NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

Specifier Reports

Occupancy Sensors

Motion-sensing devices for lighting control

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Contents

Introduction

In October 1992, the National Lighting Product Information Program (NLPIP) published its first report on occupancy sensors, products that save lighting energy when spaces are unoccupied. Since that report, the use of occupancy sensors as a lighting control strategy in the U.S. has become much more common, especially in commercial applications. Between January 1995 and April 1996, participants in the United States Environmental Protection Agency's Green Lights program installed over 110,000 occupancy sensors in commercial and industrial applications, nearly double the number installed over the previous twenty-eight months (September 1992 through December 1994) (EPA 1996).

During this interval of rapid growth, manufacturers have introduced many new products designed to address some of the known problems with occupancy sensors, such failure to detect small motion and inappropriate or false switching of lamps. This issue of *Specifier Reports* highlights occupancy sensors for industrial and commercial use (see Figure 1 on p. 2) introduced since the 1992 occupancy sensor report, and provides guidance for equipment selection and successful installation. It also describes performance evaluations for some of the products.

Open-Plan Office Test Site

Technologies

Most occupancy sensors used in commercial applications use passive infrared or ultrasonic motion-sensing technologies. A few use hybrid or dual technologies, which combine these two technologies or others, such as microphonic, in one sensor. NLPIP tested only passive infrared and ultrasonic occupancy sensors for this report.

Passive Infrared Occupancy Sensors

Passive infrared occupancy sensors respond to movement of infrared sources, such as human bodies in motion. These sensors use a pyroelectric detector located behind an infrared-transmitting lens to detect motion. The lens is etched with an optical pattern that divides the field of view of the pyroelectric detector into wedge-shaped segments. The occupancy sensor responds when it detects a heat source crossing from one segment to another. Because infrared occupancy sensors must have a direct line-of-sight to the motion, they should not be used where furniture, partitions, or other objects are positioned between the sensor and the motion.

Figure 1. Occupancy Sensors Tested

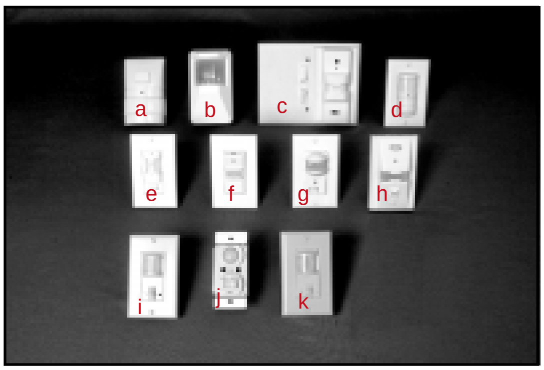


Photo 1. Passive Infrared Occupancy Sensors for Wall-Switch Replacement

- a The Watt Stopper, Inc. WI-200
- b Visonic, Ltd. SRN-2000ET
- c Universal Energy Control, Inc. SOM-1200-2-HD
- d The Watt Stopper, Inc. WS-120
- e Universal Energy Control, Inc. IWS120-227V
- f Lightolier Controls IS2-600VA-W
- g Leviton Manufacturing Co. 6775-W
- h Universal Energy Control, Inc. SOM-1000-A (Series B)
- i MYTECH LP2-IVORY
- j RAB Electric Manufacturing LOS 300
- k Sensor Switch WSD

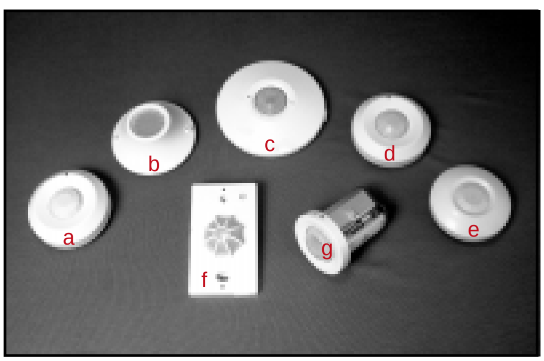


Photo 2. Ceiling-Mounted Passive Infrared Occupancy Sensors

- a Bryant Electric, Inc. MSCM-1000DC
- b Bryant Electric, Inc. MSCM-600HD
- c Lightolier OS-C
- d Hubbell, Inc. HMC1DC
- e Visonic Ltd. DISC-ET
- f Universal Energy Controls, Inc. PIR2000QTI
- g Leviton 6778

