

*Guide to Commissioning Lighting Controls*



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Electrical Design Library (EDL) publications are prepared for architects, consulting engineers, and qualified electrical contractors, as well as owners, developers, investors, and their electrical construction specifying personnel. Issued periodically by the National Electrical Contractors Association (NECA), the publications provide factual explanations of the increasing variety of sophisticated electrical systems and the economics of their installation by professional electrical contractors. They are distributed by the Association's chapters, located in all sections of the United States.

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# Introduction

**A**ccording to the New Buildings Institute, automatic lighting controls can reduce lighting energy consumption by 50% in existing buildings and at least 35% in new construction.

Commissioning lighting control systems is a critical step for a successful installation. Commissioning can help ensure proper equipment operation, user acceptance and intended energy savings in both new construction and renovation projects.

Florida Power & Light defines commissioning as a “systematic process of ensuring that all building systems perform interactively according to the documented design intent and the owner’s operational needs.”

This can include factory start-up, sensor calibration and owner notification of the operation and intent of the control systems. Commissioning should involve all members of the design and construction team and is typically led by the commissioning agent, who may be an electrical contractor, commissioning specialist, manufacturer technician or some other professional.

Optimal commissioning occurs when it is planned and budgeted as part of the design and construction process. Architects and lighting designers should provide a controls “narrative” that describes the functionality of the control system.

Engineers should write detailed commissioning requirements in their project specifications and include a sequence of operations for each control point. And the entire construction team should ensure that commissioning is not removed as a cost-saving measure.

Most energy codes now require lighting automation, and the 2005 California Title 24 energy code now requires control system commissioning as a part of project certification.

Demand created by factors such as energy codes implies business opportunities for electrical contractors who can provide skilled commissioning as a service to customers. Electrical contractors can also add value by helping to clarify the documented design intent of Division 16 (or the applicable division under CSI MasterFormat2004, if adopted) of the building specification so as to best meet the operating requirements of the owner—by ensuring that there is a sequence of operation for all lighting controls and showing how the design intent can be met economically.



# Commissioning Components

Commissioning lighting control systems can include factory start-up, calibration, commissioning, and operator and user education, followed by ongoing maintenance. (See figure.) These ideas are described below.

**Factory Start-up:** Factory start-up prior to the commissioning process and entails the manufacturer or its representative ensuring that its products perform as intended within the designed system. Factory-startup is also considered the first step in calibration.

**Field Calibration:** Calibration involves adjusting sensors, such as occupancy sensors and photosensors, so that they operate properly within actual field conditions.

In the case of occupancy sensors, the factory default settings (time delay and sensitivity) must be tuned to application conditions to ensure proper operation and expected energy savings.

For example, a small difference in the time delay setting can translate to a significant difference in energy savings and lamp life, while a small difference in the sensitivity setting can make a significant difference in whether the lights are activated only when the space is occupied and deactivated only when it is unoccupied.

In the case of photosensors, sensors must be calibrated according to field conditions. For example, a photosensor in a room with light-painted walls will respond differently than a photosensor in a room right next door with dark-painted walls. This small difference in application

conditions can make a big difference in controls system performance and energy savings for the owner.

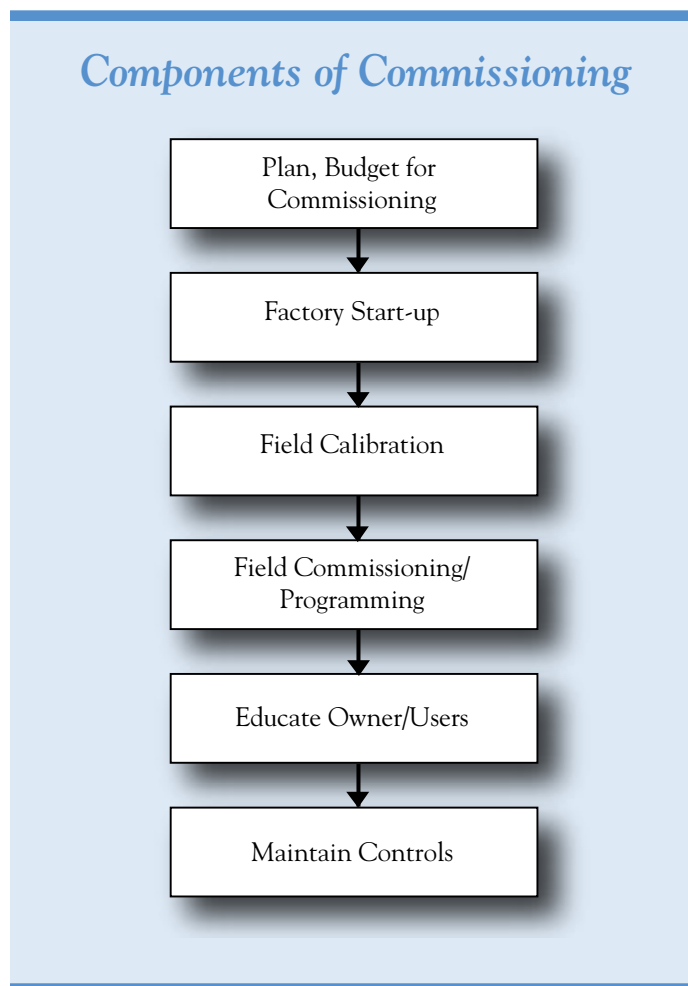
In older systems, sensors are calibrated mechanically. In newer systems, sensors may be calibrated using software.

