Occupancy sensor design guide introduction

Introduction

Now that you’ve determined that occupancy sensors are the right lighting control strategy for your facility, choosing and implementing the ideal sensor for each application is essential to achieving the most efficient and reliable control. This design and application guide aids the lighting professional in selecting, laying out, specifying, installing and commissioning an occupancy-based lighting control system.

In this guide you’ll find:

- A flow chart that helps select the correct sensor technology for each application.
- A list of dos and don’ts that are important rules to follow for every installation.
- Detailed design steps for implementing occupancy-based control, where you’ll be guided through selecting and implementing the appropriate occupancy sensor product for each application. Design steps include:
  
  Step 1. Evaluate space characteristics

  Step 2. Match sensor technology to an application

  Step 3. Layout and specify
  - Select coverage patterns
  - Select product features
  - Choose power pack
  - Integrate with other control devices

  Step 4. Installation and commission
  - Select optimal mounting configuration
  - Sensor placement, installation, and settings

- Application examples for specific building spaces

Together, these tools will help you in defining and implementing the optimal occupancy-based control solution for every type of building space.

Watt Stopper/Legrand’s application experts are available for design support and assistance on any lighting control question. Call our technical support at 800-879-8585.
Occupancy sensor selection flow chart

Although there are several steps involved in implementing occupancy sensor controls [outlined on the following pages], this flow chart offers a quick way to determine which sensor technology is best for your application.
Getting started “Dos and Don’ts”

Following these rules helps to ensure that the sensors work effectively, providing comfort for occupants while saving money for the facility. Be sure to review the following pages for detailed product selection guidance.

<table>
<thead>
<tr>
<th>Do</th>
<th>Don’t</th>
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<tbody>
<tr>
<td>• Use ultrasonic sensors in areas screened by partitions or furni-</td>
<td>• Use ultrasonic sensors in spaces with heavy air flow</td>
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<td>ture</td>
<td>• Install ultrasonic sensors in spaces where the ceiling height</td>
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<td>• Use PIR in enclosed spaces</td>
<td>exceeds 14 feet</td>
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<tr>
<td>• Create zones controlled by different sensors to manage lighting</td>
<td>• Use PIR sensors in spaces where there are fixtures or furniture</td>
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<td>in large areas</td>
<td>that obstruct a clear line of sight</td>
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<tr>
<td>• Use dual technology sensors for areas with very low activity</td>
<td>• Install PIR sensors so that their line of sight continues beyond</td>
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<td>levels</td>
<td>doorways</td>
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<tr>
<td>• Install sensors on vibration-free, stable surfaces</td>
<td>• Install sensors within 6-8 feet of HVAC outlets or heating blowers</td>
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<td>• Position sensors above or close to the main areas of activity</td>
<td>• Position a wall switch sensor behind an office door</td>
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<td>in a space</td>
<td>• Control emergency or exit lighting with sensors</td>
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<tr>
<td>• Mask the sensor lens to define coverage of the controlled zone</td>
<td>• Install PIR sensors in spaces where there are extremely low</td>
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<td>even more accurately</td>
<td>levels of occupant motion</td>
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<td>• Integrate sensor use with other control methods (i.e. time</td>
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<td>scheduled control, daylighting)</td>
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<tr>
<td>• Educate occupants about the new devices and what to expect</td>
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Identifying the ideal occupancy sensor for a particular application involves the consideration of several factors that are equally critical to an effective control solution. Because different sensors work best under different circumstances, incorporating these factors into the decision making process will provide optimal results:

Design steps

1. Evaluate space characteristics
2. Match sensor technology to application
3. Layout and specify
4. Install and commission
Step 1 - Evaluate space characteristics

To evaluate the application’s characteristics, designers should become familiar with:

- Room/space size and shape
- Location(s) of occupant activity and non-activity
- Location of walls, doors, windows and drapes
- Ceiling height
- Partition height and location
- Location of shelves, book cases, file cabinets, and large equipment
- Large objects that would block or alter a sensor’s coverage
- Location of HVAC ducts and fans
- Areas with available sunlight for added light level sensing
- Location of desk/workspace – orientation with regards to walls, partitions and other obstacles

Special attention should be paid to high levels of vibration and/or air flow, extreme temperature conditions, and unusually low levels of activity because these issues may help identify the best technology solution.
Step 2 - Match technology to application

All Watt Stopper occupancy sensors use either passive infrared or ultrasonic technology, or a combination of both.

