

MPE Calculation

§ 1.1310: The criteria listed in table 1 shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

Part 1.1310 Limits for Maximum Permissible Exposure (MPE)

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 Exposures				
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
300–1500 .....	.....	.....	f/300	6
1500–100,000 .....	.....	.....	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
300–1500 .....	.....	.....	f/1500	30
1500–100,000 .....	.....	.....	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.



RSS-102 Issue 5 Exposure Limits:

**Table 4: RF Field Strength Limits for Devices Used by the General Public
(Uncontrolled Environment)**

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Reference Period (minutes)
0.003-10 ²¹	83	90	-	Instantaneous*
0.1-10	-	0.73/ <i>f</i>	-	6**
1.1-10	87/ <i>f</i> ^{0.5}	-	-	6**
10-20	27.46	0.0728	2	6
20-48	58.07/ <i>f</i> ^{0.25}	0.1540/ <i>f</i> ^{0.25}	8.944/ <i>f</i> ^{0.5}	6
48-300	22.06	0.05852	1.291	6
300-6000	3.142 <i>f</i> ^{0.3417}	0.008335 <i>f</i> ^{0.3417}	0.02619 <i>f</i> ^{0.6834}	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/ <i>f</i> ^{1.2}
150000-300000	0.158 <i>f</i> ^{0.5}	4.21 x 10 ⁻⁴ <i>f</i> ^{0.5}	6.67 x 10 ⁻⁵ <i>f</i>	616000/ <i>f</i> ^{1.2}

Note: *f* is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

1.1 Test Procedure

An MPE evaluation for was performed in order to show that the device was compliant with §2.1091. The maximum power density was calculated for each transmitter at a separation distance of 20cm.

For each transmitter the maximum RF exposure at a 20 cm distance using the formula:

$$ConductedPower_{mW} = 10^{ConductedPower(dBm)/10}$$

$$PowerDensity = \frac{ConductedPower_{mW} \times Ant.Gain}{4\pi \times (20_{cm})^2}$$



1.2 Results:

- Maximum Conducted Output Power = 27.6 dBm = 575.4 mW
- Maximum Antenna Gain = 3.0 dBi = 1.995

$$\text{Power Density} = (575.4 \text{ mW}) \cdot (1.995) / (4\pi \cdot (20\text{cm})^2)$$

$$\text{Power Density} = 0.2284 \text{ mW/cm}^2$$

$$\text{FCC §1.1310 limit at 929 MHz} = 0.6193 \text{ mW/cm}^2$$

$$\text{RSS-102 Issue 5 Exposure Limit at 2.4GHz} = 0.2796 \text{ mW/cm}^2$$

The calculated maximum power density at 20cm distance is less than the limit for general population / uncontrolled exposure.

FCC		Value	Unit	Comments
Frequency		929	MHz	
Distance		20	cm	
Maximum Scaled Power		27.6	dBm	Measured conducted power
TX Antenna Gain		3	dBi	From datasheet, or calculated from peak radiated field strength and measured conducted power
Source Based Duty Cycle		100	%	Percent of time transmitter is active
EIRP		30.6	dBm	Maximum Scaled Power x Antenna Gain
Source Based Output Power		30.6	dBm	EIRP x Duty Cycle
Power Density @ Distance		0.2284	mW/cm²	(Source Based Output Power, mW) / (4π x (distance, cm) ²)
FCC Limit		0.6193	mW/cm²	0.0026 x f ^{0.6834}
Ratio of Power Density to Limit		0.3688		Power Density / IC Limit
Maximum Permissible Antenna Gain		7.33	dBi	((Limit, mW/cm ²) x 4π x (distance, cm) ²) / ((Maximum Scaled Power, mW) x Source Based Duty Cycle)
IC		Value	Unit	Comments
Frequency		929	MHz	
Distance		20	cm	
Maximum Scaled Power		27.6	dBm	Measured conducted power
TX Antenna Gain		3	dBi	From datasheet, or calculated from peak radiated field strength and measured conducted power
Source Based Duty Cycle		100	%	Percent of time transmitter is active
EIRP		30.6	dBm	Maximum Scaled Power x Antenna Gain
Source Based Output Power		30.6	dBm	EIRP x Duty Cycle
Power Density @ Distance		0.2284	mW/cm²	(Source Based Output Power, mW) / (4π x (distance, cm) ²)
IC Limit		0.2796	mW/cm²	0.0026 x f ^{0.6834}
Ratio of Power Density to Limit		0.8171		Power Density / IC Limit
Maximum Permissible Antenna Gain		3.88	dBi	((Limit, mW/cm ²) x 4π x (distance, cm) ²) / ((Maximum Scaled Power, mW) x Source Based Duty Cycle)

