EE302: Centralized Intelligent Lighting Control, Part 2: Application

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COURSE DESCRIPTION

Intelligent lighting controls represent the ultimate in lighting control. As energy codes and owner requirements become more complex, intelligent control solutions are becoming increasingly common in new construction while becoming more adaptable to existing construction. Intelligent lighting control is also ideally suited to LED lighting.

Though solutions vary, a fully realized intelligent lighting control offers the benefits of addressable luminaires and/or groups of luminaires, layered and sophisticated control strategies, software-based zoning and rezoning, elegant wired or wireless connections, and energy measurement and monitoring. These systems are typically centralized control systems.

As these solutions are by their nature sophisticated, many factors contribute to successfully selecting, designing, specifying and commissioning a system. This Education Express course describes the basic technology of centralized intelligent lighting control systems and then provides application guidance.

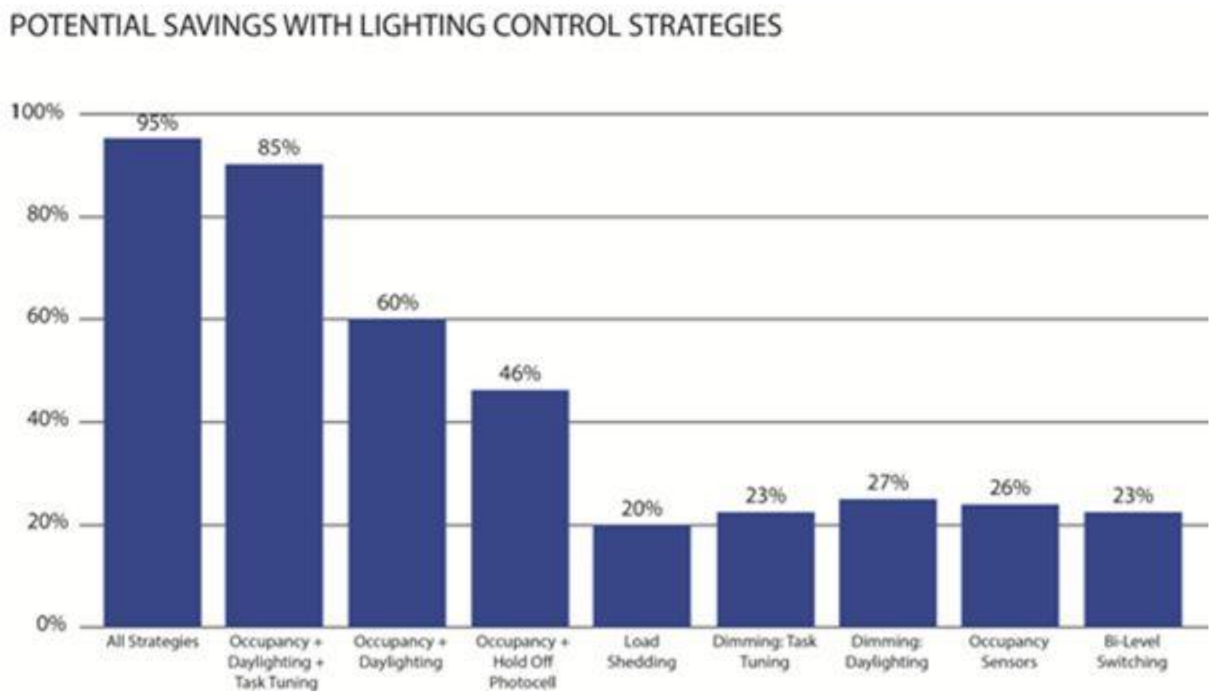

Image courtesy of Leviton.

LEARNING OBJECTIVES

Upon completion of this learning module, students will be able to:

- Design intelligent lighting control solutions with an appropriate level of control zone granularity.
- Design control zones based on given luminaire layout and acceptable level of cost.
- Produce a basic lighting control narrative with sequences of operation.
- Take advantage of common features of graphic user interfaces and consider how abnormal conditions may affect the operation of luminaires.

CONTROL ZONING: GRANULARITY

A control zone is one or more luminaires controlled simultaneously by a lighting controller. In an intelligent lighting control system, the lighting controller may be the software itself. A control design's "granularity" refers to how detailed the zoning is for an application. The smaller the control zones, the more flexible the control system's response, which can be used to optimize energy savings and user satisfaction. However, it may also increase cost and complexity.

By making each luminaire addressable (each with a discrete identification), intelligent lighting control systems allow for any level of desired granularity. Typically, occupancy sensors, photosensors and user dimming of dedicated overhead luminaires present opportunities for individual luminaire control. Other functions, such as scheduling, demand response and manual control of all luminaires in an entire area, are more often assigned to luminaires zoned in groups.

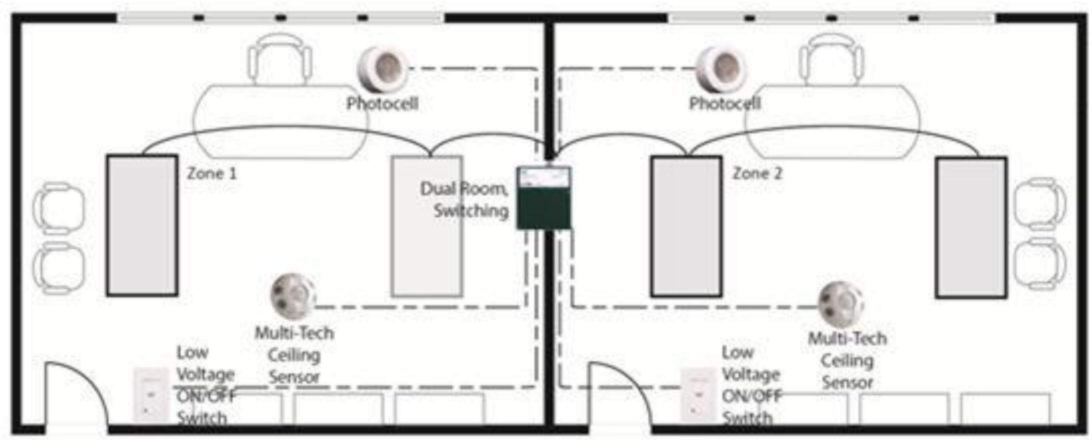

Image courtesy of Leviton.

