www.led-professional.com

ISSN 1993-890X

LED professional Review

LpR

The leading worldwide authority for LED lighting technology information

Jan/Feb 2011 | Issue 23

Intelligent Lighting (Part II): From Definition to Implementation

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While Osama Mannan, Technical Marketing Engineer of Future Lighting Solutions presented the different technologies used in an intelligent lighting system and the benefits that can be achieved using different approaches in Part I, in Part II he explains how the features presented previously can be implemented with different levels of complexity, depending on the location and the requirements of the application.

Looking closely at an intelligent lighting system, the implementation of the system comprises of a combination of a wide range of products depending on the application and its requirements. This article will focus on three implementation approaches and the products that can be leveraged to develop the intelligent lighting system.

Basic and Direct Control

A key feature that intelligent lighting control brings to LED lighting systems is dimming. In indoor applications, the most basic form of dimming can be achieved by using wall dimmers at a fixed location in the room. Standard wall dimmers send different types of signals for controlling the brightness of the LEDs, namely TRIAC, 0-10V, and DALI, and 12V Pulse Width Modulation (PWM). The dimmer has to be interfaced with an LED driver that supports any of these signals in order to ultimately control the light levels of LED luminaires. There are several dimmable LED drivers available on the market from a number of vendors, offering various output voltage ranges and drive currents to support several LED configurations.

Additionally, a simple sensor system can be added to trigger dimming or ON/OFF switching. For instance, a motion detector can be placed in the room to sense presence and send a 0-10V signal to the driver to change the state of the LED fixture from OFF to ON, or vice versa. Alternatively, a DALI-based sensor can be used to broadcast the signal to all the fixtures in the room and trigger the same action. Although communication using DALI can address each fixture and control them individually, a simple implementation of DALI would only require one signal to be broadcasted and initiate control to all the fixtures collectively. The sensors can work with a controller, which can be installed either stand-alone or integrated inside the LED driver. An example of such a system is Philips ActiLume. Combined with a pre-programmed controller, these systems consist of miniature ambient light and motion sensors that can be set for different modes of operation giving the system more versatility based on the requirements. The controller also includes a power relay, which enables ON/OFF switching of the light fixtures. Figure 1 demonstrates the functions of such a system when installed in the luminaire.

In Figure 1.a, the motion sensor detects the absence of movement in the room and sends the command to the controller to turn OFF the lights. Similarly, Figure 1.b shows the ambient light sensor sending the signal to dim the LED luminaire due to the appropriate level of illumination provided by the sunlight. This operation will ultimately lead to energy savings by reducing the power consumption of the luminaires when not required.

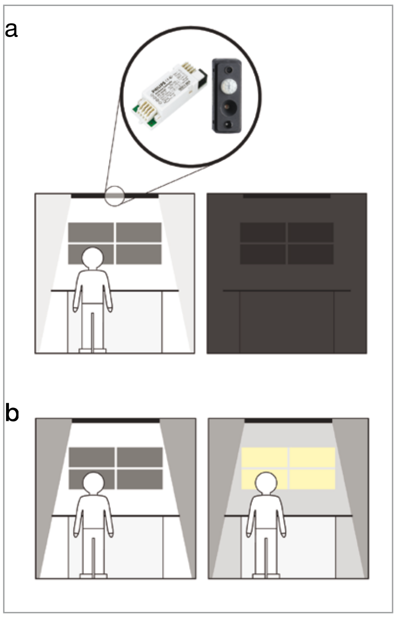
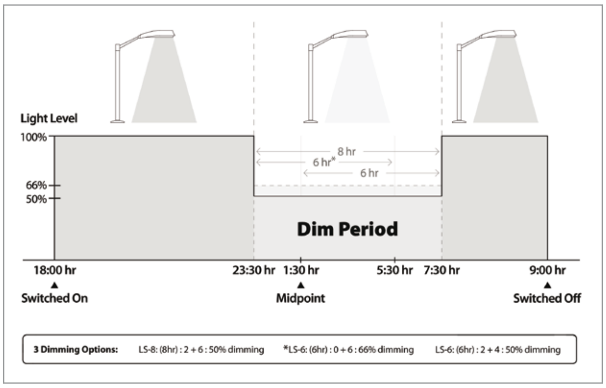


