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/cm^2);

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:

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

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	20.0	100.00	9.0	7.94	20	0.158	0.465
Upper 700MHz (C Block)	776-787	21.5	141.25	9.0	7.94	20	0.223	0.517
Cellular	824-849	20.0	100.00	9.0	7.94	20	0.158	0.549
PCS	1850-1915	22.5	177.83	9.0	7.94	20	0.281	1.00
AWS	1710-1755	20.5	112.20	9.0	7.94	20	0.177	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	24.0	251.19	9.0	7.94	20	0.397	0.485
Upper 700MHz (C Block)	746-757	23.5	223.87	9.0	7.94	20	0.354	0.497
Cellular	869-894	23.0	199.53	9.0	7.94	20	0.315	0.549
PCS	1930-1995	24.0	251.19	9.0	7.94	20	0.397	1.00
AWS	2110-2155	23.5	223.87	9.0	7.94	20	0.354	1.00

The Maximum indoor and outdoor Gain is 9 dBi.

For downlink, the maximum MPE ratio is: 0.397/0.485=**0.8186**

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 = $MPE/Limit_{Booster}$ + $MPE/Limit_{WIFI}$ = 0.8186+0.0135=0.8321＜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