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/cm^2)	Averaging Time (minutes)
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f²)	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);

Calculated Data:

Calculation of maximum antenna gain based on ERP/EIRP

Mode	Max Tune-up Power (dBm)	ERP/EIRP Limit (dBm)	Max Antenna Gain
NB-IoT Band 2	24.00	33.00	9.0dBi
NB-IoT Band 5	24.00	38.45	16.60dBi (14.45dBd)
NB-IoT Band 12	24.00	34.77	12.92dBi (10.77dBd)

Note: 0dBd = 2.15dBi

Calculation of maximum antenna gain based on MPE

Mode	Frequency Range	Tune-up Conducted Power		Power Density Limit	Maximum Power Density	Evaluation Distance	Maximum Antenna Gain Allowed based on MPE	
	(MHz)	(dBm)	(mW)	(mW/cm^2)	(mW/cm^2)	(cm)	(dBi)	(numeric)
NB-IoT Band 2	1850.1-1909.9	24.00	251.19	1.0000	0.9995	20	13.01	20.00
NB-IoT Band 5	824.1-848.9	24.00	251.19	0.5494	0.5492	20	10.41	10.99
NB-IoT Band 12	699.1-715.9	24.00	251.19	0.4661	0.4658	20	9.69	9.32

Mode	Max Allowed Antenna Gain
NB-IoT (Band 2) Frequency Range: 1850.1-1909.9MHz	9.00dBi
NB-IoT (Band 5) Frequency Range: 824.1-848.9MHz	10.41dBi
NB-IoT (Band 12) Frequency Range: 699.1-715.9MHz	9.69dBi

Result: For NB-IoT mode, to meet RF exposure & ERP/ERIP, the maximum net gains of antennas allowed are 9.0dBi @ NB-IoT (Band 2), 10.41dBi @ NB-IoT (Band 5) and 9.69dBi @ NB-IoT (Band 12). 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.