5.5 Transmit Spurious Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmit mode; per requirement of CFR47 15.205, 15.209, 15.247(d), RSS 247 Sect.5.5.

5.5.1 Test Methodology

5.5.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

Pre-scans were performed to determine the worst data rate/chains.

5.5.1.2 Final Test

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

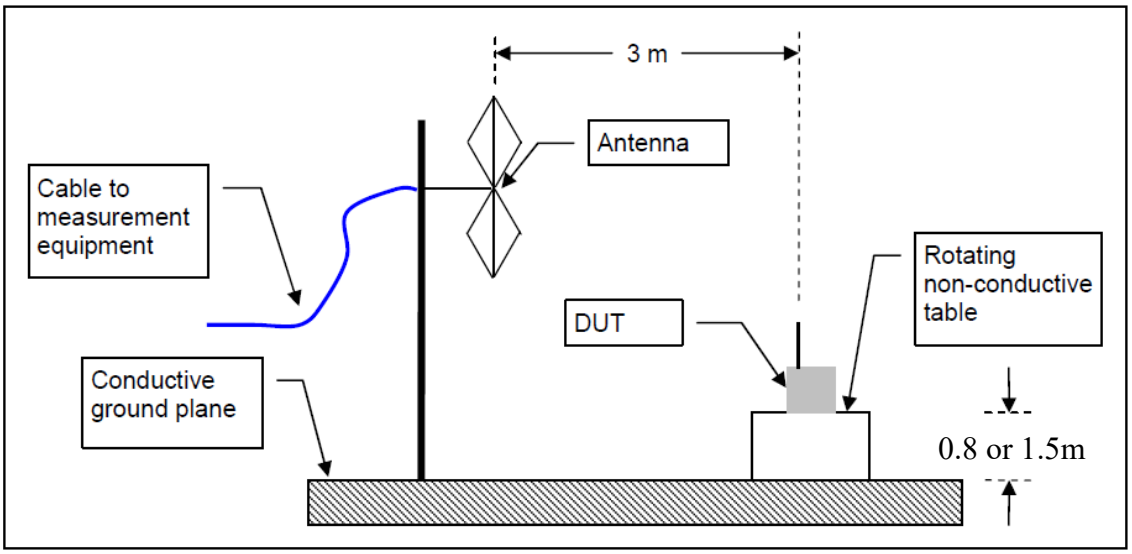
Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The resolution bandwidth of the measurement analyzer is chosen based on either peak

5.5.1.3 Deviations

None.

Test Setup:



5.5.2 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2023 and RSS Gen Sect. 8.9 and 8.10: 2018.

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (Meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30.0 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

All harmonics and spurious emission which are outside of the restricted band shall be 20dB below the in-band emission.

5.5.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and test plan.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

5.5.3.1 Bandedge Data

Table 15: Bandedge: Restricted band 2310 MHz to 2390 MHz

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.4 °C	**Relative Humidity:**	32.7 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

1Mbps									
Test Frequency: 2402 MHz									
Freq. (MHz)	**Peak (dBµV/m)**	**Average (dBµV/m)**	**Limit (dBµV/m)**	**Margin (dBµV/m)**	**BW (kHz)**	**Height (cm)**	**Pol (V/H)**	**Azimuth (deg)**	**Corr. (dB)**
2323.20	18.76	---	74	55.24	1000	154	H	293	-3.8
2323.20	---	1.95	54	52.05	1000	154	H	293	-3.8
2336.41	17.63	---	74	56.37	1000	254	V	244	-3.7
2336.41	---	-0.35	54	54.35	1000	254	V	244	-3.7
2358.32	---	1.12	54	52.88	1000	350	V	144	-3.5
2358.32	18.82	---	74	55.18	1000	350	V	144	-3.5
2370.67	17.95	---	74	56.05	1000	354	H	67	-3.3
2370.67	---	0.7	54	53.3	1000	354	H	67	-3.3
2381.91	17.57	---	74	56.43	1000	150	H	89	-3.2
2Mbps									
Test Frequency: 2402 MHz									
2322.35	16.91	---	74	57.09	1000	250	H	19	-3.8
2322.35	---	-0.75	54	54.75	1000	250	H	19	-3.8
2330.79	---	-0.61	54	54.61	1000	100	V	155	-3.7
2330.79	16.55	---	74	57.45	1000	100	V	155	-3.7
2351.63	---	-0.08	54	54.08	1000	155	H	187	-3.5
2351.63	17.44	---	74	56.56	1000	155	H	187	-3.5
2374.47	---	0.24	54	53.76	1000	250	V	79	-3.4
2374.47	17.72	---	74	56.28	1000	250	V	79	-3.4
2387.72	---	0.29	54	53.71	1000	150	V	26	-3.3

Note: None

5.5.3.2 Bandedge Data

Table 16: Bandedge: Restricted band 2483.5MHz to 2500MHz

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.4 °C	**Relative Humidity:**	32.7 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

1Mbps									
Test Frequency: 2480 MHz									
Freq. (MHz)	**Peak (dBµV/m)**	**Average (dBµV/m)**	**Limit (dBµV/m)**	**Margin (dBµV/m)**	**BW (kHz)**	**Height (cm)**	**Pol (V/H)**	**Azimuth (deg)**	**Corr. (dB)**
2487.7	---	5	54	49	1000	155	H	43	-3.2
2487.7	19.46	---	74	54.54	1000	155	H	43	-3.2
2495.0	17.65	---	74	56.35	1000	250	V	92	-3.3
2495.0	---	1.03	54	52.97	1000	250	V	92	-3.3
2Mbps									
Test Frequency: 2402 MHz									
2484.48	---	1.29	54	52.71	1000	350	V	-5	-3.3
2484.48	18.14	---	74	55.86	1000	350	V	-5	-3.3
2487.43	---	3.31	54	50.69	1000	153	H	33	-3.2
2487.43	19.59	---	74	54.41	1000	153	H	33	-3.2
2494.86	---	1.15	54	52.85	1000	350	H	252	-3.3
2494.86	17.67	---	74	56.33	1000	350	H	252	-3.3
2497.43	17.76	---	74	56.24	1000	150	H	30	-3.3
2497.43	---	1.14	54	52.86	1000	150	H	30	-3.3

Note: None

5.5.3.3 Transmitter Spurious Emissions: 9 kHz – 30 MHz

Worst case data reported in this section. The worst-case emission profile was determined by which frequency emitted the highest power, power spectral density and whose harmonics were present in antenna port emission testing.

Table 17: Transmit Spurious Emission 9 kHz – 30 MHz – 2480 MHz, 2 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	24.1 °C	**Relative Humidity:**	37.6 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer**	Nathaniel Beyer

Signal State: Modulated

2 Mbps

Test Frequency: 2480 MHz

Freq. (MHz)	Quasi-Peak (dBµV/m)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	Meas. Time (ms)	BW (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
0.0234	---	44.48	120.2	75.72	1000	0.2	155	X-Pol	62	14
0.0272	---	55.91	118.9	62.99	1000	0.2	155	X-Pol	317	13.8
0.0544	---	50.87	112.89	62.02	1000	0.2	155	X-Pol	313	11.8
0.5162	40.95	---	73.35	32.4	1000	9	155	X-Pol	69	11.4
0.7843	36.83	---	69.72	32.88	1000	9	155	X-Pol	159	11.5
1.3092	31.39	---	65.27	33.87	1000	9	155	X-Pol	177	11.8
28.3351	13.81	---	69.54	55.73	1000	9	155	X-Pol	168	9
0.0272	---	52.39	118.9	66.51	1000	0.2	155	Y-Pol	31	13.8
0.0544	---	48.1	112.89	64.79	1000	0.2	155	Y-Pol	116	11.8
0.2351	---	42.21	100.18	57.98	1000	9	155	Y-Pol	50	11.3
0.8052	36.4	---	69.49	33.09	1000	9	155	Y-Pol	15	11.5
1.4708	30.25	---	64.25	34	1000	9	155	Y-Pol	125	11.8
27.9351	14.71	---	69.54	54.83	1000	9	155	Y-Pol	84	9.1
0.02133	---	45.23	121.01	75.78	1000	0.2	155	Z-Pol	23	14.1
0.02720	---	52.37	118.9	66.54	1000	0.2	155	Z-Pol	293	13.8
0.25001	---	41.54	99.65	58.11	1000	9	155	Z-Pol	245	11.3
0.49177	41.47	---	73.77	32.3	1000	9	155	Z-Pol	308	11.4
1.21414	32.37	---	65.92	33.55	1000	9	155	Z-Pol	331	11.8
28.3623	18.76	---	69.54	50.78	1000	9	155	Z-Pol	248	9

Note: None

5.5.3.4 Transmitter Spurious Emissions: 30 MHz – 1000 MHz

Table 18: Transmit Spurious Emission 30 – 1000 MHz – 2402 MHz, 1Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	24.1 ºC	**Relative Humidity:**	37.6 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer**	Isaac Aguilar

Signal State: Modulated

1Mbps

Test Frequency: 2402 MHz

Freq. (MHz)	Quasi-Peak (dBµV/m)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	Meas. Time (ms)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
39.07	---	27.36	---	---	1000	120	100	V	-5	-13
39.07	21.34	---	40	18.66	1000	120	100	V	-5	-13
42.51	---	26.54	---	---	1000	120	100	V	142	-12.2
42.51	21.43	---	40	18.57	1000	120	100	V	142	-12.2
90.20	---	30.41	---	---	1000	120	150	V	64	-14.4
90.20	22.91	---	43.52	20.61	1000	120	150	V	64	-14.4
376.00	22.91	---	46	23.09	1000	120	100	H	334	-10.4
376.00	---	25.92	---	---	1000	120	100	H	334	-10.4
384.00	22.92	---	46	23.08	1000	120	100	H	351	-10.2
384.00	---	25.48	---	---	1000	120	100	H	351	-10.2
392.00	---	24.87	---	---	1000	120	100	H	338	-9.9
392.00	21.73	---	46	24.27	1000	120	100	H	338	-9.9
472.00	21.57	---	46	24.43	1000	120	153	H	179	-8.7
472.00	---	25.18	---	---	1000	120	153	H	179	-8.7
480.00	20.1	---	46	25.9	1000	120	195	H	150	-8.4
480.00	---	24.09	---	---	1000	120	195	H	150	-8.4
487.99	---	25.53	---	---	1000	120	159	H	175	-8.2
487.99	21.51	---	46	24.49	1000	120	159	H	175	-8.2
543.99	---	25.87	---	---	1000	120	155	H	337	-7.6
543.99	21.32	---	46	24.68	1000	120	155	H	337	-7.6

Note: None

Table 19: Transmit Spurious Emission 30 – 1000 MHz – 2442 MHz, 1 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	24.0 °C	**Relative Humidity:**	38.1 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer**	Isaac Aguilar

