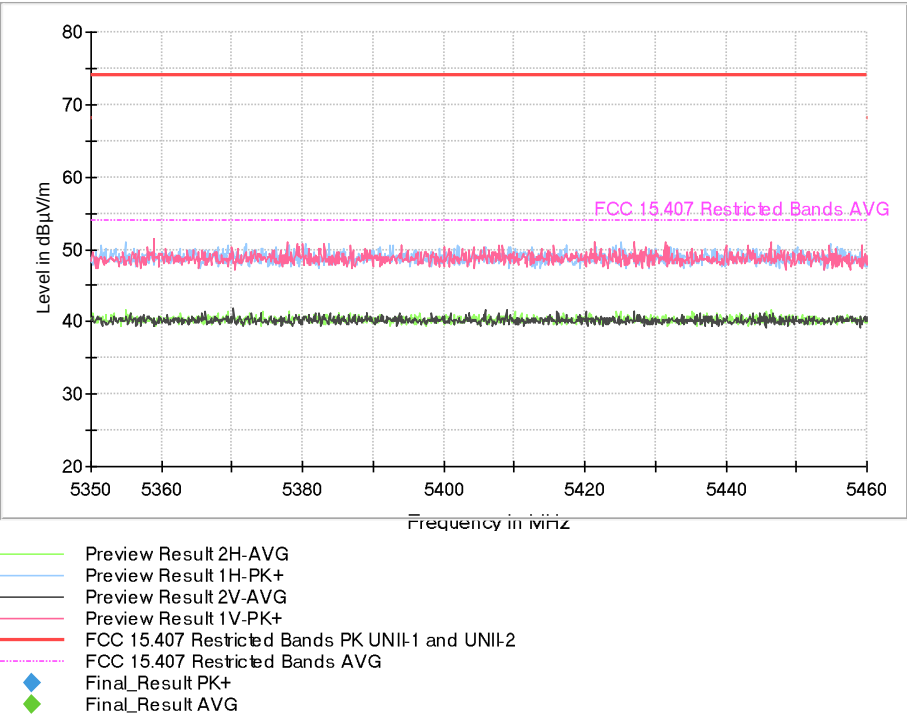
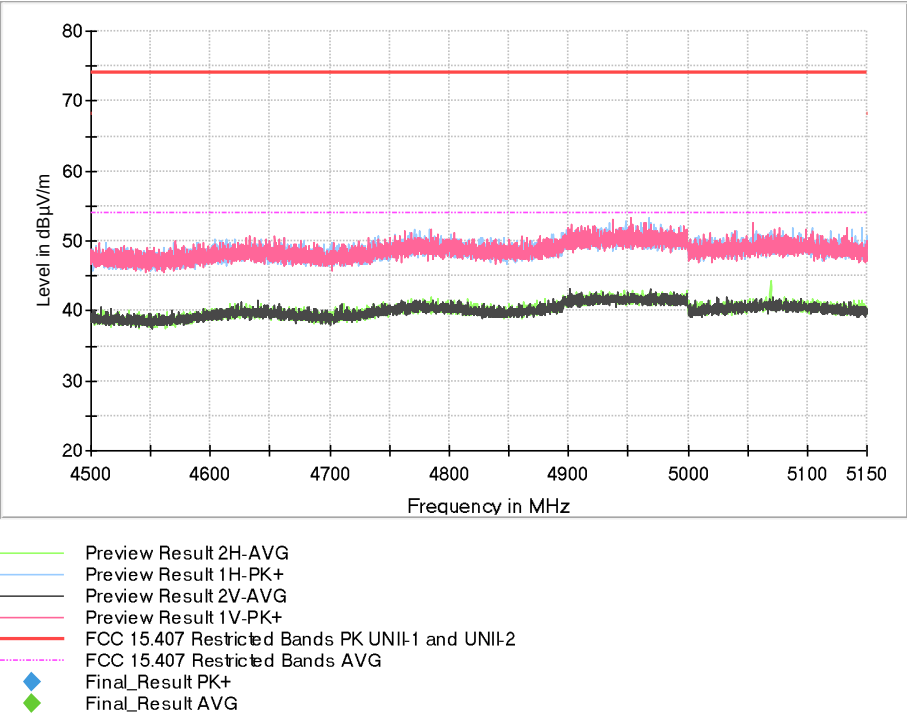
- Lower Band Edge and Upper Band Edge – High Channel (Restricted Bands)



- **MIMO 802.11 he40 SU Full-channel allocation:**
 - Lower Band Edge and Upper Band Edge – Low Channel (Restricted Bands)

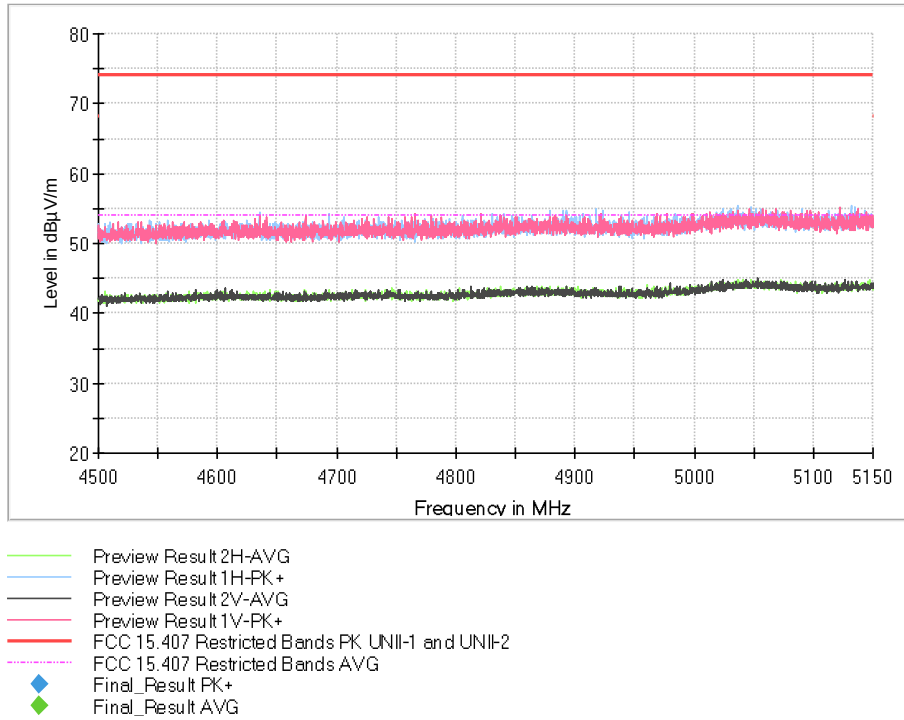


- **MIMO 802.11 he80 SU Full-channel allocation:**
 - Lower Band Edge and Upper Band Edge – (Restricted Bands)



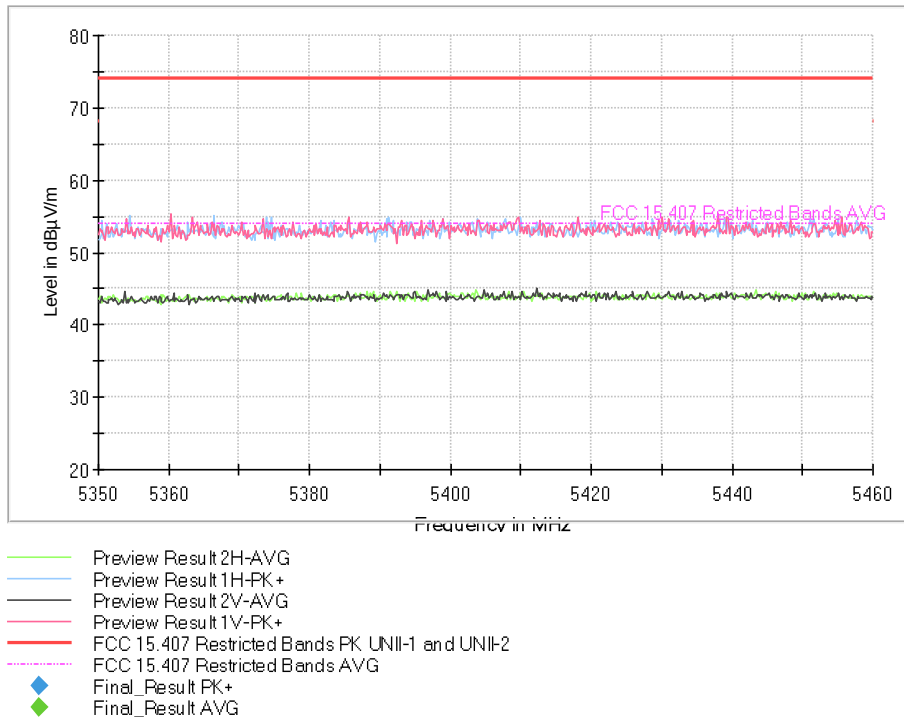
MIMO 802.11 he20 RU 26 Offset 0:

- Lower Band Edge – Low Channel (Restricted Bands)



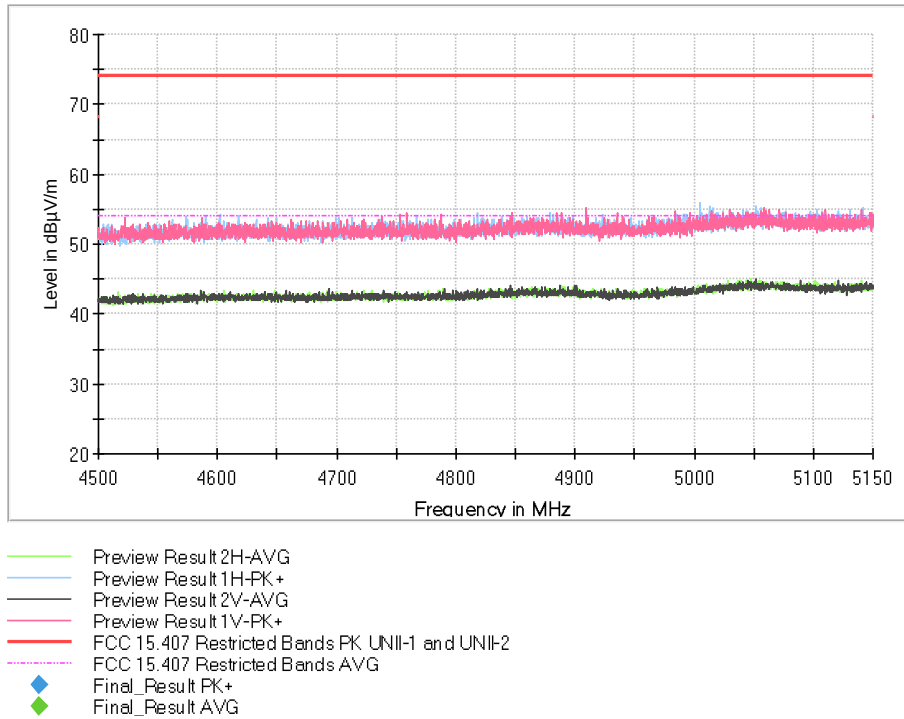
MIMO 802.11 he20 RU 26 Offset 8:

- Upper Band Edge – High Channel (Restricted Bands)



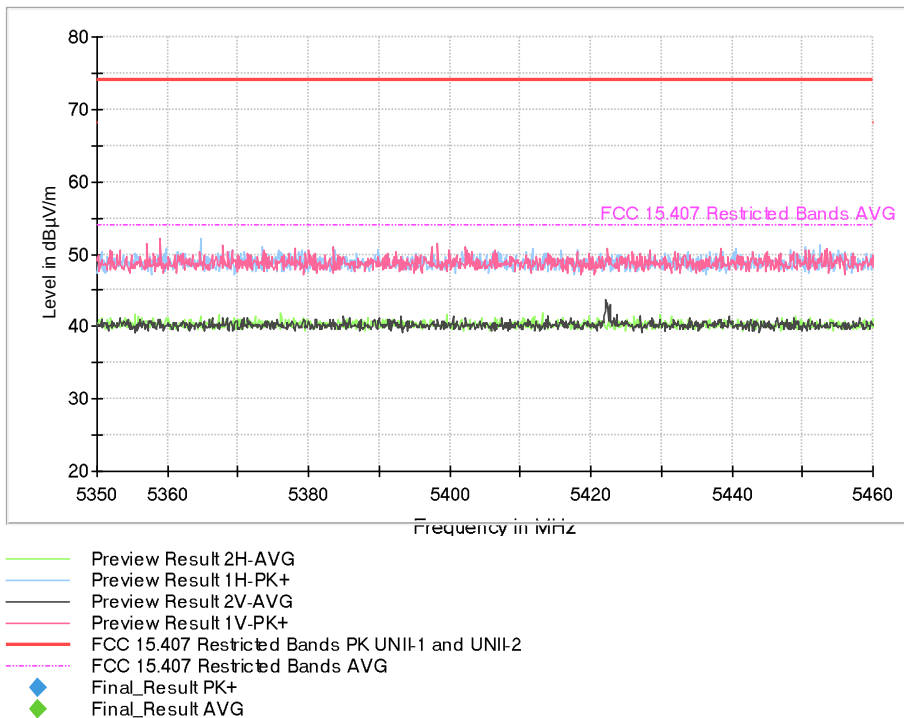
MIMO 802.11 he40 RU 26 Offset 0:

- Lower Band Edge – Low Channel (Restricted Bands)

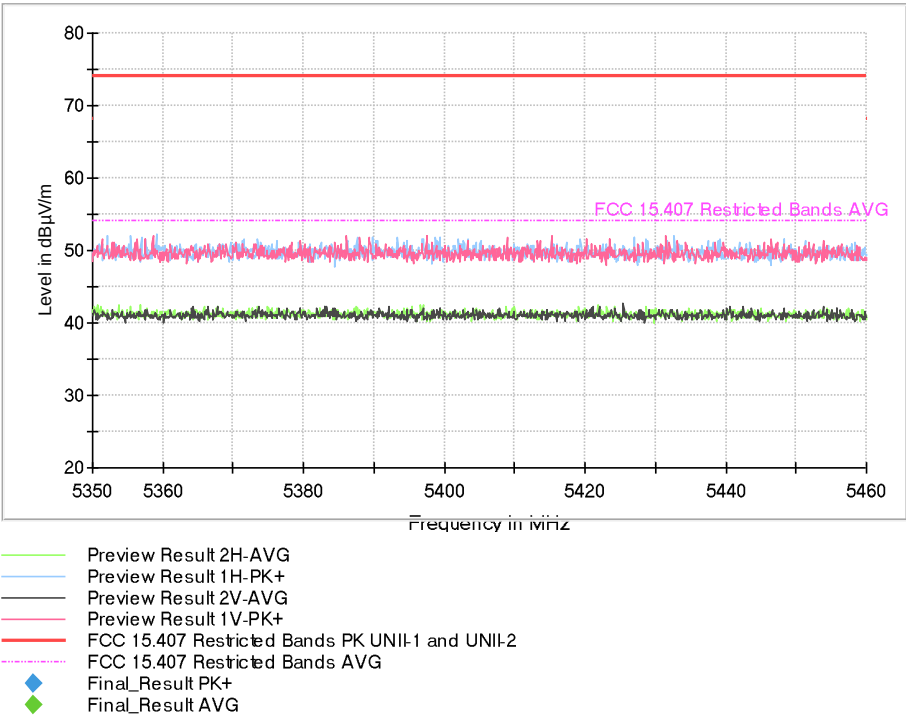
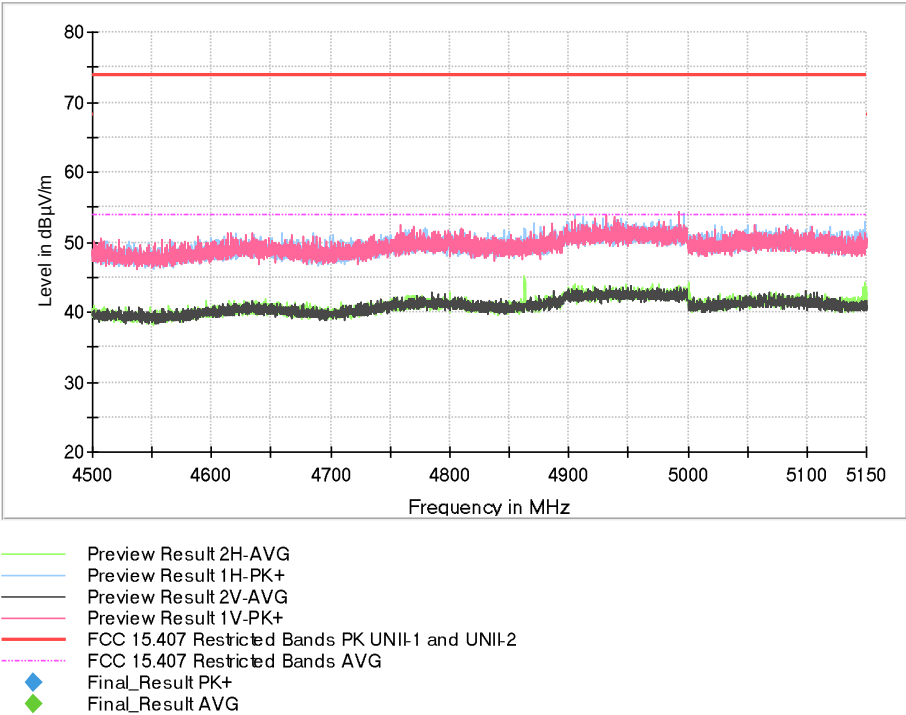


