5.2 RF Exposure Evaluation Result

Project info

Beam-forming:

For the 5G Wi-Fi, as it can support the beam-forming function,

So Directional gain = 10 log[$(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN}/10)^2/N_{ANT}$] dBi.

Directional gain = Band 2: 8.91 dBi , Band 3: 8.86 dBi

Band	Freq (MHz)	Tune-up Power (dBm)	Directional gain (dBi)	Distances (mm)	Tune-up Power (mW)	ERP (dBm)	ERP (mW)
WIFI-5GHz Band 2	5250	20.5	8.91	200	112.20	27.26	532.11
WIFI-5GHz Band 3	5500	20.5	8.86	200	112.20	27.21	526.02

§ 1.1307(b)(3)(i)(A) method is not applicable.
§ 1.1307(b)(3)(i)(C)

Band	Freq (MHz)	λ/2π (mm)	Distances applies	ERP Limit (mW)	Result Option C
WIFI-5GHz Band 2	**5250**	**9.09**	**apply**	**768.00**	**exempt**
WIFI-5GHz Band 3	**5500**	**8.68**	**apply**	**768.00**	**exempt**

The minimum separation distance (R in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates.
ERP (watts) is no more than the calculated value prescribed for that frequency.
R must be at least λ/2π.
λ is the free-space operating wavelength in meters.

Non Beam-forming:

Band	Freq (MHz)	Tune-up Power (dBm)	Ant Gain (dBi)	Distances (mm)	Tune-up Power (mW)	ERP (dBm)	ERP (mW)
WIFI-5GHz Band 2	5250	22	4.9	200	158.49	24.75	298.54
WIFI-5GHz Band 3	5500	22.5	5.1	200	177.83	25.45	350.75

§ 1.1307(b)(3)(i)(A) method is not applicable.
§ 1.1307(b)(3)(i)(C)

Band	Freq (MHz)	λ/2π (mm)	Distances applies	ERP Limit (mW)	Result Option C
WIFI-5GHz Band 2	**5250**	**9.09**	**apply**	**768.00**	**exempt**
WIFI-5GHz Band 3	**5500**	**8.68**	**apply**	**768.00**	**exempt**

The minimum separation distance (R in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates.
ERP (watts) is no more than the calculated value prescribed for that frequency.
R must be at least λ/2π.
λ is the free-space operating wavelength in meters.

The WIFI 2.4GHz and WIFI 5GHz cannot transmit simultaneously

Result: The device compliant the MPE-Based Exemption at 20cm distances.

6 FCC §15.203 – Antenna Requirements

6.1 Applicable Standard

For intentional device, according to §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used.

6.2 Antenna Information

Manufacturer	Antenna Type	Antenna Gain (dBi)	Input impedance
LYNwave Technology.	FPC Antenna	Antenna 0: 5250-5350 MHz: 3.0 5470-5725 MHz: 2.8	50Ω
		Antenna 1: 5250-5350 MHz: 4.4 5470-5725 MHz: 4.2	
		Antenna 2: 5250-5350 MHz: 4.9 5470-5725 MHz: 5.1	

The antenna is permanently connected to the EUT.

Result: Compliance

7 FCC §15.407(b)(9), §15.207(a) – AC Line Conducted Emissions

7.1 Applicable Standard

As per FCC §15.407(b) (9)

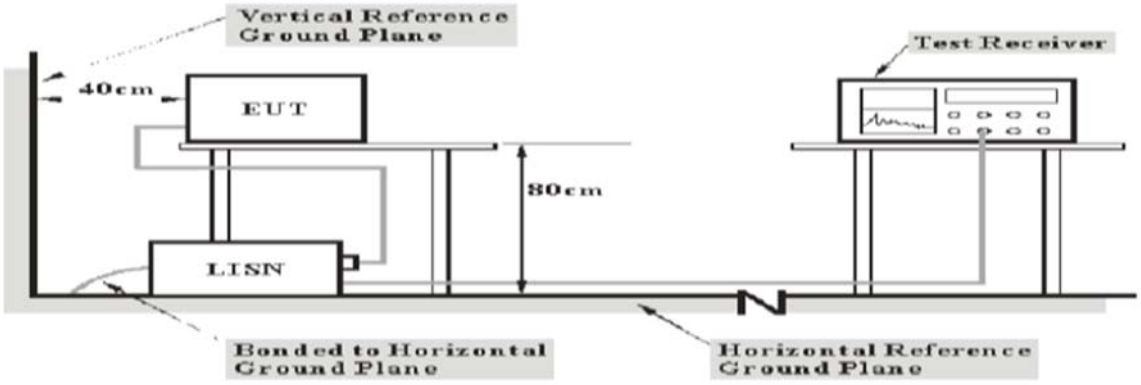
Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 Note 1	56 to 46 Note 1
0.5-5	56	46
5-30	60	50