Signal State: Modulated

1Mbps

Test Frequency: 2442 MHz

Freq. (MHz)	Quasi-Peak (dBµV/m)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	Meas. Time (ms)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
39.80	---	27.57	---	---	1000	120	100	V	43	-12.8
39.80	21.2	---	40	18.8	1000	120	100	V	43	-12.8
90.20	---	29.6	---	---	1000	120	126	V	128	-14.4
90.20	22.47	---	43.52	21.05	1000	120	126	V	128	-14.4
376.01	---	25.72	---	---	1000	120	100	H	346	-10.4
376.01	23.2	---	46	22.8	1000	120	100	H	346	-10.4
383.99	22.95	---	46	23.05	1000	120	100	H	329	-10.2
383.99	---	25.82	---	---	1000	120	100	H	329	-10.2
392.01	22.14	---	46	23.86	1000	120	100	H	346	-9.9
392.01	---	25.31	---	---	1000	120	100	H	346	-9.9
448.00	---	24.78	---	---	1000	120	100	H	346	-9.2
448.00	21.2	---	46	24.8	1000	120	100	H	346	-9.2
472.00	21.64	---	46	24.36	1000	120	155	H	162	-8.7
472.00	---	25.01	---	---	1000	120	155	H	162	-8.7
480.00	20.44	---	46	25.56	1000	120	175	H	333	-8.4
480.00	---	24.29	---	---	1000	120	175	H	333	-8.4
487.98	---	24.54	---	---	1000	120	177	H	332	-8.2
487.98	20.73	---	46	25.27	1000	120	177	H	332	-8.2
528.00	---	24.34	---	---	1000	120	176	H	330	-7.7
528.00	19.93	---	46	26.07	1000	120	176	H	330	-7.7

Note: None

Table 20: Transmit Spurious Emission 30 – 1000 MHz – 2480 MHz, 1Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.7 ºC	**Relative Humidity:**	38.2 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer**	Isaac Aguilar

Signal State: Modulated

1Mbps

Test Frequency: 2480 MHz

Freq. (MHz)	Quasi-Peak (dBµV/m)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	Meas. Time (ms)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
39.02	---	28.16	---	---	1000	120	100	V	167	-13
39.02	21.99	---	40	18.01	1000	120	100	V	167	-13
41.64	20.32	---	40	19.68	1000	120	100	V	205	-12.3
41.64	---	25.71	---	---	1000	120	100	V	205	-12.3
89.58	---	28.66	---	---	1000	120	126	V	19	-14.6
89.58	21.58	---	43.52	21.94	1000	120	126	V	19	-14.6
384.00	24.33	---	46	21.67	1000	120	100	H	338	-10.2
384.00	---	27.05	---	---	1000	120	100	H	338	-10.2
392.00	23.1	---	46	22.9	1000	120	100	H	349	-9.9
392.00	---	26.12	---	---	1000	120	100	H	349	-9.9
408.01	21.57	---	46	24.43	1000	120	100	H	323	-9.5
408.01	---	24.99	---	---	1000	120	100	H	323	-9.5
472.00	21.52	---	46	24.48	1000	120	154	H	178	-8.7
472.00	---	25.41	---	---	1000	120	154	H	178	-8.7
479.99	---	24.15	---	---	1000	120	153	H	190	-8.4
479.99	20.43	---	46	25.57	1000	120	153	H	190	-8.4
527.99	19.03	---	46	26.97	1000	120	174	H	308	-7.7
527.99	---	23.32	---	---	1000	120	174	H	308	-7.7
535.99	---	23.85	---	---	1000	120	155	H	337	-7.6
535.99	19.55	---	46	26.45	1000	120	155	H	337	-7.6

Note: None

Table 21: Transmit Spurious Emission 30 – 1000 MHz – 2402 MHz, 2 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.6 ºC	**Relative Humidity:**	37.8 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer**	Isaac Aguilar
Signal State: Modulated			

2 Mbps

Test Frequency: 2402 MHz

Freq. (MHz)	Quasi-Peak (dBµV/m)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	Meas. Time (ms)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
38.44	22.35	---	40	17.65	1000	120	100	V	205	-13.2
38.44	---	27.61	---	---	1000	120	100	V	205	-13.2
41.15	---	27.02	---	---	1000	120	100	V	113	-12.4
41.15	21.21	---	40	18.79	1000	120	100	V	113	-12.4
90.17	---	29.77	---	---	1000	120	150	V	88	-14.4
90.17	22.92	---	43.52	20.6	1000	120	150	V	88	-14.4
93.08	---	28.56	---	---	1000	120	100	V	187	-13.4
93.08	20.24	---	43.52	23.28	1000	120	100	V	187	-13.4
376.00	23.39	---	46	22.61	1000	120	100	H	328	-10.4
376.00	---	25.88	---	---	1000	120	100	H	328	-10.4
384.00	---	26.07	---	---	1000	120	100	H	334	-10.2
384.00	23.28	---	46	22.72	1000	120	100	H	334	-10.2
440.00	19.57	---	46	26.43	1000	120	100	H	-5	-9.2
440.00	---	23.78	---	---	1000	120	100	H	-5	-9.2
447.99	---	23.15	---	---	1000	120	197	H	329	-9.2
447.99	19.52	---	46	26.48	1000	120	197	H	329	-9.2
471.99	---	24.85	---	---	1000	120	158	H	165	-8.7
471.99	21.16	---	46	24.84	1000	120	158	H	165	-8.7
480.01	20.37	---	46	25.63	1000	120	178	H	335	-8.4
480.01	---	24.44	---	---	1000	120	178	H	335	-8.4

Note: None

Table 22: Transmit Spurious Emission 30 – 1000 MHz – 2442 MHz, 2 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.4 ºC	**Relative Humidity:**	37.5 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer**	Isaac Aguilar

Signal State: Modulated

2 Mbps

Test Frequency: 2442 MHz

Freq. (MHz)	Quasi-Peak (dBµV/m)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	Meas. Time (ms)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
38.23	---	27	---	---	1000	120	100	V	302	-13.3
38.23	21.54	---	40	18.46	1000	120	100	V	302	-13.3
89.27	22.9	---	43.52	20.62	1000	120	125	V	120	-14.7
89.27	---	29.92	---	---	1000	120	125	V	120	-14.7
91.98	---	30.24	---	---	1000	120	105	V	120	-13.8
91.98	22.59	---	43.52	20.93	1000	120	105	V	120	-13.8
376.00	---	25.62	---	---	1000	120	100	H	-5	-10.4
376.00	23	---	46	23	1000	120	100	H	-5	-10.4
383.99	---	26.5	---	---	1000	120	100	H	341	-10.2
383.99	23.89	---	46	22.11	1000	120	100	H	341	-10.2
392.00	23.43	---	46	22.57	1000	120	100	H	341	-9.9
392.00	---	26.03	---	---	1000	120	100	H	341	-9.9
472.00	21.65	---	46	24.35	1000	120	155	H	176	-8.7
472.00	---	24.94	---	---	1000	120	155	H	176	-8.7
488.00	---	24.11	---	---	1000	120	176	H	312	-8.2
488.00	20.46	---	46	25.54	1000	120	176	H	312	-8.2
495.99	20.21	---	46	25.79	1000	120	176	H	322	-8
495.99	---	24.28	---	---	1000	120	176	H	322	-8
528.02	---	24.41	---	---	1000	120	155	H	322	-7.7
528.02	19.53	---	46	26.47	1000	120	155	H	322	-7.7

Note: None

Table 23: Transmit Spurious Emission 30 – 1000 MHz – 2480 MHz, 2 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.2 °C	**Relative Humidity:**	36.7 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer**	Isaac Aguilar

Signal State: Modulated

2 Mbps

Test Frequency: 2480 MHz

Freq. (MHz)	Quasi-Peak (dBµV/m)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	Meas. Time (ms)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
38.92	---	27.48	---	---	1000	120	100	V	169	-13.1
38.92	21.86	---	40	18.14	1000	120	100	V	169	-13.1
90.63	---	29.03	---	---	1000	120	127	V	191	-14.3
90.63	21.73	---	43.52	21.79	1000	120	127	V	191	-14.3
375.99	---	25.61	---	---	1000	120	100	H	334	-10.4
375.99	23.07	---	46	22.93	1000	120	100	H	334	-10.4
384.00	---	25.63	---	---	1000	120	100	H	309	-10.2
384.00	23.07	---	46	22.93	1000	120	100	H	309	-10.2
392.00	22.89	---	46	23.11	1000	120	100	H	322	-9.9
392.00	---	25.81	---	---	1000	120	100	H	322	-9.9
440.00	20.28	---	46	25.72	1000	120	100	H	339	-9.2
440.00	---	23.87	---	---	1000	120	100	H	339	-9.2
472.00	---	25.32	---	---	1000	120	155	H	179	-8.7
472.00	21.47	---	46	24.53	1000	120	155	H	179	-8.7
479.99	---	24.54	---	---	1000	120	175	H	326	-8.4
479.99	20.7	---	46	25.3	1000	120	175	H	326	-8.4
487.99	20.85	---	46	25.15	1000	120	176	H	330	-8.2
487.99	---	24.96	---	---	1000	120	176	H	330	-8.2
495.99	20.04	---	46	25.96	1000	120	176	H	327	-8
495.99	---	24.08	---	---	1000	120	176	H	327	-8

Note: None

5.5.3.5 Transmitter Spurious Emissions: 1 GHz – 18 GHz

Table 24: Transmit Spurious Emission 1 – 18 GHz – 2402 MHz, 1Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.2 ºC	**Relative Humidity:**	35.4 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Isaac Aguilar

Signal State: Modulated

1 Mbps

Test Frequency: 2402 MHz

Freq. (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
2209.62	40.74	---	74	33.26	1000	154	H	114	-3.5
2209.62	---	29.52	54	24.48	1000	154	H	114	-3.5
4804.38	---	40.27	54	13.73	1000	154	V	92	5.2
4804.38	48.27	---	74	25.73	1000	154	V	92	5.2
7206.74	55.22	---	74	18.78	1000	100	H	139	10.1
7206.74	---	46.99	54	7.01	1000	100	H	139	10.1
8852.78	48.73	---	74	25.27	1000	100	H	100	13.7
8852.78	---	34.39	54	19.61	1000	100	H	100	13.7
14077.68	---	40.81	54	13.19	1000	106	H	172	20.4
14077.68	54.27	---	74	19.73	1000	106	H	172	20.4
17800.50	64.1	---	74	9.9	1000	150	V	10	29.9
17800.50	---	50.33	54	3.67	1000	150	V	10	29.9

Note: None

Table 25: Transmit Spurious Emission 1 – 18 GHz – 2442 MHz, 1Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.3 °C	**Relative Humidity:**	34 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