MIMO 802.11 he40 RU 26 Offset 17:

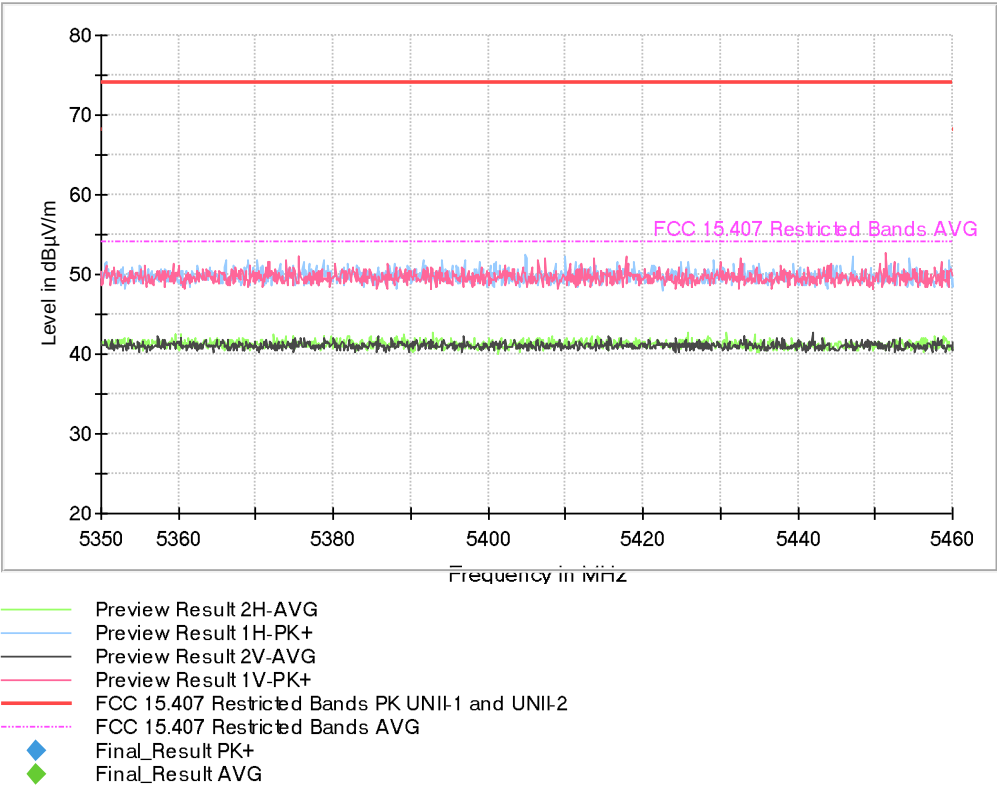
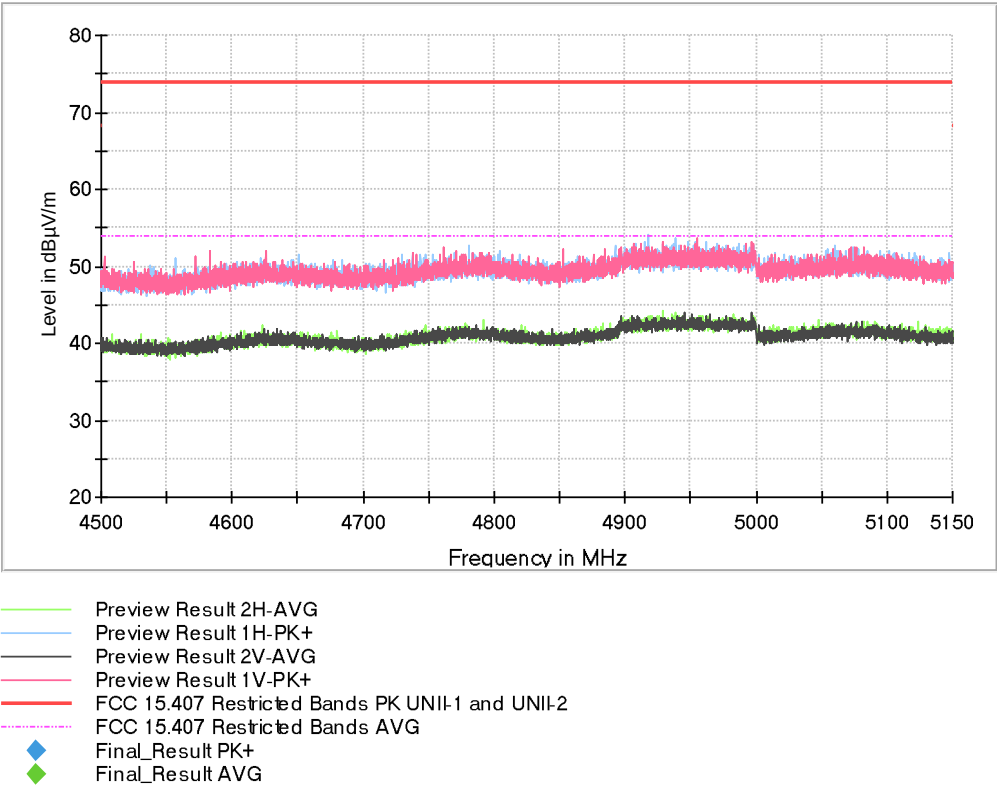
- Upper Band Edge – High Channel (Restricted Bands)



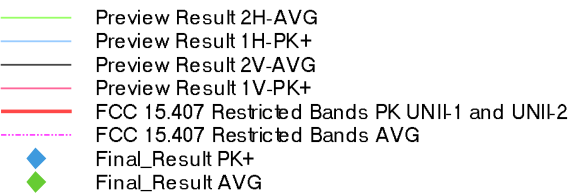
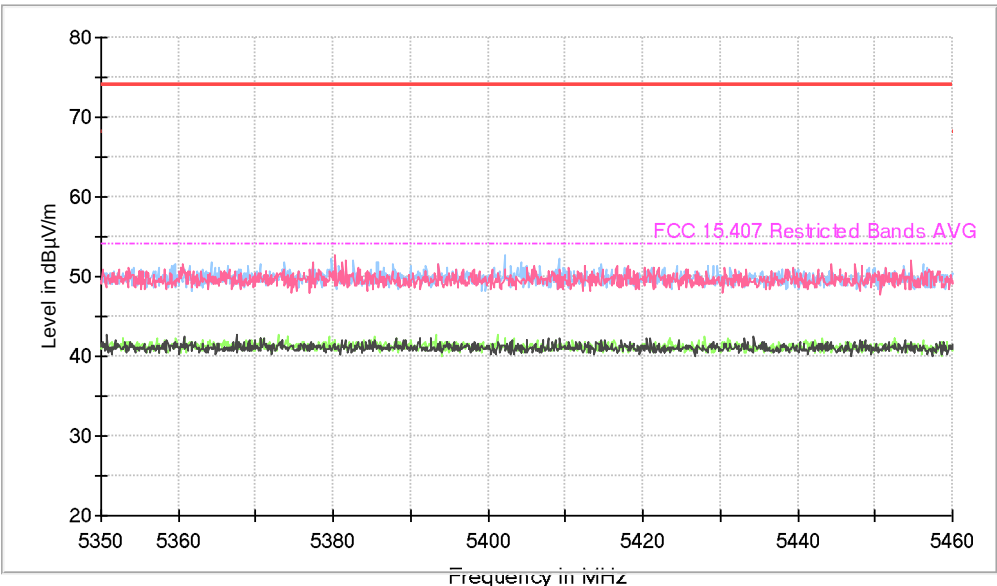
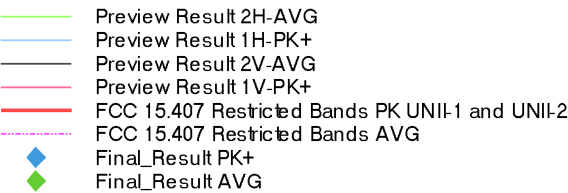
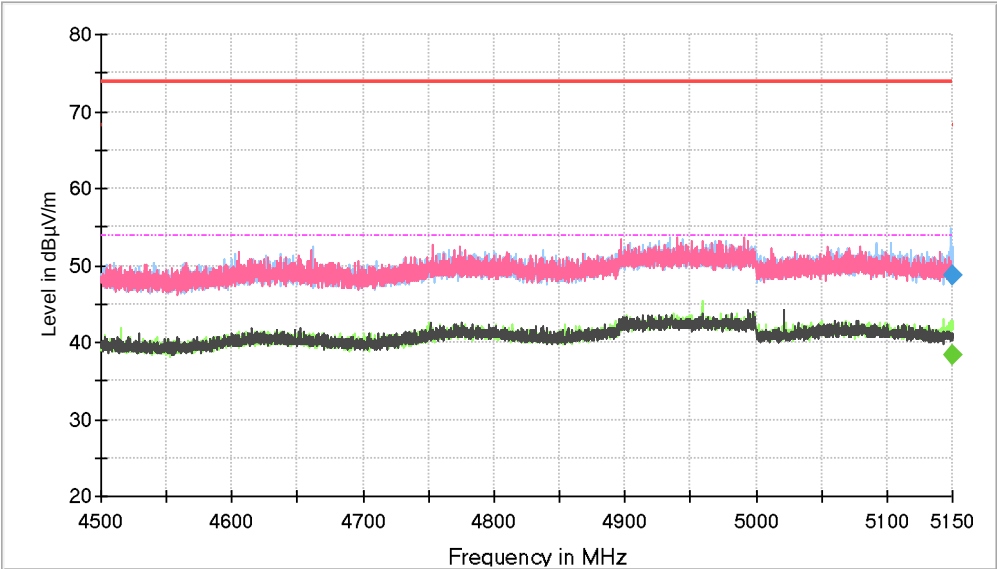
- **MIMO 802.11 n40:**
 - Lower Band Edge and Upper Band Edge – Low Channel (Restricted Bands)



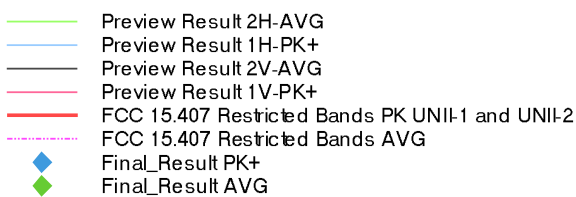
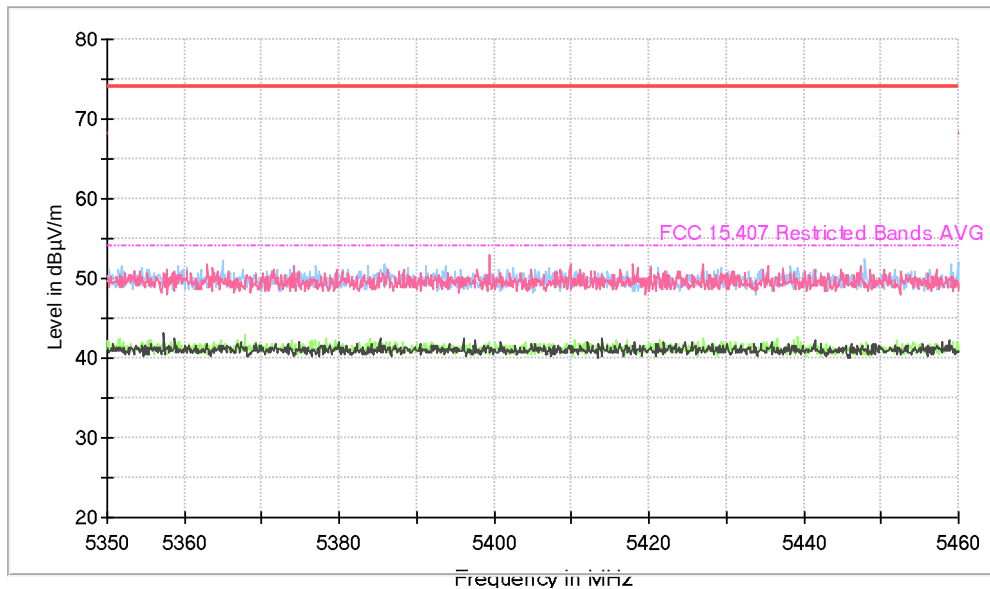
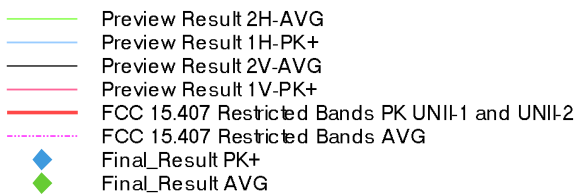
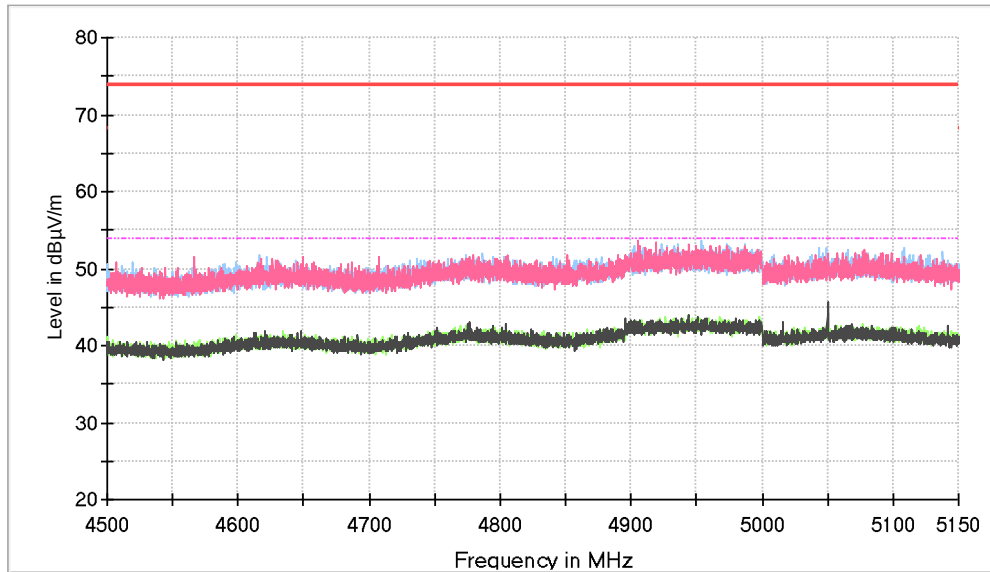
- Lower Band Edge and Upper Band Edge – High Channel (Restricted Bands)



