EPSON WHITE PAPER

YOUR GUIDE TO COLOUR LIGHT OUTPUT

DAZZLED BY COLOUR LIGHT OUTPUT?

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The importance of colour light output (CLO) when evaluating and comparing digital projectors

It may be hard to believe but it isn't that long since the humble overhead projector (OHP) was viewed as an essential tool, much loved by teachers, lecturers and anyone tasked with delivering business presentations. Yes, they were far from ideal and rarely portable, however, using often hand-drawn, mostly black and white slides the overhead projector just about did the job. More than that, buying was easy and it was possible to choose the correct product based purely on its brightness or white light output.

The days of the OHP are, thank goodness, long gone and it has been replaced by the digital equivalent which is connected, often wirelessly these days, to a desktop or notebook computer. However, such an evolution brings with it new challenges, not least when it comes to distinguishing between the many different projectors on offer today.

The main challenge is that, in this era of ultra-vivid multimedia presentations, HD video and animation, simple white light brightness (typically quoted in lumens) is, by itself, no longer the best way of deciding what to buy. Indeed, in our multi-colour world, colour brightness is equally, if not more, important.

According to a recent study conducted on behalf of Epson by TFCinfo[1], a leading market research firm focused solely on the audio visual industry, when it comes to business and education projector purchasers, 86 per cent of the content they display is colour. The Projector Brand Customer Perception and Preference Study also revealed that 40 per cent of this group display **only** colour content.

On top of this, the survey also questioned purchasing behaviour with regard to projectors in a wider audience spanning the entire channel. This diverse group did agree on many points, not least of which being that image quality is the most important factor when choosing a projector (on average 89 per cent either agreed or strongly agreed). Alongside this, 99 per cent of the entire group agreed or strongly agreed that colour is an important aspect of image quality.

Given this, and the development of an industry standard way of measuring Colour Light Output (CLO), launched in 2012, the industry now recognises the importance of CLO and its impact on picture quality.

In light of this, this whitepaper looks in more detail at CLO, explains why it is important, how it is measured and why it matters.

Measuring projector brightness – the old-fashioned way

The brightness of a projector has, traditionally, been measured using a test methodology developed by the American National Standards Institute (ANSI), which is why you will sometimes see ANSI Lumens figures quoted by vendors.

Lumens – measuring the white

A lumen is a measure of the total amount of light emitted by a source such as a digital projector - effectively its brightness. As an absolute measure it will be fairly meaningless to most people, but as a way of comparing brightness, a lumens value is a good starting point.

Here are a few figures for reference:

- *A domestic 100 Watt bulb will emit 1,600 lumens or more*
- *Sunlight on a sunny day will vary from 32,000 – 100,000 lumens per square metre*
- *A well-lit office will have light levels of 400 lumens per square metre*

Developed back in the 1990s, the ANSI test starts by calibrating the projector's contrast. Then the brightness is measured on a full white field at nine specific locations around the screen and averaged. This average is then multiplied by the screen area to give the brightness of the projector in "ANSI lumens".

When it comes to choosing a projector to suit the size of the audience and the environment in which it will be used, these lumens brightness figures are considered highly accurate and seen as a key tool.

Why is brightness important? It's all about obtaining a clearly defined image considering the levels of ambient light. Take projectors bought by consumers for home use, for example. These will mostly be used to watch movies and TV by a handful of people in small, easily darkened rooms, in which case between 1-3,000 lumens is more than adequate. Business users giving PowerPoint presentations will,

[1] www.tfcinfo.net

typically, need more, particularly when it comes to ad-hoc presentations in offices where total light blackout is not an option. In such situations a brightness of at least 3,000 lumens will be required and, for projectors installed in large rooms for bigger audiences, anywhere around 5,000 lumens and above can be required.

