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Projector Colour Brightness: Test Data

Equal White and Colour Light Output levels ensure bright, vibrant colours and true-to-life images – essential for today's digital content. Epson's 3LCD projector engine produces equally high White and Colour Light Output (colour brightness), with rich colours that are **three times brighter**[1].

Measure the brightness of the component red, green and blue light from a projector and the resulting value is your Colour Light Output or colour brightness. Many manufacturers only quote the brightness of their projectors' White Light Output. This doesn't give the full picture, as a projector's colour light brightness, also given in lumens, can be significantly lower than its white light brightness. When this occurs, projected images appear dull.

So, what is the technology behind this and why should you care?

Technology affects colour brightness

Not all projectors produce colour in the same way. This leads to significant differences in the projector's ability to deliver colour.

Some projectors create white light by showing the red, green and blue light simultaneously, combining them to make the final image – this is the case with a 3LCD projector.

Others break down the white light source into a sequence of consecutive red, green and blue images, which are then shown so quickly that they seem to be a full colour image – this is the case with a single-chip DLP projector.

The difference may seem to lie only in the wording but the results in terms of white and colour brightness can be surprisingly different.

Let's look first at the DLP way of showing colour...

The colour wheel spins hundreds of times a second to show the colours sequentially. A four-segment wheel would show red, green, blue, white (clear), red, etc. This tricks the mind to "see" all these colours at once and turn them into the full colour image. And, while the eye may be fooled into seeing full colour, the loss of brightness from creating the full colour image by showing sequential red, green and blue (with a burst of white light) is difficult to overcome.

This is why standard 1-chip DLP projectors have colour light that is significantly lower than the white light brightness, delivering dull colours.

What about how 3LCD projectors show colour?

Well, a full colour image delivered on a 3LCD projector uses every single lumen that comes from the light source. It just uses dichroic mirrors to split the light and then – and this is the clever part – recombines the colours back together. The image is made on the screen, not in your mind, so every single lumen is visible in the image on the screen.

Because of this, all Epson projectors have identical lumens ratings for both white and colour brightness, as do other projectors based on Epson's 3LCD technology.

And, because its white and colour light outputs are equally high, you get brighter colours with a 3LCD projector than with a comparable 1-chip DLP projector with similar quoted lumens for white light.

CLO now an industry standard

Colour Light Output or colour brightness can now be measured via a published industry standard methodology. Released in May 2012, this standard quantifies the brightness of all digital projectors' red, green and blue colour output.

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.

The complete Information Display Measurements Standard (IDMS) document, containing all the standard testing methodologies, including the colour brightness test, can be downloaded from the SID website for free. Although we will briefly explain the test itself here, the IDMS book is the place to go for the full technical details.

[1] 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

[2] www.icdm-sid.org

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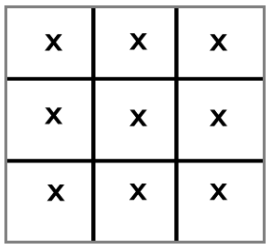
The colour brightness test

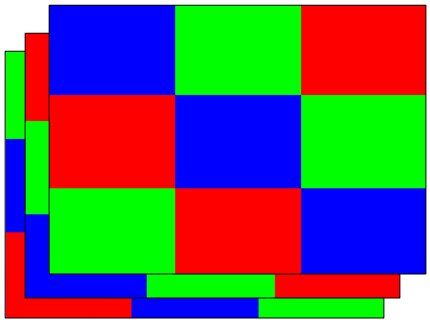
To give insight into the test itself, in essence Colour Light Output is measured in almost exactly the same way as white light output. However, instead of taking measurements across a grid of white blocks, a grid made up of the component colours (red, green and blue) is used. And because of the three component colours three different grids are employed.

White light brightness or white light output takes nine measurements from the X points indicated on the grid below.

White light output measurement grid



Colour Light Output uses three 9-point grids to measure the brightness of each of the primary colours, as per the grid patterns below.