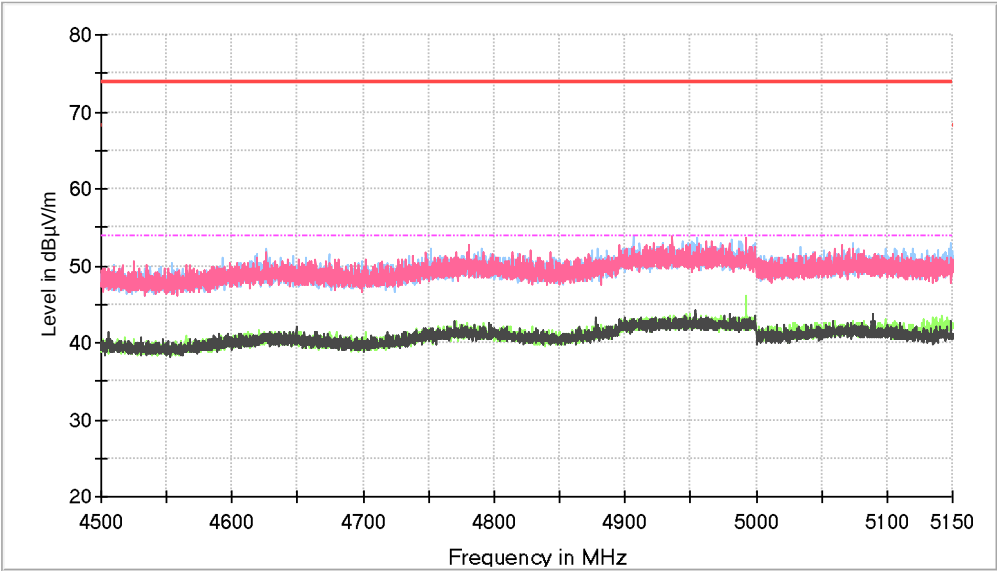
- MIMO 802.11 ac40:
 - Lower Band Edge and Upper Band Edge – Low Channel (Restricted Bands)



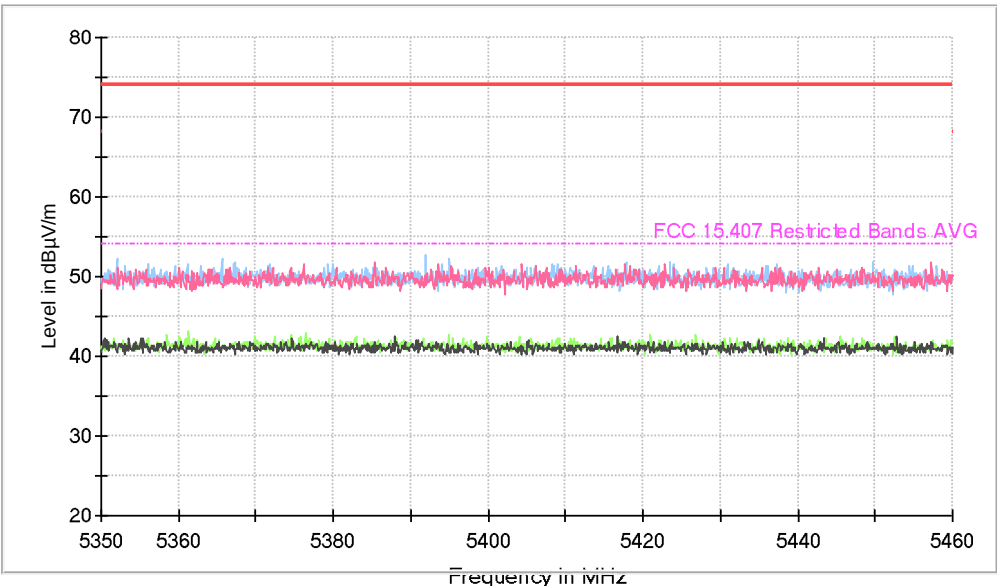
- Lower Band Edge and Upper Band Edge – High Channel (Restricted Bands)



- **MIMO 802.11 ac80:**
 - Lower Band Edge and Upper Band Edge – Single Channel (Restricted Bands)



Preview Result 2H-AVG
Preview Result 1H-PK+
Preview Result 2V-AVG
Preview Result 1V-PK+
FCC 15.407 Restricted Bands PK UNII-1 and UNII-2
FCC 15.407 Restricted Bands AVG
Final_Result PK+
Final_Result AVG



Preview Result 2H-AVG
Preview Result 1H-PK+
Preview Result 2V-AVG
Preview Result 1V-PK+
FCC 15.407 Restricted Bands PK UNII-1 and UNII-2
FCC 15.407 Restricted Bands AVG
Final_Result PK+
Final_Result AVG

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

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TEST CONDITIONS.....72

FCC 15.407(b)(4)(6) Transmitter Out of Band Radiated Emissions and Transmitter Band Edge
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TEST CONDITIONS

(*) Declared by the Client.

POWER SUPPLY (*):

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

ANTENNA (*):

Type of Antennas: External.

Band U-NII-3:

Technology Tested:	WLAN (IEEE 802.11 a20 / n2040 / ac204080 / ax204080 2x2)	
Modes:	802.11a: 6, 9, 12, 18, 24, 36, 48 & 54 Mbps (SISO, or MIMO with CDD)	
	802.11n HT20: MCS0 to MCS23 (1 or 2 spatial stream with either SISO or 2 chain MIMO CDD)	
	802.11n HT40: MCS0 to MCS23 (1 or 2 spatial stream with either SISO or 2 chain MIMO CDD)	
	802.11ac VHT20: MCS0 to MCS9 (1 or 2 spatial stream) (SISO, or MIMO with CDD without TxBF)	
	802.11ac VHT40: MCS0 to MCS9 (1 or 2 spatial stream) (SISO, or MIMO with CDD without TxBF)	
	802.11ac VHT80: MCS0 to MCS9 (1 or 2 spatial stream) (SISO, or MIMO with CDD without TxBF)	
	802.11ax HE20: MCS0 to MCS9 (1 or 2 spatial stream) (SISO, or MIMO with CDD without TxBF)	
	802.11ax HE40: MCS0 to MCS9 (1 or 2 spatial stream) (SISO, or MIMO with CDD without TxBF)	
	802.11ax HE80: MCS0 to MCS9 (1 or 2 spatial stream) (SISO, or MIMO with CDD without TxBF)	
Setting of cores / ports:	Chain 0, Chain 1, Chain 0 & 1	
Beamforming:	No.	
Frequency Range:	5725 - 5850 MHz	
Operating Channel Bandwidth:	20 MHz	
Transmission Channels:	Channels	Channel Frequency (MHz)
	Low (149)	5745
	Middle (157)	5785
	High (165)	5825
Operating Channel Bandwidth:	40 MHz	
Transmission Channels:	Channels	Channel Frequency (MHz)
	Low (151)	5755
	High (159)	5795
Operating Channel Bandwidth:	80 MHz	
Transmission Channels:	Channels	Channel Frequency (MHz)
	Single (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 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 Mbps SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.
- 802.11n HT20: MCS0 SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.
- 802.11n HT40: MCS0 SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.
- 802.11ac VHT20: MCS0 SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.
- 802.11ac VHT40: MCS0 SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.
- 802.11ac VHT80: MCS0 SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.
- 802.11ax HE20: MCS0 SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.
- 802.11ax HE40: MCS0 SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.
- 802.11ax HE80: MCS0 SISO 1Tx on Chain 0 and 1Tx on Chain 1 / MIMO 2Tx on Chain 0 & 1.

RADIATED MEASUREMENTS:

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz) and 1 GHz-18 GHz Double ridge horn antenna is situated at a distance of 3 m and a distance of 1.5 m for the frequency range 17 GHz-40 GHz (18 GHz-40 GHz horn antenna).

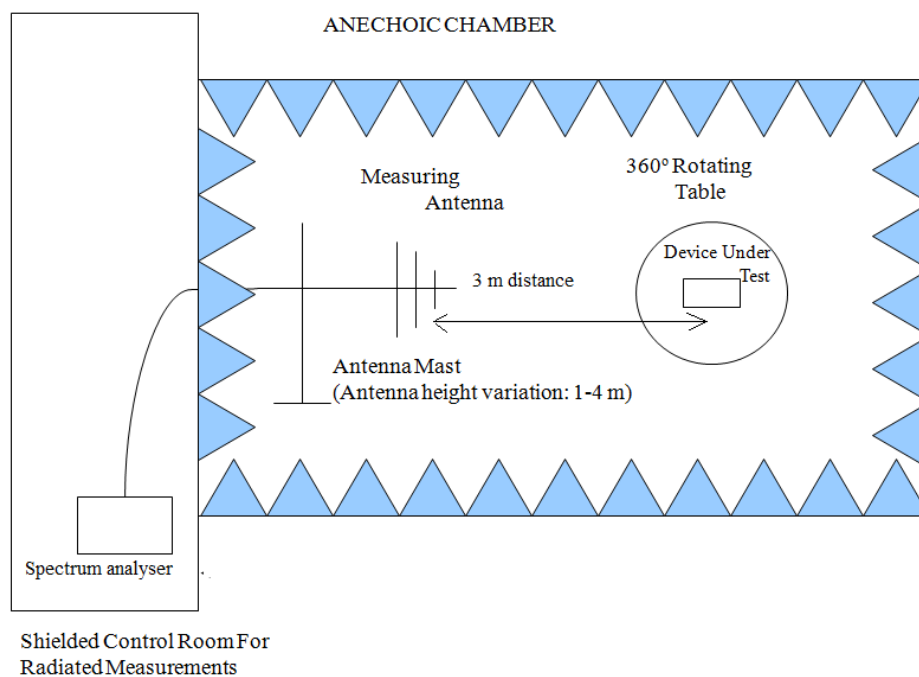
For radiated emissions in the range 17 GHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find the maximum radiated emission.

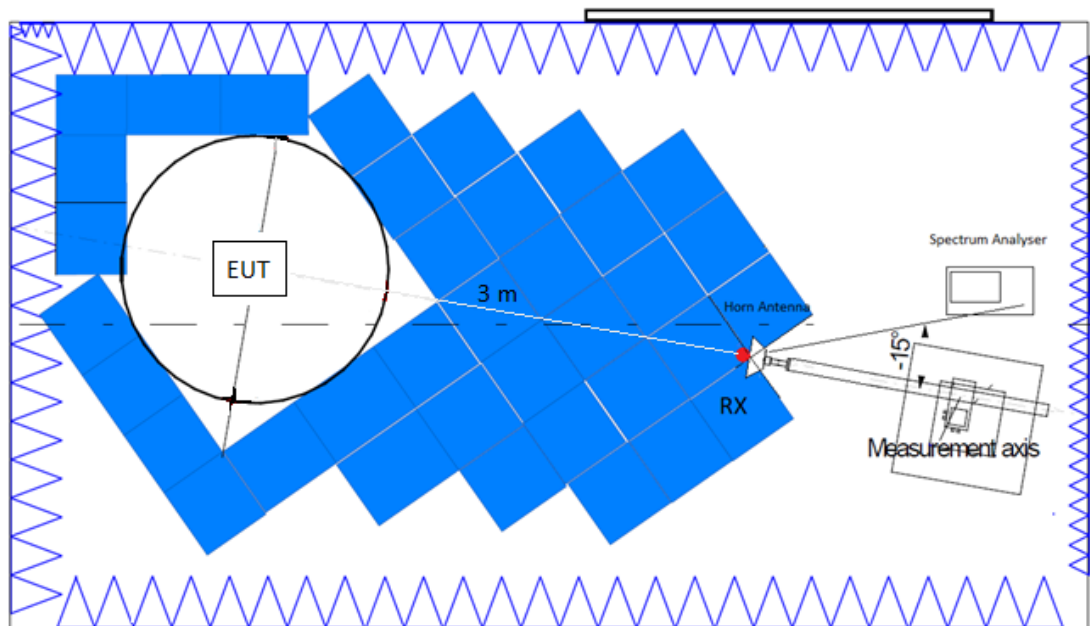
Measurements were made in both horizontal and vertical planes of polarization.

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

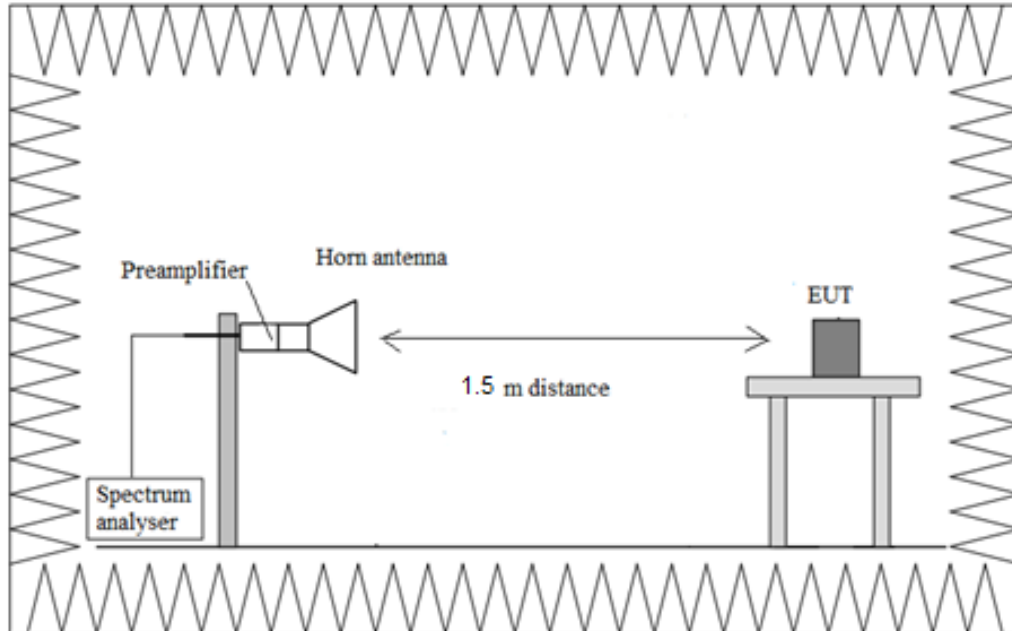
Radiated measurements setup $f < 1$ GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup $f > 17$ GHz:



FCC 15.407(b)(4)(6) 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)	-	30
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, specified when measuring with peak detector function.

RESULTS:

The situation and orientation of the equipment under test were 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 1.5m for the frequency range 17 GHz-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 analyser. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

OUT OF BAND EMISSIONS: For spurious emissions outside of the U-NII-3 band edge mask of 5.65-5.925 GHz, the worst-case was determined after preliminary measurements of the E.I.R.P. density (radiated).

The worst-case was determined by measuring the e.i.r.p density (radiated). Test performed on the worst case.

Preliminary tests determined the worst-case:

SISO Chain 1:

Worst-case: 802.11 ax20 SU Full-channel allocation

Frequency range 30 MHz - 1 GHz (SISO Chain 1):

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

Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBμV/m)	Polarization	Detector
875.0215	29.50	H	Quasi-Peak
624.9730	25.75	H	Quasi-Peak

Measurement Uncertainty (dB) $\leq \pm 5.1$

Frequency range 1 - 40 GHz (SISO Chain 1):

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.

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.

