Analysis of Non-Ionizing Radiation for a 4.1 Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 4.1 meter earth station system. The analysis and calculations performed in this report are in compliance with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with 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 a 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 an 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 the earth station in the far-field, near-field, transition region, between the subreflector or 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.

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

Frequency Range (MHz)	Power Density (mWatts/cm**2)
30-300	0.2
300-1500	Frequency(MHz)*(0.8/1200)
1500-100,000	1.0

Table 2. Limits for Occupational/Controlled Exposure(MPE)

Frequency Range (MHz)	Power Density (mWatts/cm**2)
30-300	1.0
300-1500	Frequency(MHz)*(4.0/1200)
1500-100,000	5.0

Table 3 contains the parameters that are used to calculate the various power densities for the earth stations.

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Abbreviation	Value	Units
Antenna Diameter	D	4.1	meters
Antenna Surface Area	Sa	II * D**2/4	meters**2
Feed Flange Diameter	Df	19.1	cm
Area of Feed Flange	Fa	II * Df**2/4	cm**2
Frequency	Frequency	6175	MHz
Wavelength	lambda	300/frequency(MHz)	meters
Transmit Power	P	500.00	Watts
Antenna Gain	Ges	45.9	dBi
Pi	II	3.1415927	n/a
Antenna Efficiency	n	0.55	n/a

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:(1)

Distance to the Far Field Region,(Rf) = 0.60 * D**2 / lambda (1)
= 207.6 meters

The maximum main beam power density in the Far Field can be determined from the following equation:(2)

On-Axis Power Density in the Far Field,(Wf) = Ges * P / 4 * II * Rf**2 (2)
= 35.916 Watts/meters**2
= 3.592 mWatts/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 from the following equation:(3)

Extent of the Near Field,(Rn) = D**2 / (4 * lambda) (3)
= 86.5 meters

The maximum power density in the Near Field can be determined from the following equation:(4)

Near Field Power Density,(Wn) = 16.0 * n * P / II * D**2 (4)
= 83.844 Watts/meters**2
= 8.384 mWatts/cm**2

3. Transition Region Calculations

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 in the Transition region will not exceed that calculated for the Near Field region. The power density calculated 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 Rt can be determined from the following equation:(5)

Transition region Power Density,(Tt) = Wn * Rn / Rt (5)
= 8.384 mWatts/cm**2

4. Region between Feed Assembly and Antenna Reflector

Transmissions from the feed assembly are directed toward the antenna reflector surface, and are confined within a conical shape defined by the type of feed assembly. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the feed assembly and reflector surface can be calculated by determining the power density at the feed assembly surface. This can be determined from the following equation:(6)

Power Density at Feed Flange,(Wf) = 4 * P / Fa (6)
= 6980.289 mWatts/cm**2

5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the feed assembly. The area is now the area of the reflector aperture and can be determined from the following equation:(7)

Power Density at the Reflector Surface,(Ws) = 4 * P / Sa (7)
= 151.486 Watts/meters**2
= 15.149 mWatts/cm**2

6. Region between Reflector and Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and ground can be determined from the following equation:(8)

Power Density between Reflector and Ground,(Wg) = P / Sa (8)
= 37.871 Watts/meters**2
= 3.787 mWatts/cm**2

Table 4. Summary of Expected Radiation levels for Uncontrolled Environment

Region	Calculated Maximum Radiation Power Density Level (mWatts/cm**2)	Hazard Assessment
1. Far Field (Rf) = 207.6 meters	3.592	Potential Hazard
2. Near Field (Rn) = 86.5 meters	8.384	Potential Hazard
3. Transition Region Rn < Rt < Rf, (Rt)	8.384	Potential Hazard
4. Between Feed Assembly and Antenna Reflector	6980.289	Potential Hazard
5. Main Reflector	15.149	Potential Hazard
6. Between Reflector and Ground	3.787	Potential Hazard

Table 5. Summary of Expected Radiation levels for Controlled Environment

Region	Calculated Maximum Radiation Power Density Level (mWatts/cm**2)	Hazard Assessment
1. Far Field (Rf) = 207.6 meters	3.592	Satisfies FCC MPE
2. Near Field (Rn) = 86.5 meters	8.384	Potential Hazard
3. Transition Region Rn < Rt < Rf, (Rt)	8.384	Potential Hazard
4. Between Feed Assembly and Antenna Reflector	6980.289	Potential Hazard
5. Main Reflector	15.149	Potential Hazard
6. Between Reflector and Ground	3.787	Satisfies FCC MPE

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

7. Conclusions

Based on this analysis it is concluded that the FCC RF Guidelines have been exceeded in the specific regions of Tables 1 and 2. The applicant proposes to comply with the Maximum Permissible Exposure (MPE) limits of 1 mW/cm2 for the Uncontrolled areas and the MPE limits of 5 mW/cm2 for the Controlled areas by one or more of the following methods:

Means of Compliance Uncontrolled Areas

The area around this antenna will be roped off. The roped off area will be sufficient to prohibit access to the areas that exceed the MPE limits. The general public will not have access to areas within ½ diameter removed from the edge of the antenna.

Since one diameter removed from the main beam of the antenna or ½ diameter removed from the edge of the antenna the RF levels are reduced by a factor of 100 or 20 dB. None of the areas exceeding the MPE levels will be accessible by the general public.

Radiation hazard signs will be posted while this earth station is in operation.

The applicant will ensure that no buildings or other obstacles will be in the areas that exceed the MPE levels.

Means of Compliance Controlled Areas

The earth station’s operational will not have access to the areas that exceed the MPE levels while the earth station is in operation.

The transmitters will be turned off during antenna maintenance.