White isn't always right

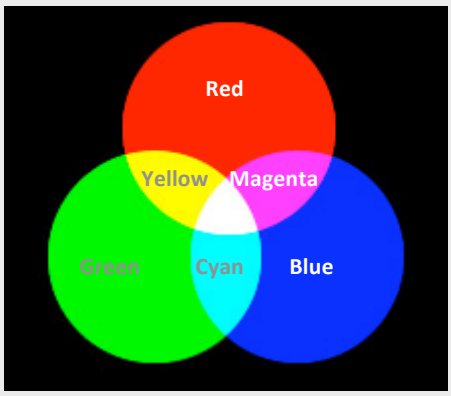
Unfortunately, while the lumens rating tells you how bright a projector will be when showing white light, it doesn't measure the brightness of its Colour Light Output. Depending on the technology used to generate the colours (discussed in more detail shortly) colour brightness can often be much lower than that of white light, making the image as a whole appear dimmer.

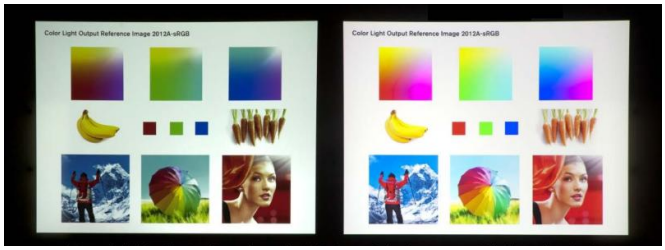
A dimmer image will, in turn, make presentations harder to see, both in darkened environments and in those with high levels of ambient light. Clearly that's far from ideal and will detract from a presentation's content and impact. This, in turn, drives projector buyers to seek models with higher lumens than required, just to get better colour images.

Why RGB?

The extensive palette of colours generated on computer displays and by digital projectors is made up of just three component colours – red, green and blue – mixed together in different ratios and intensities to fool the eye.

The simplest way of measuring colour brightness is, therefore, to test the brightness of each of the component colours.





The projector on the left (2,700 lumens) has low colour output (700 lumens) whereas, on the right, colour and white output are the same (2,800 lumens each)

Colour Light Output alongside white light output is therefore a key indicator of picture quality. The TFCinfo survey underlined this, as picture quality then brightness, are the top purchasing criteria. However, only a fifth (21 per cent) of buyers surveyed correctly understood that most vendors only published figures for white light brightness, while the remainder believed that the lumens figures quoted automatically included colour.

Interestingly, when asked if the availability of colour brightness information would have an impact on their buying decisions, the majority of people in the TFCinfo study (91 per cent) said yes. In fact this specification is so important that, on average, most buyers would pay around a 19 per cent premium for brighter colours.

These figures, if nothing else, reflect the need for vendors to measure and publish colour brightness figures for their products. Fortunately, there is now an industry measurement process which vendors can use, designed specifically to give projector buyers a standard of brightness for Colour Light Output.

Measuring projector brightness – the modern way

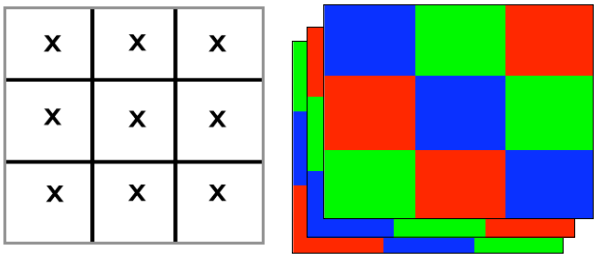
Colour Light Output can now be measured via a published industry standard methodology. Released in May 2012, this standard quantifies the brightness of red, green and blue colour output, the primary colours used both to generate images on computer displays and by digital projectors.

Brightness measurements are of little value unless this standard methodology is employed when taking them, as they cannot be compared reliably across the industry. The CLO methodology has been devised by the Society for Information Displays (SID)[2], a globally recognised organisation comprised of around 5,000 display professionals working to educate members of the display and projection industry.