**Field Commissioning:** Field commissioning requires systematic testing of all controls in the building

to ensure that they provide specified performance and interact properly as a system. During commissioning, it is helpful to understand the sequence of operation for each control point, which should be tested to ensure that the control system delivers desired results based on typical operating conditions. Besides operating factors, other factors, such as location of controls, should be considered during field commissioning. In addition, commissioning may require programming of microprocessor-based controls. Time-of-day, override and event scheduling must also be programmed and tested.

**After Commissioning:** After commissioning, the commissioning agent should tell the owner and the users about the intent and functionality of the controls, especially about overrides—local control capability that allows users to override a schedule or master command.

In addition, the commissioning agent should turn over all documentation and instructions to the owner's maintenance personnel to allow them to maintain and re-tune the system as needed, implying that calibration and commissioning is an ongoing process. It is recommended that maintenance personnel inspect all lighting controls at least once per year for proper operation.



## Lighting Controls and Methods for Commissioning and Calibration

### Control Type

### Commissioning and Calibration

Occupancy sensors and photosensors

Ensure that the sensor is correctly placed and oriented per the specifications and/or construction drawings. If unanticipated obstructions are present, it may be necessary to adjust the sensor location and orientation.

Occupancy sensors

Adjust the sensitivity and time delay of the occupancy sensor, and test to ensure it provides appropriate response. For optimal user acceptance, energy savings and lamp life, set the time delay initially for a minimum of 15 minutes (NEMA recommendation).

Daylight harvesting

All furnishings and interior finishes and materials should be installed before calibrating the sensors. Adjust the photosensor to determine the threshold for switching based on detected light level. It may be helpful to calibrate under normal daylight conditions and dusk conditions (it may be possible to close window blinds to approximate dusk). Record the calibration adjustments, if possible, and replicate in similar spaces.

Automatic shut-off (“sweep off”)

Input the schedule into the programmable scheduling controls, incorporating weekday, weekend and holiday operating times. Ensure that overrides work and that they are located conveniently for users.

Dimming systems

It is recommended that fluorescent lamps be “seasoned” before dimming by operating them at full light output, so as to ensure uniform dimming performance across all lamps in a system. Recommendations vary, but NEMA recommends seasoning fluorescent linear lamps overnight, or about 12 hours, and compact fluorescent lamps for 100 hours, prior to dimming. Consult the lamp manufacturer to determine whether the select lamp type must be seasoned and for how long prior to dimming.

Manual dimming

Ensure correct placement of the dimmer per the construction drawings. Adjust the upper limit of the dimming range according to the task being performed, and set the lower limit of the range so that the minimum light level meets the use/application of the space.

# Calibrating & Commissioning Sensors

**W**hile self-calibrating sensors that need little or no adjustment of their sensitivity and time delay settings are available, many occupancy sensors require field adjustment of these settings to optimize performance according to the application conditions.

**Motion Sensitivity:** Most, but not all, occupancy sensors feature automatic-on operation in addition to automatic shut-off of controlled lights. The occupancy sensor's motion sensitivity level indicates how much movement causes the lights to turn on. Too high a sensitivity setting can cause false-on triggering (lights turning on due to airflow, for example). Too low a sensitivity setting can cause false-off triggering (the lights shutting off while somebody is still in the room). Sensitivity is also related to coverage; changing the sensitivity setting can change the coverage pattern of the sensor.

