Colour Management White Paper

Light Emitting Diodes (LED)
vs.
Cold Cathode Fluorescent Lamps (CCFL)

… and their use for backlighting in reference displays.

By M. Chenery,
Colour Scientist / Cine-tal product expert

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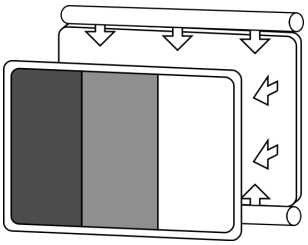
Introduction

Backlights are used for displays that require illumination from the behind such as liquid crystal Displays (LCDs). These can include devices as small as hand held PCs and phones or as large as big screen TVs. A typical backlight consist of a light source such as a Cold Cathode Fluorescent Lamp (CCFL) or Light Emitting Diodes (LED) and a rectangular light guide, which is also referred to as light pipe.

The light is usually located at one edge of the light guide to minimize the thickness of the display. Some high-end LED displays use arrays of LEDs and a diffuser rather than a light guide. The key requirements for postproduction reference displays are uniform illumination across the LCD surface, and constant luminance, colour and spectral response over time.

Below we will take a look at both LED and CCFL technology in respect to these requirements and the suitability of these technologies for use as backlighting in the high-end reference displays used in postproduction for film and television.

CCFL (Cold Cathode Fluorescent Lamp)



In the cold cathode fluorescent lamp, construction typically includes a hollow glass cylinder that has been coated on the inside with a phosphor material composed of rare earth elements such as zinc silicate and various types of halophosphates.

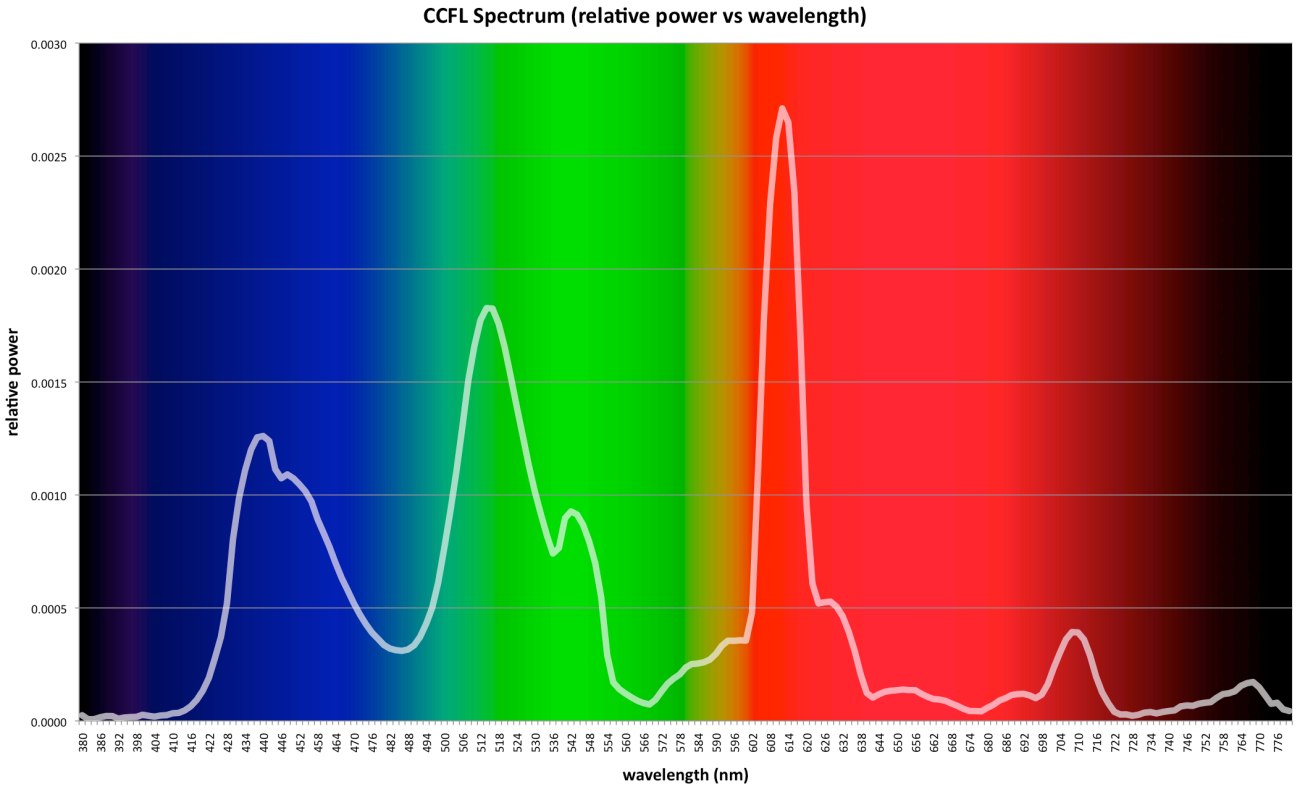
The tube is then sealed at both ends, each of which also contains an electrode; mercury- dispensing anode and an iron-nickel cathode, connected to copper sheathed iron alloy leads. Lamps normally contain 2 to 10 milligrams of mercury, and a mixture of gasses such as argon and neon.

