October 29, 2001

SIERRACOM'S FIBERCONNECTIONä SERIES 60 GHZ RADIOS, MODEL: 3261-0000-1/2 AND 3264-0000-1/2

Evaluation of Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields

This analysis is based on OET Bulletin 65, Edition 97-01 and performed for the SierraCom's FiberConnection™ Series 60 GHz Radio Model: 3261-0000-1/2 and 3264-0000-1/2, hereafter referred as "the SierraCom's Radio". These radios are operating with the folowing parameters:

FCC ID Number:	**PWL3260**			
Model Number	**3261-0000-1**	**3261-0000-2**	**3264-0000-1**	**3264-0000-2**
Transmitting Frequency:	**60.25 GHz**	**62.75 GHz**	**60.25 GHz**	**62.75 GHz**
Frequency Accuracy:	**30 MHz**	**30 MHz**	**30 MHz**	**30 MHz**
Receiving Frequency:	**62.75 GHz**	**60.25 GHz**	**62.75 GHz**	**60.25 GHz**
Protocol:	**OC-3**	**OC-3**	**OC-12**	**OC-12**
Data Rate (no FEC):	**155 mbs**	**155 mbs**	**622 mbs**	**622 mbs**
Data Rate (with FEC):	**165 mbs**	**165 mbs**	**661 mbs**	**661mbs**
Transmitter Output Power:	**6.3mW/8 dBm (typ), 10mW/10 dBm (max)**			
T/R Spacing:	**2500 MHz**			
Modulation:	**DBPSK**			
Spurious Emissin:	**FCC Part 15, Subpart C, 15.255**			
Antenna Type:	**Parabolic**			
Antenna Aperture:	**700 cm ^{2}**			
Antenna Aperature Efficiency:	**h (59GHz) = 0.368, h (64GHz) = 0.313**			
Antenna Gain:	**41.0 dBi (max), G_N = 12,589.3**			
Near Field Extent:	**439.4 cm @ 59 GHz, 476.6 cm @64 GHz**			
Beginning of Far Field:	**10.55 m @ 59 GHz, 11.44 m @ 64 GHz**			

	Avgerage Value	**Maximum Value**
Antenna Beamwidth:	**1.5 deg**	**1.1 deg**
Antenna Injection Power:	**5.0 mW** **(7 dBm)**	**10.0 mW** **(10 dBm)**

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A. Evaluation of the worst case, maximum power density of the radiated RF power in the frequency range 59-64 GHz.:

The antenna used on the SierraCom's Radio has a parabolic surface and circular cross section. The RF power is fed to the antenna from the rectangular waveguide (WR-15) feed it her Focal Point. Radiation from this source provide a collimated beam with a circular spread angle α, where 1.1 deg < α < 1.5 deg. Because of the highly directional nature of this antenna, the likelihood of significant human exposure to RF radiation is considerably reduced. Factors that are taken into account are mainly the main-beam orientation and antenna heights above ground.

To evaluate compliance with guidelines for human exposure for the systems, which are using a parabolic aperture antenna with circular cross section, the following procedure will be used:

1. Calculate Power Density on the antenna feed (waveguide horn), based on the maximum power transmitted by the waveguide [(1),(3)],
2. Calculate Power Density on the antenna surface, based on maximum power level fed to the antenna [(2),(3)],
3. Evaluate Power density in the near-field region [(2),(3)],
4. Evaluate Power density in the transition region [(2),(3)], and
5. Estimate worst case Power Density in the far-field region [(1-3)],

All calculations are based on the maximum power level (P_0), fed to the antenna. Calculations are based on the recommended method by OET Bulletin 65 [(2)] .

