Bridging the Knowledge Gap for Intelligent Lighting and the Semiconductor Market

By Gavin Hesse, Product Marketing Engineer, Cypress Semiconductor

To fully realize the potential of the burgeoning High Brightness LED market, new tools and techniques must be utilized including semiconductor technology. With many current lighting engineers needing to come quickly up to speed on basic microcontroller usage, it is necessary to find avenues to effectively create even basic fixed-color designs. Cypress Semiconductor's EZ-Color technology uses the power of PSoC Express to bridge this knowledge gap by decreasing time to market, integrating functionality and giving users a distinct advantage in a competitive market.

Much has already been written about the creation of High Brightness LEDs and the revolutionary possibilities that are now available for intelligent lighting. No longer must lamps be forced into one shade of fluorescent white. No longer must complicated mirror systems be utilized to bend particular wavelengths. The range of color possible using LED mixing is too great to ignore; too powerful to avoid. As many companies are discovering, holding on to previous solutions is done at their own risk, and, even if reluctantly, many are beginning to embrace the potential.

RELATIVE LIGHT OUTPUT VS. JUNCTION TEMPERATURE									
	15	30	45	60	75	90	105	120	135
Blue	1.00	1.00	0.99	0.98	0.97	0.97	0.96	0.95	0.94
Green	1.05	0.99	0.92	0.86	0.80	0.74	0.68	0.62	0.56
Red	1.07	0.98	0.88	0.77	0.66	0.56	0.46	0.37	0.29

Figure 1.

With this transition, many traditional lighting designers are discovering that critical knowledge barriers lie in their path. Most designers with significant experience in the lighting market know a great deal about power supply and mechanical design issues. Unfortunately for these brethren, to achieve a truly unique design, simplistic current or voltage control methodology is no longer enough.

Figure 2.

Instead, intelligence in the form of microcontrollers or FPGAs is needed for such basic functions as scrolling through colors or adjusting accuracy on the fly. In order to take advantage of the LED color gamut, this control is needed to accurately "lock" on a particular color over various operating conditions.

Within this transition to the world of microcontrollers lies the knowledge gap. "C" programming, general microcontroller terminology, and such can prove a costly barrier to entry, as many lighting design houses have turned to expensive consultants to stay in the game. The amount of time necessary to come up to speed on basic MCU fundamentals can mean the loss of a bid on a national landmark. Time to market is all-important, to stay ahead of the rapidly moving curve.

Two particular inherent hurdles with LEDs stand out as necessary for a microcontroller to overcome. Temperature knocks LEDs for a loop, degrading the luminous flux and modifying the dominant wavelength. Figure 1 shows how actual LEDs react to temperature changes. It is not a pretty picture, especially for red.

There are few good solutions in the market currently to compensate for these changes. Engineers essentially have to use a thermistor or temperature sensor and then do some form of a two or three dimensional lookup table to accurately adjust the dimming waveform to compensate for a reduction in luminous intensity. The thermistor itself must be located as close to the LEDs as possible in order to read the board temperature and utilize an approximation equation for the junction temperature of the LEDs.

The second hurdle is the variance of particular LEDs, even of the same part number. This is known as binning. LEDs are binned dependant on their luminous flux, dominant wavelength and forward voltage. The difference of a single dominant wavelength bin can be noticeable to the human eye. Again, multidimensional lookup tables have to be created, since the designer will not know which bin he will receive until the reel arrives at the production floor. To make matters even worse, bin definitions vary from LED manufacturer to LED manufacturer, so additional software lookup tables have to be created for multiple brands of LEDs. Customers are often forced to pay significant premiums to manufacturers to only receive particular bins to avoid these variances and assure themselves of a fixed color point.

These are only two of the issues surrounding High Brightness LED design. With these and more staring at designers, it becomes obvious that microcontrollers are not only necessary, but also a vital component of accurate color mixing. It is also obvious that using a microcontroller can be far more complicated than at first envisioned, ratcheting up the knowledge requirement necessary to complete a fully functional design.

One recently released method for overcoming these LED shortcomings is Cypress' EZ-Color programmable solution using PSoC Express.

How does it work? PSoC Express is an embedded system design tool eliminating the need for writing code. The tool itself works at the system level instead of at the design level. In other words, it utilizes specific functions instead of "for" loops. Those functions themselves are real-world devices, such as sensors, thermistors or LED drivers.

This is visual embedded system design. While it sounds impressive, in action it may be even more so. EZ-Color and PSoC Express can radically alter a company's entrance into the LED marketplace. Not only does it eliminate the need to learn color-mixing science (an enterprising venture in and of itself), but it can also eliminate the need to create those aforementioned multidimensional lookup tables for a thermistor or for binning. Even more remarkable, EZ-Color can accomplish these tasks in the span of minutes.

Let's take a simple example. EZ-Color will turn on three LEDs (red, green and blue) to create a mixed color. We will utilize the 1931 CIE Chromaticity Diagram and create the color (0.1, 0.12), which should be vaguely purplish.

Reprinted from the September/October Issue of LED Journal. © 2007 Webcom Communications Corp.
7355 E. Orchard Road, Suite 100, Greenwood Village, CO 80111 USA
Phone 720-528-3770. Fax 720-528-3771. www.infowebcom.com

First the designer can look to the shown catalog to discover the Lumileds K2 3LED Color Mixing driver. This catalog is split up into four sections. Inputs and Outputs are functional drivers (the real-world devices discussed above), while the other two tabs will be discussed later. An Input would be a sensor; an Output would be a Triple Luxeon Color Mixing Driver. The driver name is so specific (not only the LED manufacturer, but also the part number) because it has been regulated to K2's specific functionality. The bin information contained is only that necessary for K2 LEDs. The temperature response equation is only suitable for K2 LEDs. This already eliminates a significant amount of software overhead from a typical color system.