When high voltage is applied to the electrodes, ultraviolet energy at 254nm is produced as the mercury and the internal gasses are ionized. The resulting ultraviolet energy from the mercury discharge stimulates the phosphor lining inside the lamp producing visible light output in the 380 to 780nm range (also known as the photopic region).

CCFL backlights have been in use for a number of years and are now considered a well-understood and stable technology. CCFL backlights are usually very spatially uniform and do not tend to vary across the screen even as the display ages.

CCFLs have a broad spectrum that covers the entire visible range. This means that it can be harder to achieve a wide gamut on the display as the individual LCD sub-pixels need to be more selective in their filtering properties to achieve a wide separation in the chromaticities of the primaries. Modern LCD panels are able to do this very well and can achieve over 100% of the Rec.709 (HD / broadcast) gamut and up to 97% of the AdobeRGB gamut.

The wide spectrum of CCFLs is very well understood and allows for accurate measurement by colorimeters that work by using filters, tuned to the response of the human eye. This means that CCFL displays can be accurately measured without the need for a very expensive spectroradiometer, allowing colour managing the device to be done in a very economical way.



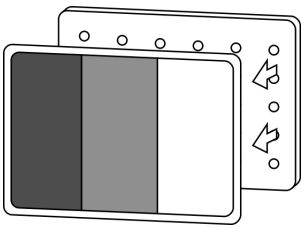
CCFL - Pros

- Long work-life: 25,000 to 50,000 Hours.
- Wide and well-understood spectral response means displays can be accurately measured with cheaper colorimeter based devices enabling cost effective colour management.
- Easy to achieve display uniformity.
- Good colour stability over time.
- Low power consumption.
- Infinitely dimmable between 20 and 100%.

CCFL - Cons

- Cold starts & low temperature performance (they take time to warm up and stabilize).
- Wide and flat spectral response means it is more difficult to achieve very wide gamuts.

LED (Light Emitting Diode)



LED backlighting in color screens comes in two flavors: white LED backlights and RGB LED backlights. White LEDs are used most often in notebooks and desktop screens, and in virtually all mobile LCD screens. A white LED is a blue LED with yellow phosphor added to give the impression of white light. The spectral curve of white LEDs has significant gaps in the green and red regions. RGB LEDs consist of a red, a blue, and a