Note 1: Decreases with the logarithm of the frequency.

7.2 EUT Setup



The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 limits.

7.3 EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150kHz to 30MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations

Frequency Range	IF B/W
150kHz – 30MHz	9kHz

7.4 Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All data was recorded in the Quasi-peak and average detection mode.

7.5 Corrected Factor & Over Limit Calculation

The factor is calculated by adding LISN/ISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

The “Over Limit” column of the following data tables indicates the degree of compliance with the applicable limit. For example, an over limit of -7 dB means the emission is 7 dB below the limit. The equation for Over Limit calculation is as follows:

Over Limit = Result – Limit Line

7.6 Test Results

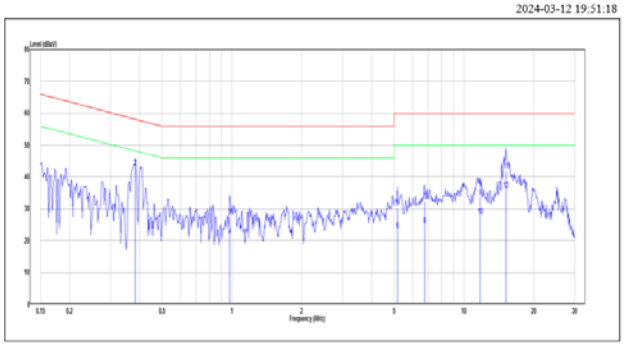
Test Mode: Transmitting

Main: AC120 V, 60 Hz

Non Beamforming Mode:

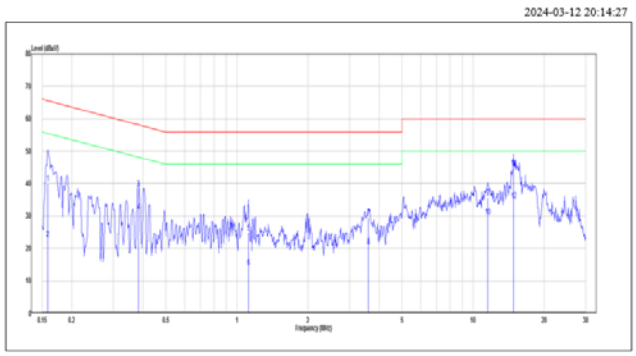
(Worst case is 802.11ac40 mode, 5310 MHz)

Line



No.	Frequency (MHz)	Reading dBuV	Correct Factor(dB)	Result dBuV	Limit dBuV	Over limit (dB)	Remark	Phase
1	0.383	23.79	19.52	43.31	58.21	-14.90	QP	Line
2	0.383	23.36	19.52	42.88	48.21	-5.33	Average	Line
3	0.979	7.47	19.81	27.28	56.00	-28.72	QP	Line
4	0.979	1.63	19.81	21.44	46.00	-24.56	Average	Line
5	5.166	10.28	20.11	30.39	60.00	-29.61	QP	Line
6	5.166	3.13	20.11	23.24	50.00	-26.76	Average	Line
7	6.769	12.34	20.10	32.44	60.00	-27.56	QP	Line
8	6.769	4.88	20.10	24.97	50.00	-25.03	Average	Line
9	11.745	13.52	20.13	33.65	60.00	-26.35	QP	Line
10	11.745	7.66	20.13	27.80	50.00	-22.20	Average	Line
11	15.146	21.68	20.24	41.92	60.00	-18.08	QP	Line
12	15.146	15.64	20.24	35.87	50.00	-14.13	Average	Line

