The importance of ANSI Contrast in High Performance Residential Applications

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Table of content

Introduction

In any visualization system, the contrast ratio is one of the key parameters that define image quality. A metric for comparing the brightest whites to the darkest blacks in the image, you could say that a good contrast ratio truly adds depth to the image. A low contrast ratio makes an image look washed out. Details as well as the artistic intent get lost. This is true for direct view displays as well as for projectors. In this white paper we will zoom in on contrast ratio in a cinema projection setup, since different definitions lead to different quantifications and interpretations. More specifically, we will focus on the so-called “ANSI contrast ratio”: what is it? What makes it different from “the contrast ratio”? And why is it so important?

The need for clarification comes from the ambiguous definition of contrast ratio above: “how the brightest whites compare to the darkest dark in the image”. Several more parameters need to be defined when putting forward an accurate definition of contrast ratio [1]:

- Where (on screen) am I showing these whites and blacks?
- What is the ambient condition of the room while I’m showing (and measuring) these whites and blacks?

This is crucial in a residential setup where the screen dimensions can be bigger than in other application and where the screen properties (gain, age, curve,…) can vary significantly. The ambient room conditions, mainly ambient light and reflections, in a residential installation are close to that of a – perfectly - dark room… except for a living room/Media room setup where you also have to calculate for that as well.

Sequential contrast

The easiest configuration in which to measure contrast ratio is one where the full screen is white when measuring the maximum luminance and the full screen is black when measuring the minimum luminance, and where no ambient light is present. This is called the “sequential contrast” (or sometimes “off-to-on contrast”). When no other specification is mentioned in the brochure or spec sheet of a projector, it is typically the sequential contrast that is being used. The good thing about this definition is that it is easy to measure and hence reproduce in the field. The actual quantification can also happen quickly with one brightness measurement on white, one on black and a calculation of the ratio between the two. The downside of the method is that it is so easy to do that it is also simple to do it badly (intentionally or accidentally):

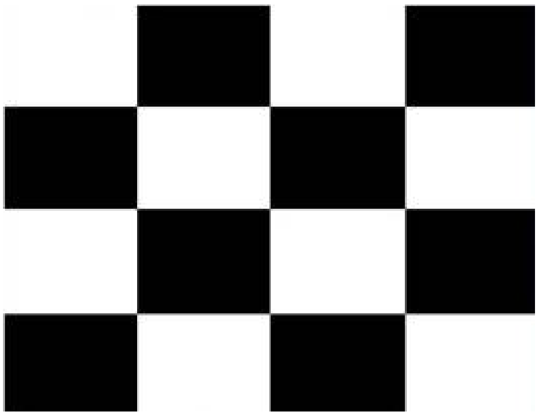
- The ambient light level needs to be absolutely zero. Even the smallest amount of light leaking from a window, lamp, other room, for example, will be added to the measured dark level and can ruin the calculated ratio. [2]
- The light level on screen when measuring black needs to be representative and correct for the black “color” that the projector will put on the screen in normal operation. There have been cases in the past where manufacturers switched the unit’s light source off (or mechanically blocked it) when measuring the darkest possible black. This of course reduces the measured luminance (we will later explain why) and artificially boosts the contrast ratio.[2]

- When measuring white, the on-screen light level also needs to be correctly configured. Projectors have a so-called native brightness: the total amount of lumens they can generate, without taking into account system calibration to cinema specifications or other specifications used in the Residential market. When operated in the field, the system is configured to meet target colors for the specification you are aiming for, including that of white. The brightness of this calibrated white point can be slightly lower than the native white point. Since the brightness of the calibrated white point depends on parameters outside the projector (e.g. the color of the walls and seats in the room), using the native brightness makes things more reproducible. That is why it is typically used when specifying and measuring the sequential contrast spec, to make comparison possible.

ANSI contrast

A more representative and accurate parameter for quantifying the contrast ratio is the so-called ANSI contrast, sometimes also called “checkerboard contrast” or “simultaneous contrast”. In this method, you again measure the brightest whites and darkest blacks, but in a setup that is much more representative of how the system will eventually be used in reality and perceived by the audience. The ANSI contrast measurement is also more difficult to cheat on when trying to boost the results.

When measuring the ANSI contrast, the pattern on screen is not full-screen white or black, but a 4x4 checkerboard pattern consisting of 8 white and 8 black squares. The black again needs to be the same level as when showing black content: since you are at the same time displaying white squares, playing tricks by dimming the light source will not help as the bright zones will be equally impacted.



