Smart Lighting PIONEERS
How LIFX Reinvented the Light Bulb

- Paper-thin Display Technology
- Digital Drivers in Legacy Systems

Interview with Marc Alexander CEO of LIFX

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For the launch of the Tiva C Series Connected LaunchPad, TI has partnered with Exosite, mentioned briefly above, to provide easy access to the LaunchPad from the Internet. The LaunchPad takes about 10 minutes to set up and you can immediately interact with it across the Internet and do things like turn an LED on and off remotely from the website and see the reported temperature as well. It can also display approximate geographic location based on the assigned IP address and display a map of all other connected LaunchPad owners if they are active and plugged-in to Exosite. “In addition, it supports a basic game by enabling someone to interface to the Connected LaunchPad through a serial port from a terminal while someone else is playing with them through their browser. It is basically showing how you can interact remotely with this product and a user even if you are across the globe,” Folkens explained.

The Tiva C Series Connected LaunchPad is shipping now and the price is right; at $19.99 USD, it is less than half the price of other Ethernet-ready kits. The LaunchPad comes complete with quick start and user guides, and ample online support to ensure developers of all backgrounds are well equipped to begin creating cloud-based applications. “We have assembled an online support team to monitor the Engineering-to-Engineering (or E2E) Community,” Folkens said. “Along with this, you also got a free Code Composer Studio Integrated Development Environment, which allows developers to use the full capability. We also support other tool chains like Keil, IAR and Mentor Embedded.

Affordable, versatile, and easy to use, the Tiva Series Connected LaunchPad is well suited for a broad audience and promises to facilitate the expansion of ingenious IoT applications in the cloud. As Folkens concluded, “The target audiences actually are the hobbyists, students and professional engineers. A better way of looking at it is that we are targeting people with innovative ideas and trying to help them get those ideas launched into the cloud.”
Why digital drivers are key to making LEDs work better in legacy electrical infrastructure

Compared with incandescent or halogen lamps, LEDs have long promised much greater efficiency, cooler operating temperatures, lower CO2 emissions, and substantial cost savings—at least over the longer term. But as soon as people started to retrofit them within existing infrastructure, the limitations of LED technology became apparent.
Why Legacy Transformers and MR16 LEDs Haven’t Mixed Well

LEDs in MR16 packages are designed to replace 12 VAC halogen lamps. These lamps are often used where the presence of grid-level AC voltages is undesirable. For example, low-voltage lamps are preferred—or required by regulation—in bathrooms and kitchens where moisture creates safety concerns. Originally, step-down magnetic transformers were used to achieve the required voltage drop, but in the interests of efficiency, electronic transformers are now more common. Installations vary, but in most instances, one transformer feeds one 25W to 50W halogen downlight. Most of these transformers are designed to work with a resistive load of at least 20W. An 8W LED bulb, with roughly the same lumen output as a 40 or 50W halogen, is an insufficient load. As a result, the LED either doesn’t function at all, or just flickers. One solution has been to add an active or passive bleeder circuit inside the LED housing. Active ones are a little more efficient but both options significantly compromise overall efficiency. What’s more, both involve adding components to the lamp—adding cost, size and complexity—and both generate heat, which has to be dissipated from the assembly. This usually means a larger, heavier, and more expensive heat sink because if heat is not dissipated effectively, the operating life of the bulb is severely compromised.

Critically, the life of aluminum electrolytic capacitors found in almost every LED driver circuit is halved with every 10°C rise in temperature. It’s these electrochemical components that are the main culprits in limiting the operating life of an LED bulb.

The Need for a Brighter Approach to Dimming

The challenge of achieving smooth, shimmer-free dimming of LED lamps became apparent early on in their adoption. Mainstream TRIAC dimmers work by cutting off part of the sinusoidal mains waveform to reduce the RMS voltage powering the lamps. They either cut the leading edge at the start of each cycle, or the trailing edge towards the end of the cycle. Dimmers are further classified for compatibility: R-type for tungsten-filament (GLS) or high-voltage halogen lamps, L-type for low-voltage halogens connected via magnetic transformers, and C-types for low-voltage lamps running from electronic transformers. To add further complexity, the dimmers can be R-type, R-C types, RL-type, or RLC-type, depending on how many types of lamp they’re compatible with.

