

1 FCC §2.1091, §15.407(f), & LP0002-2018 §5.20.2 - RF Exposure

1.1 Applicable Standards

According to FCC §15.247(i), §15.407(f) and §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minutes)
Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	* (100)	30
1.34-30	824/f	2.19/f	* (180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

1.2 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: S = power density

P = power input to antenna

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the center of radiation of the antenna

1.3 MPE Results for FCC

BLE:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>2.4</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>1.74</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>2402</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>3.98</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.0006</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

2.4 GHz Do1 Wi-Fi (4x4):

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>20.5</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>112.20</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>2437</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>12</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>15.85</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.16</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

2.4 GHz ChillWave Wi-Fi (SISO):

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>9.2</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>8.32</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>2412</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>3.98</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.003</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Do1 Wi-Fi (4x4)-5.2 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>18</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>63.10</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5230</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>8.77</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>7.53</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.04</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Do1 Wi-Fi (4x4)-5.3 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>17.61</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>57.68</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5270</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>12.02</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>15.92</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.08</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Do1 Wi-Fi (4x4)-5.6 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>17.82</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>60.53</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5550</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>12.02</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>15.92</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.09</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Do1 Wi-Fi (4x4)-5.8 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>22.5</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>177.83</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5755</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>12.02</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>15.92</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.25</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Do2 Wi-Fi (4x4)-5.2 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>19.72</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>93.76</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5230</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>8.77</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>7.53</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.06</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Do2 Wi-Fi (4x4)-5.3 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>18.4</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>69.18</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5270</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>10.77</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>11.94</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.07</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Do2 Wi-Fi (4x4)-5.6 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>18.96</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>78.70</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5550</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>10.77</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>11.94</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.08</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Do2 Wi-Fi (4x4)-5.8 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>21.9</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>154.88</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5795</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>12.02</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>15.92</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.22</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Wi-Fi (8x8)-5.2 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>21.14</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>130.02</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5240</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>13.78</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>23.88</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.27</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Wi-Fi (8x8)-5.3 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>16.01</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>39.90</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5270</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>13.78</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>23.88</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.08</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Wi-Fi (8x8)-5.6 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>15.42</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>34.83</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5610</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>13.78</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>23.88</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.07</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz Wi-Fi (8x8)-5.8 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>22.16</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>164.44</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5775</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>13.78</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>23.88</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.35</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz ChillWave Wi-Fi (SISO)-5.2 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>9.1</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>8.13</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5180</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>3.98</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.003</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz ChillWave Wi-Fi (SISO)-5.3 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>8.7</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>7.41</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5260</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>3.98</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.003</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz ChillWave Wi-Fi (SISO)-5.6 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>9.8</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>9.55</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5560</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>3.98</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.003</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

5 GHz ChillWave Wi-Fi (SISO)-5.8 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>7.2</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>5.25</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5745</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>3.98</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.002</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1</u>

Radio Co-location

Case	Standalone MPE (mW/cm ²)							Total MPE Ratio	Limit
	BLE	2.4 GHz ChillWave	5 GHz ChillWave	2.4 GHz Do1	5 GHz Do1	5 GHz Do2	5 GHz 8x8		
1	0.0006	0.003	-	0.16	0.25	0.22	-	0.634	1
2	0.0006	-	0.003	0.16	0.25	0.22	-	0.634	1
3	0.0006	0.003	-	-	-	-	0.35	0.354	1
4	0.0006	-	0.003	-	-	-	0.35	0.354	1

Conclusion

The device is compliant with the requirement MPE limit for uncontrolled exposure. All transceiver modules must be installed with a separation distance of no less than **30** cm from all persons. less than **30** cm from all persons.