Radiation Hazard Study

KU-Band Earth Station located in Southfield, Michigan

Longitude/Latitude 42°27’59.29” N 83°14’5.95”

The purpose of this study is to ascertain and then tabulate the Near Field and Far Field, both on-axis and off-axis, flux densities of the non-ionizing radiation for this fixed earth station. The results were then compared to the acknowledged ANSI maximum permissible exposure level (MPE) of five (5) milliwatt per square cm – 5 mW/cm^2 - over a 6 (six) minute exposure period.

The location of this fixed transmit antenna site is in a parking lot at the rear of a Data Center with minimal human or vehicular traffic in the immediate vicinity.

This earth station facility is located on private property designated as industrial, with magnetic card security access and also equipped with CCTV cameras which are monitored 24/7. This Data Center property is not designated as an animal sanctuary, not First-Nation land and there are no Public Parks or Municipal Playgrounds in the vicinity.

A six foot (6) tall chain-link fence surrounds the perimeter of the transmit antenna that keeps people back > five (5) linear feet from the nearest component of the earth station - the lip of the transmit antenna is seven (7) feet from ground level. Several visible radiation warning signs are posted on all four (4) sides of the perimeter fence and also on the gate to this restricted area. These additional precautions also further minimize unauthorized human access to the radiation source.

DEFINITIONS AND GLOSSARY OF TERMS

The following specific words and terms may be used in this bulletin. These definitions are adapted from those included in the American National Standards Institute (ANSI) 1992 RF exposure standard [Reference 1], from NCRP Report No. 67 [Reference 19] and from the FCC's Rules (47 CFR § 2.1 and § 1.1310).

Average (temporal) power

The time-averaged rate of energy transfer.

Averaging time

The appropriate time period over which exposure is averaged for purposes of determining compliance with RF exposure limits.

Continuous exposure

Exposure for durations exceeding the corresponding averaging time.

Decibel (dB)

Ten times the logarithm to the base ten of the ratio of two power levels.

Duty factor

The ratio of pulse duration to the pulse period of a periodic pulse train. Also, may be a measure of the temporal transmission characteristic of an intermittently transmitting RF source such as a paging antenna by dividing average transmission duration by the average period for transmissions. A duty factor of 1.0 corresponds to continuous operation.

Effective radiated power (ERP) (in a given direction).

The product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction.

Equivalent Isotropically Radiated Power (EIRP)

The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna.

Electric field strength (E)

A field vector quantity that represents the force (**F**) on an infinitesimal unit positive test charge (**q**) at a point divided by that charge. Electric field strength is expressed in units of volts per meter (V/m).

Energy density (electromagnetic field)

The electromagnetic energy contained in an infinitesimal volume divided by that volume.

Exposure

Exposure occurs whenever and wherever a person is subjected to electric, magnetic or electromagnetic fields other than those originating from physiological processes in the body and other natural phenomena.

Exposure, partial-body

Partial-body exposure results when RF fields are substantially non-uniform over the body. Fields that are non-uniform over volumes comparable to the human body may occur due to highly directional sources, standing-waves, re-radiating sources or in the near field. See

Far-field region

That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In this region (also called the free space region), the field has a predominantly plane-wave character, i.e., locally uniform distribution of electric field strength and magnetic field strength in planes transverse to the direction of propagation.

Gain (of an antenna)

The ratio, usually expressed in decibels, of the power required at the input of a loss-free reference antenna to the power supplied to the input of the given antenna to produce, in a given direction, the same field strength or the same power density at the same distance. When not specified otherwise, the gain refers to the direction of maximum radiation. Gain may be considered for a specified polarization. Gain may be referenced to an isotropic antenna (dBi) or a half-wave dipole (dBd).

General population/uncontrolled exposure

For FCC purposes, this applies to human exposure to RF fields when the general public is exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Therefore, members of the general public always fall under this category when exposure is not employment-related.

Hertz (Hz)

The unit for expressing frequency (***f***). One hertz equals one cycle per second.

Magnetic field strength (H)

A field vector that is equal to the magnetic flux density divided by the permeability of the medium. Magnetic field strength is expressed in units of amperes per meter (A/m).