**Passive infrared (PIR) technology**
Relies on "line-of-sight" coverage to detect occupancy by sensing the difference in heat emitted by humans in motion from that of the background space.

**Ultrasonic technology**
Utilizes the Doppler principle to detect occupancy through emitting ultrasonic sound waves throughout a space.

**Dual technology (DT)**
Employs both PIR and ultrasonic technologies. DT sensors will activate lights when both sensing technologies detect occupancy, but will continue to hold lighting on as long as only one technology detects continued occupancy.

The matrix below summarizes these technologies and the space characteristics that would favor the use of one technology over another. Also use the flow chart on Page 3 to help determine which technology is ideal for your application.

<table>
<thead>
<tr>
<th>Coverage type</th>
<th>PIR wall switches</th>
<th>PIR ceiling &amp; wall mount sensors</th>
<th>Ultrasonic ceiling sensors</th>
<th>Dual technology sensors</th>
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<td></td>
<td>- line of sight</td>
<td>- line of sight</td>
<td>- volumetric</td>
<td>- complete coverage</td>
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<td></td>
<td>- cut off</td>
<td>- cut off</td>
<td>- no clear cut off</td>
<td>- cut off</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compatible applications</th>
<th>PIR wall switches</th>
<th>PIR ceiling &amp; wall mount sensors</th>
<th>Ultrasonic ceiling sensors</th>
<th>Dual technology sensors</th>
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<tbody>
<tr>
<td></td>
<td>- smaller, enclosed spaces</td>
<td>- spaces where the sensor has a view of the activity</td>
<td>- open spaces</td>
<td>- classroom</td>
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<td>- spaces with obstacles</td>
<td>- spaces with low motion levels by occupants</td>
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<td>- bathrooms</td>
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<tr>
<th>Incompatible application characteristics</th>
<th>PIR wall switches</th>
<th>PIR ceiling &amp; wall mount sensors</th>
<th>Ultrasonic ceiling sensors</th>
<th>Dual technology sensors</th>
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<td>- low motion levels by occupants</td>
<td>- low motion levels by occupants</td>
<td>- high ceilings</td>
<td>- high levels of air flow</td>
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<td>- obstacles blocking sensor view</td>
<td>- obstacles blocking sensor view</td>
<td>- high levels of vibration or air flow</td>
<td>- warehouse</td>
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</tbody>
</table>

**Note**
"Cut off” refers to the ability to clearly define or limit sensor coverage so that detection capability will not intrude into adjacent spaces.
Step 3 - Specify and layout the project

Select coverage patterns
Many different coverage sizes and shapes are available for each sensor technology. While a small application is easily covered with one sensor, larger applications benefit from grouping controlled lighting into zones (with each zone controlled by a sensor). Familiarity with these coverage patterns will help designers specify the right product, ensuring the greatest sensor accuracy and occupant comfort.

Example [Dual technology coverage]
In a large space, such as a lecture hall, dual technology sensors provide coverage that suits the variable levels of motion present. The DT-200 is mounted in the corner. Its passive infrared portion of coverage defines exact cutoff near the doorway. The DT-300, with 360° coverage, fills in the rest of the space.

Products Used
DT-200 and DT-300 dual technology sensors

Tip! Do occupants engage in major motions, such as walking, or fine motions, such as typing or reading. Coverages change depending on motion type.

Example [Ultrasonic coverage]
In an open, partitioned office, designers select ultrasonic sensors. To adequately cover the entire space, multiple sensors are positioned to cover a specific zone.

Products Used
Ultrasonic occupancy sensors (UT-300)

Tip! When creating zones of coverage, such as the coverage illustrated in the example above, take care to ensure that sensor coverages overlap by 20%.
Step 3 - Specify and layout the project

Lighting designers should also consider specific features, which can add functionality and flexibility to the control solution.