CONTROL ZONING: LAYERING

In an intelligent lighting control system, all controllers and accessory devices in an area are connected to a low-voltage wiring bus or wireless network. As a result, it is economical to layer control strategies on the same controllers and accessory devices. A given luminaire may be programmed to respond to a wide range of inputs either individually or in varying groups. For example, Luminaire A may be individually controlled by an onboard occupancy sensor and a photosensor, and controlled in a larger group for scheduling, demand response and manual control.

As the resulting hierarchy can be complex, a control narrative is important. Further, manufacturers may accomplish zoning differently for their products, so it pays to get to know the selected control solution thoroughly.

Luminaire					
A	B	C	D	E	F
Facility tuning					
Demand response					
Manual switching				Manual switching	Manual switching
Vacancy sensing		Vacancy sensing		Vacancy sensing	Vacancy sensing
Daylight harvesting	Daylight harvesting	Daylight harvesting	Daylight harvesting	Daylight harvesting	Daylight harvesting

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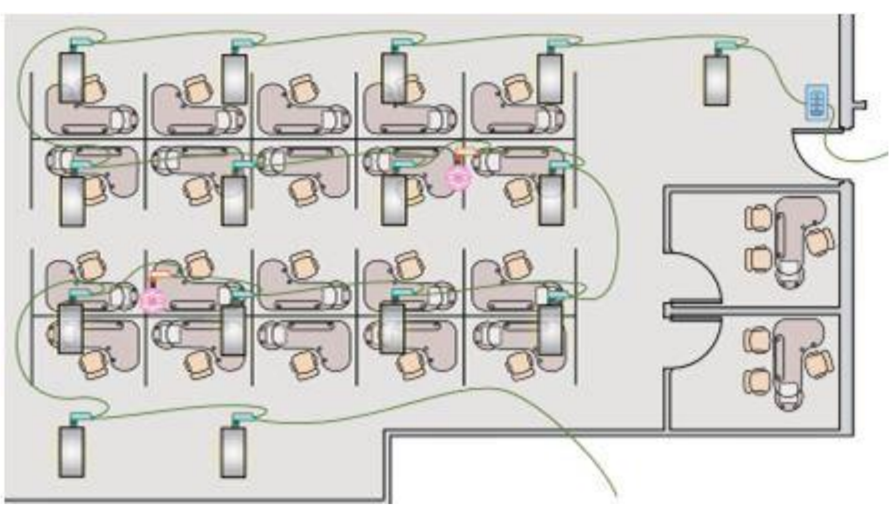
CONTROL ZONING: DETAILING THE DESIGN

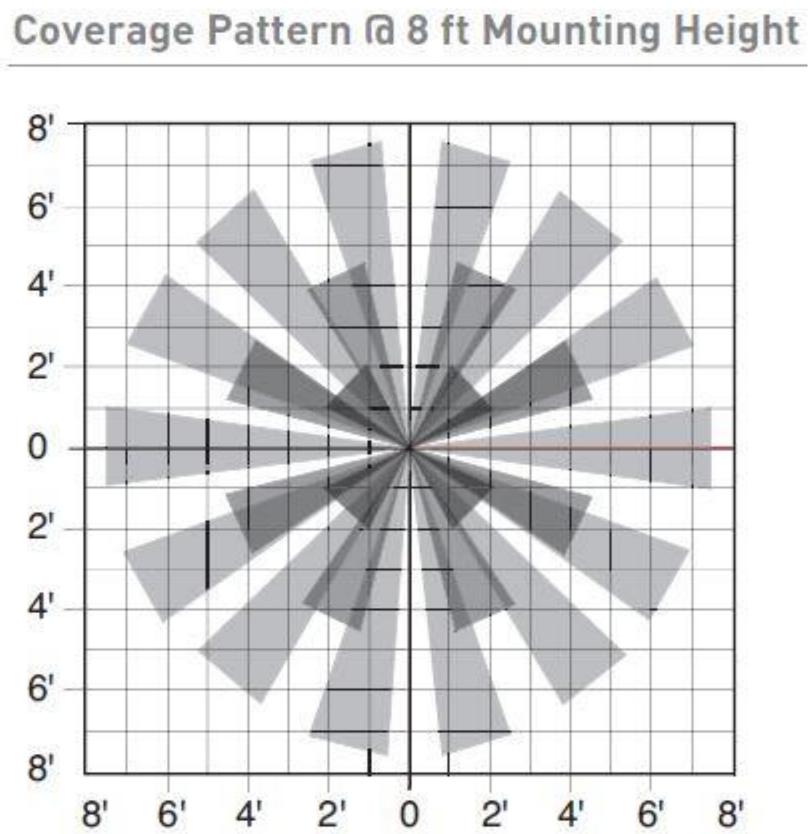


While an ideal solution is to make every luminaire individually addressable and therefore independently controllable (such as in the below open office example), individual control is not always needed. For each space, the designer must weigh the benefits of individual luminaire control versus potential added cost, complexity and the ability of the owner to operate and maintain the system.

The ultimate in control responsiveness is for each luminaire to be individually controllable, with dedicated occupancy sensor and photosensor, and then assigned to groups for scheduling, demand response and basic manual control of large areas. Typically, the designer determines which luminaires require control by dedicated sensors and which can be grouped.

Image courtesy of OSRAM Encelium.

CONTROL ZONING: OCCUPANCY SENSORS



For occupancy sensors, control zones are typically established by whoever designs or specifies the system. Control zones are created that roughly match the size and shape of the coverage pattern of the selected sensors, which in turn were selected based on the desired level of control zone granularity.