1. Antenna Feed:

Based on equation [11] from the OTE Bulletin 65, the maximum power density directly in the front of the waveguide horn of the antenna is:

$$S_{horn} = 4P_0/A_w$$

Where: S_{horn} = maximum power density at the antenna surface (mW/cm^2)
P_0 = 10 mW, power fed to the antenna
A_w = 0.0726 cm^2, physical area of the waveguide horn

The calculated power density at the waveguide horn is $S_{horn} = 367.8\ mW/cm^2$

2. Antenna Surface:

Based on equation [11] from the OTE Bulletin 65, the maximum power density directly in the front of the antenna (Antenna Interface) is:

$$S_{surface} = 4P_0/A$$

Where: $S_{surface}$ = maximum power density at the antenna surface (mW/cm^2)
P_0 = 10 mW, power fed to the antenna
A = 700.0 cm^2, effective physical area of the antenna

The calculated power density at the antenna surface is $S_{surface} = 0.038$ mW/cm^2

3. Near-Field Region:

The extent of the near field can be described by the equation [12] from the OTE Bulletin 65:

$$R_{nf} = D^2/4\lambda_f$$

Where: R_{nf} = extent of near-field (cm)
D = 30.48 cm, diameter of the antenna
$\lambda_f = \lambda_{64}$ = 0.467 cm, wavelength at at RF frequency f = 64 GHz
$\lambda_f = \lambda_{59}$ = 0.507 cm, wavelength at worst case at RF frequency f = 59 GHz

The calculated extent of near field is **$R_{nf} = 439.4$ cm**.

The maximum value of the near-field power density located on the main beam axis is calculated from equation [13]:

$$S_{nf} = 16\eta P/\pi D^2$$

Where: S_{nf} = maximum near-field power density (mW/cm^2)
$\eta_{59} = (G\lambda^2/4\pi)/(\pi D^2/4) = 0.368$ worst case scenario for the antenna operating at 59 GHz
P_0 = 10 mW, RF power fed to the antenna
D = 30.0 cm, effective antenna diameter

The calculated maximum power density in near field is $S_{nf} = 0.014$ mW/cm^2.

4. Transition Region:

The distance between near-field and far-field region is described as a transition region. The maximum extent of the transition region is to the beginning of the far-field region and is defined by R_{ff} . R_{ff} is described by the equation [16] from the OTE Bulletin 65:

$$R_{ff} = 0.6D^2/\lambda_f$$

Where: R_{ff} = distance to beginning of far-field (cm)
D = 30.0 cm, effective diameter of the antenna
$\lambda_f = \lambda_{64}$ = 0.467 cm, wavelength at RF frequency f = 64 GHz
$\lambda_f = \lambda_{59}$ = 0.507 cm, wavelength at worst case at RF frequency f = 59 GHz

The calculated beginning of the far-field region is R_{ff} = 10.55 m

The maximum value of the power density in the transition region, which is extending from R_{nf} to R_{ff} can be determined from the equation [17] of the OTE Bulletin 65:

$$S_t = S_{nf} R_{nf} / R$$

Where: S_t = power density in the transition (mW/cm^2)
S_{nf} = 0.014 mW/cm^2, maximum power density for near-field region calculated above
R_{nf} = 439.4 cm, extend of near-field, calculated above
R = distance to point of interest, 4.39 m < R < 10.55 m

The calculated maximum power density in the transition region is 4.64 μW/cm^2 < S_t < 0.014 mW/cm^2.

5. Far-Field Region:

This evaluation is based on OET Bulletin 65, Edition 97-01. For the single radiating antenna, a prediction for power density in the far field of the antenna can be made by use equations 1(1).

$$S_{ff} = PG/4\pi R^2 = EIRP/4\pi R^2$$

Where: S – Power Density (mW/cm^2)
P – Input Power to the Antenna (mW)
G – Antenna Numeric Gain
G_{dB} – Antenna Gain (dBi)
R – Distance to the Center of the Antenna (cm)
EIRP – Equivalent (or effective) isotropically radiated power
$G = 10\exp(G_{dBi}/10)$

The calculated maximum power density in the far-field region is S_{ff} = 4.64 μW/cm^2 @ 59 GHz

B. Compliance with guidelines for human exposure – Summary:

Table 1 shows tabulated calculated values of power density in different regions. The SierraCom's FiberConnection™ Series 60 GHz Radio Model: 3261-0000-1/2 and 3264-0000-1/2 are meeting all regulatory requirements of FCC Part 15, Subpart C, 15.255. The tested data are included in the Test Report attachement submitted by Intertek Testing Services NA, Inc.