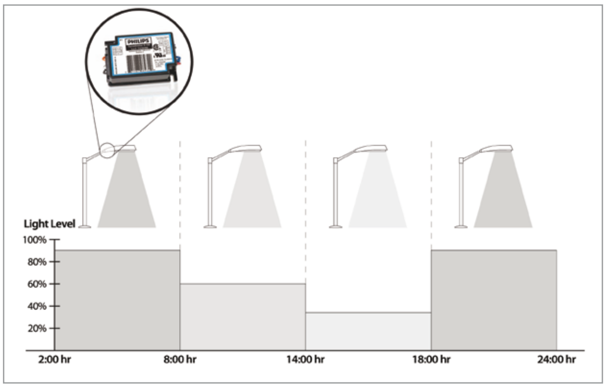
Figure 1: **A simple intelligent controller and sensor system**

As for a simple implementation of an outdoor application, the use of sensors can be eliminated and a programmable dimming controller can be used to schedule actions. For example, Philips LumiStep dimming controller, which is a standalone controller, but has also been integrated inside some LED drivers, provides pre-set dimming modes based on the need of the application. The controller will set the driver to dim for a certain period of time depending on ON/OFF switch points. The dimming options include 6 hour and 8 hour dimming periods depending on the requirements and product selected. A dynamic timer changes the dimming mid point as time passes. Figure 2 shows an outline of the controller concept implemented in street light poles. For instance,

Figure 2 (left):
Dynamic dimming control for street lighting

Figure 3 (right):
Programmable dimmer control for street lighting offer additional options



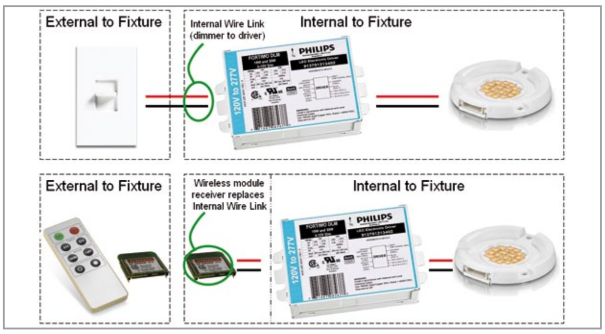


considering the 8 hour dimming option, the controller will dim the lights by 50% two hours before the midpoint and then go back to full intensity six hours after. This implementation option is commonly known as “2+6”. Depending on when the lights are switched ON and OFF, based on season for example, the dimmer will adjust the midpoint and dim the lights accordingly.

A more feature rich dimming control can also be achieved, for instance by using Philips Dynadimmer. This controller, which can also be either inside or outside the driver, sends a 1-10V signal to LED drivers and initiates dimming time and levels based on configurable schedules. The dimming schedule in the dimmer is set via a programming kit or computer software. Figure 3 shows a dimmer schedule implemented for street lights to follow a specific dimming schedule to ultimately achieve energy savings.

In summary, the most basic form of control is to send the control commands directly from one component to the other, such as sensor signals to the LED drivers, without feedback or monitoring capabilities. In this case, there is no need for wireless communication RF modules or metering devices in the system.

Figure 4:
Wireless control using Synapse RF Engines



Local Wireless Control

The basic intelligent lighting implementation can be enhanced in a local network that includes communication between fixtures and controlling them wirelessly.