As with step-down transformers for low-voltage lighting, dimmers based on TRIACS need a minimum load. TRIACS don’t conduct unless the holding current reaches a certain threshold and LED bulbs often don’t draw enough current to meet it. Once again, bleeder circuits have been used to keep TRIACS conducting, albeit in a costly and inefficient way, and these sometimes comprise ten or more components. However, even if a circuit is designed to provide a good match for one dimmer, it won’t suit them all. As we’ve discussed, there are many designs of dimmer, some digital and some TRIAC-based, some leading edge and some trailing edge, some smart and some not so smart. Figure 1 shows the holding current requirements of five different TRIACs. The spikes—produced by chopping the mains sine wave to dim the LEDs—show the minimum current that an LED driver would need to draw to work with all of them.
How the Latest Generation of Digital LED Drivers Addresses the Issues

Digitally controlled LED drivers are now evolving to address the challenges described and, crucially, in the price-sensitive market for LED lighting, doing so while enabling the cost and complexity of drive circuits to be reduced.

Two recent examples from Dialog Semiconductor are the iW3662 for overcoming transformer and dimmer compatibility issues when driving MR16 lamps rated at 4W to 8W, and the iW3688 for grid-level driving of A-style, BR, Candle, GU10 and PAR lamps, and T8 LED tubes up to 20W. The iW3688 can also be used with external ballasts.

Both devices automatically detect the type of transformer or dimmer to which they’re connected and then dynamically adjust their outputs in response. Both eliminate external bleeder circuits and by modulating an internal bleeder FET to draw sufficient current at all times, flicker is eliminated, including during dimming. Furthermore, the drivers employ advanced IC power management and voltage sensing to work in circuits with standard, off-the-shelf inductors, keeping costs down.

These digital drivers feature the added advantage of sophisticated over-temperature protection—Dialog’s patented over-temperature (OTP) de-rating technology. As mentioned earlier, keeping the temperate of the LED within acceptable limits is a key requirement for ensuring long operating life. If the maximum threshold temperature is exceeded, the driver gradually reduces its output current until things cool down. The resulting reduction in lumen output from the bulb will often not be noticeable—the human eye is not particularly sensitive to the small changes in light level. If the temperature drops below a pre-determined threshold, the current delivered to the LED is increased again, resulting in higher lumen output.

The iW3662 works with 12VAC or 10 to 24VDC inputs and offers a choice of single or two-stage operation and the ability to operate in Boost-Buck mode (Figure 2) or Boost-Linear mode (Figure 3). This means that the same driver can be used for low voltage LEDs or high voltage COB strings of LEDs. As a result, one driver can be used across a range of products, keeping development time and inventory requirements to a minimum. It delivers a dimming range from 5% to 100%, and works equally well with leading or trailing-edge dimmers, with digital dimmers and with electronic or magnetic transformers (when the iW3662 detects a magnetic transformer, an output drives an external switch to add extra input capacitance and ensure proper operation). In the cost-sensitive MR16 consumer market, the iW3662 bill of materials is also minimized because the device operates at a high (1MHz) switching frequency so that external components are small and low-cost.
For main voltage applications, the single-stage iW3866 is a highly integrated digital driver that eliminates the need for around 20 external components required in earlier designs. This includes ten for the bleeder circuit, which is no longer needed. The driver also reduces costs by simplifying EMI filter design and integrating current sink, switching and VCC charging circuits. Good noise immunity avoids lighting shimmer and the dimming range is exceptionally wide at 1% to 100%.

Figure 4 shows a simplified circuit diagram for an iW3688 driver. Figure 5 shows the dramatic reduction in component count and board complexity that's achievable with the new device.

Summary

Digital LED drivers now achieve levels of performance that could not be implemented within analogue technology. The latest generation of digital drivers add adaptability and flexibility to the design of LED bulbs while at the same time reducing costs and improving the experience of consumers, whatever their transformer and dimmer legacy infrastructure.
HARDWARE DESIGN MADE EASY.

PCBWeb Designer is a free CAD desktop application for designing and manufacturing electronics hardware. The tool supports schematic capture and board layout, including integrated “click-to-order” manufacturing.

www.PCBWeb.com
OLED displays are, without question, the best displays on the market today. With unbelievable contrast ratios, these displays have the darkest blacks achievable, meaning the display is vibrant and never looks washed out. OLEDs provide both color and light at each pixel, meaning that when the pixel is turned off to show black, there is no backlight still trying to leak through. Okaya sent EEWeb a variety fixed segment, character, and graphic OLED displays to see the clarity, brightness, and efficiency up close.
The character displays are designed to show set characters and the graphic displays are designed to allow for customizable and changing graphics. These displays consume anywhere from 10 to 100 milliamps, dependent on the size and brightness, and the OLED brightness can be easily controlled to optimize power. The character OLEDs can operate on a single 3V or 5V power supply can operate for 11 years of continuous use.