Colour Light Output measurement grids

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.

Colour brightness test results

As it isn't supplied, to clearly establish the colour brightness for single-chip DLP models, tests were conducted according to IDMS 15.4 (the measurement criteria for projector colour brightness).

The quoted specifications for the projector's white brightness in lumens were taken from the manufacturer's website and only the colour brightness was tested.

All results to date (and testing is still on-going, so more models will be available soon) are listed in the following tables.

The data does indeed indicate that Epson's projectors do deliver significantly brighter colours – three times brighter[3] and, in some cases, much more. See the results in the tables over the page for the details.

"With all Epson digital 3LCD projectors the brightness of the white light always matches the colour brightness – and that's why they deliver vivid colours."

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

[3] 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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Colour brightness test results...

		Manufacturer's Specification for White Light Output (Lumens)	Measured colour brightness or CLO[4] (Lumens)
EPSON	**All models**	**e.g. 3000**	**e.g. 3000**
3M	MP225A	32	30
Aaxa	P3	50	20
Aaxa	P4X	95	40
Acer	H5360	2500	600
Acer	H6500	2100	720
Acer	P5271	3100	700
Acer	X110P	2700	700
Acer	X1161P	2700	720
Acer	X1211K	2500	670
Acer	X1261P	2700	640
Acto	DX221ST	3200	470
BenQ	Joybee GP2	200	30
BenQ	LW61ST	2000	550
BenQ	MP512	2200	610
BenQ	MP515	2500	750
BenQ	MP522	2000	540
BenQ	MP522ST	2000	590
BenQ	MP525P	2500	840
BenQ	MP622	2700	1090
BenQ	MP622c	2200	1010
BenQ	MP780 ST	2500	600
BenQ	MS502	2700	760
BenQ	MS510	2700	730
BenQ	MS513	2700	700
BenQ	MS517	2800	700
BenQ	MS612ST	2500	710
BenQ	MS614	2700	710
BenQ	MW516	2800	670
BenQ	MW519	2800	700
BenQ	MW814ST	2500	770
BenQ	MW851UST	2500	460
BenQ	MW860USTi	3000	480
BenQ	MX503	2700	830
BenQ	MX511	2700	700
BenQ	MX518	2800	720
BenQ	MX520	300	610
BenQ	MX613ST	2500	660
BenQ	MX660P	3000	790
BenQ	MX711	3200	770
BenQ	MX763	3700	830
BenQ	MX764	4200	980
BenQ	MX810ST	2500	490
BenQ	MX815ST	2700	720
BenQ	MX816ST	3000	640

		Manufacturer's Specification for White Light Output (Lumens)	Measured colour brightness or CLO[4] (Lumens)
BenQ	MX850UST	2500	400
BenQ	W1070	2000	1500
BenQ	W7000	2000	1500
Casio	XJ-A130	2000	540
Casio	XJ-A141	2500	1200
Casio	XJ-A256	3000	1370
Casio	XJ-H1700	4000	770
Casio	XJ-M140	2500	1440
Casio	XJ-M240	2500	1280
Casio	XJ-M245	2500	1160
Casio	XJ-ST145	2500	510
Dell	1409X	2500	820
Dell	2400MP	3000	710
Dell	4320	4300	1080
Dell	S300wi	2200	480
Dell	S500wi	3200	840
Hitachi	CP-DX250	2500	480
Hitachi	CP-DX300	3000	440
InFocus	IN102	2500	740
InFocus	IN1110	2100	530
InFocus	IN1112	2200	590
InFocus	IN112	2700	640
InFocus	IN114	2700	660
InFocus	IN114ST	2700	560
InFocus	IN116	2700	630
InFocus	IN122	3200	760
InFocus	IN124	3200	840
InFocus	IN124ST	3000	690
InFocus	IN126	3200	810
InFocus	IN126ST	3000	630
InFocus	IN2102	2500	760
InFocus	IN2104	2500	650
InFocus	IN2112	3000	750
InFocus	IN2114	3000	760
InFocus	IN2116	3000	730
InFocus	IN2124	3200	660
InFocus	IN2126	3200	840
InFocus	IN3102	3000	840
InFocus	IN3104	3500	1010
InFocus	IN3114	3500	910
InFocus	IN3116	3500	930
InFocus	IN35	2500	840
InFocus	IN37	3000	970
InFocus	IN3914	2700	730
InFocus	IN5312	4500	1190
InFocus	Work Big IN24+	2400	720
InFocus	Work Big IN26+	2400	640
InFocus	Work Big IN32	2000	940

