# Appendix B. Maximum Permissible Exposure

# 1. Maximum Permissible Exposure

## 1. 1. Applicable Standard

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 levels in excess limit for maximum permissible exposure. In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1091 this device has been defined as a mobile device whereby a distance of 0.2 m normally can be maintained between the user and the device.

(A) Limits for Occupational / Controlled Exposure

| Frequency Range (MHz) | Electric Field Strength (E) (V/m) | Magnetic Field Strength (H) (A/m) | Power Density (S) (mW/ cm²) | Averaging Time \|E\|², \|H\|² or S (minutes) |
|---|---|---|---|---|
| 0.3-3.0 | 614 | 1.63 | (100)* | 6 |
| 3.0-30 | 1842 / f | 4.89 / f | (900 / f)* | 6 |
| 30-300 | 61.4 | 0.163 | 1.0 | 6 |
| 300-1500 | | | F/300 | 6 |
| 1500-100,000 | | | 5 | 6 |

(B) Limits for General Population / Uncontrolled Exposure

| Frequency Range (MHz) | Electric Field Strength (E) (V/m) | Magnetic Field Strength (H) (A/m) | Power Density (S) (mW/ cm²) | Averaging Time \|E\|², \|H\|² or S (minutes) |
|---|---|---|---|---|
| 0.3-1.34 | 614 | 1.63 | (100)* | 30 |
| 1.34-30 | 824/f | 2.19/f | (180/f)* | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1500 | | | F/1500 | 30 |
| 1500-100,000 | | | 1.0 | 30 |

Note: f = frequency in MHz ; *Plane-wave equivalent power density

## 1.2. MPE Calculation Method

E (V/m) = $\frac{\sqrt{30 \times P \times G}}{d}$ Power Density: *Pd* (W/m²) = $\frac{E^2}{377}$

**E** = Electric field (V/m)

**P** = Average RF output power (W)

**G** = EUT Antenna numeric gain (numeric)

**d** = Separation distance between radiator and human body (m)

The formula can be changed to

***Pd*** = $\frac{30 \times P \times G}{377 \times d^2}$

From the EUT RF output power, the minimum mobile separation distance, d=0.2m, as well as the gain of the used antenna, the RF power density can be obtained.

## 1.3. Calculated Result and Limit

**Exposure Environment: General Population / Uncontrolled Exposure**

**For 5GHz UNII Band:**

**Antenna Type : PIFA Antenna**

**Conducted Power for IEEE 802.11ac VHT20 : 20.77dBm**

| Distance (m) | Directional Gain (dBi) | Antenna Gain (numeric) | The maximum combined Average Output Power | | Power Density (S) (mW/cm²) | Limit of Power Density (S) (mW/cm²) | Test Result |
|---|---|---|---|---|---|---|---|
| | | | (dBm) | (mW) | | | |
| 0.2 | 8.01 | 6.3246 | 20.7715 | 119.4387 | 0.150358 | 1 | Complies |

Note: $DirectionalGain = 10 \cdot \log\left[\frac{\sum_{j=1}^{N_{ANT}}\left\{\sum_{k=1}^{N_{ANT}} g_{j,k}\right\}^2}{N_{ANT}}\right]$

**For 5GHz ISM Band:**

**Antenna Type : PIFA Antenna**

**Conducted Power for IEEE 802.11ac VHT40: 20.97dBm**

| Distance (m) | Directional Gain | Antenna Gain (numeric) | The maximum combined Average Output Power | | Power Density (S) (mW/cm²) | Limit of Power Density (S) (mW/cm²) | Test Result |
|---|---|---|---|---|---|---|---|
| | | | (dBm) | (mW) | | | |
| 0.2 | 8.01 | 6.3246 | 20.9653 | 124.8908 | 0.157221 | 1 | Complies |

Note: $DirectionalGain = 10 \cdot \log\left[\frac{\sum_{j=1}^{N_{ANT}}\left\{\sum_{k=1}^{N_{ANT}} g_{j,k}\right\}^2}{N_{ANT}}\right]$

**For 2.4GHz Band:**

**For WLAN**

**Antenna Type : PIFA Antenna**

**Conducted Power for IEEE 802.11n 20: 20.95 dBm**

| Distance (m) | Directional Gain (dBi) | Antenna Gain (numeric) | The maximum combined Average Output Power | | Power Density (S) (mW/cm²) | Limit of Power Density (S) (mW/cm²) | Test Result |
|---|---|---|---|---|---|---|---|
| | | | (dBm) | (mW) | | | |
| 0.2 | 6.51 | 4.4774 | 20.9504 | 124.4630 | 0.110923 | 1 | Complies |

Note: $DirectionalGain = 10 \cdot \log\left[\frac{\sum_{j=1}^{N_{ANT}}\left\{\sum_{k=1}^{N_{ANT}} g_{j,k}\right\}^2}{N_{ANT}}\right]$

**For Bluetooth**

**Antenna Type : PIFA Antenna**

**Max Conducted Power for Bluetooth ER (GFSK) 1Mbps : 3.32 dBm**

| Distance (m) | Antenna Gain (dBi) | Antenna Gain (numeric) | Average Output Power | | Power Density (S) (mW/cm²) | Limit of Power Density (S) (mW/cm²) | Test Result |
|---|---|---|---|---|---|---|---|
| | | | (dBm) | (mW) | | | |
| 0.2 | 3.50 | 2.2387 | 3.3200 | 2.1478 | 0.000957 | 1 | Complies |

**Max Conducted Power for Bluetooth 4.0 : 3.24 dBm**

| Distance (m) | Antenna Gain (dBi) | Antenna Gain (numeric) | Average Output Power | | Power Density (S) (mW/cm²) | Limit of Power Density (S) (mW/cm²) | Test Result |
|---|---|---|---|---|---|---|---|
| | | | (dBm) | (mW) | | | |
| 0.2 | 3.50 | 2.2387 | 3.2400 | 2.1086 | 0.000940 | 1 | Complies |

**CONCULSION:**

Both of the WLAN 2.4GHz Band and Bluetooth can transmit simultaneously, the formula of calculatedthe MPE is:

**CPD1 / LPD1 + CPD2 / LPD2 + .....etc. < 1**

**CPD = Calculation power density**

**LPD = Limit of power density**

Therefore, the worst-case situation is 0.110923 / 1 + 0.000957 / 1 = 0.11188, which is less than "1". This confirmed that the device comply with FCC 1.1310 MPE limit.

Both of the WLAN 5GHz Band and Bluetooth can transmit simultaneously, the formula of calculatedthe MPE is:

**CPD1 / LPD1 + CPD2 / LPD2 + .....etc. < 1**

**CPD = Calculation power density**

**LPD = Limit of power density**

Therefore, the worst-case situation is 0.157221 / 1 + 0.000957 / 1 = 0.158178, which is less than "1". This confirmed that the device comply with FCC 1.1310 MPE limit.