1 Mbps

Test Frequency: 2442 MHz

Freq. (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
1772.00	---	17.86	54	36.14	1000	354	V	138	-5.1
1772.00	32.65	---	74	41.35	1000	354	V	138	-5.1
2222.00	35.16	---	74	38.84	1000	105	H	14	-3.5
2222.00	---	20.11	54	33.89	1000	105	H	14	-3.5
3884.90	38.22	---	74	35.78	1000	105	V	324	3.1
3884.90	---	23.73	54	30.27	1000	105	V	324	3.1
4883.56	50.5	---	74	23.5	1000	155	V	157	5.5
4883.56	---	43.28	54	10.72	1000	155	V	157	5.5
7325.15	---	46.54	54	7.46	1000	155	V	50	10.6
7325.15	54.95	---	74	19.05	1000	155	V	50	10.6
9768.91	50.47	---	74	23.53	1000	153	H	349	13.3
9768.91	---	38.68	54	15.32	1000	153	H	349	13.3
12208.76	52.35	---	74	21.65	1000	155	H	4	16.6
12208.76	---	39.69	54	14.31	1000	155	H	4	16.6
17934.74	64.27	---	74	9.73	1000	100	H	219	30.6
17934.74	---	50.78	54	3.22	1000	100	H	219	30.6

Note: None

Table 26: Transmit Spurious Emission 1 – 18 GHz – 2480 MHz, 1 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.4 ºC	**Relative Humidity:**	33 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

1 Mbps

Test Frequency: 2480 MHz

Freq. (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
18038.62	---	35.22	54	18.78	1000	356	H	79	-2.9
18038.62	48.61	---	74	25.39	1000	356	H	79	-2.9
18872.68	47.75	---	74	26.25	1000	103	H	265	-2.2
18872.68	---	34.32	54	19.68	1000	103	H	265	-2.2
20407.68	---	34.38	54	19.62	1000	250	H	280	-0.3
20407.68	47.46	---	74	26.54	1000	250	H	280	-0.3
21431.34	---	34.75	54	19.25	1000	250	V	217	0.2
21431.34	48.59	---	74	25.41	1000	250	V	217	0.2
22017.50	---	34.87	54	19.13	1000	255	H	292	0.2
22017.50	48.09	---	74	25.91	1000	255	H	292	0.2
24953.34	49.02	---	74	24.98	1000	105	V	99	2.4
24953.34	---	35.2	54	18.8	1000	105	V	99	2.4

Note: None

Table 27: Transmit Spurious Emission 1 – 18 GHz – 2402MHz, 2 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.6 ºC	**Relative Humidity:**	31 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

1 Mbps

Test Frequency: 2402 MHz

Freq. (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
2081.68	---	24.06	54	29.94	1000	235	H	238	-3.9
2081.68	36.03	---	74	37.97	1000	235	H	238	-3.9
4804.92	47.6	---	74	26.4	1000	154	V	123	5.3
4804.92	---	38.16	54	15.84	1000	154	V	123	5.3
7204.54	---	44.37	54	9.63	1000	236	V	57	10
7204.54	54.03	---	74	19.97	1000	236	V	57	10
9609.91	51.23	---	74	22.77	1000	350	V	123	13.3
9609.91	---	39.62	54	14.38	1000	350	V	123	13.3
13532.50	52.74	---	74	21.26	1000	255	H	182	20
13532.50	---	39.02	54	14.98	1000	255	H	182	20
14103.07	---	40.18	54	13.82	1000	253	V	283	20.4
14103.07	53.96	---	74	20.04	1000	253	V	283	20.4
17961.85	64.75	---	74	9.25	1000	236	V	313	30.7
17961.85	---	50.94	54	3.06	1000	236	V	313	30.7
2081.68	---	24.06	54	29.94	1000	235	H	238	-3.9
2081.68	36.03	---	74	37.97	1000	235	H	238	-3.9

Note: None

Table 28: Transmit Spurious Emission 1 – 18 GHz – 2442MHz, 2Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.6 ºC	**Relative Humidity:**	31 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

2 Mbps

Test Frequency: 2442 MHz

Freq. (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
2210.00	---	19.43	54	34.57	1000	154	V	248	-3.7
2210.00	33.73	---	74	40.27	1000	154	V	248	-3.7
4884.95	49.87	---	74	24.13	1000	155	H	42	5.6
4884.95	---	40.7	54	13.3	1000	155	H	42	5.6
7324.47	53.57	---	74	20.43	1000	354	V	24	10.6
7324.47	---	43.9	54	10.1	1000	354	V	24	10.6
9765.85	49.54	---	74	24.46	1000	350	V	101	13.2
9765.85	---	36.87	54	17.13	1000	350	V	101	13.2
14095.05	---	40.35	54	13.65	1000	350	H	326	20.5
14095.05	53.67	---	74	20.33	1000	350	H	326	20.5
17997.72	64.93	---	74	9.07	1000	234	V	134	30.8
17997.72	---	51.08	54	2.92	1000	234	V	134	30.8

Note: None

Table 29: Transmit Spurious Emission 1 – 18 GHz – 2480 MHz, 2 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/25/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.4 ºC	**Relative Humidity:**	31 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

2 Mbps

Test Frequency: 2480 MHz

Freq. (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
1999.60	34.58	---	74	39.42	1000	255	H	241	-4.1
1999.60	---	20.83	54	33.17	1000	255	H	241	-4.1
4958.99	---	40.26	54	13.74	1000	254	H	140	5.4
4958.99	49.58	---	74	24.42	1000	254	H	140	5.4
7438.40	55.45	---	74	18.55	1000	253	V	41	11
7438.40	---	45.64	54	8.36	1000	253	V	41	11
9921.73	---	37.23	54	16.77	1000	255	H	104	13.4
9921.73	50.07	---	74	23.93	1000	255	H	104	13.4
14211.46	53.77	---	74	20.23	1000	350	V	66	20.6
14211.46	---	40.01	54	13.99	1000	350	V	66	20.6
17998.89	64.8	---	74	9.2	1000	350	V	286	30.8
17998.89	---	51.1	54	2.9	1000	350	V	286	30.8

Note: None

5.5.3.6 Transmitter Spurious Emissions: 18 GHz – 26.5 GHz

Worst case data reported in this section. The worst-case emission profile was determined by which frequency emitted the highest power, power spectral density and whose harmonics were present in antenna port emission testing.

Table 30: Transmit Spurious Emission 18 – 26.5 GHz – 2480 MHz, 1 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/26/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.5 ºC	**Relative Humidity:**	36 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

1 Mbps

Test Frequency: 2480 MHz

Freq. (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
18038.62	---	35.22	54	18.78	1000	356	H	79	-2.9
18038.62	48.61	---	74	25.39	1000	356	H	79	-2.9
18872.68	47.75	---	74	26.25	1000	103	H	265	-2.2
18872.68	---	34.32	54	19.68	1000	103	H	265	-2.2
20407.68	---	34.38	54	19.62	1000	250	H	280	-0.3
20407.68	47.46	---	74	26.54	1000	250	H	280	-0.3
21431.34	---	34.75	54	19.25	1000	250	V	217	0.2
21431.34	48.59	---	74	25.41	1000	250	V	217	0.2
22017.50	---	34.87	54	19.13	1000	255	H	292	0.2
22017.50	48.09	---	74	25.91	1000	255	H	292	0.2
24953.34	49.02	---	74	24.98	1000	105	V	99	2.4
24953.34	---	35.2	54	18.8	1000	105	V	99	2.4

Note: None

Table 31: Transmit Spurious Emission 18 – 26.5 GHz – 2480 MHz, 2 Mbps

Test Condition:	Radiated, Normal Temperature	**Date:**	6/26/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	23.7 ºC	**Relative Humidity:**	34.3 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer:**	Nathaniel Beyer

Signal State: Modulated

2 Mbps

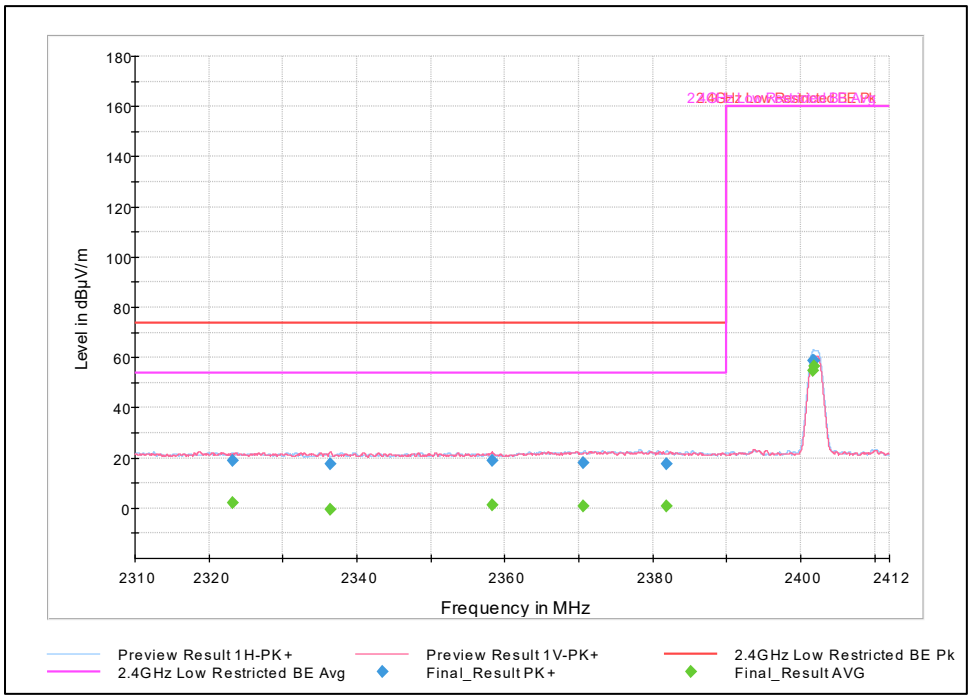
Test Frequency: 2480 MHz

Freq. (MHz)	Peak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dBµV/m)	BW (kHz)	Height (cm)	Pol (V/H)	Azimuth (deg)	Corr. (dB)
18042.98	---	35.19	54	18.81	1000	155	V	104	-2.9
18042.98	49.37	---	74	24.63	1000	155	V	104	-2.9
18728.75	---	34.56	54	19.44	1000	256	V	308	-2.3
18728.75	48.69	---	74	25.31	1000	256	V	308	-2.3
20164.95	47.64	---	74	26.36	1000	103	V	190	-0.5
20164.95	---	34.45	54	19.55	1000	103	V	190	-0.5
20765.50	48.1	---	74	25.9	1000	355	V	77	-0.2
20765.50	---	34.25	54	19.75	1000	355	V	77	-0.2
23807.04	47.22	---	74	26.78	1000	150	V	291	0.7
23807.04	---	33.69	54	20.31	1000	150	V	291	0.7
25643.25	47.82	---	74	26.18	1000	253	V	40	3.6
25643.25	---	34.87	54	19.13	1000	253	V	40	3.6

