Extract of document 29 January 2012

A note on the design of optics for a nanowave transmitter © G8AGN 28 July 2011

With an optical point source placed at the focal point of a Fresnel lens, if the latter has a known f/D, it is easy to determine the angle, θ, of the outermost ray in the cone of rays emitted from the source which just clips the edge of the lens (assumed here to be circular in cross-section).

$$\theta = \operatorname{atan}\left(\frac{1}{2f/D}\right) \quad \ldots (1)$$

Figure 1, below, plots this angle against lens f/D.

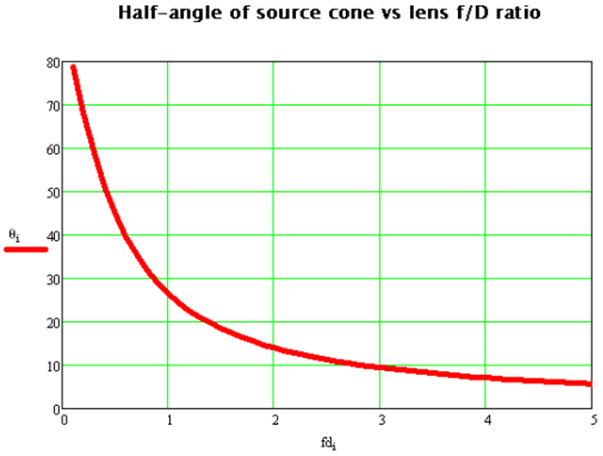

Figure 1

In practice, a LED source acts approximately as a Lambertian emitter; hence the optical intensity at angle θ from the axis is given by

$$I(\theta) = I_0 cos\theta \quad \ldots (2)$$

Assuming that the LED emits light over a full hemisphere then it is possible to estimate the fraction of this power emitted through a cone of half-angle θ.

In spherical coordinates, an elemental area of surface on a sphere of unit radius is given by $sin\theta d\theta d\varphi$. Let us assume that at the centre of this elemental area, the optical intensity is $I_0 cos\theta$. Then the integrated power emitted over a cone of half-angle θ is given by

$$P_\theta = I_0 \int_0^{2\pi} \int_0^{\theta} sin\theta cos\theta d\theta d\varphi = \frac{\pi I_0}{2}(1 - cos2\theta) \quad \ldots (3)$$

And the integrated power emitted over the whole hemisphere is

$$P_T = I_0 \int_0^{2\pi} \int_0^{\pi} sin\theta cos\theta d\theta d\varphi = \pi I_0 \quad \ldots (4)$$

Hence the percentage of the total power which is emitted by a cone of rays with half-angle θ is given by

$$A = 100\frac{P_\theta}{P_T} = 50(1 - cos2\theta) \quad \ldots (5)$$

A can then be expressed as a function of the lens f/D via equation (1). The results of this calculation are shown in Figure 2

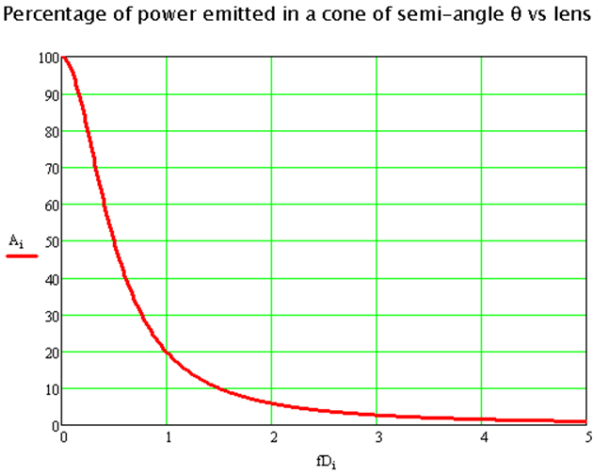

Figure 2

It can be seen that even with a lens f/D of 0.5, only 50% of the power emitted by the Lambertian point source can potentially be intercepted by the Fresnel lens. More typically, f/D will be 1.1 – 1.4.