[4] The White Brightness data in the table above was obtained through Projector Central, as specified by the manufacturers. These manufacturers do not provide Colour Brightness (Colour Light Output) data. Colour Brightness was determined in compliance with IDMS 15.4 by third party laboratory testing of a single unit of each model. Serial numbers available on request from Tim.Anderson@3LCD.com

		Manufacturer's Specification for White Light Output (Lumens)	Measured colour brightness or CLO[4] (Lumens)
InFocus	Work Big IN34	2500	670
InFocus	Work Big IN36	3000	870
LG	BS-275	2700	700
LG	PA-75U	700	230
Mimio	mimioProjector	2800	550
Mitsubishi	EX240	2500	510
Mitsubishi	HC1500	1600	720
Mitsubishi	HC4000	1300	400
Mitsubishi	HC7800D	1500	1090
Mitsubishi	HD4000U	2000	690
Mitsubishi	WD380U-EST	2800	660
Mitsubishi	XD211U	2200	660
Mitsubishi	XD221U	2300	810
Mitsubishi	XD221U-ST	2000	650
Mitsubishi	XD250U	2700	1050
Mitsubishi	XD3500U	5000	940
Mitsubishi	XD360U-EST	2500	350
Mitsubishi	XD460U	2600	850
Mitsubishi	XD490U	3000	780
Mitsubishi	XD500U	2200	640
Mitsubishi	XD700U	5000	850
NEC	NP110	2200	640
NEC	NP200	2100	480
NEC	NP40	2200	830
NEC	NP4001	4500	1640
NEC	NP50	2600	740
NEC	NP60	3000	790
NEC	NP61	3000	700
NEC	NP-PX750U	7500	1250
NEC	NP-U260W	2600	540
NEC	NP-U300X	3000	770
NEC	NP-U310W	3100	690
NEC	NP-V260	2600	620
NEC	NP-V260W	2600	620
NEC	NP-V260X	2600	640
NEC	NP-V300W	3000	740
NEC	NP-V300X	3000	740
NEC	NP-VE281	2800	590
NEC	NP-VE281X	2800	700
Optoma	DS339	2600	760
Optoma	DS550	2600	650
Optoma	DX550	2600	640
Optoma	EP1691	2500	820
Optoma	EP716	1800	510
Optoma	EP719	2000	600
Optoma	EP721	2200	550
Optoma	EP727	2200	590
Optoma	EP728	2700	810
Optoma	EP771	3000	930
Optoma	ES522	2800	660
Optoma	EW1691e	3000	770