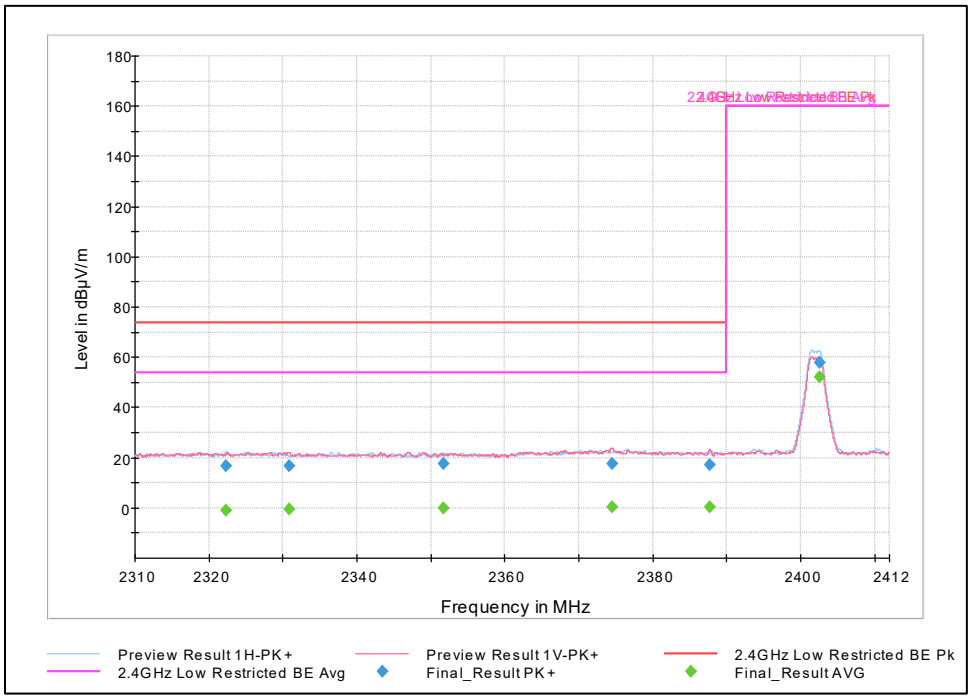
Note: None

5.5.4 Analyzer Data

5.5.4.1 Restricted Band 2310 – 2390 MHz – Bandedge

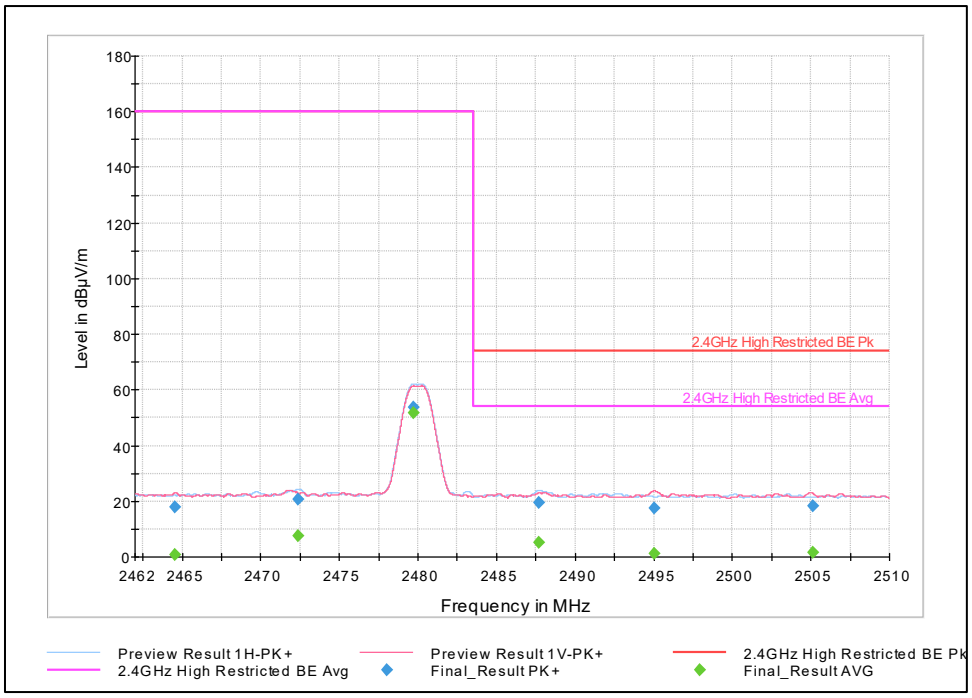


2402 MHz, 1Mbps Pre-Scans

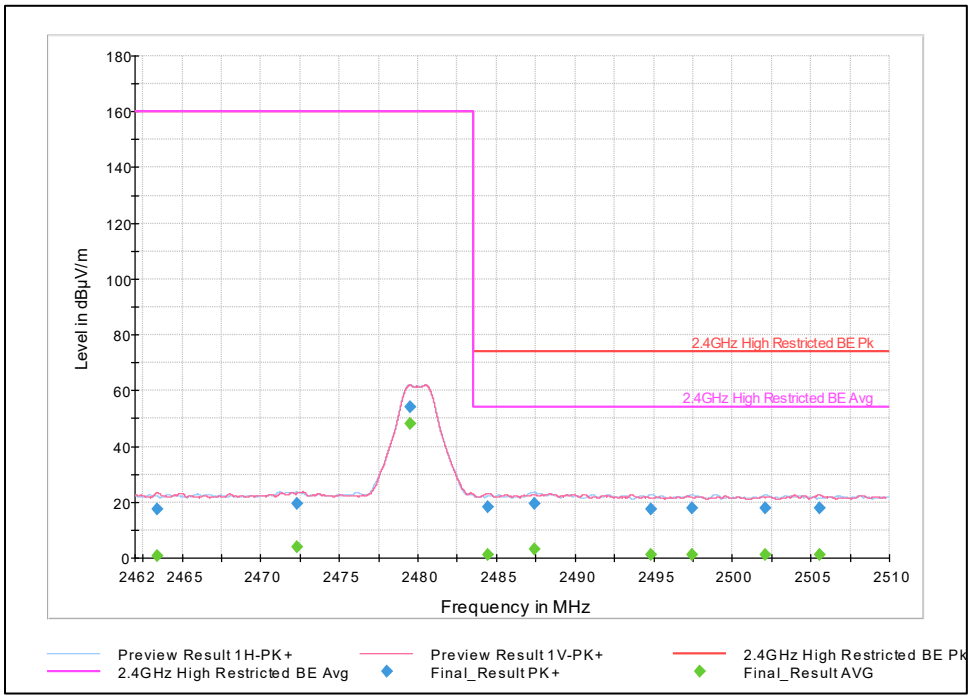


2402 MHz, 2 Mbps Pre-Scans

5.5.4.2 Restricted Band 2483.5 – 2500 MHz – Bandedge

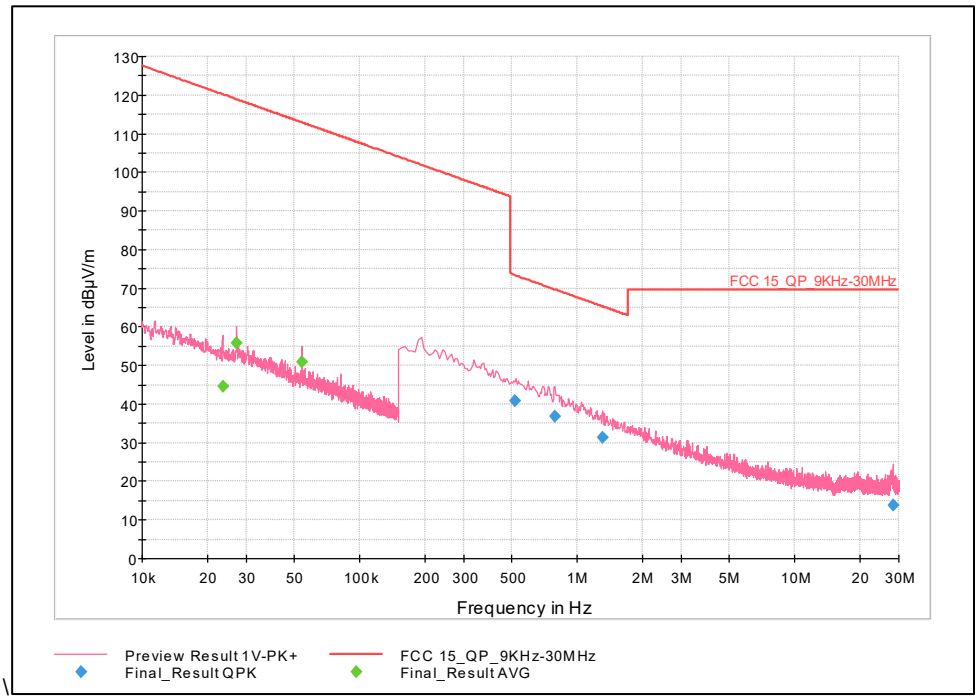


2480 MHz, 1Mbps Pre-Scans