Alerts
Visual (light flash) and/or audible alerts warn occupants of impending shutoff.

Dual relays
Dual relay wall switches contain two separate relays for controlling two independent lighting loads or circuits. This satisfies bi-level lighting control energy code requirements.

Hard lens
Wall switches that are placed in public spaces or schools require a lens that can stand up to substantial contact. Up to five times the thickness of a comparable wall switch lens, a hard lens makes the device resistant to vandalism or unintentional damage. The WN and WA wall switches offer a hard lens.

Isolated relay
An isolated relay enables interfacing with a facility's HVAC, BAS, or monitoring systems. For example, people entering a building after hours trigger not only the necessary lighting, but the heat or A/C as well. In automatic wall switches, an isolated relay can be used to control different circuits or loads.

Light level
The light level feature holds lighting OFF when natural light levels rise above a pre-set level. This setting is adjustable and can be overridden. It is available in several Watt Stopper wall switches and ceiling sensors.

This light level feature is recommended for spaces that have access to abundant natural light. Although multiple sensors may be used, only one sensor should be actively utilizing the light level feature within a controlled area.

Low profile
Many applications call for lighting controls that don’t take up a lot of space and that leave the ceiling looking uncluttered. Several Watt Stopper sensors are designed to be extremely low profile and compact.

Nightlight
Wall switch sensors with built-in nightlights provide users with a bright LED that remains illuminated whenever overhead lights are off.

ON Mode operation
Some automatic wall switches feature a choice of either automatic or manual on operation. For manual on operation with ceiling mount sensors, some sensors feature the ability to work with a momentary low voltage switch for manual on/off operation.
Step 3 - Specify and layout the project

Product features

SmartSet™
SmartSet automatically adjusts the sensor’s time delay and sensitivity settings for optimal performance and energy efficiency. SmartSet is found in the WA, DT-300, UT-300, and CI-300 series sensors.

Terminal wiring
Contractor friendly terminal style wiring makes installation quick and easy by eliminating the need for wire nuts.

Voltage choice - line or low
Having a choice of line or low voltage sensors, gives the installer the flexibility to use the type of wiring that is most appropriate for their requirements.

Walk through Mode
For extra energy savings, walk through mode switches lights off three minutes after an area is initially occupied if no motion is detected after the first 30 seconds.

Zero crossing
Zero Crossing Circuitry ensures that a wall switch sensor or power pack’s switching takes place at the beginning of the voltage wave very close to zero volts. This reduces stress on the relay and increases sensor life.
## Step 3 - Specify and layout the project

### Product features matrix

<table>
<thead>
<tr>
<th></th>
<th>Alerts</th>
<th>Dual relays</th>
<th>Hard lens</th>
<th>Isolated relay</th>
<th>Light level</th>
<th>Low profile</th>
<th>Nightlight</th>
<th>ON Mode operation</th>
<th>SmartSet™</th>
<th>Terminal wiring</th>
<th>Voltage choice - line or low</th>
<th>Walk through Mode</th>
<th>Zero crossing</th>
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Step 3 - Specify and layout the project

Choose the power pack

Power packs are a key component of low voltage sensor based lighting control systems. Power packs provide low voltage power to sensors and other control devices and respond to signals from those devices to switch a relay(s). However, power packs can also provide advanced features such as switched inputs, inputs for scheduling, and dimming control. These features and many others provide a finer degree of control over the different loads in a building.

Single relay power packs
Provide power to control devices and switch a single load in response to a signal from the control devices. These power packs may also provide additional control inputs to hold on or off the relay.

Auxillary packs
Used in conjunction with a power pack to switch other loads. Do not have a transformer so they do not provide power to a control device.

Form C power packs
Provide customizable control scenarios by including two switching options in one relay.

Dual relay power packs
Can switch two loads simultaneously from a single control device signal.

Intelligent power packs
Offer advanced features to customize applications, including dual switch inputs, dimming capability, multiple control inputs, programmable switching scenarios.