Occupancy sensors are shipped with a factory setting, which can be adjusted in the field. The contractor can tune the sensor so that it responds properly to primary tasks in the space at the designated distance, while addressing possible sources of nuisance switching such as airflow. Setting the sensor at the most appropriate sensitivity setting will minimize the possibility of nuisance switching.

## **Time**

**Delay:** The time delay setting indicates how much time it will take to shut off the lights after detecting

that the space is unoccupied. Time delays avoid continual on/off cycling of the lighting as people may go in and out of the space frequently. Typical factory settings are 5-10 minutes, which can be adjusted by the contractor in the field.

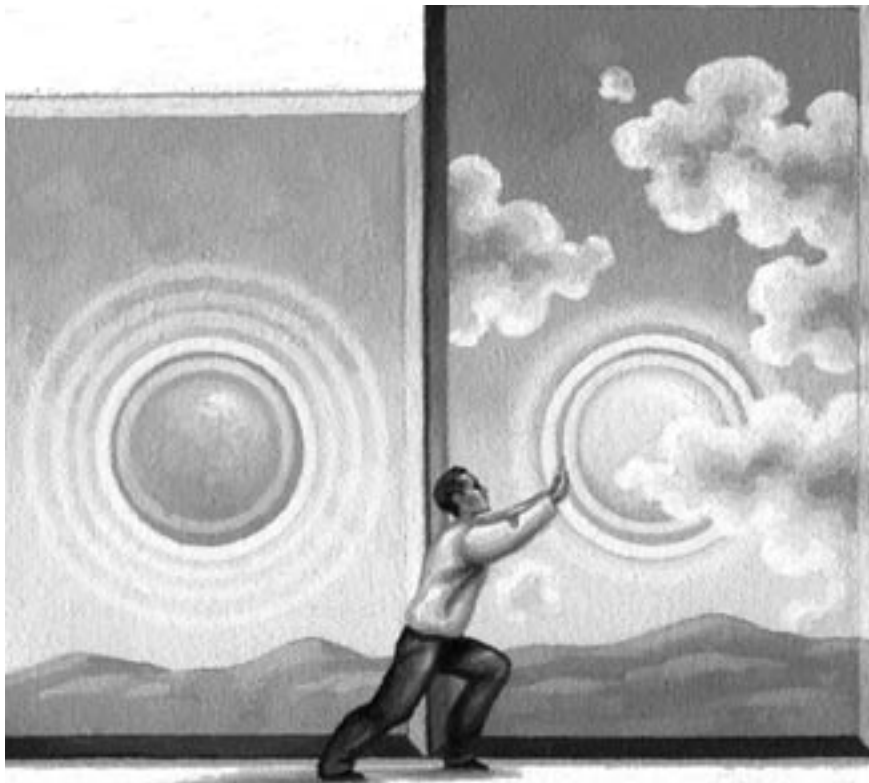
Shorter time delays save more energy but also shorten lamp life, due to more frequent on/off switching, which results in more wear and tear on the lamps. For many applications, the National Electrical Manufacturers Association (NEMA) recommends a minimum time delay of 15 minutes to optimize lamp life. If lamp life is of further concern, ballasts that meet ANSI requirements for lamp ignition should be used, as well as programmed-start ballasts.

Two simple tests can be performed to commission occupancy sensors after calibration, after which the installation can be fine-tuned through recalibration, relocating the sensor, or moving obstructions that may be blocking the sensor's view.

**Entry Test:** If the sensor is used to automatically turn on the lighting, then it should do so within two seconds after the person gets three feet into the space. The sensor should not turn on the lights when a person passes outside the room with the door open.

## **Perimeter Test:**

Walk and wave your hand in different places around the room to try to find spots where the sensor is least effective in detecting major and minor motion.



