Fresnel Lenses in Rear Projection Systems

In a rear projection system, the image is created by taking light from the light engine and projecting the image onto the viewing screen, where the viewer sees the information. The projection lens projects an equal amount of light toward all areas of the viewing screen, however, the corners of the image on the screen will look darker than the center. There are two main reasons for this. First, the center of the screen is closer to the projector lens than the corners of the screen. As we get farther and farther away from the projected light source, the luminance will decrease by the square of the distance. For projectors that throw their light only over narrow angles, such as most front projectors, the difference in distance, screen center vs. screen corner, is small, however for rear projection system where the throw distance (distance from the projector lens to the screen) is nearly equal to corner to corner distance (aperture) across the screen, this distance difference (R2-R1) becomes significant (Figure 1).

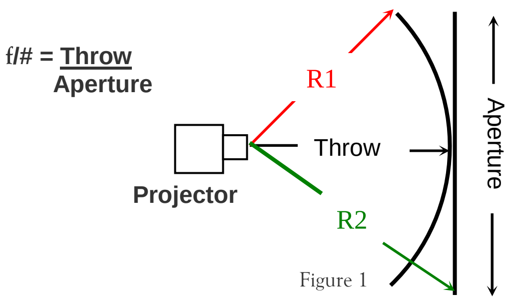

Figure 1

To fix this problem, we would need to curve the screen into a section of a sphere so that all points on the screen are equidistant from the projector lens. This is not practical in monitor applications.

A second reason that the corners are darker is more complex and has to do with the viewing screen. The viewing screen diffuses the projected light into many different directions. This is what allows the viewer to see the entire image. However this diffusion of light is not uniform with regard to direction. In almost all cases, the light is brightest in the same direction as the projected light. The brightness (or luminance) will drop off as the viewer moves off the axis of the projected light through the screen. This drop off function is typically gaussian or bell-shaped. The angle where the brightness drops to half of the maximum is called the half gain angle. The special case where the diffuser distributes the light uniformly over all viewing angle (a hemisphere) is called a Lambertian diffuser. (See figure 2).

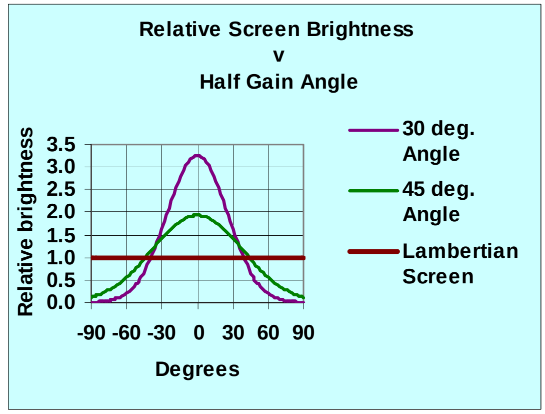

Figure 2

So for the viewer who is standing directly in front of the screen and is looking at the center of the screen, they will see the brightest image, while a person standing off to the side and looking at center of the screen will see a dimmer image. A viewer who is directly in front of the edge of the screen and who looks at the edge of the screen also sees this similar dimmer image. This is because the light from the projector is not being directed in line with the viewer, but rather at an angle to screen as shown in Figure 1 (R2).

There is a practical way to reduce this effect. Use a Fresnel lens to collimate the light coming from the projector so that all the light is directly perpendicularly through the viewing screen. With all of the light now perpendicularly striking the viewing screen, the uniformity of the light reaching the viewer from any place on the screen has been significantly increased. Even better is that the viewer can now be anywhere in front of the screen and have the brightness uniformity increased. Figure 3 shows the brightness v position on the screen and gives an example of the increased uniformity of a projection screen when using a Fresnel lens. In this example, the f/# is 1.0 and half gain viewing angles of the screen are 45 degrees.

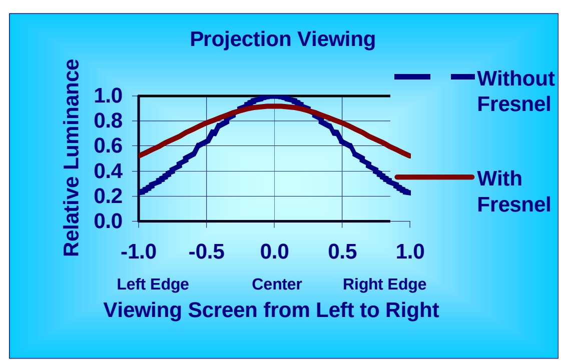

Figure 3

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