APPENDIX A: RF EXPOSURE CALCULATIONS FOR HIGH GAIN ANTENNAS

From FCC 1.1310 table 1A, the maximum permissible RF exposure for an uncontrolled environment is $1mW/cm^2$. The Electric field generated for a $1mW/cm^2$ exposure (S) is calculated as follows:

$S = E^2/Z$

where:
S = Power density
E = Electric field
Z = Impedance.

$E = \sqrt{S \times Z}$

$1mW/cm^2 = 10\ W/m^2$

The impedance of free space is 337 ohms, where E and H fields are perpendicular.

Thus:

$E = \sqrt{10 \times 377} = 61.4$ V/m which is equivalent to $1mW/cm^2$

Using the relationship between Electric field E, Power in watts P, and distance in meters d, the corresponding Antenna numeric gain G and the transmitter output power and solving for d,

$$d = \sqrt{\frac{P_{eak} \times 30 \times G}{E}}$$

Example using the Stub Omni-directional antenna

1. The Numeric gain G of antenna with a gain specified in dB is determined by:

$G = \text{Log}^{-1}(\text{dB gain}/10)$

$G = \text{Log}^{-1}\ 0.22 = 1.66$

The table below identifies the distances where the $1mW/cm^2$ exposure limits may be exceeded during continuous transmission using the external antenna

TABLE 24: CISCO DIPOLE ANTENNA

Antenna Type	Gain (dBi)	Gain Numeric	Peak output EIRP Power (mW)	Calculated RF Exposure Separation Distance (cm)	Minimum RF Exposure Separation Distance (cm)
External	2.2	1.66	177.8	4.8	20

TABLE 25: DELL DIPOLE ANTENNA

Antenna Type	Gain (dBi)	Gain Numeric	Peak output EIRP Power (mW)	Calculated RF Exposure Separation Distance (cm)	Minimum RF Exposure Separation Distance (cm)
External	-5.6	0.27	30.0	1.5	20

TABLE 26: DELL INVERTED F ANTENNA

Antenna Type	Gain (dBi)	Gain Numeric	Peak output EIRP Power (mW)	Calculated RF Exposure Separation Distance (cm)	Minimum RF Exposure Separation Distance (cm)
External	-5.6.	0.27	30.0	1.5	20

TABLE 27: TOSHIBA CHIP ANTENNA

Antenna Type	Gain (dBi)	Gain Numeric	Peak output EIRP Power (mW)	Calculated RF Exposure Separation Distance (cm)	Minimum RF Exposure Separation Distance (cm)
External	2.1	1.6	176.8	3.7	20

TABLE 28: TOSHIBA INVERTED F ANTENNA

Antenna Type	Gain (dBi)	Gain Numeric	Peak output EIRP Power (mW)	Calculated RF Exposure Separation Distance (cm)	Minimum RF Exposure Separation Distance (cm)
External	1.0	1.25	137.2	3.6	20