Analysis of Non-Ionizing Radiation for a 0.6m Earth station system

This report analyzes the non-ionizing radiation levels for a 0.6m earth station system. The analysis and calculations performed in this report comply with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and revised in 1987 in Edition 97-01. The radiation safety limits used in the analysis are in conformance the FCC R&O 96-326. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependant on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of earth station in the far-field, near-field, transmission region, between the feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,00	1.0

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,00	1.0

Table 2. Limits for Occupationa;/Controlled Exposure (MPE)

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	0.6	m
Antenna Surface Area	$A_{surface}$	$\pi D^2/4$	0.2826	m^2
Frequency	F	Input	6250	MHz
Wavelength	λ	300/F	0.048	M
Transmit Power	P	Input	4	W
Antenna Gain (dBi)	G_{es}	Input	28	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	630	n/a
Pi	π	Constant	3.1415927	n/a
Antenna Efficiency	η	$G \lambda^2/(\pi^2 D^2)$	65	%

Table 3. Formulas & Parameters Used for determining Power Flux Densities

1. Far Field distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region $R_{ff} = 0.60\, D^2 / \lambda$

$= 4.5$ m

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far-Field $S_{ff} = G\, P / (4\, \pi\, R_{ff}^2)$

$= 10\ W/m^2$

$= 1 mW/cm^2$

2. Near field Calculation

Power Flux Density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined using the following equation:

Extent of the Near Field $R_{nf} = D^2 / (4\, \lambda)$

$= 1.875$ m

The maximum power Flux Density in the Near Field can be determined from the following equation:

Near Field Power Flux Density $S_{nf} = 16\, \eta\, P / (\pi\, D^2)$

$= 3.6\ mW/cm^2$

3. Transition Region Power Density

The transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the transition region, the power density decreases inversely with the square of the distance in the Far Field Region. The maximum power density calculation in Section 1 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance R_t can be determined from the following equation:

Transition Region Power Density $S_t = S_{nf}\, R_{nf} / R_t$

$= 1.5\ mW/cm^2$

4. Main Reflector Region

The power density in the main reflector is determined using the following equation:

Power Density at Main Reflector $S_{surface} = 4 P / A_{surface}$
$= 5.6$ mW/cm^2

5. Region Between the Main Reflector and the Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and the ground can be determined from the following equation:

Power density between Reflector and Ground $S_g = P / A_{surface}$
$= 1.4$ mW/cm^2

6. Summary of Calculations

Region	**Calculated Maximum Radiation power Density Level (mW/cm^2)**		Hazard assessment
1. Far Field	Sff	9.8	Satisfies FCC MPE
2. Near Field	Snf	3.6	Satisfies FCC MPE
3. Transition Region (Rnf<Rt<Rff)	St	0.99	Satisfies FCC MPE
4. Main Reflector	Ssurface	5.6	Satisfies FCC MPE
5. Between Main Reflector and Ground	Sg	1.4	Satisfies FCC MPE

Table 4. Summary of Expected Radiation Levels for Uncontrolled Environments

1. Far Field	Sff	1.875	Satisfies FCC MPE
2. Near Field	Snf	3.6	Satisfies FCC MPE
3. Transition Region (Rnf<Rt<Rff)	St	1.5	Satisfies FCC MPE
4. Main Reflector	Ssurface	5.6	Satisfies FCC MPE
5. Between Main Reflector and Ground	Sg	1.4	Satisfies FCC MPE

Table 4. Summary of Expected Radiation Levels for Controlled Environments

It is the applicant’s responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

7. Conclusion

Based on the above analysis it is concluded that harmful levels of radiation will not exist in regions normally occupied by the public or the earth station’s operating personne. The transmitter will be turned off during antenna maintenance so that FCC MPE of 5 mW/cm^2 will be complied with for those regions with close proximity to the reflector that exceed acceptable levels.