

FCC §1.1307 & §2.1091 - MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247 (i) and subpart 1.1307 (b)(1), 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

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/f ²) | 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

Result

Calculated Formulary:

Predication of MPE limit at a given distance

$$S = PG/4 \pi R^2$$

S = power density (in appropriate units, e.g. mW/cm²);

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:

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

For worst case:

Booster:

Uplink

| Test Band | Frequency (MHz) | Tune up power (dBm) | Tune up Output Power (mW) | Antenna Gain | | Evaluation Distance (cm) | Power Density (mW/cm ²) | MPE Limit (mW/cm ²) |
|----------------------------|-----------------|---------------------|---------------------------|--------------|-----------|--------------------------|-------------------------------------|---------------------------------|
| | | | | (dBi) | (numeric) | | | |
| Lower 700MHz (A+B+C Block) | 698-716 | 23.00 | 199.53 | 9.0 | 7.94 | 20 | 0.32 | 0.47 |
| Upper 700MHz (C Block) | 776-787 | 22.00 | 158.49 | 9.0 | 7.94 | 20 | 0.25 | 0.52 |
| Cellular | 824-849 | 22.50 | 177.83 | 9.0 | 7.94 | 20 | 0.28 | 0.55 |
| PCS | 1850-1915 | 21.50 | 141.25 | 9.0 | 7.94 | 20 | 0.22 | 1.00 |
| AWS | 1710-1755 | 20.50 | 112.20 | 9.0 | 7.94 | 20 | 0.18 | 1.00 |

Downlink

| Test Band | Frequency (MHz) | Tune up power (dBm) | Tune up Output Power (mW) | Antenna Gain | | Evaluation Distance (cm) | Power Density (mW/cm ²) | MPE Limit (mW/cm ²) |
|----------------------------|-----------------|---------------------|---------------------------|--------------|-----------|--------------------------|-------------------------------------|---------------------------------|
| | | | | (dBi) | (numeric) | | | |
| Lower 700MHz (A+B+C Block) | 728-746 | 24.00 | 251.19 | 9.0 | 7.94 | 20 | 0.40 | 0.49 |
| Upper 700MHz (C Block) | 746-757 | 24.0 | 251.19 | 9.0 | 7.94 | 20 | 0.40 | 0.50 |
| Cellular | 869-894 | 25.50 | 354.81 | 9.0 | 7.94 | 20 | 0.56 | 0.58 |
| PCS | 1930-1995 | 25.00 | 316.23 | 9.0 | 7.94 | 20 | 0.50 | 1.00 |
| AWS | 2110-2155 | 24.00 | 251.19 | 9.0 | 7.94 | 20 | 0.40 | 1.00 |

The Maximum indoor and outdoor Gain is 9 dBi.

For downlink, the maximum MPE ratio is: 0.56/0.58=0.97

Bluetooth/Wi-Fi:

This EUT contains FCC ID: 2AC7Z-ESP32WROOM32U, according to the original report, WIFI and Bluetooth function cannot transmitting simultaneously and the worst power density is

| Mode | Frequency (MHz) | Antenna Gain | | Maximum Tune up Output Power | | Evaluation Distance (cm) | Power Density (mW/cm ²) | MPE Limit (mW/cm ²) |
|-----------|-----------------|--------------|-----------|------------------------------|-------|--------------------------|-------------------------------------|---------------------------------|
| | | (dBi) | (numeric) | (dBm) | (mW) | | | |
| WIFI | 2412-2462 | 2.33 | 1.710 | 16.0 | 39.81 | 20 | 0.0135 | 1.0 |
| BLE | 2402-2480 | 2.33 | 1.710 | 1.5 | 1.41 | 20 | 0.0005 | 1.0 |
| Bluetooth | 2402-2480 | 2.33 | 1.710 | 3.0 | 2.00 | 20 | 0.0007 | 1.0 |

The maximum MPE ratio is: 0.0135/1.0=**0.0135**

For the simultaneously transmitting:

The total MPE ratio = MPE/LimitBooster + MPE/LimitWIFI = 0.97+0.0135=0.9835<1.0

So it can meet the requirement of the simultaneously transmitting.

Note: To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Compliant