Radiation Hazard Study

Grand Valley State University
Transmit/Receive Earth Station Application

ANALYSIS OF NON-IONIZING RADIATION
FOR A 7.0 METER EARTH STATION

This report analyzes the non-ionizing radiation levels for a 7.0 meter earth station. The Office of Science and Technology Bulletin, No. 65, specifies that the maximum level of non-ionizing radiation that a person may be exposed to over a six minute period is an average power density equal to 5 mW/cm^2 (five milliwatts per centimeter squared). It is the purpose of this report to determine the power flux densities of the earth station in the far field, near field, and at the main reflector surface, and between the antenna edge and the ground.

The following parameters were used to calculate the various power flux densities for this earth station:

Antenna Diameter, (D)	= 7.0 meters
Antenna surface area, (Sa)	= pi (D^2) / 4 = 38.48 m^2
Subreflector Diameter, (Ds)	= 97.7 cm
Area of Subreflector, (As)	= pi (Ds^2) /4 = 7496.85 cm^2
Wavelength at 14.0 GHz, (lambda)	= 0.021 meters
Transmit Power at Flange, (P)	= 213.00 Watts
Antenna Gain, (Ges) Antenna Gain at 14,0 Ghz = 58.0 dBi Converted to a Power Ratio Given by: AntiLog (58.0 / 10)	= ^{6}0.631
Pi, (pi)	= 3.1415927
Antenna aperture efficiency, (n)	= 0.65

<u>1. Far Field Calculations</u>

The distance to the beginning of the far field region can be found by the following equation:

Distance to the Far Field Region, (Rf) $= \dfrac{0.60\,(D^2)}{\text{Lambda}}$

= 1373.8 m

The maximum main beam power density in the far field can be calculated as follows:

On-Axis Power Density in the Far Field, (Wf) $= \frac{(Ges)\ (P)}{4\ pi\ (Rf^2)}$

$= 5.67\ W/m^2$
$= 0.57\ mW/cm^2$

2. Near Field Calculations

Power flux density is considered to be at a maximum value throughout the entire length of the defined region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the extent of the near field region the power density decreases with distance from the transmitting antenna.

The distance to the end of the near field can be determined by the following equation:

Extent of near field, (Rn) $= D^2\ /\ 4(lambda)$

$= 572.43\ m$

The maximum power density in the near field is determined by:

Near field Power Density, (Wn) $= \frac{16.0\ (n)\ P}{Pi\ (D^2)}$

$= 14.39\ W/m^2$
$= 1.44\ mW/cm^2$

3. Transition Region Calculations

The transition region is located between the near and far field regions. As stated above, the power density begins to decrease with 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 in the near filed region, as shown above, will not exceed 1.44 mW/cm^2.

4. Region Between Main Reflector and Subreflector

Transmissions from the feed horn are directed toward the subreflector surface, and are reflected back toward the main reflector. The energy between the subreflector and the reflector surfaces can be calculated by determining the power density at the subreflector surface. This can be accomplished as follows:

Power Density at Subreflector, (Ws) = (2 (P) / As)

= 568.24 W/m^2
= 56.82 mW/cm^2

5. Main Reflector Region

The power density in the main reflector region is determined in the same manner as the power density at the subreflector, above, but the area is now the area of the main reflector aperture:

Power Density at Main Reflector Surface, (Wm) = (2 (P) / Sa)

= 11.07 W/m^2
= 1.11 mW/cm^2

6. Region between Main Reflector and Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and ground can be calculated as follows:

Power density between Reflector and Ground, (Wg) = (P / Sa)

= 5.53 W/m^2
= 0.55 mW/cm^2

Summary of Expected Radiation Levels

Region	Calculated Maximum Radiation Level (mW / cm^2)	Hazard Assessment
1. Far Field, (Rf) = 1373.8m	0.57	Satisfies Ansi
2. Near Field, (Rn) = 572.43m	1.44	Satisfies Ansi
3. Transistion Region, (Rt) Rn< Rt< Rf	1.44	Satisfies Ansi
4. Between Main Reflector and Subreflector	56.82	Potential Hazard
5. Reflector Surface	1.11	Satisfies Ansi
6. Between Antenna and Ground	0.55	Satisfies Ansi

7. Conclusions

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's station operating personnel. The transmitter will be turned off during antenna maintenance so that the ANSI Standard of 5.0 mW/cm^2 will be complied with for those regions with close proximity to the reflector that exceeds acceptable levels.