

FCC §1.1307 & §2.1091 –MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart §2.1091 and 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):

Mode	Frequency Range (MHz)	Maximum Antenna Gain		Tune-up Conducted Power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)	MPE ratio
		(dBi)	(numeric)	(dBm)	(mW)				
802.11b	2412-2462	0.00	1.00	18.00	63.0957	20	0.0126	1.00	0.0126
802.11g		0.00	1.00	17.00	50.1187	20	0.0100	1.00	0.0100
802.11n-HT20		0.00	1.00	17.00	50.1187	20	0.0100	1.00	0.0100
802.11n-HT40	2422-2452	0.00	1.00	17.00	50.1187	20	0.0100	1.00	0.0100
BLE	2402-2480	0.00	1.00	1.00	1.2589	20	0.0003	1.00	0.0003
BT 3.0	2402-2480	0.00	1.00	12.00	15.8489	20	0.0032	1.00	0.0032

Calculation of maximum antenna gain based on ERP/EIRP

Mode	Max Tune-up Power (dBm)	ERP/EIRP Limit (dBm)	Max Antenna Gain (dBd)	Max Antenna Gain (dBi)
WCDMA Band II	23.00	33.00	/	10.00
WCDMA Band IV	23.00	30.00	/	7.00
WCDMA Band V	24.00	38.45	14.45	16.60
LTE Band 2	22.00	33.00	/	11.00
LTE Band 4	23.00	30.00	/	7.00
LTE Band 5	23.00	38.45	15.45	17.60
LTE Band 7	23.00	33.00	/	10.00
LTE Band 12	25.00	34.77	9.77	11.92
LTE Band 13	23.00	34.77	11.77	13.92
LTE Band 17	25.00	34.77	9.77	11.92

Note:0dBd=2.15dBi

Calculation of maximum antenna gain based on MPE Ratio

Mode	Frequency Range	Tune-up Conducted Power		Power Density Limit	Maximum Power Density	Evaluation Distance	Maximum Antenna Gain Allowed based on MPE		MPE ratio
	(MHz)	(dBm)	(mW)	(mW/cm ²)	(mW/cm ²)	(cm)	(numeric)	(dBi)	
WCDMA Band II	1850.0-1910.0	23.00	199.5262	1.00	0.9855	20	24.83	13.95	0.9855
WCDMA Band IV	1710.0-1755.0	23.00	199.5262	1.00	0.9855	20	24.83	13.95	0.9855
WCDMA Band V	824.0-849.0	24.00	251.1886	0.55	0.5416	20	10.84	10.35	0.9847
LTE Band 2	1850.0-1910.0	22.00	158.4893	1.00	0.9855	20	31.26	14.95	0.9855
LTE Band 4	1710.0-1755.0	23.00	199.5262	1.00	0.9855	20	24.83	13.95	0.9855
LTE Band 5	824.0-849.0	23.00	199.5262	0.55	0.5416	20	13.65	11.35	0.9847
LTE Band 7	2500.0-2570.0	23.00	199.5262	1.00	0.9855	20	24.83	13.95	0.9855
LTE Band 12	699.0-716.0	25.00	316.2278	0.47	0.4631	20	7.36	8.67	0.9853
LTE Band 13	777.0-787.0	23.00	199.5262	0.52	0.5125	20	12.91	11.11	0.9856
LTE Band 17	704.0-716.0	25.00	316.2278	0.47	0.4631	20	7.36	8.67	0.9853

Note: Wi-Fi/ BLE/ BT 3.0& WCDMA/FDD can transmit simultaneously; the worst condition is 802.11b of Wi-Fi & FDD (Band13), as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0126 + 0.9856 = 0.9982 < 1.0$$

Mode	Max Allow Antenna Gain (dBi)
WCDMA Band II/LTE Band 2	10.0
WCDMA Band IV/ LTE Band 4	7.00
WCDMA Band V/ LTE Band 5	10.35
LTE Band 7	10.00
LTE Band 12/ LTE Band 17	8.67
LTE Band 13	11.11

Result: To meet RF exposure & ERP/ERIP, the maximum net gains of antennas allowed are 10dBi@ WCDMA Band II/LTE Band 2 , 7dBi@ WCDMA Band IV/ LTE Band 4 , 10.35dBi@ WCDMA Band V/ LTE Band 5 , 10.00dBi @LTE Band 7, 8.67dBi @ LTE Band 12/LTE Band 17, 11.11dBi @ LTE Band 13. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.