Okaya’s OLED displays boast a 170-degree viewing angle, which allows for a clear view no matter where you are in reference to the displays. They also have an extremely fast response time of 10 microseconds, which means that animations and movements, particularly on the graphic displays, are very smooth, without any flicker. All of these features can be easily and inexpensively integrated into your product to make sure that the information that you want to display is clear and professional.

OLED FEATURES
• Unmatched Contrast Ratio
• 10 µs response time
• 170-degree viewing angle

To watch an overview of Okaya’s OLED displays, click the image below:
The Chronos 2 family addresses a wide range of applications due to the various functions and configurations available. EEWeb received a demo unit comprised of three 17.5mm DIN rail modules, but there are also 22.5mm DIN rail industrial modules as well as 35mm removable industrial modules with an 8- or 11-pin connector. These Crouzet timer modules are all available from OnlineComponents.com.
Specs

With the 17.5mm DIN rail demo unit, timing functions can be set from one-tenth of a second to one hundred hours, and the timers are available in mono or multifunction models. The demo unit has a large variety of programmable functions. The MLR1 is a single function timer with that function being an asymmetrical recycler. The output alternates high and low, with the high and low time set separately on the timer, meaning you can set any duty cycle you need. The MUR1 is a multifunction timer, which is popular due to its high flexibility. This multifunction timer allows for simple delayed turn ons, or combined functions for start-up routines that lead into programmed functions. The MXR1 is another multifunction timer with different functions from the MUR1. Function N is a safeguard timer and will set the output high when the button is pressed and will go low when the timer expires. It also has functions like Tt, which turns the output on for a determined time, but the switch also acts as a manual turn-off before time expires.

OnlineComponents.com and Crouzet Control offer these and many other control and automation products for applications in a variety of industries. The Chronos 2 family of timers is highly versatile and can address virtually any need in any industry.

Hardware

Timing Range Selection: 0.1-100h

Time Setting

Function Setting

Watch Video

For more information on the Chronos 2 timers and other products from Crouzet Control, visit OnlineComponents.com.

To watch a video overview of the Chronos 2 demo unit, click the image at the right.
In 2012, a small LED lighting company called LIFX reinvented the light bulb. The result spawned the “smart lighting” industry: a Wi-Fi-enabled, multi-colored bulb that is controllable via smart device. When we say multi-colored, we mean it—“The Original” LIFX bulb offers up to 16 million color options, with over 1,000 shades of white. LIFX offers users the ability to customize the mood and luminance of their environment through an intuitive app and color selection interface. The innovation doesn’t stop there; while LED bulbs are known for their efficiency, the LIFX bulb boasts up to 22 years of use, easily becoming one of the most efficient bulbs available. With the success of the initial roll-out of their bulbs, LIFX has introduced two more bulbs to their family—the Color 650 and the White 800. EEWeb spoke to Marc Alexander, CEO of LIFX, about their current family of smart bulbs, the user experience with their lighting products, and how their bulbs will integrate with other smart home devices.
Could you give us a brief overview of LIFX’s mission and current product offering?

Creating beautiful, bright, and automatically connected lighting products is very important to LIFX. Our connectivity is built in, so the take-home experience for the customer is very strong. I wanted to make sure that the LIFX lighting that you experience is superior to anything you have in your home already. Our products range from the White 800 through to the Color 1000—delivering the warmest whites to the coolest daylights, then adding a rich, vibrant range of color lighting experiences. Even just in the “white” mode of our bulbs, all of our lighting customers get to control their experience and the ambience in their home.

On the color side, we put a lot of development into not only shifting our color temperature throughout the white spectrum, but delivering a full range of very rich and vibrant colors. This not only lets you enjoy the mood and the environment for, let’s say, movies or a party, but it gives you a range of interactive experiences with our app and our partners, which allows you to interact with your connected home. On the safety and security side, our app will notify you of what is happening within or remote to the home.

What research did LIFX conduct on how lighting affects mood?

We have looked at a number of emerging studies on environment lighting and mood, and conducted some great in-house and customer-driven experience discussions. It’s great to work in a company that creates a product that touches on so many aspects of your environment and enjoyment of experiences. Lighting is pervasive and has an enjoyable and distinctive effect—we live most of our waking hours under the illumination of lighting and now LEDs.

