Panasonic Avionics Corporation
Modification to VSAT License

Technical Appendix

I. ThinKom Terminal – Radiation Hazard Analysis
II. ThinKom Terminal – Data Sheet

I. Radiation Hazard Analysis for ThinKom Terminal

This analysis predicts the radiation levels around a proposed earth station terminal, comprised of one array type antenna. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01, pp 26-30.

The maximum level of non-ionizing radiation to which personnel may be exposed is limited to a power density level of 5 milliwatts per square centimeter (5 mW/cm^2) averaged over any 6-minute period in a controlled environment and the maximum level of non-ionizing radiation to which the general public is exposed is limited to a power density level of 1 milliwatt per square centimeter (1 mW/cm^2) averaged over any 30-minute period in an uncontrolled environment.

The worse-case radiation hazards exist along the beam axis. The antennas will be either roof-mounted or installed in an area inaccessible to the general public with a clear view of the southern sky. Thus, under normal circumstances, it is highly unlikely that the antenna axis will be aligned with any occupied area since that would represent a blockage to the desired signals, thus rendering the link unusable and disabling the transmitter.

The ThinKom VICTS antenna will typically operate above 20 degree elevation. The main beam gain will vary with elevation as shown in Figure 1 and Table 1 below. The system is equipped with a 50 watt amplifier and has 2.7 db of output circuit losses. The analysis provided considers low elevation and high elevation angle scenarios. The worst case scenario, in terms of worst power density levels, involves the high elevation angle and has been presented here.

TABLE 1 - EARTH STATION TECHNICAL PARAMETERS

Antenna Aperture major axis	0.62 meters
Antenna Aperture minor axis	0.33 meters
Antenna Surface Area	0.2183 sq. meters
Antenna Isotropic Gain	29.54 dBi @10° to 37.6 dBi @70°, *see* Figure 1
Number of Identical Adj. Antennas	1
Nominal Frequency	14.25 GHz
Nominal Wavelength (λ)	0.0211 meters
Maximum Transmit Power / Carrier	50.00
Watts @70° Number of Carriers	1
Total Transmit Power	50.00 Watts W/G
Loss from Transmitter to Feed	2.7 dB
Total Feed Input Power	26.8535 Watts
Terminal EIRP	43.8 dBW @10° to 51.9 dBW @70° , *see* Figure 2
Near Field Limit	$R_{nf} = D^2/4\lambda = 5.198$ meters
Far Field Limit	$R_{ff} = 0.6\ D^2/\lambda = 12.5$ meters
Transition Region	R_{nf} to R_{ff}

In the following sections, the power density in the above regions, as well as other critically important areas, will be calculated and evaluated. The calculations are done in the order discussed in OET Bulletin 65.