- LOW CHANNEL. Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBμV/m)	Polarization	Detector
1375.375	44.86	V	Peak
2116.562	44.06	V	Peak

- MIDDLE CHANNEL. Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBμV/m)	Polarization	Detector
1375.000	43.88	V	Peak
3498.250	48.80	V	Peak

- HIGH CHANNEL. Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (MHz)	Emission Level (dBμV/m)	Polarization	Detector
1375.750	43.69	V	Peak
2116.562	44.05	V	Peak

Measurement uncertainty (dB) $\leq \pm 4.6$ for $f \geq 1$ GHz up to 17 GHz
 $\leq \pm 4.89$ for $f \geq 17$ GHz up to 26.5 GHz
 $\leq \pm 5.14$ for $f \geq 26.5$ GHz up to 40 GHz

Verdict: PASS

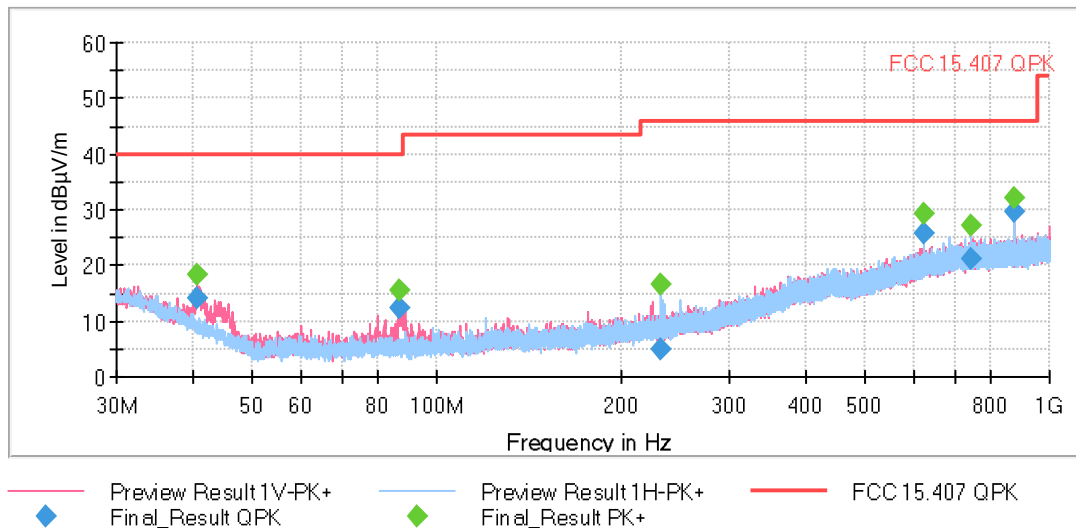
SISO Chain 1:

The setting for each range of frequency is indicated in the following tables:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW44] 30 MHz - 1 GHz	30,312 kHz	PK+	100 kHz	1 s	30 dB
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW44] 1 GHz – 7 GHz	187.5 kHz	PK+ ; AVG	1 MHz	1 s	0 dB
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW44] 7 GHz - 17 GHz	312.5 kHz	PK+ ; AVG	1 MHz	1 s	30 dB
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW44] 17 GHz – 28.5 GHz	383.3 kHz	PK+ ; AVG	1 MHz	0.3 s	0 dB
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW44] 28.5 GHz - 40 GHz	383.3 kHz	PK+ ; AVG	1 MHz	0.3 s	0 dB

FREQUENCY RANGE 30 MHz - 1 GHz (SISO Chain 1):

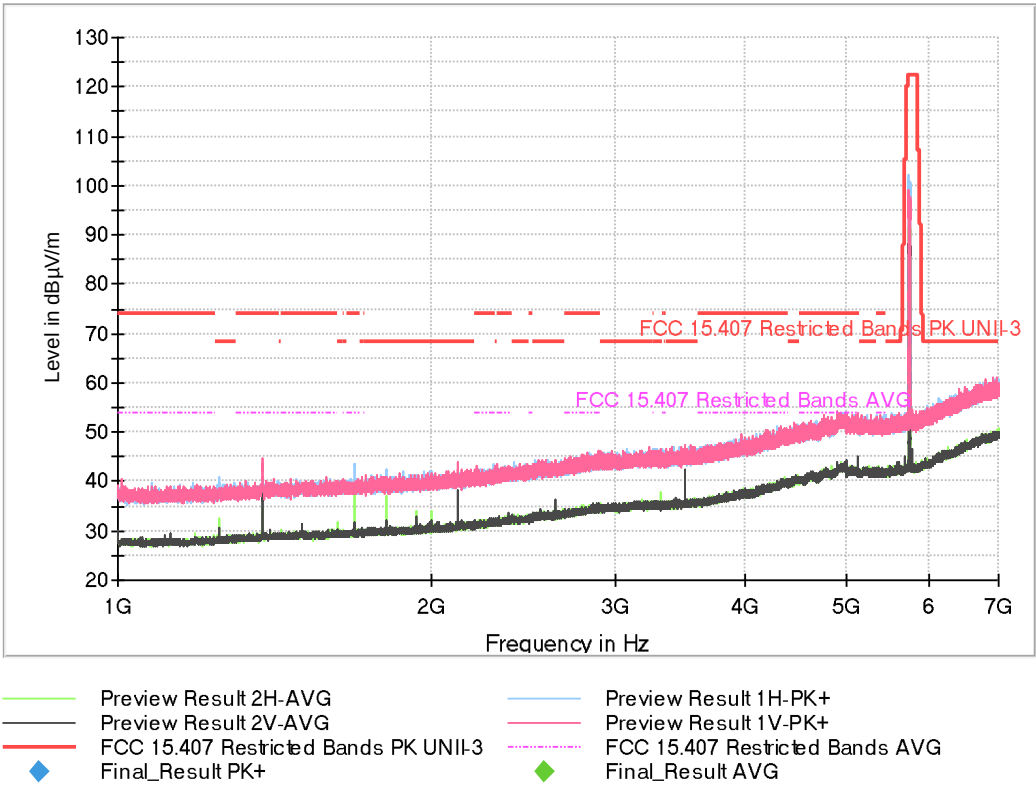
This plot is valid for all the Channels.



FREQUENCY RANGE 1 - 7 GHz (SISO Chain 1):

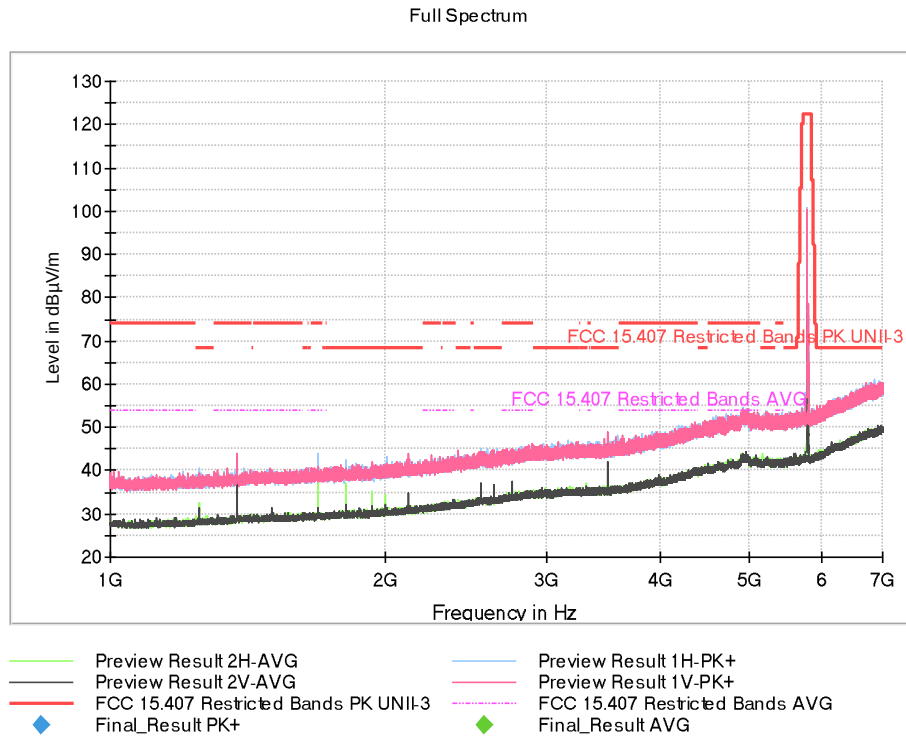
- Low Channel:

Full Spectrum



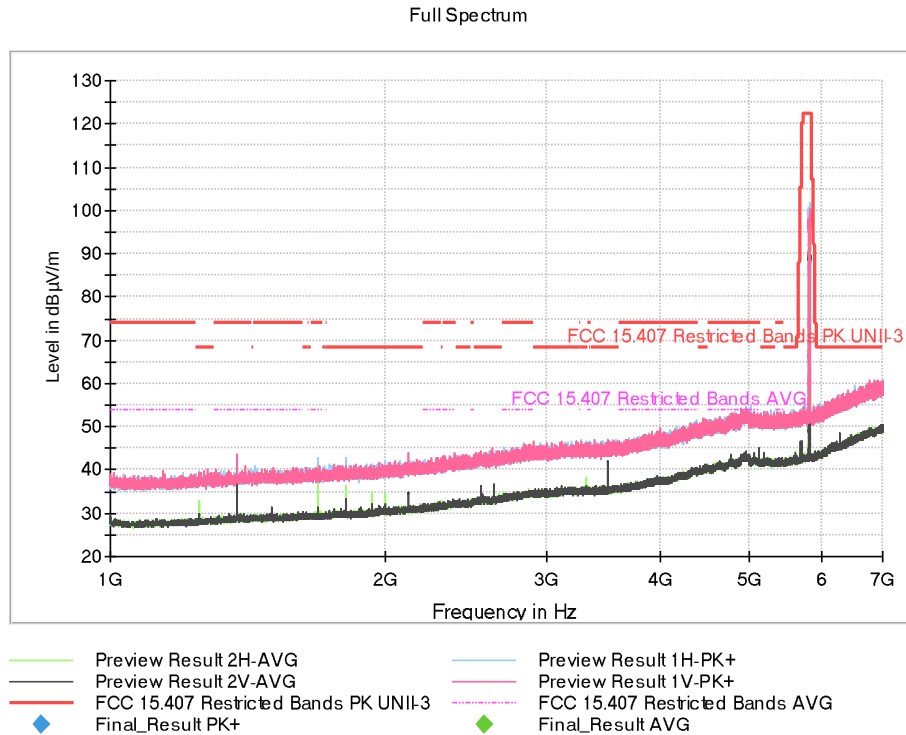
Note: The highest peak is the carrier frequency.

- Middle Channel:



Note: The highest peak is the carrier frequency.

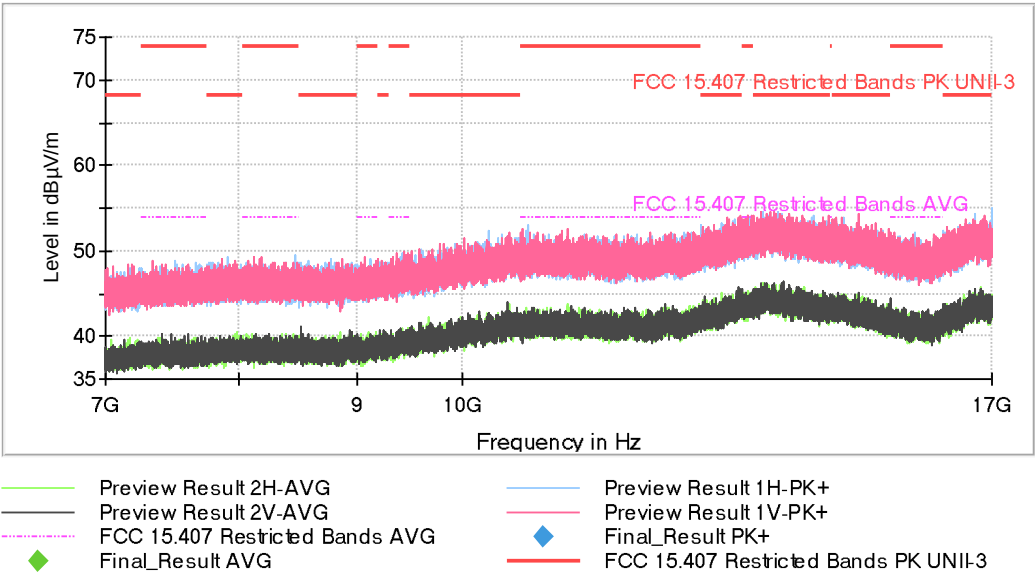
- High Channel:



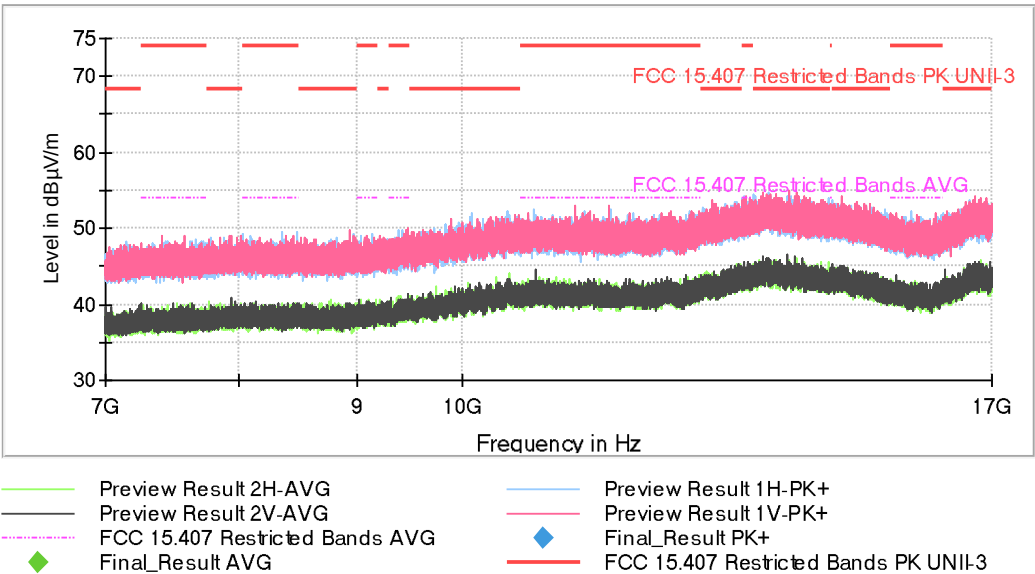
Note: The highest peak is the carrier frequency.

FREQUENCY RANGE 7 - 17 GHz (SISO Chain 1):

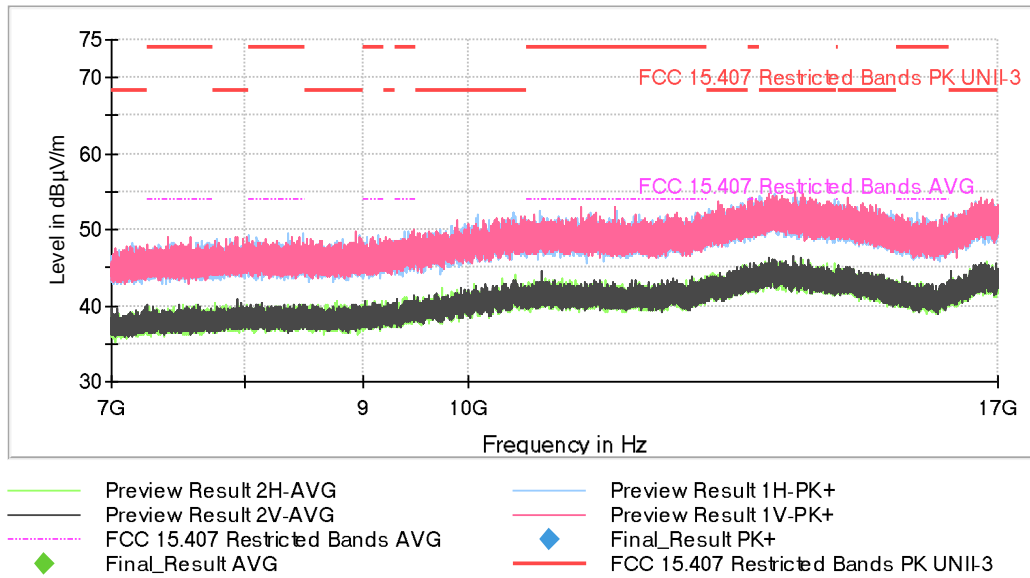
- Low Channel:



- Middle Channel:

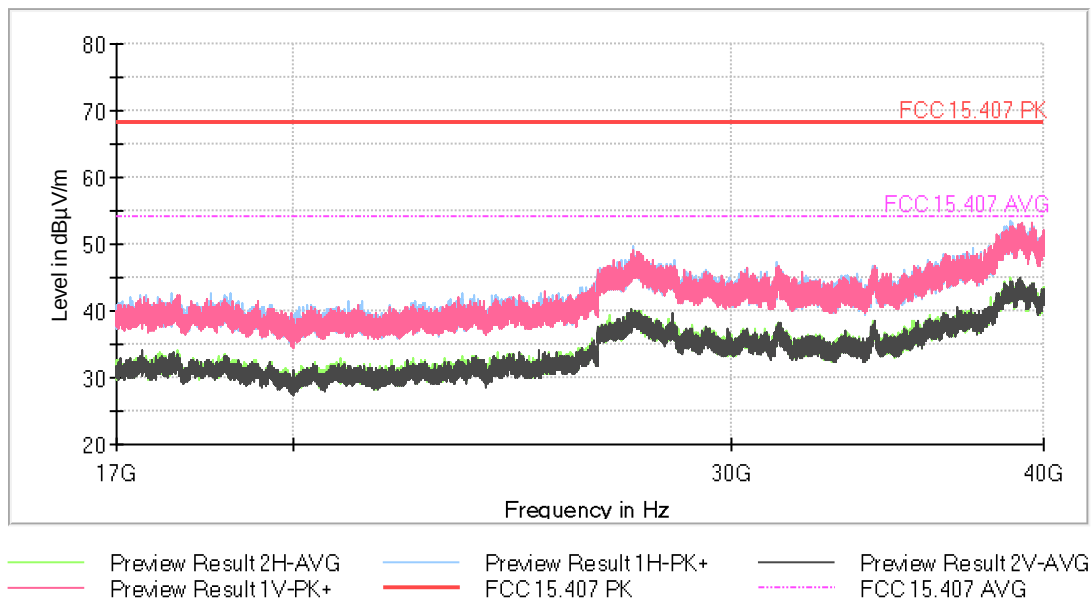


- High Channel:



FREQUENCY RANGE 17 - 40 GHz (SISO Chain 1):

This plot is valid for all the Channels.