While sensors designed for large open areas offer coverage from 500 up to 2,000 sq.ft., others have smaller patterns, such as luminaire-mounted sensors (see graphic for example).

Applications such as aisle and corridor lighting may involve sensors with specially designed coverage patterns.

Note that a majority of intelligent lighting control systems can respond to input from more than one occupancy sensor to change the lights in a given zone, operating the same as parallel-wired analog occupancy sensors.

Image courtesy of WattStopper.

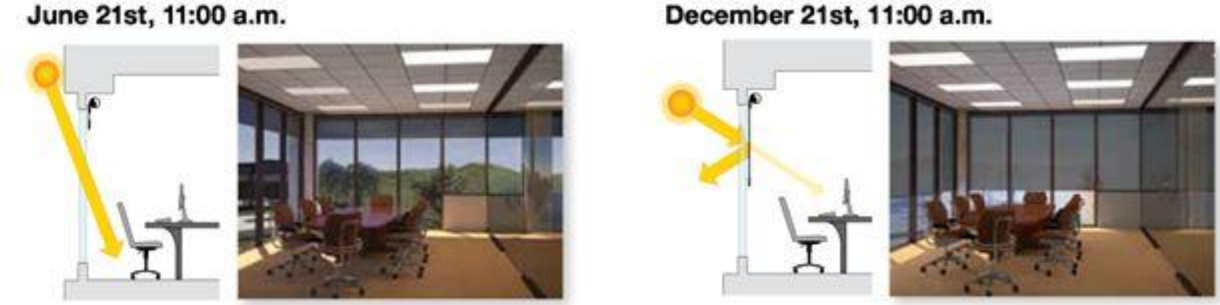
CONTROL ZONING: PHOTOSENSORS

Intelligent lighting control systems by different manufacturers may vary in how photosensors (and occupancy sensors) affect which groups of luminaires. Some systems use logical control zones with an occupancy sensor and/or photosensor dedicated to all luminaires within that zone. Others allow a luminaire to be dimmed based on input from any photosensor regardless of where the sensor is located.

Another approach is to allow for "offsets." Within a given control zone, all luminaires dim based on input from the same photosensor. Luminaires farther from the window wall, however, can be "offset" in terms of the dimming response. For example, a row of luminaires adjacent to a window might dim to 50% of full output while the next luminaire row dims to 75%. This effectively implements daylight harvesting in primary and secondary daylight zones using a single photosensor.

Because approaches by different manufacturers can vary, get to know the systems under consideration.

June 21st, 11:00 a.m. | **December 21st, 11:00 a.m.**



Hyperion software automatically positions shades to let useful daylight into the space. Lights near windows dim to save energy.

Shades lower to block harsh low-angled winter sun. Lights near windows remain bright, maintaining preferred light levels.

Image courtesy of Lutron Electronics.

CONTROL ZONING: IMPACT OF LUMINAIRE LAYOUT

Centralized intelligent lighting control systems are often used to control lighting layouts with individual recessed luminaires. If the luminaires are spaced 10x10 on center, the layout has a density of 100 sq.ft. per luminaire.

If we change the layout to suspended luminaires comprised of 4-ft. sections in continuous rows spaced 10 ft. on center, the layout has changed the density to 40 sq.ft. per luminaire. If every luminaire has an addressable controller, the suspended luminaire layout would use substantially more control equipment. Based on desired control zones, it may be acceptable to use one controller for an 8-ft. luminaire instead (or even longer segments). That would bring the density of control equipment in proximity to that of the above recessed lighting scheme.

