Analysis of Non-Ionizing Radiation for a 0.7-Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 0.7-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the Federal Communications Commission ("FCC") Office of Engineering and Technology Bulletin No. 65 ("Bulletin No. 65"), which was 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 Report and Order ("R&O") 96-326. Bulletin No. 65 and the FCC R&O (collectively "FCC RF Guidelines") specifies that there are two separate tiers of exposure limits that are dependent 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, 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 (mW/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 (mW/cm^2)
30-300	1.0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

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

Parameter	**Symbol**	**Formula**	**Value**	**Units**
Antenna Diameter	D	Input	0.74	m
Ant Equiv Surface Area	$A_{surface}$	10 elements	2.0#	m^2
Frequency	F	Input	402.5	MHz
Wavelength	λ	300 / F	0.7453	m
Transmit Power	P	Input	70.00	w
Antenna Gain (dBi)	G_{es}	Input	11.5	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	14.13	N/A
Pi	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G*\lambda^2/(4*\pi)/A_{surface}$	1.25	N/A

For a Log Periodic Antenna with 10 elements the surface area of each element is estimated to be 0.2 m^2. Total surface area is 2.0 m^2.

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	$R_{ff} = 0.60\ D^2 / \lambda$ $= 0.44$ m	(1)

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	$S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$ $= 404.92\ W/m^2$ $= 40.49\ mW/cm^2$	(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:

Extent of the Near Field	$R_{nf} = D^2 / (4\ \lambda)$ $= 0.184$	(3)

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

Near Field Power Density	$S_{nf} = 4 * \eta * P / A_{surface}$ $= 174.85\ W/m^2$ $= 17.49\ mW/cm^2$	(4)

3. Transition Region Calculation

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 2 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance S_t can be determined from the following equation:

Transition Region Power Density	$S_t = S_{nf} * R_{nf} / R$ $= 102.85\ W/m^2$ $= 10.29\ mW/cm^2$	(5)

R above is given at a halfway point (0.312m) between the edge of the near field, and the beginning of the far field, but can be any value between R_{nf} and R_{ff}.

4. Region between the Antenna and the Ground

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

Power Density between Antenna and Ground	$S_g = P / A_{surface}$ $= 35\ W/m^2$ $= 3.5\ mW/cm^2$	(6)

5. Summary of Calculations

Table 4. Summary of Expected Radiation Levels for Uncontrolled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm^2)		Hazard Assessment
Far Field (R_{ff} = 0.44m)	S_{ff}	40.49	Potential Hazard
Near Field (R_{nf}=0.184m)	S_{nf}	17.48	Potential Hazard
Transition Region ($R_{nf}<R_t<R_{ff}$)	S_t	10.29	Potential Hazard
Between Antenna and Ground	S_g	3.5	Potential Hazard

Table 5. Summary of Expected Radiation Levels for Controlled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm^2)		Hazard Assessment
Far Field (R_{ff} = 0.44m)	S_{ff}	40.49	Potential Hazard
Near Field (R_{nf}=0.184m)	S_{nf}	17.48	Potential Hazard
Transition Region ($R_{nf}<R_t<R_{ff}$)	S_t	10.29	Potential Hazard
Between Antenna and Ground	S_g	3.5	Potential Hazard

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

6. Conclusions

Based upon the above analysis, it is concluded that FCC RF Guidelines have been exceeded in all fields of the Uncontrolled (Table 4) environments and in all fields of the Controlled (Table 5) environments. The applicant proposes to comply with the MPE limits of 0.27 mW/cm^2 for the Uncontrolled Areas and the MPE limits of 1.34 mW/cm^2 for the Controlled Areas.

The earth station Log Periodic antenna will be mounted on a dedicated pedestal, so the applicant agrees that the antenna is in an area secured from the public and worker personnel not familiar with the earth station system. Non-assigned worker personnel and the general public must be accompanied by knowledgeable earth station personnel when they enter the earth station secured area.

The earth station's secured area will be marked with the required radiation hazard signs as described in the recent FCC R&O 13-39. The area in the vicinity of the earth station secured area will also have signs to inform those in the general population and those who may be working in the area or otherwise present that they are close to a RF system capable of producing hazardous levels.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*