EMF Exposure Assessment 4.8-Meter Antenna for OmniTRACS Earth Station

May 18, 2005

80-Jxxxx-1 Rev A

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Contents

1. Introduction

This report assesses non-ionizing electromagnetic field radiation from a 5-meter antenna for OmniTRACS earth station with pursuant to FCC OET Bulletin, No. 65, Edition 97-01 [1]. Power flux densities generated from the antenna at far field, near field, transition region, sub-reflector, and main reflector surface are calculated based on the method recommended by the FCC Bulletin.

Table 1 outlines the limits of exposure to EMF in the Ku-band in terms of power density specified by FCC and ICNIRP [2].

Table 1. Maximum permissible exposure (MPE) limits at Ku-band

Exposure environment	Power density (W/m^2)	Average time (min)	
		FCC	ICNIRP
General public/uncontrolled	10	30	4 (based on $68/f^{1.05}$)
Occupational/controlled	50	6	4 (based on $68/f^{1.05}$)

2. Antenna and System Parameters

The antenna and system specifications for power density assessment are listed in Table 2. Drawing of the antenna assembly and partition of power density are shown in Fig.1 and Fig.2 respectively. The worst case of simultaneous transmit of 13 carriers are considered in the analysis.

Table 2. Antenna and system specs

Main reflector diameter and area	$D = 4.8\,\mathrm{m}$, $A_a = \pi D^2/4 = 18.1\,\mathrm{m}^2$
Sub-reflector diameter and area	$D_S = 0.356\,\mathrm{m}$, $A_S = \pi D_S{}^2/4 = 0.1\,\mathrm{m}^2$
Wavelength at mid-band 14.25 GHz	$\lambda = 0.021\,\mathrm{m}$
Maximum feed power at antenna flange feed under 13 systems	$P_{\max} = 10\log(300) - 9 + 10\log(13) = 26.9\,\mathrm{dBW} = 491\,\mathrm{W}$
Average power in any 30-min and 6-min period at flange feed	$P_{\mathrm{avg}} = 10\log(52) - 9 + 10\log(13) = 19.3\,\mathrm{dBW} = 85\,\mathrm{W}$
Antenna gain	$G = 55\,\mathrm{dBi} = 10^6$
Antenna aperture efficiency	$\eta = \left(G\lambda^2/4\pi A_a\right) = 0.62$
Antenna pattern beam-width	-15dB (0.032) at 0.59°

