

## FCC §1.1307 (b) (1) & §2.1091 –MAXIMUM PERMISSIBLE EXPOSURE (MPE)

### Applicable Standard

According to 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

| 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

### MPE Calculated :

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = 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)

**MPE Results**

Tune-Up Power Including Tolerance:

| Mode     | Frequency band (MHz) | Antenna Gain |           | Maximum Tune-up Power | Cable Loss (dB) | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) |
|----------|----------------------|--------------|-----------|-----------------------|-----------------|--------------------------|-------------------------------------|---------------------------------|
|          |                      | (dBi)        | (numeric) | (dBm)                 |                 |                          |                                     |                                 |
| Uplink   | 698-716              | 8            | 6.31      | 20                    | 4.97            | 20                       | 0.040                               | 0.465                           |
|          | 776-787              | 8            | 6.31      | 20                    | 4.97            | 20                       | 0.040                               | 0.517                           |
|          | 824-849              | 8            | 6.31      | 21                    | 5.17            | 20                       | 0.048                               | 0.549                           |
|          | 1710-1755            | 9            | 7.94      | 20                    | 7.51            | 20                       | 0.028                               | 1.0                             |
|          | 1850-1915            | 9            | 7.94      | 21                    | 7.51            | 20                       | 0.035                               | 1.0                             |
| Downlink | 728-746              | 5            | 3.16      | 17                    | 4.97            | 20                       | 0.010                               | 0.485                           |
|          | 746-757              | 5            | 3.16      | 17                    | 4.97            | 20                       | 0.010                               | 0.497                           |
|          | 869-894              | 5            | 3.16      | 17                    | 5.17            | 20                       | 0.010                               | 0.579                           |
|          | 2110-2155            | 7            | 5.01      | 17                    | 7.51            | 20                       | 0.009                               | 1.0                             |
|          | 1930-1995            | 7            | 5.01      | 17                    | 7.51            | 20                       | 0.009                               | 1.0                             |
| Wi-Fi*   | 2412-2462            | 3.74         | 2.37      | 24                    | 0               | 20                       | 0.1182                              | 1.0                             |
| BLE*     | 2402-2480            | 3.74         | 2.37      | 2                     | 0               | 20                       | 0.0007                              | 1.0                             |
| BT*      | 2402-2480            | 3.74         | 2.37      | 5.5                   | 0               | 20                       | 0.0017                              | 1.0                             |

Note:

\*The EUT contains a certified module (FCC ID: 2AC7Z-ESP32WROVERB)

According to the MPE reports of FCC ID: 2AC7Z-ESP32WROVERB, Wi-Fi and Bluetooth can't transmit simultaneously, so consider the Booster and Wi-Fi transmitting simultaneously is the worst case:  
 The ratio=  $MPE/Limit_{Booster} + MPE/Limit_{Wi-Fi} = 0.048/0.549 + 0.1182/1 = 0.2058 < 1.0$

The maximum power density was calculated base on the maximum value of antenna gain and cable loss combination.

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

**Result: Pass**