What are the tradeoffs of not using a hub for the control of your lighting products?

I am not a big believer in the hub-based products because no matter how many times you try and expand it, you reach a resource limit in your interface that controls your experience. For us, it was very important to actually bring that instant Wi-Fi connectivity that works on your home network. All of our products are genuinely Cloud connected, so they are not going through an arbitration service or having hub radio link issues. It was important to have that connectivity built into every product rather than having a higher-cost hub and a slightly lower-cost bulb. It was a challenge to fit all of that extra connectivity gear into the product. Even though a non-hub system was more expensive and a bigger technical challenge, we thought it was beneficial for the overall user experience.

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Can you speak to some of the other challenges of integrating connectivity in with the driver and LEDs?

The biggest and most significant technical challenge was thermal. The temperature of power LEDs is quite high and is significantly higher than the available embedded Wi-Fi at the time when we were first developing LIFX. 70°C was the maximum available temperature of nearly every Wi-Fi solution at the time and we worked very hard to get the temperature rating up to 85°C. We came up with a unique industrial design for our first light bulb, where we went through about seven different prototypes before we found a solution where the radio range, the exposure of the antenna, and the angle of the wireless transmission were all more than satisfactory. We used a whole combination of industrial design plastics, thermal conductivity management and insulation, and an air management system to support our temperature goals.

What are some of the differences and benefits of LIFX’s White 800 compared to others on the market?

Apart from being a no-hub solution that customers can take home immediately and use, our bulb is significantly bright.

get to experience notifications, mood, dimming, and ambience settings and all of the connectivity experiences that you would normally enjoy with LIFX. If you look at other dimmable, low-cost bulbs, you will see that they generally have many low-cost compromises; they are not as bright, and—being only single-channel dimmable white—they do not have the range of environment and ambience experiences that we provide.

In what ways can these bulbs interact with other connected devices?

We have many touchpoints in use with our connected device partners and a greater community of developers. LIFX provides local LAN-based APIs for customers and local connected device partners to interact with, and we have a Cloud API that a number of our higher-level partners connect to for cloud-based connected home product interactions, remote, and experience connected triggers.

We have also partnered with Nest and their smart thermostat to provide unique smart home experiences. Our recently released IFTTT channel has launched with great engagement of a diverse range of automatic and triggered interactions—everything from weather to event triggers. Many of these interactions and experiences are easily selectable via our recent LIFX app releases for iOS and Android.

What do you see as the next step not only for LIFX, but for the smart lighting area in general?

I don’t believe our job is done in the smart lighting area until we don’t have to think about it anymore. For example, when you come home and your smart home automatically makes these adjustments that you won’t even notice after a while, like when you pull into your driveway and the lights in the front of your house turn on.

The experience has to happen automatically to the point where you take it for granted—that is what is important for us. That point where as many of the connected devices are communicating with each other in the background and you have selected the experience you want is our ultimate goal.

I think this goal is only a few years away now. There has been a lot of work done on the connected home in the past few years—like the miniaturization of certain technologies—and the ecosystem of the connected home being driven by the ability of these devices to talk to each other across these different products will bring this goal towards the finish line. Within a few years, I think the industry will finally be able to market the complete “connected home” that we only dreamed about not long ago.
Displays are dominating our world. Studies have shown that Americans spend seven hours in front of screens on average. Computers, phones, televisions, and tablets are among the popular devices we use on a daily and hourly basis. However, recent advancements in display technologies will lead to unlikely new devices—applications so unassuming that the user can barely tell that the device is an electronic screen. At the forefront of this trend is electronic paper (e-paper). E-paper is an easily readable screen solution; there is no need for a backlight unless the user is in low-light situations, and glare is acutely reduced. These qualities give e-paper a unique edge over other display technologies.
On the surface, e-paper might seem like traditional LED or LCD display technology, when in fact, it employs entirely new production processes. While there are flexible displays being produced using OLED display technology, these are not true e-paper technologies. Most current displays use LCD technology, with LED displays using LCD with LEDs as a backlight. LEDs do help reduce the power consumption of an LCD television while providing more vibrant colors, but they don’t provide the same effect as e-paper technology.

There are a few different types of e-paper technologies in development that are based on the same concept. A chemical liquid compound is placed in one location, and when an electric charge is applied to the unit, the compound moves to the location of the opposite charged particles. This movement represents a single pixel. Pixels are arranged in arrays and depending on where the voltage is applied, an image appears. This can then be controlled to display different images.

