TECH BRIEF

Improving Giant Screen images
Contrast matters

Image contrast is what gives your films "snap" and "clarity", (Figures 1 and 2). Generally, you can count on your filmmakers to produce good contrast images, but how you present or show those images depends on your projector and lens capabilities, and many other system factors.

When we talk about image contrast, we are generally referring to the different luminance between the darkest and lightest portions of the images – the blacks and whites.

Understanding contrast

How much contrast can we perceive? An incredible amount it turns out. Our eyes can perceive about nine orders of magnitude in brightness sequentially from about 1/1000th Lux[1] (moonless, overcast night sky – starlight) to 100,000 Lux (direct sunlight), but not all at the same time. Because this range of brightness in the real world is so very large, our eye brain system reacts logarithmically with an adapted S-shaped response curve and that is one way that our human visual system adapts to the environment and objects it is seeing.

Figure 1: A low contrast (left) vs high contrast (right) image.

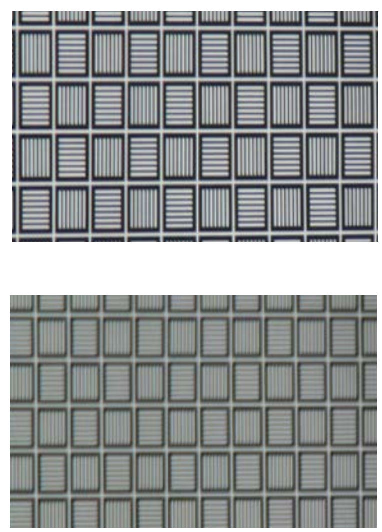

Figure 2: The higher the contrast, the higher the perceived resolution.

[1]What is a Lux? https://en.wikipedia.org/wiki/Lux

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How can we get image contrast up to the required thousands to one? We use a similar trick as our eyes do with a non-linear curve called a gamma curve to expand the range of light projected. The term brightness is often confused with luminance. Luminance is the measurement of light from a surface while brightness is the subjective appearance of the surface. In rough terms image contrast means the ratio of measured luminance on the screen between the whitest white and the darkest black, in the same units such as fL (footlamberts - one footlambert is about the luminance of a twilight sky and is about the minimum for human color vision). If the white area measured 100 fL and the black area measured 0.1 fL, we would call the contrast ratio 100/0.1 = 1000:1.

^ Christie® D4K40-RGB and Mirage 4K40-RGB provide an exceptionally wide color gamut and a 5000:1 On/Off contrast ratio.

Measuring contrast

There are different "standard" methods to determine projector contrast. A common way to measure contrast within one scene is to display a checkerboard with black and white rectangles large enough to easily measure with a photometer. This is called "intra-frame contrast ratio" in standards parlance because it is simultaneous – all on screen at one time, within one frame, not one-at-a-time sequentially. However, this does not really tell a meaningful story with actual contrast as audiences do not look at black and white test patterns.

Sequential contrast ratio or "interframe contrast ratio" in DIGSS 2.0 is commonly very high – typically many thousands to one on standard projectors. This is when a full black frame is compared to the brightness of a full white frame. The challenge here is that some projectors simply turn off the light source or use a dynamic iris, so the contrast ratio is "technically" measured accurately. If these projector features are used, the resulting measurement does not represent actual performance.

True on-off (sequential) contrast ratio is a good measure to see what the potential of the system is. If a rising average picture level (APL) brightness is also factored in the measurement, this is the most useful and accurate method to try to quantify real-world performance.

There is also a difference between "projector contrast ratio" and "complete system contrast ratio" where the light bouncing off the audience and the theater, and the cross-reflection between projectors in a multi-projector system are taken into consideration. Dome screens always have lower system contrast performance when compared to flat screens due to direct cross-reflections.

Photo spectrometers are commonly used to measure brightness and contrast ratio at any point on the screen, including six stories up high where it is hard to get to in a Giant Screen theater or dome with an incident meter. For good looking images in a flat screen theater you need a minimum of 150:1 intra-frame contrast ratio per DIGSS 2.0 guidelines. This is with all your normal exit signs and stair lights on, which degrade the blacks on-screen somewhat. Obviously the darker your theater the better. Both high sequential and intra-frame contrast are important. The minimum DIGSS 2.0 standard for sequential image contrast ratio is 1500:1 but you should really aspire to 4000:1 or higher on screen if you want to match about the best that film used to produce on high quality prints, in a fully black theater.

Understanding HDR

Why does HDR matter? You might wonder if this recent development of ultra-high contrast, true HDR (high dynamic range) projection technology really makes any difference in giant flat screen theaters and domes?

True HDR RGB laser projection systems do not compromise onscreen brightness because they produce true blacks – blacks without any residual light. Therefore, no optical filters or black-level blending are required for multi-projector blended systems (Figures 3 and 4).