Power supplies
Provide extra low voltage power for large applications with many control devices.
Step 3 - Specify and layout the project

Considerations when selecting a power pack

Power output needs
Matching the current consumption of all the devices connected to the power pack to the amount of power the power pack can provide is very important. Simply sum the current consumption ratings from all the sensors to be connected to one power pack. If this number is less than the power pack output rating, the power pack is appropriate for the application. If the number is greater, consider decreasing the switching zones or providing an extra power pack/supply to properly power the sensors.

Voltage
When selecting a power pack, consider the voltage of the electrical systems. Many power packs are capable of accepting a range of line voltage inputs, including two phase, while some are voltage specific. Pay attention to the input ratings of the power pack.

Relay type
The relay in the power pack is the key component that switches the load. Many power packs provide an isolated relay so the power pack can switch a load that is different than the line voltage supplying the power pack. Isolated relays provide better switching flexibility in different applications. Some power packs also have different types of relays so the specifier can customize the switching of the application. While most power packs provide a simple form A relay (normally closed) other power packs offer increased switching flexibility with a form C relay (both normally open and normally closed). In addition, larger power packs may have two or more isolated relays in the same enclosure. These power packs can provide simultaneous or independent control of two or more loads. Smaller, low voltage rated relays may also be present in some power packs. These relays are used to signal other systems such as security or HVAC systems.

Relay ratings
Most power packs can switch a full 20 Amp load which is sufficient for sensor based lighting control. An exception to this load rating is the form C power packs. Make sure the load being switched does not exceed the load rating of the power pack.

Type of load to be switched
Power packs have specific ratings for different load types. Most common load types can be controlled by power packs including incandescent, fluorescent and motor loads. Make sure the power pack relay ratings match the type of load to be controlled. One load type of concern for power packs are the newer electronic ballasts. These ballasts can cause strain on relays due to high inrush current. To alleviate this situation, many power packs use zero crossing technology to eliminate the potential for relay damage from high inrush. If electronic ballasts are specified, try to choose a power pack that uses zero crossing (such as the BZ-100 or the LC-100).
Power packs are generally mounted by a nipple externally onto the knock-out of a junction box. This places the power pack itself in the plenum space. Make sure the power pack is plenum rated. Smaller power packs can also be installed inside a standard junction box. Power packs are designed so that line voltage connections are made inside the junction box and low voltage connections are made externally. Make sure all low voltage wiring is plenum rated as well.

Intelligent power packs provide inputs so that multiple control devices can be connected. This allows the installer to customize the control scenario for different applications and end user preferences. Use intelligent power packs when multi-device, manual switching, and dimming applications are considered.
For increased flexibility and energy savings, occupancy sensors seamlessly integrate with many lighting controls.

**Lighting control panels**
Integrating occupancy sensors with lighting control panels provides convenience and savings benefits. Rather than the panel’s system clock signalling all lights to turn off at a specific time, occupancy sensor control takes over during after hours. Here, lights remain on only in spaces that are occupied, and turn off after the space is vacated.

**Daylighting controls**
Occupancy sensors also integrate well with daylighting controls in building spaces that receive daylight. When used together, the occupancy sensors can keep lights off in unoccupied spaces, even when the daylighting controls signal that there is not adequate daylight.
Step 4 - Install and commission

Mounting configuration

Watt Stopper sensors are available in three basic mounting configurations:

- wall switch replacements (line voltage)
- ceiling or wall mount sensors with power packs (low voltage)
- ceiling or wall mount (line voltage)

Wall switch replacements
Wall switch sensors are designed to replace existing wall switches. Wall switch sensors utilize passive infrared technology and therefore require a clear line of sight of the coverage area from the switch location.

Ceiling/wall mount sensors
Some sensors are recommended for ceiling mount use, such as the CI-200, W series, WT series, DT-300 series and WPIR. Others, such as the CX and DT-200 series, contain built-in bracket systems that provide ceiling mounting as well as wall mounting. This is important for applications where the ceiling is unavailable for sensor installation.

Many ceiling/wall mount sensors are available in both line and low voltage models. Although both models provide the same function, there are situations when one model is a better choice than the other.

