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PHILCO-FORD 10.4 METER C-BAND ANTENNA WITH 2000 WATT BUC

PHILCO-FORD 1.8 METER L-BAND ANTENNA WITH 10.7 WATT BUC

ANALYSIS OF NON-IONIZING RADIATION FOR 10.4 METER EARTH STATION

This report analyzes the non-ionizing radiation levels for a 10.4 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)	= 10.4 meters	
Antenna surface area, (Sa)	= pi (D**2) / 4 =	84.95 m**2
Subreflector Diameter, (Ds)	= 133.0 cm	
Area of Subreflector, (As)	= pi (Ds**2) / 4 =	13892.91 cm**2
Wavelength at 6.1750 GHz, (lambda)	=	0.049 meters
Transmit Power at Flange, (P)	= 2000.00 Watts	
Antenna Gain, (Ges)	Antenna Gain at = 2.239E+05 6.1750 GHz = 53.5 dBi Converted to a Power Ratio Given By: AntiLog (53.5 / 10)	
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

= 1335.8 m

(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) $= \frac{(GES)\ (P)}{4(pi)(Rf**2)}$

= 19.97 W/m**2

= 2.00 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) = 556.57 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

= 51.80 W/m**2

= 5.18 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 5.18 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

= 575.83 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)

= 94.17 W/m**2

= 9.42 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)

= 2.35 mW/cm**2

7. Conclusions

Based upon the above analysis, it is concluded that harmful levels of radiation could exist in those regions noted for the Controlled (Table1) and Uncontrolled Environments (Table 2).

The earth station facility is located in Santa Paula, California, which is a rural area, and distant from any offices or buildings, which could be occupied by the public. Also, the satellite arc is such, that the antennas are pointed away from any public areas.

Further, the antenna facility is surrounded by a fence, which restricts any public access.

Since the facility is located in a rural location, and is surrounded by a fence, which will restrict public access, and since one diameter removed from the center of the main beam the levels are down at least 20 dB, or by a factor of 100, public safety, as well as operating personnel safety will be ensured.

Finally, occupational exposure will be limited, and the transmitter will be turned off during periods of maintenance, so that the MPE standard of 5.0 mw/cm**2 will be complied with for those regions in close proximity to the main reflector, and subreflector, which could be occupied by operating personnel.

Analysis of Non-Ionizing Radiation for 1.8 Meter Earth Station System

This report analyzes the non-ionizing radiation levels for a 1.8 meter earth station system. The analysis and calculations performed in this report are in compliance with the methods described in the FCC Office of Engineering and Technology Bulletin, No. 65 first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC R&O 96-326. Bulletin No. 65 and the FCC R&O specifies that there are two separate tiers of exposure limits that are dependant on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure. The Maximum Permissible Exposure (MPE) limits for persons in a General Population/ Uncontrolled environment are shown in Table 1. The General Population/ Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, between the subreflector or feed and main reflector surface, at the main reflector surface, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mWatts/cm**2)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1. 0

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mWatts/cm**2)
30-300	1. 0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

Table 3 contains the parameters that are used to calculate the various power densities for the earth stations.

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Abbreviation	Value	Units
Antenna Diameter	D	1.8	meters
Antenna Surface Area	Sa	II* D**2/4	meters**2
Feed Flange Diameter	Df	7.5	cm
Area of Feed Flange	Fa	II* Df**2/4	cm**2
Frequency	Frequency	1640	MHz
Wavelength	lambda	300/frequency(MHz)	meters
Transmit Power	p	10.70	Watts
Antenna Gain	Ges	27.7	dBi
Pi	II	3.1415927	n/a
Antenna Efficiency	n	0.62	n/a

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation: (1)

Distance to the Far Field Region, (Rf) = 0.60 * D**2 / lambda (1)
= 10.6 meters

The maximum main beam power density in the Far Field can be determined from the following equation: (2)

On-Axis Power Density in the Far Field, (Wf) = Ges *PI 4 *II* Rf**2 (2)
= 4.440 Watts/meters**2
= 0.444 mWatts/cm**2