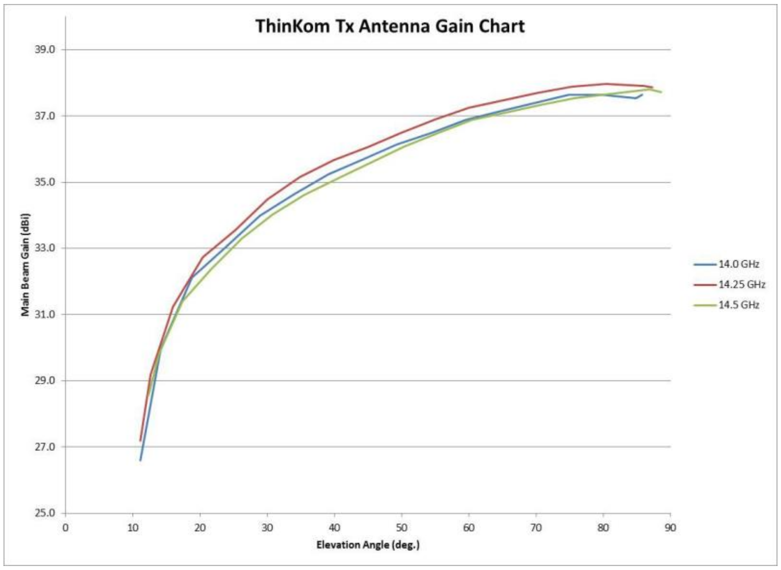

Figure 1 - ThinKom VICTS Antenna Gain versus Elevation Angle

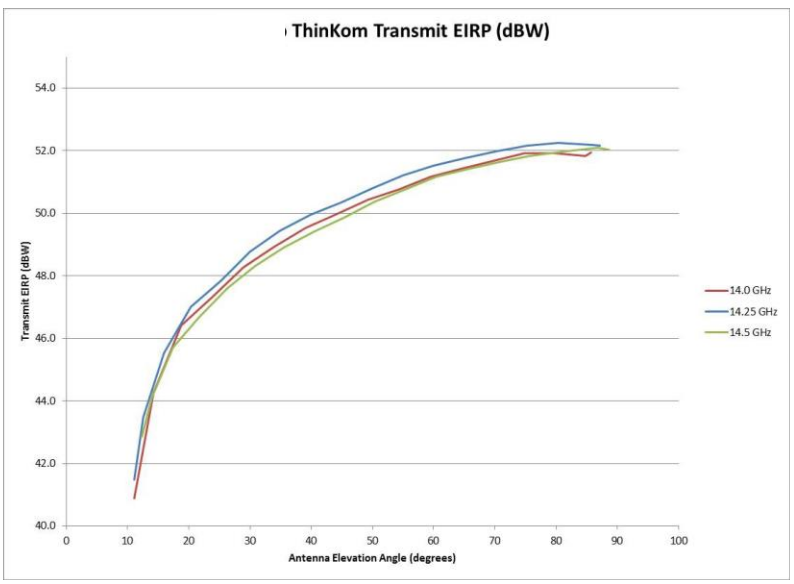

Figure 2 – ThinKom VICTS EIRP versus Elevation Angle

1.0 At the Antenna Surface

The power density at the antenna radiating surface can be calculated from the expression:

PD_{refl} = 4P/A = 49.194 mW/cm² (1)

Where: P = total power at feed, milliwatts

A = Total area of reflector, sq. cm

In the normal range of transmit powers for satellite antennas, the power densities at or around the reflector surface are expected to exceed safe levels. This area will not be accessible to the general public. Operators and technicians shall receive training specifying this area as a high exposure area. Procedures have been established that will assure that all transmitters are rerouted or turned off before access by maintenance personnel to this area is possible.

2.0 On-Axis Near Field Region

The geometrical limits of the radiated power in the near field approximate a cylindrical volume with a diameter equal to that of the antenna. In the near field, the power density is neither uniform nor does its value vary uniformly with distance from the antenna. For the purpose of considering radiation hazard it is assumed that the on-axis flux density is at its maximum value throughout the length of this region. The length of this region, *i.e.*, the distance from the antenna to the end of the near field, is computed as R_{nf} above.

The maximum power density in the near field is given by:

$PD_{nf} = (16\varepsilon P)/(\pi D^2) =$ **18.67** mW/cm² (2)

Where: P = total power at feed

ε = antenna efficiency

D = effective antenna diameter in meters

Evaluation

Uncontrolled Environment: **Does Not Meet Uncontrolled Limits**

Controlled Environment: **Does Not Meet Controlled Limits**

3.0 On-Axis Transition Region

The transition region is located between the near and far field regions. As stated in Bulletin 65, the power density begins to vary inversely with distance in the transition region. The maximum power density in the transition region will not exceed that calculated for the near field region, and the transition region begins at that value. The maximum value for a given distance within the transition region may be computed for the point of interest according to:

$PD_t = (PD_{nf})(R_{nf})/R$ = dependent on R (3)

Where: PD_{nf} = near field power density

R_{nf} = near field distance

R = distance to point of interest

For: $5.20 < R < 12.47$ meters

We use Eq (3) to determine the safe on-axis distances required for the two occupancy conditions:

Evaluation

Uncontrolled Environment Safe Operating Distance (meters), Rsafeu:

13.9 @10° elevation (in the far field)

35.1@70° elevation (in the far field)

Controlled Environment Safe Operating Distance (meters), Rsafec:

12.5 @10° elevation (in the transition region)

15.7 @70° elevation (in the far field)

4.0 On-Axis Far-Field Region

The on- axis power density in the far field region (PDff) varies inversely with the square of thedistance as follows:

PDff = $PG/(4\pi R^2)$ = dependent on R (4) where:

Where: P = total power at feed

G = Numeric Antenna gain in the direction of interest relative to isotropic radiator

R = distance to the point of interest

For: $R > R_{ff} = 12.5$ meters

PD_{ff} = 1.23 mW/cm² at R_{ff} @10°

7.90 mW/cm² at R_{ff} @70°

We use Eq (4) to determine the safe on-axis distances required for the two occupancy conditions:

Evaluation

Uncontrolled Environment Safe Operating Distance (meters), Rsafeu : *See* Section 3

Controlled Environment Safe Operating Distance (meters), Rsafec : *See* Section 3

5.0 Off-Axis Levels at the Far Field Limit and Beyond

In the far field region, the power is distributed in a pattern of maxima and minima (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. This will correspond to the antenna gain pattern for an off-axis angle. For the ThinKom VICTs antenna at 1.5 degrees off axis the antenna gain is:

G_{off} = 29.04 dBi at 1.5 degree @10°

31.60 dBi at 1.5 degree @70° @70°

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, the off axis gain reduction may be used to further reduce the power density levels.