Low voltage
Low voltage occupancy sensors use a power pack. They offer flexible wiring configurations (such as multiple sensors wired to a single power pack) and the placement of sensors on the ceiling or wall is easy to change upon installation and during building renovations. However, in hard cap ceiling applications, a line voltage sensor is recommended.

Line voltage
Line voltage occupancy sensors feature standard wiring (conduit and wire), and terminal wiring makes installation easy. They are a good choice for applications where there is no plenum or junction boxes are hard to access.
Step 4 - Install and commission

Placement

**Sensor placement**
Installers should position the sensor so it has the best view of the entire coverage area. Care should be taken to minimize the possibility of false ONs or OFFs due to sensor location. For instance, an ultrasonic sensor should not be positioned near an open doorway, since a passerby could trigger lighting ON.

Tip!
When installing ultrasonic sensors, installers should position the receiving side toward the area of greatest traffic.

Installation

**Installation**
When installing the sensor, the contractor should wire it according to manufacturer’s instructions to eliminate any functional problems or sensor damage. For instance, all Watt Stopper wall switch sensors require grounding for proper functioning.

Settings

**Settings**
Following sensor installation, additional adjustments may need to be made. This is often due to last minute changes in furniture or fixture placement. Ideally, the sensor settings for sensitivity and time delays should match the activity levels of the monitored spaces. For sensors that feature SmartSet technology, adjustments are typically not needed after installation.
Application Examples
Occupancy sensor applications

Partitioned office space

Application description
Large office area with partitioned cubicles. A majority of work is done at computers in individual cubicles.

Control needs
A sensor that can ‘see around’ obstacles such as cubicle walls, and that has a high sensitivity to detect fine movements such as typing.

Solution
UT-300 Ultrasonic Ceiling Sensors.

Ultrasonics detect movement through obstacles so occupants working in cubicles are detected. To ensure the entire area receives coverage, place the sensors in zones that overlap.

Enclosed office

Application description
Enclosed single-occupant office with a window. Primary activities are computer work, reading and meetings.

Control needs
ON/OFF control with light level sensing. The sensor should be able to detect small movements such as typing.

Solution
WA-200 Automatic Wall Switch Sensor.

The sensor replaces a standard wall switch. It should have a direct and clear view of the front of the occupant. Be sure not to place the sensor behind a door or other obstacle that blocks its view. Light level sensing ensures that lights stay off if enough ambient light is available in the room. The WA's SmartSet technology automatically adjusts the time delay and sensitivity settings for optimal performance and savings.
Occupancy sensor applications

Conference/ training room

Application description
Medium conference room that is used for meetings and training.

Control needs
A sensor with ON/OFF control. The sensor should have high sensitivity, as there is often little motion in the room during meetings. Lights need to be capable of staying off during presentations.

Solution
DT-300 360° Dual Technology Occupancy Sensor. The DT-300 uses both PIR and ultrasonic technologies to sense occupancy, resulting in enhanced sensing capability for applications where activity varies greatly. The sensor should be placed in the middle of the room. A manual OFF override is useful when lights need to be off during presentations.

Classroom

Application description
High school classroom.

Control needs
ON/OFF control with high sensitivity, since occupants sit still for long periods of time.

Solution
DT-200 Dual Technology Occupancy Sensor. The sensor accommodates lower levels of activity without false triggers. The DT-200 is corner mounted behind the teacher’s desk for optimum coverage, without seeing out the door.

Classroom

Application description
Elementary classroom.

Control needs
Automatic ON/OFF of lights based on occupancy. Daylight dimming of fixture row next to the windows. Manual ON/OFF and dimming of two zones of lights for different presentation scenes: one zone is the middle lamps of direct/indirect fixtures, the second zone is the outer lamps.

Solution
LC-100 Intelligent Power Pack, DT-200 Dual Technology Occupancy Sensor and LS-301 Dimming Photosensor. The occupancy and photosensors can be connected to a single LC-100. In addition, the LC-100 facilitates dual zone switching and dimming with its dual relay and dual 0-10V dimming outputs. A low voltage momentary switch is simply connected to the dual switch inputs.
Occupancy sensor applications

**Library**

**Application description**
Library book stacks 14' in length that are occupied intermittently throughout the day.

**Control needs**
ON/OFF control in individual book stacks. Lights should turn when someone enters the aisle from either side and lights should not turn on in adjacent stacks if they are not occupied.

