

Radiation Hazard Study

400 MHz Earth Station

This study analyzes the non-ionizing radiation levels for a 400 MHz Yagi tracking earth station. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01.

Bulletin No. 65 specifies that there are two separate tiers of exposure limits that are depending on the area of exposure and/or the status of the individuals who are subject to the exposure -- the General Population/Uncontrolled Environment and the Controlled Environment, where the general population cannot access.

The maximum level of non-ionizing radiation to which individuals may be exposed is limited to a power density level of 1.33 milliwatts per square centimeter (1.33 mW/cm^2) averaged over any 6 minute period in a controlled environment, and the maximum level of non-ionizing radiation to which the general public is exposed is limited to a power density level of 0.27 milliwatt per square centimeter (0.27 mW/cm^2) averaged over any 30 minute period in a uncontrolled environment.

In the normal range of transmit powers for satellite antennas, the power densities at or around the antenna surface are expected to exceed safe levels. The purpose of this study is to determine the power flux density levels for the earth station under study as compared with the MPE limits. This comparison is done in each of the following regions:

1. Far-field region
2. Near-field region
3. Transition region
4. The region between the antenna edge and the ground

Input Parameters

The following input parameters were used in the calculations:

<u>Parameters:</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>
<i>Antenna Diameter</i>	3.57	m	<i>D</i>
<i>Antenna Transmit Gain</i>	16.3	dBi	<i>G</i>
<i>Transmit Frequency</i>	402	MHz	<i>f</i>
<i>Power Input to the Antenna</i>	12.53	W	<i>P</i>

Calculated Parameters:

The following values were calculated using the above input parameters and the corresponding formulas:

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>	<u>Formula</u>
<i>Antenna Surface Area</i>	1.964	m ²	A	$G\lambda^2/(4\pi)/\lambda$
<i>Antenna Efficiency</i>	0.95		η	$G\lambda^2/(\pi^2 D^2)$
<i>Gain Factor</i>	41.7		g	$10^{G/10}$
<i>Wavelength</i>	0.75	m	λ	$300/f$

Behavior of EM Fields as a Function of Distance

The behavior of the characteristics of EM fields varies depending on the distance from the radiating antenna. These characteristics are analyzed in three primary regions: the near-field region, the far-field region and the transition region. Of interest also is the region between the antenna and ground.

For yagi antennas with circular cross sections, such as the antenna under study, the near-field, far-field and transition region distances are calculated as follows:

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Formula</u>
<i>Near-Field Distance</i>	4.25	m	$R_{nf} = D^2/(4\lambda)$
<i>Distance to Far-Field</i>	10.2	m	$R_{ff} = 0.60D^2/(\lambda)$
<i>Distance of Transition Region</i>	4.25	m	$R_t = R_{nf}$

The distance in the transition region is between the near and far fields. Thus, $R_{nf} \leq R_t \leq R_{ff}$. However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

Power Flux Density Calculations

The power flux density is considered to be at a maximum through the entire length of the near-field. This region is contained within a cylindrical volume with a diameter, D, equal to the diameter of the antenna. In the transition region and the far-field, the power density decreases inversely with the square of the distance. The following equations are used to calculate power density in these regions.

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>	<u>Formula</u>
<i>Power Density in the Near-Field</i>	2.42	mW/cm ²	S_{nf}	$16.0 \eta P/(\pi D^2)$
<i>Power Density in the Far-Field</i>	0.04	mW/cm ²	S_{ff}	$GP/(4\pi R_{ff}^2)$
<i>Power Density in the Transition Region</i>	2.42	mW/cm ²	S_t	$S_{nf} R_{nf}/(R_t)$

The power density between the antenna and ground, is calculated as follows:

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>	<u>Formula</u>
<i>Power Density b/w Reflector and Ground</i>	0.64	mW/cm ²	S_g	P/A

The below table summarizes the calculated power flux density values for each region. In a controlled environment, the only regions that exceed FCC limitations are shown below. These regions are only accessible by trained technicians who, as a matter of procedure, turn off transmit power before performing any work in these areas.

<u>Power Density</u>	<u>Value</u>	<u>Unit</u>	<u>Controlled Environment</u>
<i>Far Field Calculation</i>	0.04	mW/cm ²	Satisfies FCC MPE
<i>Near Field Calculation</i>	2.42	mW/cm ²	Exceeds Limits
<i>Transition Region</i>	2.42	mW/cm ²	Exceeds Limits
<i>Region b/w Antenna & Ground</i>	0.64	mW/cm ²	Satisfies FCC MPE

The results show that the antenna, in a controlled environment, may exist in the regions noted above and applicant will take the proper mitigation procedures to ensure it meets the guidelines specified in 47 C.F.R. § 1.1310.

The earth station will be marked with the standard radiation hazard warnings, as well as the area in the vicinity of the earth station to inform any residents or guests who might be working or otherwise present in or near the path of the main beam. The earth station will be installed on private property and inaccessible to the general public. In addition, because power levels are down at least 20 dB (or by a factor of 100) one diameter removed away from the center of the main beam, public safety will be ensured by minimum elevation angles that result in upward pointing towards the satellite and away from inhabited areas.

Finally, because there is no potential for public access to the earth station site (on private property), the General Population/Uncontrolled Environment limits are not implicated. Furthermore, only operations and maintenance personnel will have access to areas that may potentially exceed the MPE limits and they will do so only while the earth station is not in operation. The transmitter will be turned off during periods of maintenance so that the Controlled Environment MPE standard will be satisfied.