

RF Exposure Analysis

Revision	Report Date	Reason for Revision
Ø	July 12, 2021	Initial Issue.
1	September 12, 2021	Review Updates
2	September 28, 2021	TCB Updates

RF Exposure Evaluation of Devices

RF Exposure Requirements: **§1.1307(b)(1) and §1.1307(b)(2):** 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 levels in excess of the Commission's guidelines.

RF Radiation Exposure Limit: **§1.1310:** As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*(100)	≤6
3.0-30	1842/f	4.89/f	*(900/f ²)	<6
30-300	61.4	0.163	1.0	<6
300-1,500			f/300	<6
1,500-100,000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
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
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

RF Exposure Limits

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{PG / 4\pi S}$$

where, S = Power Density (mW/cm²)
P = Power Input to antenna (mW)
G = Antenna Gain (numeric value)
R = Distance (cm)

For Antenna Gain → **dBi = 10log(Numeric)**

Technology	TX Frequency Range (MHz)	Peak Gain (dBi)	Type
WCDMA Band II	1852.4 – 1907.6 MHz	3.90 dBi	LDS
WCDMA Band V	826.4 – 846.6 MHz	-0.27 dBi	LDS
LTE Band 2	1850 – 1910 MHz	3.90 dBi	LDS
LTE Band 4	1710 – 1755 MHz	2.10 dBi	LDS
LTE Band 5	824.7 – 848.3 MHz	-0.27 dBi	LDS
LTE Band 12	699 – 716 MHz	-0.89 dBi	LDS
WiFi	2412 – 2462 MHz	4.20 dBi	LDS

EUT Antenna Gain Specification

Technology	TX Frequency Range (MHz)	Maximum Conducted Output Power (dBm) Adjusted for Tune Up Tolerance
WCDMA Band II	1852.4 – 1907.6 MHz	24.5 (-3 ~ +1dB) = 25.5
WCDMA Band V	826.4 – 846.6 MHz	24.5 (-3 ~ +1dB) = 25.5
LTE Band 2	1850 – 1910 MHz	23.5 (-3 ~ +1dB) = 24.5
LTE Band 4	1710 – 1755 MHz	24 (-3 ~ +1dB) = 25
LTE Band 5	824.7 – 848.3 MHz	24 (-3 ~ +1dB) = 25
LTE Band 12	699 – 716 MHz	24 (-3 ~ +1dB) = 25
WiFi	2412 – 2462 MHz	22.3 (-3 ~ +1dB) = 23.3

Tune up Power

Test Results:

Band	Frequency (MHz)	Tuned Up Power (dBm)	Conducted Power (mW)	Antenna Gain (dBi)	Antenna Gain (Numeric)	Power Density (mW/cm ²)	Limit (mW/cm ²)	Margin	Distance (cm)	Result
WCDMA Band II	1850	25.50	354.81	3.90	2.455	0.173	1	0.827	20	Pass
WCDMA Band V	824	25.50	354.81	-0.27	0.940	0.066	0.549	0.483	20	Pass
LTE Band 2	1850	24.50	281.84	3.90	2.455	0.138	1	0.862	20	Pass
LTE Band 4	1755	25.00	316.23	2.10	1.622	0.102	1	0.898	20	Pass
LTE Band 5	824	25.00	316.23	-0.27	0.940	0.059	0.549	0.490	20	Pass
LTE Band 12	699	25.00	316.23	-0.89	0.815	0.051	0.466	0.415	20	Pass
WiFi	2437	23.30	213.80	4.28	2.679	0.114	1	0.886	20	Pass

MPE Calculation for Bands

The safe distance where Power Density is less than the MPE limit listed above was found to be 20 cm.

Note: Results are based on KDB 447498 D01 (Section 7.2) Transmitters used in mobile devices exposure conditions for simultaneous transmission operations.

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0 , according to calculated/estimated, numerically modeled, or measured field strengths or power density. The MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to the MPE limit at the test frequency.

Cellular & WiFi can transmit simultaneously, the formula for calculating the simultaneous MPE is

$$\text{CPD1/LPD1} + \text{CPD2/LPD2} + \dots + \text{CPDn/LPDn} < 1$$

CPD: Calculated Power Density

LPD: Limit of Power Density

$$\begin{aligned}
 \text{Simultaneous MPE} &= \text{Cellular} & + & \text{WiFi} \\
 &= 0.066/0.549 & + & 0.114/1 \\
 &= 0.120 & + & 0.114 \\
 &= 0.234
 \end{aligned}$$

Result: $0.234 < 1$ (Pass)