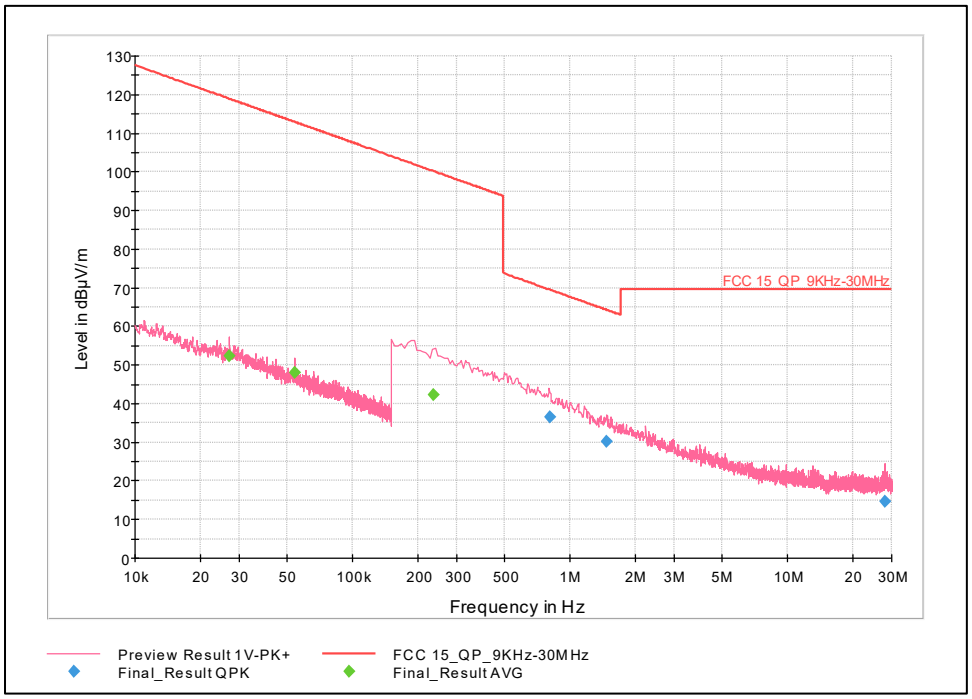


2480 MHz, 2 Mbps Pre-Scans

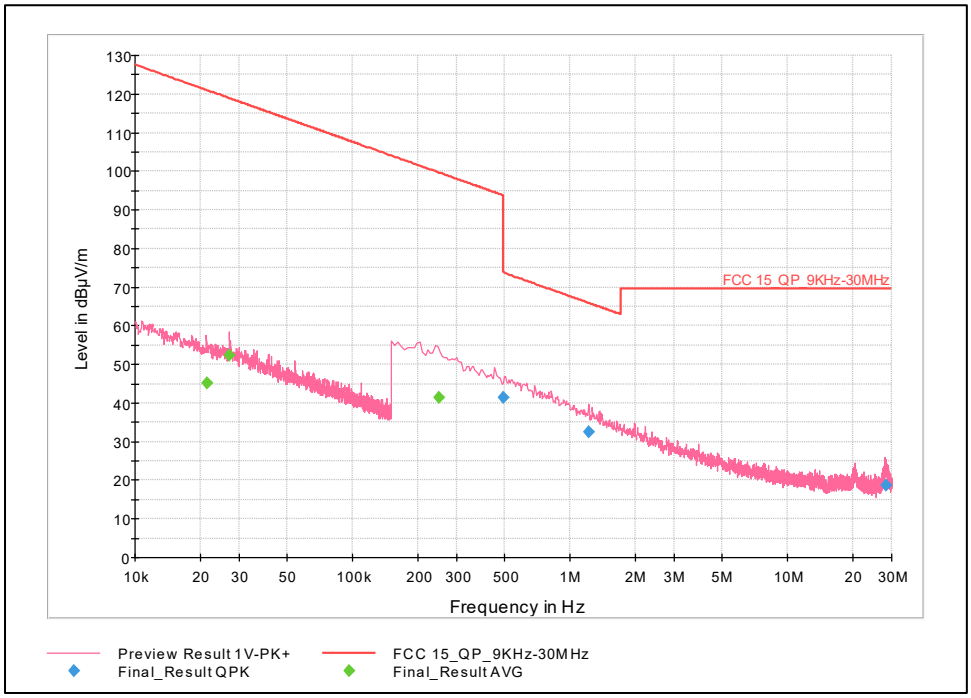
5.5.4.3 Spurious Emissions 9 kHz to 30 MHz



2480 MHz 2 Mbps X-polarizaiton

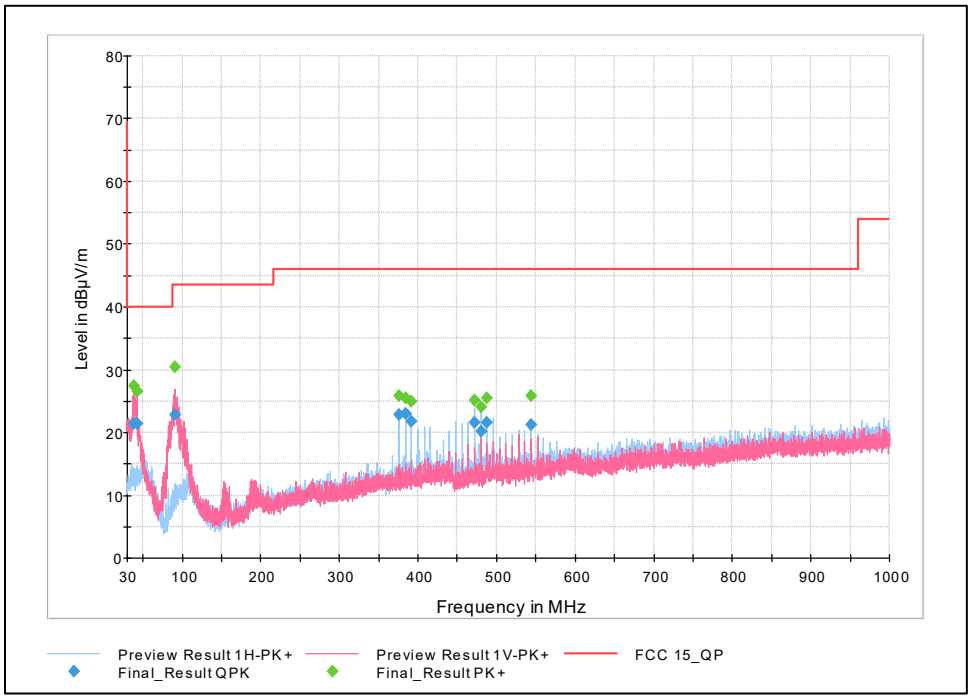


2480 MHz, 2Mbps Y-Polarization

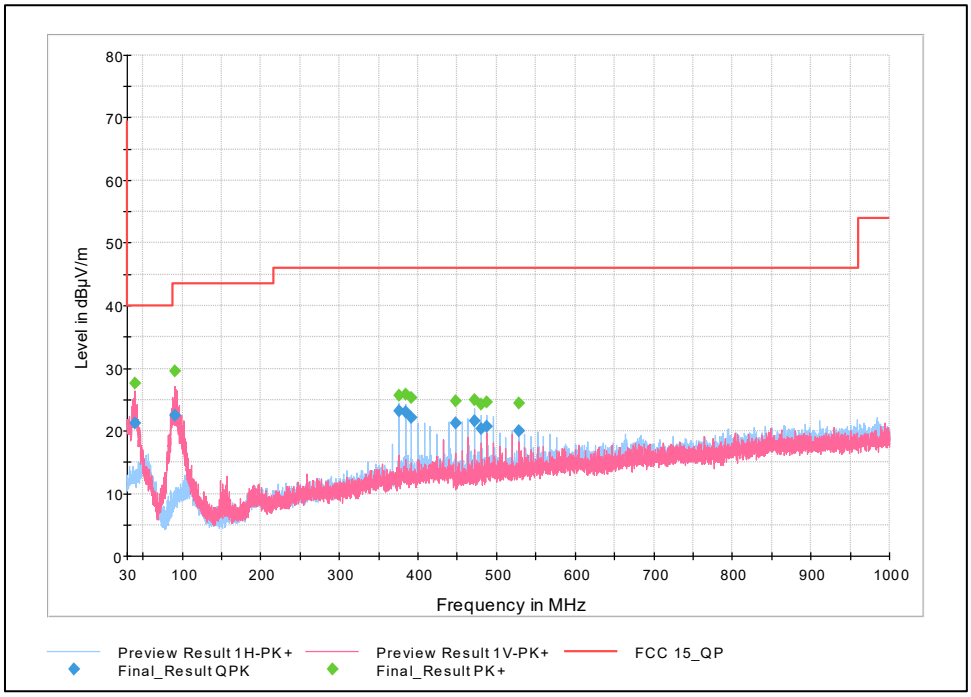


2480 MHz, 2 Mbps, Z-Polarization

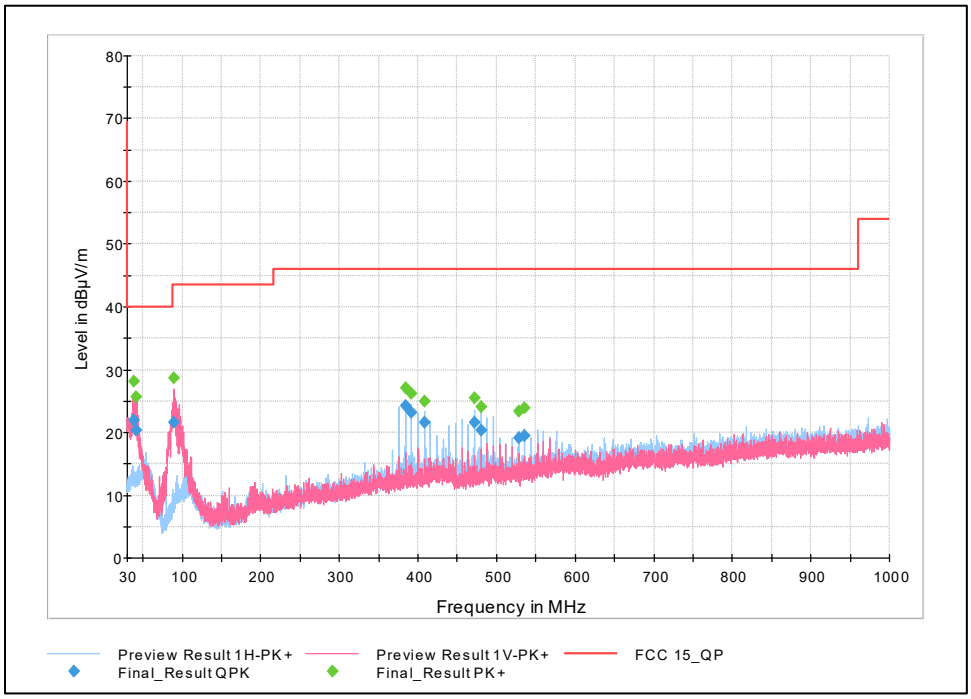
5.5.4.4 Spurious Emissions 30 MHz to 1000 MHz



