

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>4.21</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>2.64</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>2</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1.58</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.0004</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

2.4 GHz Wi-Fi:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>24.3</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>269.15</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>10</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>10</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.238</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

5.2 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>21.04</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>127.06</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5200</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>14.45</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>27.86</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.313</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

5.3 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>13.68</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>23.335</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>23.878</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.049</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

5.6 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>20.75</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>118.85</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5700</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6.88</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>4.88</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm²):</u>	<u>0.051</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

5.8 GHz band:

<u>Maximum average output power at antenna input terminal (dBm):</u>	<u>23.87</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>243.78</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>0.343</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

Radio Co-location

BLE + 2.4 GHz Wi-Fi + 5 GHz Wi-Fi:

$$0.0004/1 + 0.238/1 + 0.343/1 = 0.581 < 1$$

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.