

## FCC §1.1307 & §2.1091 –MAXIMUM PERMISSIBLE EXPOSURE (MPE)

### Applicable Standard

According to subpart §2.1091 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:

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

**Calculated Data:**

| Mode         | Frequency Range (MHz) | Antenna Gain |           | Tune-up Conducted Power |        | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) | MPE ratio     |
|--------------|-----------------------|--------------|-----------|-------------------------|--------|--------------------------|-------------------------------------|---------------------------------|---------------|
|              |                       | (dBi)        | (numeric) | (dBm)                   | (mW)   |                          |                                     |                                 |               |
| 802.11b      | 2412~2462             | 1.30         | 1.35      | 23                      | 199.53 | 20                       | 0.0535                              | 1.00                            | <b>0.0535</b> |
| 802.11g      |                       | 1.30         | 1.35      | 21                      | 125.89 | 20                       | 0.0338                              | 1.00                            | 0.0338        |
| 802.11n-HT20 |                       | 1.30         | 1.35      | 21                      | 125.89 | 20                       | 0.0338                              | 1.00                            | 0.0338        |
| 802.11n-HT40 | 2422~2452             | 1.30         | 1.35      | 21                      | 125.89 | 20                       | 0.0338                              | 1.00                            | 0.0338        |
| BLE          | 2402-2480             | 1.30         | 1.35      | 5                       | 3.16   | 20                       | 0.0008                              | 1.00                            | 0.0008        |
| BT 3.0       | 2402~2480             | 1.30         | 1.35      | 6                       | 3.98   | 20                       | 0.0011                              | 1.00                            | 0.0011        |
| LoRa         | 902-928               | 0.87         | 1.22      | 20                      | 100.00 | 20                       | 0.0243                              | 0.60                            | <b>0.0405</b> |
| Sigfox       | 902-928               | 0.87         | 1.22      | 20                      | 100.00 | 20                       | 0.0243                              | 0.60                            | 0.0405        |

Calculation of maximum antenna gain based on ERP/EIRP

| Mode          | Max Tune-up Power (dBm) | ERP/EIRP Limit (dBm) | Max Antenna Gain (dBi) |
|---------------|-------------------------|----------------------|------------------------|
| FDD (Band 4)  | 23.00                   | 30.00                | 7.00                   |
| FDD (Band 12) | 23.50                   | 34.77                | 11.27                  |
| FDD (Band 13) | 23.00                   | 34.77                | 11.77                  |

Calculation of maximum antenna gain based on MPE Ratio

| Mode          | Frequency Range | Tune-up Conducted Power |        | Power Density Limit   | Maximum Power Density | Evaluation Distance | Maximun Antenna Gain Allowed based on MPE |       | MPE ratio     |
|---------------|-----------------|-------------------------|--------|-----------------------|-----------------------|---------------------|-------------------------------------------|-------|---------------|
|               | (MHz)           | (dBm)                   | (mW)   | (mW/cm <sup>2</sup> ) | (mW/cm <sup>2</sup> ) |                     | (numeric)                                 | (dBi) |               |
| FDD (Band 4)  | 1710-1755       | 23.00                   | 199.53 | 1.0000                | 0.9051                | 20                  | 13.58                                     | 22.80 | <b>0.9051</b> |
| FDD (Band 12) | 699-716         | 23.50                   | 223.87 | 0.4717                | 0.4263                | 20                  | 9.81                                      | 9.57  | 0.9037        |
| FDD (Band 13) | 777-787         | 23.00                   | 199.53 | 0.5213                | 0.4717                | 20                  | 10.75                                     | 11.89 | 0.9049        |

**Note:** Wi-Fi/ BLE/ BT 3.0& LoRa/Sigfox & FDD can transmit simultaneously; the worst condition is 802.11b of Wi-Fi & FDD (Band 4), as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0535 + 0.0405 + 0.9051 = \mathbf{0.9991} < \mathbf{1.0}$$

| Mode                                                | Max Allow Antenna Gain<br>(dBi) |
|-----------------------------------------------------|---------------------------------|
| FDD (Band 4)<br>Uplink Frequency: 1710 MHz~1755 MHz | 7.00                            |
| FDD (Band 12)<br>Uplink Frequency: 699 MHz~716MHz   | 9.81                            |
| FDD (Band 13)<br>Uplink Frequency: 777 MHz~787 MHz  | 10.75                           |

**Result: For FDD mode,** to meet RF exposure & ERP/ERIP, the maximum net gains of antennas allowed are 7.00 dBi @ FDD (Band 4), 9.81 @ FDD (Band 12) and 10.75 @ FDD (Band 13). The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.