6P laser projection:
Redefining 3D cinema

CHRISTIE®

Redefining 3D cinema

A sharp decline in 3D box office sales, especially in the domestic market, is raising concern in the cinema industry. What was heralded as an innovative and powerful platform for filmmakers, studios and exhibitors to create and showcase immersive and impactful 3D content, has failed to keep consumers interested, leading to a downward spiraling of 3D box office returns.

One perspective on the problem lies on the content side, meaning that filmmakers are making films in 3D that were never intended for 3D or, worse still, they are just doing a poor job with 3D production in general. On this topic, Dreamworks Animation CEO Jeffrey Katzenberg went on record in a 2010 *Variety* interview condemning filmmakers and studios that "killed the goose that is delivering us golden eggs" through mass production of "terrible" 3D films[1]. As a clear and unfortunate testament to his vision, the 3D box office take rates (vs. 2D) in the United States market since then have declined from 67 percent in 2009 to 42 percent in 2013.

This is a serious problem, mainly because the 3D premium ticket price that benefits everyone in the industry – from studios through to exhibitors – is experiencing an equally
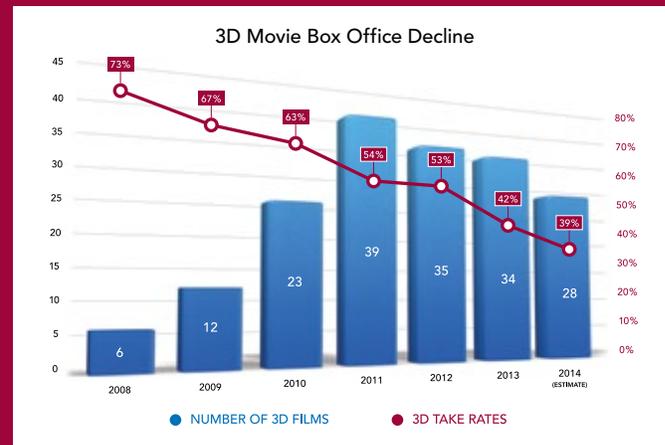
▲ Sharp decline in domestic 3D take rates for 3D films.

sharp decline. However, to place the blame entirely on the shoulders of Hollywood studios would be unfair – technology suppliers, system integrators and exhibitors also need to take responsibility and understand the potential impacts that technology decisions have on creating and delivering the overall 3D experience.
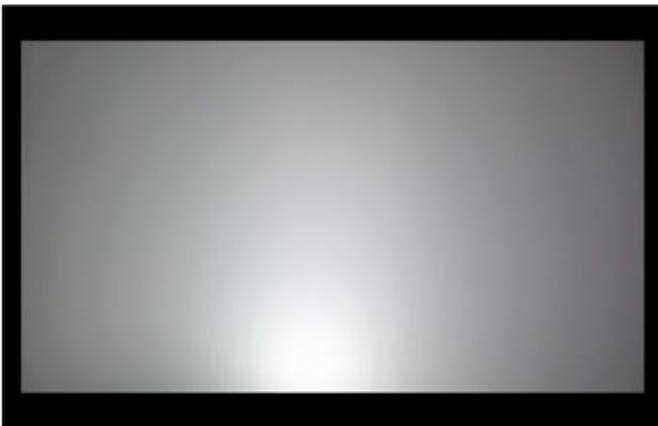
▲ A non-uniform image on a high gain silver screen.

What's wrong with the 3D cinema experience?

3D cinema has been enabled by the mass adoption of digital cinema projectors. In converting screens to digital, installers generally design projection systems to achieve a brightness level of 14 fL on-screen in accordance with the Digital Cinema Initiatives (DCI) specification. However, equipment is typically specified assuming that all films are shown in 2D. A major problem arises because 3D equipment (various polarizers, wheels, glasses, etc.) effectively absorbs between 70-90 percent of the light, leaving only a small fraction of the 14 fL brightness. This means audiences struggle to discern the details making up the image; everything disappears into the background and colors appear unnatural. A direct analogy to watching a low-brightness movie is reading in low-light conditions, complete with the accompanying headache and eyestrain.

Making matters worse, most 3D systems need a high gain silver screen, featuring a brighter spot on the screen directly in front of the viewer, and rapidly deteriorating brightness on areas of the screen that are farther away. This is far from a natural and immersive experience. Until screen manufacturers develop uniform engineered surfaces that can retain light polarization, the only way to achieve natural and immersive 3D experiences is to use low gain white screens.

