

FCC §1.1310 & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247 (i) and subpart 1.1310, 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/cm²)	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

Calculated Formulary:

Predication of MPE limit at a given distance

$S = PG/4\pi R^2$ = 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:

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

Calculated Data (worst case):**2.4G Wi-Fi&BLE&Zigbee&5G Wi-Fi:**

Mode	Frequency (MHz)	Maximum Antenna Gain		Tune-up Conducted Power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		(dBi)	(numeric)	(dBm)	(mW)			
2.4G Wi-Fi 802.11b	2412~2462	2.0	1.58	21.50	141.25	20	0.0444	1.0
2.4G Wi-Fi 802.11g		2.0	1.58	21.00	125.89	20	0.0396	1.0
2.4G Wi-Fi 802.11n-HT20		2.0	1.58	24.50	281.84	20	0.0886	1.0
2.4G Wi-Fi 802.11n-HT40	2422~2452	2.0	1.58	25.00	316.23	20	0.0994	1.0
BLE(1Mbps)	2402~2480	0	1.00	8.50	7.08	20	0.0014	1.0
BLE(2Mbps)	2402~2480	0	1.00	8.50	7.08	20	0.0014	1.0
Zigbee	2405~2480	0	1.00	19.50	89.13	20	0.0177	1.0
5G Wi-Fi 802.11a	5150~5250	2.0	1.58	16.00	39.81	20	0.0125	1.0
	5725~5850	2.0	1.58	14.00	25.12	20	0.0079	1.0
5G Wi-Fi 802.11ac20	5150~5250	2.0	1.58	15.50	35.48	20	0.0112	1.0
	5725~5850	2.0	1.58	16.50	44.67	20	0.0140	1.0
5G Wi-Fi 802.11n20	5150~5250	2.0	1.58	15.50	35.48	20	0.0112	1.0
	5725~5850	2.0	1.58	16.50	44.67	20	0.0140	1.0
5G Wi-Fi 802.11ac40	5150~5250	2.0	1.58	16.00	39.81	20	0.0125	1.0
	5725~5850	2.0	1.58	15.00	31.62	20	0.0099	1.0
5G Wi-Fi 802.11n40	5150~5250	2.0	1.58	15.50	35.48	20	0.0112	1.0
	5725~5850	2.0	1.58	14.50	28.18	20	0.0089	1.0
5G Wi-Fi 802.11ac80	5150~5250	2.0	1.58	15.50	35.48	20	0.0112	1.0
	5725~5850	2.0	1.58	14.50	28.18	20	0.0089	1.0

GSM:

Mode	Frequency Range (MHz)	Maximum Antenna Gain		Tune-up Conducted Power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		(dBi)	(numeric)	(dBm)	(mW)			
GSM 850	824.2-848.8	4	2.51	27.50	562.34	20	0.2810	0.55
GSM 1900	1850.2-1909.8	4	2.51	26.50	446.68	20	0.2232	1.00

Note:

GPRS 850: Tune-up maximum output power with 1 slot is 32.50 dBm, 2 slots is 32.50 dBm, 3 slots is 31.50 dBm, 4 slots is 30.50 dBm, so the tune-up time based Ave. power compared to slotted Ave. power is 27.50dBm.

EGPRS 850: Tune-up maximum output power with 1 slot is 27.00 dBm, 2 slots is 27.00 dBm, 3 slots is 26.50 dBm, 4 slots is 26.50 dBm so the tune-up time based Ave. power compared to slotted Ave. power is 23.50 dBm.

GPRS 1900: Tune-up maximum output power with 1 slot is 30.00 dBm, 2 slots is 30.00 dBm, 3 slots is 30.00 dBm, 4 slots is 29.50 dBm so the tune-up time based Ave. power compared to slotted Ave. power is 26.50 dBm.

EGPRS 1900: Tune-up maximum output power with 1 slot is 26.50 dBm, 2 slots is 26.00 dBm, 3 slots is 26.00 dBm, 4 slots is 26.00 dBm so the tune-up time based Ave. power compared to slotted Ave. power is 23.00 dBm.

Number of Time slot	1	2	3	4
Duty Cycle	1:8	1:4	1:2.66	1:2
Time based Ave. power compared to slotted Ave. power	-9 dB	-6 dB	-4.26 dB	-3 dB

LTE CAT-M1:

Mode	Frequency Range (MHz)	Maximum Antenna Gain		Tune-up Conducted Power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		(dBi)	(numeric)	(dBm)	(mW)			
LTE Band 2	1850.7~1909.3	4	2.51	24	251.19	20	0.1255	1.00
LTE Band 4	1710.7~1754.3	4	2.51	23	199.53	20	0.0997	1.00
LTE Band 5	824.7~848.3	4	2.51	24	251.19	20	0.1255	0.55
LTE Band 12	699.7~715.3	4	2.51	24	251.19	20	0.1255	0.47
LTE Band 13	779.5~784.5	4	2.51	24	251.19	20	0.1255	0.52
LTE Band 26	814.7~848.3	4	2.51	24	251.19	20	0.1255	0.54

LTE NB-IOT:

Mode	Frequency Range (MHz)	Maximum Antenna Gain		Tune-up Conducted Power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		(dBi)	(numeric)	(dBm)	(mW)			
LTE Band 2	1850.7~1909.3	4	2.51	25	316.23	20	0.1579	1.00
LTE Band 4	1710.7~1754.3	4	2.51	25	316.23	20	0.1579	1.00
LTE Band 5	824.7~848.3	4	2.51	25	316.23	20	0.1579	0.55
LTE Band 12	699.7~715.3	4	2.51	25	316.23	20	0.1579	0.47
LTE Band 13	779.5~784.5	4	2.51	25	316.23	20	0.1579	0.52

Note:

1. For the above tune up power were declared by the manufacturer.
2. For 802.11b, 802.11g, 802.11a, the tune-up power is base on SISO mode
For 802.11ac20/n20/n40/ac40/ac80, the tune-up power is base on MIMO mode
3. The LTE module FCC ID: XMR201707BG96 (Grant:09/08/2020).
4. 2.4G Wi-Fi & BLE & Zigbee & 5G Wi-Fi & GSM850 can transmit simultaneously; the worst condition as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0994/1.00 + 0.0014/1.00 + 0.0177/1.00 + 0.0140/1.00 + 0.2810/0.55 = 0.6434 < 1.0$$

Conclusion: The device meets MPE at distance 20cm.