

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

Applicable Standard

According to subpart §1.1310, 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 level in excess of the Commission’s guidelines.

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/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;

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

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.