SDM2 RF Exposure Assessment

September 9, 2008

80-J9813-5 Rev A

Fang Han

QUALCOMM® | Wireless Business Solutions

QUALCOMM Incorporated
5775 Morehouse Drive
San Diego, CA 92121-1714
U.S.A.

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Contents

1. Introduction

This report assesses non-ionizing electromagnetic field radiation from a satellite data module (SDM2) of Ku-band OmniVISION MCP system designed, and manufactured by Qualcomm Inc., 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, and antenna 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 SDM System Parameters

The antenna and system specifications for power density assessment are listed in Table 2.

Table 2. Antenna and system specs

Antenna aperture width	$W = 1.9\,\text{in} = 0.0483\,\text{m}$
Antenna aperture length	$L = 9.95\,\text{in} = 0.2527\,\text{m}$
Antenna aperture area	$A_a = W \times L = 0.0122\ \text{m}^2$
Wavelength at mid-band 14.25 GHz	$\lambda = 0.021\,\text{m}$
Max transmit power at antenna flange	$P_{\max} = 2.5\,\text{W}$
Antenna gain	$G = 19\,\text{dBi} = 79$
Antenna aperture efficiency	$\eta = \frac{\left(G\lambda^2 / 4\pi\right)}{A_a} = 0.23$
Actual transmit duty cycle over 30-min period	$d = 5\%$

3. Power Density Calculation

3.1 Far Field Calculations

The distance to the beginning of the far field can be estimated as below [1]

$$R_{FF} = \frac{0.6L^2}{\lambda} = 1.82\ \text{m}$$

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

$$S_{FF} = \frac{G \times P_{\max}\ (\text{or } EIRP)}{4\pi R_{FF}^2} = 4.8\ \text{W/m}^2$$

Considering the actual duty cycle for transmit, the average on-axis power density in the far field can be then calculated as

$$S_{FF\_avg} = S_{FF} \times d = 0.24\ \text{W/m}^2$$

3.2 Near-Field Calculations

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

$$R_{NF} = \frac{L^2}{4\lambda} = 0.76\ \text{m}$$

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

$$S_{NF} = \frac{16\eta P_{\max}}{\pi L^2} = 45.8\ \text{W/m}^2$$

Considering the actual duty cycle for transmit, the average on-axis power density in the near field can be then calculated as

$$S_{NF\_\text{avg}} = S_{NF} \times d = 2.3\ \text{W/m}^2$$

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.,

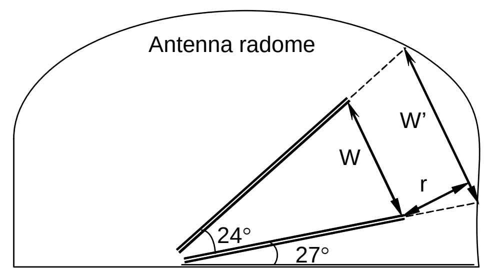
$$S_{FF} < S_{TF} < S_{NF}$$

Therefore the average power density in transition region will not exceed 1.2 $\mathrm{W/m^2}$.

3.4 Antenna Surface

The antenna is covered by a radome to prevent the antenna being touched. The distance between the radome and the antenna is approximately *r*=2.5 cm, and thus the equivalent aperture area at the radome surface becomes

$$\begin{aligned} A_{Eq} &= L \times \left(W + 2r \tan \frac{\theta}{2} \right) \\ &= 0.015\,\mathrm{m}^2 \end{aligned}$$



where θ is the angle of the antenna aperture. The average power density at equipment (radome) surface can be then assessed by

$$S_{Eq\_avg} = \frac{P_{\max}}{A_{Eq}} \times d = 8.3\,\mathrm{W/m^2}$$

4. Conclusions

Table 2 summarizes the expected radiation exposure levels from the above analysis. At all regions, the EMF exposure levels satisfy MPE limits for both public environment and occupational environment.

The SDM is designed to be installed on the roof of driver's cabin and would be at least 0.5 meter away from the driver. Since the main beam of the antenna will be elevated at least 25 degree to communicate with satellite, there would be no chance of beam exposure toward inside the driver's cabin or nearby the vehicle. Furthermore, it is required that the transmitter be turned off during equipment maintenance. Therefore, there would be no hazard risk to public and occupational personnel.

Table 3. Summary of expected exposure levels

Region	Average power density (W/m^2)	Hazard assessment
Far field (R>1.8 m)	PD<0.24	Meet FCC MPE limit for public exposure
Transition field (0.76 m<R<1.8 m)	0.24<PD<2.3	Meet FCC MPE limit for public exposure
Near field (R>0.76 m)	S<2.3	Meet FCC MPE limit for public exposure
Antenna radome surface	S=8.3	Meet FCC MPE limit for public exposure

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: September 9, 2008