For wireless communication, whether it’s an indoor office using a 2.4GHz band or an outdoor parking lot leveraging sub-2.4Ghz frequencies, RF engines integrated into the controllers and LED drivers can enable intelligent lighting features within the local boundary of the application, such as a room, a building, or a parking lot. As a result, there is no wide area network or a need to send data over the Internet. For lighting manufacturers who want to design and develop their own controller, the RF engines or IC’s can be incorporated to the controllers or drivers. Such RF modules are available from Synapse Wireless. By adding some additional circuitry to the system, these RF engines can be configured to provide a digital or analog signal and can interface with many LED drivers to enable wireless control. The use of such RF engines enables more convenient control of light fixtures as well as eliminating the need for additional cable connections between the controller and luminaires. Figure 4 illustrates how a Synapse RF engine can replace the physical link between the dimmer and the LED driver. The extra circuitry required to send the appropriate signal to the LED driver is not shown in Figure 4.

For a lighting system to communicate and interoperate seamlessly, the communication modules must share the same protocol or network operating system (NOS). An example of a unified protocol that can be installed in the wireless modules is Synapse’s operating system SNAP®. Since SNAP is a network operating system, it can be installed on multiple microprocessor based platforms such as communication modules from various vendors or 8 to 32-bit microcontrollers and radios from multiple IC manufacturers. It enables a robust mesh network that provides embedded intelligence and secure communication for connecting devices with each other, requiring no setup and minimal application development. It’s also a multi-hopping and self-healing system that supports software update over-the-air.

Although developing intelligent lighting systems that directly leverage communication modules provides a high level of flexibility, many lighting manufacturers may not have the required competencies to design custom controller solutions. As a result, these lighting manufacturers require a plug-and-play solution that would seamlessly connect to their existing system and achieve the same wireless control capability. One example of a finished system component that already integrates a communication module is the SNAP DIM-10.

As illustrated in Figure 5, the SNAP DIM-10 can be connected to multiple LED drivers, which enables a simple approach to group and control up to 10 luminaires. Furthermore, most dimmable LED drivers do not dim down to 0%, which means that the user cannot directly “switch OFF” the lights. Therefore, the module also includes a power relay that turns off