[2] www.icdm-sid.org

The complete Information Display Measurements Standard document, containing the CLO testing methodology can be downloaded from the SID website for free. To give insight into the test itself, in essence Colour Light Output is measured in almost exactly the same way as white light output. However, instead of taking measurements across a grid of white blocks, a grid made up of the primary colours (red, green and blue) is used. And because of the three component colours three different grids are employed.

Brightness (white light output) takes nine measurements from the X points indicated on the grid. Colour Light Output uses three 9-point grids to measure the brightness of each of the primary colours. Accordingly, the number of measurements also rises. Instead of the nine used to calculate standard brightness, a total of 27 measurements are taken to give a value for CLO. The readings from the sample images for CLO are summed, averaged and multiplied by the screen area to determine the overall colour brightness level which, for consistency, is also specified in lumens.



White light output measurement grid (left) and Colour Light Output measurement grids (right)

Actual values may vary but, ideally, CLO should be close to or the same as the white light level output in lumens to give bright, vivid colours. Unfortunately, establishing a Colour Light Output value for some products may not be straightforward, as some vendors only give white light values. You can, however, make some assumptions based on the imaging technology used in a particular projector which we will explain in more detail.

Technology can make a visual difference

Apart from one or two exceptions[3], two main technologies are found inside modern digital projectors – either DLP or 3LCD.

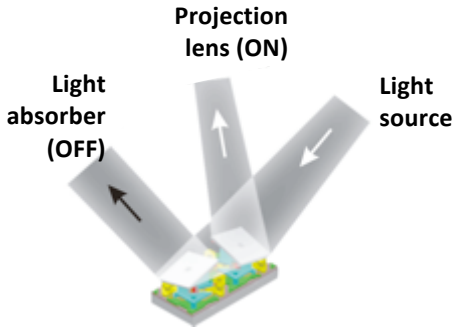
Short for Digital Light Processing, DLP uses a chip technology developed originally by Texas Instruments but now widely licensed and used throughout the industry to drive digital projectors and other imaging devices. DLP projectors are available to suit a wide range of applications, from home theatre use, through business presentations and classroom deployment, to use in professional auditoria and cinemas.

3LCD technology was, similarly, developed by Epson and launched in the 1970s. It is promoted and developed by the affiliated body also called 3LCD[4] and is licensed to a large number of other vendors. As a result, alongside Epson, there are around 40 vendors who offer 3LCD projects covering, like DLP, all the major applications from home theatre to business and educational use.

When it comes to generating images the two technologies work in fundamentally different ways, especially when it comes to how they handle colour. Differences that can have a major impact on colour brightness. Let's take a look at what each involves.

How DLP works

Digital Light Processing employs a chip with a reflective surface comprised of up to two million tiny hinged mirrors, each responsible for a single pixel. Light from the projector lamp is reflected from the mirrors on the surface of the DLP chip towards the lens. The mirrors tilt to shine the light either towards the lens, which turns a pixel ON, or away from lens onto a light absorber to turn it OFF. This can happen thousands of times per second. With regard to the frequency, a mirror that is on more often than off creates a lighter pixel; one that's off more often creates a darker pixel.



How the DLP mirror array works

DLP Technology

- *The DLP chip is a sophisticated light switch made up of 2 million hinged mirrors*
- *Each mirror can be tilted to turn its associated pixel on or off*
- *A single-chip DLP projector requires a separate colour wheel to generate the required RGB colours*

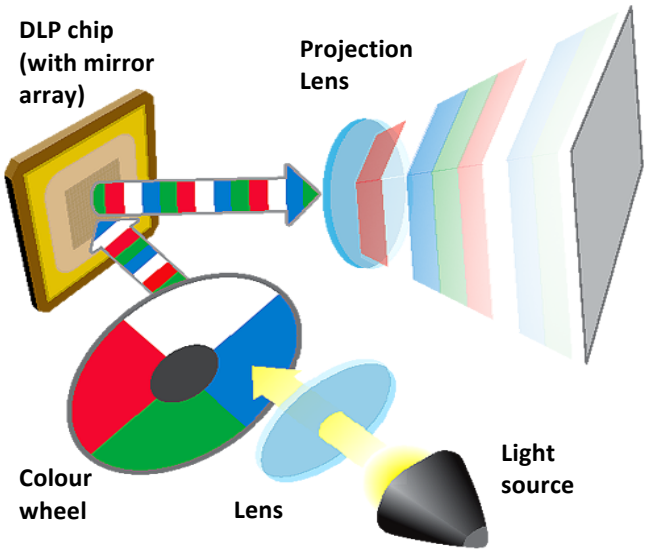
In cinema projectors and other expensive high-end products, three separate DLP chips can be used, one each for the red, green and blue component colours. However, in order to bring prices within the reach of most business users, the

