5 FCC §2.1091, §15.247(i) & ISEDC RSS-102 - RF Exposure

5.1 Applicable Standards

According to FCC §15.247(i) 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^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 MHz[6] 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.

5.2 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

5.3 MPE Results

2.4 GHz Wi-Fi

Maximum output power at antenna input terminal (dBm):	11.68
Maximum output power at antenna input terminal (mW):	14.723
Prediction distance (cm):	20
Prediction frequency (MHz):	2412
Maximum Antenna Gain, typical (dBi):	2.0
Maximum Antenna Gain (numeric):	1.585
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.004642
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	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 0.004642 mW/cm^2. Limit is 1.0 mW/cm^2.

2.4 GHz BLE

Maximum peak output power at antenna input terminal (dBm):	-3.04
Maximum peak output power at antenna input terminal (mW):	0.497
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^2):	0.000157
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	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 0.000157 mW/cm^2. Limit is 1.0 mW/cm^2.

3G/4G

Pixieboard Version	Mode	Mobile Module	FCC ID	IC ID
PixieBoard Core	*SO-0G-3GG*	UMTS/HSPA+3G Module	XMR201510UC20	1022A-201510UC20
PixieBoard DUO	*DO-1G-3GG,*	UMTS/HSPA+3G Module	XMR201510UC20	1022A-201510UC20
PixieBoard PRO	*PO-2G-LTA*	LTE Module	XMR201605EC25A	10224A-201611EC25A
PixieBoard PRO+	*PP-4G-LTA*	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^2):	0.000442
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	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^2. Limit is 1.0 mW/cm^2.

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^2):	0.009744
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	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^2. Limit is 1.0 mW/cm^2.

Worst case colocation 2.4 GHz Wi-Fi, 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^2)	MPE Limit (mW/cm^2)	Worst-Case MPE Ratios	Sum of MPE Ratios	Limit
Worst Case							
2.4 GHz WiFi	11.68	20	0.004642	1.0	0.464 %	35.21 %	100%
2.4 GHz Classic Bluetooth	1.47	20	0.000442	1.0	0.044 %		
LTE (Band XII)	24	20	0.161708	0.466	34.701 %		

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 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.

5.4 RF exposure evaluation exemption for IC

2.4 GHz Classic Bluetooth

$1.47 + 2.0 \text{ dBi} = 3.47 \text{ dBm} < 1.31\times10^{-2}f^{0.6834} = 2.736 \text{ W} = 34.370 \text{ dBm}$

Therefore the RF exposure is not required.