Figure 5:
An RF controller module connected to multiple drivers and fixtures

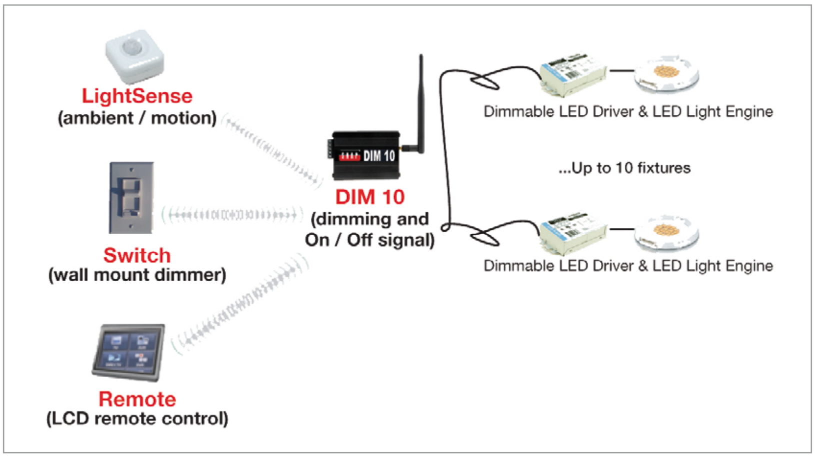
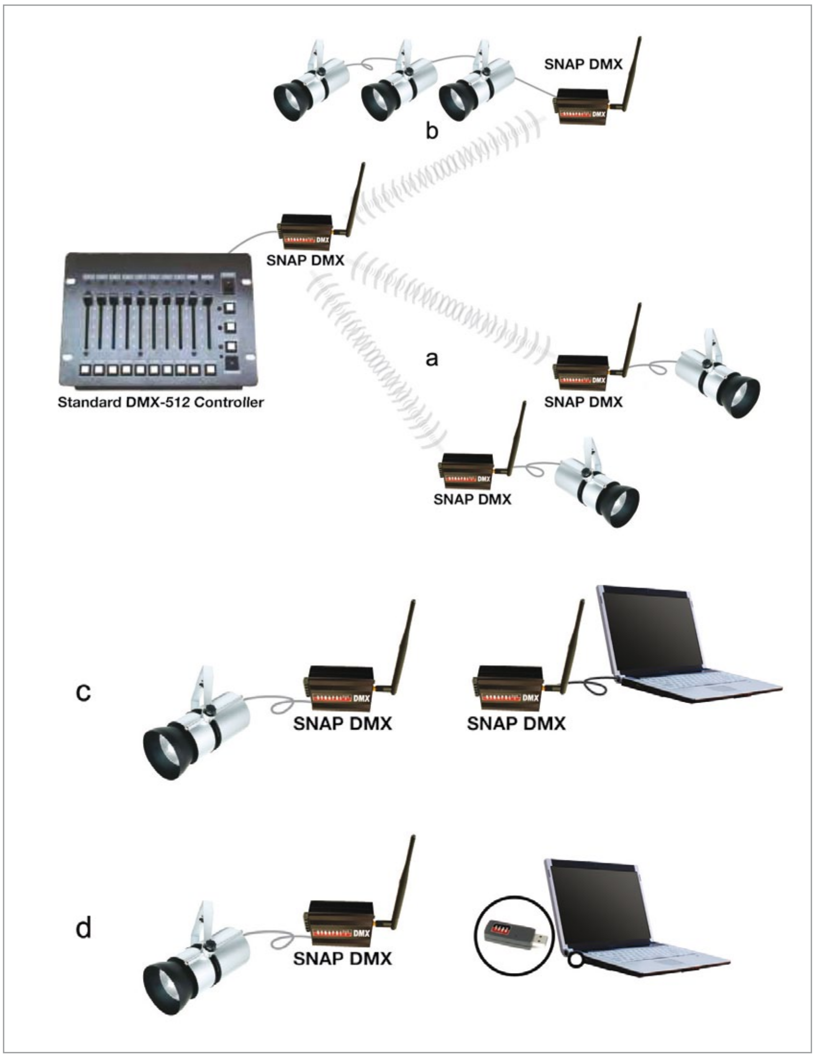


Figure 6:
DMX implementations



the power to the LED driver at low dimming levels. There are two primary versions available, one that supports 0-10V and PWM dimming signals and the other that supports digital lighting protocols such as DALI. It can receive the control commands from various sources. As shown in Figure 5, a wireless wall-mounted dimmer can be used to control the lights from a fixed location. Also, an ambient sensor and motion detector would send signals to the SNAP DIM-10 to trigger actions. Additionally, an LCD remote control can be employed to control all the lights connected to the module within the area of coverage.

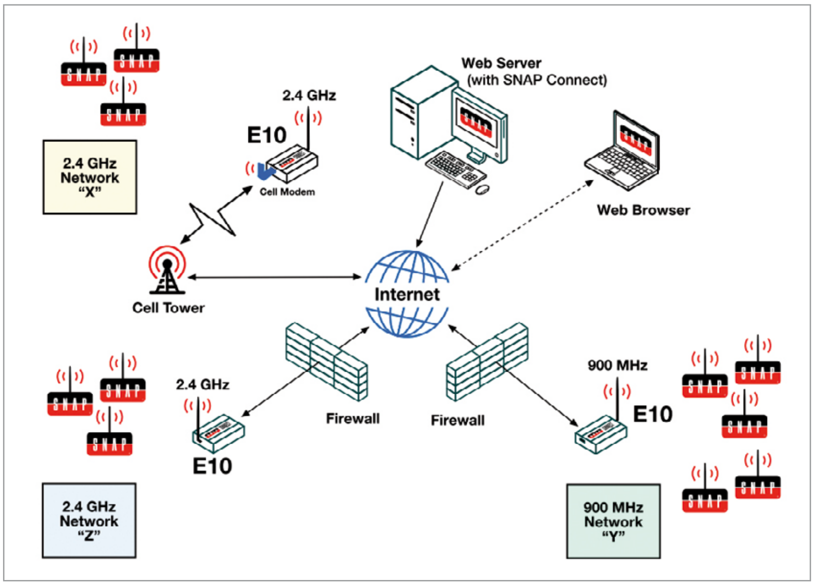
Besides the standard dimming control signals, such as 0-10V, DALI, and 12V PWM, intelligent lighting can be achieved via the DMX 512 protocol.