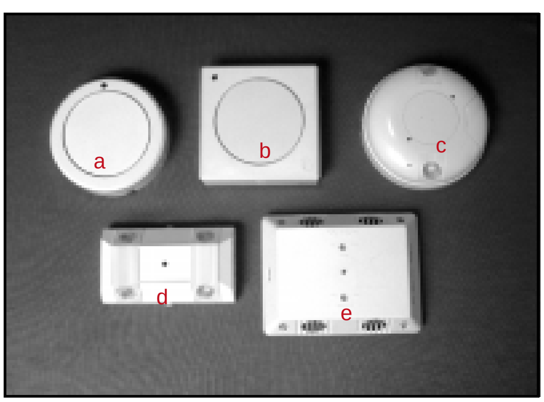


Photo 3. Ceiling-Mounted Ultrasonic Occupancy Sensors

- a Honeywell, Inc. EL7612A 1001
- b The Watt Stopper, Inc. W-1000A
- c Universal Energy Controls, Inc. C-800-1500QTI
- d Universal Energy Controls, Inc. C-500-2000QTI
- e MYTECH LAS 2200

Relative size of sensors among photographs are not comparable.

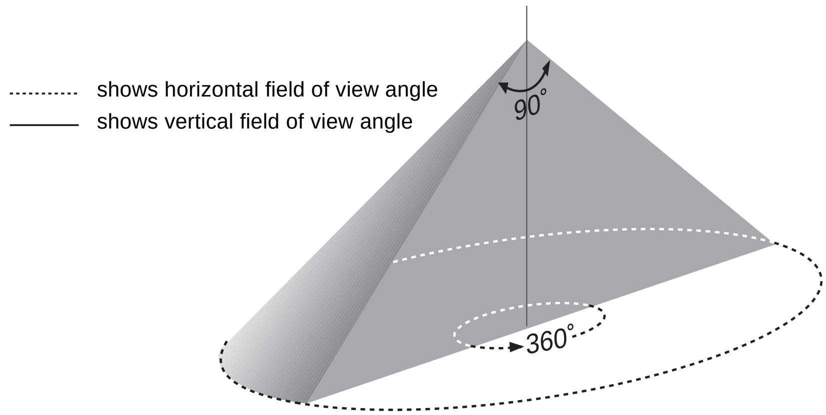
Coverage area. The coverage area of passive infrared occupancy sensors is generally reported in square feet and represents the maximum floor space that a sensor can monitor. Although manufacturers publish maximum coverage areas, actual coverage areas depend on mounting location and height, furniture layout, the size of the motion to be detected, and the sensitivity setting of the occupancy sensor.

Most occupancy sensor manufacturers publish coverage areas for the maximum sensitivity setting at a specific mounting height for a specific body motion. Some manufacturers offer adjustable sensitivity settings for these passive infrared sensors; setting a lower sensitivity on these types reduces the coverage area. For ceiling-mounted passive infrared occupancy sensors, a lower than recommended mounting height decreases the coverage area because the sensor's field of view covers less area on the floor. Higher-than-recommended mounting height increases coverage area but also increases the size of the detection segments at floor level, so that larger motions will be required for detection. Large spaces may require more than one occupancy sensor in order to detect motion throughout the area. Tables 2a and 2b on pp. 16–23 show manufacturer-reported maximum coverage areas.