[3] Other minority use imaging technologies such as LCoS (Liquid Crystal on Silicon) are available but are not included in the discussion on colour brightness in this white paper

[4] www.3lcd.com

majority of DLP products have only one chip, and that calls for additional technology to cope with colour.

In most cases the mechanism employed is a colour wheel, typically divided into red, green and blue filter areas[5], which spins in the light path between the light source and the DLP chip to add the required colour elements.



Inside a DLP optical engine

One drawback of using a spinning colour wheel is that, on a single-chip DLP projector, only one colour can be projected at a time, but because of the spin speed, the eye is fooled into thinking it is seeing composite colour images.

The speed of the colour wheel is critical. If it's too slow viewers may see so-called "rainbow" effects – momentary flickers of colour – although this mostly occurs with moving images rather than static presentations.

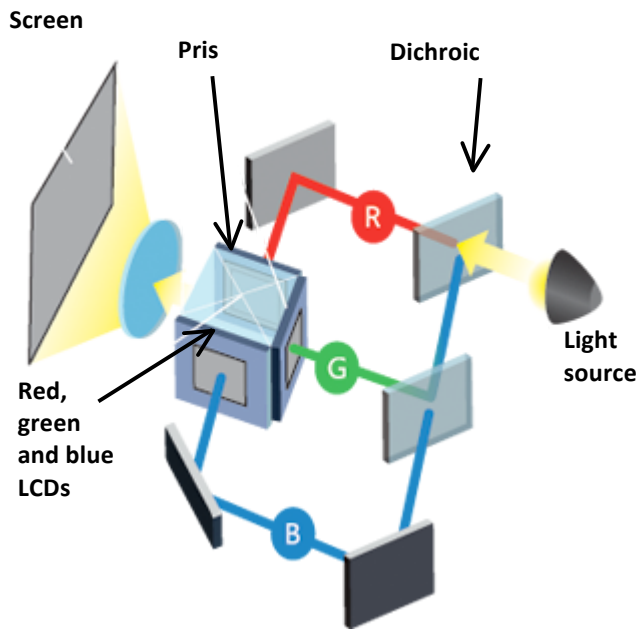
How 3LCD works

As the name implies, 3LCD projectors employ a set of three separate LCD (Liquid Crystal Display) panels, one each for the red, green and blue components of a colour image. Just like the LCD display in a notebook or colour TV, each panel is made up of millions of liquid crystals. The panel can be visualised as a shutter or blind, with one liquid crystal in each panel corresponding to each pixel in the projected image.

Red, green and blue light is shone through its own LCD panel. Each liquid crystal in every panel is then opened, closed or partially closed to allow different amounts of light to pass through, so controlling how much light of each colour is needed in that pixel to make up the final image.

Rainbow effects are not a problem with 3LCD projectors because the outputs from the three colour LCD panels are combined to create the composite colour images projected onto the screen.

Inside a 3LCD optical engine



3-Chip LCD Technology

- *Mirrors split the light into its three component colours (RGB)*
- *Three LCD panels then allow the precise amount of light required to pass through*
- *The three colour images are combined using a prism to form a full-colour image*
- *The vibrant, full-colour image passes through a lens and is projected onto a screen*

How technology can affect colour brightness

Measure the brightness of the component red, green and blue light from a 3LCD projector and the resulting value is your Colour Light Output. This will be the same as the white light output. All Epson projectors, for example, have identical lumens ratings for both white and colour light, as do other projectors based on Epson's 3LCD technology. This is hardly surprising as 3LCD works by generating white light by combining the three component colours.