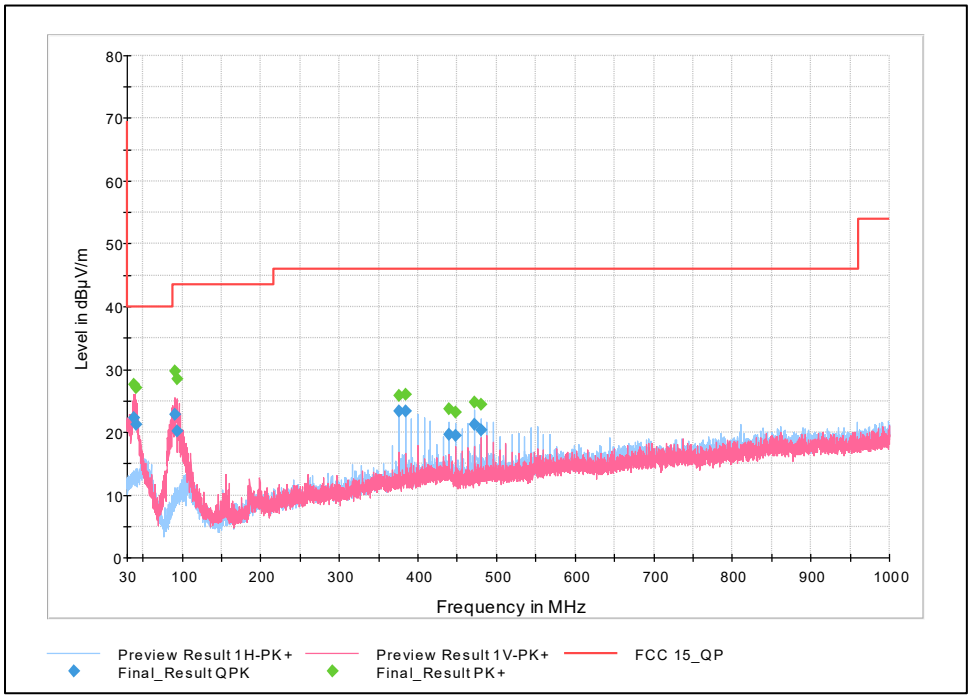
2402 MHz, 1 Mbps



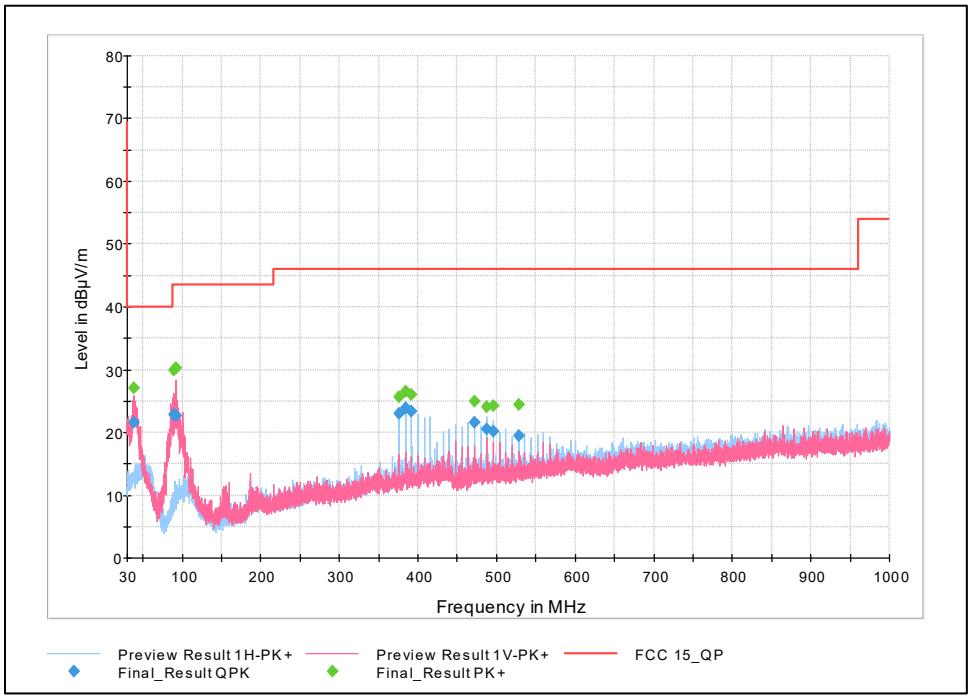
2442 MHz, 1 Mbps



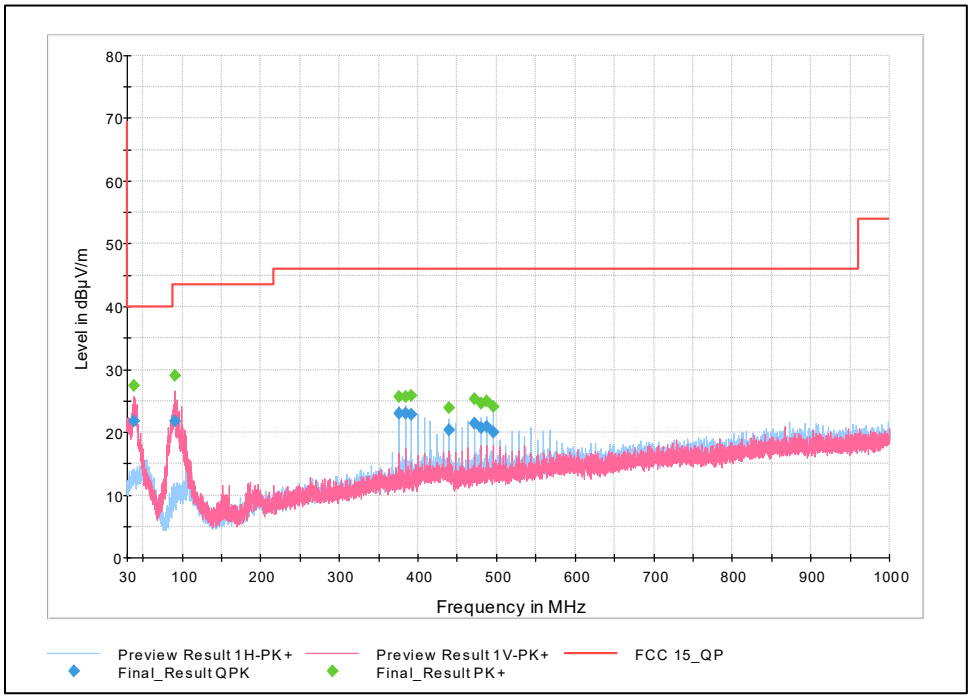
2480 MHz, 1 Mbps



2402 MHz, 2 Mbps

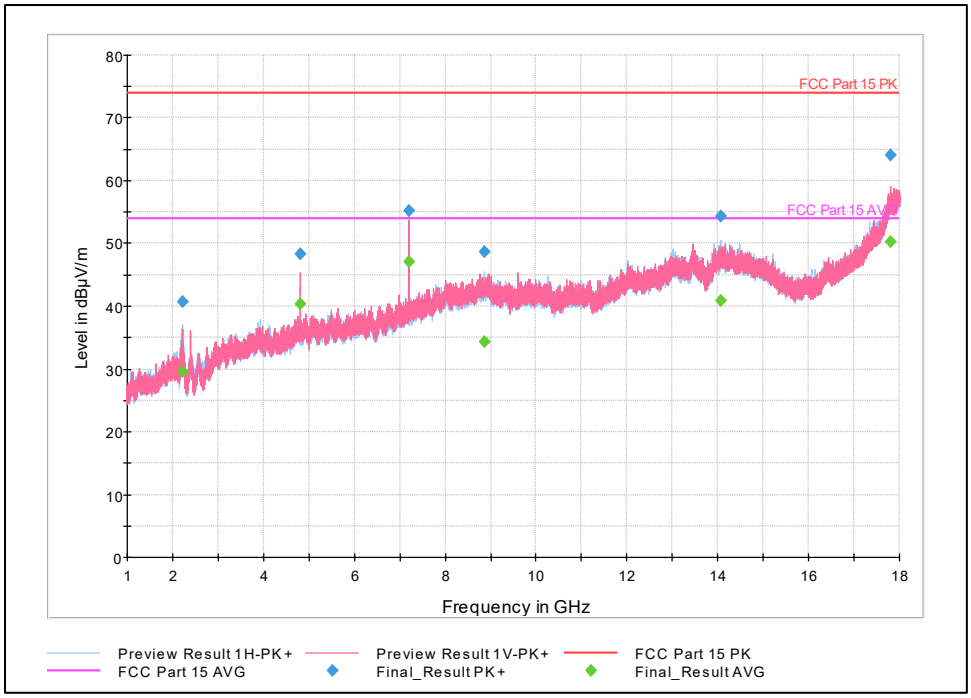


2442 MHz, 2 Mbps

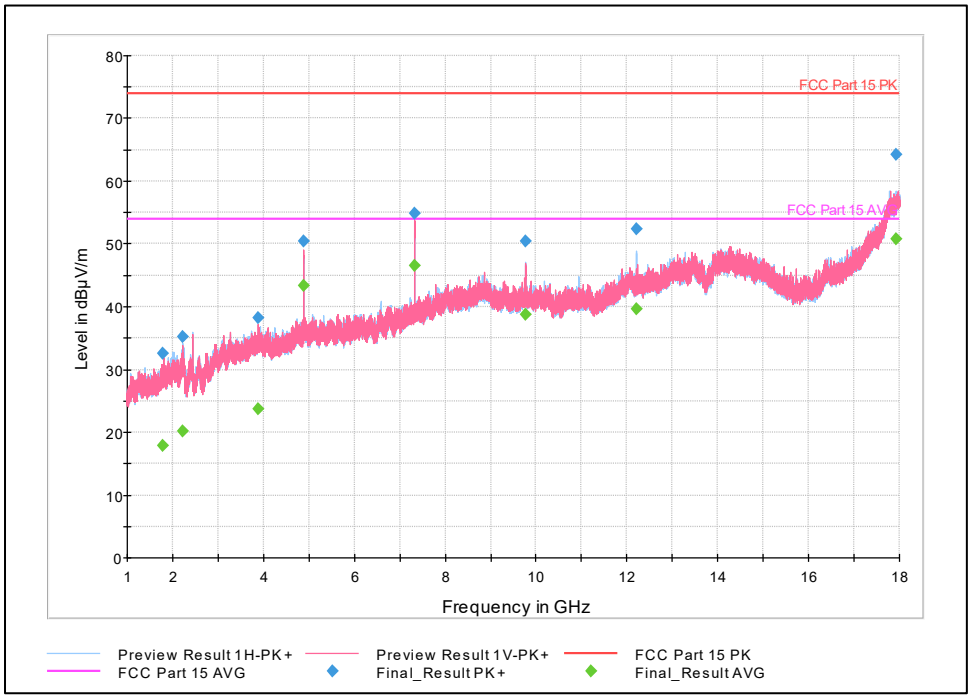


2480 MHz, 2 Mbps

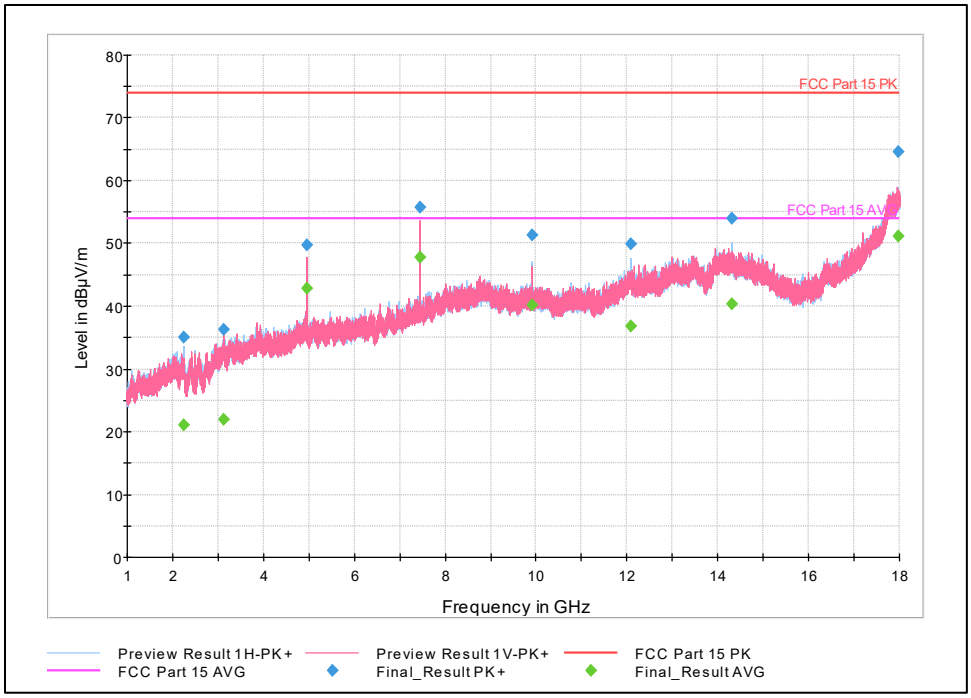
5.5.4.5 Spurious Emissions 1 GHz to 18 GHz



