

## 10. MAXIMUM PERMISSIBLE EXPOSURE

### FCC RULES

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (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.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

| Frequency range (MHz)                                   | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | 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 <sup>2</sup> )              | 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 <sup>2</sup> )              | 30                       |

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|-----------------------|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| 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.

## IC RULES

IC Safety Code 6, Section 2.2.1 (a) A person other than an RF and microwave exposed worker shall not be exposed to electromagnetic radiation in a frequency band listed in Column 1 of Table 5, if the field strength exceeds the value given in Column 2 or 3 of Table 5, when averaged spatially and over time, or if the power density exceeds the value given in Column 4 of Table 5, when averaged spatially and over time.

**Table 5**  
**Exposure Limits for Persons Not Classed As RF and Microwave Exposed Workers (Including the General Public)**

| 1<br>Frequency<br>(MHz) | 2<br>Electric Field<br>Strength; rms<br>(V/m) | 3<br>Magnetic Field<br>Strength; rms<br>(A/m) | 4<br>Power<br>Density<br>(W/m <sup>2</sup> ) | 5<br>Averaging<br>Time<br>(min) |
|-------------------------|-----------------------------------------------|-----------------------------------------------|----------------------------------------------|---------------------------------|
| 0.003–1                 | 280                                           | 2.19                                          |                                              | 6                               |
| 1–10                    | 280/ $f$                                      | 2.19/ $f$                                     |                                              | 6                               |
| 10–30                   | 28                                            | 2.19/ $f$                                     |                                              | 6                               |
| 30–300                  | 28                                            | 0.073                                         | 2*                                           | 6                               |
| 300–1 500               | 1.585 $f^{0.5}$                               | 0.0042 $f^{0.5}$                              | $f/150$                                      | 6                               |
| 1 500–15 000            | 61.4                                          | 0.163                                         | 10                                           | 6                               |
| 15 000–150 000          | 61.4                                          | 0.163                                         | 10                                           | 616 000 / $f^{1.2}$             |
| 150 000–300 000         | 0.158 $f^{0.5}$                               | 4.21 x 10 <sup>-4</sup> $f^{0.5}$             | 6.67 x 10 <sup>-5</sup> $f$                  | 616 000 / $f^{1.2}$             |

\* Power density limit is applicable at frequencies greater than 100 MHz.

- Notes:**
1. Frequency,  $f$ , is in MHz.
  2. A power density of 10 W/m<sup>2</sup> is equivalent to 1 mW/cm<sup>2</sup>.
  3. A magnetic field strength of 1 A/m corresponds to 1.257 microtesla (μT) or 12.57 milligauss (mG).

## **EQUATIONS**

Power density is given by:

$$S = \text{EIRP} / (4 * \text{Pi} * D^2)$$

where

S = Power density in W/m<sup>2</sup>

EIRP = Equivalent Isotropic Radiated Power in W

D = Separation distance in m

Power density in units of W/m<sup>2</sup> is converted to units of mW/cm<sup>2</sup> by dividing by 10.

Distance is given by:

$$D = \text{SQRT} (\text{EIRP} / (4 * \text{Pi} * S))$$

where

D = Separation distance in m

EIRP = Equivalent Isotropic Radiated Power in W

S = Power density in W/m<sup>2</sup>

Where applicable (for example, multi-slot cell phone applications) a duty cycle factor may be applied.

$$\text{Source-based time-averaged EIRP} = (\text{DC} / 100) * \text{EIRP}$$

where

DC = Duty Cycle in %, as applicable

EIRP = Equivalent Isotropic Radiated Power in W

For multiple colocated transmitters operating simultaneously in frequency bands where the limit is identical, the total power density is calculated using the total EIRP obtained by summing the Power \* Gain product (in linear units) of each transmitter.

$$\text{Total EIRP} = (P_1 * G_1) + (P_2 * G_2) + \dots + (P_n * G_n)$$

where

P<sub>x</sub> = Power of transmitter x

G<sub>x</sub> = Numeric gain of antenna x

For multiple colocated transmitters operating simultaneously in frequency bands where different limits apply, a fraction of the exposure limit is established for each band, such that the sum of the fractions is less than or equal to one.

In the table(s) below, Power and Gain are entered in units of dBm and dBi respectively and conversions to linear forms are used for the calculations.

## **LIMITS**

From FCC §1.1310 Table 1 (B), the maximum value of S = 1.0 mW/cm<sup>2</sup>

From IC Safety Code 6, Section 2.2 Table 5 Column 4, S = 10 W/m<sup>2</sup>

## **RESULTS**

### **CO-LOCATED RESULTS**

| Band     | Mode      | Separation Distance (m) | Output Power (dBm) | Antenna Gain (dBi) | Duty Cycle (%) | IC Power Density (W/m <sup>2</sup> ) | FCC Power Density (mW/cm <sup>2</sup> ) |
|----------|-----------|-------------------------|--------------------|--------------------|----------------|--------------------------------------|-----------------------------------------|
| 2.4 GHz  | Bluetooth |                         | -0.60              | -2.95              | 100            |                                      |                                         |
| 2.4 GHz  | WLAN      |                         | 26.07              | 9.68               | 100            |                                      |                                         |
| Combined |           | 0.20                    |                    |                    |                | 7.48                                 | 0.748                                   |

| Band     | Mode      | Separation Distance (m) | Output Power (dBm) | Antenna Gain (dBi) | Duty Cycle (%) | IC Power Density (W/m <sup>2</sup> ) | FCC Power Density (mW/cm <sup>2</sup> ) |
|----------|-----------|-------------------------|--------------------|--------------------|----------------|--------------------------------------|-----------------------------------------|
| 2.4 GHz  | Bluetooth |                         | -0.60              | -2.95              | 100            |                                      |                                         |
| 5 GHz    | WLAN      |                         | 25.17              | 11.27              | 100            |                                      |                                         |
| Combined |           | 0.20                    |                    |                    |                | 8.77                                 | 0.877                                   |