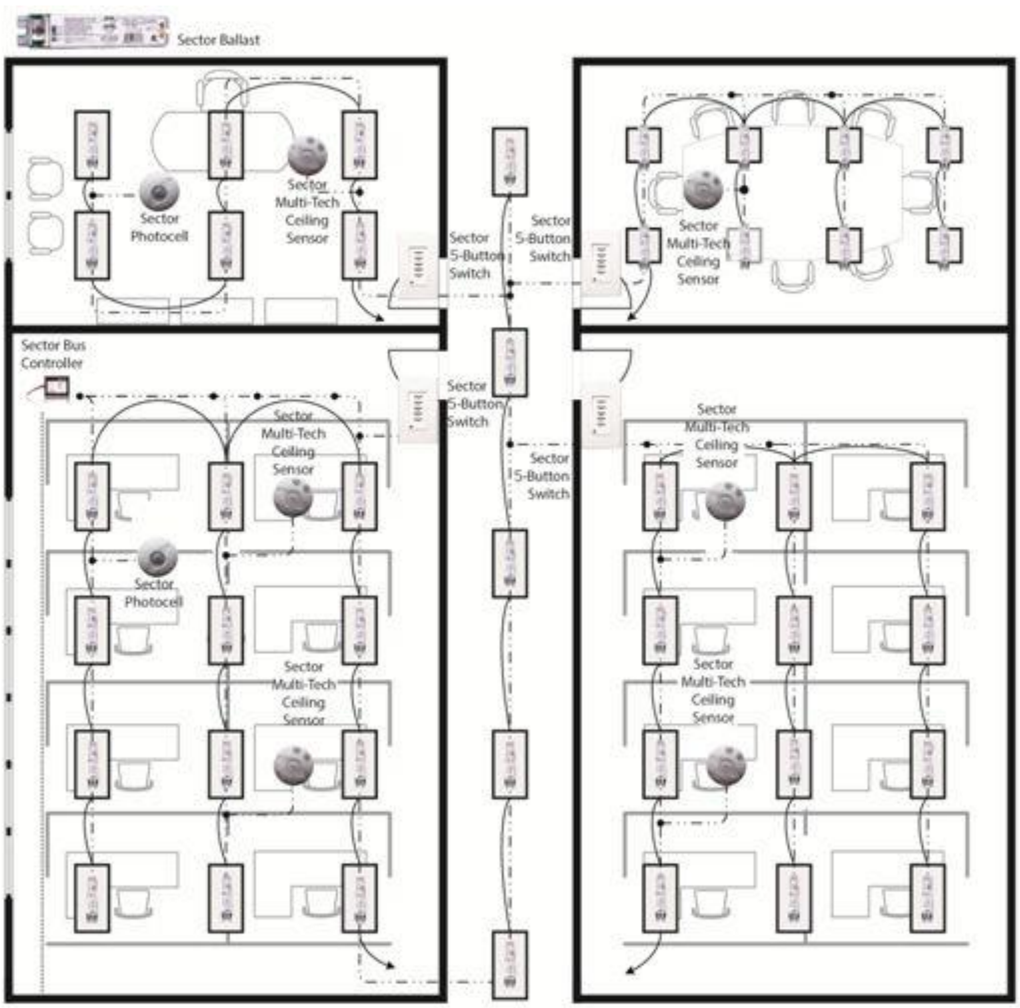


Image courtesy of Leviton.

EMERGENCY LIGHTING CONSIDERATIONS

In a majority of centralized intelligent lighting control systems, addressable ballasts, drivers and onboard controllers are designed to bring light output to full (and close the integral relay to ON in the case of onboard controllers) during a “normal” power loss.

This typically happens because the low-voltage network of control wires loses power if it comes from a “normal” power source (from a gateway or other distribution panel). In some systems, an additional UL924 relay may be required to bypass these low-voltage wires carrying the dimming signal, and/or a separate relay to entirely bypass the controller. This ensures the luminaires are getting emergency power with no possibility for the controller to affect the amount of light in an emergency situation.

Emergency lighting requirements also vary by location. For example, in California, “emergency” luminaires must be turned OFF when other luminaires are OFF, as long as they can turn ON as required in an emergency. It’s important to determine how any system handles emergency lighting and whether it can satisfy local requirements.

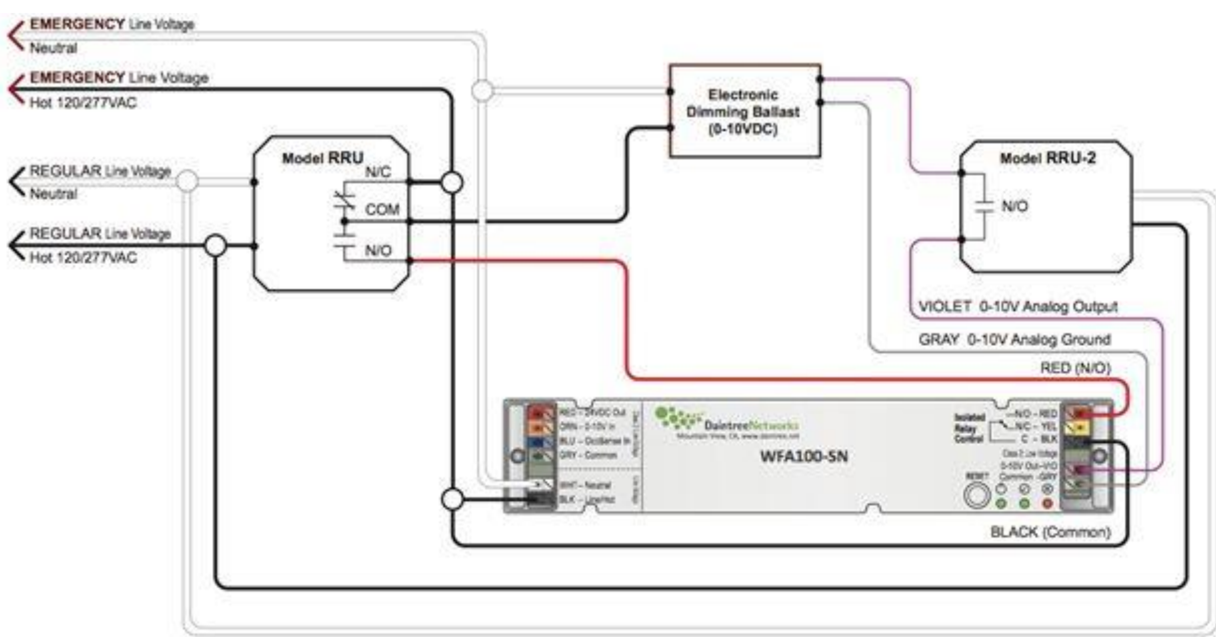


Image courtesy of Daintree Networks.

THE LIGHTING CONTROL NARRATIVE

The lighting control narrative, or sequence of operation, must be developed by the specifier or owner to describe the intended behavior of the lighting control system (at least under typical conditions), including all settings. This document provides a roadmap for commissioning.

A majority of intelligent lighting control systems allow the creation of control profiles that contain variables for controlling luminaires. Control profiles are typically activated automatically by creating blocks of time in the software's schedule, during which a specific profile is in effect (or otherwise enacts a default profile). They contain many variables that instruct the system how to control luminaires based on the control narrative.