Standard 1-chip DLP projectors, because of the limitations of the technology, only have colour light that is around a third of the white light brightness, producing duller colours than 3LCD projectors. Because its white and colour light outputs are the same, buyers will get three times brighter colours with a

[5] In addition to red, green, and blue filters, colour wheels can contain other segments such as a white (clear) filter, commonly used to boost brightness

3LCD projector[6] than with a comparable DLP projector with similar quoted lumens.

The majority of business-class DLP projectors cannot achieve the same levels of colour brightness because they include a white segment in the colour wheel used to create the RGB image, specifically to boost perceived brightness. As a result, the colour light output ends up far lower than the white light – often as much as a third of the brightness.

To further complicate matters some DLP projectors employ colour wheels with filters for more than just the primary colours. Filters for cyan, magenta and yellow are available, which can improve colour quality but reduce brightness further. This also does nothing to boost the Colour Light Output as it still does not match the brightness level of the white light output.

Three times as bright

- *The CLO (Colour Light Output) ratings for 3LCD projectors will, typically, be the same as their white light outputs, with both measured in lumens.*
- *On single-chip DLP projectors, Colour Light Output can be a third of the brightness of white*
- *3LCD projectors consistently deliver up to three times brighter colours at the same lumens levels*

Conclusion – CLO is important to all projector buyers

While there are many factors to take into consideration when buying a projector, such as resolution, ease of use, robustness and portability, image quality and brightness consistently come out as the top criteria. Bright colours are also recognised as an important aspect of picture quality as content becomes increasing colour-heavy and the market is ready for a new way of looking at colour.

Brightness in lumens is no longer the best specification to compare projectors, yet the industry has a long way to go before the impact of colour light on image quality is widely recognised by purchasers.

White brightness alone is insufficient to gauge true picture quality, whereas Colour Light Output (CLO) gives projector buyers the data they need for an effective comparison of devices. Data they have, until now, been missing from all but the leading 3LCD projector manufacturers (interestingly companies such as Epson have been talking about CLO for many years).

Colour brightness is determined in part by the imaging technology used in a projector. The 3LCD technology pioneered by Epson delivers the same levels of brightness for both white and colour light. The single-chip DLP implementations in most business-class projectors often fall way short of this target, only delivering around a third of the quoted brightness in lumens when it comes to CLO. This is primarily because white light output is artificially boosted on such products. And buyers who demand high-quality pictures would do well to note that 3LCD delivers three times brighter colours when compared to 1-chip DLP models which quote similar lumens.

The Colour Light Output measurement standard that was published in May of 2012 gives end users reliable data which can be used to compare the colour brightness levels, and consequently image quality, of different projectors.

Leading manufacturers – most notably Epson (which has done for some time) – are adopting the CLO standard and now include two measurements, White Brightness (White Light Output) and Colour Brightness (Colour Light Output), in their projector specifications. However, publication of CLO figures is far from universal and projector buyers should look for and demand this information. Not only that, for the optimum visual experience they should make sure that the Colour Light Output is equal to the White Light Output on every projector they buy.

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For more information visit:
www.epson.eu/CLO

Appendix

Sources of information on Colour Light Output:

Epson's Colour Light Output site: www.epson.eu/CLO

3LCD Group guide to Colour Light Output: www.colorlightoutput.com

[6] Compared to leading 1-chip DLP business and education projectors based on NPD data, July 2011 through June 2012. Colour Brightness (Colour Light Output) measured in accordance with IDMS 15.4. Colour Brightness will vary depending on usage conditions. For more information please visit www.epson.eu/CLO

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3LCD website: www.3lcd.com

Society for Information Displays (SID): www.sid.org

Free download of the Information Display Measurements Standard (IDMS): www.sid.org/lcdm.aspx