RADIATION HAZARD EVALUATION

For

Clear Channel Satellite Services - 2.4 Ku-Band Antenna (Channel Master 243)

1 Overview

Determining the region around an antenna where radiation hazardous to human health is a consideration of many factors. With a parabolic dish antenna, the region is highly directional and the actual hazardous region is dependent on the antenna elevation angle. The following formulae are used to determine the near and far field regions. These regions are in the main beam of the radiation pattern, which we will assume consists of a conical angle extending +/- 3 degrees from the center axis of the antenna.

The analysis contained herein predicts the radiation levels around the proposed antenna. The calculations contained in this report are in accordance with FCC guidelines as contained in CFR 47 Part 1.1310 and OET Bulletin 65. The maximum level of non-ionizing radiation to which the general public is exposed is defined for controlled and uncontrolled environments as follows:

Environment	Exposure Limit: Power	Exposure Limit: Duration
Controlled - (applicable to system operators and technicians in the service area of the antenna):	**5 mW/cm^2**	**6 Minutes**
Uncontrolled - (applicable to general public in proximity of the antenna):	**1 mW/cm^2**	**30 Minutes**

2.1 Earth Station Technical Parameters - Input Data

1A	Antenna Diameter - Standard Parabola	2.4	meters
1B	Antenna Diameter - Elliptical Reflector		meters
1B1	Major Axis Diameter		meters
1B2	Minor Axis Diameter		meters
2	G = Antenna Isotropic Gain	49.3	dBi
3	h = Nominal Antenna Efficiency	68	Percent
4	Nominal Frequency	14.25	GHz
5	Maximum Transmit Power Amplifier Size	100	Watts
6	Number of Carriers	1	each
7	W/G Loss from Transmitter to Feed	0.5	dB
8	Multicarrier Fixed Backoff	2	dB
9	Desired Object Clearance Height	3	meters

2.2 Earth Station Technical Parameters - Calculated Data

10	A = Antenna Surface Area	4.52	sq meters		
10A	Standard Parabolic Reflector	4.523893421	sq meters		
10B	Elliptical Reflector	0.00	sq meters		
11	D = Effective Antenna Diameter	2.4	meters		
12	Total Transmit Power	100	Watts		
13	P = Total Feed Input Power (watts)	56.23	Watts		
14	E = Maximum E/S EIRP - Calculated	66.80	dBW		
15	λ = Wavelength (= c/f in m/GHz)	0.0210	m/GHz		
16	p = Pi	3.14159			
17	R_{nf} = Near Field Limit ($D^2/4\lambda$)	68	meters	223	feet
18	R_{ff} = Far Field Limit (R_{ff}=0.6D2/λ)	164	meters	538	feet
19	R_{nf} to R_{ff} = Transition Region	68 to 164	meters	223 to 538	feet

3 Power Density at the Antenna Surface

The power density at the reflector surface is expected to exceed the safe limits. The reflector is not accessible to the public and will not present a hazard. Terminal operators and technicians receive training identifying the area as presenting high exposure levels. Procedures are incorporated requiring that transmitters are not operating when access to the reflector surface is required.

The power density at the antenna reflector surface can be calculated by the expression:

$PD_{REFL} = 4P/A =$ **4.97 mW/cm^2**

Where: P = Total power at the feed, milliwatts
A = Total area of reflector, sq cm

Evaluation:

Controlled Environment (less than 5 mW/cm^2 in 6 minutes): **SAFE**

Uncontrolled environment (less than 1 mW/cm^2 in 30 minutes): **Mitigation Required**

4 On-Axis Power Density in the Near Field Region

The Radiating Near Field Region for a parabolic, circular reflector, is defined as extending from the reflector to a distance equal to the diameter squared divided by twice the wavelength. This distance is referred to as the Rayleigh distance. In this region the power is nearly all contained within a cylinder of radius 0.5D. As a safety measure the highest possible power density is applied to the whole of this region.

The power density in the Near Field Region of the antenna can be calculated by the expression:

$16 \cdot P \cdot h / \pi \cdot D^2 =$ **3.38 mW/cm^2**

Where: P = Total power at the feed, milliwatts
h = Nominal antenna efficiency
D = Effective antenna diameter, meters

Evaluation:

Controlled Environment (less than 5 mW/cm^2 in 6 minutes): **SAFE**

Uncontrolled environment (less than 1 mW/cm^2 in 30 minutes): **Mitigation Required**

5 On-Axis Power Density in the Transition Region

The transition region is located between the Near Field and Far Field regions. The power density begins to vary inversely with distance from the antenna in the transition region. The maximum power density in this region will not exceed the power density calculated for the Near Field region. Once again the power density figures are for the On-Axis and contained with a cylinder extending within +/- 1 degree of beam center. Where the antennas are normally operated at an elevation angle typically greater than 10°, the actual safe distance in front of the antenna may be found in paragraph 10. The formula for the calculation is used to evaluate the power density at any given distance in the transition as expressed below:

