XICATO

Why Integrate Electronics in an LED Module?

One might easily have asked a mere decade ago "why put sensors and microcontrollers into a mobile phone"? The answer we know now is that this device that is always with us, had the potential to serve many roles and provide significantly more value. The same potential is in front of us for lighting. It's ubiquitous, and with the increasing adoption of LED technology, lighting is becoming part of the digitally controllable world where the light source continues to fulfill its primary functional task, as does the smartphone, and at the same time becomes a connected, controllable device that can give and receive information and data, respond autonomously or to commands, and improve the quality of light in any environment. This is the start of Lighting 2.0.

Integration in the module has clear benefits and affords lighting professionals new opportunities to create business value.

- Total system cost reduction
- Simplified installation, maintenance and repair
- Superior dimming and flicker performance
- Real-time data and information including diagnostics

The attachment of electronics and sensors to enable a light source to do more than illuminate has been seen first in the streetlight and wide area lighting segments. Here, short term payback through energy and maintenance reductions have been easy and quality of light relatively unimportant. For these applications, luminaires provide ample real estate to "bolt-on" a variety of sensors and electronics without significant concern for the aesthetics of the luminaire or the space.

Energy saving and monitoring, tracking shopping behavior, pushing content to shoppers, improving facility management and managing the lighting based on user preferences are all capabilities that can be realized with Lighting 2.0. At the same time, as the demand for connected lighting comes to architectural and indoor communities, the concerns for quality light, aesthetics and space are crucial. We believe that the best way to address market needs is with the integration of the 'smart' features in the module. This will reduce costs and provide an aesthetically manageable light source that still provides the best quality and reliability.

Given the broad ranging nature of Lighting 2.0 and the many ways that it is being imagined depending on segment, lighting type and business model, it makes sense to consider the key elements that support integration at the module level.

<u>Performance monitoring</u>

It is possible to track a wide variety of performance parameters related to the operation of a light source such as run-time, LED temperature, and power (current, voltage) in much the same way as is done for a car's engine or for an airplane: by integrating sensors and a small microprocessor close to the critical parts of the light source. Collected data is then stored in the module and can be accessed by technicians when needed or appropriate. If the light sources are connected through a wireless or wired communications protocol, then the data can be transmitted directly from the module.

Alternatively, locating this information in a driver or power supply that may support multiple light points puts the data of those light points at risk and may force decommission of multiple rather than a single light point if service is needed. And in the case of a driver replacement, the data would need to be transferred which is impractical and unlikely to be done in practice.

Dimming quality

While there are excellent dimming drivers available today, there are still improvements that can be made with regard to dimming levels, smoothness of level transitions, and flicker. Dimming is done either by constant current reduction (CCR) which reduces the drive current through the LED arrays and thereby lowers light output or by Pulse Width Modulation (PWM) which reduces the amount of time that the LEDs are lit and therefore reduces light output.

Dimming through constant current reduction is preferred as it offers better efficacy and does not produce flicker which is especially noticeable in video including that is captured by security cameras, cell phones and business conference systems. Unfortunately, the minimum light level that can be achieved with CCR depends on the electrical parameters of the LED chips being used and the LED array configuration. This information is not available to the driver manufacturer and varies from light source to light source, even within a single manufacturer. When dimming levels below what are possible with CCR are required, PWM dimming is the primary option. The best drivers today are a hybrid of CCR and PWM and can be optimized for very smooth dimming. Because the driver has little or no information about the LED arrays, very conservative assumptions have to be made to assure compatibility between the driver and the many different LED arrays that it may be connected to. This approach results in increased costs and lower performance.

It is possible to communicate detailed information about the LED load to the driver instead but would require either proprietary communication between the driver and array manufacturer or the development of industry standards that do not exist today. However, if done as part of an integrated module, the LED chip and array data is readily available. This approach reduces costs, optimizes performance and creates a fail proof and robust dimming system.

Over Temperature Protection

The lifetime and performance of every LED system depends in large part on temperature management which in-turn is determined by the ambient temperature, the thermal design engineered by the OEM, and the material makeup of the light source itself. For a module, the maximum operating temperature depends in large part on the phosphors and chips used within the module.

The solution to managing the temperature of an LED system is to integrate a temperature sensor with the array and allow the drive current to be reduced if an over-temperature state is detected. This too can be done on a driver but would require that the OEM set the right parameters for maximum operating temperature of the module. They would also need to engineer a solution to read the embedded sensor and convert the results into data that the driver could interpret, which is complicated by the fact that the driver would need to know what type of temperature sensor is used.

LED Technology and Performance Changes

From a practical perspective we must consider the effect of continued innovation in LEDs and arrays as well as field management of installed devices. LED innovation is so rapid that drive current, flux, and temperature parameters are changing multiple times in a year. These changes force a continuous effort on the part of OEMs and driver manufacturers to adjust and engineer simply in order to keep up with the changes. As importantly, any failure in the field would be replaced by a new module or array that likely has different parameters than the original source. It's would be cost prohibitive and impractical to have to change power supplies or drivers with a source failure.

In the XIM platform the drive control and over temperature protection can be implemented within the module, and fully configured and optimized by Xicato. Xicato as the module manufacturer can and will ensure that future versions of the modules will implement the right drive conditions and over-temperature protection correctly and protect the module and the fixture from early failures due to overheating.

A Future-Proof, Integrated Approach Lowers Costs and Simplifies System Design
Integration of electronics in the module clearly has three benefits

- It minimizes cost
- It simplifies installation, maintenance and repair
- It provides a future-proof platform that assures that light quality and electrical control and connectivity remain the same over time.

XIM has been designed from the start to allow the lighting community to realize these key benefits and provide a platform that allows for the greatest design flexibility and aesthetics.