**Solution**
WPIR PIR Occupancy Sensor.

The WPIR sensors are ideal for aisles under 15' in length (longer aisles should be zoned with multiple sensors). Place the WPIR at the beginning of the aisle. The use of the LC-100 for the power pack will provide additional features such as

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**Lunch/Break Room**

**Application description**
Large lunch/break room occupied intermittently throughout the day.

**Control needs**
ON/OFF control what can detect a variety of activity levels.

**Solution**
UT Ultrasonic Ceiling Sensor.

The UT provides 360° of coverage and ensures lights turn on when someone enters the room. Place the sensor above the main activity area for complete coverage.
Occupancy sensor applications

Utility Room

**Application description**
Small utility room used sporadically during the day.

**Control needs**
ON/OFF sensor that ensures lights come on as soon as the door opens.

**Solution**
WS-200 PIR Wall Switch Sensor.
The sensor directly replaces the wall switch. It should not have obstacles that block coverage, as PIR technology cannot see around objects.

Note: as an alternative to using occupancy sensors, the TS Digital Time Switch is well suited to areas such as utility rooms where the lights remain on for a preset, user adjustable amount of time.

Warehouse

**Application description**
Aisleways in a warehouse with high ceilings. Aisles are occupied sporadically throughout the day.

**Control needs**
ON/OFF control that only triggers lights in the aisleway that is occupied.

**Solution**
CX-100 PIR Ceiling Sensor.
The CX can be mounted at ceiling heights up to 50 feet. The sensor’s coverage zone can be tightly defined so lights are on only where needed.
### Restroom

**Application description**
Public restroom with six partitioned stalls. Ceiling is hard-cap or concrete.

**Control needs**
ON/OFF control with technology that can see around obstacles.

**Solution**
The UT-355 line voltage Ultrasonic Sensor.

Place the sensor close to the stalls, about 2’ out from the stall door so the sensor has the best opportunity to detect presence in the entire restroom. Special attention should be given to larger stalls to ensure they are well covered. Use the UT-355 in restrooms with hard-cap or concrete ceilings. Add a 4 square or Wiremold junction box to mount the sensor on to the ceiling surface.

### Lobby

**Application description**
Lobby with high ceilings and windows.

**Control needs**
ON/OFF control and light level sensing. The sensor should also provide accurate coverage at greater heights and a defined cut off.

**Solution**
DT-200 Dual Technology Occupancy Sensor.

Place the sensor behind the reception desk so it can see the entire space while also detecting small movements at the desk. Pay special attention to covering the entrance, reception desk and waiting area. In addition, the DT-200 features light level sensing, which increases energy savings by keeping lights off when ambient light is sufficient.

Additionally, the lobby would be an ideal application for integrating daylighting controls.
Occumancy sensor applications

**Hallway**

**Application description**
Office building hallway with walls on both sides. The hallway has no windows, but has doors along each side.

**Control needs**
ON/OFF control that ensures lights turn on immediately when someone enters the hallway from either side or from a doorway.

**Solution**
WT-2250 Ultrasonic Sensor.

Place the sensor in the middle of the hallway, halfway between entrances. The sensor will detect when someone enters the hallway from either side or when someone enters through a door in the middle of the hallway.

**Hotel guestrooms**

**Application description**
Hotel guestroom bathroom

**Control needs**
Lights turn off automatically based on occupancy. Since guests don’t always want lights on in the bathroom, lights should not turn on automatically when the room is occupied. Provide users with a nightlight that is illuminated when the overhead lights are off.

**Solution**
WN-100 Motion Sensor Nightlight Switch.

The WN directly replaces a bathroom wall switch. As a convenience to guests, the WN provides a nightlight when lights are off. A button on the front of the switch allows guests to turn on lighting when desired. Lights automatically turn off during times of vacancy.