Neutral



No.	Frequency (MHz)	Reading dBuV	Correct Factor(dB)	Result dBuV	Limit dBuV	Over limit (dB)	Remark	Phase
1	0.158	20.69	19.45	40.14	65.56	-25.42	QP	Neutral
2	0.158	3.41	19.45	22.86	55.56	-32.70	Average	Neutral
3	0.383	19.04	19.53	38.56	58.21	-19.65	QP	Neutral
4	0.383	11.81	19.53	31.34	48.21	-16.87	Average	Neutral
5	1.117	4.98	19.85	24.83	56.00	-31.17	QP	Neutral
6	1.117	-5.60	19.85	14.25	46.00	-31.75	Average	Neutral
7	3.603	9.46	20.07	29.53	56.00	-26.47	QP	Neutral
8	3.603	0.54	20.07	20.61	46.00	-25.39	Average	Neutral
9	11.559	15.58	20.15	35.74	60.00	-24.26	QP	Neutral
10	11.559	9.68	20.15	29.84	50.00	-20.16	Average	Neutral
11	14.828	24.51	20.27	44.78	60.00	-15.22	QP	Neutral
12	14.828	14.66	20.27	34.93	50.00	-15.07	Average	Neutral

Note:

Result = Reading + Factor

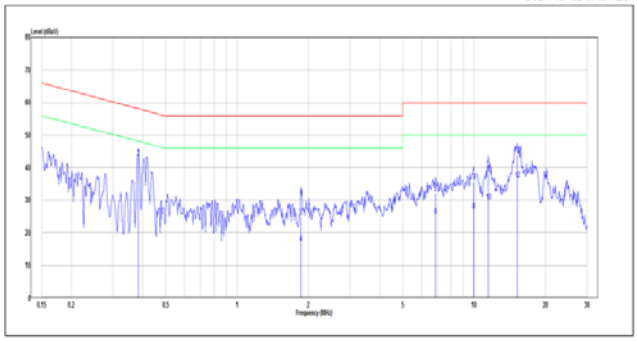
Over Limit = Result – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Beamforming Mode:

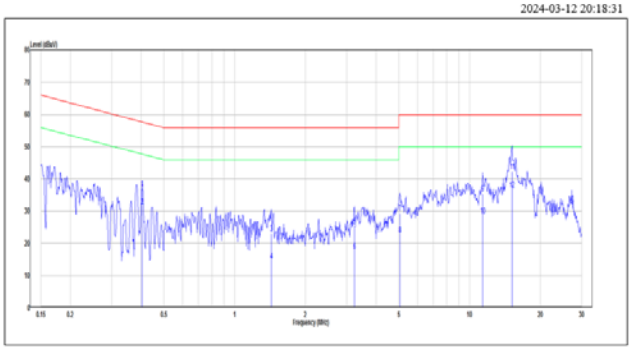
(Worst case is 802.11ax160 mode, 5570 MHz)

Line



No.	Frequency (MHz)	Reading dBuV	Correct Factor(dB)	Result dBuV	Limit dBuV	Over limit (dB)	Remark	Phase
1	0.383	23.77	19.52	43.29	58.21	-14.92	QP	Line
2	0.383	23.34	19.52	42.86	48.21	-5.35	Average	Line
3	1.858	4.71	19.99	24.70	56.00	-31.30	QP	Line
4	1.858	-3.10	19.99	16.89	46.00	-29.11	Average	Line
5	6.878	12.02	20.10	32.12	60.00	-27.88	QP	Line
6	6.878	5.07	20.10	25.17	50.00	-24.83	Average	Line
7	9.966	15.57	20.08	35.65	60.00	-24.35	QP	Line
8	9.966	6.56	20.08	26.64	50.00	-23.36	Average	Line
9	11.498	17.98	20.12	38.10	60.00	-21.90	QP	Line
10	11.498	9.43	20.12	29.55	50.00	-20.45	Average	Line
11	15.226	23.66	20.24	43.90	60.00	-16.10	QP	Line
12	15.226	15.99	20.24	36.23	50.00	-13.77	Average	Line