2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation: (3)

Extent of the Near Field, (Rn) = D**2 / (4 *lambda) (3)
= 4.4 **meters**

The maximum power density in the Near Field can be determined from the following equation: (4)

Near Field Power Density, (Wn) = 16.0 * n * P /II* D**2 (4)
= 10.364 Watts/meters**2
= 1.036 mWatts/cm**2

3. Transition Region Calculations

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing 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 calculated in Section 1 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance Rt can be determined from the following equation: (5)

Transition region Power Density, (Tt) = Wn *Rn / Rt (5)
= 1.036 mWatts/cm**2

4. Region between Feed Assembly and Antenna Reflector

Transmissions from the feed assembly are directed toward the antenna reflector surface, and are confined within a conical shape defined by the type of feed assembly. The most common feed assemblies are waveguide flanges, horns or subreflectors. The energy between the feed assembly and reflector surface can be calculated by determining the power density at the feed assembly surface. This can be determined from the following equation: (6)

Power Density at Feed Flange, (Wf) = 4 *PI Fa (6)
= 968.794 mWatts/cm**2

5. Main Reflector Region

The power density in the main reflector is determined in the same manner as the power density at the feed assembly. The area is now the area of the reflector aperture and can be determined from the following equation: (7)

Power Density at the Reflector Surface, (Ws) = 4 *PI Sa (7)
= 16.819 Watts/meters**2
= 1.682 mWatts/cm**2

6. Region between Reflector and Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and ground can be determined from the following equation: **(8)**

Power Density between Reflector and Ground, (Wg) = P / Sa (8)
= 4.205 Watts/meters**2
= 0.420 mWatts/cm**2

Table 4. Summary of Expected Radiation levels for Uncontrolled Environment

Region	Calculated Maximum Radiation Power Density Level (mWatts/cm**2)	Hazard Assessment
1. Far Field (Rf) = 10.6 meters	0.444	Satisfies FCC MPE
2. Near Field (Rn) = 4.4 meters	1. 036	Potential Hazard
3. Transition Region Rn< Rt < Rf, (Rt)	1. 036	Potential Hazard
4. Between Feed Assembly and Antenna Reflector	968.794	Potential Hazard
5. Main Reflector	1. 682	Potential Hazard
6. Between Reflector and Ground	0.420	Satisfies FCC MPE

Table 5. Summary of Expected Radiation levels for Controlled Environment

Region	Calculated Maximum Radiation Power Density Level (mWatts/cm**2)	Hazard Assessment
1. Far Field (Rf) = 10.6 meters	0.444	Satisfies FCC MPE
2. Near Field (Rn) = 4.4 meters	1. 036	Satisfies FCC MPE
3. Transition Region Rn< Rt < Rf, (Rt)	1. 036	Satisfies FCC MPE
4. Between Feed Assembly and Antenna Reflector	968.794	Potential Hazard
5. Main Reflector	1. 682	Satisfies FCC MPE
6. Between Reflector and Ground	0.420	Satisfies FCC MPE

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

7. Conclusions

Based upon the above analysis, it is concluded that harmful levels of radiation may exist in those regions noted for the Uncontrolled (Table 4) Environment.

The antenna is installed at Airbus DS SatCom Government Inc. Santa Paula, California Teleport facility, which is located in a rural area. Further, the complex is surrounded by a fence, which will restrict any public access. The earth station will be marked with the standard radiation hazard warnings, as well as the area in the vicinity of the earth stations to inform those in the general population, who might be working or otherwise present in or near the direct path of the main beams.

Airbus DS SatCom Government Inc will ensure that the main beam of the antenna will be pointed at least one diameter away from any building, or other obstacles in those areas that exceed the MPE levels.

Finally, the earth station's operating personnel will not have access to areas that exceed the MPE levels, while the earth station is in operation. The transmitter will be turned off during periods of maintenance, so that the MPE standard of 5.0 mw/cm**2 will be complied with for those regions in close proximity to the main reflector, which could be occupied by operating personnel.