

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

According to FCC §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

Before equipment certification is granted, the procedure of IC RSS-102 must be followed concerning the exposure of humans to RF field

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.

## 4.1 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

## 4.2 MPE Results

### 2.4 GHz BLE

<u>Maximum peak output power at antenna input terminal (dBm):</u>	<u>-3.04</u>
<u>Maximum peak output power at antenna input terminal (mW):</u>	<u>0.497</u>
<u>Prediction distance (cm):</u>	<u>20</u>
<u>Prediction frequency (MHz):</u>	<u>2480</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>2.0</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1.585</u>
<u>Power density of prediction frequency at 20.0 cm (mW/cm<sup>2</sup>):</u>	<u>0.000157</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 20 cm is 0.000157 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

### 3G/4G

Pixieboard Version	Mode	Mobile Module	FCC ID	IC ID
<i>PixieBoard Core</i>	<i>SO-0G-3GG</i>	UMTS/HSPA+3G Module	XMR201510UC20	1022A-201510UC20
<i>PixieBoard DUO</i>	<i>DO-1G-3GG</i> ,	UMTS/HSPA+3G Module	XMR201510UC20	1022A-201510UC20
<i>PixieBoard PRO</i>	<i>PO-2G-LTA</i>	LTE Module	XMR201605EC25A	10224A-201611EC25A
<i>PixieBoard PRO+</i>	<i>PP-4G-LTA</i>	LTE Module	XMR201605EC25A	10224A-201611EC25A

Mode	Frequency (MHz)	Target Power (dBm)	Target Power (mW)	Maximum Antenna Gain (dBi)	Numeric Antenna Gain	Evaluation Distance (cm)	Power density @20cm (mW/cm^2)	FCC MPE Limit (mW/cm^2)
WCDMA (Band V)	826.4-846.6	23.5	223.87	5.1	3.236	20	0.144122	0.551
WCDMA (Band II)	1852.4-1907.6	23.5	223.87	5.1	3.236	20	0.144122	1.0
WCDMA (Band IV)	1712.4-1752.6	23.5	223.87	5.1	3.236	20	0.144122	1.0
LTE (Band II)	1850.7-1909.3	24	251.19	5.1	3.236	20	0.161708	1.0
LTE (Band IV)	1710.7-1754.3	24	251.19	5.1	3.236	20	0.161708	1.0
LTE (Band XII)	699.7-715.3	24	251.19	5.1	3.236	20	0.161708	0.466

Note: Worst Case module was evaluated for 3G/4G.

## 2.4 GHz Classic Bluetooth

Maximum peak output power at antenna input terminal (dBm): 1.47  
Maximum peak output power at antenna input terminal (mW): 1.403  
Prediction distance (cm): 20  
Prediction frequency (MHz): 2480  
Maximum Antenna Gain, typical (dBi): 2.0  
Maximum Antenna Gain (numeric): 1.585  
Power density of prediction frequency at 20.0 cm (mW/cm<sup>2</sup>): 0.000442  
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>): 1.0

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.000442 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

## 5 GHz Wi-Fi

Maximum output power at antenna input terminal (dBm): 14.40  
Maximum output power at antenna input terminal (mW): 27.542  
Prediction distance (cm): 20  
Prediction frequency (MHz): 5745  
Maximum Antenna Gain, typical (dBi): 2.5  
Maximum Antenna Gain (numeric): 1.778  
Power density of prediction frequency at 20.0 cm (mW/cm<sup>2</sup>): 0.009744  
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>): 1.0

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.00974 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

**Worst case colocation 3G/4G, 2.4 GHz Classic Bluetooth, 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 Classic Bluetooth	1.47	20	0.000442	1.0	0.044 %	35.72 %	100 %
5 GHz WiFi	14.40	20	0.009744	1.0	0.974 %		
LTE (Band XII)	24	20	0.161708	0.466	34.701 %		

Note: Worst Case module was evaluated for 3G/4G.

### 4.3 RF exposure evaluation exemption for IC

#### 5 GHz Wi-Fi

$$14.40 + 2.5 \text{ dBi} = 16.90 \text{ dBm} < 1.31 \times 10^{-2} j^{0.6834} = 4.857 \text{ W} = 36.864 \text{ dBm}$$

Therefore the RF exposure is not required.