

FCC §15.247 (I) & §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/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

Calculated Formulary:

Predication of MPE limit at a given distance

S = PG/4πR² = 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	19.00	79.43	20	0.0158	1.00	0.0158
802.11g		0.00	1.00	20.00	100.00	20	0.0199	1.00	0.0199
802.11n-HT20		0.00	1.00	18.50	70.79	20	0.0141	1.00	0.0141
802.11n-HT40	2422-2452	0.00	1.00	17.50	56.23	20	0.0112	1.00	0.0112
802.11a	5150~5250	0.00	1.00	12.00	15.85	20	0.0032	1.00	0.0032
	5250~5350	0.00	1.00	12.00	15.85	20	0.0032	1.00	0.0032
	5470~5725	0.00	1.00	12.50	17.78	20	0.0035	1.00	0.0035
	5725~5850	0.00	1.00	12.50	17.78	20	0.0035	1.00	0.0035
802.11n-HT20	5150~5250	0.00	1.00	12.50	17.78	20	0.0035	1.00	0.0035
	5250~5350	0.00	1.00	11.50	14.13	20	0.0028	1.00	0.0028
	5470~5725	0.00	1.00	12.50	17.78	20	0.0035	1.00	0.0035
	5725~5850	0.00	1.00	12.50	17.78	20	0.0035	1.00	0.0035
802.11n-HT40	5150~5250	0.00	1.00	9.50	8.91	20	0.0018	1.00	0.0018
	5250~5350	0.00	1.00	9.00	7.94	20	0.0016	1.00	0.0016
	5470~5725	0.00	1.00	11.50	14.13	20	0.0028	1.00	0.0028
	5725~5850	0.00	1.00	11.50	14.13	20	0.0028	1.00	0.0028
BLE	2402-2480	0.00	1.00	1.50	1.41	20	0.0003	1.00	0.0003
BT 3.0	2402-2480	0.00	1.00	11.50	14.13	20	0.0028	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
FDD (Band 2)	22.00	33.00	/	11.00
FDD (Band 4)	22.50	30.00	/	7.00
FDD (Band 5)	22.50	38.45	15.95	18.10
FDD (Band 7)	22.50	33.00	/	10.00
FDD (Band 12)	23.00	34.77	11.77	13.92
FDD (Band 13)	23.00	34.77	11.77	13.92
FDD (Band 17)	23.00	34.77	11.77	13.92

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 (cm)	Maximum Antenna Gain Allowed based on MPE		MPE ratio
	(MHz)	(dBm)	(mW)	(mW/cm ²)	(mW/cm ²)		(numeric)	(dBi)	
WCDMA Band II	1850.0-1910.0	23.00	199.53	1.00	0.9788	20	24.66	13.92	0.9788
WCDMA Band IV	1710.0-1755.0	23.00	199.53	1.00	0.9788	20	24.66	13.92	0.9788
WCDMA Band V	824.0-849.0	24.00	251.19	0.55	0.5619	20	19.59	12.92	0.9788
FDD (Band 2)	1850.0-1910.0	22.00	158.49	1.00	0.9789	20	31.05	14.92	0.9789
FDD (Band 4)	1710.0-1755.0	22.50	177.83	1.00	0.9788	20	22.67	14.42	0.9788
FDD (Band 5)	824.0-849.0	22.50	177.83	0.55	0.5619	20	22.67	14.42	0.9788
FDD (Band 7)	2500.0-2570.0	22.50	177.83	1.00	0.9788	20	22.67	14.42	0.9788
FDD (Band 12)	699.0-716.0	23.00	199.53	0.47	0.4802	20	24.66	13.92	0.9788
FDD (Band 13)	777.0-787.0	23.00	199.53	0.52	0.5313	20	24.66	13.92	0.9788
FDD (Band 17)	704.0-716.0	23.00	199.53	0.47	0.4802	20	24.66	13.92	0.9788

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:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0199 + 0.9789 = 0.9988 < 1.0$$

Mode	Max Allow Antenna Gain (dBi)
WCDMA Band II/LTE Band 2	10.0
WCDMABand IV/ LTE Band 4	7.00
WCDMABand V/ LTE Band 5	12.92
LTE Band 7	10.00
LTE Band 12/ LTE Band 17	13.92
LTE Band 13	13.92

Result: To meet RF exposure & ERP/ERIP, the maximum net gains of antennas allowed are 10dBi@ WCDMA Band II/LTE Band 2 , 7dBi@ WCDMABand IV/ LTE Band 4 , 12.92dBi@ WCDMABand V/ LTE Band 5 , 10.00dBi @LTE Band 7, 13.92dBi @ LTE Band 12/LTE Band 17, 13.92dBi @ LTE Band 13. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm 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.