# 9. RF EXPOSURE

## 9.1. FCC RULES

From FCC Rules §1.1310 (b) (1) Table 1, the device operates under Subpart Q of Part 101 and has an EIRP > 1640 W, therefore is subject to routine environmental evaluation.

The calculations of RF Exposure in this report do not consider the potential impact of any site related conditions therefore are provided for reference.

## 9.2. FCC LIMITS

From FCC §1.1310 Table 1 (b), the maximum value of S = 1.0 mW/cm^2

§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 ($mW/cm^2$) | 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 |

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

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density ($mW/cm^2$) | 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.

## 9.3. EQUATIONS

**FAR FIELD BOUNDARY**

The far-field boundary is given in IEEE C95.3 Annex B.2 as:

$$R_{FarField} = (2 * D^2) / \lambda$$

where

$R_{FarField}$ = Far-field boundary in m [or cm]
D = Largest Antenna Dimension, including the reflector, in meters [or cm]
$\lambda$ = wavelength in meters [or cm]

**FAR FIELD POWER DENSITY**

Power density is given in IEEE C95.3 Annex B.2 Equation 37 as:

$$S = EIRP / (4\pi D^2)$$

where

S = Power density in $W/m^2$ [or $mW/cm^2$]
EIRP = Equivalent Isotropic Radiated Power in W [or mW]
D = Separation distance in m [or cm]

IEEE C95.3 Annex B.2 Equation 37 is generally valid for distances greater than $(0.5 D^2)/ \lambda$

**NEAR-FIELD POWER DENSITY**

The maximum near-field power density is given in IEEE C95.3 Annex B.2, equation 38 as:

$$S = 4*P / A$$

where

P = Antenna Power in W [or mW]
A = Area of antenna in $m^2$ [or $cm^2$]

## 9.5. FAR-FIELD CALCULATIONS

**FAR FIELD BOUNDARY**

The closest far-field boundary for a given antenna diameter is at the lowest frequency in each applicable band.

| Frequency (GHz) | Antenna Diameter (feet) | Antenna Diameter (m) | Lambda (m) | R (Far Field) (m) | R (Far Field) (cm) |
|---|---|---|---|---|---|
| 81 | 1 | 0.300 | 0.0037 | 48.60 | 4860 |

**MAXIMUM FAR FIELD POWER DENSITY**

The maximum far-field power density occurs at the closest far-field boundary:

| Frequency Band (GHz) | Far-Field Distance (cm) | Maximum EIRP (dBm) | Maximum EIRP (mW) | Power Density (mW/cm^2) |
|---|---|---|---|---|
| 81-86 | 4860 | 67.06 | 5081594 | 0.017 |

# 9.6. RADIATING NEAR-FIELD CALCULATIONS

## 9.6.1. RADIATING NEAR-FIELD BASED ON FAR-FIELD CONDITIONS

**APPLICABILITY OF IEEE C95.3 ANNEX B.2 EQUATION 37**

The closest distance for which IEEE C95.3 Annex B.2 Equation 37 is generally valid is:

| Frequency (GHz) | Antenna Diameter (feet) | Antenna Diameter (m) | Lambda (m) | Distance for Validity of Equation 37 (m) | Distance for Validity of Equation 37 (cm) |
|---|---|---|---|---|---|
| 81 | 1 | 0.300 | 0.0037 | 12.15 | 1215 |

At closer distances, the values predicted by Equation (37) are too large and near-field estimates must be used.

**ESTIMATED RADIATED NEAR-FIELD POWER DENSITY ASSUMING FAR-FIELD CONDITIONS**

The power density at the closest distance for which IEEE C95.3 Annex B.2 Equation 37 is generally valid is estimated as:

| Frequency Band (GHz) | Transition-Field Distance (m) | Transition-Field Distance (cm) | Maximum EIRP (dBm) | Maximum EIRP (mW) | Power Density (mW/cm^2) |
|---|---|---|---|---|---|
| 81-86 | 12.15 | 1215 | 67.06 | 5081594 | 0.274 |

## 9.6.2. RADIATING NEAR-FIELD BASED ON NEAR-FIELD CONDITIONS

The maximum near-field power density expected in the radiating near-field can be estimated by IEEE C95.3 Annex B.2, equation 38 as:

| Frequency (GHz) | Conducted Output Power (dBm) | Conducted Output Power (mW) | Antenna Diameter (m) | Antenna Radius (cm) | Aperature Area (cm^2) | Power Density (mW/cm^2) |
|---|---|---|---|---|---|---|
| 82.25 | 21.16 | 130.6 | 0.305 | 15.3 | 730.2 | 0.715 |

IEEE C95.3 Annex B.2, equation 38 is suitable for circular apertures with tapers ranging from uniform up to $(1-q^2)^3$.

If the computation from Equation (38) reveals a power density value that is equal to or greater than the MPE, it must be assumed that this value may exist at any point in the radiating near-field region and attention should be directed to the exposure fields in the far-field region.

IEEE C95.3 Annex B.2, Equation (37) and Equation (38) do not include the effect of ground reflections. Values of power density that exceed the free-space value by a factor of four times can result when the main beam is directed toward a planar ground or reflecting surface. If the shape of the reflecting surface is such that it produces focusing effects, even greater values may result.