		Manufacturer's Specification for White Light Output (Lumens)	Measured colour brightness or CLO[4] (Lumens)
Optoma	EW536	2800	700
Optoma	EX525ST	2500	650
Optoma	EX530	2600	570
Optoma	EX532	2800	650
Optoma	EX551	2800	640
Optoma	EX765	4000	810
Optoma	EX784	5000	1060
Optoma	EX785	5000	1300
Optoma	GT750e	3000	950
Optoma	HD20	1700	1020
Optoma	HD23	2500	680
Optoma	HD25-LV	3200	630
Optoma	HD33	1800	940
Optoma	HD65	1600	650
Optoma	HD66	2500	710
Optoma	ML300	300	130
Optoma	ML500	500	140
Optoma	PK320	100	60
Optoma	PRO150S	2800	810
Optoma	PRO160S	3000	810
Optoma	PRO250X	2800	740
Optoma	PRO260X	3000	770
Optoma	PRO360W	3000	820
Optoma	PT100	50	10
Optoma	PT110	100	20
Optoma	TS526	2800	700
Optoma	TS551	2800	640
Optoma	TW766W	4000	800
Optoma	TX536	2800	670
Optoma	TX542	2800	680
Optoma	W303	3200	500
Optoma	X303	3000	410
Optoma	ZW210ST	2000	410
Optoma	ZW212ST	2500	390
Optoma	ZX210ST	2000	360
Optoma	ZX212ST	2500	280
Panasonic	PT-CW230EA	2500	550
Panasonic	PT-D5700U	6000	3050
Panasonic	PT-DZ570U	4000	2240
Panasonic	PT-DZ6710	6000	2990
Panasonic	PT-DZ770UK	7000	2340
Panasonic	PT-LS26U	2600	670
Panasonic	PT-RZ370U	3500	840
Panasonic	PT-RZ470UW	3500	830
Panasonic	PT-SD2600C	2600	670
Sharp	PG-F212X	2300	860
Sharp	PG-LX2000	2800	790
Sharp	XR-30X	2300	740
Sharp	XR-32X	2500	750
Sharp	XR-41X	2600	660
Smart	LightRaise 40wi	2500	750

		Manufacturer's Specification for White Light Output (Lumens)	Measured colour brightness or CLO[4] (Lumens)
Smart	LightRaise 60wi	2500	620
Smart	UX60	2000	730
Toshiba	TDP-T45U	2500	670
ViewSonic	PJ506D	2000	630
ViewSonic	PJD5123	2700	730
ViewSonic	PJD5132	2800	730
ViewSonic	PJD5133	2700	700
ViewSonic	PJD5223	2700	680
ViewSonic	PJD5232	2800	580
ViewSonic	PJD5233	2700	640
ViewSonic	PJD5523W	2700	620
ViewSonic	PJD6220	2300	640
ViewSonic	PJD6531W	3000	940
ViewSonic	PJD6553w	3500	870
ViewSonic	PJD7583w	3000	730
ViewSonic	PLED-W500	500	120
ViewSonic	Pro8200	2000	780

		Manufacturer's Specification for White Light Output (Lumens)	Measured colour brightness or CLO[4] (Lumens)
ViewSonic	Pro8450w	4500	980
ViewSonic	PRO8500	5000	1300
Vivitek	D512-3D	2600	560
Vivitek	D530	3200	790
Vivitek	D535	3200	620
Vivitek	D536-3D	3200	610
Vivitek	D537W	3200	720
Vivitek	D538-W	3200	680
Vivitek	D554	3000	650
Vivitek	D557WH	3000	640
Vivitek	D791ST	3000	340
Vivitek	D795WT	3000	320
Vivitek	D832MX	3200	780
Vivitek	D940VX	4300	930
Vivitek	Qumi Q2	300	50
Vivitek	Qumi Q5	500	80

"You get **three times brighter colours**[5] with Epson projectors."

[5] 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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Test technical information

Here are the technical details on the Colour Brightness testing and how it was carried out.

Testing laboratories

Two independent laboratories conducted the Colour Brightness testing.

With more than 33,000 employees in 1,000 locations in over 100 countries, Intertek is a leader in the field of product testing and compliance. Intertek holds extensive global accreditations and recognitions.

With 20 years of experience in the digital imaging industry, Lumita, Inc. specialises in the development and testing of display hardware with an emphasis on colour measurement, calibration and image processing. Lumita provides display measurement services for a wide variety of imaging companies. For more information about Lumita visit www.Lumita.com.

Product data

Tests were conducted on individual units of over 170 different models. For additional information about this testing email: questions@colorbrightness.com.