Neutral



No.	Frequency (MHz)	Reading dBuV	Correct Factor(dB)	Result dBuV	Limit dBuV	Over limit (dB)	Remark	Phase
1	0.404	17.47	19.54	37.01	57.77	-20.76	QP	Neutral
2	0.404	11.86	19.54	31.40	47.77	-16.37	Average	Neutral
3	1.433	3.21	19.92	23.12	56.00	-32.88	QP	Neutral
4	1.433	-5.37	19.92	14.55	46.00	-31.45	Average	Neutral
5	3.241	5.20	20.06	25.26	56.00	-30.74	QP	Neutral
6	3.241	-2.51	20.06	17.55	46.00	-28.45	Average	Neutral
7	5.058	9.33	20.11	29.44	60.00	-30.56	QP	Neutral
8	5.058	2.58	20.11	22.69	50.00	-27.31	Average	Neutral
9	11.377	15.24	20.15	35.38	60.00	-24.62	QP	Neutral
10	11.377	8.51	20.15	28.66	50.00	-21.34	Average	Neutral
11	15.146	22.03	20.28	42.31	60.00	-17.69	QP	Neutral
12	15.146	16.30	20.28	36.58	50.00	-13.42	Average	Neutral

Note:

Result = Reading + Factor

Over Limit = Result – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

8 FCC §15.209, §15.205, §15.407(b) – Spurious Emissions

8.1 Applicable Standard

As Per FCC §15.205(a) except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	608 – 614	4.5 – 5.15
0.495 – 0.505	16.69475 – 16.69525	960 – 1240	5.35 – 5. 46
2.1735 – 2.1905	16.80425 – 16.80475	1300 – 1427	7.25 – 7.75
4.125 – 4.128	25.5 – 25.67	1435 – 1626.5	8.025 – 8.5
4.17725 – 4.17775	37.5 – 38.25	1645.5 – 1646.5	9.0 – 9.2
4.20725 – 4.20775	73 – 74.6	1660 – 1710	9.3 – 9.5
6.215 – 6.218	74.8 – 75.2	1718.8 – 1722.2	10.6 – 12.7
6.26775 – 6.26825	108 – 121.94	2200 – 2300	13.25 – 13.4
6.31175 – 6.31225	123 – 138	2310 – 2390	14.47 – 14.5
8.291 – 8.294	149.9 – 150.05	2483.5 – 2500	15.35 – 16.2
8.362 – 8.366	156.52475 – 156.52525	2690 – 2900	17.7 – 21.4
8.37625 – 8.38675	156.7 – 156.9	3260 – 3267	22.01 – 23.12
8.41425 – 8.41475	162.0125 –167.17	3.332 – 3.339	23.6 – 24.0
12.29 – 12.293	167.72 – 173.2	3 3458 – 3 358	31.2 – 31.8
12.51975 – 12.52025	240 – 285	3.600 – 4.400	36.43 – 36.5
12.57675 – 12.57725	322 – 335.4		Above 38.6
13.36 – 13.41	399.9 – 410		

As per FCC §15.209(a): Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (micro volts/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 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

Note 1: Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

According to ANSI C63.10-2013, section 5.3.3

Measurements may be performed at a distance other than the limit distance provided they are not performed in the near field, and the emissions to be measured can be detected by the measurement equipment (see 4.3.4). Measurements shall not be performed at a distance greater than 30 m for frequencies above 30 MHz, unless it can be further demonstrated that measurements at a distance of 30 m or less are impractical. Measurements from

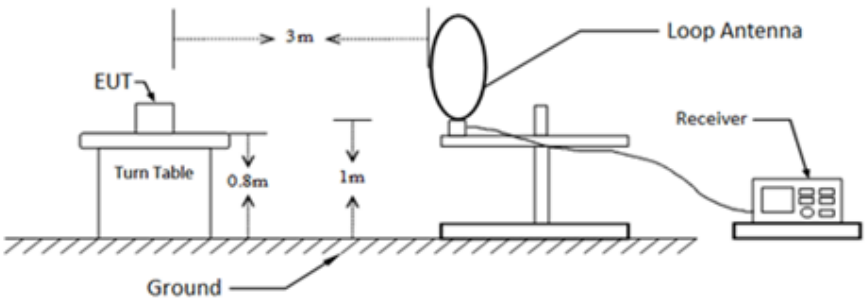
18 GHz to 40 GHz are typically made at distances significantly less than 3 m from the EUT. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade of distance (inverse of linear distance for field-strength measurements or inverse of linear distance-squared for power-density measurements).

