5. RF EXPOSURE EVALUATION

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/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:

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

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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:

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

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

= 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 *****