

Exposure of humans to RF fields

As per FCC KDB 447498 D01 and Section 2.1091 radio frequency transmitters are required to be operated in a manner that ensures the public is not exposed to RF energy levels.

Calculations have been made using the General Public/Uncontrolled Exposure limits that are defined in Section 1.1310.

For MPE calculations, 960.000 MHz has been selected.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) 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
(B) 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

f = frequency in MHz * = Plane-wave equivalent power density

Limits for maximum permissible exposure (MPE)

- General Population / Uncontrolled exposure is f/1500. At 928.000 MHz, the calculated limit is 0.62 mW/cm²

- Occupational /Controlled exposure is f/300. At 928.000 MHz, the calculated limit is 3.10 mW/cm²

Minimum safe distances have been calculated below.

For Uncontrolled Environment

At 928.000 MHz, Power Density = 0.62 mW/cm² = E²/3770

$$E = \sqrt{0.62 \times 3770}$$

$$E = 49.3 \text{ V/m}$$

For Controlled Environment

At 960.000 MHz, Power Density = $3.10 \text{ mW/cm}^2 = E^2/3770$

$$E = \sqrt{3.10 \times 3770}$$

$$E = 108.1 \text{ V/m}$$

The rated maximum transmitter power = 0.25 W (+24 dBm).

A worst case scenario duty cycle of 100% has been used for the calculations.

Shown below is the typical list of antennas (Information supplied by the client) that would be used with the product:

Dual Polarized Omni-Directional Antenna	8dBi, 2xN Female
Dual Polarized Compact Panel Antenna	8dBi, 2xN Female
Dual Polarized, MIMO Directional Panel Antenna	9dBi, 2xN Female
Compact Panel Antenna	9dBi, 2xN Female / 2x4.3-10 Female
Compact Panel Antenna	11dBi, 2xN Female / 2x4.3-10 Female
MIMO Low Profile Panel Antenna	12dBi, 2xN Female
MIMO Panel Antenna	16dBi, 2xN Female / 2x4.3-10 Female
MIMO Yagi Antenna (with optional Radome available)	12dBi, 2xN Female
MIMO Yagi Antenna (with optional Radome available)	15dBi, 2xN Female

The minimum distance from the antenna at which the MPE is met is calculated from the following

Field strength in V/m (FS),
 Transmit power in watts (P)
 Transmit antenna gain (G)
 Transmitter duty cycle (DC)
 Separation distance in metres (D)

The calculation is as follows:

$$FS = (\sqrt{30 * P * G * DC}) / D$$

The calculations have been shown with following scenarios:

- MPE calculations for the product with both ports terminated in a 50 Ohm load
- Using 8 dBi gain antenna
- Using 9 dBi gain antenna
- Using 11 dBi gain antenna
- Using 12 dBi gain antenna
- Using 15 dBi gain antenna
- Using 16 dBi gain antenna

a) For Uncontrolled environments, the minimum distance is:

$$D = (\sqrt{(30 * P * G * DC)}) / FS$$

$$P = 0.25 \text{ W}$$

$$FS = E = 49.3 \text{ V/m}$$

Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain Numeric	Duty cycle	Safe distance (metres)
928.000	No gain (0)	1.0	100%	0.06
	8.0	6.3	100%	0.14
	9.0	7.9	100%	0.16
	11.0	12.6	100%	0.20
	12.0	15.8	100%	0.22
	15.0	31.6	100%	0.31
	16.0	39.8	100%	0.35

a) For Controlled environments, the minimum distance is:

$$D = (\sqrt{(30 * P * G * DC)}) / FS$$

$$P = 0.25 \text{ W}$$

$$FS = E = 108.1 \text{ V/m}$$

Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain Numeric	Duty cycle	Safe distance (metres)
928.000	No gain (0)	1.0	100%	0.02
	8.0	6.3	100%	0.06
	9.0	7.9	100%	0.07
	11.0	12.6	100%	0.09
	12.0	15.8	100%	0.10
	15.0	31.6	100%	0.14
	16.0	39.8	100%	0.16

Result: Complies if a safe distance shown in the calculations above is followed.

