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

Applicable Standard

According to 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/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.

Calculated Formulary:

Predication of MPE limit at a given distance

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

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

Calculated Data:

2.4G Wi-Fi & 5G Wi-Fi & LTE:

Mode	Frequency Range (MHz)	Antenna Gain		Tune-up Conducted Power		Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(numeric)	(dBm)	(mW)			
802.11b	2412~2462	4.0	2.51	26.50	446.68	30	0.0991	1.0
802.11g		4.0	2.51	26.00	398.11	30	0.0883	1.0
802.11n-HT20		4.0	2.51	27.00	501.19	30	**0.1112**	**1.0**
802.11n-HT40	2422~2452	4.0	2.51	26.00	398.11	30	0.0883	1.0
802.11a	5150~5250	4.0	2.51	17.00	50.12	30	**0.0111**	**1.0**
	5725~5850	4.0	2.51	17.00	50.12	30	0.0111	1.0
802.11ac20	5150~5250	4.0	2.51	17.00	50.12	30	0.0111	1.0
	5725~5850	4.0	2.51	16.50	44.67	30	0.0099	1.0
802.11n20	5150~5250	4.0	2.51	17.00	50.12	30	0.0111	1.0
	5725~5850	4.0	2.51	17.00	50.12	30	0.0111	1.0
802.11ac40	5150~5250	4.0	2.51	17.00	50.12	30	0.0111	1.0
	5725~5850	4.0	2.51	17.00	50.12	30	0.0111	1.0
802.11n40	5150~5250	4.0	2.51	17.00	50.12	30	0.0111	1.0
	5725~5850	4.0	2.51	17.00	50.12	30	0.0111	1.0
802.11ac80	5210	4.0	2.51	17.00	50.12	30	0.0111	1.0
	5775	4.0	2.51	17.00	50.12	30	0.0111	1.0
LTE Band 2	1850~1910	2.3	1.70	22.50	177.83	30	0.0267	1.0
LTE Band 4	1710~1755	2.0	1.58	22.50	177.83	30	0.0249	1.0
LTE Band 5	824~849	1.5	1.41	23.50	223.87	30	0.0279	0.55
LTE Band 7	2500~2570	2.7	1.86	23.00	199.53	30	0.0328	1.0
LTE Band 12	699~716	1.3	1.35	23.50	223.87	30	0.0267	0.47
LTE Band 13	777~787	1.35	1.36	24.00	251.19	30	**0.0303**	**0.52**
LTE Band 25	1850~1915	2.3	1.70	24.00	251.19	30	0.0377	1.0
LTE Band 26	814~849	1.5	1.41	23.50	223.87	30	0.0280	0.55
LTE Band 41	2496~2690	2.7	1.86	23.50	223.87	30	0.0369	1.0
LTE Band 66	1710~1780	2.0	1.58	24.00	251.19	30	0.0352	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	824~849	1.5	1.41	26.74	472.06	30	0.0590	0.55
GSM 1900	1850~1910	2.3	1.70	24.50	281.84	30	0.0423	1.00

Note:
1. Antenna Gain (numeric): 1.5 dBi (1.41) for GSM 850
   Antenna Gain (numeric): 2.3 dBi (1.70) for GSM 1900
GPRS 850: Tune-up maximum output power with 1 slot is 35.0 dBm, 2 slots is 32.5 dBm, 3 slots is 31.0 dBm, 4 slots is 29.5 dBm, so the tune-up time based Ave. power compared to sloted Ave. power is 26.74 dBm.
EGPRS 850: Tune-up maximum output power with 1 slot is 31.5 dBm, 2 slots is 30.5 dBm, 3 slots is 28.5 dBm, 4 slots is 27.5 dBm so the tune-up time based Ave. power compared to sloted Ave. power is 24.5 dBm.
GPRS 1900: Tune-up maximum output power with 1 slot is 30.5 dBm, 2 slots is 28.5 dBm, 3 slots is 26.5 dBm, 4 slots is 24.0 dBm so the tune-up time based Ave. power compared to sloted Ave. power is 22.5 dBm.
EGPRS 1900: Tune-up maximum output power with 1 slot is 29.0 dBm, 2 slots is 27.5 dBm, 3 slots is 26.0 dBm, 4 slots is 24.5 dBm so the tune-up time based Ave. power compared to sloted Ave. power is 21.74 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

WCDMA:

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)			
Band Ⅱ	1850~1910	2.3	1.70	23.00	199.53	30	0.0300	1.00
Band Ⅳ	1710-1755	2.0	1.58	23.50	223.87	30	0.0314	1.00
Band Ⅴ	824-849	1.5	1.41	23.50	223.87	30	0.0280	0.55

Note:
1. For the above tune up power were declared by the manufacturer.
2. The LTE module FCC ID: 2AJYU-8PYA003
3. 2.4G Wi-Fi, 5G Wi-Fi and LTE can transmit simultaneously, The worst condition is as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.1112/1.0+0.0111/1.0+0.059/0.55 = 0.1112+0.0111+0.107 = 0.2293 < 1.0$$

Result: The device meets FCC MPE at 30cm distance.