As per FCC Part 15.407 (b)

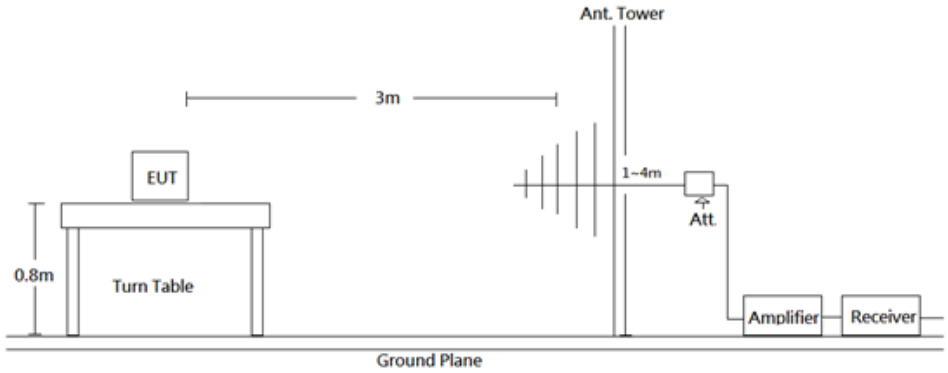
- For transmitters operating in the 5.15-5.25 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.
- For transmitters operating in the 5.25–5.35 GHz band: All emissions outside of the 5.15–5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.
- For transmitters operating in the 5.47–5.725 GHz band: All emissions outside of the 5.47–5.725 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.
- For transmitters operating in the 5.725-5.85 GHz band: All emissions shall be limited to a level of −27 dBm/MHz 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.
- Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in § 15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease before March 2, 2020.
- The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.
- Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209.

8.2 EUT Setup

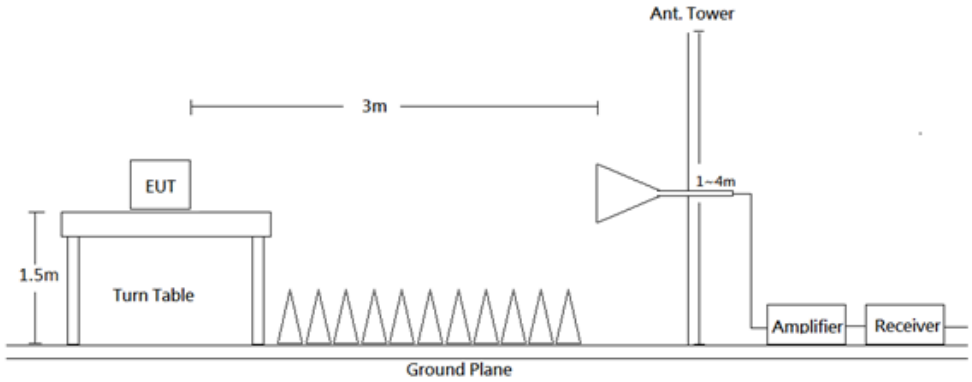
9kHz-30MHz:



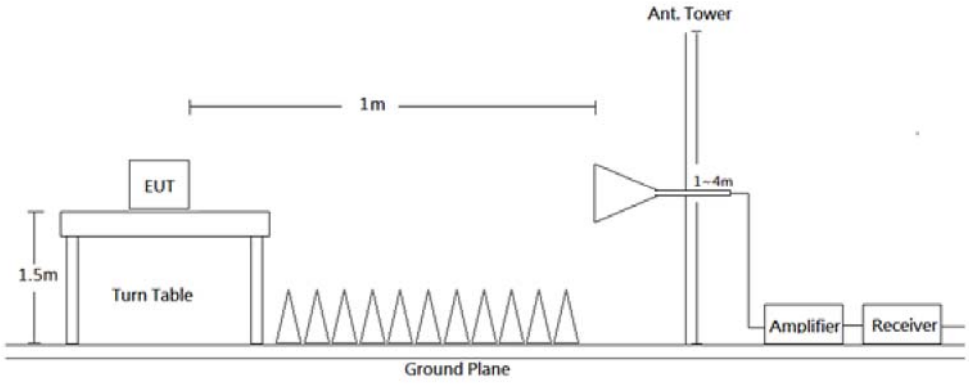
30MHz-1GHz:



1-18 GHz:



18-40 GHz:



Radiated emission tests were performed in the 3 meters chamber test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC Part 15.209, FCC 15.407 Limits.