One drawback of a DMX system is that it requires a great deal of cabling to control several light fixtures spread apart at different locations. Consequently, implementing DMX control wirelessly could significantly simplify the installation of the lighting system. Wireless DMX control can, for instance, be accomplished using a SNAP DMX controller, which enables wireless communication between a standard DMX console to existing DMX 512 installations without the need to modify the original equipment.

This DMX controller can be leveraged in various ways. As shown in Figure 6, the module can provide a completely cable-free implementation by connecting a module to each fixture and communicating wirelessly, as in Figure 6a. Another method is implementing a hybrid system which connects the DMX console to one DMX controller that communicates wirelessly to another controller connected to the first DMX lighting fixture. Other DMX fixtures are then physically wired together from the first fixture as they would for a traditional DMX installation, as shown in Figure 6b. Finally, if the DMX console is replaced by a computer, the DMX controller includes a USB port with the appropriate USB-to-DMX conversion capabilities. As a result, third party PC-based DMX software in combination with the DMX controller can be leveraged to send wireless DMX signals to the other DMX controllers, as shown in Figure 6c. For control from a computer, SNAP Stick, which is a compact wireless device with a USB interface, the same size as a standard USB memory stick can be leveraged. It enables plug-and-play wireless control of the SNAP DMX controller, since both communicate using the same operating system (see Figure 6d).

All the components mentioned serve a local network of control that does not go beyond the application boundaries. That is, no wide area communication is established via the Internet, a cell phone network, or remotely via a monitoring base.

Figure 7: Communication using a gateway



Wide Area Control

Implementing intelligent lighting on a larger scale allows for full control over the lighting system from multiple locations and enables comprehensive monitoring capabilities. These systems are designed to be scalable with the ability to add locations and metering functionalities with feedback for corrective actions.

Communication via the Internet makes it possible to control fixtures without the need to be near the physical location of the lighting installation. This gives more flexibility to the lighting system and the convenience of controlling the lights from anywhere. For example the SNAP Connect E10 interfaces with other modules that use the SNAP network operating system connects them to the Internet. As shown in Figure 7, the E10 gathers data from all SNAP-enabled modules, where a user can monitor single or multiple lighting installations via a standard web browser. The web-interface can also send commands from the Internet to multiple wireless modules, to enable dimming, luminaire grouping, and scheduling for the lighting system.

Furthermore, taking measurements of parameters such as current, voltage, and power factor adds monitoring and energy metering capabilities to the system, which enhances energy management options. This information can be relayed to the Internet and stored to a database where reports can be generated or immediate actions can be triggered if necessary. There are several energy metering products that facilitate this task, such as SNAP GridSense that captures and sends energy metering data to the Internet.

A complete hardware system solution is presented in Figure 8. The system makes use of all the components needed for a comprehensive intelligent lighting system. In the figure, sensors send signals to DIM-10 modules that trigger actions in the LED drivers to initiate actions in the light fixtures. These, in turn, are connected to energy metering modules that measure current and voltage. This entire local network connects through the Internet to remotely monitor the system performance and send out actions accordingly.

This type of arrangement enables control and monitoring of fixtures in groups. That is, the SNAP GridSense will take measurements from all the modules connected to it as a whole, and not for individual light fixtures. Similarly, all the light fixtures connected to one DIM-10 module can be controlled collectively and not separately. This approach allows for the amortization of the cost of the intelligent lighting components across multiple luminaires in order to accelerate payback.