## Troubleshooting Occupancy Sensor Nuisance Switching

Problem	Possible Causes	Prescription
False-on (PIR sensors)	Sensor is detecting heat from an artificial source	Sensor should not be located within 6-8 ft. of HVAC outlet, heating blower or other heat source
	Sensor is detecting motion in an area adjacent to the control zone	Re-orient sensor if high wall- or corner-mounted, use masking labels to restrict coverage area, or move the sensor
	Sensor is detecting motion in an adjacent warehouse aisle	Use narrow-view sensor so that it “sees” only the aisle in its control zone
	Re-commission the installation.	
False-on (ultrasonic sensors)	Heavy airflow from HVAC outlet, open window or other source	Reorient or relocate sensor
	Vibration	Ensure the sensor is mounted on a vibration-free, stable surface
	Object is moving in the space	Ensure drapes and other hanging objects are not moving due to airflow
	Sensor is detecting motion in an area adjacent to the control zone	Re-orient sensor if high wall- or corner-mounted, use masking labels to restrict coverage area, or move the sensor  Ultrasonic sensors are suitable for restricted coverage in closed areas, such as corridors, but not open areas—use a PIR sensor for open areas requiring restricted coverage, such as warehouse aisles
	Re-commission the installation.	
False-off (PIR sensors)	Very low levels of occupant motion	Use ultrasonic sensor or dual-technology sensor for greater sensitivity/reliability
	Occupant is too far from sensor	Check the range and coverage area of the sensor; note the sensor's range and coverage area is affected by the sensitivity setting
		Check the sensitivity level and adjust if too low and adjustment is acceptable
		Place the sensor as close as possible to the main activity
	Occupant is behind object obstructing direct line of sight	Move the task, object or replace with an ultrasonic sensor, which does not require a direct line of sight  Ensure sensor is not installed where a door swing will obstruct view
	Re-commission the installation.	
False-off (ultrasonic sensors)	Very low levels of occupant motion	Ultrasonic sensors are more sensitive than PIR sensors, but very low levels of occupant motion may still result in false-off; consider replacing with a dual-technology sensor
	Ceiling-mounted sensor mounted too high	Sensor should not be mounted higher than 14 ft.
	Occupant is too far from the sensor	Check the range and coverage area of the sensor and note if they are affected by the sensitivity setting
		Check the sensitivity level and adjust if too low and adjustment is acceptable
	High partitions, bookshelves or equipment	High partition walls can restrict range of sensors; the coverage area must be de-rated and the sensors spaced closer together as needed
		Place the sensor as close to the main activity as possible  If sensors are networked to control large area, 20% overlap in coverage patterns is recommended
	Soft surfaces such as fabric-walled partitions are resulting in poor reflection of ultrasonic waves	Provide a clear line of sight between the sensor and the occupant
Re-commission the installation.		