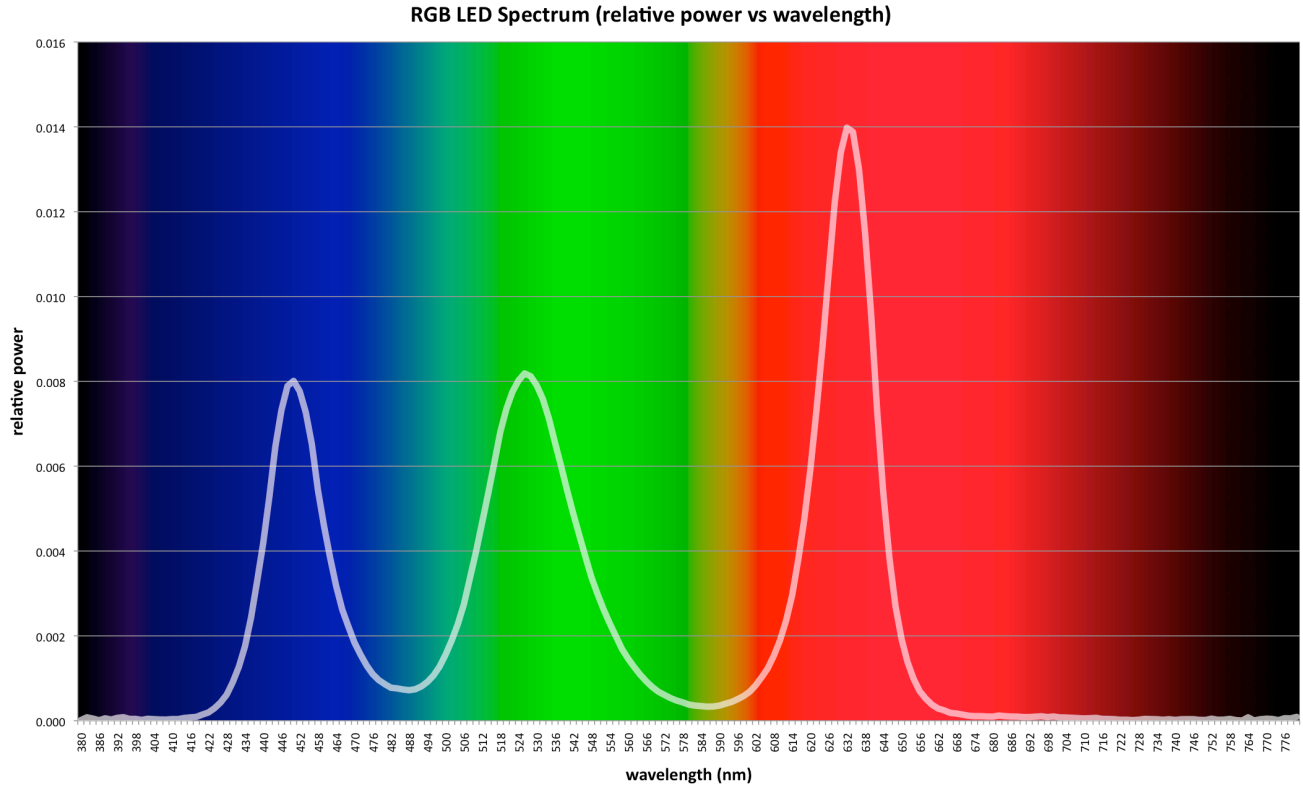
green LED and can be controlled to produce different temperatures of white. RGB LEDs for backlighting are found in the high-end displays used for postproduction.

To achieve the necessary brightness levels reference displays also tend to use an LED array rather than a strip of LEDs with a light guide.

There are several challenges with LED backlights. Good uniformity is harder to achieve, especially as the LEDs age, with each LED possibly aging at a different rate. Also, the use of three separate light sources for red, green, and blue means that the white point of the display can move as the LEDs age at different rates. Aging also occurs with White LEDs, with changes of several 100K being recorded. White LEDs also suffer from blue shifts at higher temperatures.

The ability for LEDs to provide a wider gamut comes from the narrow spectral response of the individual red, green and blue LEDs used. This narrow spectral response makes LED based LCD displays difficult to measure accurately with standard colorimeter based monitor probes unless the colorimeter has been specifically designed for the LEDs being used. Currently to accurately measure colours from LED backlit displays requires the use of a spectroradiometer, making colour management of these displays expensive.

Heat dissipation is also an issue. It is difficult to stabilize LED backlights without some reasonably complex heat regulation. Lack of good heat regulation will severely decrease LED life span and create “brown out” on the backlighting system resulting in non-uniformity of brightness and colour across the LCD display.