However, if there is a requirement to control and monitor each and every luminaire, intelligent LED drivers that incorporate the energy metering and control capabilities is the most cost effective and flexible approach. Not only does this approach enable better control, it also minimizes the number of components, which greatly improves the system from an efficiency and cost perspective.

Some companies are developing a family of intelligent LED drivers that incorporate the energy metering and control functionalities provided by the components as seen in Figure 8. These fully programmable LED drivers support dimming control using 0-10V and DALI and accept universal input voltages. They also have an integrated control for timed dimming schedules.

Figure 8: Complete hardware system solution

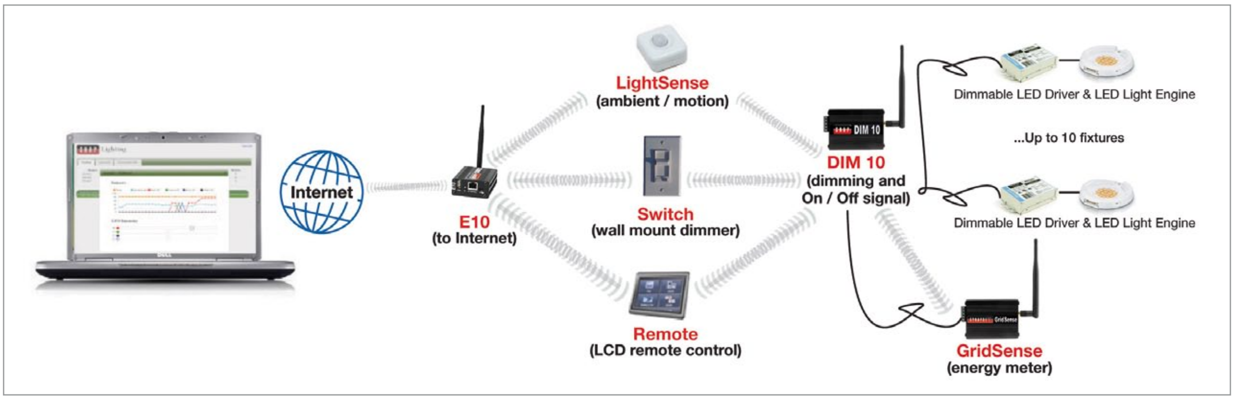


Figure 9. **Complete system solution with programmable driver**

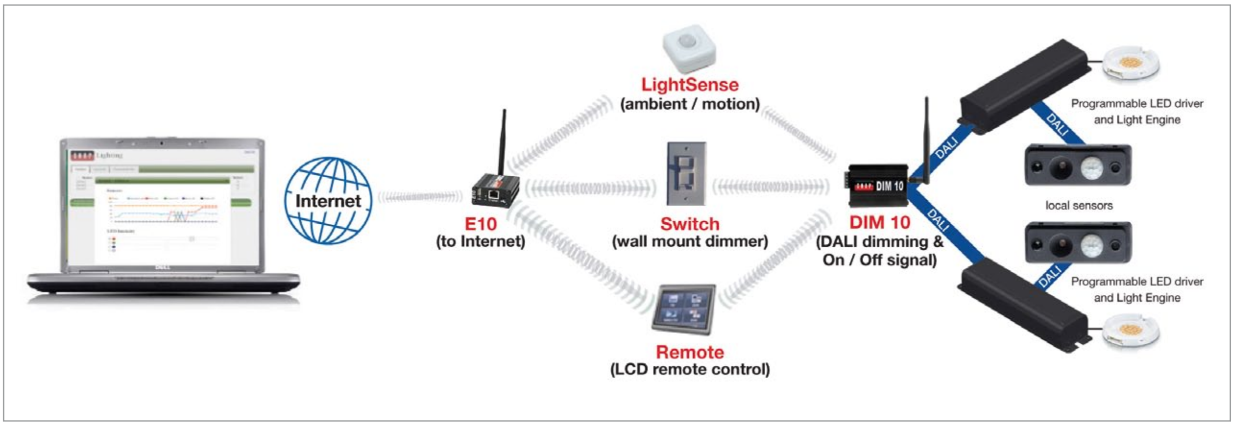


Figure 10. **Complete wire-free communication and control system**

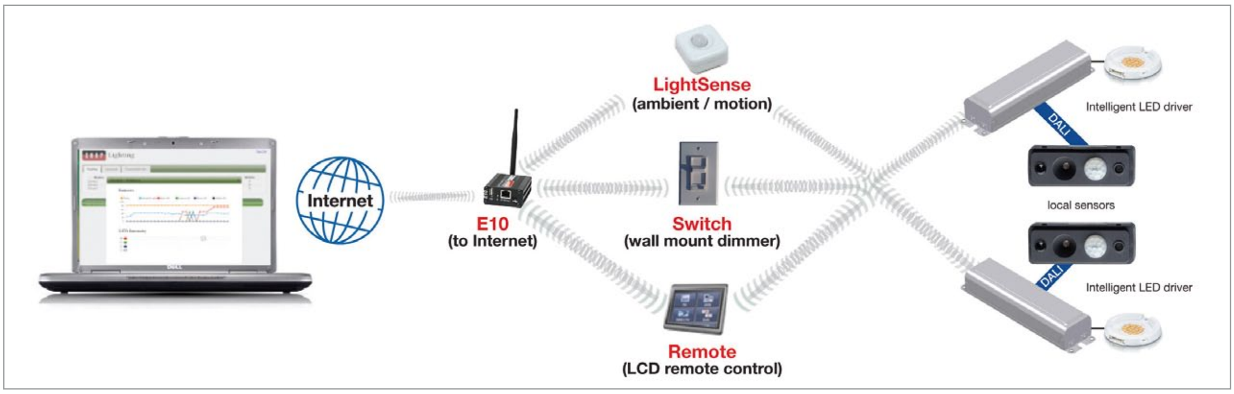


Figure 11. **Web-based software for commissioning and control via the Internet**

For luminaire manufacturers that want to provide constant light output over time, these drivers also allow the luminaire manufacturer to program a curve that will automatically increase current over the lifetime of the luminaire to offset the LED lumen depreciation. The driver also collects diagnostic data such as voltage, current, and temperature.

All these control and monitoring capabilities in the driver can be accessed via the DALI protocol. As a result, the DALI version of the DIM-10 can set the drive current and driver dimming level as well as read all the diagnostic data in the driver in order to send the data over the Internet via the gateway. Figure 9 shows how the programmable driver can connect to fixture-based DALI-compatible sensors and replace multiple components, thus simplifying yet enhancing the system.

However, the ultimate goal is to have a completely wireless system that involves a minimum amount of wiring yet provides complete control over the system. Figure 10 shows an intelligent LED driver that incorporates wireless communication with sensors, controllers, and switches allowing for complete wire-free communication and control with a link that runs all the way from the light fixture to the Internet.

The lighting system monitoring and control from the Internet is achieved by using a standard web-based software that provides the user with full control over the system regardless of the location or control device used. Figure 11 shows an example of an application layout from which the user can set different control criteria to each section and assign different actions accordingly. The lights can be individually controlled or as groups of luminaries, where sophisticated schedules and scenes based on seasons or holidays can be incorporated.

The software can also be used for commissioning the lighting system and allocate functions and rules to the light fixtures based on their role and location. Alternatively, basic commissioning can be achieved by using the remote control at the lighting installation location.

Conclusion

The implementation of intelligent lighting can include different components with different levels of complexity depending on the application and required features. The solutions presented in this article are either already available or will soon be accessible in the coming months. Whether the system is implemented with the most basic components for simple dimming and sensing, or incorporating more functionality such as energy metering and wireless sensor interaction, an intelligent control system takes lighting design a step further and allows for the development of lighting products that enhance the energy saving and performance value proposition of solid state lighting. ■