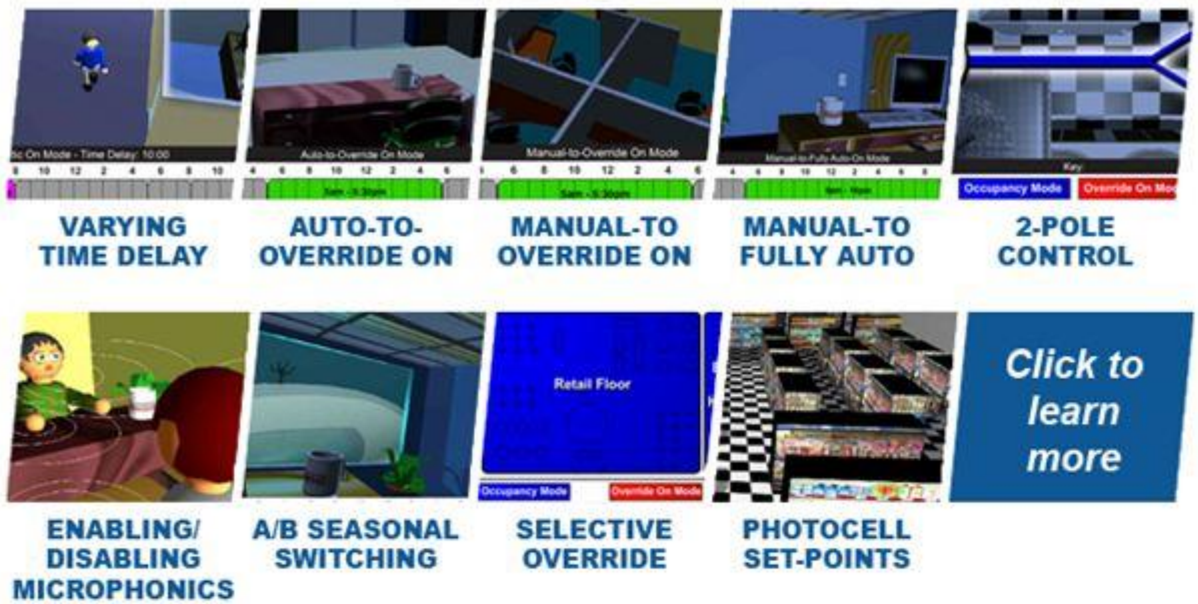


Image courtesy of Acuity Brands.

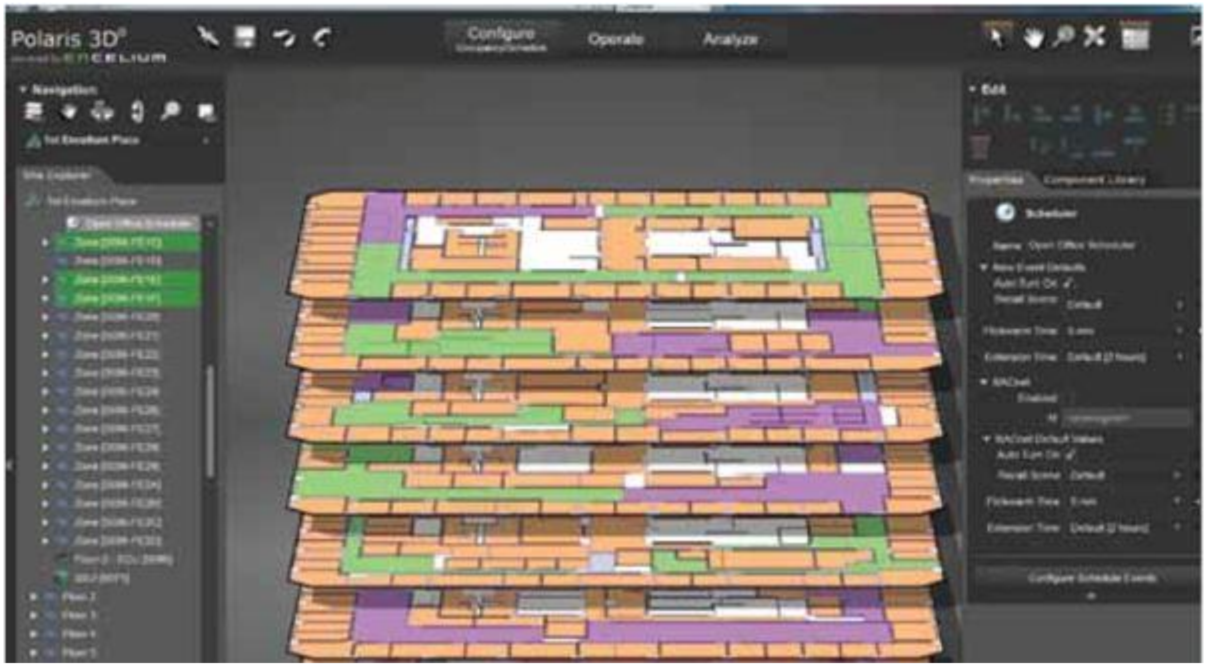
THE LIGHTING CONTROL NARRATIVE

Examples of factors to be included or addressed by control profiles include:

1. Occupancy sensor input—whether or not occupancy or vacancy sensors are used, time delays upon sensing occupancy or vacancy before changing the lights, sensitivity, fade rates, etc.
2. Daylight harvesting—high and low setpoints to create a deadband for dimming or switching luminaires in response to daylight, time delay before change of electric lighting is allowed, fade rates, etc.
3. Daylight "hold OFF"—do lights remain OFF if there is enough available daylight, even if the controlled area is occupied? If so, what is the threshold light level?
4. Manual override—is occupant override of the program allowed? If so, is there a maximum override time period before the lights return to programmed operation?

Some control systems have fewer—and in many cases, considerably more—variables that can be programmed. The specifier must determine if a system being considered allows for programming all variables needed to ensure that luminaires perform as required by the control narrative.

SOFTWARE: GRAPHICAL USER INTERFACE



The control system's graphical user interface (GUI) typically displays energy use in kWh in different time increments (e.g., day, week, month, etc.), near real-time luminaire status (e.g., dimmed level), alarms and error messages, and demand response/demand reduction condition.

Increasingly, GUIs are being designed to display information about other operating parameters such as temperature and occupancy.

Note that not all GUIs are designed to show instantaneous power (kW). If there is a need for that, verify the software has an option that allows it.

Most allow floor plans (typically JPEG or BITMAP files) to be imported; luminaires and control system components are then overlaid onto the plans. In some cases, these are only used to display information. In other cases, you can use the plans to create control zones or even to control luminaires.

Image courtesy of OSRAM Encelium.