LED - Pros

- Narrow spectrum enables the potential for very wide gamuts

LED - Cons

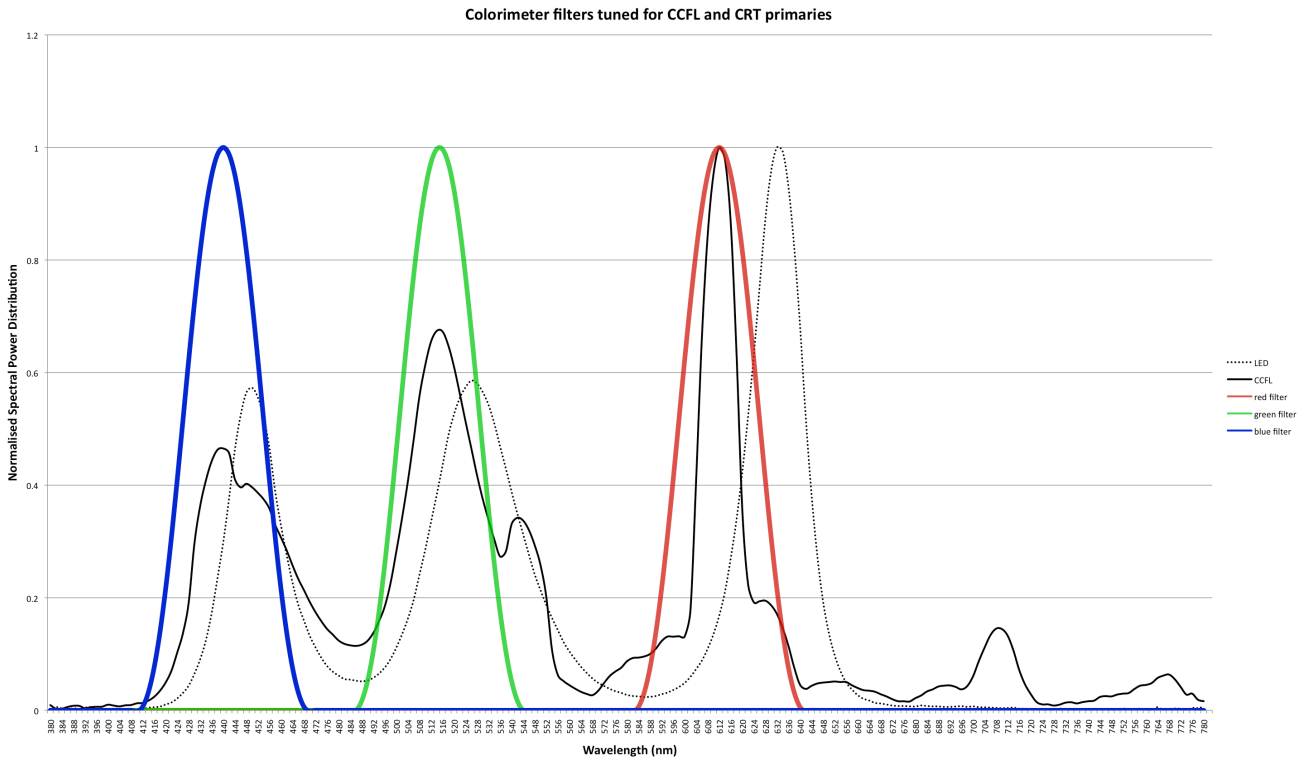
- Heat dissipation
- Harder to achieve uniformity (especially as the display ages)
- Narrow spectral response means that currently measuring and colour managing LED displays requires the use of an expensive spectroradiometer or similar device.
- Cold starts & low temperature performance (they take time to warm up and stabilize).

Current status and recommendations with respect to reference displays

LED technology will continue to improve. Volume production and better precision in manufacturing will produce LEDs that will provide excellent backlighting for LCD systems. As probes that are designed for use with specific LED types become available colour management will become easier, more reliable and more cost effective for LED backlit displays.

Some manufacturers are blazing brave paths in this technology especially as a wide gamut display tends to “look” better to an average viewer; which is a major factor driving consumer television sales.

The diagram below shows how typical low-mid range colorimeter filters are currently tuned to the primaries achieved by CCFL and CRT displays. Until new colorimeters are released that are tuned for LED backlights, measurements made using current low-mid range colorimeters of displays backlit by LEDs will be inaccurate. While LED technology is still developing very rapidly it is not known what LED primary spectral distributions should be targeted by probe manufacturers.



For high-end colour accurate reference displays, the best choice for stability, ease of colour management and ability to match existing monitor systems remains CCFL backlighting.

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For further information please contact Cine-tal Systems:

Cine-tal Systems Inc
8651 Castle Park Dr
Indianapolis IN 46256

Phone: +1 317 576 0091
Fax: +1 317 576 0117
Email: info@cine-tal.com

The author Michael Chenery can be contacted via:

Phone: +61 8 7120 6197
Email: mchenery@cine-tal.com