1 Radio Emission Characteristics

We now estimate the transceivers in band and out of band emission for the different deployment sites.

1.1 In-band Emissions

The transceiver Cassegrain transmit antenna used in the collector radio has the following specifications:

Operating Frequencies(Wavelength λ)	=	59 GHz(5.1 mm) to 62 GHz(4.8 mm)
Antenna Input Power(P)	=	200 mW(23 dBm)
Directivity(G) with $3dB$ antenna loss	=	40 dB
EIRP	=	2 kW
Diameter(D)	=	30 cm
Peak to average Power ratio	=	5dB
Main Lobe Width	=	2° azimuth & zenith

FCC Office of Engineering and Technology Bulletion 65(OET-65) provides guidelines and methods for evaluating compliance with FCC's human exposure regulations[1]. Emission limits for operation in the the desired unlicensed 57-64 GHz band are specified in [2].

The power densities are now calculated at $60GHz$ or $5mm$ wavelength. The near field boundary is defined by[1] as

$$R_{nf} = \frac{D^2}{2\lambda} = \frac{(0.3)^2}{4 * 0.005} = 4.5m$$

and the power density in the near field is

$$S_{nf} = \frac{16\eta P}{\pi D^2} = \frac{16 * \eta * 10^{-0.7}}{\pi * 0.3^2} = 1.13\eta \text{ mW/cm}^2$$

where η is the aperture efficiency give by

$$\eta = \frac{G\lambda^2}{\pi^2 D^2} = \frac{10^4 * 0.005^2}{\pi^2 * 0.3^2} = 0.2814.$$

Therefore, in the near field(for distances less than R_{nf}),

$$S_{nf} = 318\,\mu W/cm^2.$$

For distance greater than R_{ff},

$$R_{ff} = \frac{0.6D^2}{\lambda} = \frac{0.6(0.3)^2}{0.005} = 10.8m$$

the power density at a distance R is

$$S_{ff} = \frac{PG}{4\pi R^2} = \frac{30 * 10^4}{4 * \pi * 100^2 * R^2} = 238.732\ W/R^2,$$

for e.g. with R = $1m$, $S_{ff} = 238.732\ W/m^2 = 23.8\ mW/cm^2$. The emission levels for operation of RF devices in 57-64 GHz band are 9 $\mu W/cm^2$ average and 18 $\mu W/cm^2$ peak measure at 3 m from the antenna. The power density for the Cassegrain used is $318\mu W/cm^2$ average and $954\mu W/cm^2$ peak power density (in the near field).

1.2 Out of band emissions

The out-of-band radiations are minimized by a combination of a transmit band-pass filter and the inherent high-pass filter characteristics of millimeter-wave waveguides. The rectangular V-band waveguides(e.g. Aerowave 15-1205) in the transmitter has a cut-off frequency of $40 GHz$ below which any out-of-band signals from the transmitter are attenuated very strongly. In the 2" length of waveguide, the loss at 38 GHz exceeds 100 dB. The RF transmit filter(Quinstar QFB-6103V0) used has an insertion loss of 1dB in the passband of 59-62 *GHz*. The transmit filter has a stopband (< 57 and > 64 *GHz*) with attenuation of atleast 25dB i.e. power transmitted in the stopband is less than 1 mW even under the extreme worst-case assumption of 100% of the transmitter output power being out-of-band.

References

[1] *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*, FCC Office of Engineering & Technology, Bulletin 65, August 1997

[2] Section 15.255, *Part 15, FCC Rules and Regulations*, FCC Office of Engineering & Technology, February 2006