## Troubleshooting Fluorescent Dimming Installations

Problem	Possible Causes	Prescription
Premature lamp failure	Miswiring	Verify fixture wiring versus wiring diagram on ballast. Pay special attention to "shared" wires
	Incorrect lamp type	Use only rapid-start lamps
	Lamp not making good contact in socket	Use proper socket and ensure proper lamp contact
	Lamp and ballast not compatible	Verify compatibility
	Ballast not properly grounded	Check ballast mounting and wiring. Ensure fixture is properly grounded
	Lamp dimmed too low	Raise low-end setting
	Ballast-to-lamp lead lengths exceed specified maximum	Verify lead length is within maximum
Premature ballast failure	Defective lamp	Replace lamp
	Poor heat dissipation	Check wiring diagram Check ambient heat in area Ensure ballast is properly mounted and grounded
	Control is leaking voltage to ballast in off state	Use control that provides positive disconnection from power when off
Premature dimmer failure	Ballast is dimmed to lower level than it can handle	Raise low-end setting
	In-rush current from ballast	Use ballast that has in-rush current-limiting circuitry. Confirm compliance with NEMA Guideline 410-2004 Use control that is designed to handle in-rush current
Lamp flicker	Circuit is overloaded	Size dimmer appropriately, add power pack, or reduce load on circuit
	Poor connections	Check connections at sockets, connectors at ballast, wire nuts. Look for pinched wires causing intermittent shorts. Ensure connection to ground
	Ballast is dimmed to lower level than it can handle	Raise low-end setting
	Line noise	Try on different breaker 0-10VDC: Control wires should not exceed maximum wire run length 0-10VDC: Consider conduit or shielded cable Add choke or inductor to line
	Ballast-to-lamp lead lengths exceed specified maximum	Verify lead length is within maximum
	Defective lamp	Replace lamp
Lamps do not dim	Control wires reversed	Verify proper connections and orientation of control and power wires (0-10VDC ballast) Verify proper connections for Hot and Dimmed Hot wires (three-wire phase-control ballast)
	Dimmer not communicating with ballast	Verify dimmer status and wiring to ballast Verify compatibility of ballast and control Ensure that line and 0-10V low-voltage wires are separated by conduit.
	Processor failure at dimming panel	Check the panel. Check address set-up
	Other problem at panel	Check the panel
Lamps do not sufficiently dim	Ballast's dimming range	Check ballast performance parameters Check ground
	Miswiring	Verify fixture wiring versus wiring diagram on ballast. Pay special attention to "shared" wires
Lamps have problems starting or do not start	Lamps not warmed up	Ensure lamps have had time to warm up
	Incorrect lamp type	Use only rapid-start lamps
	Lamp not making good contact in socket	Make sure proper socket is used and that lamp is making good contact
	Lamp and ballast are not compatible	Verify compatibility
	Ballast-to-lamp lead lengths exceed specified maximum	Verify lead length is within maximum
Lamps cannot be turned off	Defective lamp	Replace lamp
	Circuit is overloaded	Size dimmer appropriately, add power pack, or reduce load on circuit; check that dimmer has not been shorted
Inconsistent dimming performance	Brand-new lamps	Operate lamps at full light output for period specified by lamp manufacturer prior to dimming
	Different lamp and ballast brands mixed on same dimmer	Use only one lamp brand and wattage, and one ballast brand and model, on a single dimmer
Premature lamp end blackening	Miswiring	Verify fixture wiring versus wiring diagram on ballast. Pay special attention to "shared" wires
	Lamp and ballast are not compatible	Verify compatibility
	Lamp not making good contact in socket	Make sure proper socket is used and that lamp is making good contact
	Ballast not properly grounded	Check ballast mounting and wiring
	Defective lamp	Replace lamp
Lamp color shifts towards blue during low-end dimming	Normal for fluorescent, incandescent and HID to undergo some color shift during dimming	Raise the low-end setting; insufficient data exists about this issue, however, for manufacturers to be able to recommend how much to raise it
Audible noise	Panel noise	Use panel that dampens fan noise or use a convection-cooled panel Isolate the panel from acoustically sensitive spaces
	Ballast is dimmed to lower level than it can handle	Raise low-end setting

# Commissioning Matters

**E**ffective commissioning can determine the success or failure of lighting control projects. Performed correctly, it can ensure that the controls system operates according to design intent, satisfies users and delivers expected energy savings.

As automated controls continue to be specified and

installed in mainstream construction and existing buildings due to energy codes and incentives, demand will increase for skilled commissioning expertise.

Electrical contractors, properly educated about controls commissioning, are well positioned to provide this service when it is planned and budgeted in a project.

## *NEIS and Lighting Control Devices and Systems*

National Electrical Installation Standards are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They are voluntary and define a minimum baseline of quality and workmanship for installing electrical products and systems and are intended to be referenced in contract documents for electrical construction projects.

*ANSI/NECA/IESNA NEIS-504, Standard for Installing Lighting Control Devices and Systems* is currently under review and is expected to be released in mid-2007. To purchase National Electrical Installation Standards, call the NECA Order Line at (301) 215-4504. Or contact the Illuminating Engineering Society of North America (IESNA), Publications Department, at (212) 248-5000. NEIS can also be purchased in .pdf download format at [www.neca-neis.org/standards](http://www.neca-neis.org/standards).



Commissioning requires an understanding of the technology to be used. Here are some basic definitions related to motion sensors used with lighting from the upcoming *ANSI/NECA/IESNA NEIS-504*.

**Passive Infrared (PIR)**—A device that senses the motion of warm bodied objects by detecting movement of the object between viewing “windows.” Detection is limited to line-of-sight. Sensors can be used in cold and wet locations, including outdoors.

**Ultrasound**—A device that senses motion by detecting Doppler effect changes in ultrasonic radiation emitted by the sensor. Typically used indoors, not limited to line of sight.

**Microwave**—A device that senses motion by detecting Doppler effect changes in microwave radiation emitted by the sensor. Typically used in exterior applications; not often used indoors.

**Microphonic**—A device that senses sound and activates lights.

**Dual technology**—A device that uses two sensing technologies to improve performance. Common combinations include PIR and ultrasound, and PIR and microphonic.

**Falsing**—False detection of movement or improper failure to detect subsequent motion.

**Small Motion**—Movements, such as hand motions, that are hard to detect using motion sensors.

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