Non-Ionizing Radiation Hazard Assessment
For the
1m Ka Earth Station Terminal
April 3, 2019

1. Introduction

This analysis calculates the non-ionizing radiation levels for a ViaSat, Inc, (“ViaSat”) 1m Ka-band earth station terminal (“ES terminal”). The calculations performed in this analysis comply with the methods described in FCC Office of Engineering and Technology Bulletin, Number 65 (Edition 97-01) (“Bulletin 65”). This analysis demonstrates that the 1m Ka ES terminals are compliant and will not result in exposure levels exceeding the applicable radiation hazard limits.

Bulletin 65 and section 1.1310 of the Commission's rules specify two separate tiers of exposure limits: one for Occupational/Controlled Exposures and one for General Population/Uncontrolled Exposures. Limits for Occupational/Controlled Exposures apply in situations when persons are exposed as a consequence of their employment and are fully aware of and can control their exposure. These limits also apply in situations when a person is transient through a location where such limits would otherwise apply provided the person is made aware of the potential for exposure. The limits for General Population/Uncontrolled Exposure apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure. ViaSat will typically deploy its CP terminals in General Population/Uncontrolled Environments. Accordingly, this analysis discusses only the Maximum Permissible Exposure (“MPE”) limit for those types of exposures, which is a power density equal to 1 milliwatt per centimeter squared averaged over a thirty minute period.

As described in the definitional section of Appendix A, this report analyzes the maximum power density levels in the vicinity of a CP terminal antenna in five regions:

1. The far field
2. The near field
3. The transition region between near field and far field
4. Near the main reflector surface

These radiation regions were analyzed using the definitions and formulas in Bulletin 65 for aperture antennas. The results of this analysis are summarized in Tables 1, which identify the potential exposure under nominal operating conditions and worst-case conditions, respectively. The assessment is conservative as the radome loss is excluded from the analysis.

2. ES Terminal Description

The ES terminal's antenna is housed inside a radome. It is intended for maritime applications, and is typically mounted on a mast. The ES terminal is capable of operating in low burst rate and high burst rate modes. In low burst rate mode, the ES terminal transmits bursts at lower EIRP, but at higher duty cycles. In high burst rate mode, the ES terminal transmits bursts at higher EIRP, but at reduced duty cycles. Transmits bursts of information at designated times that are assigned to the terminal by the network. The length and carrier frequency of each transmission burst depend on the ES terminal's mode of operation and its traffic requirements. In normal operation, the ES terminal transmit EIRP and duty cycle is limited to the followings:

- Low burst rate mode: Maximum power level of 3 Watts, and a nominal duty cycle of less than 30%.
- High burst rate mode: Maximum power level of 25 Watts, and a nominal duty cycle of less than 6.25%.

The ES terminal incorporates two "fail safe" features that limit the potential for human exposure. First, the transmitter is not enabled until the receive down link connection to the satellite has been established and an acceptable down link bit error rate has been achieved. The transmitter is disabled very quickly, in less than 40 milliseconds, if a loss of down connectivity occurs. Transmissions will not resume until approximately 10 seconds after downlink communications have been reestablished. Secondly, the terminal's transmitter is not capable of operating in a continuous transmit mode of operation. The ES terminal's outdoor unit incorporates a watchdog timer that will shut down the transmitter if it remains in a continuous transmit state for more than 10 seconds. Under these conditions, the transmitter will be turned off briefly then resume normal operation after an internal reset has occurred.

3. Explanation of the Analysis

The "Calculated Values" in Tables 2 (low burst rate and high burst rate) are the exposure rates calculated first using the formulae from the Office of Engineering and Technology Bulletin Number 65 (Edition 97-01) for a system with continuous (100% transmit duty cycle) transmission. The ViaSat network, however, is based on so-called "shared pipes". ES terminals transmit short bursts of data periodically as instructed by the network and are neither designed for nor capable of continuous transmission. Therefore, in order to compute the effective radiated energy of a ES terminal operating on ViaSat network, the ES terminal's transmitter duty cycle has been used to adjust the values calculated from Bulletin Number 65.

