

## 5. FCC §15.247(i), §1.1310, § 2.1091 - Maximum Permissible Exposure (MPE)

### 5.1. Applicable Standard

According to subpart 15.247(i) and subpart §1.1310, 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 Maximum Permissible Exposure (MPE) (§1.1310, §2.1091)

| (B) 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) |
| 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;

According to §1.1310 and §2.1091 RF exposure is calculated.

#### Calculated Formulary:

Predication of MPE limit at a given distance

$S = PG/4\pi R^2$  = power density (in appropriate units, e.g. mW/cm<sup>2</sup>);

P = power input to the antenna (in appropriate units, e.g., mW);

G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain;

R = distance to the center of radiation of the antenna (appropriate units, e.g., cm);

For simultaneously transmit system, the calculated power density should comply with:

$$\sum_i \frac{S_i}{S_{Limit,i}} \leq 1$$

**5.2. RF Exposure Evaluation Result****Calculated Data (worst case):****Model 1**

| Mode                         | Frequency Range (MHz) | Antenna Gain |           | Target Power |         | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) |
|------------------------------|-----------------------|--------------|-----------|--------------|---------|--------------------------|-------------------------------------|---------------------------------|
|                              |                       | (dBi)        | (numeric) | (dBm)        | (mW)    |                          |                                     |                                 |
| LoRa (125kHz)                | 902.3-927.7           | 0.87         | 1.222     | 24           | 251.189 | 20                       | 0.0611                              | 0.602                           |
| LoRa (250kHz)                | 902.3-927.5           | 0.87         | 1.222     | 24           | 251.189 | 20                       | 0.0611                              | 0.602                           |
| LoRa (500kHz)                | 903-927.5             | 0.87         | 1.222     | 23.5         | 223.87  | 20                       | 0.0544                              | 0.602                           |
| WIFI (Internal Antenna)      | 2412-2462             | -0.5         | 0.891     | 18           | 63.096  | 20                       | 0.0112                              | 1                               |
| BLE (Internal Antenna)       | 2402-2480             | -0.5         | 0.891     | 3.5          | 2.239   | 20                       | 0.0004                              | 1                               |
| BT2.1+EDR (Internal Antenna) | 2402-2480             | -0.5         | 0.891     | 5.5          | 3.548   | 20                       | 0.0006                              | 1                               |
| WIFI (External Antenna)      | 2412-2462             | 2            | 1.585     | 18           | 63.096  | 20                       | 0.0199                              | 1                               |
| BLE (External Antenna)       | 2402-2480             | 2            | 1.585     | 3.5          | 2.239   | 20                       | 0.0007                              | 1                               |
| BT2.1+EDR (External Antenna) | 2402-2480             | 2            | 1.585     | 5.5          | 3.548   | 20                       | 0.0011                              | 1                               |

Note: WIFI 2.4G/BLE/BT (FCC ID: 2AJMTWIPY3R) and LoRa can transmit simultaneously; the worst condition as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0611/0.602 + 0.0199/1.00 = 0.1213 < 1.0$$

**Model 2**

| Mode          | Frequency Range (MHz) | Antenna Gain |           | Target Power |         | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) |
|---------------|-----------------------|--------------|-----------|--------------|---------|--------------------------|-------------------------------------|---------------------------------|
|               |                       | (dBi)        | (numeric) | (dBm)        | (mW)    |                          |                                     |                                 |
| LoRa (125kHz) | 902.3-927.7           | 0.87         | 1.222     | 24           | 251.189 | 20                       | 0.0611                              | 0.602                           |
| LoRa (250kHz) | 902.3-927.5           | 0.87         | 1.222     | 24           | 251.189 | 20                       | 0.0611                              | 0.602                           |
| LoRa (500kHz) | 903-927.5             | 0.87         | 1.222     | 23.5         | 223.87  | 20                       | 0.0544                              | 0.602                           |
| WIFI          | 2412-2462             | 1.3          | 1.349     | 23           | 199.526 | 20                       | 0.0535                              | 1                               |
| BLE           | 2402-2480             | 1.3          | 1.349     | 3            | 1.995   | 20                       | 0.0005                              | 1                               |
| BT3.0         | 2402-2480             | 1.3          | 1.349     | 6            | 3.981   | 20                       | 0.0011                              | 1                               |
| Sigfox        | 902-928               | 0.87         | 1.222     | 20           | 100.000 | 20                       | 0.0243                              | 0.601                           |

Note: WIFI 2.4G/BLE/BT (FCC ID: 2AJMTLOPY4R) and LoRa can transmit simultaneously; the worst condition as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0611/0.602 + 0.0535/1.00 = 0.1549 < 1.0$$

**Model 3**

| Mode          | Frequency Range (MHz) | Antenna Gain |           | Target Power |         | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) |
|---------------|-----------------------|--------------|-----------|--------------|---------|--------------------------|-------------------------------------|---------------------------------|
|               |                       | (dBi)        | (numeric) | (dBm)        | (mW)    |                          |                                     |                                 |
| LoRa (125kHz) | 902.3-927.7           | 0.87         | 1.222     | 24           | 251.189 | 20                       | 0.0611                              | 0.602                           |
| LoRa (250kHz) | 902.3-927.5           | 0.87         | 1.222     | 24           | 251.189 | 20                       | 0.0611                              | 0.602                           |
| LoRa (500kHz) | 903-927.5             | 0.87         | 1.222     | 23.5         | 223.87  | 20                       | 0.0544                              | 0.602                           |
| WIFI          | 2412-2462             | 1.3          | 1.35      | 23           | 199.526 | 20                       | 0.0535                              | 1                               |
| BLE           | 2402-2480             | 1.3          | 1.35      | 5            | 3.16    | 20                       | 0.0008                              | 1                               |
| BT3.0         | 2402-2480             | 1.3          | 1.35      | 6.5          | 4.47    | 20                       | 0.0012                              | 1                               |
| FDD Band4     | 1710-1755             | 7            | 5.012     | 23           | 199.53  | 20                       | 0.1989                              | 1                               |
| FDD Band12    | 699-716               | 9.4          | 8.710     | 23.5         | 223.87  | 20                       | 0.3879                              | 0.466                           |
| FDD Band13    | 777-787               | 10.4         | 10.965    | 23           | 199.53  | 20                       | 0.4352                              | 0.518                           |

Note: WIFI 2.4G/BLE/BT, LTE (FCC ID: 2AJMTGPY01R) and LoRa can transmit simultaneously; the worst condition as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0611/0.602 + 0.0535/1.00 + 0.4352/0.518 = 0.995 < 1.0$$

**Result:** MPE evaluation of single and simultaneous transmission meet **20cm** the requirement of standard.