# Daylight Harvesting Methods and Practice

*by Bryan Palmer, ETC Architectural Controls Product Manager*

## Introduction

Daylighting for energy savings and conservation has become common design practice. Daylight harvesting is something that is required by some energy codes, and soon to be adopted by others. Instead of being encouraged by energy programs, it's becoming required. California's Title 24, IECC 2012, and ASHRAE 90-1 already have daylighting guidelines; and they are likely to become more stick over the coming years. Most commercial buildings that have windows and skylights are required to have some type of daylight harvesting control in the adjacent area. Green sentiment and construction practices bring additional attention to energy saving practices like Daylighting, help to further acceptance of the practice, and grow the technology that makes it possible

Daylight harvesting's proposed value is simple: As natural light levels increase, electric light levels can be decreased to maintain an acceptable level of light in a space, and save energy (and money). Daylighting systems automate this process, removing the human element of control by using a light sensor that measures light levels and sends them to a controller that is connected to the lighting control system. The control system can then dim or switch electric lights in response to the measured level.

The light sensor is typically small, and uses a light-sensitive photocell, input optics and an electronic circuit used to convert the photocell signal into a control signal. Light Sensors may be mounted on walls, ceilings and even as a part of light fixtures.

## Daylighting Control Types

Daylight harvesting controls may be "open loop" or "closed loop" systems. Each type works differently, and provides benefit for certain applications.

*Open-loop* systems measure only the natural light, and do not consider the electric lighting contributions. The light sensor is not exposed to any electric light and is typically mounted outside of the building or near a window or skylight facing away from the controlled light fixtures. Because there is no feedback from the electric lighting, this is considered an open loop.

With open loop systems, the sensor is affected by passing light level changes, but it does not measure interior electric light levels. For example, a sensor placed outside a window or on a roof would not know that the blinds were closed, and would dim the lighting inside when clouds moved away. Open loop systems are often preferred for applications that are not dependent on accuracy or in outdoor environments. Some examples include hallway or atrium, and parking lots or garages.

Open loop systems are typically programmed by setting lighting setpoints that activate specific lighting presets or looks. As the light level changes to a specific range, the electric light output is adjusted to a predetermined level. It is typical to set a threshold, or setpoint, that triggers a system action. For simplicity consider two setpoints, one for when the space is too bright and one for too dark. You then configure an action to switch circuit off when the space is too bright, and switch circuits on when it is too dark. In some systems, you can create multiple setpoints that switch more and more circuits on or off based on different levels; this is called stepped switching.
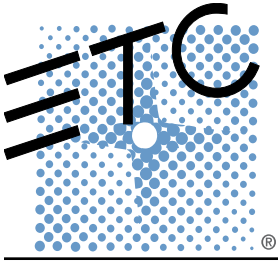
*Closed-loop* systems measure the combined contribution from both natural and the electric lighting. Because the light sensor measures the electric lighting system's light output, it is exposed to a combination of electric light and sunlight. Because the system is adjusting the lighting that contributes to the light reading, the system is proving itself feedback, creating a closed loop.

With closed loop systems, the light sensor measures real-time light levels, and is considered more accurate than open loop. Control is typically limited to a single zone per sensor and the system must be properly configured so that transient light level changes to do not cause frequent dimming or switching. Closed loop is commonly utilized for applications where a specific target light level will be closely maintained. Some examples include small offices, classrooms, museums and studios.

Closed loop systems are configured to be dynamic based on the light levels seen by the sensor. The configuration is different for *switched* and *dimmed* systems because of differences in capabilities.

### Switched Daylighting Systems

For *Switched Daylighting Systems*, like with open loop systems, it is common to set a threshold, or setpoint, that triggers a system action. For simplicity consider two setpoints, one for when the space is too bright and one for too dark. You then configure an action to switch the circuit off when the space is too bright, and switch circuits on when it is too dark. In some systems, you can create multiple setpoints that switch more and more circuits on or off based on different levels; this is called stepped switching.

### Dimmed Daylighting Systems

For *Dimmed Daylighting Systems,* you typically set a target level that should be kept in the space and a set of criteria for how the system responds to maintain the configured level. For example, if you select a target light level of 300 lux (~30 FC), it is typical to additionally configure a deadband, a delay time, and fade time.

- Deadband – The amount of change from the target level that must be passed before the system responds. This creates a range around the target level that is acceptable and is commonly set in a specific Lux or Foot candle value, or as a percentage of the target level.

- Delay Time – The amount of time the system waits to start adjusting levels when the viewed level is outside of the deadband. This delay prevents the system from adjusting levels as a cloud passes by or another short environmental change happens.

- Fade Time – The length of time the system will take to adjust the light levels once a change to electric light level is initiated. The system will generally adjust lighting by a certain percentage over this time, take a new reading, and then adjust again until the viewed light level is at the target light level.

## Light Level Response

Light sensors typically have a range of level they accept. This range is usually noted in either LUX or foot-candles (FC). There is a simple conversion between the two values; 1 Foot-candle = 10.764 lux. For most calculation this is rounded to 1 foot-candle = 10 lux

Common ranges for light sensors are:

- 1-500 lux (~.1 - 50 FC) – light sensors mounted on an interior ceiling or space with windows
- 1-1000 lux (1-100 FC) – light sensors mounted on an interior ceiling, in an atrium or skylight
- Up to 6,4000lux ~6,400 FC) – light sensors mounted outside

There are typical ranges considered "normal" for applications

- Dusk and dawn readings are less than 10 foot-candles
- Offices are controlled at less than 100 fc,
- Atrium spaces are controlled at less than 1,000 fc,
- Open loop sensors see up to 6,400 fc of sunlight.

It is important that a sensor is selected that supports the proper range of response, and that the light sensor matches the light levels that will be found in the installation. Some light sensors support a wide range from 1-64000 lux, with a variable resolution of change based on the reading. At lower levels updates are sent based on small changes (1 or 2 lux), while at high light readings changes are sent every 100 or more lux; This allows a single light sensor to be used in any application.

## Control Signals

There are several different methods for a light sensor to send readings back to a controller. This may be a low voltage signal, or a specialty signal developed by the manufacturer. There are also some standard protocols like DALI that may be used.

Each method has its benefits and draw backs. For example, a sensor with analog low -voltage output works well when it is within 500 ft. of a controller. At greater distances the signal can be problematic. A sensor with current output can drive signal thousands of feet and provide better immunity to electrical noise in more rugged power environments.

Many manufacturers use proprietary signals between the light sensor and the controller. This allows for special features to be implemented in their products, and for the sensors to sit directly on a station wiring infrastructure that is used with other control stations in the system.