The DB-100 controller: A breakthrough in simplifying LED control

Ed Rodriguez - August 03, 2016

For centuries, there’s been awareness of differences in natural light (sunlight) and artificial light (such as fire), even if the term “color temperature” was not used. Until approximately 60-70 years ago, there was no way to do too much about that difference.

Artists have long understood how to arrange their studios to always make best use of natural light based on the time of day and weather conditions. When inexpensive photography and camera options spread to mass markets after WWI, camera buffs learned to master “indoor” and “outdoor” film to compensate for the yellowish tint of candlelight and indoor incandescent lighting, or the bluish tint of an outdoor overcast-sky.

Solid-state lighting—A game changer

More recently, the development of LED emitters of all colors and smaller point sources of light opened up a myriad of possibilities. When blue LEDs achieved commercial viability in the late '90s, all the pieces fell into place.

All sources of white LED lighting employ one of two techniques:

1. Mixing of red, blue, and green light, and occasionally amber, to create white light, sometimes with a tint toward blue or toward red, i.e. warm white or cool white—known as “RGB” LED emitters.
2. A blue emitter chip with a yellow phosphor coating in its light path. The combination creates what is called “secondary emission” of white light. This is a process similar to when a regular fluorescent tube generates UV light, which reacts with an inside phosphor coating to create white light.

It has long been known that mixing red, blue, and green light creates white light. Sunlight, made up of all the colors of the rainbow, being the best example.

Figure 1 shows what happens on a surface when different colors of light are combined (all together they make white). In **Figure 2**, the “subtractive process,” is what we see on a surface by mixing colors of paint, crayons, etc. (all together they make black). We will only concern ourselves with **Figure 1** in this article.

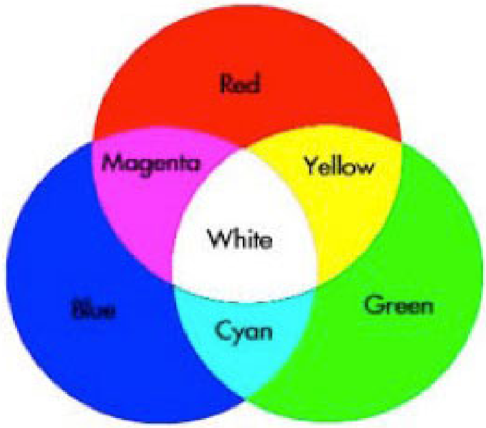

Figure 1 When different colors of light are combined, all together they make white.

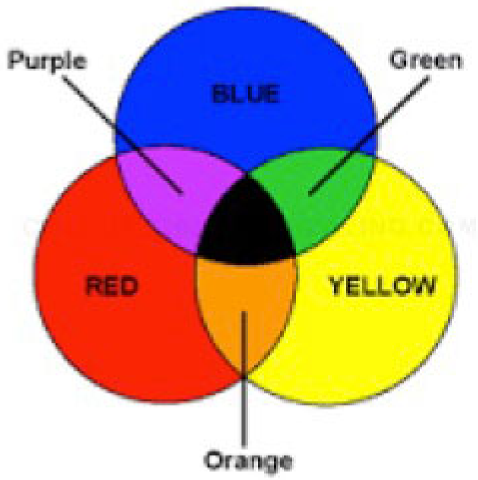

Figure 2 With the subtractive process, mixing colors together makes black.

Only a few combinations are shown here but the variations are essentially infinite. Our eyes "mix" all the colors and give us a perception of white light and any combination of the individual rainbow colors.

Until 2005, the spectral characteristics of blue-LED/yellow-phosphor types were so poor ("bluish") that RGB light sources were used only whenever incandescent equivalent light was needed in specialty markets. The RGB approach also facilitated explosive growth in multicolored digital displays, even TV displays, where it was possible to create an infinite number of color combinations using standard digital circuits and pulse-width-modulation (PWM) to vary the amplitude of the individual chip colors.

