Optimize Color Management Capabilities in LED Lighting Fixtures

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LEDs will reduce cost of ownership of lighting systems thanks to their intrinsic improved energy efficiency and life expectancy compared to more traditional light sources.

LED light sources are also available in a much wider variety of colors and can enable fixture with very precise and possibly active color control.

Both benefits (improved cost of ownership and improved light quality) can only be enabled if optimized drivers are used. These drivers take into consideration the unique characteristics of the LED semiconductor (i.e. color shift over temperature and age, life expectancy over temperature etc) and enable the highest possible return for the user of the LED lighting fixture.

As an added benefit, since the markedly superior benefits of LED are convincing many users to change or upgrade their lighting fixture for the first time in years, this transition is opening the doors to “smart fixtures.” The user is increasingly expecting to be able to control and monitor the fixture remotely, and this often leads to more complex lighting network solutions.

According to Frost & Sullivan, LED Fixtures are set to grow from a 3 percent penetration into one of the world’s most dominant lighting technologies. In its July 2011 report, entitled “World LED Lighting Market,” the firm said that it expects earned revenues in the LED used in general illumination applications market to grow from $491.1 million in 2010 to nearly $1.89 billion in 2017. According to Frost & Sullivan Senior Research Analyst Neetha Jayanth, “Suppliers across the globe are undertaking to improve the quality of LED lamps by enhancing their efficiency, quality of light output, color rendition and thermal management. Thus, LED lamps are set to become better equipped for use in functional lighting across all building sectors.”

LED-fixture color control is one of these key enhancement targets, because it can offer both a better fixture to fixture match as well as a customized experience for the user.

The complexity of color controls can vary widely – each is appropriate in specific applications. The highest the desired complexity the more critical the driver and its design become.

At its most basic level, a color control system can simply consist of LEDs that have been “binned” (i.e., carefully selected based on specific parameters) so that all new fixtures will have the same color.

Individual bins can then be mixed to obtain specific photometric results. This can be a physical static mix at the time of the fixture manufacturing, or it can actively be controlled during lamp operation.

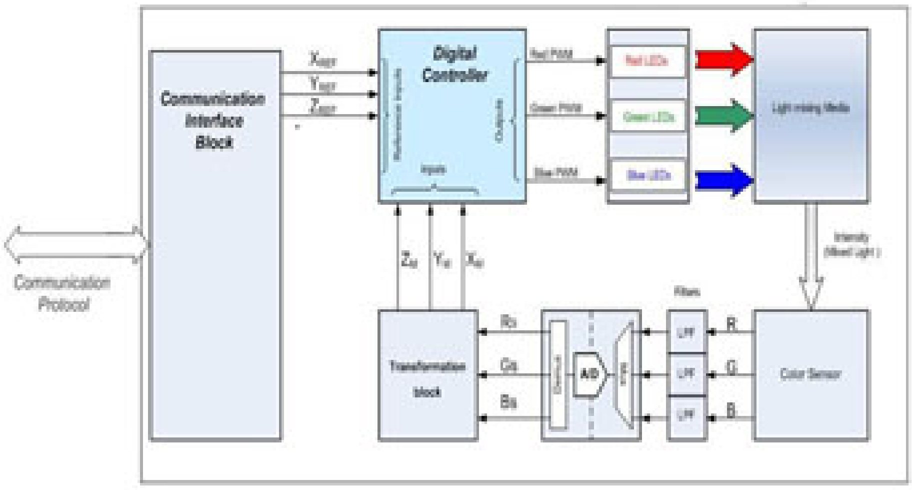

Figure 1. A color management system for RGB luminaries.

It is important to note that LED chromaticity coordinates do vary based on temperature and LED current. Active monitoring of the current and temperature by the optimized driver and subsequent adjustments is possible, but because of the initial binning on chromaticity, this specific effect should be minimal in well-designed fixtures. The active control of current over temperature is typically enabled by well-designed drivers. This is mostly done to compensate for LED luminous flux variations over temperature (not chromaticity variation) as there since a dependence of LED temperature versus current.

If active color control during lamp operation is desired, it will typically require a light source made with various LEDs of different colors.

Active color mixing of the different LEDs can then be achieved either by direct user input and static correlation tables or, the most complex solution, by using an RGB sensor whose output is then used by the driver system to mix the colors. If the design demands the highest color accuracy possible while meeting color maintenance requirements, an intelligent LED driver system with integrated color-management is needed. Applications that might benefit from this high level of accuracy are commercial displays and architectural lighting.

Figure 1 shows asystem consisting of an RGB color sensor, color manager and LED drivers that performs high-performance, high-accuracy color management for RGB luminaries. This system’s targeted white color point can be represented by color temperature (CT) and luminance level (Yref), or by tristimulus values (Xref, Yref, Zref).

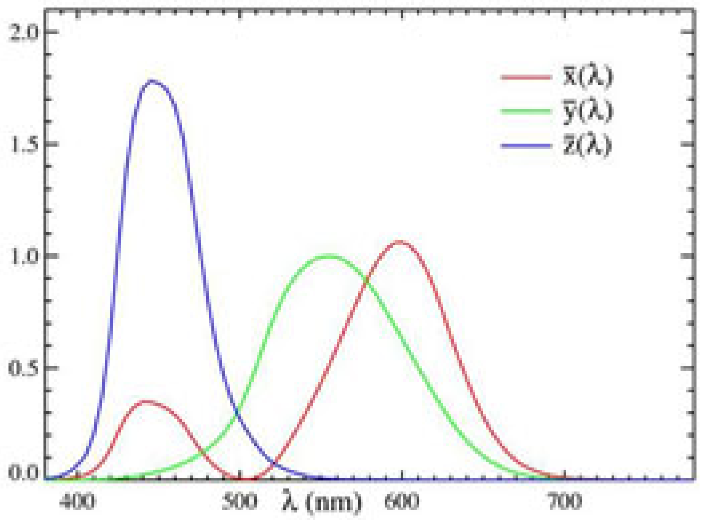

Figure 2. CIE 1931 color-matching functions.

Color-management accuracy depends on the RGB color sensor's response times, which must be fast enough to perform the necessary CIE color-matching functions (see Figure 2). Not all commercially available RGB sensors can deliver these response times, so compensation techniques are required. One example is Microsemi's compensation mechanism, which is implemented during the calibration process. The output of color sensor [R, G, B] is sent through low pass filters (LPF), which are connected to the input of the color manager. The color manager's calibration block then converts the color sensor's [R, G, B] value to the tristimulus value. A digital controller then compares reference data to measured data and uses a digital proportional integral (PI) algorithm to develop RGB pulse width modulation (PWM) signals for the LED drivers.

LEDs are enabling opportunities for lighting fixtures whose color can be perfectly targeted to the specific application. According to the level of color control and dynamic adjustment required (and economically acceptable), different optimized drivers will be needed. The most complex solution can enable LED lighting systems that automatically perform all necessary CIE color matching functions.