Maximum permissible exposure (MPE)

The rms and peak electric and magnetic field strength, their squares, or the plane-wave equivalent power densities associated with these fields to which a person may be exposed without harmful effect and with an acceptable safety factor.

Near-field region

A region generally in proximity to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character, but vary considerably from point to point. The near-field region is further subdivided into the reactive near-field region, which is closest to the radiating structure and that contains most or nearly all of the stored energy, and the radiating near-field region where the radiation field predominates over the reactive field, but lacks substantial plane-wave character and is complicated in structure. For most antennas, the outer boundary of the reactive near field region is commonly taken to exist at a distance of one-half wavelength from the antenna surface.

Occupational/controlled exposure

For FCC purposes, applies to human exposure to RF fields

when persons are exposed as a consequence of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure. Occupational/controlled exposure limits also apply where exposure is of a transient nature as a result of incidental passage through a location where exposure levels may be above general population/uncontrolled limits (see definition above), as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

Peak Envelope Power (PEP)

The average power supplied to the antenna transmission line by a radio transmitter during one radiofrequency cycle at the crest of the modulation envelope taken under normal operating conditions.

Power density, average (temporal)

The instantaneous power density integrated over a source repetition period.

Power density (S)

Power per unit area normal to the direction of propagation, usually expressed in units of watts per square meter (W/m2) or, for convenience, units such as milliwatts per square centimetre (mW/cm2) or microwatts per square centimetre (µW/cm2). For plane waves, power density, electric field strength (E) and magnetic field strength (H) are related by the impedance of free space, i.e., 377 ohms, as discussed in Section 1 Bulletin 65 Although many survey instruments indicate power density units ("far-field equivalent" power density), the actual quantities measured are E or E2 or H or H2.

Power density, peak

The maximum instantaneous power density occurring when power is transmitted.

Power density, plane-wave equivalent or far-field equivalent

A commonly-used terms associated with any electromagnetic wave, equal in magnitude to the power density of a plane wave having the same electric (E) or magnetic (H) field strength.

Radiofrequency (RF) spectrum

Although the RF spectrum is formally defined in terms of frequency as extending from 0 to 3000 GHz, for purposes of the FCC's exposure guidelines, the frequency range of interest in 300 kHz to 100 GHz. In this study 14.25 GHz is the frequency being studied.

Re-radiated field

An electromagnetic field resulting from currents induced in a secondary, predominantly conducting, object by electromagnetic waves incident on that object from one or more primary radiating structures or antennas. Re-radiated fields are sometimes called "reflected" or more correctly "scattered fields." The scattering object is sometimes called a "reradiator" or "secondary radiator".

RF "hot spot"

A highly localized area of relatively more intense radio-frequency radiation that manifests itself in two principal ways:

(1) The presence of intense electric or magnetic fields immediately adjacent to conductive objects that are immersed in lower intensity ambient fields (often referred to as re-radiation), and

(2) Localized areas, not necessarily immediately close to conductive objects, in which there exists a concentration of RF fields caused by reflections and/or narrow beams produced by high-gain radiating antennas or other highly directional sources. In both cases, the fields are characterized by very rapid changes in field strength with distance. RF hot spots are normally associated with very nonuniform exposure of the body (partial body exposure). This is not to be confused with an actual thermal hot spot within the absorbing body.

Root-mean-square (rms)

The effective value, or the value associated with joule heating, of a periodic electromagnetic wave. The rms value is obtained by taking the square root of the mean of the squared value of a function.

Scattered radiation

An electromagnetic field resulting from currents induced in a secondary, conducting or dielectric object by electromagnetic waves incident on that object from one or more primary sources.

Short-term exposure

Exposure for durations less than the corresponding averaging time.

Specific absorption rate (SAR)

A measure of the rate of energy absorbed by (dissipated in) an incremental mass contained in a volume element of dielectric materials such as biological tissues. SAR is usually expressed in terms of watts per kilogram (W/kg) or milliwatts per gram (mW/g). Guidelines for human exposure to RF fields are based on SAR thresholds where adverse biological effects may occur. When the human body is exposed to an RF field, the SAR experienced is proportional to the squared value of the electric field strength induced in the body.