Experiment design

The US National Institute of Standards and Technology in NISTIR 6657 (January 2009) provides detailed guidance on the measurement of Colour Light Output. The same guidelines are part of the ICDM-DMS 1.03a Section 15.4 (International Committee on Display Metrology - Display Measurement Standard.) Both of these documents were carefully followed in the design and implementation of the experiment and the apparatus used.

Light measurement devices, calibration and their experimental control

Two types of measurement instruments were used by Lumita for this study. Primary data for the nine standard measurement test points was gathered by a Photo Research PR-524 Illuminance meter with nine PR-514 remote heads. A NIST traceable calibration was performed at the factory on these heads prior to this experiment and a current certificate of calibration is available.

Spectral measurements used as a control in every experiment and to correct the PR-514 data were made with a Photo Research PR-670 Spectroradiometer and a CR-670 Illuminance head. The PR-670/CR-670 combination also holds a current NIST traceable certificate of calibration for both illuminance and spectral accuracy.

Filter-based photopic illuminance meters like the PR-524 are calibrated using Illuminant A (Tungsten). Because of the mercury lamps and dichroic filters used in DLP front projection displays, the absolute accuracy of filter-based photometry that is calibrated with a wide spectrum source, such as illuminant A, could be questioned. In fact, our own experiences at Lumita demonstrate wide variability (when measuring projectors) among different brands and models of photometers depending on the quality of their filter set.

In order to remove any error that might result from the unique spectra of the projector, a baseline spectral correction factor was calculated for each projector model. With the projector stabilised, measurements were taken of white at test point five (centre). The measurement jig allows the CR-670 head to be accurately (+-0.5mm) swapped with the PR-514 head. Eight alternating measurements were made and a spectral correction factor for the PR-514 was calculated for each projector type.

As a further control to assure accurate operation of all systems the PR-670 was placed in the centre position at the beginning of data collection. For each trial a control spectral illuminance measurement was taken, then the PR-514 head was returned and the trial completed. At the end of each trial the control was checked and compared to the average test point five PR-514 data to make sure it was within the expected variability.

Below is a partial list of the test equipment used at Intertek to measure Colour Brightness:

- Digital Power Meter: Yokogawa, WT230
- Hydra II Data Acquisition Unit: Fluke, 2625A
- Programmable Power Source: 0-300 V/DC,15-1kHz / 2KVA: Chroma, 1604
- Hygro-Thermometer Datalogger: Extech, Easy View 25
- Chroma Meter Model CL-200A: Konica Minolta, CL-200A

