Avoiding and Overcoming Installation Problems with Occupancy-Sensing Lighting Control Systems

Task 4.8 of “Reducing Barriers to the Use of Energy-Efficient Lighting”

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Passive infra-red (PIR) occupancy sensors

How do they work?

PIR sensors detect changes in the temperature pattern within their field of view. Such changes can be caused by the movement of people or objects, or by sudden changes in their temperature.

PIR sensors “look” at a few segments of their field of view (see fig. 1), and sense whether the amount of heat (IR) arriving from each segment is changing. Movements across the segments are more likely to trigger the sensor than movements towards or away.

The segments fan out away from the sensor, so small movements (e.g. hand movements) a long way from the sensor may fall between segments and not be detected.

All solid materials (even glass) block the view of PIR sensors.

What makes PIR sensors trigger?

Sensors trigger in response to changes in the amount of IR arriving from any of their “segments” of view.

What are PIRs best at detecting?

- Movements in a direct line of sight from the sensor – PIRs cannot look around corners
- Movements across the field of view (across the segments) rather than movements toward or away from the sensor

What can cause “false triggering”?

- People walking by in adjacent spaces that are visible to the sensor (example: through a doorway)
- Surfaces with sunlight falling on them (example: desks near south-facing windows)
- HVAC outlets or other machinery that heat up nearby objects
Ultrasonic occupancy sensors

How do they work?

Ultrasonic sensors emit high-frequency pressure waves in all directions and listen to the reflected waves. If an object such as a person is moving towards the sensor, the frequency (pitch) of the reflected waves will be higher, whereas if the person is moving away the pitch will be lower. This is why the sound of a train or a police car siren drops in pitch as it passes you – an effect known as “Doppler shift.”

Ultrasonic waves, like sound waves, are not completely blocked by furniture or partitions, so people can be detected throughout the space. This can be beneficial because it extends the effective range of the sensor beyond that of a typical PIR, but “false triggering” by passers-by is also more common with this technology.

What makes ultrasonic sensors trigger?

Sensors trigger in response to changes in the pitch of reflected ultrasonic waves, caused by movement within the space.

What are ultrasonic sensors best at detecting?

- Movement in any part of the space, even around corners or behind obstructions such as washroom partitions
- Movement toward the sensor, rather than movement across the space

What can cause “false triggering”?

- People walking by in adjacent spaces that are within the sensor’s range
- Any object blown around by the wind or by the ventilation system, such as plant foliage or mobiles.
- High velocity air currents from HVAC systems
Examples

Partitioned office space

In offices it is essential that lights are not switched off automatically while people are still working beneath them. The body movements of seated office workers are usually small, so the sensitivity of the occupancy sensing system should be as high as possible to ensure detection.

To maximize energy savings, one sensor should be used for each separate work area – sometimes this will mean one sensor per occupant. Similarly, the grouping of luminaires should reflect the partitioning of the office, and each group should not extend beyond the range of the sensor (typically a 20x20 foot area). If ceiling-mounted PIRs are used, they should be of the type that look directly downward to avoid “dead zones” directly beneath, where they cannot see movement.

False triggering can be caused by poorly-positioned PIRs, which detect passers-by, or by ultrasonic sensors, which can detect people on the other side of office partitions, outside the zone of luminaires they control. To maximize energy savings, the system should be set up to require people to turn on a light switch manually, rather than providing automatic on-switching.

**PIR, ceiling-mounted**

This is a good solution for a partitioned space if sensors are placed directly above each workstation to maximize the chance of detecting small movements.

If partitions block the view of the sensors, false triggering is unlikely.

This solution will likely result in the maximum achievable energy savings if one sensor is used for each separate work area.

**PIR, wall-mounted**

This is a good solution for a partitioned space if sensors can be mounted close to each workstation and are not blocked by opened doors, hat stands, foliage etc.

If partitions block the view of the sensors, false triggering is unlikely.

This solution will likely result in the maximum achievable energy savings if one sensor is used for each separate work area.