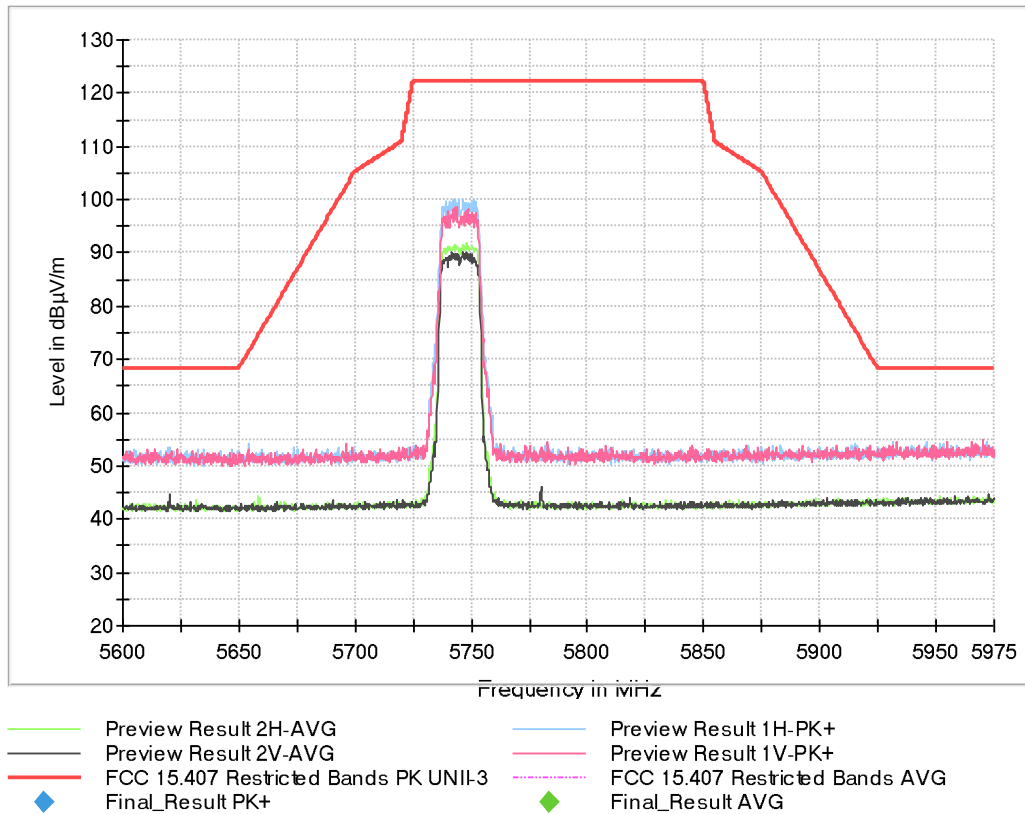


Band Edge Emissions:

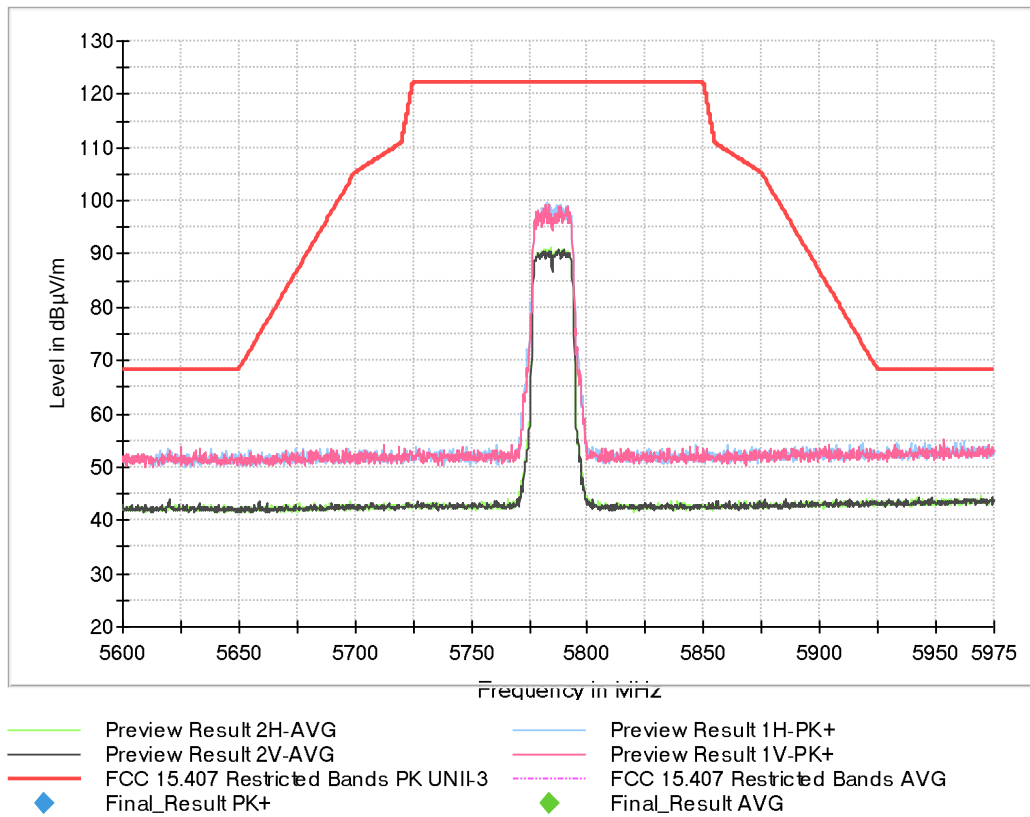
Attachments

802.11 a20. Spurious emissions inside of the mask 5.65-5.925 GHz:

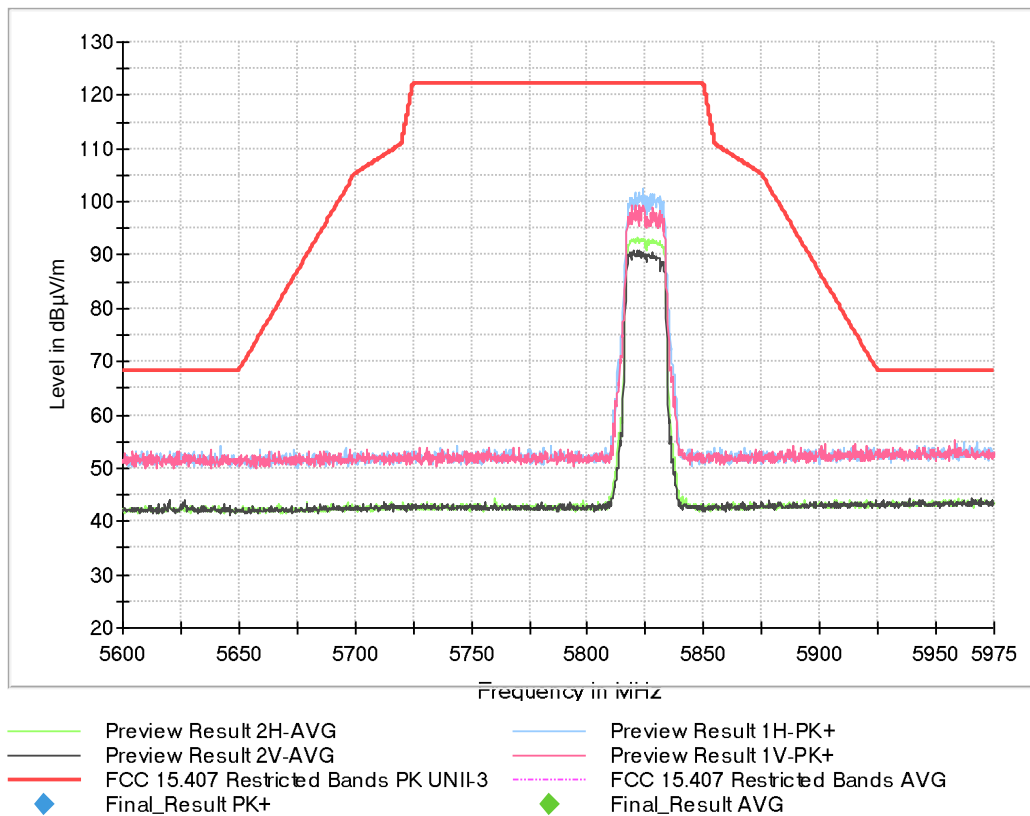
- Low Channel 149 (5745 MHz)



- Middle Channel 157 (5785 MHz)

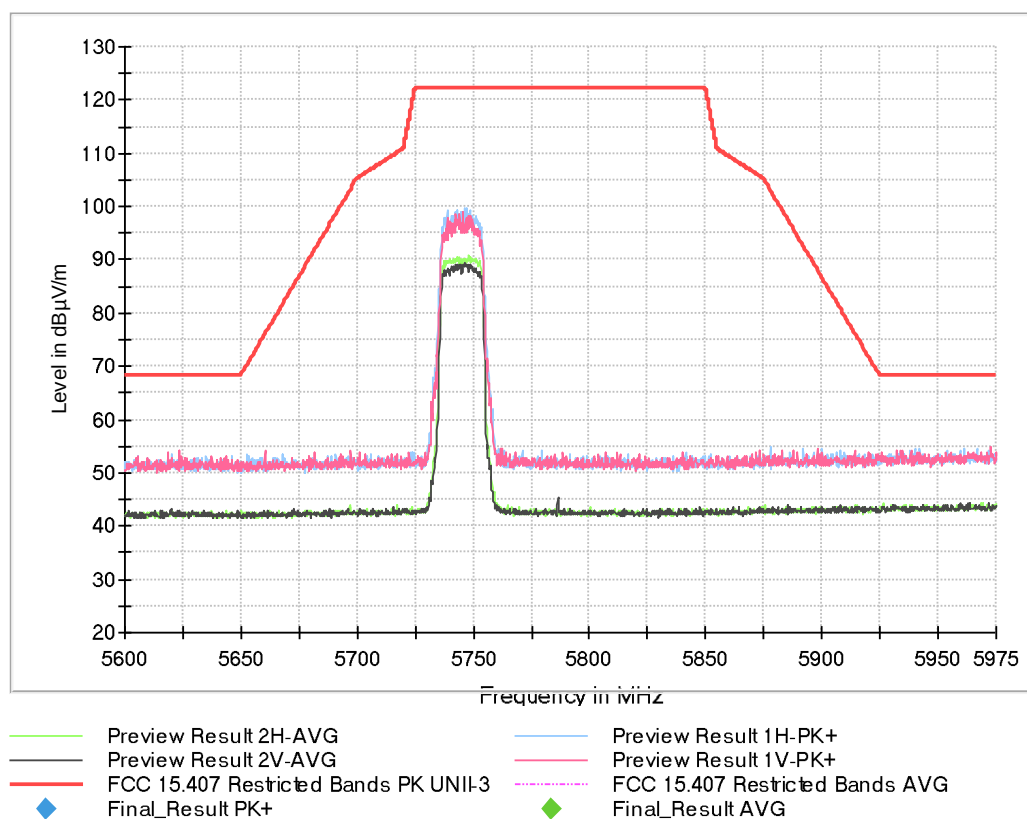


- High Channel 165 (5825 MHz)

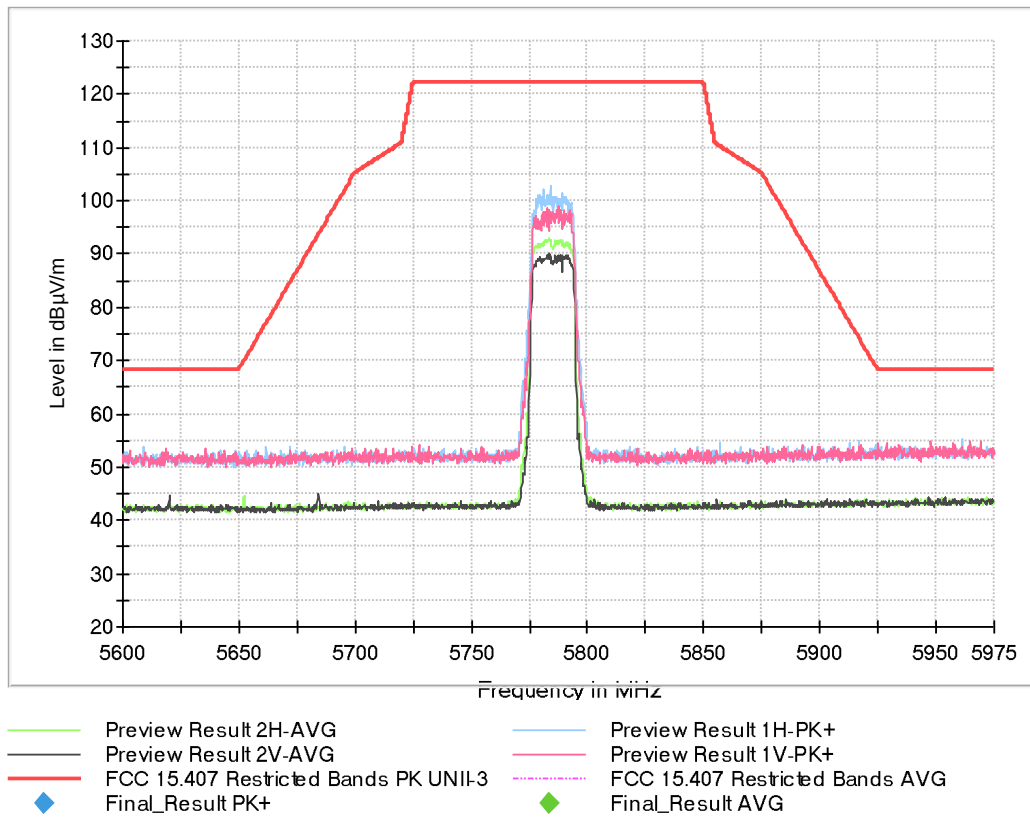


802.11 n20 (HT20). Spurious emissions inside of the mask 5.65-5.925 GHz:

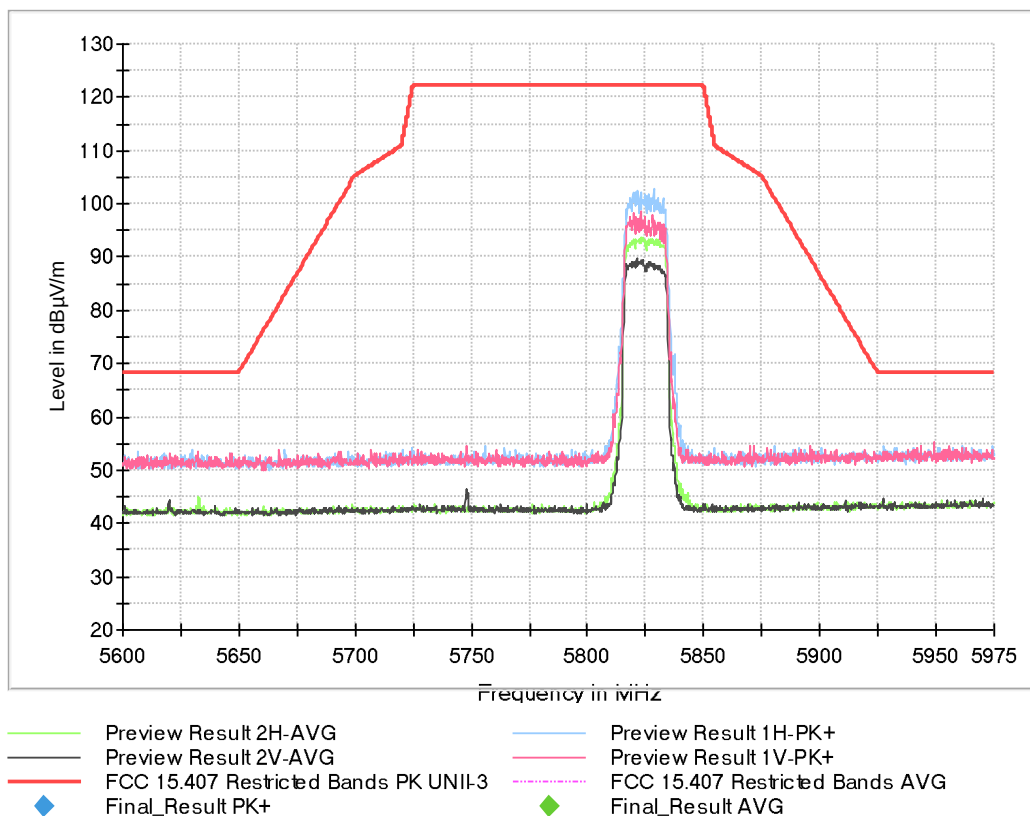
- Low Channel 149 (5745 MHz)



- **Middle Channel 157 (5785 MHz)**

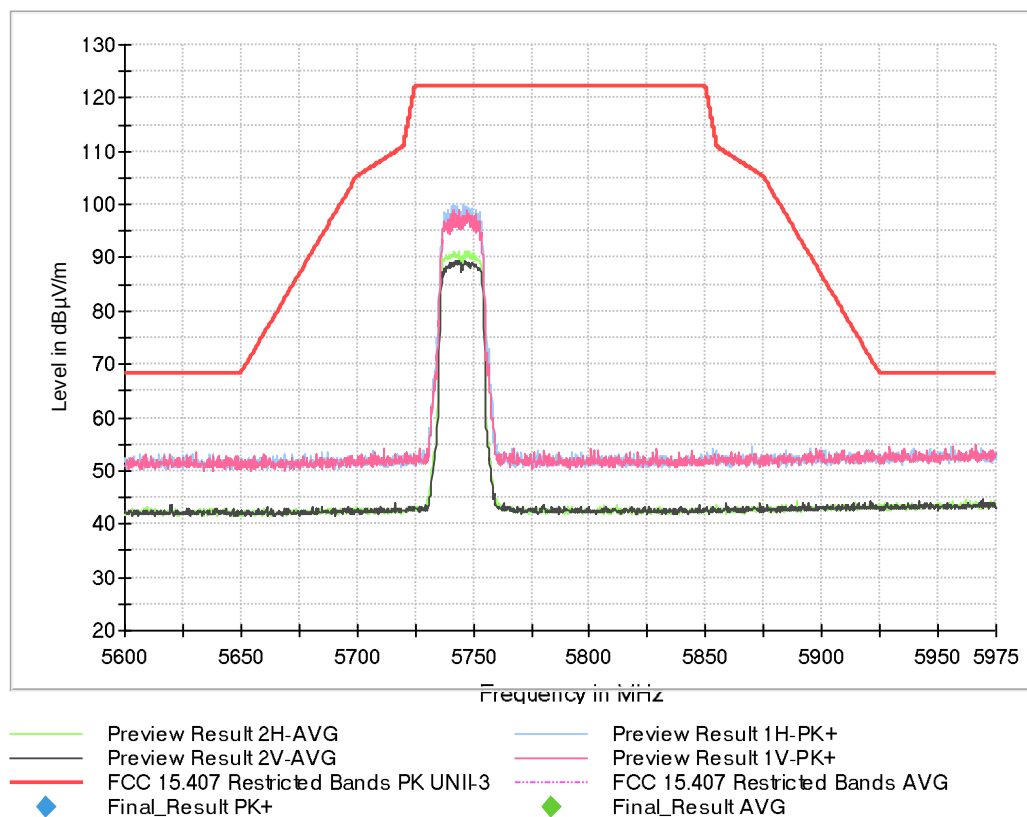


- **High Channel 165 (5825 MHz)**

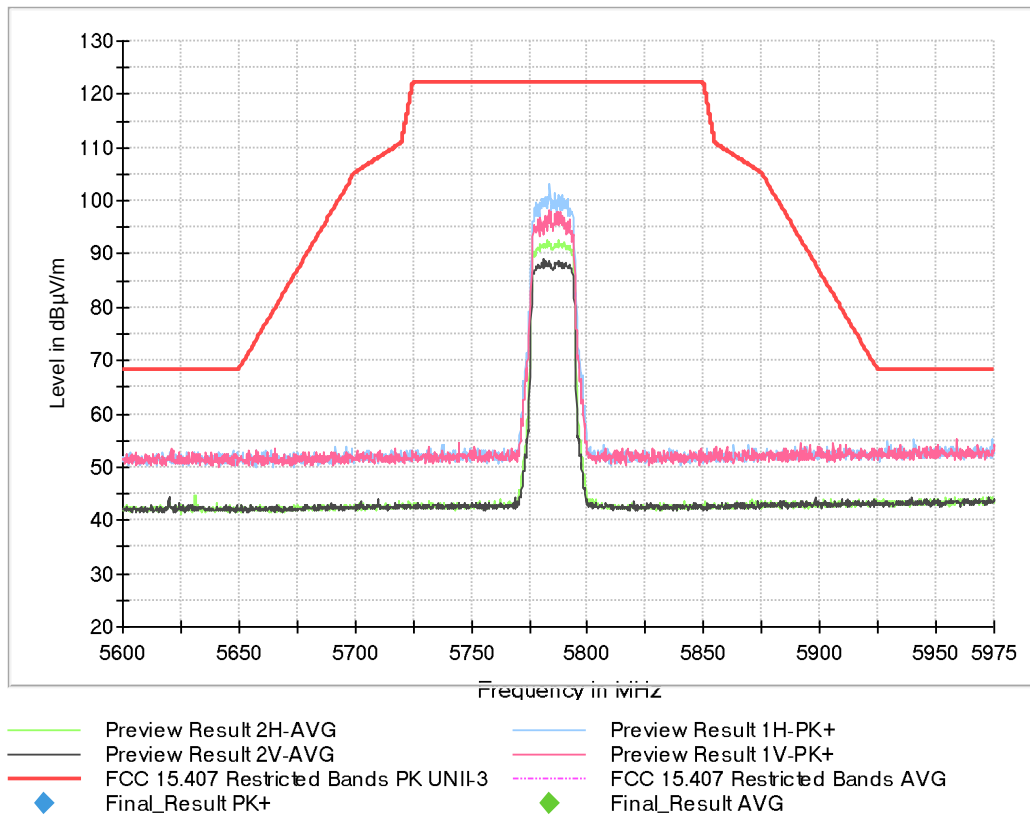


802.11 ac20 (VHT20). Spurious emissions inside the mask 5.65-5.925 GHz:

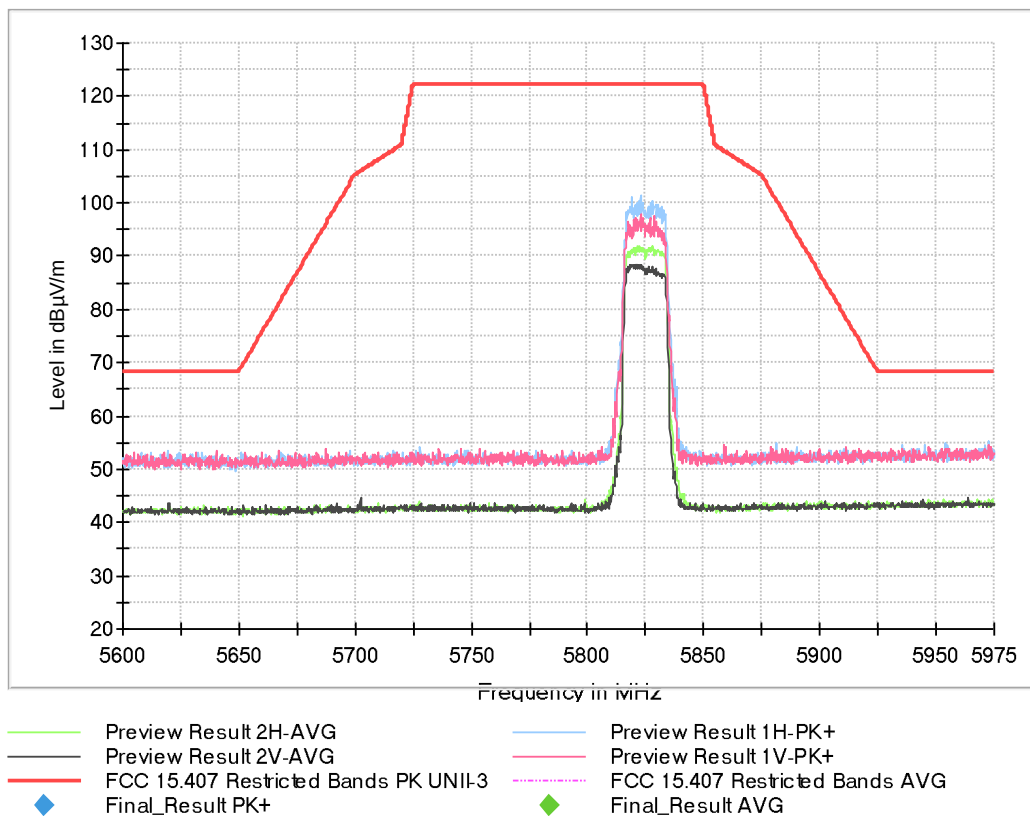
- Low Channel 149 (5745 MHz)



- Middle Channel 157 (5785 MHz)

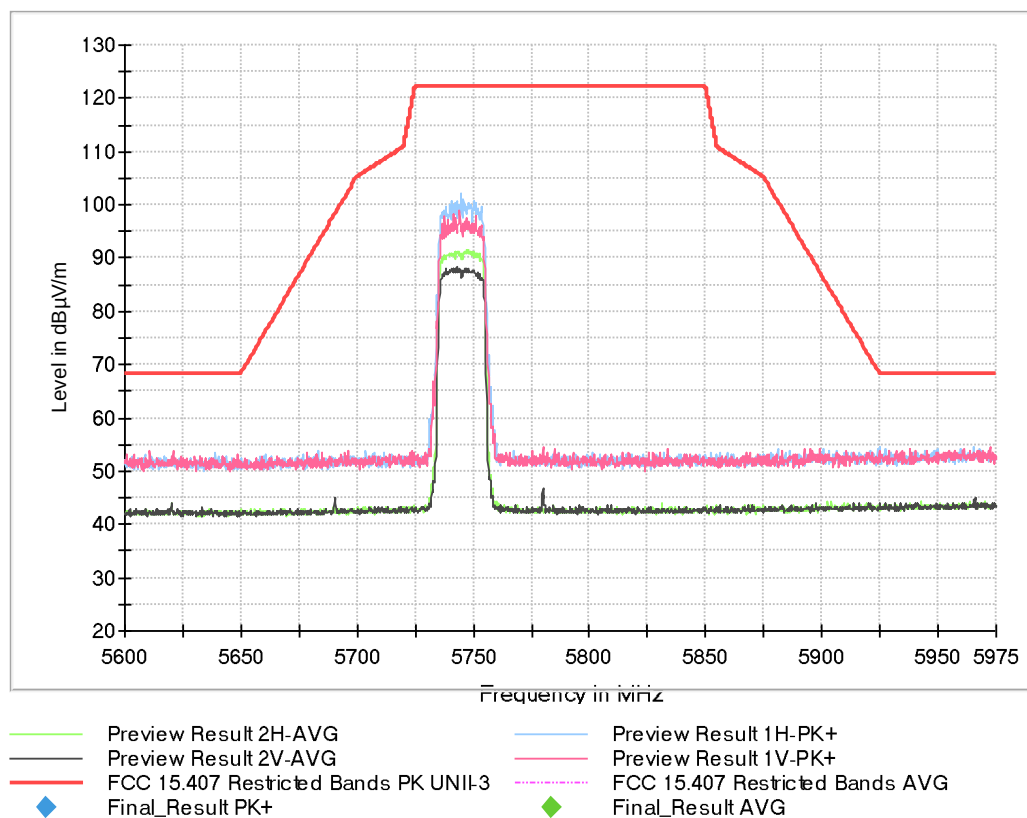


- High Channel 165 (5825 MHz)

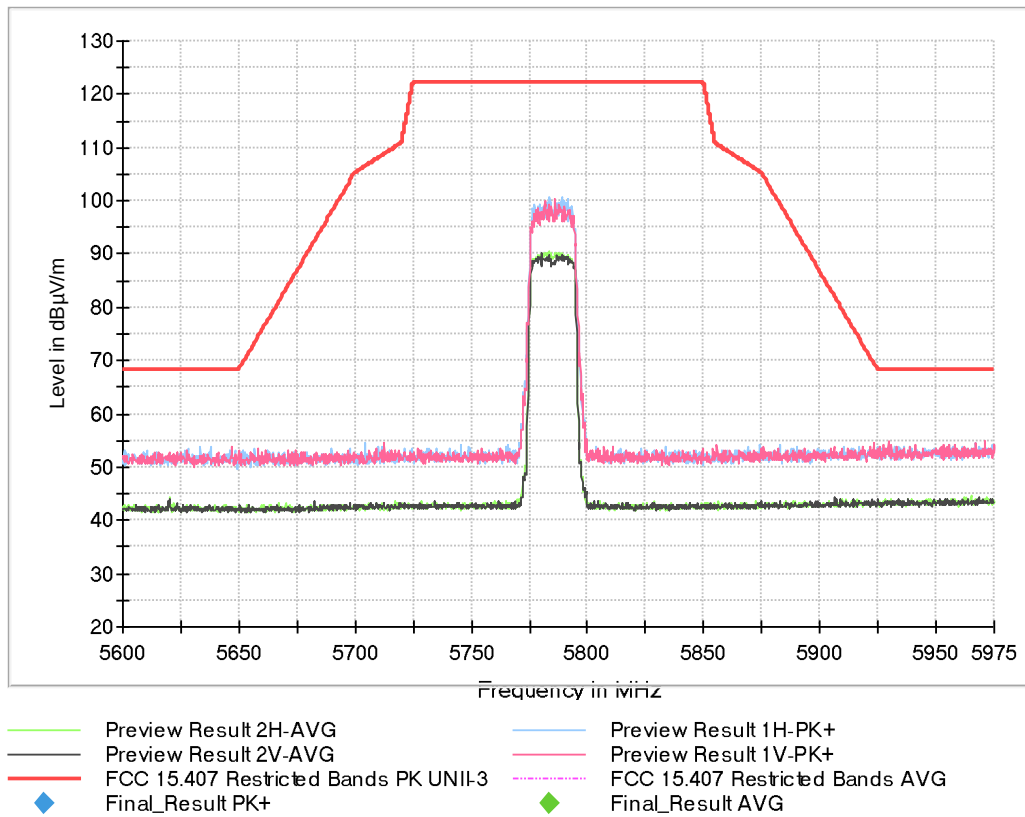


802.11 ax20 (HE20) - SU full-channel allocation. Spurious emissions inside of the mask 5.65-5.925 GHz:

