

## 4 FCC §2.1091, §15.407(f) & ISED RSS-102 & LP0002– RF Exposure

### 4.1 Applicable Standards

According to FCC §15.407(f), §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:

### 2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz<sup>6</sup> and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than  $4.49/f^{0.5}$  W (adjusted for tune-up tolerance), where  $f$  is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than  $1.31 \times 10^{-2} f^{0.6834}$  W (adjusted for tune-up tolerance), where  $f$  is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

## 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 Aux

<u>Maximum output power at antenna input terminal (dBm):</u>	<u>19.56</u>
<u>Maximum output power at antenna input terminal (mW):</u>	<u>90.36</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>2462</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>3</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>2</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	<u>0.0160</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 0.016 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

### 2.4 GHz Wi-Fi Regular

<u>Maximum output power at antenna input terminal (dBm):</u>	<u>22.9</u>
<u>Maximum output power at antenna input terminal (mW):</u>	<u>194.98</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/cm<sup>2</sup>):</u>	<u>0.1725</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 0.1725 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>3.67</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>2.33</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>3</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>0.0004</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 0.0004 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

**5 GHz Wi-Fi Aux**

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>21.4</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>138.04</u>
<u>Prediction distance (cm):</u>	<u>30</u>
<u>Prediction frequency (MHz):</u>	<u>5825</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>5</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>3.16</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	<u>0.0386</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 0.0386 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

**5 GHz Wi-Fi XOR**

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>23.6</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>229.09</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>11</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>12.59</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	<u>0.2551</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 0.2551 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

**5 GHz Wi-Fi Regular**

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>23.7</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>234.42</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>11</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>12.59</u>
<u>Power density of prediction frequency at 30.0 cm (mW/cm<sup>2</sup>):</u>	<u>0.2611</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 0.2611 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

**Worst case colocation 5 GHz Wi-Fi Regular, 5 GHz Wi-Fi Aux, 5 GHz Wi-Fi XOR and BLE.**

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>							
5 GHz Wi-Fi Regular	23.7	30	0.2611	1.0	26.11 %	55.52 %	100%
5 GHz Wi-Fi Aux	21.4	30	0.0386	1.0	3.86 %		
5 GHz Wi-Fi XOR	23.6	30	0.2551	1.0	25.51%		
2.4 GHz BLE	3.67	30	0.0004	1.0	0.04%		

Note: EUT can operate in the following colocation case, the worst colocation case has been selected to analyse.

- Case1: 5 GHz Wi-Fi Regular, 5 GHz Wi-Fi Aux, 5 GHz Wi-Fi XOR and BLE.  
Case2: 5 GHz Wi-Fi Regular, 2.4 GHz Wi-Fi Aux, 5 GHz Wi-Fi XOR and BLE.  
Case3: 5 GHz Wi-Fi Regular, 2.4 GHz Wi-Fi Aux, 2.4 GHz Wi-Fi and BLE.  
Case4: 5 GHz Wi-Fi Regular, 5 GHz Wi-Fi Aux, 2.4 GHz Wi-Fi and BLE.

#### **4.4 RF exposure evaluation exemption for ISED**

##### **5 GHz Wi-Fi Aux**

$$21.4 + 5 \text{ dBi} = 21.9 \text{ dBm} < 1.31 \times 10^{-2} f^{0.6834} = 4.903 \text{ W} = 36.904 \text{ dBm}$$

##### **5 GHz Wi-Fi XOR**

$$23.6 + 11 \text{ dBi} = 34.6 \text{ dBm} < 1.31 \times 10^{-2} f^{0.6834} = 4.880 \text{ W} = 36.884 \text{ dBm}$$

##### **5 GHz Wi-Fi Regular**

$$23 + 11 \text{ dBi} = 34 \text{ dBm} < 1.31 \times 10^{-2} f^{0.6834} = 4.880 \text{ W} = 36.884 \text{ dBm}$$

Therefore the RF exposure is not required.