This contrast measurement method is much more representative of how the image will eventually be perceived:

- Any scene, animated or camera-shot will contain a combination of bright and dark zones. No movie content consists of full-screen white or full-screen black. You could debate whether the average brightness of 50% of the ANSI pattern is closest to reality as possible, but it has some other practical benefits. The different squares are big enough to be measured accurately with a standard luminance meter: if you would go to e.g. an average brightness of 10%, the white patches would be too small for doing accurate and consistent measurements.

- The fact that you project white and black simultaneously on-screen means you take into account reflections and flare of the projector and the room. Light intended for the white squares will find its way and fall onto the black squares where they will raise the light level and reduce the contrast ratio [3]. This is what happens on real content, so the test pattern should reflect the phenomenon. This light leakage has its origin both inside and outside the projector. Inside the projector, light scatters in the optical elements and leaves the lens in places where it is not intended to be. This is impacted by the material quality of the glass elements, light absorbers and coatings inside the projector; but also by the inherent light modulating technology used (DMD, LCD, LCOS …). Light leakage outside the projector is defined by properties of the auditorium: scattering in the porthole window; the color of the walls; the position of the screen and audience, etc. Careful room design can help minimize these effects and boost the contrast ratio [2]. Note that the two symptoms will be visible when projecting real movie content, but not (or much less) when projecting full screen black such as in the sequential contrast measurement. It will be completely absent when tricking the sequential contrast measurement by artificially blocking the light. This confirms that the sequential contrast is not a very representative way to assess perceived contrast.
- In the ANSI contrast measurement method, the measured brightness of the eight white squares is averaged out to come to the peak brightness defining the contrast. The same applies to the measured black levels on the 8 dark squares. This is again a step forward compared to the sequential contrast (where you only measure in the center of the screen) since you take into account the full screen and image surface to quantify the contrast ratio. Again, in real setups, the audience also perceives the whole screen. Things like screen gain or side effects caused by the walls closest to the image borders can create a spread in the actual contrast ratio across the screen surface. This spread is reflected in the average ANSI measurement, not in the sequential contrast metric.

As mentioned above, a projector's ANSI contrast spec can be more representative of the actual perceived contrast, since it comes closest to how the system will be used in reality. A projector with a good sequential contrast can look very bad in an average room. A projector with a good ANSI contrast will keep its image quality in most setups; although it is important to remember that a badly designed room (high ambient light, many reflections,…) will ruin any experience.

This link with the boundary and usage conditions also means that any ANSI contrast spec is linked to the conditions it was measured in. Projector manufacturers will typically measure it in a dark room with minimal scatter and reflection caused by the room. This means that the value measured by the customer in the field can differ, specifically due to changes introduced by the room itself. This is called the *in situ* contrast [1].

Quantification

When thinking about "the contrast ratio" of a digital cinema projector, people typically think about a number around 2000:1. When linking this to the numbers mentioned above, this is the sequential contrast of a mainstream DLP-based DCI-compliant projector (which make up >85% of the cinema market). In recent years, the topic of HDR (or high dynamic range) has gotten more attention in cinema [4], which has led to new contrast ratio numbers going around. Some high contrast DLP projectors have been presented with numbers exceeding 5000:1; which is again a unit of sequential contrast. When people talk about the main stream commercial residential projectors, they think of numbers like 2,000 000 :1 or infinite contrast. Very high numbers.

So, how do we bring ANSI contrast into the mix? It is important to realize the significant impact of internal light scattering. This effect causes the ANSI contrast to always be lower than the sequential contrast. Where a mainstream sequential contrast is around 2000:1, with high-end projectors exceeding 5000:1; these numbers are a factor 5-10 lower for ANSI contrast. A projector with an ANSI contrast of 1000:1 is an exceptionally good projector.

It is also important to understand that the impact of the internal projector technology also causes a decorrelation between sequential and ANSI contrast. A projector with a high sequential contrast can have a very low ANSI contrast, due to the technological choices in the projector architecture. A projector with a mainstream sequential contrast can outperform a premium model when comparing the ANSI contrast. This can be seen typically e.g. when comparing DLP-technology to LCoS. The former holds its ANSI contrast better where for LCoS it has been measured to be a factor 50 or more below the sequential contrast. [3]

Conclusion

With the interest for HDR growing, so has the importance of a properly specified contrast ratio. When evaluating and interpreting "the contrast ratio" of a residential projector, it is important to know that both sequential and ANSI contrast exist. The former is the easiest to measure (on site) and therefore the most frequently-used by manufacturers and integrators. However, the ANSI contrast is a much more representative metric. It takes careful consideration of the measurement conditions but shows a better correlation with the perceived contrast by the audience. In its high contrast models, Barco has started including the ANSI contrast ratio as a specification.

References

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