SOFTWARE: SCHEDULING

A majority of centralized intelligent lighting control systems are operated using software that incorporates a time scheduling function. Weekly calendars are common, but most systems also allow daily or monthly views. This allows creation of schedules that determine the operation of luminaires.

Since scheduling is a common control strategy, these calendars automatically enable that function. They also provide the framework for using control profiles that implement occupancy/vacancy sensing, facility tuning, daylight harvesting, demand response, etc.

Typically, default values can be set for each zone. Distinct blocks of time can be created when other profiles and/or variables are in effect instead of those in the default mode. This allows the owner to select which control strategies and variables are most effective for different times of day or different days of the week. Additionally, temporary exceptions can be created—e.g., holidays, 100-hour lamp burn-in, initial system testing, demand response events, sensor calibration, etc.

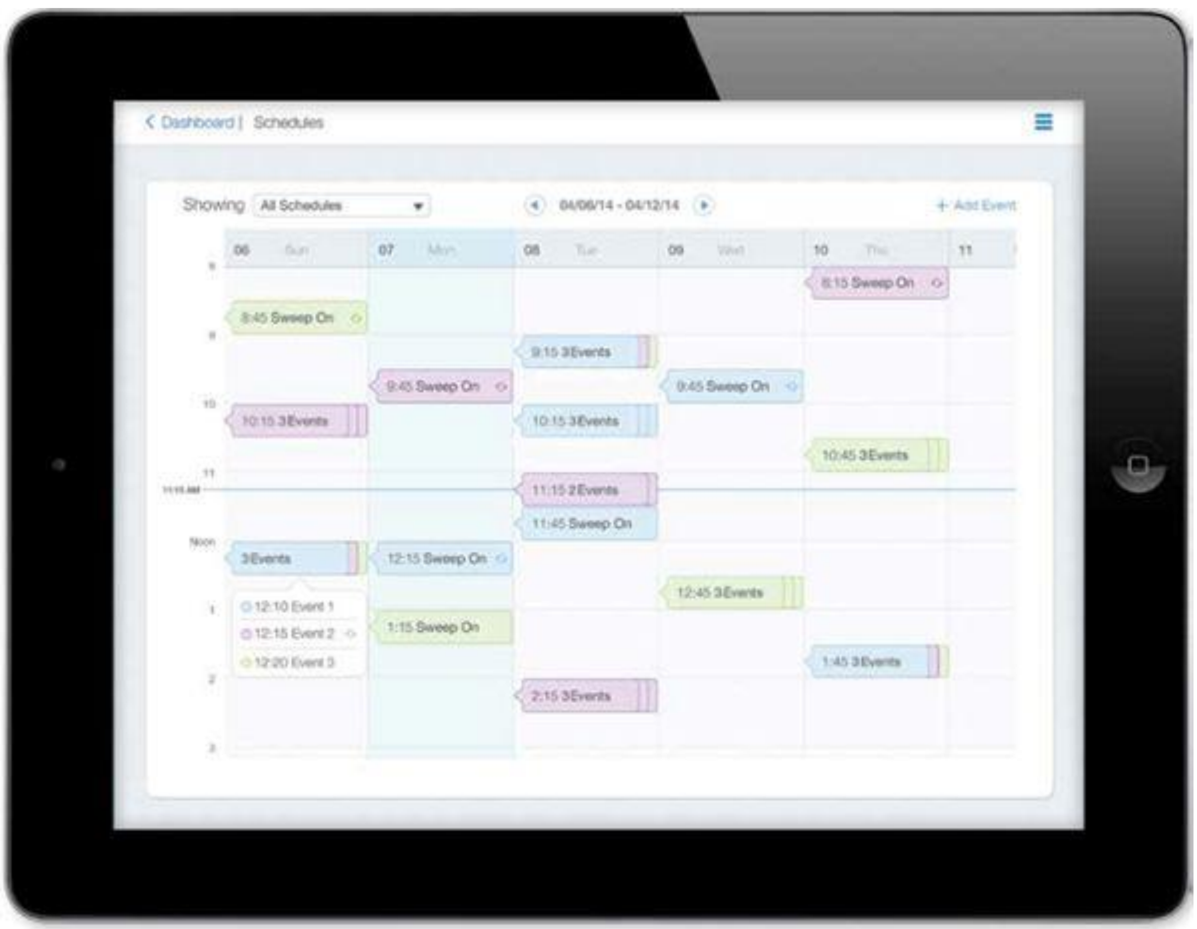


Image courtesy of Lutron Electronics.

SYSTEM FAILURES/POWER LOSS

In a complex control system, it's possible that any component may fail over time. Ask the manufacturer what will happen should any component fail. Similarly, ask what happens in the event of a loss of power to any component:

- Server: If a centrally located server fails or loses power, will other system components continue to operate normally? Will there be a loss of usage data or event information during the time that the server was down?
- Gateways: If wired or wireless gateways fail or lose power, will luminaires still operate normally? Will usage data be lost during that time?
- Onboard controllers: If controllers fail or lose a signal from the control system, will luminaires operate normally? Will lights come to full power or to some other level? What about when the power is restored?
- Sensors and switches: If sensors or switches fail, will lights still operate based on default behavior as determined by the server/software? Will they turn ON, turn ON to full brightness, or turn OFF?

Image courtesy of Leviton.

SYSTEM FAILURES/POWER LOSS

Similarly to any computer system, software for most lighting control systems is regularly updated by the manufacturer. Ask what happens if an update causes abnormal operation, whether the system can be reverted to its previous version, and how and how often the manufacturer fixes software bugs.

If there are critical tasks being performed in a space, understand how the system will operate under normal as well as abnormal conditions. Manufacturers with a proven track record of system deployment for at least three years should have a clear understanding of what happens under different conditions for various configurations and topologies.

Finally, should the system begin to behave erratically for any reason, ask the manufacturer if there is a method to entirely bypass it and operate luminaires manually until the problem can be identified and corrected. This would require local switches and/or other components to operate normally even though the rest of the system would be temporarily disabled.