The columns in the tables labeled "Low Burst Rate" and "High Burst Rate" reflect the total potential for human exposure based on the length of time that the CP terminal transmits energy during a rolling

4. Summary of Analysis

This analysis demonstrates that the ES terminal is not a radiation hazard because the terminal does not exceed the MPE limit of 1 milliwatt per centimeter squared averaged over a thirty minute period. As demonstrated in Tables 1, power density in both near field, far field, and antenna surface are less than MPE for general population/uncontrolled environments. If the down link (receive signal) is interrupted, the uplink (transmit signal) is shut down in less than 40 milliseconds and the receiver down link recovery time is 10 seconds. The uplink will remain off until the blockage is removed and the downlink recovery is complete. This feature, coupled with the terminal's use of uplink power control and non-continuous operation, ensures that the general population will not be exposed to harmful levels of radiation.

5. Conclusion

This radiation hazard analysis demonstrates that the 1m Ka ES terminal will not result in exposure levels exceeding the applicable radiation hazard limits.

6. Definition

Region Near Main Reflector Surface

The power density near the main reflector surface can be estimated as equal to four times the power divided by the area of the main reflector surface, assuming that the illumination is uniform and that it would be possible to intercept equal amounts of energy radiating towards and reflected from the antenna surface.

Near Field Region

The near field region is a cylindrical volume co-incident with the boresight of the main beam extending outward from the main reflector. The length of the near field is $D^2/(4\lambda)$ meters, where D is the diameter of the antenna.

Transition Region

The transition region is located between the near field region and the far field region. This region has a power density that decreases inversely with increasing distance. Therefore, the power density in the transition region will be less than the power density in the near field for the purpose of evaluating potential exposure.

Far Field Region

The far field region extends outward from the main reflector, beginning at a distance of $0.6*D^2/\lambda$ meters. The maximum power density is calculated using the equation recommended in Bulletin 65.

7. Radiation Hazard Assessment

Table 1: Input Parameters

Item	Parameter	Value
1	Antenna diameter, D	1.0 meter
2	Antenna aperture area, $A = \pi D^2/4$	0.79 m^2
3	Wavelength, λ, at 30.00 GHz	0.01 meter
4	Aperture efficiency, ε_a, $= G \lambda^2 / (\pi D)^2$, at 30GHz	0.64
5	Antenna effettive aperture area, $A_e = \varepsilon_a A$, at 30 GHz	0.5056 meter
6	Boresight gain, G(dB), $= 10LOG_{10} (4\pi A_e / \lambda^2)$, at 30 GHz	48.0 dBi
7	Maximum power into antenna, low burst rate mode, at 30 GHz	2.8 Watt
8	Maximum transmit duty cycle, low burst rate mode	30%
7	Maximum power into antenna, high burst rate mode, at 30 GHz	25 Watt
8	Maximum transmit duty cycle, low burst rate mode	6.25%

Table 2: Calculated Values

1	Extent of near field	$R_{nf} = D^2 / (4\lambda)$	25.00	25.00	m
2	Begin of far field	$R_{ff} = 0.6{*}D^2 / \lambda$	60.00	60.00	m
3	Max on axis Power density near field	$S_{nf} = 16\ \varepsilon_a {*}P / (\pi D^2)$	0.913	8.149	mW/cm^2
4	Max on axis Power density near field, w/ duty cycle	$d{*}S_{nf}$	0.274	0.509	mW/cm^2
5	Max on axis power density, far field	$S_{ff} = P{*}G / (4\pi R_{ff}^2)$	0.391	3.491	mW/cm^2
6	Max on axis Power density, far field, w/ duty cycle	$d{*}S_{ff}$	0.117	0.218	mW/cm^2
7	Max on axis PFD, far field, w/ duty cycle	$Sf_f = P{*}G / (4\pi R^2)$	0.12	0.02	mW/cm^2
8	PFD at the aperture	4P/A	1.426	1.426	mW/cm^3
9	PFD at the aperture, w/duty cycle	d*4P/A	0.428	0.089	mW/cm^3