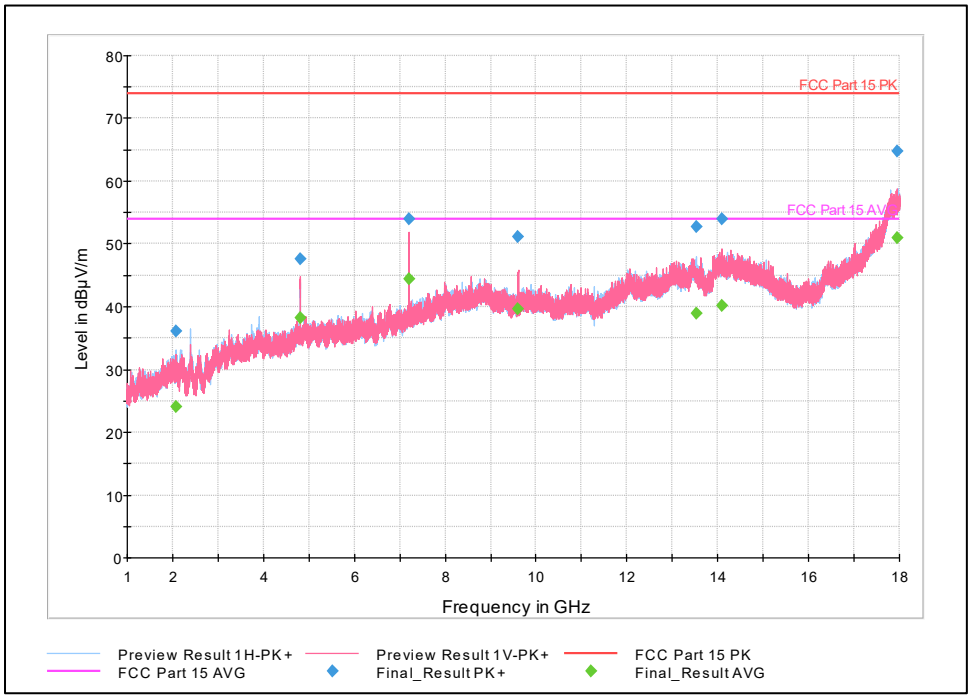
2402 MHz, 1 Mbps



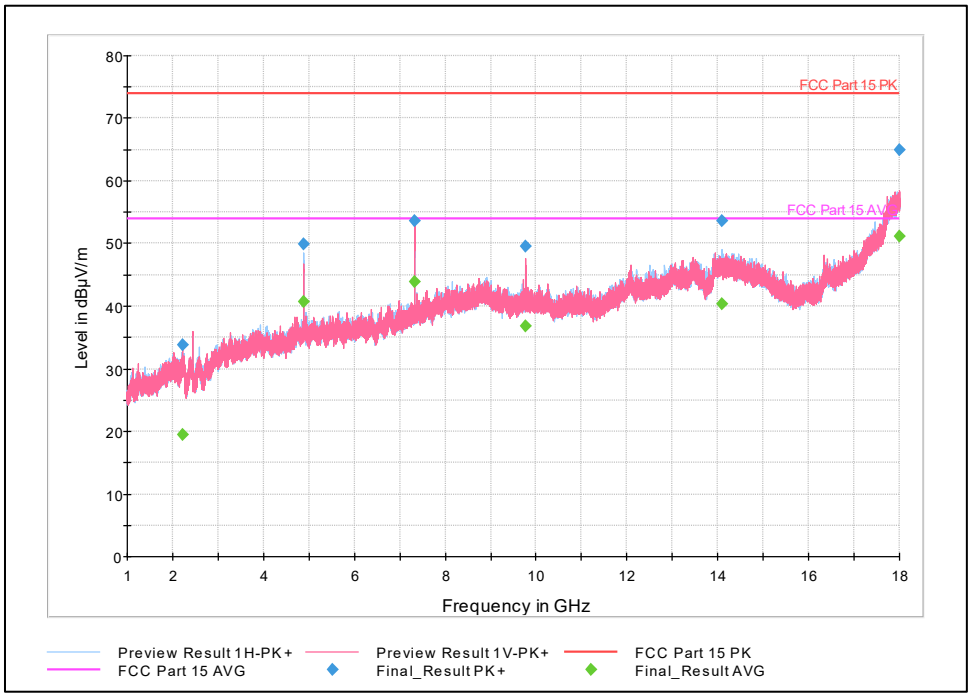
2442 MHz, 1 Mbps



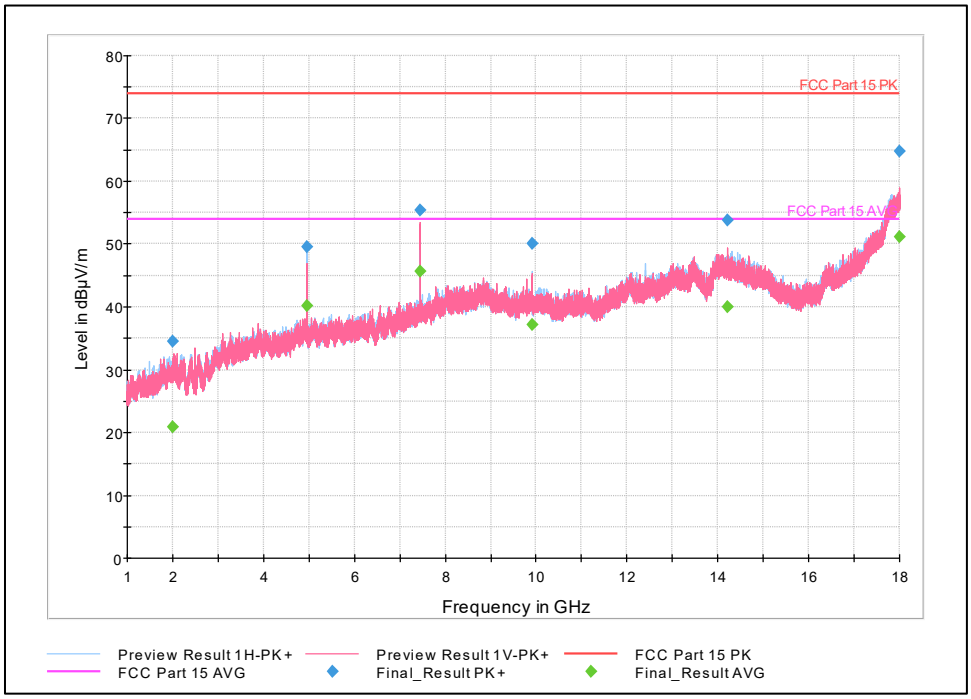
2480 MHz, 1 Mbps



2402 MHz, 2 Mbps

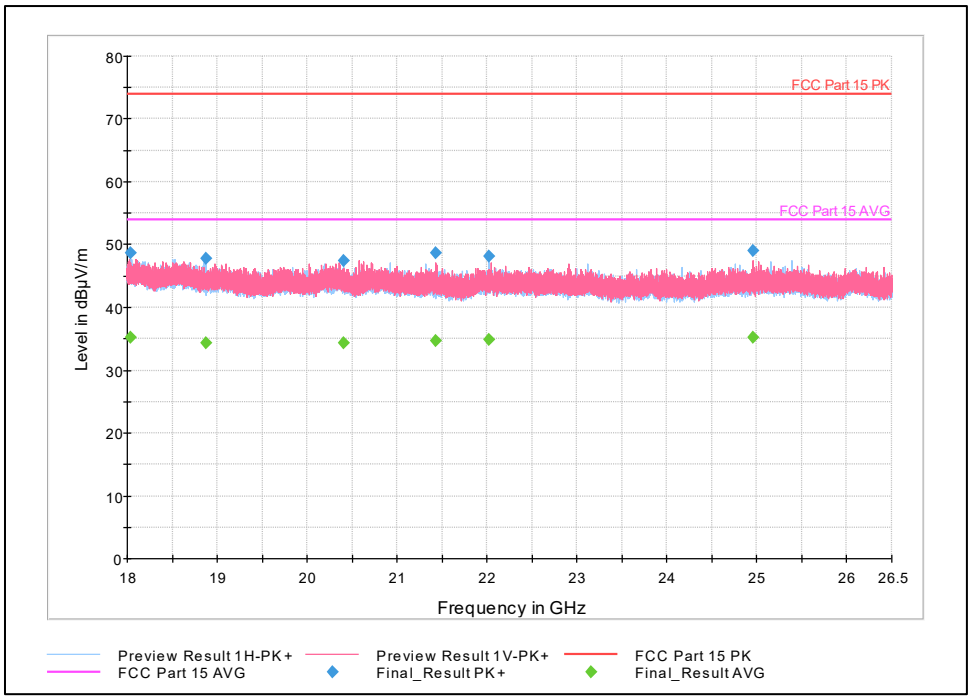


2442 MHz, 2 Mbps

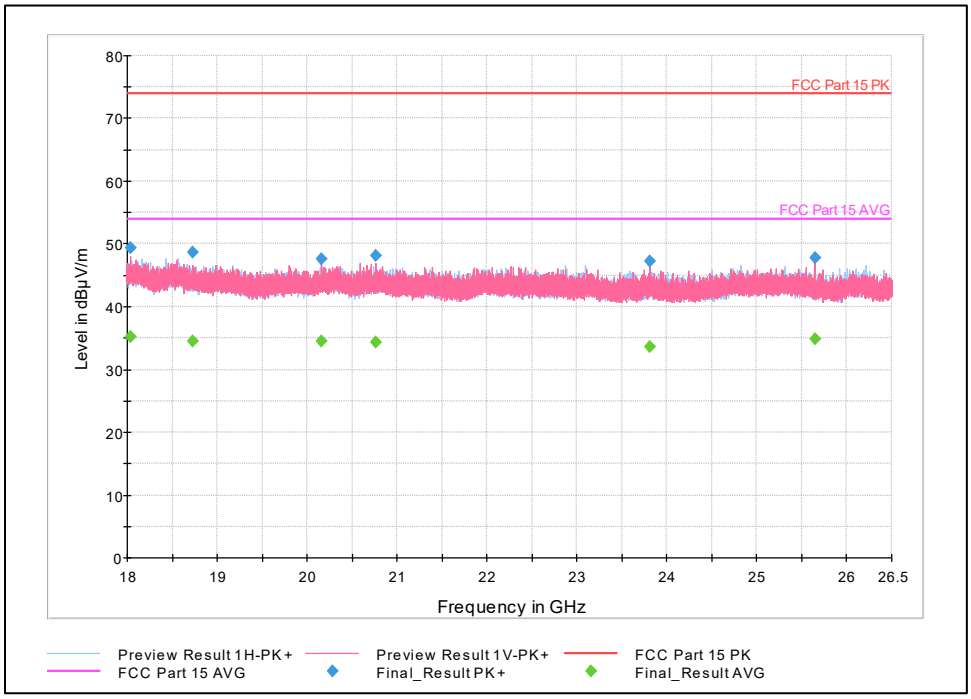


2480 MHz, 2 Mbps

5.5.4.6 Spurious Emissions 18 GHz to 26.5 GHz



2480 MHz, 1 Mbps



2480 MHz, 2 Mbps

5.6 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.4:2014. These test methods are listed under the laboratory's A2LA Scope of Accreditation.