LOGIC FOR MANUAL OVERRIDES

Variables may be set in the system's software to control the behavior of manual override devices or methods. Here are three examples.

1. The default system logic may dictate that after a zone is manually overridden, it will automatically revert to the preprogrammed behavior after the next change in schedule (or it may not).

2. A time delay may be set in the system software that cause an overridden zone to revert to the current control profile in the schedule after a specified period of time. This time delay may vary by profile or schedule. For example, a wallbox switch/dimmer may override the operation of a zone for up to two hours during normal daytime use, but only for one hour during evening or nighttime use.

3. A hierarchical structure may be created so that different devices and/or methods have greater levels (and/or longer periods) of control over the default system behavior. For example, an emergency input signal from a building automation system may override all default system behavior and prevent the system from automatically reverting to normal operation until the BAS has cleared the emergency condition.

LOGIC FOR MANUAL OVERRIDES

The sequence of control logic must be clear in the operation manuals and online help provided by the system manufacturer. For example, what happens if a zone is switched OFF using a wallbox switch/dimmer? Does the zone switch back ON after the specified override timeout expires? Does the zone remain OFF regardless of the timeout, only turning back ON if occupancy is sensed, or only at the next normal schedule change, or only if it is subsequently turned ON manually?

By their nature, centralized intelligent lighting control systems are complex, so specifiers must ask questions upfront to determine every aspect of the system's behavior. Otherwise, behavior of luminaires may not correspond to expectations and requirements.

Image courtesy of Crestron.

NOTIFICATIONS

Some centralized intelligent lighting control systems offer methods for sending notifications about problems that require attention. These notifications are typically sent via email, though they may also be sent by text or other methods. Availability and operation of such a feature should be verified with the manufacturer during the specification/selection process.

These systems typically allow multiple recipients. Each recipient can be designated to receive different types of notifications.

Some systems provide daily reports of equipment requiring servicing or replacement, such as failed lamps and ballasts to control system components.

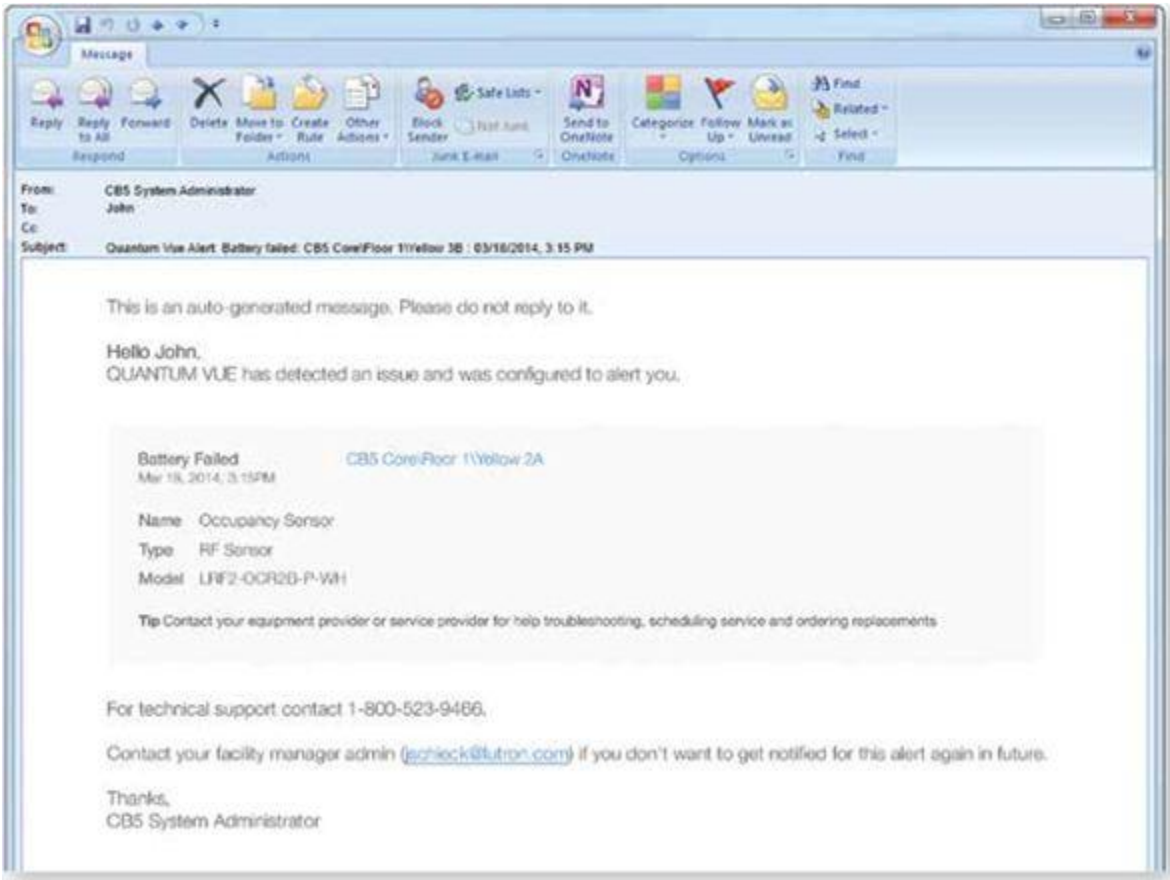


Image courtesy of Lutron Electronics.

USER ACCESS

A majority of centralized intelligent lighting control systems allow users to have access to different system functions. When specifying a system, verify whether it allows for different access levels—and if so, how.

The system administrator, for example, must have access to all functions and control over all lighting. This would include programming/reprogramming control profiles, changing schedules or adding/deleting events, zoning/rezoning luminaires, adding/deleting other users, etc.

If the system is used to control lights in a multi-tenant spaces, tenants may be given access of their luminaires.

Occupants may be given control over local luminaires.

The system may also be configured to recognize certain users as guests, able to monitor the system without having the ability to make changes.