**Ultrasonic**

This is a poor solution for a partitioned space because of the high probability of false triggering by people in adjacent spaces.

It is a good and cost-effective solution for an open-plan space, or workgroups consisting of several people, although only moderate energy savings can typically be achieved in an open-plan space.
Examples

Corridors and other public areas

The body movements of people in public areas are not usually difficult to detect, so the occupancy sensing system does not need to be highly sensitive. However, in order to realize the best energy savings, it must avoid false triggering, so the acceptance angle and/or sensitivity of the sensors should be closely tailored to the geometry and sight-lines of the space.

In order to maximize energy savings, the system should be set up to require people to turn on a light switch manually, rather than providing automatic on-switching. In many cases, the space is already lit by daylight or “borrowed” light, and additional light is not needed. An additional 10% energy savings is typically achievable by requiring manual on-switching.

**PIR, ceiling-mounted, looking outward**

This is a poor solution because it is very susceptible to false triggering caused by passers-by. However, it does provide the quickest switch-on of all the examples shown here.

False triggering may be overcome by adjusting the sensitivity of the sensor during commissioning, but settings are likely to drift over time and false triggering will recur.

This solution will likely result in moderate energy savings.

**PIR, ceiling-mounted, looking inward**

This is a good solution because false triggering by passers-by is highly unlikely. A slight drawback is that it will not immediately detect people entering the corridor, due to the “dead zone” beneath the sensor.

This solution will likely realize the maximum achievable energy savings.

**PIR, wall-mounted**

This is an excellent solution if there is a suitable recessed angle in which to mount the sensor. It will immediately detect people entering the corridor, and is unlikely to suffer false triggering.

This solution will likely realize the maximum achievable energy savings.

**Ultrasonic**

This is a good solution because ultrasonic sensors are unlikely to be triggered by passers-by walking across the entrance to the corridor, but will be triggered by people walking towards it.

Some adjustment of the sensitivity of the sensor may be required during commissioning, and staff should be trained to maintain commissioned settings.

This solution will likely result in the maximum achievable energy savings.
Checklist:

Providing occupancy-sensing lighting controls does not mean that wall switches can be disregarded - they are still essential to give occupants control over the lighting. Following the advice below will help to ensure that occupants will not become resentful at control being taken from them, and that the system will not be decommissioned by users.

1. Eliminate “false triggering” caused by passers-by
   Reduce the sensitivity of the sensor, or realign or reposition it to prevent false triggering.

2. Keep controlled office luminaire groups small (<20’x20’), to minimize complaints
   Ensure that controlled luminaire groups correspond to occupancy patterns – generally this means one sensor per occupant in partitioned offices.

3. The system should have the following best-practice features:
   - Automatic on-switching for public areas
   - Manual on-switching for private and semi-private areas

4. Locate all manual switches within line of sight of luminaires
   People should be able to see which luminaires are turning on and off as they push a switch.

5. Locate all manual switches in intuitive and accessible positions
   People expect light switches to be near to doorways, or near to the luminaire itself if there is no doorway nearby. Placing switches near doorways also makes it more likely that people will switch lights off when leaving a room.

6. Switches should be clearly labeled to show which luminaires they control
   People are less likely to use unlabeled switches, because they will often forget which switch controls which luminaire and don’t want to waste time finding out.

7. Choose labels that are easy to change without damage to the switch faceplate
   Since the occupancy patterns and the lighting of a space often changes, embossed, incised, printed or other permanent labeling is usually unsuitable. Building up layer upon layer of paper labels is also unsightly. Interchangeable paper labels are a common solution.

8. Leave wiring diagrams and instructions for use with the end-user
   Wiring diagrams should be drawn to US standards, and should show every component of the system. Instructions should cover recommissioning as well as everyday use. Contact details of the equipment manufacturer or a qualified agent should be included.

Sources:
- Design Brief: Lighting Control, Energy Design Resources, a program of Southern California Edison Inc. (www.sce.com)
- Specifier Report: Occupancy Sensors, Lighting Research Center (www.lrc.rpi.edu)