Lighting Control

Essentials

White Paper

Part 1/4

:hager

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Executive Summary

Lighting controls have traditionally been used to create moods. Today, they are also used as part of a high quality energy efficient lighting system that integrates daylight and electric light sources to provide a comfortable and visually pleasing environment for the occupants of a space. Lighting controls are appropriate for a wide variety of spaces, from intimate spaces to large open offices, from conference rooms to classrooms. They can be incorporated with daylight dimming/switching to provide flexibility, energy savings, and ecological benefits. Although lighting controls are still most commonly used in commercial buildings, they are also increasingly being used in residential applications.

Lighting controls are used in lighting design projects to achieve high quality energy efficient lighting systems. Specifying a layered, daylight-integrated lighting and control system gives the occupants control of the lighting while providing appropriate lighting levels, minimizing glare, balancing surface brightness, and enhancing the surrounding architecture.

When lighting controls are used properly, energy will be saved and the life of lamps and ballasts can be extended. Lighting controls will help reduce energy by:

- Reducing the amount of power used during the peak demand period by automatically dimming lights or turning them off when they are not needed
- Reducing the number of hours per year that the lights are on
- Reducing internal heat gains by cutting down lighting use, which allows for reduced HVAC system size and a reduction in the building's cooling needs
- Allowing occupants to use controls to lower light levels and save energy

There are other reasons to use lighting controls. For example, dimming controls can provide the lighting flexibility which is often required in multi-use rooms or rooms in which projectors are used. Occupancy sensors can be used to turn lights on when people are present. Moreover, by tuning an environment for the individual occupant's or group's visibility, comfort and productivity can be improved.

Types of Lighting Controls

The most common form of lighting control is the on/off switch. Other forms of lighting control include occupancy sensors, daylight sensors, time switches, a variety of manual and automatic dimming devices, and centralized controls. Some controls operate on mains voltage, while others are low-voltage (DC) powered. Note that fluorescent fixtures that are intended to be dimmed require special compatible dimming ballasts. Also, controls can be linked together which can perform multiple control tasks.

Standard on/off switches and relays can be used to turn groups of lights on and off together. Creative design options can be developed with this simple tool, if the circuiting is properly designed. For example, some of the lamps in each fixture can be switched together, every other fixture can be switched as a group, or lighting near the windows can be turned off when daylight is plentiful.

Occupancy Sensors

Occupancy sensors (including passive infrared, ultrasonic, and dual technology sensors) serve three basic functions:

1. To automatically turn lights on when a room becomes occupied,
2. To keep the lights on without interruption while the controlled space is occupied, and
3. To turn the lights off within a pre-set time period after the space has been vacated.

Some sensors have settings that allow the specifier to select between the functions listed above (manual on instead of automatic on, for example). Note that sensor characteristics may vary considerably from manufacturer to manufacturer, so it is important to carefully evaluate the options for each device.

Passive infrared sensors (PIR) are triggered by the movement of a heat-emitting body through their field of view. Ceiling mounted PIR occupancy sensors are best suited for spaces such as private offices, where the sensor can cover a wide area. PIR sensors cannot “see” through opaque walls, partitions, or windows so occupants must be in direct line-of-site of the sensor.

Ultrasonic sensors emit an inaudible sound pattern that is disrupted by any moving object altering the signal returning to the sensor (Doppler shift). They are best suited for spaces where line-of-sight view to the occupant is not always available. This type of sensor detects very minor motion better than most infrared sensors and is often used in toilets since the hard surfaces will reflect the sound pattern.

Dual-technology occupancy sensors use both passive infrared and ultrasonic technologies for less risk of false triggering (lights coming on when the space is unoccupied). Combining the technologies requires a more reliable, yet slightly larger and more expensive device.
Occupancy sensor placement is very important to the successful implementation of the control design intent. Occupancy sensors must be located to ensure that they will not detect movement outside of the desired coverage area, through an open doorway, for example. Ultrasonic devices are sensitive to air movement and should not be placed near an HVAC diffuser, where air movement may cause false tripping.

Occupancy controls can be used in conjunction with dimming or daylight controls to keep the lights from turning completely off when a space is unoccupied, or to keep the lights off when daylight is plentiful and the room is occupied. This control scheme may be appropriate when occupancy sensors control separate groups of luminaires, or “zones”, in a large space, such as in a laboratory or an open office area. In these situations, the lights can be dimmed to a predetermined level in one specific area when the space is unoccupied.