Coverage pattern. A coverage pattern is determined by the lens on the infrared sensor and any segment masking. Manufacturers commonly report the pattern as a two-dimensional shape such as square, circle, rectangle, or ellipse. In addition to coverage area, it is important that a specifier consider the product's coverage pattern. For example, an occupancy sensor with a long, narrow, rectangular coverage pattern is better suited for use in a corridor than in a large, square room, and an occupancy sensor with a round coverage pattern used in a square room might not cover the corners of the room.

Because of the wide variation in how manufacturers report coverage pattern, NLPIP did not report these data in the manufacturer-supplied data tables (Tables 2a, 2b, 3a, 3b, or 4 on pp. 16–29).

Ceiling-Mounted Passive Infrared Occupancy Sensors



NLPIP recommends that specifiers consult manufacturers' cut sheets or the manufacturers' customer service representatives to find a suitable coverage pattern.

Field of view. Field of view refers to the angle within which the occupancy sensor will detect motion. For ceiling-mounted passive infrared occupancy sensors designed for a central location, the field of view is defined by a solid angle forming a cone with the center at the vertex. For ceiling-mounted passive infrared occupancy sensors, the horizontal field of view is almost always 360°, since the sensor typically covers a circular area in the horizontal plane. More useful is the vertical field of view angle, which can be up to 180°. The vertical field of view and the ceiling height determine how much area an occupancy sensor can cover.

For wall-mounted passive infrared occupancy sensors, the field of view is defined by a wedge-shaped solid angle. Both the horizontal and vertical components of the solid angle are usually reported, with the horizontal angle ranging up to 180°, and the vertical angle up to 90°. A sensor on the wall with a horizontal field of view of 180° is like a fully opened fan. Each segment has a vertical field of view of 90°, which means that the each segment has 90° of depth.

Sensitivity. Of the passive infrared occupancy sensors received by NLPIP, only a few have adjustable sensitivity settings. Those few use either a potentiometer for continuous adjustment or dip switches for discrete steps of adjustment.

Manufacturer-Reported Coverage Areas

The coverage areas reported by occupancy sensor manufacturers were initially based on security industry applications. In the security industry, an occupancy sensor is commonly required to maintain detection of a person walking at a speed of one foot per second. At first, many occupancy sensor manufacturers used this rate of whole body motion as a definition of motion for their lighting-control product ratings. Because there is no industry standard method for occupancy-sensor testing, different manufacturers may report coverage areas based on different test methods.

Time delay. Time delay for an occupancy sensor is the interval between the last detected motion and the switching off of the lamps. Some products have a fixed setting, but most occupancy sensors have an adjustable time delay. Manufacturer-reported time delay settings range from 3 seconds (s) to 30 minutes (min). The longer the time delay, the less chance of lamps switching off when a room is occupied but the motions are small. A longer delay in a space that people frequently enter and leave also reduces the incidence of rapid switching, which can shorten lamp life and increase lamp replacement costs. On the other hand, setting a shorter time delay will reduce wasted energy in a room that is infrequently and briefly occupied, such as a janitor's closet.

Adjusting the time delay poses a trade-off between saving energy and avoiding occupant complaints; reducing the time delay will increase energy savings but will also increase the possibility of the lamps being switched off while the room is occupied. For most office applications, NLPIP recommends a time delay setting of two to five minutes.

Ultrasonic Occupancy Sensors

Ultrasonic occupancy sensors transmit pressure waves at frequencies of 25–40 kilohertz (kHz). These waves are similar to sound waves except that they are at a higher, inaudible frequency. The ultrasonic waves travel through the air and are reflected from room surfaces and objects back to a receiver in the occupancy sensor. Motion within the space changes the frequency of the reflected vibrations; the receiver detects this change and turns or maintains the lamps on. Unlike passive infrared occupancy sensors, ultrasonic occupancy sensors are sensitive to motion of inanimate objects, such as blowing curtains. However, these sensors do not need a clear line of sight to an occupant and are preferred for spaces with partitions, tall filing cabinets, or other obstacles.

