

4 FCC §2.1091, §15.247(i) & ISEDC 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 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

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 ²)	Reference Period (minutes)
0.003-10 ²¹	83	90	-	Instantaneous [*]
0.1-10	-	0.73/ f	-	6 ^{**}
1.1-10	87/ f ^{0.5}	-	-	6 ^{**}
10-20	27.46	0.0728	-2	6
20-48	58.07/ f ^{0.25}	0.1540/ f ^{0.25}	8.944/ f ^{0.5}	6
48-300	22.06	0.05852	1.291	6
300-6000	3.142 f ^{0.3417}	0.008335 f ^{0.3417}	0.02619 f ^{0.6834}	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/ f ^{1.2}
150000-300000	0.158 f ^{0.5}	4.21 x 10 ⁻⁴ f ^{0.5}	6.67 x 10 ⁻⁵ f	616000/f ^{1.2}
Note: f is frequency in MHz. [*] Based on nerve stimulation (NS). ^{**} 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/cm²):</u>	<u>0.336</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</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/cm². Limit is 1.0 mW/cm².

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/cm²):</u>	<u>0.00099</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</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/cm². Limit is 1.0 mW/cm².

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/cm²):</u>	<u>0.29907</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</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/cm². Limit is 1.0 mW/cm².

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 ²)	MPE Limit (mW/cm ²)	Worst-Case MPE Ratios	Sum of MPE Ratios	Limit
Worst Case							
2.4 GHz WiFi	23.8	30	0.336	1.0	33.6 %	63.606 %	100%
2.4 GHz BLE	4.47	30	0.00099	1.0	0.099 %		
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/m²):</u>	<u>3.362</u>
<u>ISEDC MPE limit for uncontrolled exposure at prediction frequency (W/m²):</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/m². Limit is 5.404 W/m².

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/cm²):</u>	<u>0.0099</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (W/cm²):</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/m². Limit is 5.387 W/m².

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/m²):</u>	<u>2.99756</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (W/m²):</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/m². Limit is 9.756 W/m².