There are several different kinds of coverage patterns and mounting configurations for occupancy sensors, such as:

- Ceiling-mounted controls with 360° coverage
- Ceiling-mounted controls with elongated “corridor” coverage
- Wall-mounted controls with a fan-shaped coverage pattern
- Ceiling-mounted controls with a rectangular coverage pattern
- and more!

Additionally, take note of the difference between each device’s sensitivity to minor motion (working at a desk) vs. major motion (walking or half-step activity). The sensor manufacturer should provide coverage diagrams for both levels of activity. HID lamps do not work well with occupancy sensors because most HID lamps take a long time to start each time they are switched off. If using LED fittings, you must calculate the inrush current.

Manual Dimming

Manual dimming gives occupants of a space an added degree of control and satisfaction, as well as an opportunity to save energy. It provides users with the flexibility to instantly change the characteristics of a space to make it a more comfortable and productive environment. There are several families of manual pre-set dimming control.

- Manual hard-wired control
- Pre-set scene control
- Remote infrared control
- Remote radio frequency control

Manual hard-wired control consists of a dimmer, connected to a single luminaire or zone which is operated by the user at the device. Pre-set scene dimming controls change the light level settings for multiple zones simultaneously at the press of a button.

Remote Control Dimming

Remote control dimming is another form of manual dimming that is well suited for retrofit projects to minimize rewiring. Infrared and radio frequency technologies are most successful in these applications. Remote infrared control operates in a similar fashion to other infrared technologies like television, for example. Radio frequency controls are equipped with a sender that "talks" to other dimmer's receivers. This allows multi-zone control from a single-zone device. Personal control systems are now available that allow users to change levels of lighting, sound, heating/cooling, etc., in their own workspaces..

Light Level Sensors

Light-level sensors or photo sensors can be used to automatically turn lights on or off, or dim them, depending on the available daylight available in the space. Daylight dimming can maintain the desired light level while providing a smooth, barely noticeable transition to or from electric lighting as daylight increases or decreases. Care must be taken when selecting luminaires as some types will not dim down to zero.

Time Switches

Time switches turn lights on or off for a specific period of time. They are especially useful for turning off photocell-activated exterior lighting late at night (as long as that lighting is not needed after a certain time).

Centralised Controls

Centralised controls can be used to automatically turn on, turn off, and/or dim lighting at specific times or under certain load conditions. This type of control can be used in a conference room (using a Lighting Control Module, LCM) or on a building-wide scale using a building automation system. Centralised control strategies can also integrate lighting controls with other building systems such as mechanical or security systems. A KNX protocol system is ideal for this application.

Distributed Controls

Distributed controls are based on digital communication protocols. These systems are local, or integral, to the luminaire itself, not housed in a central cabinet or enclosure. They integrate with building automation or energy management system. A Digital Addressable Lighting Interface (DALI) system provides a means of control which can speak to individual ballasts or groups of ballasts. The "control wiring" is independent of the "power wiring" and provides the highest degree of flexibility available at this time. When space configuration or occupant needs change, the system can respond by reassigning the ballasts accordingly.

Selecting the Appropriate Lighting Control

There are many guides and services available for designing lighting control systems. Some suppliers can do a controls layout on the building plans or even on electronic drawing files. If you prefer to do the controls layout yourself, it is advisable that you provide a written “sequence of control” which describes the design intent and a “performance specification” which describes the performance characteristics of individual components. Further, some coordination with the selected controls manufacturer will help to avoid surprises during construction and commissioning.

Space Type	Room Number	Manual Wall Switch ON	Manula Wall Switch OFF	Dimming Wall Switch	Override Switch	Multi Zone Switch	Emergency Key Switch	Timed Switch ON	Timed Switch OFF	Night Mode/Off Peak Setting	Occupancy Sensor ON	Occupancy Sensor OFF	Photo Control Switching	Photo control Dimming	Exterior Photocell ON/OFF	Drawing Reference	Sequence of Operation Reference
Open Offices	10, 12, 14, 16									X	X	X				160/13//2	SO1
Private Rooms	11, 13, 15	X										X		X		160/13//3	SO2
Meeting Rooms	etc.	X	X	X		X						X				etc.	etc.
Break Rooms	etc.	X										X				etc.	etc.
Kitchen	etc.	X			X											etc.	etc.
Pantry	etc.	X										X				etc.	etc.
Cafeteria	etc.	X										X	X			etc.	etc.
Corridors	etc.					X	X	X	X		X	X				etc.	etc.
Toilets	etc.						X				X	X				etc.	etc.
Storage Rooms	etc.										X	X				etc.	etc.
Ground Floor Lobby/ Reception	etc.	X	X			X	X	X	X				X			etc.	etc.
Main Floor Lobbies/ Reception	etc.	X	X			X	X	X	X							etc.	etc.
Electrical/ Mechanical Room	etc.	X	X													etc.	etc.
Exterior Car Park Lighting	etc.					X		X							X	etc.	etc.