8.3 EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 9 kHz to 40 GHz. During the radiated emission test, the EMI test receiver was set with the following configurations measurement method 6.3 in ANSI C63.10.

Frequency Range	RBW	VBW	Duty cycle	Measurement method
9 kHz - 150 kHz	200 Hz/300 Hz	1 kHz	/	QP/AV
150 kHz - 30 MHz	9 kHz/10 kHz	30 kHz	/	QP/AV
30-1000 MHz	120 kHz	300 kHz	/	QP
Above 1 GHz	1 MHz	3 MHz	/	PK
	1 MHz	10 Hz	>98%	Ave
	1 MHz	1/T	<98%	Ave

Note: T is minimum transmission duration

If the maximized peak measured value complies with under the QP/Average limit more than 6dB, then it is unnecessary to perform an QP/Average measurement.

8.4 Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All data was recorded in Quasi-peak and average detector mode from 9 kHz to 30 MHz, Quasi-peak detector mode from 30 MHz to 1 GHz and PK and average detector modes for frequencies above 1 GHz.

According to C63.10, emission shall be computed as: E [dBμV/m] = EIRP[dBm] + 95.2, for d = 3 meters.

All emissions under the average limit and under the noise floor have not recorded in the report

8.5 Corrected Factor & Margin Calculation

The Correct Factor is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

The “Margin” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the limit. The equation for margin calculation is as follows:

Margin = Level – Limit

8.6 Test Results

Test Mode: Transmitting

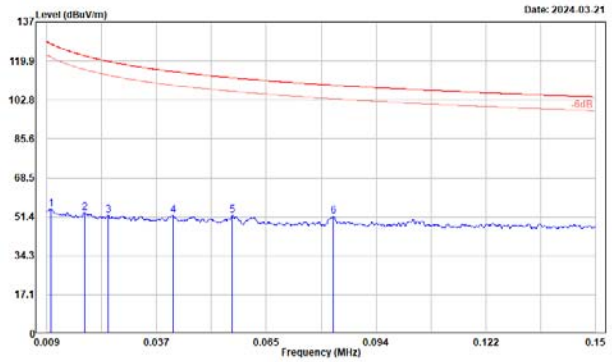
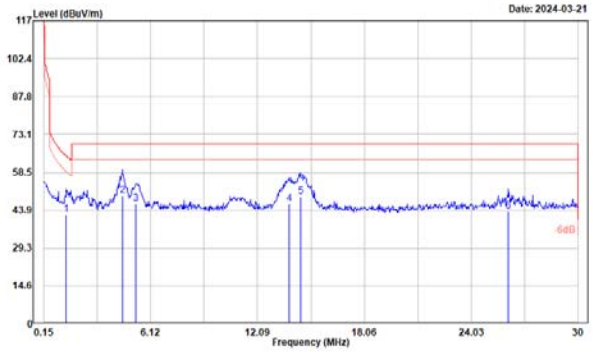
(Pre-scan with three orthogonal axis, and worse case as Z axis.)

9kHz-30MHz:

(Pre-scan using three directional polarities, worst case as parallel.)