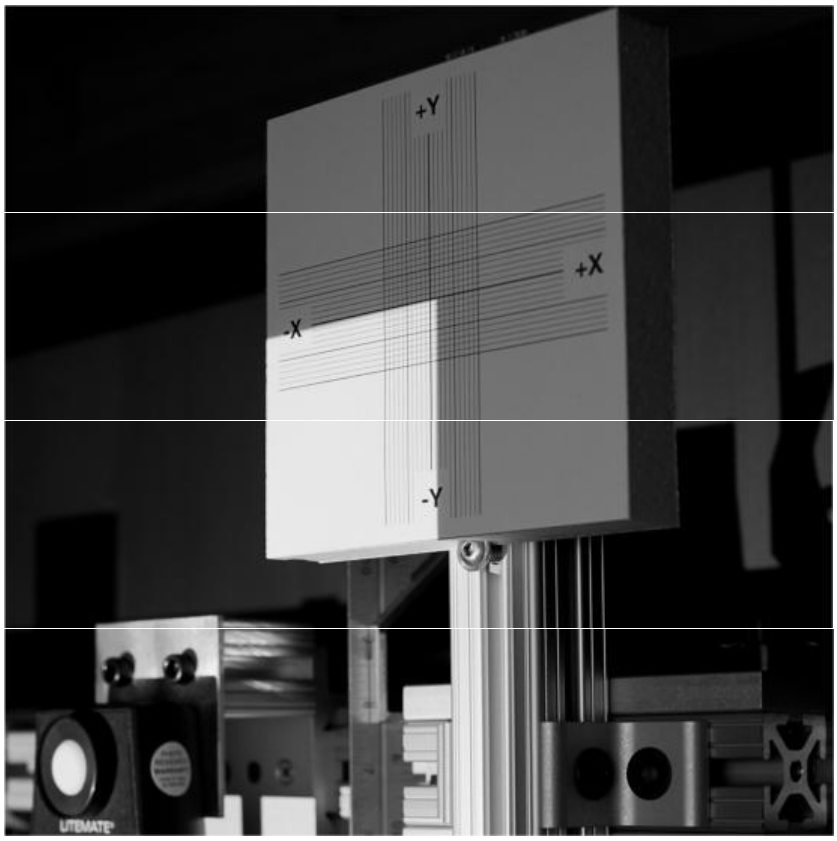
Measurement jig

A precision measurement jig was constructed to provide precise alignment and positioning of the illuminance heads and the focal plane of the projector. The jig creates a relative repeatability specification of +-2mm for the placement of the measurement heads in all axis X,Y and Z. The Z accuracy of the placement within the focal plane for all the measurement heads is +-2mm and the total focal plane uncertainty based on possible focus error is 6mm. The jig also allows the precise swapping of the CR-670 and the PR-514 Illuminance heads at position five. This allows a control measurement to be taken at the beginning of each experiment.

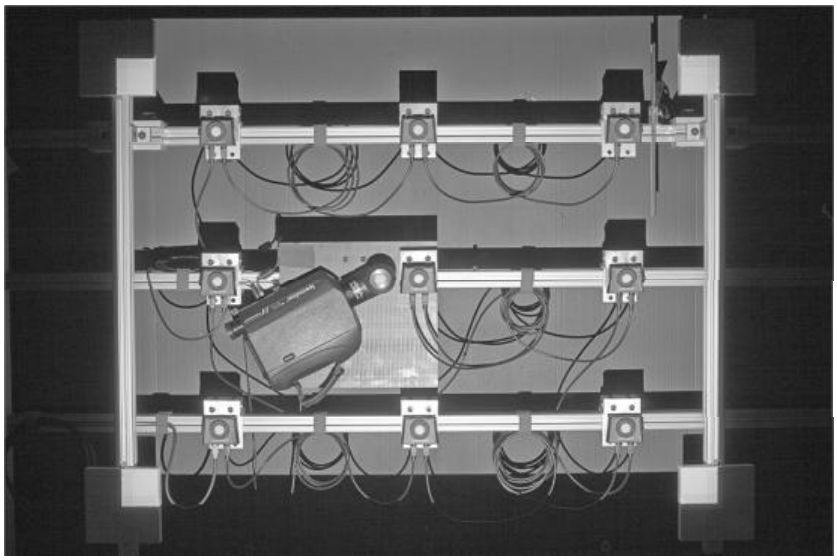
The jig provides corner focus targets allowing the projector geometry to be properly aligned to the jig. A laser centre line is projected during setup to facilitate aligning the optical axis of the projector perpendicular to the focal plane.

Focal Plane Area

Due to minor anomalies and deviations in each projector's optics precise placement of all four corners in an exact rectangle can be difficult or impossible to achieve. This can cause inaccuracy in the calculation of light output due to the need for a precise screen area measurement. The focal plane targets in each of the four corners of the jig have a precision X,Y grid in 2mm steps. This allows the experimenter to record the deviation in X,Y for each of the four corners. The measurement software uses these values to calculate the diagonals of the focal plane from which the actual focal plane area is calculated for each individual trial. This procedure is described in NISTIR 6657 and ICDMDMS 1.03a.



Actual photograph of the focal plane area jig



Actual photograph of the measurement jig used

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