Wavelength

(**λ**). The wavelength (**λ**) of an electromagnetic wave is related to the frequency (***f***) and velocity (***v***) by the expression $v = f\lambda$. In free space the velocity of an electromagnetic wave is equal to the speed of light, i.e., approximately 300 x 10^6 m/s.

Southfield Earth Station Physical Inventory

Antenna:	4.6 meter ESA-E2 type approved
Manufacturer:	Andrews (Now ASI Signal)
Model:	10245
Antenna Surface area:	16.619 m^2
Antenna gain:	56.60 dBi or
Antenna efficiency @ 14.25 GHz:	55%
Elevation:	40^0
Azimuth:	210.6°
Feed horn design:	Hyperbolic sub-reflector
Feed Input:	2 port Tx/Rx
De-Icing:	Full electric blanket/feedhorn output - electric heater
Dynamic Range:	14.250 GHz +/- 250 MHz
Transmit Power:	50 W nominal – 100 W c/w UPC

Transition Region

Power density in the transition region decreases inversely with distance from the antenna, while power density in the far-field (Fraunhofer region) of the antenna decreases inversely with the **square** of the distance. For purposes of evaluating RF exposure the maximum power density in the transition region will not exceed that calculated for the near field region – use S_{nf} value below.

Near-Field Region

In the near-field, or Fresnel region, of the main beam, the power density can reach a maximum before it begins to decrease with distance. The extent of the near-field can be described by the following equation (**D** and **λ** in same units):
where:

$\mathbf{R_{nf}}$ = extent of near-field
D = maximum dimension
λ = wavelength

Far-Field Region

The power density in the far-field or Fraunhofer region of the antenna pattern decreases inversely as the square of the distance. The power density in the far-field region of the radiation pattern can be estimated by the general equation discussed earlier where:

S_{ff} = power density
P = power fed to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the point of interest

Conclusions

Description	Input	Calculations		Units	Hazard Assessment
Antenna Size, (**D**)	4.6			m	
Antenna Surface Area, (**$A_{surface}$**)		ð D^2 / 4	16.619	m^2	
Sub reflector Diameter (**D_{sr}**)	43.82			cm	
Area of Sub reflector (**A_{sr}**)		ð D_{sr}^2 / 4	1508.12	cm^2	
Frequency (**F**)	14.25			GHz	
Speed of Light (**c**)	300 X 10^6			m/s	
Wavelength at, (**lambda ë**)		300 X 10^6/c	0.02105	m	
Transmit Power, (**P**)	100			W	
Antenna Gain, (**Ges**)	56.6			dBi	
Antenna Gain Factor, (**G**)		$10^{Ges/10}$	457,088.2	n/a	
PI	3.142			n/a	
Antenna Aperture Efficiency, (**n**)	55%			%	
ANSI Safe Power Density, (**W_s**)	5			mW/cm^2	
Far Field Calculations					
Distance to the Far Field Region, (**R_{ff}**)		R_{ff} = 0.60 D^2/ë	603.1	m	
Far Field On-axis power density, (**S_{ff}**)		S_{ff} = G P/(4 ð R_{ff}^2)	10.002	W/m^2	
			1.0002	mW/cm^2	Satisfies FCC MPE
Near Field Calculations					
Extent of Near Field, (R_{nf})		R_{nf} = D^2 /(4ë)	251.3	m	
Near Field On-axis power density, (**S_{nf}**)		S_{nf} = 16.0 n P/(ð D^2)	13.238	W/cm^2	
			1.3238	mW/cm^2	Satisfies FCC MPE
Region Between The Main Reflector And The Sub Reflector					
Power Density at the sub reflector (**S_{sr}**)		S_{sr} = 4000 P / A_{sr}	265.232	mW/cm^2	Potential Hazard
Main Reflector Region					
Power Density at the Main Relector Surface (**$S_{surface}$**)		$S_{surface}$ = 4 P / $A_{surface}$	24.069	W/cm^2	
			2.407	mW/cm^2	Satisfies FCC MPE
Region between the Main Reflector and the Ground					
Power Density between Reflector and Ground (**S_g**)		S_g = P / $A_{surface}$	6.017	W/cm^2	
			0.602	mW/cm^2	Satisfies FCC MPE

Bill Barr – P Eng. Ver. 2.1 Jan. 15, 2010