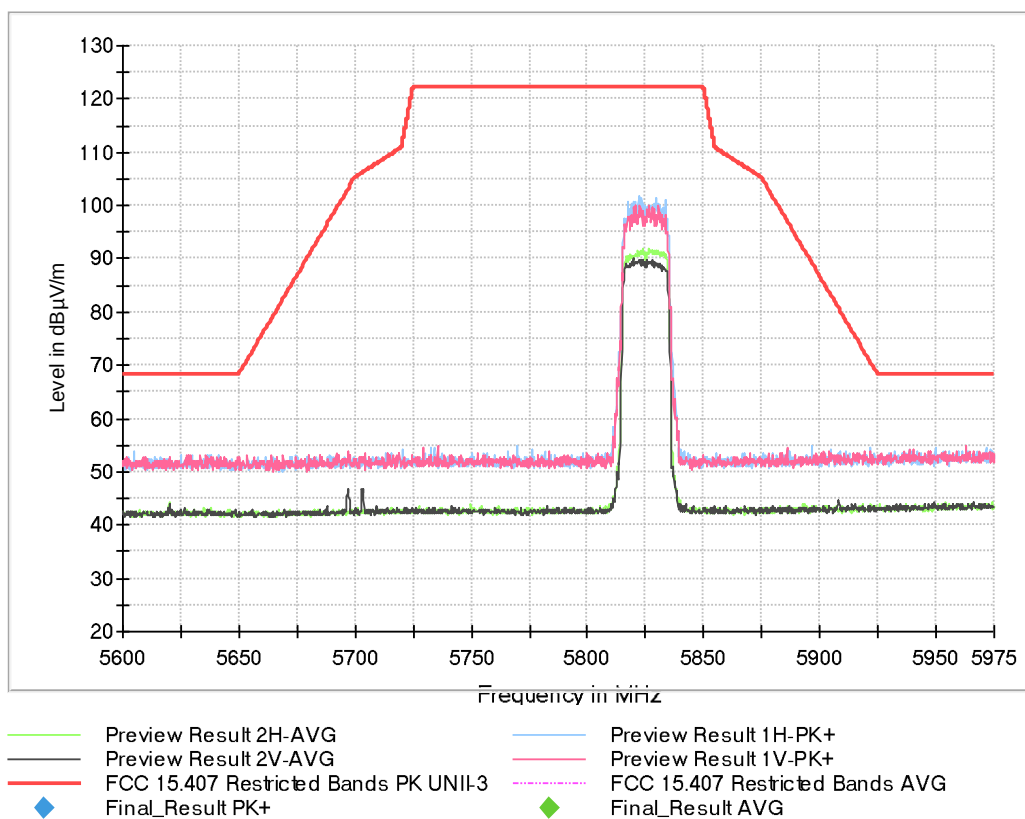
- Low Channel 149 (5745 MHz)



- Middle Channel 157 (5785 MHz)

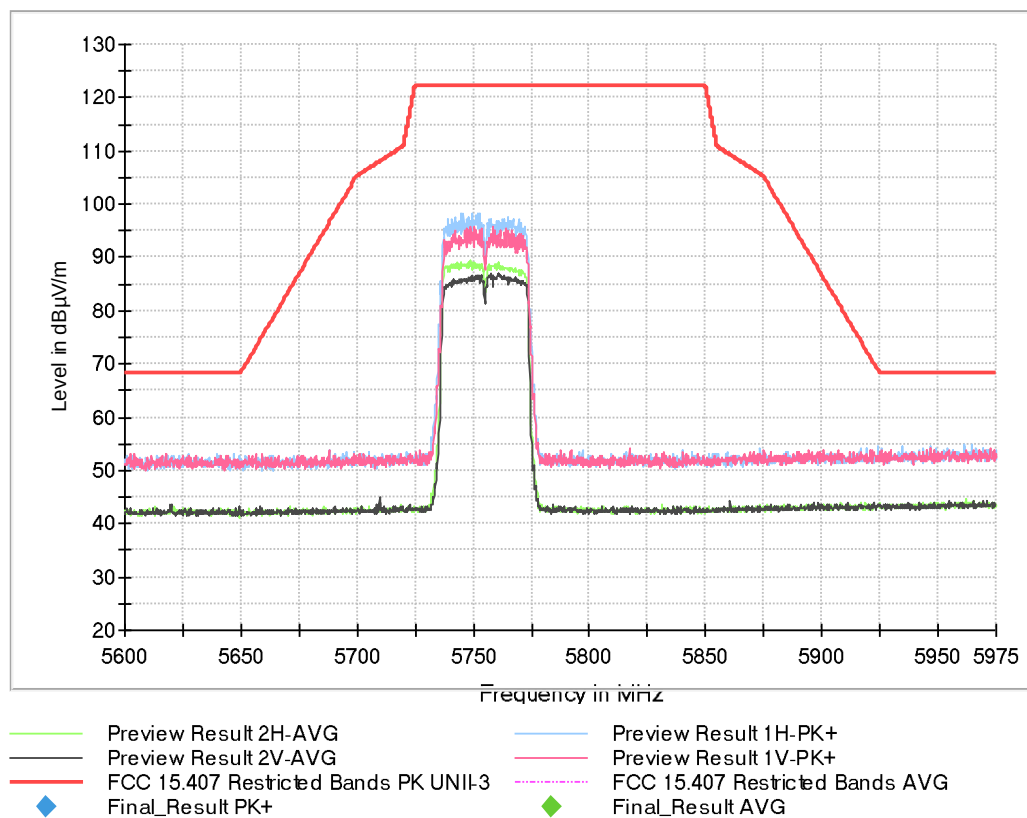


- High Channel 165 (5825 MHz)

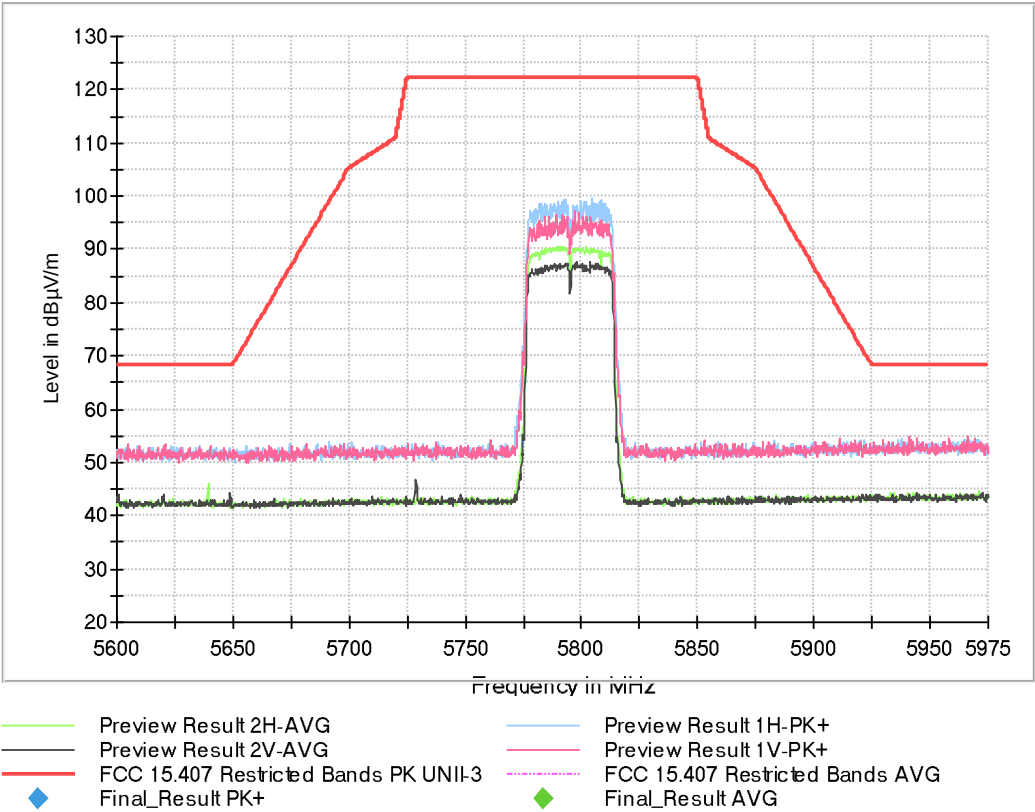


802.11 n40 (HT40). Spurious emissions inside the mask 5.65-5.925 GHz:

- Low Channel 151 (5755 MHz)

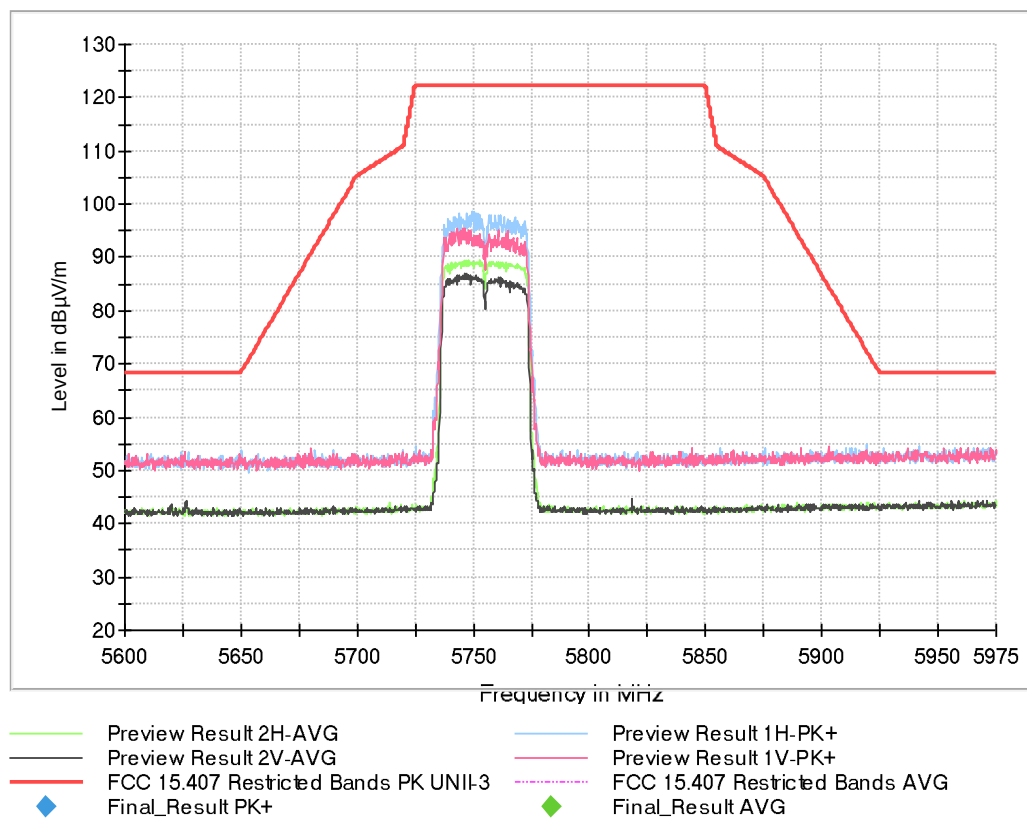


- High Channel 159 (5795 MHz)

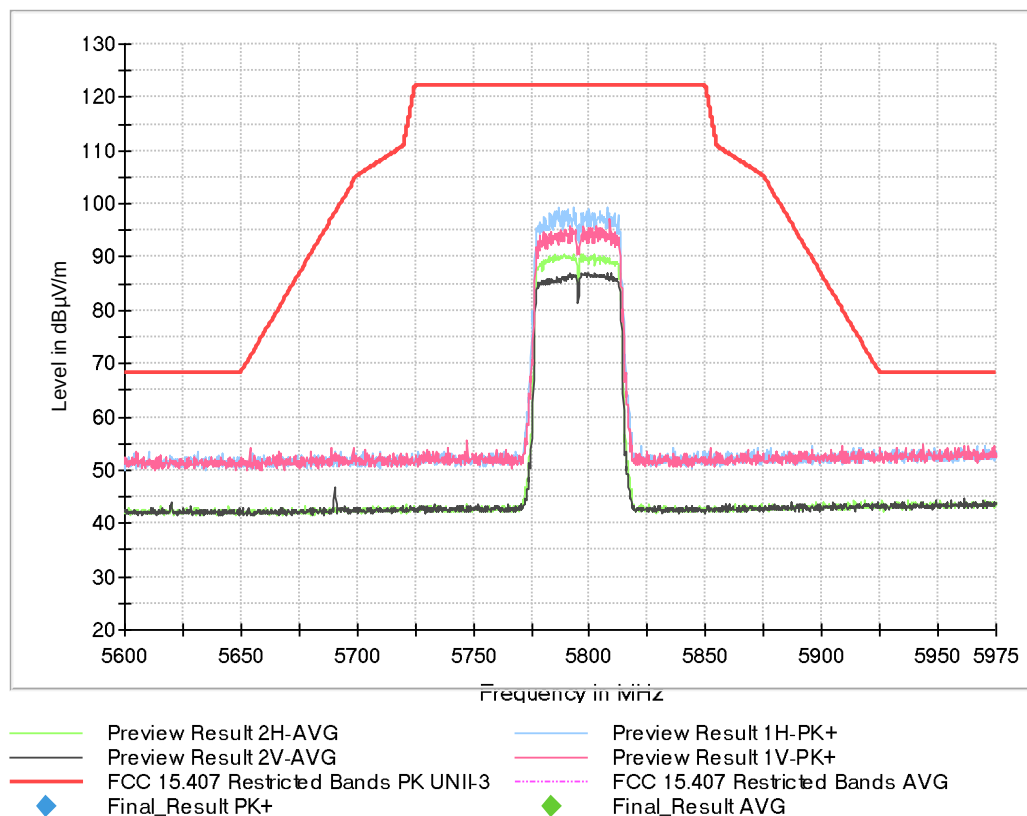


802.11 ac40 (VHT40). Spurious emissions inside the mask 5.65-5.925 GHz:

- Low Channel 151 (5755 MHz)

