

## 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 <sup>2</sup> )	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 <sup>2</sup> )	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/cm<sup>2</sup>):</u>	<u>0.0006</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</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/cm<sup>2</sup>):</u>	<u>0.16</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</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/cm<sup>2</sup>):</u>	<u>0.003</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</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>	18
<u>Maximum average output power at antenna input terminal (mW):</u>	63.10
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5230
<u>Maximum Antenna Gain, typical (dBi):</u>	8.77
<u>Maximum Antenna Gain (numeric):</u>	7.53
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.04
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	17.61
<u>Maximum average output power at antenna input terminal (mW):</u>	57.68
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5270
<u>Maximum Antenna Gain, typical (dBi):</u>	12.02
<u>Maximum Antenna Gain (numeric):</u>	15.92
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.08
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	17.82
<u>Maximum average output power at antenna input terminal (mW):</u>	60.53
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5550
<u>Maximum Antenna Gain, typical (dBi):</u>	12.02
<u>Maximum Antenna Gain (numeric):</u>	15.92
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.09
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	22.5
<u>Maximum average output power at antenna input terminal (mW):</u>	177.83
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5755
<u>Maximum Antenna Gain, typical (dBi):</u>	12.02
<u>Maximum Antenna Gain (numeric):</u>	15.92
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.25
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm <sup>2</sup> ):	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	19.72
<u>Maximum average output power at antenna input terminal (mW):</u>	93.76
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5230
<u>Maximum Antenna Gain, typical (dBi):</u>	8.77
<u>Maximum Antenna Gain (numeric):</u>	7.53
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.06
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	18.4
<u>Maximum average output power at antenna input terminal (mW):</u>	69.18
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5270
<u>Maximum Antenna Gain, typical (dBi):</u>	10.77
<u>Maximum Antenna Gain (numeric):</u>	11.94
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.07
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	18.96
<u>Maximum average output power at antenna input terminal (mW):</u>	78.70
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5550
<u>Maximum Antenna Gain, typical (dBi):</u>	10.77
<u>Maximum Antenna Gain (numeric):</u>	11.94
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.08
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	21.9
<u>Maximum average output power at antenna input terminal (mW):</u>	154.88
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5795
<u>Maximum Antenna Gain, typical (dBi):</u>	12.02
<u>Maximum Antenna Gain (numeric):</u>	15.92
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.22
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	21.14
<u>Maximum average output power at antenna input terminal (mW):</u>	130.02
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5240
<u>Maximum Antenna Gain, typical (dBi):</u>	13.78
<u>Maximum Antenna Gain (numeric):</u>	23.88
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.27
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	16.01
<u>Maximum average output power at antenna input terminal (mW):</u>	39.90
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5270
<u>Maximum Antenna Gain, typical (dBi):</u>	13.78
<u>Maximum Antenna Gain (numeric):</u>	23.88
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.08
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	22.16
<u>Maximum average output power at antenna input terminal (mW):</u>	164.44
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5775
<u>Maximum Antenna Gain, typical (dBi):</u>	13.78
<u>Maximum Antenna Gain (numeric):</u>	23.88
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.35
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	9.1
<u>Maximum average output power at antenna input terminal (mW):</u>	8.13
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5180
<u>Maximum Antenna Gain, typical (dBi):</u>	6
<u>Maximum Antenna Gain (numeric):</u>	3.98
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.003
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	8.7
<u>Maximum average output power at antenna input terminal (mW):</u>	7.41
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5260
<u>Maximum Antenna Gain, typical (dBi):</u>	6
<u>Maximum Antenna Gain (numeric):</u>	3.98
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.003
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	9.8
<u>Maximum average output power at antenna input terminal (mW):</u>	9.55
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5560
<u>Maximum Antenna Gain, typical (dBi):</u>	6
<u>Maximum Antenna Gain (numeric):</u>	3.98
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.003
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

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

<u>Maximum average output power at antenna input terminal (dBm):</u>	7.2
<u>Maximum average output power at antenna input terminal (mW):</u>	5.25
<u>Prediction distance (cm):</u>	30
<u>Prediction frequency (MHz):</u>	5745
<u>Maximum Antenna Gain, typical (dBi):</u>	6
<u>Maximum Antenna Gain (numeric):</u>	3.98
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	0.002
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	1

**Radio Co-location**

Case	Standalone MPE (mW/cm <sup>2</sup> )							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.