

## 4 FCC §2.1091, §15.247(i) & ISED RSS-102 & LP0002– RF Exposure

### 4.1 Applicable Standards

According to FCC §15.247(i), §1.1307(b)(1) and LP0002 5.20.2.2, 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

According to ISED RSS-102 Issue 5:

**Table 4: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)**

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m <sup>2</sup> )	Reference Period (minutes)
0.003-10 <sup>21</sup>	83	90	-	Instantaneous <sup>a</sup>
0.1-10	-	0.73/f	-	6 <sup>bb</sup>
1.1-10	87/f <sup>0.5</sup>	-	-	6 <sup>bb</sup>
10-20	27.46	0.0728	-2	6
20-48	58.07/f <sup>0.25</sup>	0.1540/f <sup>0.25</sup>	8.944/f <sup>0.5</sup>	6
48-300	22.06	0.05852	1.291	6
300-6000	3.142 f <sup>0.3417</sup>	0.008335 f <sup>0.3417</sup>	0.02619 f <sup>0.6834</sup>	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/f <sup>1.2</sup>
150000-300000	0.158 f <sup>0.5</sup>	4.21 x 10 <sup>-4</sup> f <sup>0.5</sup>	6.67 x 10 <sup>-5</sup> f	616000/f <sup>1.2</sup>

Note: f is frequency in MHz.

<sup>a</sup> Based on nerve stimulation (NS).

<sup>bb</sup> Based on specific absorption rate (SAR).

## 4.2 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

## 4.3 MPE Results for FCC

### 2.4 GHz Wi-Fi

<u>Maximum output power at antenna input terminal (dBm):</u>	<u>23.8</u>
<u>Maximum output power at antenna input terminal (mW):</u>	<u>239.88</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>0.336</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	<u>1.0</u>

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 30 cm is 0.336 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

### 2.4 GHz BLE

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>4.47</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>2.80</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>2426</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6.0</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>0.00099</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	<u>1.0</u>

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 30 cm is 0.00099 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

**5 GHz Wi-Fi**

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>23.29</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>213.30</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5785</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>0.29907</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	<u>1.0</u>

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 30 cm is 0.29907 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

**Worst case colocation 2.4 GHz Wi-Fi, BLE and 5 GHz Wi-Fi.**

Frequency Band	Max Conducted Power(dBm)	Evaluated Distance (cm)	Worst-Case MPE (mW/cm <sup>2</sup> )	MPE Limit (mW/cm <sup>2</sup> )	Worst-Case MPE Ratios	Sum of MPE Ratios	Limit
<b>Worst Case</b>							
2.4 GHz WiFi	23.8	30	0.336	1.0	33.6 %		
2.4 GHz BLE	4.47	30	0.00099	1.0	0.099 %	63.606 %	100%
5 GHz WiFi	23.29	30	0.29907	1.0	29.907 %		

#### 4.4 RF exposure evaluation for ISEDC

##### 2.4 GHz Wi-Fi

<u>Maximum output power at antenna input terminal (dBm):</u>	<u>23.8</u>
<u>Maximum output power at antenna input terminal (W):</u>	<u>0.2399</u>
<u>Prediction distance (m):</u>	<u>0.3</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 (W/m<sup>2</sup>):</u>	<u>3.362</u>
<u>ISEDC MPE limit for uncontrolled exposure at prediction frequency (W/m<sup>2</sup>):</u>	<u>5.404</u>

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 0.3 m is 3.362 W/m<sup>2</sup>. Limit is 5.404 W/m<sup>2</sup>.

##### 2.4 GHz BLE

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>4.47</u>
<u>Maximum peak output power at antenna input terminal (W):</u>	<u>0.0028</u>
<u>Prediction distance (m):</u>	<u>0.3</u>
<u>Prediction frequency (MHz):</u>	<u>2426</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>6.0</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>3.98</u>
<u>Power density of prediction frequency at 30.0 cm (W/cm<sup>2</sup>):</u>	<u>0.0099</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (W/cm<sup>2</sup>):</u>	<u>5.387</u>

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 0.3 m is 0.0099 W/m<sup>2</sup>. Limit is 5.387 W/m<sup>2</sup>.

##### 5 GHz Wi-Fi

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>23.3</u>
<u>Maximum peak output power at antenna input terminal (W):</u>	<u>0.21380</u>
<u>Prediction distance (m):</u>	<u>0.3</u>
<u>Prediction frequency (MHz):</u>	<u>5785</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 (W/m<sup>2</sup>):</u>	<u>2.99756</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (W/m<sup>2</sup>):</u>	<u>9.756</u>

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 0.3 m is 2.99756 W/m<sup>2</sup>. Limit is 9.756 W/m<sup>2</sup>.