ANALYSIS OF NON-IONIZING RADIATION FOR A 5.5 METER EARTH STATION

This report analyzes the non-ionizing radiation levels for a 5.5 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 mW/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 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, 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)	= 5.5 meters	
Antenna surface area, (Sa)	= pi (D**2) / 4	= 23.76 m**2
Subreflector Diameter, (Ds)	= 88.9 cm	
Area of Subreflector, (As)	= pi (Ds**2)/ 4	= 6207.17 cm**2
Wavelength at 14.2500 GHz, (lambda)		= 0.021 meters
Transmit Power at Flange, (P)	= 300.00 Watts	
Antenna Gain, (Ges)	Antenna Gain at 14.2500 GHz Converted to a Power Ratio Given By: AntiLog (56.2 / 10)	= 4.169E+05 = 56.2 dBi
pi, (pi)	= 3.1415927	
Antenna aperture efficiency, (n)	= 0.55	

1. Far Field Calculations

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

Distance to the Far Field Region, (Rf) = 0.60(D**2) / lambda

= 862.1 m

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

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

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

= 13.39 W/m**2

= 1.34 mW/cm**2

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)

Extent of near field, (Rn) = D**2 / 4(lambda) = 359.22 m

The maximum power density in the near field is determined by: (1)

Near field Power Density, (Wn) = $\frac{16.0(n)P}{pi(D**2)}$ mW/cm**2

= 27.78 W/m**2

= 2.78 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 field region, as shown above, will not exceed 2.78 mW/cm**2.

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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 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) = 4(P) / As

= 193.32 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) = (4(P) / Sa)

= 50.51 W/m**2

= 5.05 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)

= 1.26 mW/cm**2

Table 1

Summary of Expected Radiation Levels

Based on (5 mW/cm**2) MPE for Controlled Environment

Region	Calculated Maximum Radiation Level (mW/cm**2)	Hazard Assessment
1. Far Field, (Rf) = 862.1 m	1.34	SATISFIES ANSI
2. Near Field, (Rn) = 359.22 m	2.78	SATISFIES ANSI
3. Transition Region, (Rt) Rn < Rt < Rf	2.78	SATISFIES ANSI
4. Between Main Reflector and subreflector	193.32	POTENTIAL HAZARD
5. Reflector Surface	5.05	POTENTIAL HAZARD
6. Between Antenna and Ground	1.26	SATISFIES ANSI

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

Table 2

Summary of Expected Radiation Levels

Based on (1 mW/cm**2) MPE for Uncontrolled Environment

Region	Calculated Maximum Radiation Level (mW/cm**2)	Hazard Assessment
1. Far Field, (Rf)= 862.1 m	1.34	POTENTIAL HAZARD
2. Near Field, (Rn)= 359.22 m	2.78	POTENTIAL HAZARD
3. Transition Region, (Rt) Rn < Rt < Rf	2.78	POTENTIAL HAZARD
4. Between Main Reflector and subreflector	193.32	POTENTIAL HAZARD
5. Reflector Surface	5.05	POTENTIAL HAZARD
6. Between Antenna and Ground	1.26	POTENTIAL HAZARD

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

7. 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 and 2 for the Maximum Permissible Exposure (MPE) limits of 1 mW/cm2 for the Uncontrolled areas and the MPE limits of 5 mW/cm2 for the Controlled areas.

ANALYSIS OF NON-IONIZING RADIATION FOR A 5.6 METER EARTH STATION

This report analyzes the non-ionizing radiation levels for a 5.6 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 mW/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 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, 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)	= 5.6 meters	
Antenna surface area, (Sa)	= pi (D**2) / 4	= 24.63 m**2
Subreflector Diameter, (Ds)	= 55.7 cm	
Area of Subreflector, (As)	= pi (Ds**2)/ 4	= 2436.69 cm**2
Wavelength at 14.2500 GHz, (lambda)		= 0.021 meters
Transmit Power at Flange, (P)	= 300.00 Watts	
Antenna Gain, (Ges)	Antenna Gain at 14.2500 GHz Converted to a Power Ratio Given By: AntiLog (56.9 / 10)	= 4.898E+05 = 56.9 dBi
pi, (pi)	= 3.1415927	
Antenna aperture efficiency, (n)	= 0.55	

1. Far Field Calculations

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

Distance to the Far Field Region, (Rf) = 0.60(D**2) / lambda

= 893.8 m

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

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

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

= 14.64 W/m**2

= 1.46 mW/cm**2

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)

Extent of near field, (Rn) = D**2 / 4(lambda) = 372.40 m

The maximum power density in the near field is determined by: (1)

Near field Power Density, (Wn) = $\frac{\text{16.0(n)P}}{\text{pi(D**2)}}$ mW/cm**2

= 26.80 W/m**2

= 2.68 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 field region, as shown above, will not exceed 2.68 mW/cm**2.

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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 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) = 4(P) / As

= 492.47 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) = (4(P) / Sa)

= 48.72 W/m**2

= 4.87 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)

= 1.22 mW/cm**2

Table 1

Summary of Expected Radiation Levels

Based on (5 mW/cm**2) MPE for Controlled Environment

Region	Calculated Maximum Radiation Level (mW/cm**2)	Hazard Assessment
1. Far Field, (Rf)= 893.8 m	1.46	SATISFIES ANSI
2. Near Field, (Rn)= 372.40 m	2.68	SATISFIES ANSI
3. Transition Region, (Rt) Rn < Rt < Rf	2.68	SATISFIES ANSI
4. Between Main Reflector and subreflector	492.47	POTENTIAL HAZARD
5. Reflector Surface	4.87	SATISFIES ANSI
6. Between Antenna and Ground	1.22	SATISFIES ANSI

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

Table 2

Summary of Expected Radiation Levels

Based on (1 mW/cm**2) MPE for Uncontrolled Environment

Region	Calculated Maximum Radiation Level (mW/cm**2)	Hazard Assessment
1. Far Field, (Rf) = 893.8 m	1.46	POTENTIAL HAZARD
2. Near Field, (Rn) = 372.40 m	2.68	POTENTIAL HAZARD
3. Transition Region, (Rt) Rn < Rt < Rf	2.68	POTENTIAL HAZARD
4. Between Main Reflector and subreflector	492.47	POTENTIAL HAZARD
5. Reflector Surface	4.87	POTENTIAL HAZARD
6. Between Antenna and Ground	1.22	POTENTIAL HAZARD

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

7. 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 and 2 for the Maximum Permissible Exposure (MPE) limits of 1 mW/cm2 for the Uncontrolled areas and the MPE limits of 5 mW/cm2 for the Controlled areas.