Non Beamforming Mode:

(Worst case is 802.11ax20 mode 5700 MHz)

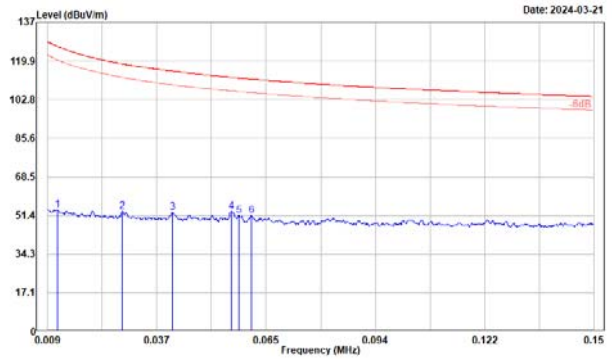
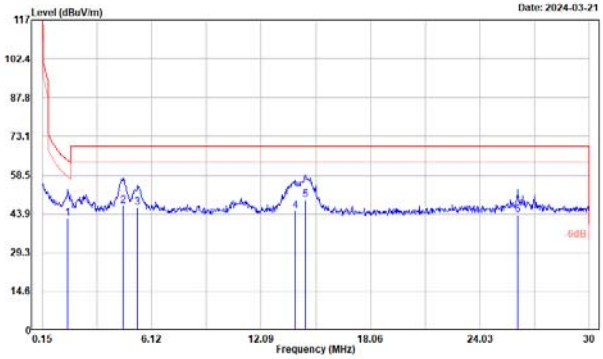
9kHz-150kHz	150kHz-30MHz
	

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
0.010	37.85	16.82	54.67	127.61	-72.94	100	203	Average
0.019	37.99	15.15	53.14	122.15	-69.01	100	194	Average
0.025	37.73	14.34	52.07	119.72	-67.65	100	220	Average
0.041	39.27	12.71	51.98	115.26	-63.28	100	155	Average
0.057	40.02	11.93	51.95	112.54	-60.59	100	184	Average
0.083	40.18	11.27	51.45	109.25	-57.80	100	66	Average

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1.404	31.26	11.02	42.28	64.66	-22.38	100	333	QP
4.568	38.68	10.65	49.33	69.54	-20.21	100	306	QP
5.284	35.13	11.01	46.14	69.54	-23.40	100	185	QP
13.881	34.82	11.49	46.31	69.54	-23.23	100	221	QP
14.508	37.70	11.50	49.20	69.54	-20.34	100	318	QP
26.120	31.60	11.71	43.31	69.54	-26.23	100	102	QP

Beamforming Mode:

(Worst case is 802.11ax160 mode 5570 MHz)

9kHz-150kHz	150kHz-30MHz
	

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
0.012	37.19	16.52	53.71	126.36	-72.65	100	152	Average
0.028	39.23	13.91	53.14	118.56	-65.42	100	48	Average
0.041	39.88	12.71	52.59	115.29	-62.70	100	220	Average
0.057	41.23	11.95	53.18	112.56	-59.38	100	337	Average
0.058	39.62	11.76	51.38	112.28	-60.90	100	217	Average
0.062	39.72	11.57	51.29	111.81	-60.52	100	111	Average

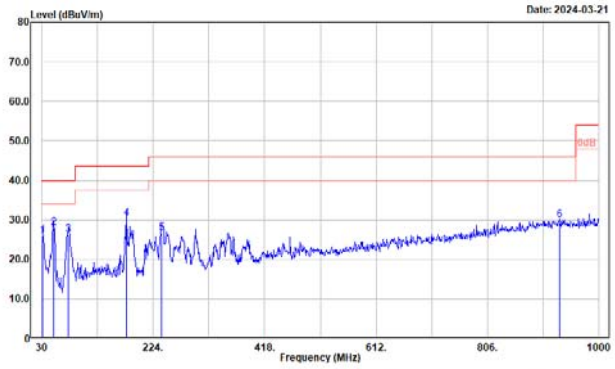
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1.523	31.34	10.97	42.31	63.95	-21.64	100	52	QP
4.538	36.13	10.64	46.77	69.54	-22.77	100	305	QP
5.344	35.20	11.08	46.28	69.54	-23.26	100	22	QP
13.941	33.62	11.49	45.11	69.54	-24.43	100	252	QP
14.508	37.71	11.50	49.21	69.54	-20.33	100	149	QP
26.120	31.81	11.71	43.52	69.54	-26.02	100	183	QP

30MHz-1GHz:

Non Beamforming Mode:

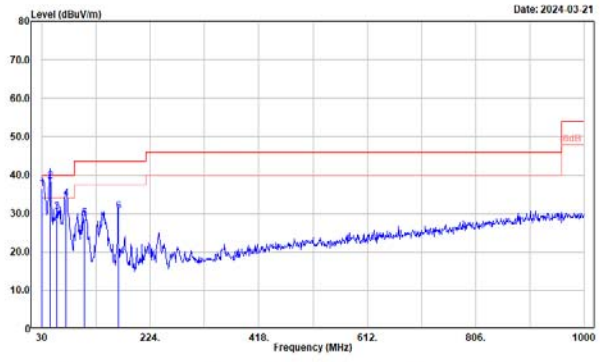
(Worst case is 802.11ac 40 Mode, 5310 MHz)

Horizontal



Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
30.970	29.37	-3.36	26.01	40.00	-13.99	100	83	QP
50.370	43.57	-15.56	28.01	40.00	-11.99	100	71	QP
76.560	41.91	-15.70	26.21	40.00	-13.79	100	311	QP
177.440	42.37	-12.03	30.34	43.50	-13.16	100	114	QP
238.550	38.23	-11.48	26.75	46.00	-19.25	100	67	QP
931.130	27.66	2.35	30.01	46.00	-15.99	100	183	QP

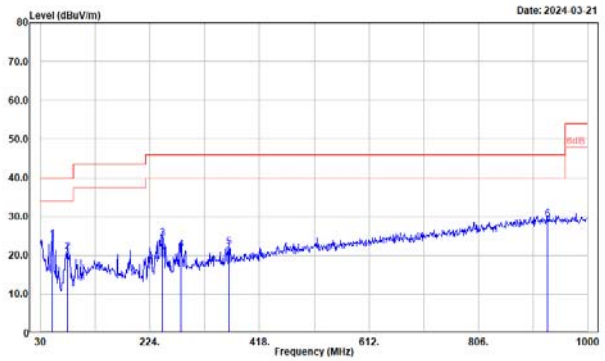
Vertical



Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
30.000	39.42	-2.89	36.53	40.00	-3.47	100	328	QP
44.550	51.54	-13.18	38.36	40.00	-1.64	100	39	QP
57.160	46.68	-16.22	30.46	40.00	-9.54	100	312	QP
73.650	49.42	-15.61	33.81	40.00	-6.19	100	113	QP
106.630	40.46	-11.77	28.69	43.50	-14.81	100	300	QP
166.770	41.75	-11.13	30.62	43.50	-12.88	100	237	QP

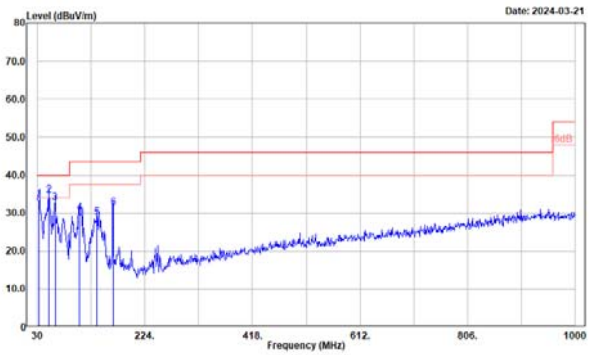
(Worst case is 802.11ax 20 Mode, 5580 MHz)

Horizontal



Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
51.340	39.71	-15.71	24.00	40.00	-16.00	100	36	QP
77.530	36.72	-15.84	20.88	40.00	-19.12	100	299	QP
246.310	35.61	-11.32	24.29	46.00	-21.71	100	62	QP
279.290	31.02	-9.51	21.51	46.00	-24.49	100	322	QP
363.680	30.16	-8.11	22.05	46.00	-23.95	100	47	QP
928.220	26.99	2.28	29.27	46.00	-16.73	100	211	QP

Vertical



Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
32.910	38.81	-5.27	33.54	40.00	-6.46	100	91	QP
50.370	50.29	-15.56	34.73	40.00	-5.27	100	167	QP
62.010	48.86	-16.15	32.71	40.00	-7.29	100	0	QP
105.660	42.14	-11.96	30.18	43.50	-13.32	100	132	QP
137.670	38.72	-9.97	28.75	43.50	-14.75	100	358	QP
166.770	42.47	-11.13	31.34	43.50	-12.16	100	279	QP