

5 FCC §2.1091, §15.247(i) & ISED 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.

According to KDB 447 498 Section (7.2), “simultaneous transmission of MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on calculated or measured field strengths or power density, is ≤ 1.0 . The MPE ratio of each antenna is determined at the minimum *test separation distance* required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to MPE limit, at the test frequency.

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 |

Where: 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 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.

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 Wi-Fi Radio 2

Worst Case: 802.11n20, Mid Channel 2437 MHz

| | |
|---|-----------------|
| <u>Maximum peak output power at antenna input terminal (dBm):</u> | <u>26.23</u> |
| <u>Maximum peak output power at antenna input terminal (mW):</u> | <u>419.7590</u> |
| <u>Prediction distance (cm):</u> | <u>20</u> |
| <u>Prediction frequency (MHz):</u> | <u>2437</u> |
| <u>Maximum Antenna Gain, typical (dBi):</u> | <u>7</u> |
| <u>Maximum Antenna Gain (numeric):</u> | <u>5.0119</u> |
| <u>Power density of prediction frequency at 20.0 cm (mW/cm²):</u> | <u>0.4185</u> |
| <u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u> | <u>1.0</u> |
| <u>MPE Ratio (numeric):</u> | <u>0.4185</u> |

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.4185 mW/cm². Limit is 1.0 mW/cm².

2.4 Wi-Fi Radio 1

Worst Case: 802.11b, Mid Channel 2437 MHz

| | |
|---|---------------|
| <u>Maximum peak output power at antenna input terminal (dBm):</u> | <u>23.14</u> |
| <u>Maximum peak output power at antenna input terminal (mW):</u> | <u>206.06</u> |
| <u>Prediction distance (cm):</u> | <u>20</u> |
| <u>Prediction frequency (MHz):</u> | <u>2437</u> |
| <u>Maximum Antenna Gain, typical (dBi):</u> | <u>4</u> |
| <u>Maximum Antenna Gain (numeric):</u> | <u>2.51</u> |
| <u>Power density of prediction frequency at 20.0 cm (mW/cm²):</u> | <u>0.10</u> |
| <u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u> | <u>1.0</u> |
| <u>MPE Ratio (numeric):</u> | <u>0.10</u> |

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.10 mW/cm². Limit is 1.0 mW/cm².

Radio Co-location

The device supports the following radio co-location configurations.

| | Wi-Fi Radio 2 2.4G | Wi-Fi Radio 2 UNII-1 | Wi-Fi Radio 2 UNII-3 |
|-----------------------------|---------------------------|-----------------------------|-----------------------------|
| BT | X | X | X |
| Wi-Fi Radio 1 2.4G | | X | X |
| Wi-Fi Radio 1 UNII-1 | X | | X |
| Wi-Fi Radio 1 UNII-3 | X | X | |

Worst Case Colocation 2.4 GHz Classic Bluetooth and 2.4 GHz Wi-Fi Radio 2 (MIMO):

| 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 | 11.81 | 20 | 0.0051 | 1.0 | 0.51% | 42.36% | 100% |
| 2.4 Wi-Fi2 Radio 2 | 26.23 | 20 | 0.4185 | 1.0 | 41.85% | | |

Worst Case Colocation 2.4 GHz Wi-Fi Radio 1 (SISO) and 5.8 GHz Wi-Fi Radio 2 (MIMO):

| 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 Wi-Fi Radio 1 | 23.14 | 20 | 0.10 | 1.0 | 10% | 32.44% | 100% |
| 5.8 GHz Wi-Fi Radio 2 | 23.02 | 20 | 0.2244 | 1.0 | 22.44% | | |

Worst Case Colocation 5.8 GHz Wi-Fi Radio 1 (SISO) and 2.4 GHz Wi-Fi Radio 2 (MIMO):

| 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 | | | | | | | |
| 5.8 GHz Wi-Fi Radio 1 | 21.77 | 20 | 0.0843 | 1.0 | 8.43% | 50.28% | 100% |
| 2.4 GHz Wi-Fi Radio 2 | 26.23 | 20 | 0.4185 | 1.0 | 41.85% | | |

5.4 RF exposure evaluation exemption for IC

2.4 Wi-Fi Radio 2

Worst Case: 802.11n20, Mid Channel 2437 MHz

Maximum EIRP power = $26.23 \text{ dBm} + 7 \text{ dBi} = 33.23 \text{ dBm}$ which is less than $1.31 \times 10^{-2} f^{0.6834} = 2.70 \text{ W} = 34.31 \text{ dBm}$

2.4 Wi-Fi Radio 1

Worst Case: 802.11b, Mid Channel 2437 MHz

Maximum EIRP power = $23.14 \text{ dBm} + 4 \text{ dBi} = 27.14 \text{ dBm}$ which is less than $1.31 \times 10^{-2} f^{0.6834} = 2.70 \text{ W} = 34.31 \text{ dBm}$