[1] "Katzenberg: Biz at 3D crossroads" *Variety*, April 2010

Stereopsis

We also need to consider stereopsis. Stereopsis is the visual process that allows two eyes to see two different images that are slightly offset from one another. The human brain takes these two images, along with other critical cues, such as relative size and surface orientation, to form a single mental image, complete with accurate depth perception.

These two images are normally seen simultaneously. However, with rare exceptions, 3D movies are shown by flashing left and right eye images sequentially through a single projection lens.

This means the brain is receiving the left and right eye images at different times and is burdened with the additional task of correcting for temporal offset. This unnatural function, while not consciously perceptible by most people, contributes to the level of fatigue or occurrences of headaches among viewers and, in some cases, even causes nausea or motion sickness when viewing 3D content. The ideal approach is to present simultaneous and persistent images independently to both eyes, rather than trying to flash between them in rapid succession.

A technical solution

It is well known that laser projection systems, along with the proper selection of efficient 3D equipment, can solve the 3D brightness problems on most screens. A public Christie® laser projection demonstration in 2013 featured a single 72,000 lumen projector that was capable of 14 fL brightness on a 65 ft. wide, high gain silver screen using a RealD XL 3D system. This was a benchmark moment for the industry, as people were finally able to see a 3D movie at the proper brightness level.
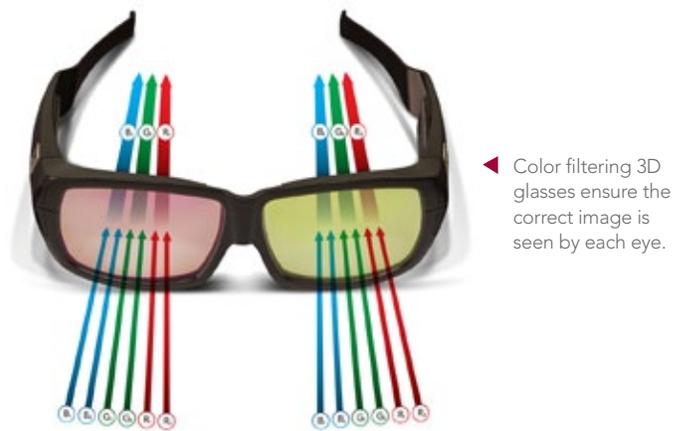
However, the system was still flashing between left and right eye images and was nearing peak brightness capabilities, so lighting up a larger screen would not have been possible. A relatively straightforward solution is to add a second projector to the system. This approach doubles the light output while providing naturally simultaneous images for both eyes. Modern computer vision-based alignment technology, such as that used in the Christie Duo system, can eliminate the chore of keeping dual projection systems perfectly aligned for cinema presentation purposes.

Christie's laser demonstration was also compromised by the fact that the 3D system in use required a high gain, non-uniform silver screen to maintain light polarization. Currently, there are really only two alternative 3D options using lower gain, white screen surfaces. One system uses shuttered glasses, flashing between left and right eye images from a single projector, alternatively blocking each eye so it only sees its intended image. This approach, however, is very inefficient from a brightness perspective and is less than ideal due to issues with stereopsis, but some may judge the overall experience to be improved due to the uniformity of the image.

The other solution available for low-gain white screens uses a technique known as color-separation-based 3D. This approach takes advantage of the fact that projected images on the screen are created using a pixel-by-pixel combination of red, green and blue (RGB) primary colors. Specifically designed glasses can filter out precise color wavelengths of light from getting through to each individual eye. By generating images for one eye from a combination of RGB primaries ($R_1G_1B_1$) while generating images for the other eye using a different combination of

primaries ($R_2G_2B_2$), the filter glasses can then be used to ensure that each eye only sees the correct image.

◀ Color filtering 3D glasses ensure the correct image is seen by each eye.

This approach is used by Dolby® Laboratories' 3D system and is widely acknowledged as the best 3D platform for accurate color reproduction and a naturally immersive, uniform 3D experience, especially if two projection heads are used for simultaneous left and right eye images. The Dolby 3D system has been available for several years now, however, a major drawback for lamp-based systems is that the process of isolating two different sets of RGB primaries from the broad spectrum (white) xenon lamp is extremely inefficient, making the low-brightness issue in large-screen auditoriums even worse.

If this is the case, then surely we should combine the high-brightness capabilities of laser projection with the superior image quality of color-separation-based 3D. Unfortunately, the solution is not that simple. Typical laser projection systems create light by combining a single set of RGB primary colors to create the image. This is known as 3-Primary (3P) laser projection, and it is the ideal solution for 2D projection in cinema and other industries. With 3P, however, there is simply no "light energy" at the secondary wavelengths to pick out of the light source for the second eye image. To create the color-separated image for the second eye, you need to add three additional laser primary colors to the light source – creating something that is aptly called a 6-Primary (6P) laser system.