The power density in the On-Axis Transition Region can be calculated by the expression:

$PD_t=(PD_{nf})(R_{nf})/R$

Where: PD_{nf} = The Near Field power density, mW/cm^2
R_{nf} = Near Field maximum distance, meters
R = Distance to point of interest

For: 68 < R < 164 meters

Evaluation:

Controlled Environment Safe Operating Distance, meters: **46 meters**

Uncontrolled environment Safe Operating Distance, meters: **230 meters**

6 On-Axis Power Density in the Far Field Region

The On-Axis power density in the far field region (PD_{ff}) varies inversely with the square of the distance. The calculation is performed below:

The Power Density at the start of the Far Field region can be calculated by the expression:

$E-10\log(4pR^2)$	11.51	dBW/m^2
$antilog((E-10\log(4pR^2)/10)/10$	**1.42**	**mW/cm^2**

Evaluation:

Controlled Environment (less than 5 $mW/cm^{2\ in}$ 6 minutes):	**SAFE**
Uncontrolled environment (less than 1 mW/cm^2 in 30 minutes):	**Mitigation Required**

7 Off-Axis Power Density Levels at the Far Field Limit and Beyond

In the far field region, the power is distributed in a pattern of sidelobes as a function of the off-axis angle between the antenna center line and the point of interest. Off-axis power density in the far field can be estimated using the antenna radiation patterns prescribed for the antenna in use. Usually this will correspond to the antenna gain pattern envelope defined by the FCC or the ITU, which takes the form of:

$G_{off} = 32 - 25\log(\theta)$

for θ from 1 to 48 degrees; -10 dBi from 48 to 180 degrees
(Applicable for commonly used satellite transmit antennas)

For example: At one (1) degree off axis At the far-field limit, we can calculate the power density as:

$G_{off} = 32 - 25\log(1) = 32 - 0$ dBi =	1585	numeric
$PD_{1\ deg\ off\text{-}axis} = PD_{ff} x\ 1585/G$	**0.0264**	**mW/cm^2**

Evaluation:

Considering that satellite antenna beams are aimed skyward, power density in the far field will usually not be a problem except at low look angles. In these cases, off axis gain reduction techniques may be used to further reduce the power density levels.

8 Off-Axis Power Density Levels at the Near Field and Transitional Regions

According to Bulletin 65, off-axis calculations in the near field may be performed as follows: assuming that the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point is at least a factor of 100 (20 dB) less than the value calculated for the near field main beam power density. This may be calculated as follows:

$PD_{nf(off\text{-}axis)} = PD_{nf}/100$ =	**0.0338**	**mW/cm^2**

9 Region Between the Feed Horn and Reflector/Sub-Reflector

Transmissions from the feed horn are directed toward the main reflector or the sub-reflector depending on the type of antenna (prime focus, Gregorian or Cassegrain). The transmission is confined within a conical shape defined by the feed horn. The energy between the feedhorn and the reflector/sub-reflector is assumed to be in excess of any limit for permissible exposure. This region is not accessible to the general public, and operators and technicians should be suitable trained and procedures in place to preclude access to this region during active transmission.

10 Evaluation of Safe Occupancy Area in Front of the Antenna

The distance (L) from a vertical axis passing through the dish center to a safe off-axis point in front of the antenna can be determined based on the dish diameter. Assuming a flat terrain and a point on the horizontal plane with the center point of the antenna, the relationship is determined by the following formula:

L = (D/sin a) + (2h - D - 2)/(2 tan a)

Where: a = minimum elevation angle of antenna

D = Dish diameter in meters

h = Maximum height of object to be cleared, meters

For distances equal to or greater than determined by the equation above, the radiation hazard will be below safe levels

For:	D =	2.4	meters
	h=	3	meters

Safe distance for the following elevation angles (a):

a - Elevation Angle (degrees)	L - Safe Distance	
10	**18.36**	**meters**
15	**12.26**	**meters**
20	**9.22**	**meters**
25	**7.39**	**meters**
30	**6.19**	**meters**
40	**4.69**	**meters**
50	**3.80**	**meters**

11 Mitigation Analysis

Mitigation of accessibility to hazardous regions may take several forms depending on the antenna application and location. In instances such as mobile applications, the antenna may be located such that the hazardous region is not accessible during operation. An example may be in a mobile configuration where the antenna is located on top of a vehicle during operation. In other fixed installation instances the hazardous area may be fenced off to prevent access. In areas where only operators and technicians have access, training in safeguards and proper markings of hazardous areas may be sufficient. This analysis tool is designed to identify the hazardous exposure regions around an operating antenna system in accordance with the defined power density limits in CFR 47, part 1.1310 and OET bulletin 65.