Warm white, cool white, no problem. It meant that one could take that same methodology perfected for displays: add very slight blue tint to the white light, shifting it higher in color temperature, making it more like the outdoor light you might experience on a cloudy day. One might add a reddish or yellowish tint so that the light is "warmer" and similar to that of a sunset on a clear day, or what you would observe indoors with a room illuminated by a regular incandescent lamp.

All this was just fine as long as white LEDs for general illumination had poor efficacy (i.e. less than 40-50 lumens per watt), high prices (over $1.00/watt), and a Color Rendering Index (CRI) less than

75. The CRI figure is a measure of how accurately a white LED replicates the “true” color of an object. For general task performance, CRI is of little importance. However, where color perception is important, such as in studio lighting (TV, motion pictures, photography), retail (fabrics, cosmetics), or museums (paintings, displays), a CRI over 90 is now considered to be a must.

While RGB lighting still dominates the display industry, phosphor-based white LED light is now dramatically more cost effective, has much higher lumens per watt, and is far simpler to use. A few things happened after 2012 to move things along. Even CRIs over 90 are now available from a number of vendors, for correlated color temperatures (CCTs) from 2700K to 5600K, something just not possible a couple of years ago.

What all this means is that after 10-12 years of complaints that LED lighting could not faithfully replicate this or that color or lighting condition, a properly selected LED product can now replicate virtually any incandescent or outdoor lighting condition.

These cost and performance advances have resulted in companies in multiple market areas introducing variable-CCT items—from novelty products for DIY consumers to serious high-end applications. Color temperature variability is now a marketing tool. In this context there are still impediments to more widespread use of such variable CCT.

A survey of variable-CCT offerings will invariably lead to two categories:

1. Novelty products and offerings, which can be perceived as way overpriced unless one needs certain specific "bells and whistles."
2. A product that can facilitate “more bang for the buck” performance and versatility previously found only in lighting products with double or triple the price.

CCT variability in phosphor-based white LEDs

All variable-CCT approaches using phosphor-based white LEDs start with the same concept. Two separate LED strings are used, one with high-CCT LEDs and the other, low-CCT LEDs. Strings may consist of SMD or through-hole LEDs—or can be a single- or two-string COB type. For example, one string might be 2700K and the other 5600K. Typically, each string is driven from a separate dimmable, constant-current drive as shown in in **Figure 3**.

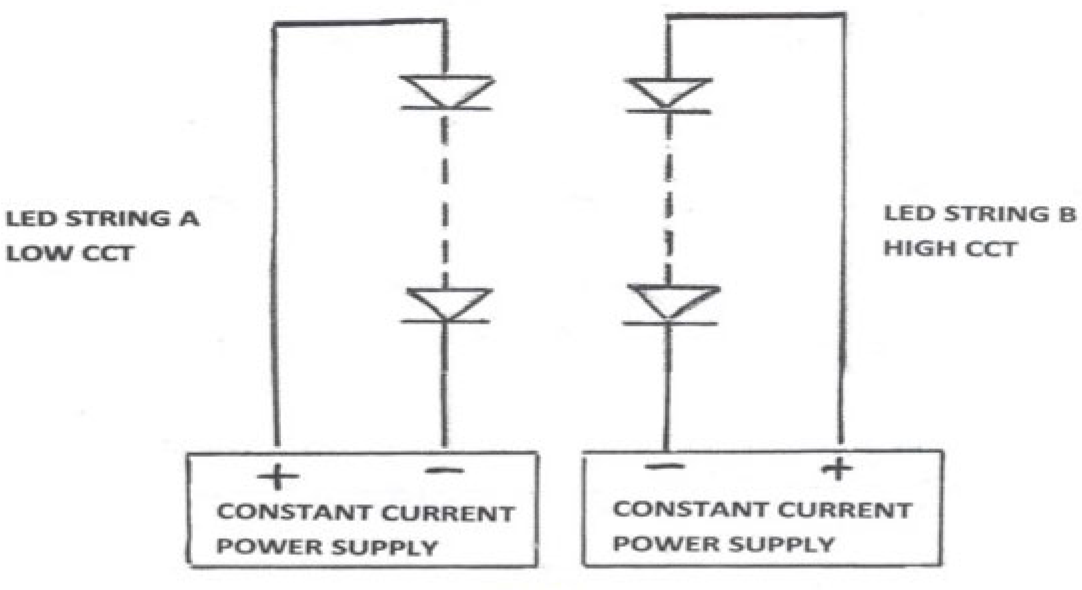

Figure 3 The LED strings are driven by separate dimmable, constant-current drives.