Image quality, as we all know, is impacted not only by contrast ratio, but also resolution, color and frame rate. Take resolution, for example: In a dome, a single 4K projector can only deliver 8.8 Megapixels. Multi-projector systems can provide anywhere between 16.4 to 45 Megapixels or more, depending on the configuration and number of projectors. This is why their onscreen images look so much sharper[2].

Simply put, a true HDR, multi-projector RGB laser system combines optimal resolution and brightness performance with an unparalleled contrast ratio of up to 20,000,000:1, resulting in an image quality that is unmatched by any other projection technology on the market today.

[2]Read the Resolution matters tech brief here for more detailed information.

Figure 3: An illustration of various residual black levels and blend zones.

Figure 4: True HDR RGB laser projection systems produce true blacks without any residual light so you cannot see the edge of the frame, nor any blend zones on multi-projector arrays.

With its true HDR capability, Christie® Eclipse can actually project light with an incredible 20,000,000:1 contrast ratio by using six DMDs. Not quite as high as the real world billion to one, but pretty close.

When seen with images like a planetarium night sky starfield the effect is spectacular – like the most beautiful dark sky you have ever seen, with brilliant pinpoint stars dazzling your eyes. A Christie Eclipse projection system can replace a planetarium "star ball" projector, producing the same or better image quality.

Unlike film or older generation projectors, the blacks are perfectly black, so black that you cannot see the edge of the frame, nor any blend zones on multi-projector arrays.

HDR in domes

Why use projectors with a million to one sequential contrast in domes?

The answer is that their images look much better than regular projectors because filmmakers are usually wise enough not to fill half the dome with white (like a 50/50 ANSI contrast chart). In fact, Kodak determined that average outdoor scene reflectance is more like 18%. For an extreme case like white stars or specular highlights in a black sky, where maybe only 1% of the screen is full white and the rest dark, the system contrast could approach the same contrast ratios as seen on flat screens of 150:1 or greater since there is so little white area cross-reflecting to degrade the blacks. In fact, Christie has measured >20,000:1 local contrast on flat screens with small white squares in corners and black in the center, even with light scattering in the lens and some back-reflected light from the room. A fully darkened planetarium could now rival the darkest viewing skies on the planet for contrast, since a true HDR RGB laser projector can make the whites so very bright and the blacks so utterly pitch black.

Why is the DIGSS intra-frame contrast ratio only 10:1 for domes?

To understand this, it is important to remember that this is only when half of the dome or more is illuminated with a 50/50 ANSI black/white test chart. In a hemispherical dome screen one of the biggest factors limiting contrast is cross-reflection of light from other portions of the screen. For example, full white light hitting the side of the dome from either a test chart or a bright object like the sun, moon or space shuttle will bounce or reflect directly across the dome to brighten or degrade any dark or black areas of the picture. The blacks will become more gray, reducing the contrast ratio. Not only direct light, but diffuse light that scatters from the screen will go off in many directions and degrade other dark areas anywhere on the screen. The lighter the dome screen paint (the higher the reflectivity) the more you will get not only one-time light bounces, but multiple bounces, which degrades blacks on every single bounce from cross-reflections.

In the early days of Giant Screen domes, the industry did not understand this effect very well and thought that whiter domes would be brighter and better. Flat paints with reflectivity of 90% or more were sometimes used so system contrast levels were dreadful – as low as 2:1 or 3:1 contrast ratio. This is a common mistake of valuing image brightness more than contrast. We now know that a much better solution for improving system contrast is to use lower reflectivity paints.

For example, if the peak on-axis reflectivity is only 30% instead of 90% say, such that 70% of the incident light is absorbed, not reflected, the white portions of the image are dimmer, but the cross-reflected light attenuates very rapidly after a few bounces, such that each black square remains much darker due to less bounce light. The effect is much better ANSI contrast. Our eyes can and do rapidly and easily adapt to different brightness within a scene, but they cannot adapt or correct low or missing contrast.

Bit depth matters

10 bits per color is a practical requirement for artifact-free optical blending in highw-performance servers, if you want to preserve HDR contrast ratio. It may also be required to improve our entire Giant Screen post-production chain to take full advantage of new HDR and HFR projectors. Otherwise contouring and other objectionable artifacts might result, detracting from the spectacular image quality possible.

What kind of environment is needed for true HDR projection systems to really shine (pun intended)?

Contrast ratio degrades exponentially with increasing ambient light, so it is also critically important to reduce all ambient light sources in your flat screen theater or dome to the minimum possible by safety regulations to achieve the best-looking images.

Connect with an expert

If you have additional questions, or if you need some help in selecting the right solution, please contact us. We can connect you with our team of experts who will be happy to help you work through the various steps of your evaluation and procurement process.

christiedigital.com/imagematters

^ Great Lakes Science Center, Cleveland Clinic DOME Theater

For the most current specification information, please visit christiedigital.com

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