

FCC §1.1307(b) & §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

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)	Cable Loss	Tune up power (dBm)	Tune up Output Power (mW)	Antenna Gain		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		dB			(dBi)	(numeric)			
Lower 700MHz	698-716	1.2	17.5	56.23	10	10.00	20	0.0849	0.4653
Upper 700MHz	776-787	1.2	19.0	79.43	10	10.00	20	0.1199	0.5173
Cellular	824-849	1.2	19.0	79.43	10	10.00	20	0.1199	0.5493
PCS	1850-1915	1.8	19.5	89.13	11	12.59	20	0.1475	1.0000
AWS	1710-1755	1.8	19.5	89.13	11	12.59	20	0.1475	1.0000

Note1: The maximum MPE ratio is: $0.1199/0.5173=0.2318$

Note2: The worst Antenna Gain and Cable Loss refer to the following information

Uplink Frequency(MHz)	698-716	776-787	824-849	1710-1755	1850-1915
Wide Band Directional Antenna 11dBi Antenna with 30' 400 N male			Kit numbers: WD11-30400		
Antenna Gain (dBi)	10	10	10	11	11
Coax Cable Loss (dB)	1.2	1.2	1.2	1.8	1.8
Final Gain Less Loss (dB)	8.8	8.8	8.8	9.2	9.2

Downlink

Test Band	Frequency (MHz)	Cable Loss	Tune up power (dBm)	Tune up Output Power (mW)	Antenna Gain		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		dB			(dBi)	(numeric)			
Lower 700MHz	728-746	1.2	8.0	6.31	1	1.26	20	0.0012	0.4853
Upper 700MHz	746-757	1.2	9.0	7.94	1	1.26	20	0.0015	0.4973
Cellular	869-894	1.2	11.0	12.59	1	1.26	20	0.0024	0.5793
PCS	1930-1995	1.8	11.0	12.59	1.5	1.41	20	0.0023	1.0000
AWS	2110-2155	1.8	10.5	11.22	1.5	1.41	20	0.0021	1.0000

Note1: The maximum MPE ratio is: $0.0024/0.5793=0.0041$

Note2: The worst Antenna Gain and Cable Loss refer to the following information

Downlink Frequency(MHz)	728-746	746-757	869-894	2110-2155	1930-1995
1 Whip Antenna with 30' 400 N male			Kit numbers:5-30400-50		
Antenna Gain (dBi)	1	1	1	1.5	1.5
Splitter/Coax Loss (dB)	1.2	1.2	1.2	1.8	1.8
Final Gain Less Loss (dB)	-0.2	-0.2	-0.2	-0.3	-0.3

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 = $MPE/Limit_{Booster} + MPE/Limit_{WIFI} = 0.2318+0.0135=0.2453 < 1.0$

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