6P laser projection

With a 6P laser projection system, the required wavelengths of light are generated right from the source with no light wasted or thrown away while isolating the specific colors for the separate left and right eye images. The result is that a 6P dual-head 3D system is almost twice as light efficient as the most efficient 3D system available today – with the added benefit that it does not need a high gain, non-uniform silver screen. Also, implementing a 6P laser system can be achieved easily using two projection heads in a Christie Duo configuration, with each projection head designated as a left- or right-eye projector and separately connected to its own set of distinct RGB primary lasers.

When contemplating a 6P dual-head 3D projection system, it is reasonable to consider system designs using only a single projection head since the extra head appears to add cost and complexity to the system. However, if you consider what is being accomplished with 6P laser, a dual-head system is the only available solution that makes any sense. The practical alternative for a high power cinema system is sequential flashing of the left and right eye images through a single projection head, which is clearly not ideal based on the aforementioned issues with stereopsis.

More importantly, though, is that a single-head 6P system is less than half as light efficient as a dual-head system that displays both left and right eye images simultaneously. To achieve sequential image display, a single-head system is turning off or mechanically blocking either the $R_1G_1B_1$ primaries or the $R_2G_2B_2$ primaries on an alternating basis. This means each set of lasers is used less than 50 percent of the time when you account for switching and color transient effects that need to be masked by absolute dark time. Hence, with a single-head 6P laser system, you will need at least twice as many lasers to achieve the same 3D light output as a dual-head 6P laser system. With the current cost of lasers far outweighing the cost of projection heads, this means that a single-head system will cost almost twice as much as a dual-head system to achieve the same 3D brightness.

6P laser projection – the future of cinema

As with any new technology, early adopters can expect to pay a premium and may indeed witness significant price drops of similar product offerings during the early years of ownership. For that reason, it is essential that buyers carefully study the options available to them to make sure that whatever they buy today is both scalable and upgradable, such as the modular laser projection system architecture sold by Christie.

6P laser projection is absolutely the future of cinema and will someday become the mainstream source of projection system illumination. Christie and other industry voices strongly believe and expect that laser projection will raise the bar for all 3D screens, satisfying the market need and restoring the 3D box office to reflect the astonishing 3D experience that audiences can only get at their local movie theater.

Why two heads are better than one

As an explicit warning, under no circumstances should an exhibitor consider a single-head 6P sequential 3D system. Not only does this type of system exhibit "flashing" artifacts on screen, it also suffers from extremely inefficient use of the lasers for color-separation-based 3D (versus a dual-head system) and suboptimal performance for all other 2D and 3D system configurations (versus 3P). A buyer can easily be misled. For example, if a 6P laser projection is offered featuring 60,000 lumens of light output, then that specification is very likely the 2D light output only; the actual 3D light output would be less than 30,000 lumens after accounting for the alternate flashing or shuttering of each set of laser primary colors. Clearly, in this case, the technology would not be addressing the market need for brighter 3D nor would it be offering a compelling 2D solution, but merely taking advantage of the current market hype for 6P laser projection.

▲ Implementing a 6P laser system can be achieved easily using two projection heads in a Christie Duo configuration.

Corporate offices

Christie Digital Systems USA, Inc.
USA – Cypress
ph: 714 236 8610

Christie Digital Systems Canada Inc.
Canada – Kitchener
ph: 519 744 8005

Independent sales consultant offices

Italy
ph: +39 (0) 2 9902 1161

Worldwide offices

Australia ph: +61 (0) 7 3624 4888	France ph: +33 (0) 1 41 21 44 04	Republic of South Africa ph: +27 (0)11 510 0094
Brazil ph: +55 (11) 2548 4753	Germany ph: +49 2161 664540	Singapore ph: +65 6877 8737
China (Beijing) ph: +86 10 6561 0240	India ph: +91 (080) 6708 9999	Spain ph: +34 91 633 9990
China (Shanghai) ph: +86 21 6278 7708	Japan (Tokyo) ph: 81 3 3599 7481	United Arab Emirates ph: +971 4 3206688
Eastern Europe and Russian Federation ph: +36 (0) 1 47 48 100	Korea (Seoul) ph: +82 2 702 1601	United Kingdom ph: +44 (0) 118 977 8000

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