

Radiation Hazard Study

The study in this section analyzes the potential RF human exposure levels caused by the Electro Magnetic (EM) fields of a Vertex 6.1m antenna operating with a maximum power at the flange of 200 Watts. The mathematical analysis performed below complies with the methods described in the FCC Office of Engineering and Technology (OET) Bulletin No. 65 (1985 rev. 1997) R&O 96-326.¹

Maximum Permissible Exposure

There are two separate levels of exposure limits. The first applies to persons in the general population who are in an uncontrolled environment. The second applies to trained personnel in a controlled environment. According to 47 C.F.R. § 1.1310, the Maximum Permissible Exposure (MPE) limits for frequencies above 1.5 GHz are as follows:

- General Population / Uncontrolled Exposure 1.0 mW/cm²
- Occupational / Controlled Exposure 5.0 mW/cm²

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 feed and the antenna surface
5. The main reflector region
6. The region between the antenna edge and the ground

Input Parameters

The following input parameters were used in the calculations:

<u>Parameter</u>	<u>Value</u>	<u>Unit</u>	<u>Symbol</u>
Antenna Diameter	6.1	m	<i>D</i>
Antenna Transmit Gain	57.1	dBi	<i>G</i>
Transmit Frequency	14250	MHz	<i>f</i>
Antenna Feed Flange Diam.	55.8	cm	<i>d</i>
Power Input to the Antenna	200	Watts	<i>P</i>

¹ *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*, OET Bulletin 65 (Edition 97-01), Supplement B, FCC Office of Engineering & Technology, November 1997.

Calculated Parameters

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

Parameter	Value	Unit	Symbol	Formula
Antenna Surface Area	29.22	m ²	<i>A</i>	$\pi D^2/4$
Area of Antenna Flange	2455.5	cm ²	<i>a</i>	$\pi d^2/4$
Antenna Efficiency	0.62		η	$G\lambda^2/(\pi^2 D^2)$
Gain Factor	512861.4		<i>g</i>	$10^{G/10}$
Wavelength	0.0211	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 are the region between the antenna main reflector and the subreflector, the region of the main reflector area and the region between the main reflector and ground.

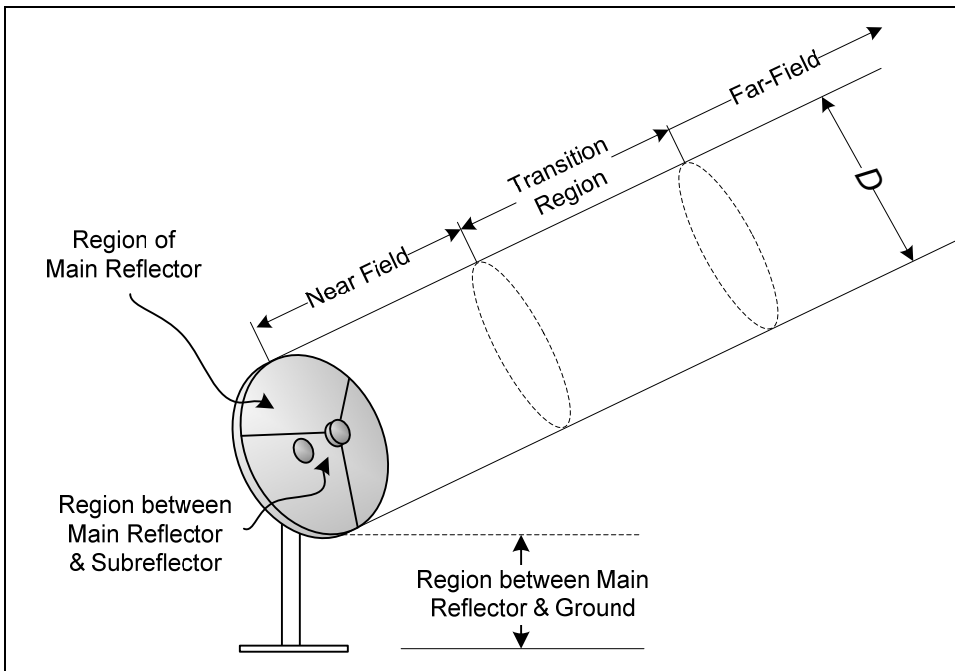


Figure 1. EF Fields as a Function of Distance

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

Near-Field Distance	$R_{nf} = D^2/(4\lambda)$	= 441.87 m
Distance to Far-Field	$R_{ff} = 0.60D^2/(\lambda)$	= 1060.485 m

$$\text{Distance of Transition Region} \quad R_t = R_{nf} \quad = 441.87 \text{ m}$$

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.

$$\begin{array}{llll} \text{Power Density in the Near-Field} & S_{nf} & = 16.0 \eta P/(\pi D^2) & = 1.694 \text{ mW/cm}^2 \\ \text{Power Density in the Far-Field} & S_{ff} & = GP/(4\pi R_{ff}^2) & = 0.726 \text{ mW/cm}^2 \\ \text{Power Density in the Transition Region} & S_t & = S_{nf} R_{nf} / (R_t) & = 1.694 \text{ mW/cm}^2 \end{array}$$

The region between the main reflector and the subreflector is confined to within a conical shape defined by the feed assembly. The most common feed assemblies are waveguide flanges. This energy is determined as follows:

$$\text{Power Density at the Feed Flange} \quad S_{fa} \quad = 4P / a \quad = 327.139 \text{ mW/cm}^2$$

The power density in the main reflector is determined similarly to the power density at the feed flange; except that the area of the reflector is used.

$$\text{Power Density at Main Reflector} \quad S_{surface} \quad = 4P / A \quad = 2.737 \text{ mW/cm}^2$$

The power density between the reflector and ground, assuming uniform illumination of the reflector surface, is calculated as follows:

$$\text{Power Density b/w Reflector and Gnd} \quad S_g \quad = P / A \quad = 0.684 \text{ mW/cm}^2$$

Summary of Calculations

Table 1 summarizes the calculated power flux density values for each region. In a controlled environment, the only region that exceeds FCC limitations is the region between the main reflector and the sub-reflector. This region is only accessible by trained technicians who, as a matter of procedure, turn off transmit power before performing any work in this area.

Power Densities	(mW/cm²)	Controlled Environment (5 mW/cm²)
Far Field Calculation	0.726	Satisfies FCC MPE
Near Field Calculation	1.694	Satisfies FCC MPE
Transition Region	1.694	Satisfies FCC MPE
Region b/w Main & Subreflector	327.139	Exceeds limitations
Main Reflector Region	2.737	Satisfies FCC MPE
Region b/w Main Reflector & Ground	0.684	Satisfies FCC MPE

Table 1. Power Flux Density for Each Region

In conclusion, the results show that the Vertex 6.1m antenna, in a controlled environment, and under the proper mitigation procedures, meets the guidelines specified in § 1.1310 of the Regulations.