Figure 1. 4.8-meter ku-band antenna assembly – side view

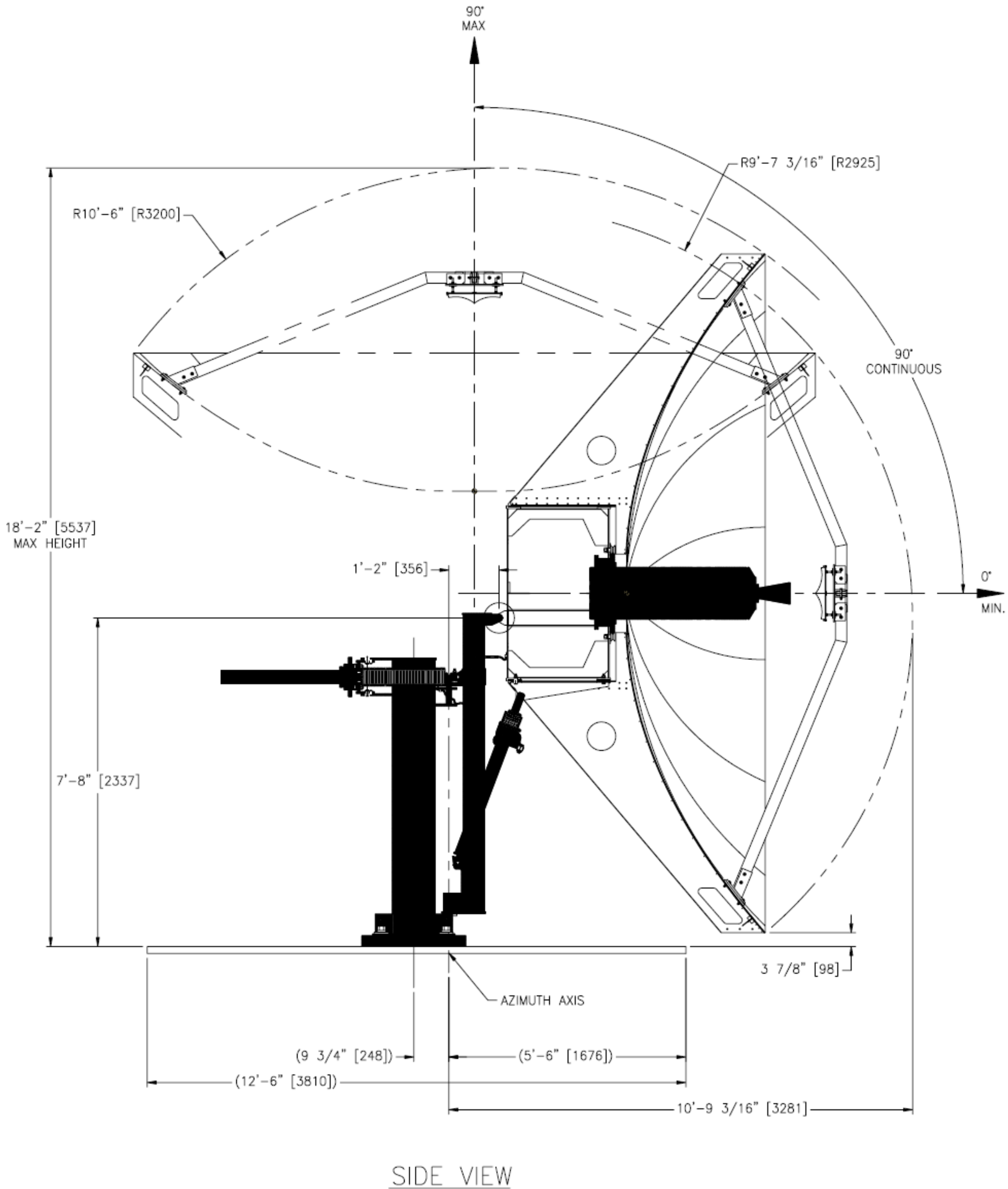
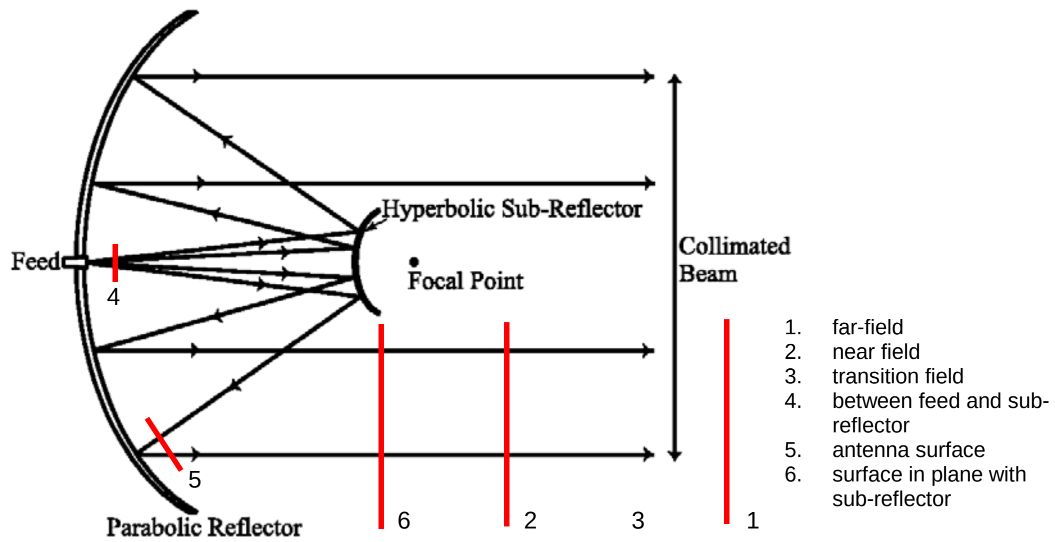


Figure 2. Radiation 4.8-meter ku-band antenna assembly – side view



3. On-Axis Power Density Calculation

3.1 Far Field Calculations

The distance to the beginning of the far field can be calculated as follows [1]

$$R_{FF} = \frac{0.60D^2}{\lambda} = 656.6\ \text{m}$$

The maximum on-axis power density in the far field can be calculated as follows

$$S_{FF} = \frac{G \times P_{\max}\ (\text{or } EIRP)}{4\pi R_{FF}^2} = 28.65\ \text{W/m}^2$$

The average on-axis power density in the far field can be then calculated as

$$S_{FF\_avg} = \frac{P_{avg}}{P_{\max}} S_{FF} = 4.96\ \text{W/m}^2$$

The average off-axis (0.3°) power density in the far field can be calculated as

$$S_{FF\_avg\_off} = 0.032 \times S_{FF\_avg} = 0.16\ \text{W/m}^2$$

3.2 Near Field Calculations

The distance to the end of the near field can be calculated as follows

$$R_{NF} = \frac{D^2}{4\lambda} = 273.6\,\text{m}$$

The maximum on-axis power density in the near field can be determined by

$$S_{NF} = \frac{16\eta P_{\max}}{\pi D^2} = 66.89\,\text{W/m}^2$$

The average on-axis power density in the near field can be then calculated as

$$S_{NF\_\text{avg}} = \frac{P_{\text{avg}}}{P_{\max}} S_{NF} = 11.58\,\text{W/m}^2$$