Display images in devices like the Kindle and the Nook use a form of e-paper called an electrophoretic display. This display technology uses titanium dioxide particles that are dispersed in a hydrocarbon oil. The oil is pumped with a dark dye surfactant and charging agent that allows the fluid to be affected by an electrical charge. The fluid is placed between two conductor plates and when an electrical charge is applied, the oils change positions across the plates allowing for a single pixel to be displayed. This is the most common e-paper display currently available on the market, made popular by e-reader tablets. But, since the device only uses dark-colored dye, it only can display images and text in black and white. On top of being colorless, the technology requires a glass plate to house the materials. Therefore, e-readers can only be as small as a normal-sized tablet. The limitations of electrophoretic displays keep current e-readers from advancing to a true electronic “paper.”

However, electrophoretic displays can also include color. This is done by using tiny microcapsules filled with the same oil solution, but the oil used is colored rather than just being dark. The electric charge

Display images in devices like the Kindle and the Nook use a form of e-paper called an electrophoretic display.

Electrowetting is a type of e-paper technology that uses a water/oil mix in that the oil sits between the water and a water-repellant material.

Photographer: Armin Kübelbeck, CC-BY-SA, Wikimedia Commons
controls whether white particles appear on top of the capsules or not. This allows for images to be displayed with color as the circuit controls which pigments should be shown. By using microcapsules, rather than two metal plates to house the oil, the electronic paper could be made on flexible plastic sheets instead of glass as one microcapsule can be used as a single pixel. Even though this might sound like a solution to the black and white problem, many of the prototypes using this technology ended up producing less-than-stellar colors, appearing washed out and faded. Plus, many of today’s e-readers are still the size of a normal tablet, even if they use much less circuitry and perform with much less power consumption. Companies have tried, but the technology is not keeping up with the demand. So, researchers and engineers set out on a different path in order to create a technology that provides both color and can fit on material that is as thin as a piece of paper. The most logical technology to research and use for e-paper is a process called electrowetting.

Electrowetting is a type of e-paper technology that uses a water/oil mix in that the oil sits between the water and a water-repellant material. To update the pigmentation, an effect occurs when there is a charge applied across the fluid, which alters the solid-electrolyte contact angle. The liquid tension of the oil allows the substance to bubble when electrically charged and disperse when not charged. So when energized, the oil cannot stay between the two layers and is brushed aside. The oil contains the pigments needed to produce color. When brushed aside, a white pixel is shown. This system is produced thousands of times as each pixel represents an electrowetting setup. This is even better than the microcapsules setup and allows e-paper to be developed in the sense of what many dreamed of.

Electrowetting has a major advantage over electrophoretic displays: it can produce video. The difference lies in the reaction time of the fluids in each pixel. With electrowetting, the transition between a white and colored reflection is very fast, allowing a screen to update within the time frame of a person’s average perception. The process of electrowetting is low power and low voltage, allowing for displays to be flat and thin. Displays utilizing the electrowetting effect can fit on a sheet of plastic as thin as a piece of paper, and current research is attempting to actually place the pixel array on actual paper. Each pixel in the electrowetting process is independent and only requires the water/oil combination along with a water-resistant material, plus an electrical charge. Thousands of the mini-devices can be placed in an array that allow it to show a full screen, while also being bendable. The oil compound used in the electrowetting process allows for much more vibrant colors that exhibit the visual properties of paper. One sub-pixel can switch two different colors independently. By injecting a pixel with two different types of colored oils that have different chemical characteristics from each other in reference to their reaction to applied voltages, the pixel can exhibit multiple colors. Add a color filter, and two-thirds of the display area can reflect any visible light wavelength. By combining these advancements in technology, e-paper can display video while having the ease of viewing similar to newspaper while displaying any color.

Unfortunately, it might be a few years before displays based on electrowetting become widely commercially available. Currently, bendable electrophoretic and OLED displays are entering the market, but since electrophoretic displays can’t produce high-quality colors and video, and electrowetting has high power consumption, it is not a lucrative market. The future of e-paper is bright with the prospect of electrowetting display technology becoming easier and cheaper to produce while giving engineers the capability to make bendable electronics. In the near future, e-paper may be covering windows, fitting into back pockets, and displaying changing prices on grocery goods, but for now we are going to have to watch and wait.