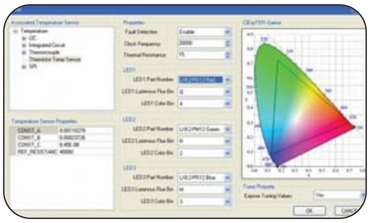

Figure 3.

After dragging it onto the screen and naming it, a properties window appears. Now a designer can select the specific bin or temperature sensor to drive their color mixing equation. In fact, EZ-Color is able to work with a wide variety of temperature sensors and thermistors. So instead of having to deal with multiple variations of software lookup tables to compensate for these issues, the problem is dealt with at the onset of design.

To set the output color, EZ-Color drivers use what are called "transfer functions". These are variables stored in memory needed to drive the internal algorithm under the surface. The ColorMix driver requires four inputs, "Enable, Relative Flux, CIE x and CIE y". To learn more about the driver and these inputs, it is always a good idea to read up on the driver datasheet. While I understand that reading datasheets can seem like a chore, it is well worth the time.

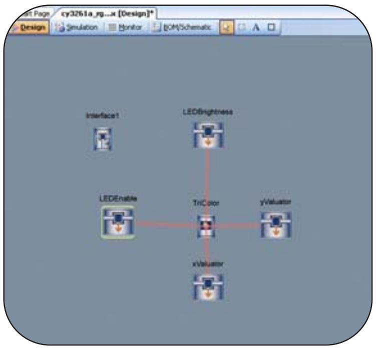

Figure 4

To establish these four inputs, another PSoC Express device is needed. This is a Valuator, which is found in the same catalog as the Inputs/Outputs. To understand the principle, think variables, only better. PSoC Express offers either set variables that would relate to "# defines" in normal C lingo, or logic based variables such as a State Machine or a Status Encoder. In our simplistic example, our four inputs only require standard Valuators.

At this point, if desired, additional communication interfaces can be added. EZ-Color can support I2C, wireless USB and various serial interfaces such as DMX512. These are separate from the color mixing driver, but will sync with specific areas in memory to rewrite the transfer function values dependant on the outside source.

While building the design, PSoC Express will first offer the EZ-Color part catalog. Only the parts that can handle the specific code size and resource requirements of your created design will be shown, eliminating the need for eight meetings at the beginning of your design flow trying to guess marketing's requirements for the finished product. It never works. We all know it.

Once the part is selected, a dynamic pinout is available. The functionality of EZ-Color is not dependant on particular pins being always utilized in a particular fashion. Everything is created in order to be as intuitive as possible for new users.

The project is now complete. Although a simple single color design, the whole process can take under 10 minutes. A schematic, individual datasheet and custom firmware are all now ready for review.

The schematic itself currently utilizes the National LM3402 buck converter. EZ-Color is by no means locked into that choice. Any power converter that is able to have a dimming waveform as an input can be used. Additional external devices, such as color sensors, temperature sensors, accelerometers, tachometers, buttons or voltage monitors can be added using the Inputs tab in the Catalog menu.

After completing the design, PSoC Express offers a Monitor function to make sure it is free of errors. This includes a graphical tool called the "Tuner"", which creates the CIE chart dependant on the LED bins selected in the Properties menu. The intensity and color can then be adjusted manually, and when used with an external color sensor such as a Konica-Minolta CL200 can test the produced mixed color. Another tuning option is to override the manual feature and let the program free-run, where the cursor will move with the color dependant on the logic discussed earlier.

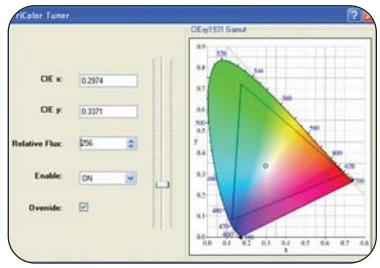

Figure 5.

One final hurdle can be the need to cut costs for the number of MCUs needed to control a wide range of RGB pixels. Many devices on the market have fewer than five hardware PWM or alternative dimming channels. PSoC Express can easily handle multiple pixels utilizing the same EZ-Color device. That integration can save additional money and time to market.

If this particular design does appear too easy and not applicable to the "real world", EZ-Color and PSoC Express have answers. The additional logic valuators available in the tool can create unique color mixing functions. Any variable that is part of the transfer function can be modified by a priority encoder or setpoint region. As such, state machine logic can easily be created to control the "x" and "y" portions of the transfer function, scrolling through the available color gamut. Additional examples are available on the PSoC Express Start Page as Express Designs.

These are complete designs. No "C" was necessary. The language itself was analogous to standard lighting technology. If this seems revolutionary, that's because it is, but revolutionary technology is necessary for such a dynamic and aggressive market. As LEDs continue their rapid adoption cycle, further tools such as what is discussed here will become necessary to keep pace with the market. It doesn't have to be scary to learn and the adoption itself can be a fascinating process.

Gavin Hesse received his BSEE from Seattle Pacific University and is now a Product Marketing Engineer responsible for EZ-Color products for Cypress Semiconductor. Gavin can be contacted at gvh@cypress.com.