

ANALYSIS OF NON – IONIZING RADIATION
FOR A 4.6 METER EARTH STATION

This report analyzes the non-ionizing radiation levels for a 4.6 meter earth station. The Office of Engineering and Technology Bulletin, No. 65, Edition 97-01, specifies that there are two separate tiers of exposure limits that are dependent on the situation in which exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limit for persons in a Uncontrolled/Public environment to non-ionizing radiation over a thirty minute period is a power density equal to $1 \text{ mW} / \text{cm}^2$ (one milliwatts per centimeter squared). The Maximum Permissible Exposure (MPE) limit for persons in a Controlled/Occupational environment to non-ionizing radiation over a six minute period is a power density equal to $5 \text{ mW} / \text{cm}^2$ (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, transition region, between the subreflector and main reflector surface, 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)	=	4.6 meters	
Antenna surface area, (A _s)	=	$\text{pi} (D^2) / 4$	= 16.62 m ²
Subreflector Diameter, (D _{sr})	=	47.85 cm	
Area of Subreflector, (A _{sr})	=	$\text{pi} (D_{sr}^2) / 4$	= 1798.27 cm ²
Feed Flange Diameter (D _f)	=	19.456 cm	
Area of Feed Flange, (A _f)	=	$\text{pi} (D_f^2) / 4$	= 297.3 cm ²
Wavelength at 14.2500 GHz, (λ)	=	0.021 meters	
Transmit Power at Flange, (P)	=	280.00 Watts	
Antenna Gain, (G _{es})	Antenna Gain at	=	3.23594E+5
	14.2500 GHz	=	55.1 dBi
	Converted to a Power		
	Ration Given By:		
	AntiLog (55.1 / 10)		
π (pi)	=	3.1415927	
Antenna aperture efficiency, (η)	=	0.55	

1. Far Field Calculations

The distance to the beginning of the far field region can be found by the following equation: (1)

$$\begin{aligned} \text{Distance to the Far Field Region, (} R_f \text{)} &= 0.60 (D^2) / \lambda \\ &= 603.1 \text{ m} \end{aligned}$$

The maximum main beam power density in the far field can be calculated as follows: (1)

$$\begin{aligned} \text{On-Axis Power Density in the Far Field, (} W_f \text{)} &= \frac{(G_{es}) (P)}{4 (\pi) (R_f^2)} \\ &= 19.83 \text{ W / m}^2 \\ &= 1.98 \text{ mW / cm}^2 \end{aligned}$$

2. Near Field Calculation

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: (1)

$$\text{Extent of near field, (} R_n \text{)} = D^2 / 4 (\lambda) = 251.275 \text{ m}$$

The maximum power density in the near field is determined by: (2)

$$\begin{aligned} \text{Near field Power Density, (} W_n \text{)} &= \frac{16.0 (n) P}{\pi (D^2)} \text{ mW / cm}^2 \\ &= 37.07 \text{ W / m}^2 \\ &= 3.707 \text{ mW / cm}^2 \end{aligned}$$

(1) Federal Communications Commission, Office of Engineering & Technology, Bulletin No. 65, pp. 17 & 18.

(2) IBID

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 field region, as shown above, will not exceed 3.707 mW / cm².

4. Region Between Subreflector and Feed

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

$$\begin{aligned} \text{Power Density at Feed Flange, } (W_f) &= 4 (P) / A_f \\ &= 3767.22 \quad \text{mW / cm}^2 \end{aligned}$$

5. Region Between Main Reflector and Subreflector

The energy between the Subreflector and reflector surfaces can be calculated by determining the power density at the Subreflector surface. This can be accomplished as follows:

$$\begin{aligned} \text{Power Density at Subreflector, } (W_{sr}) &= 4 (P) / A_{sr} \\ &= 622.82 \quad \text{mW / cm}^2 \end{aligned}$$

6. 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:

$$\begin{aligned} \text{Power Density at Main Reflector Surface, } (W_s) &= (4 (P) / A_s) \\ &= 67.39 \quad \text{W / m}^2 \\ &= 6.739 \quad \text{mW / cm}^2 \end{aligned}$$

7. 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:

$$\begin{aligned} \text{Power density between Reflector and Ground, } (W_g) &= (P / A_s) \\ &= 16.85 \quad \text{W / m}^2 \\ &= 1.685 \quad \text{mW / cm}^2 \end{aligned}$$

Table 1Summary of Expected Radiation LevelsBased on (5 mW / cm²) MPE for Controlled Environment

<u>Region</u>	<u>Calculated Maximum Radiation Level (mW / cm²)</u>	<u>Hazard Assessment</u>
1. Far Field, (R _f) = 603.1 m	1.983	NO HAZARD
2. Near Field, (R _n) = 251.275 m	3.707	NO HAZARD
3. Transition Region, (R _t) R _n < R _t < R _f	3.707	NO HAZARD
4. Between Subreflector and Feed (W _f)	3767.22	POTENTIAL HAZARD
5. Between Main Reflector and Subreflector (W _{sr})	622.82	POTENTIAL HAZARD
6. Reflector Surface (W _s)	6.739	POTENTIAL HAZARD
7. Between Antenna (W _g) and ground	1.685	NO HAZARD

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

Table 2

Summary of Expected Radiation LevelsBased on (1 mW / cm²) MPE for Uncontrolled Environment

<u>Region</u>	<u>Calculated Maximum Radiation Level (mW / cm²)</u>	<u>Hazard Assessment</u>
1. Far Field, (R _f) = 603.1 m	1.983	POTENTIAL HAZARD
2. Near Field, (R _n) = 251.275 m	3.707	POTENTIAL HAZARD
3. Transition Region, (R _t) R _n < R _t < R _f	3.707	POTENTIAL HAZARD
4. Between Subreflector and Feed (W _f)	3767.22	POTENTIAL HAZARD
5. Between Main Reflector and Subreflector (W _{sr})	622.82	POTENTIAL HAZARD
6. Reflector Surface (W _s)	6.739	POTENTIAL HAZARD
7. Between Antenna (W _g) and ground	1.685	POTENTIAL HAZARD

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

8. Conclusions

Based on the above analysis it is concluded that the FCC RF Guidelines have been exceeded in the specified region (s) of Tables 1 ad 2. The applicant proposes to comply with the Maximum Permissible Exposure (MPE) limits of $1 \text{ mW} / \text{cm}^2$ for the Uncontrolled areas and the MPE limits of $5 \text{ mW} / \text{cm}^2$ for the Controlled areas by restricting access to the antenna by fencing and the posting of warning signs. The antenna transmitter will be turned off during maintenance in order to comply with the MPE limit of $5 \text{ mW} / \text{cm}^2$ at the Reflector Surface.

Means of Compliance of Uncontrolled Areas

This antenna is located on private property at ground level and access is restricted on two sides by perimeter walls. Access to other sides of the antenna will be restricted by fencing with access gate which will be locked at all times to prohibit access by the general public.

There are no buildings in the surrounding area that are within one diameter of the main beam in the near field, far field, or transition regions.

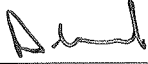
Since there are no buildings in the area that fall within one diameter of the main beam, the levels are reduced by a factor of 100 (or 20 dB).

Means of Compliance of Controlled Areas

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

The transmitter will be turned off during antenna maintenance.

Applicant Certification

Name: David Unsworth
 Title: SVP Technical and Satellite Operations
 Company: DG FastChannel, Inc.
 Signature: 
 Date: 10 Nov 2009