This test measures the levels emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

The AC conducted emissions of equipment under test shall not exceed the values in CFR47 Part 15.207 and RSS-Gen Section 8.8.

5.6.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50µH / 50Ω LISNs.

Testing is performed in Lab 5. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

The radio was transmitting when testing was performed.

5.6.2 Deviations

There were no deviations from this test methodology.

5.6.3 Test Results

The device passed as configured.

5.6.4 Test Data

Worst case data reported in this section. The worst-case emission profile was determined by which frequency emitted the highest power, power spectral density and whose harmonics were present in antenna port emission testing.

5.6.4.1 Conducted Emissions – 1 Mbps

Table 32: Conducted Emission – 2480 MHz, Line

Test Condition:	Normal Temperature			**Date:**	6/26/2024			
Antenna Type:	Linear Passive PCB Antenna			**Power Level:**	See Table 6			
Ambient Temperature:	22 ºC			**Relative Humidity:**	37 %			
Max. Antenna Gain:	+1.5 dBi			**Test Engineer**	Nathaniel Beyer			
Signal State: Modulated								
Freq. (MHz)	**Quasi-Peak (dBµV)**	**Peak (dBµV)**	**Limit (dBµV)**	**Margin (dBµV)**	**Meas. Time (ms)**	**Line**	**PE**	**Corr. (dB)**
0.1605	---	23.88	55.48	31.6	10000	L1	GND	10.1
0.1605	44.88	---	65.48	20.6	10000	L1	GND	10.1
0.3378	---	20.26	49.13	28.87	10000	L1	GND	10.1
0.3378	31.19	---	59.13	27.94	10000	L1	GND	10.1
0.5447	---	28.85	46	17.15	10000	L1	GND	10.1
0.5447	38.69	---	56	17.31	10000	L1	GND	10.1
0.7802	---	16.21	46	29.79	10000	L1	GND	10.1
0.7802	25.78	---	56	30.22	10000	L1	GND	10.1
0.8112	---	13.3	46	32.7	10000	L1	GND	10.1
0.8112	25.08	---	56	30.92	10000	L1	GND	10.1
0.9338	---	15.27	46	30.73	10000	L1	GND	10.1
0.9338	25.24	---	56	30.76	10000	L1	GND	10.1
18.0545	---	9.6	50	40.4	10000	L1	GND	10
18.0545	15.61	---	60	44.39	10000	L1	GND	10
Note: None								

Table 33: Conducted Emissions – 2402 MHz, Neutral

Test Condition:	Normal Temperature	**Date:**	6/26/2024
Antenna Type:	Linear Passive PCB Antenna	**Power Level:**	See Table 6
Ambient Temperature:	22 ºC	**Relative Humidity:**	37 %
Max. Antenna Gain:	+1.5 dBi	**Test Engineer**	Nathaniel Beyer

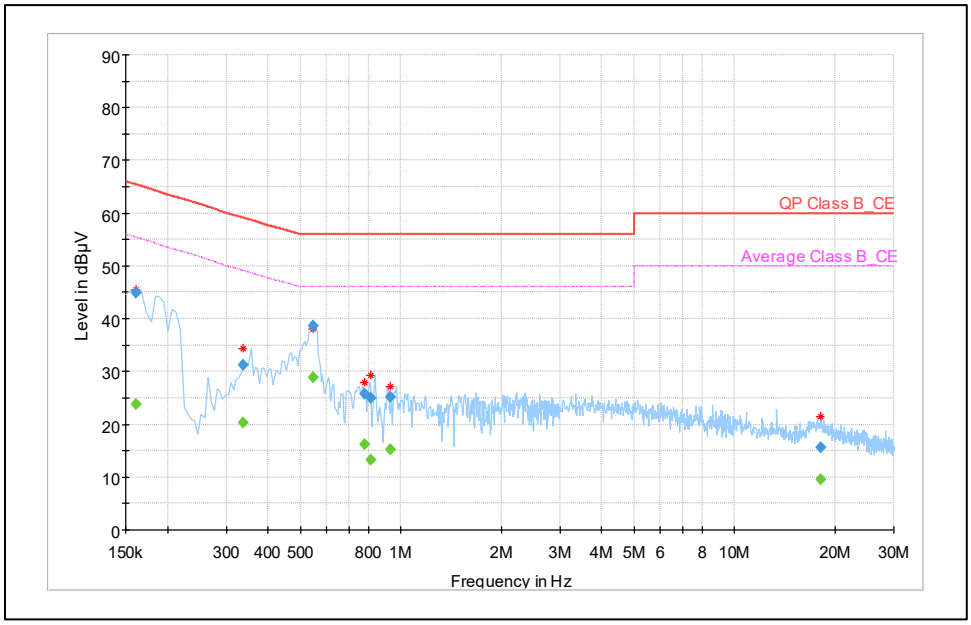
Signal State: Modulated

Freq. (MHz)	Quasi-Peak (dBµV)	Peak (dBµV)	Limit (dBµV)	Margin (dBµV)	Meas. Time (ms)	Line	PE	Corr. (dB)
0.1650	---	22.26	55.25	32.99	10000	N	GND	10.1
0.1650	43.89	---	65.25	21.36	10000	N	GND	10.1
0.1815	---	21.94	54.43	32.49	10000	N	GND	10
0.1815	42.18	---	64.43	22.24	10000	N	GND	10
0.3278	---	18.85	49.36	30.51	10000	N	GND	10
0.3278	30.81	---	59.36	28.55	10000	N	GND	10
0.3891	---	18.59	47.95	29.37	10000	N	GND	10
0.3891	28.79	---	57.95	29.16	10000	N	GND	10
0.5464	---	28.49	46	17.51	10000	N	GND	10
0.5464	38.3	---	56	17.7	10000	N	GND	10
16.7288	---	18.64	50	31.36	10000	N	GND	10.1
16.7288	26.08	---	60	33.92	10000	N	GND	10.1

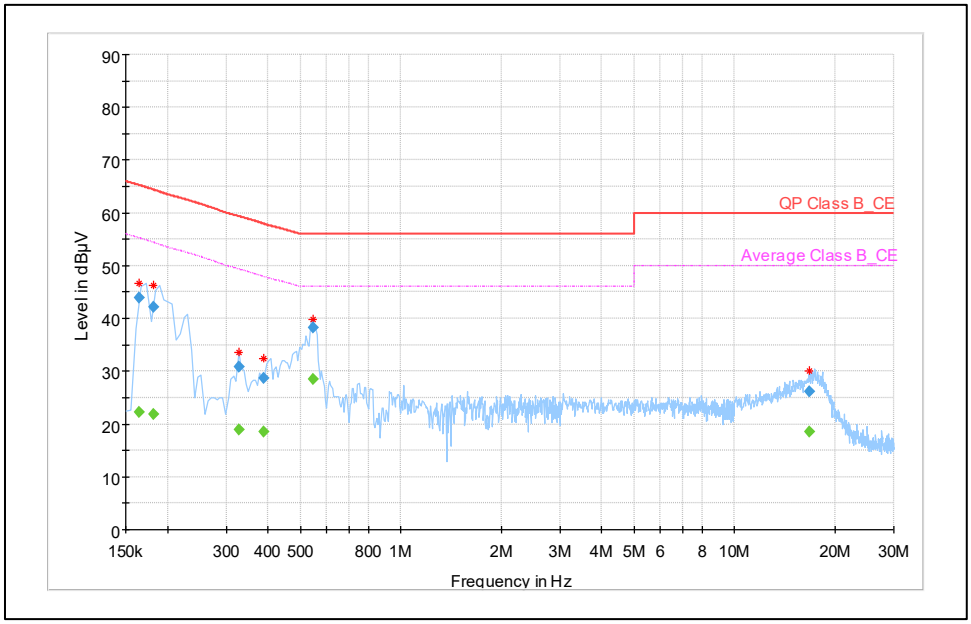
Note: None

5.6.5 Analyzer Data

5.6.5.1 Conducted Emissions – 1 Mbps



Line



Neutral

6 Test Equipment List

6.1 Equipment List

Table 34: Equipment List

Equipment	Type	Model Number	Manufacturer	Last calibration	Calibration due date
9022991	ESW44 EMI Test Receiver 2 Hz to 44 GHz	ESW44	Rohde & Schwarz	02/20/2024	02/20/2025
G1700272	Vector Network Analyzer	ZNB8	Rohde & Schwarz	02/20/2024	2/20/2025
9018108	ESW44 EMI Test Receiver 2 Hz to 44 GHz	ESW44	Rohde & Schwarz	02/21/2024	02/21/2025
G1700070	Horn Antenna, 1 GHz - 18 GHz	3115	EMCO	03/30/2023	03/30/2025
9018047	Preamplifier, 1 - 18 GHz	TS-PR18	Rohde & Schwarz	02/27/2024	02/27/2025
9024554	Small Horn Antenna, 18GHz - 40GHz	180-442-KF	ATM	06/20/2023	06/20/2024
9018046	Preamplifier, 18 - 40GHz	TS-PR1840	Rohde & Schwarz	02/27/2024	02/27/2025
G1700997	Active Loop Antenna, 10 kHz - 30 MHz	6502	EMCO	05/23/2026	05/23/2026
G1700882	Receiver, EMI, 20 Hz - 40 GHz	ESIB40	Rohde & Schwarz	02/21/2025	02/21/2025
G1701026	Transient Limiter, 10dB, 9 kHz - 200 MHz	11947A	Agilent	02/22/2025	02/22/2025
G1700229	LISN, 10 kHz - 30 MHz	LI-215A	Com-Power	02/21/2025	02/21/2025
G1700124	Filter, Notch, 2.4 -2.5 GHz	BRM50702	Micro-Tronics	N/A[1]	N/A[1]
--	Attenuator DC – 18 GHz	BW-S10W2+	Mini-circuits	N/A[1]	N/A[1]

Note:
1. Device verified before use using network analyzer.

6.2 Testing Software

Table 35: Testing Software

Manufacturer	Name	Version	Test
Rohde & Schwarz	EMC 32	3m – 10.60.10	Radiated Emissions

--- Ende des Prüfberichts / End of Test Report ---