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/cm^2
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/cm2)**	**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).