

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

4.1 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 ISSED 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

Note: According to MIMO FCC KDB 662911 D02 MIMO with Cross Polarized Antenna v01, Where an FCC rule specifies limits in radiated terms such as EIRP or ERP, the limits apply to the maximum emission that would be observed by a linearly polarized measurement antenna. Therefore, the highest output power from single antenna power was selected to calculate in this section.

4.3 MPE Results

Radio Standalone RF Exposure Configuration

2.4 GHz Wi-Fi: 802.11n40, Mid Channel 2437 MHz

<u>Maximum output power at antenna input terminal (dBm):</u>	<u>21.18</u>
<u>Maximum output power at antenna input terminal (mW):</u>	<u>131.22</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>0</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1</u>
<u>Power density of prediction frequency at 20.0 cm (mW/cm²):</u>	<u>0.026</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

5 GHz Wi-Fi: 802.11ac80, Mid Channel 5610 MHz

<u>Maximum output power at antenna input terminal (dBm):</u>	<u>20.90</u>
<u>Maximum output power at antenna input terminal (mW):</u>	<u>123.03</u>
<u>Prediction distance (cm):</u>	<u>20</u>
<u>Prediction frequency (MHz):</u>	<u>5610</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>1</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1.26</u>
<u>Power density of prediction frequency at 20.0 cm (mW/cm²):</u>	<u>0.031</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

BLE: High Channel 2480 MHz

<u>Maximum output power at antenna input terminal (dBm):</u>	<u>18.626</u>
<u>Maximum output power at antenna input terminal (mW):</u>	<u>72.88</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>0</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1</u>
<u>Power density of prediction frequency at 20.0 cm (mW/cm²):</u>	<u>0.0145</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm²):</u>	<u>1.0</u>

ZigBee: High Channel 2475 MHz

<u>Maximum output power at antenna input terminal (dBm):</u>	<u>19.74</u>
<u>Maximum output power at antenna input terminal (mW):</u>	<u>94.19</u>
<u>Prediction distance (cm):</u>	<u>20</u>
<u>Prediction frequency (MHz):</u>	<u>2475</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>0</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1</u>
<u>Power density of prediction frequency at 20.0 cm (mW/cm²):</u>	<u>0.0187</u>
<u>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 at 20 cm distance.

Radio Co-location RF Exposure Configuration

Radio	Standalone MPE (mW/cm ²)	Standalone MPE Limit (mW/cm ²)	Ratio (%)	Total Ratio for Radio Co-location Configuration (%)	Radio Co-location Limit (%)
2.4 GHz Wi-Fi	0.026	1	2.6	9.02	100
5 GHz Wi-Fi	0.031	1	3.1		
BLE	0.0145	1	1.45		
ZigBee	0.0187	1	1.87		

4.4 RF exposure evaluation exemption for IC

2.4 GHz Wi-Fi: 802.11n40, Mid Channel 2437 MHz

Maximum EIRP power = 21.18 dBm + 0 dBi = 21.18 dBm, which is less than $1.31 \times 10^{-2} f^{0.6834} = 2.70 \text{ W} = 34.31 \text{ dBm}$

5 GHz Wi-Fi: 802.11ac80, Mid Channel 5610 MHz

Maximum EIRP power = 20.90 dBm + 1 dBi = 21.90 dBm, which is less than $1.31 \times 10^{-2} f^{0.6834} = 4.88 \text{ W} = 36.88 \text{ dBm}$

BLE: High Channel 2480 MHz

Maximum EIRP power = 18.626 dBm + 0 dBi = 18.626 dBm, which is less than $1.31 \times 10^{-2} f^{0.6834} = 2.74 \text{ W} = 34.4 \text{ dBm}$

Zigbee: Low Channel 2405 MHz

Maximum EIRP power = 19.74 dBm + 0 dBi = 19.74 dBm, which is less than $1.31 \times 10^{-2} f^{0.6834} = 2.68 \text{ W} = 34.3 \text{ dBm}$

Therefore, the RF exposure Evaluation is not required.

Note:

The 2.4 GHz Wi-Fi output power was referenced from report number: R2007201-01 issued by BACL on 01-27-2021.

The 5 GHz Wi-Fi output power was referenced from report number: R2007201-02 issued by BACL on 02-09-2021.

The BLE output power was referenced from report number R2007201-03 issued by BACL on 01-27-2021.