5.1 MAXIMUM PERMISSIBLE EXPOSURE (MPE)

5.1.1 Applicable Standard

FCC §15.247 (i) & §1.1310 & §2.1091

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 of the Commission's guidelines. See §1.1307(b)(1) of this chapter.

Limits for Maximum Permissible Exposure (MPE) (§1.1310, §2.1091)

(B) 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;

According to §1.1310 and §2.1091 RF exposure is calculated.

5.1.2 Procedure

Prediction of power density at the distance of the applicable MPE limit
$S = PG/4\pi R^2$ = 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:

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

5.1.3 Calculated Result

Operation Modes	Frequency (MHz)	Antenna Gain		Conducted output power including Tune-up Tolerance		Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(numeric)	(dBm)	(mW)			
Wi-Fi	2412-2462	3.19	2.08	23	199.53	20	0.083	1.0
BLE	2402-2480	3.87	2.44	7.5	5.62	20	0.003	1.0
ZigBee	2405-2480	1.50	1.41	17	50.12	20	0.014	1.0
LoRa	902.3-927.5	2.44	1.75	19	79.43	20	0.028	0.602
Z-wave	908.4	2.20	1.66	8	6.31	20	0.002	0.606
LTE B2	1850-1910	2.94	1.97	24	251.19	20	0.098	1
LTE B4	1710-1755	2	1.58	23	199.53	20	0.063	1
LTE B5	824-849	2.04	1.60	24	251.19	20	0.080	0.549
LTE B12	699-716	0.78	1.20	24	251.19	20	0.060	0.466
LTE B13	777-787	1.78	1.51	24	251.19	20	0.076	0.518
LTE B26	814-849	2.04	1.60	24	251.19	20	0.080	0.543
NB-IoT B2	1850-1910	2.94	1.97	25	316.23	20	0.124	1
NB-IoT B4	1710-1755	2	1.58	25	316.23	20	0.099	1
NB-IoT B5	824-849	2.04	1.60	25	316.23	20	0.101	0.549
NB-IoT B12	699-716	0.78	1.2	25	316.23	20	0.076	0.466
NB-IoT B13	777-787	1.78	1.51	25	316.23	20	0.095	0.518

Note: The WLAN and BLE or ZigBee or Z-wave or LoRa can transmit simultaneously.
The WWAN and BLE or ZigBee or Z-wave or LoRa can transmit simultaneously.
The WLAN and WWAN can't transmit simultaneously.

The worst case as follow:

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

$= S_{LoRa}/S_{limit-\ LoRa} + S_{WWAN}/S_{limit-WWAN}$

$=0.028/0.602 + 0.101/0.549$

$=0.23$

< 1.0

Result: The device meet FCC MPE at 20 cm distance

******* END OF REPORT *******