# 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$^2$) | Averaging Time (minutes) |
| 0.3-1.34 | 614 | 1.63 | *(100) | 30 |
| 1.34-30 | 824/f | 2.19/f | *(180/f²) | 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/4πR² = power density (in appropriate units, e.g. mW/cm$^2$);

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/cm²) | MPE Limit (mW/cm²) | MPE ratio |
|---|---|---|---|---|---|---|---|---|---|
| | | (dBi) | (numeric) | (dBm) | (mW) | | | | |
| 802.11b | | 1.30 | 1.35 | 23.00 | 199.53 | 20 | 0.0535 | 1.00 | **0.0535** |
| 802.11g | 2412~2462 | 1.30 | 1.35 | 21.00 | 125.89 | 20 | 0.0338 | 1.00 | 0.0338 |
| 802.11n-HT20 | | 1.30 | 1.35 | 21.00 | 125.89 | 20 | 0.0338 | 1.00 | 0.0338 |
| 802.11n-HT40 | 2422~2452 | 1.30 | 1.35 | 21.00 | 125.89 | 20 | 0.0338 | 1.00 | 0.0338 |
| BLE | 2402-2480 | 1.30 | 1.35 | 5.00 | 3.16 | 20 | 0.0008 | 1.00 | 0.0008 |
| BT 3.0 | 2402~2480 | 1.30 | 1.35 | 8.00 | 6.31 | 20 | 0.0017 | 1.00 | 0.0017 |

Calculation maximum antenna gain based on ERP/EIRP

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

Calculation maximum antenna gain based on MPE Ratio

| Mode | Frequency (MHz) | Antenna Gain | | Tune-up Conducted Power | | Evaluation Distance (cm) | Power Density (mW/cm²) | MPE Limit (mW/cm²) | MPE ratio |
|---|---|---|---|---|---|---|---|---|---|
| | | (dBi) | (numeric) | (dBm) | (mW) | | | | |
| FDD (Band 4) | 1732.50 | 13.77 | 23.82 | 23.00 | 199.53 | 20 | 0.9455 | 1.0000 | 0.9455 |
| FDD (Band 12) | 707.50 | 10.51 | 11.25 | 23.00 | 199.53 | 20 | 0.4463 | 0.4717 | **0.9462** |
| FDD (Band 13) | 782.00 | 10.94 | 12.42 | 23.00 | 199.53 | 20 | 0.4928 | 0.5213 | 0.9453 |

**Note**: Wi-Fi and FDD can transmit simultaneously; the worst condition is 802.11b of Wi-Fi & FDD (Band 12), as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0535 + 0.9462 = \mathbf{0.9997 < 1.0}$$

| Mode | Max Allow Antenna Gain (dBi) |
|---|---|
| FDD (Band 4) Uplink Frequency: 1710 MHz~1755 MHz | 7.00 |
| FDD (Band 12) Uplink Frequency: 699 MHz~716MHz | 10.51 |
| FDD (Band 13) Uplink Frequency: 777 MHz~787 MHz | 10.94 |

**Result: For FDD mode, t**o meet RF exposure & ERP/ERIP, the maximum net gain of antennas allowed are 7.00 dBi @ FDD (Band 4), 10.51 @ FDD (Band 12) and 10.94 @ 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.