

5.6. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091]

5.6.1. Limits

§ 1.1310: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f ²)	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				
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

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

5.6.2. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where,
P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm²
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

5.6.3. RF Evaluation

Pursuant to KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

The EUT contained a ZigBee radio and a certified ESPRESSIF SYSTEMS (SHANGHAI) CO., LTD Wi-Fi & Bluetooth IoT module, the table below is the calculated sum of the MPE ratios from all sources for co-located MPE evaluation at 20 cm distance.

Source	Maximum MPE Ratio
EUT, MMB Networks Zigbee Radio	0.0576
ESPRESSIF SYSTEMS (SHANGHAI) CO., LTD Wi-Fi & Bluetooth IoT Module (FCC ID: 2AC7Z-ESP32WROVERE)	0.2183
Sum of the MPE ratios from all sources:	0.2759

The sum of the MPE ratios from all sources is < 1. Thus, in compliant with the general public (uncontrolled environment) MPE limit.

For detailed MPE ratios calculation, refer to the following tables.

Calculated MPE Ratio for EUT Zigbee Radio							
Frequency Band (MHz)	Frequency (MHz)	¹ Max. EIRP (dBm)	Max. EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)	MPE Ratio
2405-2480	2405	24.62	289.734	20	0.0576	1.0	0.0576

¹ Maximum EIRP = Tune-up conducted power of 21.2 dBm + maximum antenna gain of 3.42 dBi

Calculated MPE Ratio for Espressif Systems (Shanghai) Co., Ltd Wi-Fi & Bluetooth IoT Module (FCC ID: 2AC7Z-ESP32WROVERE)									
Mode	Frequency Range (MHz)	¹ Antenna Gain		¹ Tune up Conducted Power		Evaluation Distance (cm)	¹ Power Density (mW/cm ²)	MPE Limit (mW/cm ²)	MPE Ratio
		(dBi)	(numeric)	(dBm)	(mW)				
802.11b	2412-2462	3.40	2.19	27.00	501.19	20	0.2183	1.0	0.2183
802.11g		3.40	2.19	26.00	398.11	20	0.1734	1.0	0.1734
802.11n HT20		3.40	2.19	26.00	398.11	20	0.1734	1.0	0.1734
802.11n HT40	2422-2452	3.40	2.19	27.00	501.19	20	0.2183	1.0	0.2183
BLE	2402-2480	3.40	2.19	7.00	5.01	20	0.0022	1.0	0.0022
BT	2402-2480	3.40	2.19	9.00	7.94	20	0.0035	1.0	0.0035

¹ Test data derived from ESPRESSIF SYSTEMS (SHANGHAI) CO., LTD Wi-Fi & Bluetooth Internet of Things Module test report, Test Report No. RSHS200116001-00A (FCC ID: 2AC7Z-ESP32WROVERE).