The average off-axis (>0.3°) power density in the near field can be calculated as

$$S_{NF\_\text{avg\_off}} < 0.032 \times S_{NF\_\text{avg}} = 0.37\,\text{W/m}^2$$

3.3 Transition Region Calculations

The transition region will be the region extending from R_{NF} to R_{FF}. If the location falls within this transition region, the on-axis power density can be determined by the following equation:

$$S_{TF} = \frac{S_{NF} R_{NF}}{R}$$

The exposure level S_T at the transition region R ($R_{NF} < R < R_{FF}$) would be less than near-field exposure level and greater than far field exposure level, i.e.,

$$S_{FF} < S_{TF} < S_{NF}$$

Therefore the average power density in transition region will not exceed 3.0 W/m^2.

3.4 Region between Power Feed and Sub-Reflector

The maximum on-axis power density between the RF power feed and sub-reflector can be determined by the following equation:

$$S_4 = \frac{P_{\max}}{A_S} = 4944 \text{ W/m}^2$$

The average on-axis power density between the RF power feed and sub-reflector can be then calculated as

$$S_{4\_avg} = \frac{P_{avg}}{P_{\max}} S_4 = 856 \text{ W/m}^2$$

3.5 Antenna Surface (Main Reflector)

Assuming uniform illumination and full reflection of the reflector surface, the power density at the antenna surface (main reflector) can be calculated as follows:

$$S_5 = \frac{4P_{\max}}{A_a} = 108.5 \text{ W/m}^2$$

The average on-axis power density at the antenna surface (main reflector) can be then calculated as

$$S_{5\_avg} = \frac{P_{avg}}{P_{\max}} S_5 = 18.8 \text{ W/m}^2$$

The average off-axis (>0.3°) power density at the antenna surface (main reflector) can be calculated as

$$S_{5\_avg\_off} < 0.032 \times S_{5\_avg} = 0.59 \text{ W/m}^2$$

3.6 Antenna Area in Plane with Sub-Reflector

Assuming uniform illumination of the reflector surface, the power density near the antenna surface in plane with sub-reflector can be calculated as follows:

$$S_6 = \frac{2.56P}{A_a} = 69.5 \text{ W/m}^2$$

The average power density near the antenna surface in plane with sub-reflector can be then calculated as

$$S_{6\_avg} = \frac{P_{avg}}{P_{max}} S_6 = 12.0\ \mathrm{W/m^2}$$

The average off-axis (>0.3°) power density near the antenna surface in plane with sub-reflector can be calculated as

$$S_{5\_avg\_off} < 0.032 \times S_{5\_avg} = 0.38\ \mathrm{W/m^2}$$

4. Conclusions

Table 3 summarizes the expected RF exposure levels from the above analysis. Under the worst-case scenario, at regions in axis with main beam of the antenna, except the region between power feed and sub-reflector, the EMF exposure level would be below the occupational exposure limit specified by FCC and ICNIRP. At regions of off-axis (0.3º) from the main beam, the EMF exposure level would be below the public exposure limit specified by FCC and ICNIRP.

Table 3. Summary of expected RF exposure levels in beam and outside beam area

Region	On-axis average exposure level (W/m^2)	Off-axis (>0.59º) ave exposure level (W/m^2)	RF Hazard assessment (off-axis area)
Far field (R>657m)	<4.96	<0.16	Meet FCC MPE limit for public exposure
Transition field (961m<R<2308m)	5.0 – 11.6	0.16 – 0.37	Meet FCC MPE limit for public exposure
Near field (R>964m)	<11.6	<0.37	Meet FCC MPE limit for public exposure
Between power feed and sub-reflector	855.6	N/A	Potential hazard
Antenna surface (main reflector)	18.8	0.59	Meet FCC MPE limit for public exposure
Antenna area in plane with sub-reflector	12.0	0.38	Meet FCC MPE limit for public exposure

In addition, the earth station with the antenna is isolated from public access by a fence by at least 10 meters. The antenna beam will be elevated at least 30 degrees from the horizontal plane for normal operation. The actual exposure would be much lower than the above analysis. To ensure RF safety for operating personnel, the transmitter will be turned off during antenna maintenance.

5. Reference

[1] FCC OET Bullet No. 65, Edition 97-01, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields”, August 1997.

[2] ICNIRP Guidelines, “Guidelines for limiting exposure to time-varying electric magnetic, and electromagnetic fields”, Health Physics, Vol.74, No.4, April 1998.

6. Engineering Declaration

I hereby certify that the information contained in this test report is complete and true to the best of my knowledge. All test and analysis were performed in accordance with good engineering practices.

Certified by: Fang Han
Regulatory Engineer, Senior Staff
Qualcomm Inc.

Date: May 18, 2005