Reflexite Display Optics

Screen Gain and Projector Output

Definition of Screen Gain

Screen Gain is a dimensionless number that describes the directional light scattering properties of a diffuser, relative to a perfectly diffuse, or Lambertian, diffuser. In more basic terms, screen gain describes how "bright" a screen looks when compared to a standard (Lambertian) screen. Consider a perfect rear projection scatterer that is being illuminated from behind with collimated light. This perfect scatterer will transmit 100% of the light and direct it uniformly into the 2 p steradian hemisphere on the output side of the diffuser. Such a diffuser is said to have a screen gain of 1.0 and it is 1.0 regardless of where (at what angle) it is measured on the output side.

Real World Screen Gain

Real diffusers transmit less than 100% of the light - in fact a good diffuser is one that transmits 80% to 85% of the incident light. A perfectly diffusing scatterer (has uniform output over all the angles) that transmits 85% of the light will have a gain of 0.85. However, a perfectly uniform output profile is generally not ideal for most screen applications. For example, a rear projection screen in which the audience occupies ±30° horizontally (people sitting around a display) and ±10° vertically (people standing and/or sitting), any light that falls outside this envelope will not be viewed and is wasted. It is much better to redirect this light towards the audience. When this happens, the on-axis light can be greater than that of a Lambertian scatter, while light that is 40°-50° off axis and beyond will have a luminance close to zero.

Other Definitions:

◊ **Screen Luminance** is the brightness of the screen. The units are candela/m^2 or nits.

◊ **Screen Illuminance** is the measure of the amount of light per area that falls on the screen. The units are lumens/m^2 or lux.

◊ **Projector Output** is the measure of how much light is coming out of the projector. This is called luminous flux and the units are lumens. Another measure is the luminous intensity. The unit is the candela. 1 candela emits 1 lumen/steradian

◊ **Steradian** is a solid angle. There are 4 π steradians in a sphere.

If we use a "standard" candle as the light source, that candle projects 1 lumen/steradian luminous flux in all directions. A screen that is 1 m^2 in size and covers 1 steradian in angle has an illuminance of 1 lux. If that screen is a perfect Lambertian screen, then the luminance of that screen is 1 nit.

Equations:

Screen Gain = Luminance of the screen / Luminance of a Lam. Screen

Luminance of a Lambertian Screen = Illuminance incident on the Lambertian screen / π

Screen Gain = π x Luminance of the screen/ Illuminance incident on screen

Illuminance is readily measured using a photometric illuminance probe. The screen luminance has units of lumens/(m^2-Sr) or nit and, as such, has an angular dependence. That is, the luminance varies with the angle of the luminance probe with respect to the screen's optical axis. Complicating the luminance measurement is the desire to have asymmetric diffusion profiles.

After a gain profile for a screen is measured, two key parameters of the screen are obtained. The first is the peak gain, which is the maximum gain of the profile and is usually found on the optical axis. The second is the half-angle, which is that off-axis angle at which the gain has diminished by 50%. For asymmetric diffusers, both the vertical half angle and the horizontal half angle are specified.

Illuminance can also be derived from the screen size and the projector output. With the projector output known in lumens, and all of the projected light falling evenly on the screen, divide the output by the screen size in square meters to get the illuminance on the screen in lux.

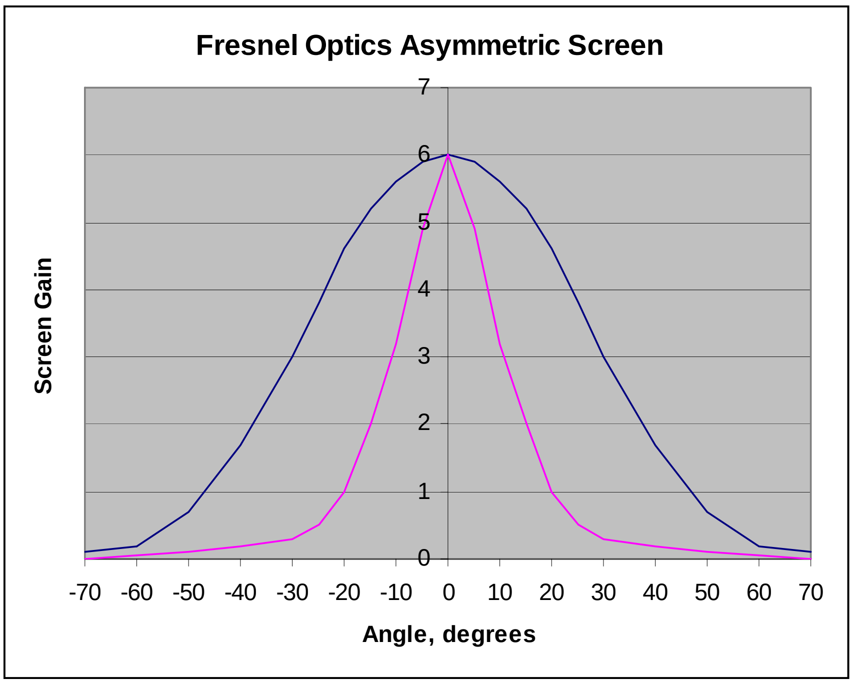
Most people want the projected image to have a certain brightness or luminance. To get from the projector output to luminance, we use the following equations:

Lumens / Screen size in m^2 = Lux

Lux x Screen Gain / π = Nits

Off-Axis Angle	Measured H Luminance	Calculated H Gain	Measured V Luminance	Calculated V Gain
-70	47.8	0.1	4.8	0.01
-60	95.5	0.2	23.9	0.05
-50	334	0.7	47.8	0.1
-40	812	1.7	95.6	0.2
-30	1432	3.0	143	0.3
-25	1814	3.8	239	0.5
-20	2200	4.6	478	1.0
-15	2480	5.2	956	2.0
-10	2670	5.6	1528	3.2
-5	2820	5.9	2340	4.9
0	2870	6.0	2870	6.0
5	2820	5.9	2340	4.9
10	2670	5.6	1528	3.2
15	2480	5.2	956	2.0
20	2200	4.6	478	1.0

Incident illumination: 1500 lm/ m²



The peak gain of this screen is found on-axis, and it is 6.0. The half angle is that angle at which the gain has fallen by 50% to 3.0, and is 30° in the horizontal direction and 10° in the vertical direction.

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