By dimming one or the other, we can change the relative proportion of “warm” light to that of the “cool” light. Consequently, we can vary the final color temperature of the light at the target surface some distance away, from 2700K to 5600K, and even from below 2000K to 10,000K if we choose the right LEDs.

If we start out with one LED string of 2700K and the second string of 5700K, we can vary between the two limits. In whatever scheme is used, the objective is to have the total power to the pair of strings remain the same to ensure that the brightness remains approximately the same across the CCT range, unless we purposely dim the total output.

How the DB-100 works

With a tiny plug-and-play, the DB-100 controller, a second LED driver (i.e. LED power supply) is unnecessary and no software or remote-wireless setup issues exist. The selective dimming of either of the two strings is achieved with virtually any single standard driver. This is done by using a microprocessor to independently dim, via pulse-width modulation, each of the two strings in a way that alters the relative average current in each string while maintaining constant total power and brightness.

Employing a microprocessor, the proprietary approach allows a very wide range of CCT control, while maintaining a high, constant-PWM frequency—above 2 KHz. This eliminates the undesired visual effects which can occur in video and motion picture lighting when a PWM frequency is too close to power-line frequency or frame rates.

In addition to basic CCT variability, the DB-100 allows control with a simple integral potentiometer. Up to 100 watts can be controlled (LED string voltages to 50 volts and currents to 4 amps) with the power limit set by the chosen constant-current LED driver.

Figure 4 shows a block diagram of a typical configuration using an off-the-shelf driver (analog dimmable by either a 100K pot or 0-10V signal) and either of two attractive LED COB options. The DB-100, currently available, along with application support and/or plug-and-play COB/controller/driver/heat-sink development kits are also available.

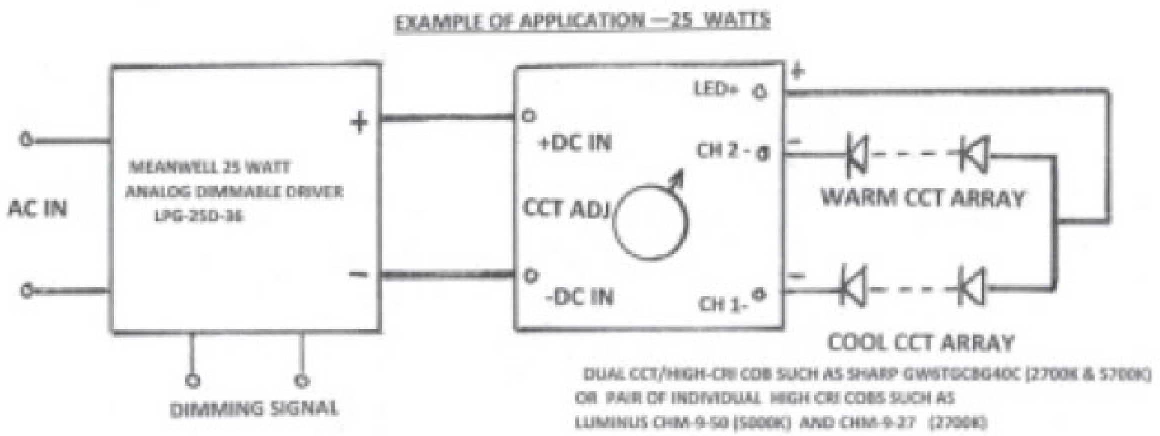

Figure 4 This block diagram shows a typical configuration using an off-the-shelf driver.

Ed Rodriguez founded OptoThermal Technologies, focusing on thermal management technologies *related to high-power LED lighting.*

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