Figure 1: Control requirements matrix example.

SO1	Sequence of operation for drawing reference 160/13/2	
STEP #	Description of events	
1	Day operation	Occupant eneters the room the occupancy sensor turns on the lights (presence setting).
2	Day operation	Lights on to required light level of 400 Lux at desk height
3	Day operation	Occupancy sensors are enabled
4	Day operation	After 20 minutes of no occupancy, lights switch off
5	Night mode/off peak	Occupant enters the room and turns on the lights from a wall switch
5	Night mode/off peak	Lights on to required light level of 200 Lux at desk height
5	Night mode/off peak	After 2 minutes of no occupancy, lights dim down to 20%
5	Night mode/off peak	After a further 5 minutes of no occupancy, lights switch off

Figure 2: Sequence of operation example.

If you know how you would like the controls scheme to work, but you are not sure what equipment to choose or how it should be connected electrically, explain your ideas to the manufacturer's technical support personnel. Chances are they will be able to help you work out the details.

Commissioning of Lighting Control Systems

It cannot be understated how important commissioning is to the ultimate success of a lighting control system. If a lighting control system is not commissioned, it may result in greater energy consumption than a building without any controls at all.

Commissioning is defined as the final adjustment, calibration, and tuning of the various components after they have been installed and the space is occupied. This process requires the participation of the building owner, a commissioning agent, the lighting designer, the electrical engineer, a manufacturer's representative, and building maintenance personnel.

Commissioning activities will vary from space to space. They can range from simply "burning in" fluorescent lamps that are to be dimmed to configuring software to respond to weekday, weekend, and holiday occupancy schedules.

Commissioning is often considered impractical, too burdensome, or costly. However, iPad apps and hand held remote commissioning devices help simplify and expedite the process. When commissioning is completed, the building maintenance personnel must be provided with all relevant documentation required for the on-going maintenance of the lighting control system and is worth noting that a system that can be maintained by the facilities manager is far more attractive to the client than one that requires an expensive visit by a specialist.

Economic Analysis of Lighting Control Systems

Lighting controls are cost-effective, especially when one considers long-term life-cycle costs along with initial costs. Lighting controls can add approximately £0.50-£1.00 per square foot initially. Payback periods vary widely by project and are difficult, at best, to predict accurately. That does not take into account the savings from reduced energy use and HVAC reduction.

The easiest way to do an economic analysis of lighting controls is to use an "effective energy charge (EEC)," which is a cost per kWh number derived by dividing the entire electricity bill (in pounds) by the total amount of energy used during that billing period (in kWh). The potential savings per controlled fixture is calculated as follows:

£ Savings per year = $([W_b \times HPY_b \times PF_b] - [W_f \times HPY_f \times PF_f])$ * (EEC) * (1 kWatt/ 1000 Watts)

Where:

W_b is the baseline watts of the controlled fixture(s)
HPY_b is the baseline number of hours per year that the fixture is on
PF_b is the baseline power fraction for the fixture or fixtures (use 1 for full power)
W_f is the final watts of the controlled fixture(s) (i.e. after retrofit or redesign)
HPY_f is the final number of hours per year that the fixture is on (i.e. after controls are installed that turn the lights off when they are not needed, such as occupancy sensors or centralized controls)
PF_f is the final power fraction for the fixture(s) (i.e. if a fixture will be dimmed to an annual average of 50%, use .5. For low dimming levels, the energy usage fraction is slightly higher than the dimming percentage due to ballast losses.)
EEC is the "effective energy charge" in £/kWh.

This method of calculating annual pound note savings is an approximate estimate because it does not allow you to calculate the exact changes in demand charges—demand charges have been wrapped up into the "effective energy charge."

For further information on lighting connection and control, please visit hager.co.uk/klik.

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