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:

For Beamforming

Antenna Type : Dipole Antenna

Conducted Power for IEEE 802.11ac VHT40 : 19.62dBm

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	8.36	6.8568	19.6222	91.6679	0.125109	1	Complies

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

For Non-Beamforming

Antenna Type : Dipole Antenna

Conducted Power for IEEE 802.11ac VHT80 : 23.69dBm

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	2.66	1.8450	23.6895	233.8554	0.085881	1	Complies

For 5GHz ISM Band:

For Beamforming

Antenna Type : Dipole Antenna

Conducted Power for IEEE 802.11ac VHT20: 25.21dBm

Distance (m)	Antenna 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	7.56	5.7032	25.2086	331.7870	0.376644	1	Complies

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

For Non-Beamforming

Antenna Type : Dipole Antenna

Conducted Power for IEEE 802.11a: 25.93dBm

Distance (m)	Antenna 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	2.79	1.9011	25.9253	391.3201	0.148075	1	Complies

For 2.4GHz Band:

For WLAN

Antenna Type : Dipole Antenna

Conducted Power for IEEE 802.11n HT20: 27.05 dBm

Distance (m)	Antenna 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	3.59	2.2856	27.0488	506.8459	0.230582	1	Complies

For Bluetooth

Antenna Type : WLAN/BT antenna

Max Conducted Power for Bluetooth EDR (8DPSK) 3Mbps : -1.35 dBm

Antenna 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)			
3.90	2.4547	-1.3500	0.7328	0.000358	1	Complies

Antenna Type : WLAN/BT antenna

Max Conducted Power for Bluetooth 4.0 : -1.43 dBm

Antenna 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)			
3.90	2.4547	-1.4300	0.7194	0.000352	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 0.230582 / 1 + 0.000358 / 1 = 0.23094, 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 0.376644 / 1 + 0.000358 / 1 = 0.377002, which is less than "1". This confirmed that the device comply with FCC 1.1310 MPE limit.