Image courtesy of Leviton.

SOFTWARE BACKUP

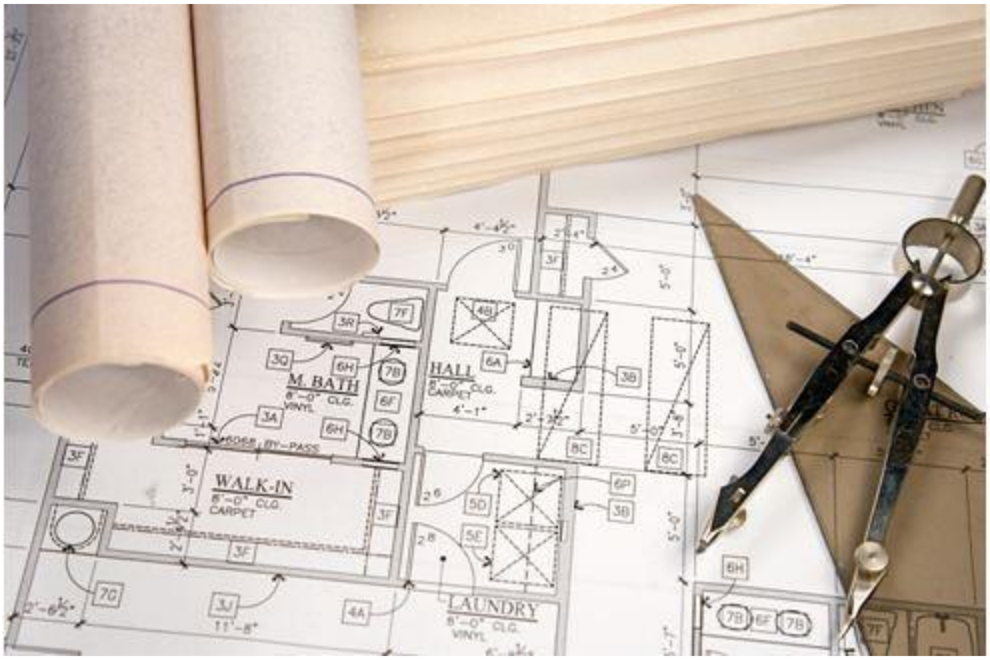
Centralized intelligent lighting control systems must provide a means to automatically back up program, usage data and log files on a regular basis.

In the event of a loss of data on the server, backup files of control profiles, schedules, etc. can be uploaded to the server to restore normal operation. Some systems allow for backup to a USB drive in a port on the server. Others allow backup files to be downloaded to—and, when necessary, uploaded from—a remote computer.

Programming during commissioning may require a considerable amount of time. It is therefore advisable to maintain more than one backup file to prevent loss of programming.

Image courtesy of Leviton.

PROCUREMENT AND SUBMITTALS



Most manufacturers require approval of submittal drawings, a Bill of Materials and/or other documents before they ship products to the job site. Verify manufacturer response time and materials they may require, such as CAD background drawings and control schedules.

Control schedules, typically spreadsheets, indicate what resides in each control zone, such as luminaires (luminaire types, quantity, wattage, lamping, emergency lighting, etc.); total lighting load; and sensors and manual controls associated with the zone.

Determine who must review and approve before releasing a purchase order.

Image courtesy of Leviton.

PROCUREMENT AND SUBMITTALS

Manufacturer documents may include plans (showing locations of control system components), one-line diagrams (showing how all components are connected). Wiring diagrams (showing every wiring connection) are not normally created for each job. Manufacturers typically rely on catalog sheets to indicate typical wiring connections, so if project-specific wiring diagrams are required, they should be requested during the design and specification project phase.

Because the topology and wiring methods for many new lighting systems are different than the existing topology and wiring in many buildings, it may be desirable for the installing contractor to obtain samples of certain equipment so as to become familiar with them. This may include LED drivers, dimmable ballasts, centrally located and onboard controllers, etc.

Image courtesy of Acuity Brands.

COMMISSIONING

Typical steps in commissioning a centralized intelligent lighting control system include:

- Startup: Energize the lighting system, paying attention to startup factors such as fluorescent lamp "seasoning" prior to dimming. Verify that all wiring and system components are properly installed and powered, without any faults. Some systems contain devices that allow testing of the network as it's being installed.
- Control zone creation: Create zones in the system software. Some systems allow zones to be created before the server is installed, saving time at the job site.
- Discovery: Once the system is installed and operational, all components in the system are "discovered" on the network.
- Assignment: Once control zones are established, lighting can be assigned to these zones.
- Programming: Create control profiles and schedules for each zone.
- Calibration: Calibrate all sensors.
- Fault correction: Identify and correct any faults in the system before system turnover.
- Software check: Verify all system software features are operating properly.

Image courtesy of Leviton.

USER TRAINING AND TECHNICAL SUPPORT

The manufacturer should provide some onsite training for designated owner personnel as well turn over operating and maintenance manuals for its equipment. This should be provided to the owner along with the written lighting control narrative, including all programming and settings; submittal data; and a schedule for recalibrating the system and its devices.

Manufacturers typically ask for remote access to the control system's server (with appropriate safeguards including firewalls, passwords, etc.). This access should be granted so that the manufacture can troubleshoot the system in the event of a malfunction. Additionally, the manufacturer may use this remote access for routine software updates.

Additionally, it is recommended that the owner provide basic training to occupants about how to interact with local lighting controls, so as to ensure occupant satisfaction and acceptance.

Image courtesy of Leviton.

USER TRAINING AND TECHNICAL SUPPORT

It may be beneficial to acquire a service plan that covers ongoing service of the lighting control system. The availability, details and cost of such plans should be verified with the manufacturer prior to placing a purchase order.

The service plan may cover troubleshooting, extended training, software and firmware upgrades, and ongoing commissioning activities such as sensor recalibration and reprogramming.

Image courtesy of Leviton.
