

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

4.1 Applicable Standards

According to FCC §15.407(f), §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

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 MHz⁶ 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/cm²):</u>	<u>0.0160</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 0.016 mW/cm². Limit is 1.0 mW/cm².

2.4 GHz Wi-Fi

<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/cm²):</u>	<u>0.1725</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 0.1725 mW/cm². Limit is 1.0 mW/cm².

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/cm²):</u>	<u>0.0004</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 0.0004 mW/cm². Limit is 1.0 mW/cm².

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/cm²):</u>	<u>0.0386</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 0.0386 mW/cm². Limit is 1.0 mW/cm².

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/cm²):</u>	<u>0.2551</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 0.2551 mW/cm². Limit is 1.0 mW/cm².

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/cm²):</u>	<u>0.2611</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 0.2611 mW/cm². Limit is 1.0 mW/cm².

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 ²)	MPE Limit (mW/cm ²)	Worst-Case MPE Ratios	Sum of MPE Ratios	Limit
Worst Case							
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 cases, the worst colocation case has been selected to analyze.

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

2.4 GHz Wi-Fi

$$22.9 \text{ dBm} + 10 \text{ dBi} = 32.9 \text{ dBm} < 1.31 \times 10^{-2} f^{0.6834} = 2.703 \text{ W} = 34.318 \text{ dBm}$$

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.