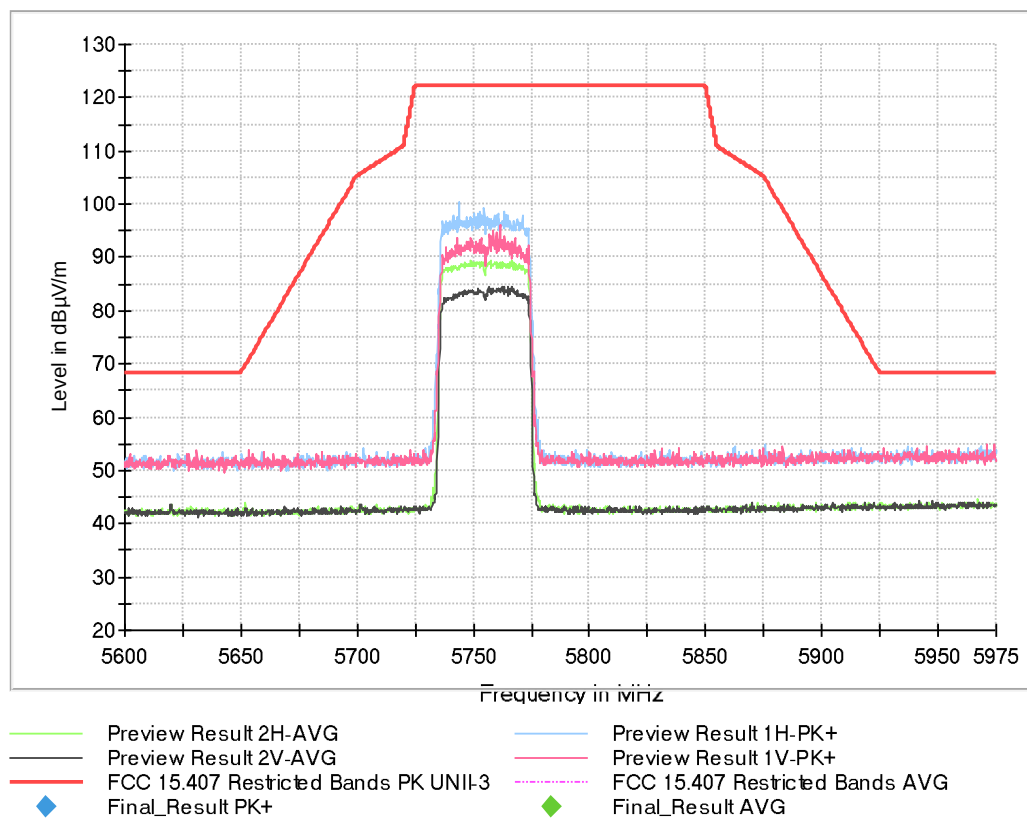


- **High Channel 159 (5795 MHz)**

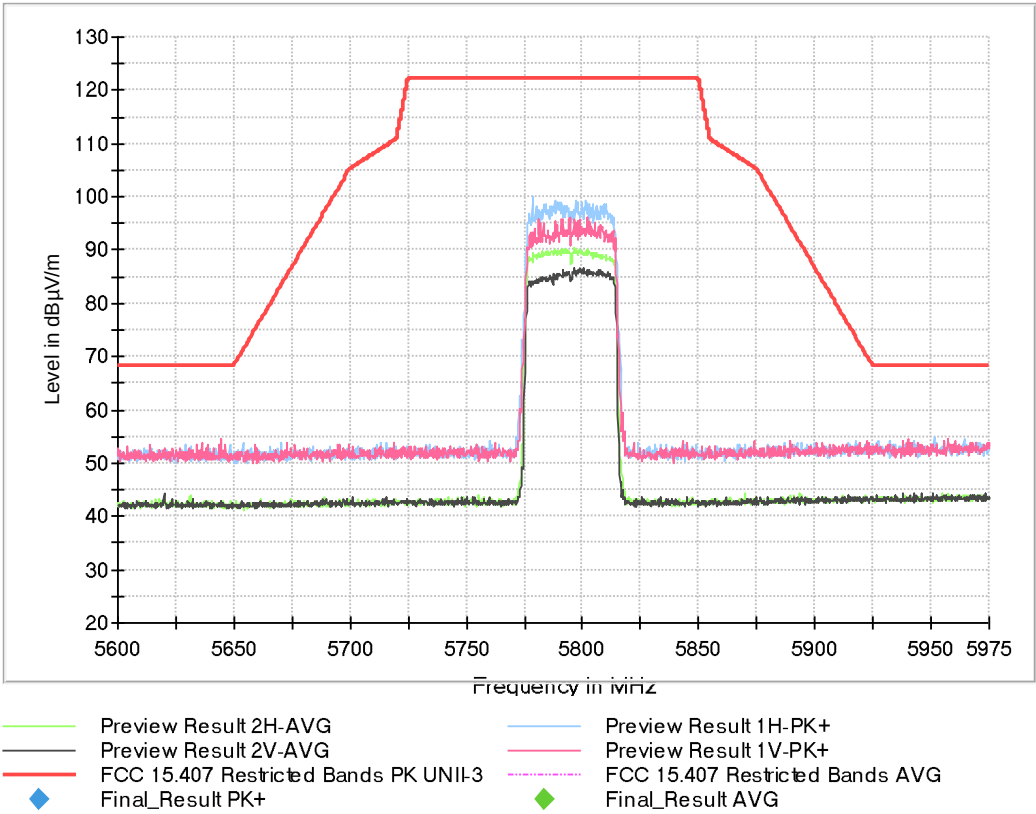


802.11 ax40 (HE40) – SU full-channel allocation. Spurious emissions inside of the mask 5.65-5.925 GHz:

- Low Channel 151 (5755 MHz)

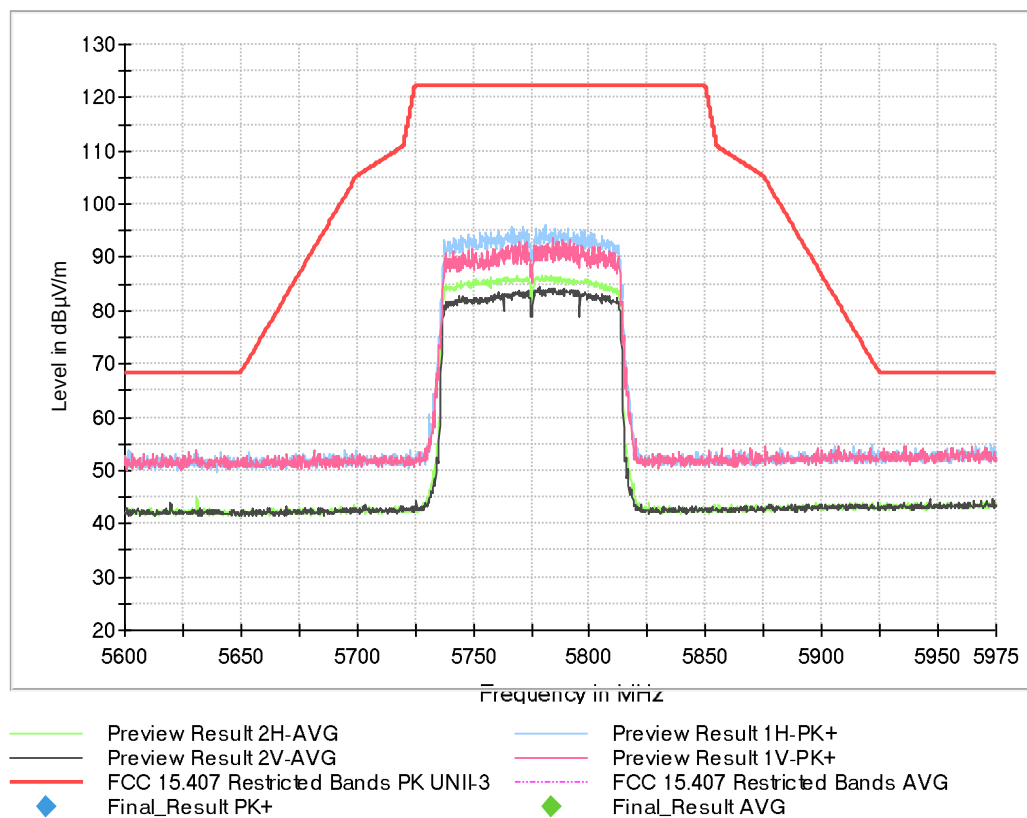


- High Channel 159 (5795 MHz)



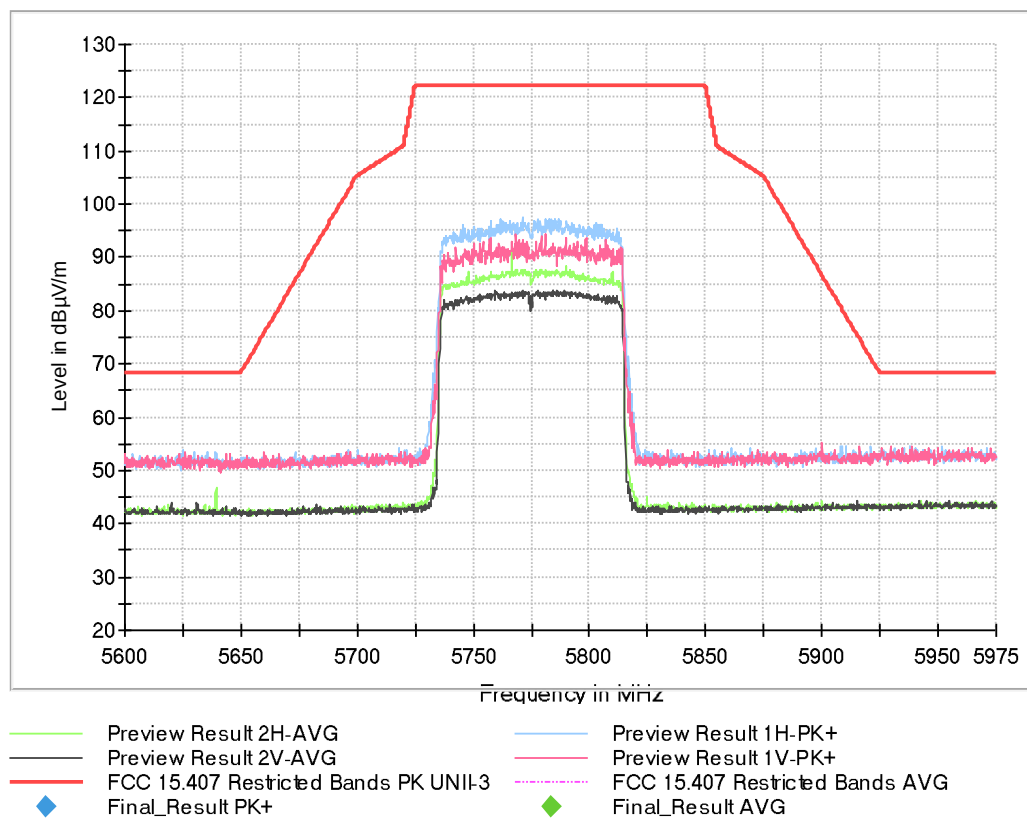
802.11 ac80 (VHT80). Spurious emissions inside the mask 5.65-5.925 GHz:

- Single Channel 155 (5775 MHz)



802.11 ax80 (HE80) SU full-channel allocation. Spurious emissions inside of the mask 5.65-5.925 GHz:

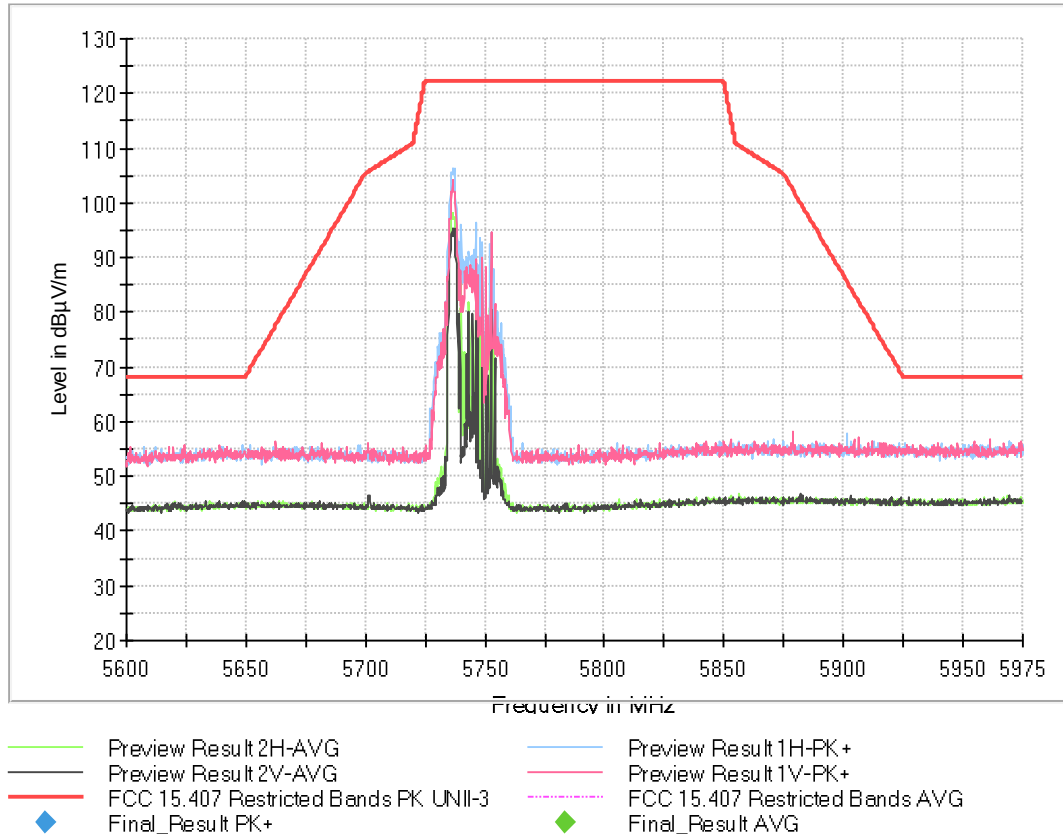
- Single Channel 155 (5775 MHz)



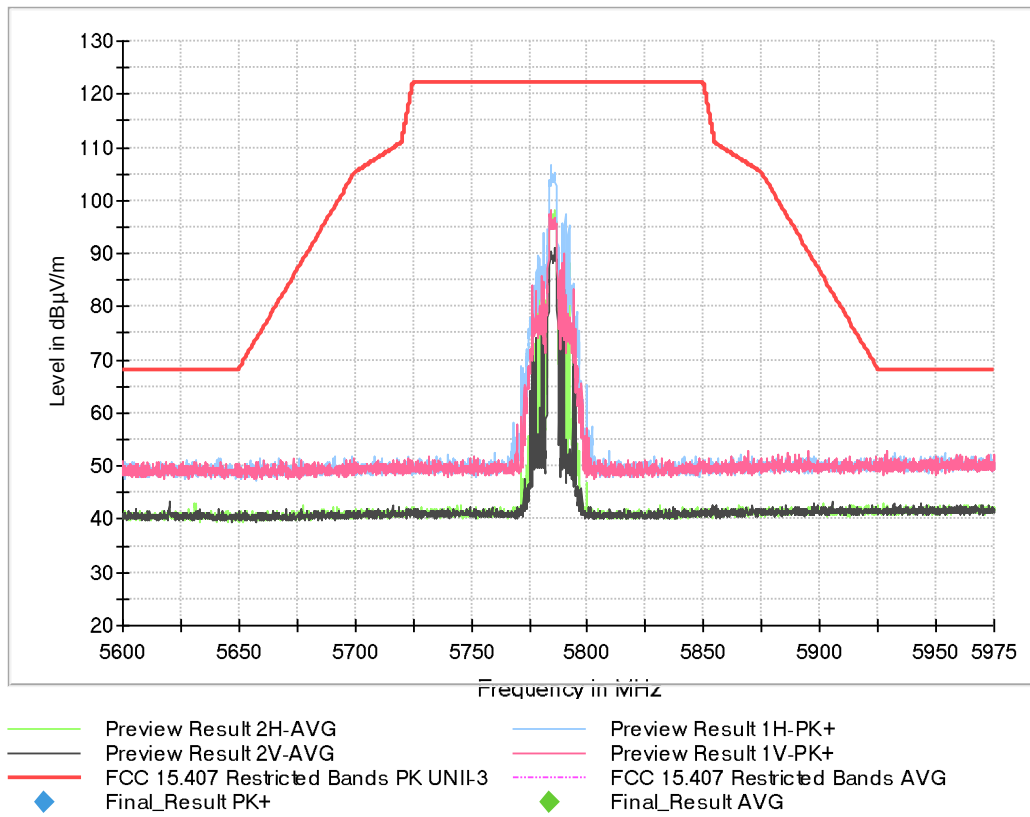
RU Subcarrier allocation (worst-case)

802.11 ax20 (HE20). Spurious emissions inside of the mask 5.65-5.925 GHz:

- Low Channel 149 (5745 MHz) - RU 26 offset 0:



- **Middle Channel 157 (5785 MHz) - RU 26 offset 4**



- **High Channel 165 (5825 MHz) - RU 26 offset 8**