For example: At 1.5 degree off axis at the far-field limit, we can calculate the power density as:

G_{off} = 29.04 dBi = 801.01 numeric @10° elevation
31.60 dBi = 1445.44 numeric @70° elevation

$PD_{1.5\ deg\ off\text{-}axis} = PD_{ff} x\ 801.01/G = 1.0999\ mW/cm^2$ (5)
$PD_{ff} x\ 1445.44/G = 1.9848\ mW/cm^2$ (5)

6.0 Off-Axis power density in 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 equivalent on-axis power density in the main beam. Therefore, for regions at least D_{eff} meters away from the center line of the antenna, whether behind, below, or in front under of the antenna's main beam, the power density exposure is at least 20 dB below the main beam level as follows:

$PD_{nf(off\text{-}axis)} = PD_{nf} /100 =$ **0.187** mW/cm^2 at D off axis (6)

7.0 Evaluation of Safe Occupancy Area in Front of Antenna

The distance (S) from a vertical axis passing through the antenna center to a safe off axis location in front of the antenna can be determined based on the effective antenna diameter rule (Item 6.0). Assuming a flat area in front of the antenna, the relationship is:

$S = (D_{eff}/ \sin \alpha) + (2(h\text{-}GD_{eff}) - D_{eff} - 2)/(2 \tan \alpha)$ (7)

Where: α = minimum elevation angle of antenna
D = effective antenna diameter in meters
h = maximum height of object to be cleared, meters

For distances equal or greater than determined by equation (7), the radiation hazard will be below safe levels.

For	D =	0.53 meters
	h =	2.0 meters
	GD =	0.0 meters - elevated height of earth station above ground (min)
Then:		
	α	S
	10	7.6 meters
	15	5.1 meters
	20	3.8 meters
	25	3.0 meters

This antenna will be an area that is not accessible to the general public and all persons working on or near the antenna will be properly trained regarding radiation hazards. The antenna transmitter will be disabled any maintenance is in progress.

8.0 Summary

The earth station site will be protected from uncontrolled access. The terminal is mounted in an area that is not accessible to the general public, and it is pointed upward. Access to the terminal will be limited to trained operations personnel and the antenna transmitter will be disabled whenever work on the antenna is being performed. There will also be proper emission warning signs placed and all operating personnel will be aware of the human exposure levels at and around the earth station.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limitsfor both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can bedetermined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.

II. ThinKom Antenna Datasheet

ThinAir® Ku3030 Ku-band Satcom Antenna for Global Inflight Broadband

Technical Specifications

Compatibility

Operating Band: Ku-band
Constellations: LEO and GEO
Satellite Services: Commercial; wide beam, HTS and XTS
Aircraft: Business and commercial aviation, military platforms

Tracking and Agility

Azimuth Coverage: 360° continuous
Elevation Coverage: +90° to +7.5° (depending on network)
Beam Agility: Up to 1000°/sec and 600°/sec²
Tracking Accuracy: <0.2°

Throughput and Performance

Data Rates: Up to 400 Mbps down and 100 Mbps up
Tx Band: 13.75 to 14.50 GHz
Rx Band: 10.70 to 12.75 GHz
G/T: 15 to 18 dB/K (12 db/K at 20° elev.)
Network Efficiency: 1.5 to 3 bits/Hz
EIRP: 51 to 54 dBW (49 dBW at 20° elev., 70W BUC)
Transmit Power Spectral Density: (per 47 CFR 25.227)
- 17 to 18 dBW/4 kHz at high latitudes (to 65° N/S)
- 16 to 18 dBW/4 kHz PSD over CONUS (83W to 118W)
- 15 to 18 dBW/4 kHz PSD over Equator (Longitude +/- 35°)

Throughput and Performance (continued)

Geo-Plane Beamwidth: 1.85° Tx and 2.15° Rx typical (24"H x 36"W elliptical-dish equivalent)
Geo-Plane Patterns: First sidelobe -22 dB typical
Polarization: Tracking linear (co-pol or orthogonal-pol)
X-pol Isolation: 30 dB typical

Dimensions and Installation

Antenna: 74"L x 35"W x 4"H
Radome: 105"L x 48"W x 6.5"H (from fuselage, retrofit)
Installation: Line fit or retrofit

Environmental

Operating Temperature: -55°C to +74°C external
Environmental Compatibility: RTCA/DO-160G and MIL-STD-810G

Compliance and Certifications

Regulatory: FCC, ITU
FAA Certifications: Part 145 Repair Station

Other Mobility Applications

The Ku3030's design and performance characteristics are also well suited for maritime and high-speed rail applications. Contact ThinKom to learn more.

TAKu3030 Rev 09/18

ThinKom
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