TABLE 1:

	Based on the OET Bulletin 65 Edition 97-01, August 1997	**Maximum Power Density (S) OET Bulletin 65, Edition 97-01, Table 1A, 1B pp67**	**COMMENTS:**
	General Population/Uncontrolled MPE Limits:	**1 mW/cm^2 @ 30 min**	**Requirements**
	Guidelines for Occupational/Controlled Exposure:	**5 mW/cm^2 @ 6 min**	**Requirements**
		CALCULATED MAXIMUM POWER DENSITY (S) @ P_{out} = 10 mW (10dBm)	
	Antenna Feed:	**S_{horn} = 367.8 mW/cm^2**	**COMPLIANCE – NOTE 1.**
	Antenna Surface:	**$S_{surface}$ = 0.038 mW/cm^2**	**COMPLIANCE**
	Near-Field Region:	**S_{nf} = 0.014 mW/cm^2**	**COMPLIANCE**
	Transition Region:	**4.64 < S_t < 14 mW/cm^2**	**COMPLIANCE**
	Far-Field Region:	**S_{ff} = 4.64 mW/cm^2**	**COMPLIANCE**

NOTE 1: The SierraCom's Radio has the permamently installed ABS radome over the antenna aparetur and waveguide feed. Radome is located at least 7 cm away from the surface of the antenna and 9 cm away from the antenna's feed (Fig.1). Radome is permanently sealed and area inside radome is not accessible. Therfore, the SierraCom's Radio also meets this requirements.

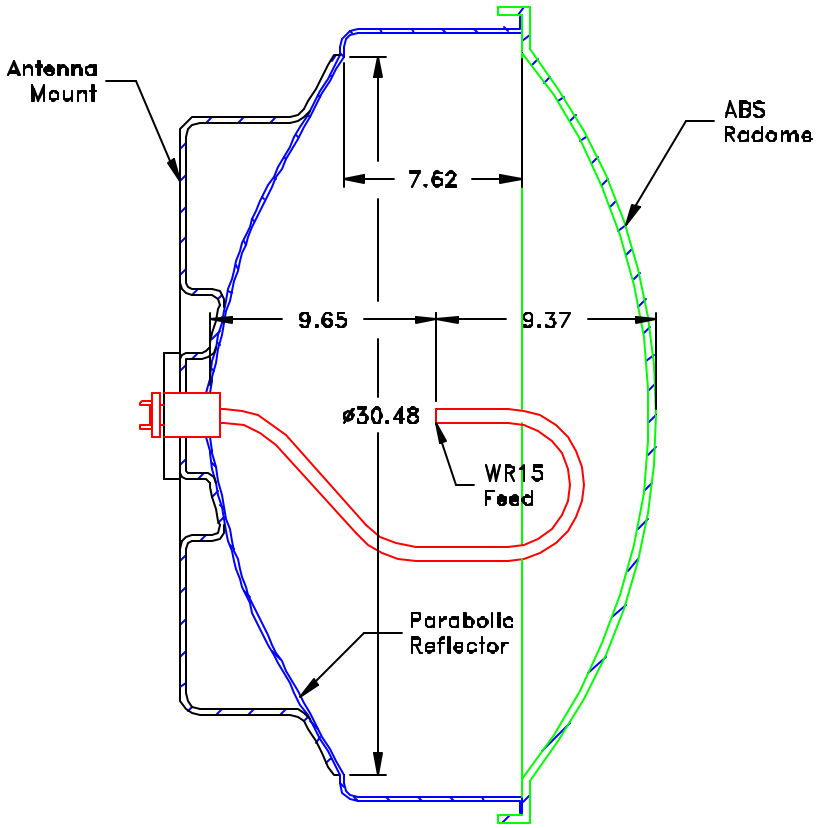

Fig.1. Antenna Assembly

C. References:

(1) – Richard C. Johnson, Antenna Engineering Handbook, Third Edition, McGraw-Hill, Inc. 1993, pp 1.9-1.17

(2) – OET Bulletine 65, Edition 97-01, August 1997, Federal Communications Commission, Office of Engineering & Technology, pp 26 – 32.

(3) – MathCAD 2000 Software, Power Density Calculation by J. Majewski, SierraCom.