Performance Characteristics of Ultrasonic Occupancy Sensors

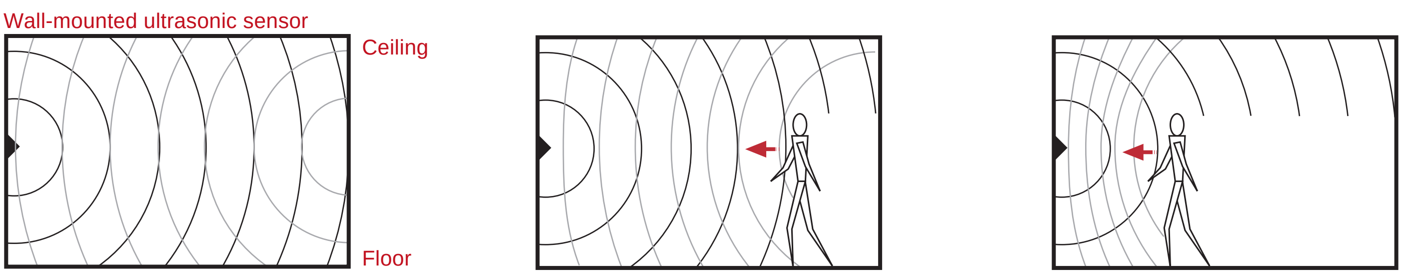
Coverage area. Manufacturer-reported coverage areas for ultrasonic occupancy sensors represent maximum values; as with passive infrared occupancy sensors, actual coverage area may be less. The further away the motion source is from the ultrasonic transmitter, the weaker the reflected signal will be and these weaker signals may result in erratic or failed detection of motion.

Coverage pattern and field of view. Coverage pattern and field of view are not relevant for ultrasonic sensors and are not reported by the manufacturers. If the area is covered with a strong signal, the sensor will respond to changes in frequency anywhere in the room.

Sensitivity. As with time delay, setting the sensitivity of an ultrasonic occupancy sensor poses a trade-off between energy savings and the likelihood of occupant complaints. If the sensitivity is too high, the occupancy sensor may respond to signals unrelated to occupant motion and turn on

Example of Motion Detection with Ultrasonic Technology

This figure shows a simplified wave pattern in an empty room. Ultrasonic waves (black) are emitted by the occupancy sensor and reflect off the back wall. The reflected waves (gray) then return to the sensor.



A person, or any object in the room, reflects waves emitted by the occupancy sensor. As a person moves in the space, the frequency of the waves reflected off the person changes. The occupancy sensor detects this change in frequency and reacts by switching on the lamps.

the lamps when no one is in the room. For example, if the sensitivity is too high, the sensor may react to motion in the hallway outside of the room and turn the lamps on. If the sensitivity is too low, the occupancy sensor might not be able to detect human motion at every point in the room, or it may turn off the lamps while people are in the room but moving very little. Because optimizing the sensitivity setting for ultrasonic occupancy sensors is site-specific, NLPIP recommends adjusting the sensitivity after installation.

Most occupancy sensors are shipped with the sensitivity setting at maximum, minimizing the risk of occupant complaints but increasing the potential for lamps being on when the room is unoccupied.

Time delay. Like passive infrared occupancy sensors, ultrasonic occupancy sensors have a time-delay feature that keeps the lamps on for a specific period after the time when the last motion was detected. Manufacturer-reported time delay ranges from 8 s to 32 min.

Dual-Technology (or Hybrid) Occupancy Sensors

Dual-technology occupancy sensors, sometimes called hybrid occupancy sensors, use two technologies, such as passive infrared and ultrasonic or passive infrared and microphonic, in combination to improve performance. NLPIP did not test dual-technology occupancy sensors for this report, but those reported by manufacturers are listed in the manufacturer-supplied data in Table 4 on pp. 28–29. These sensors are wall- or ceiling-mounted.

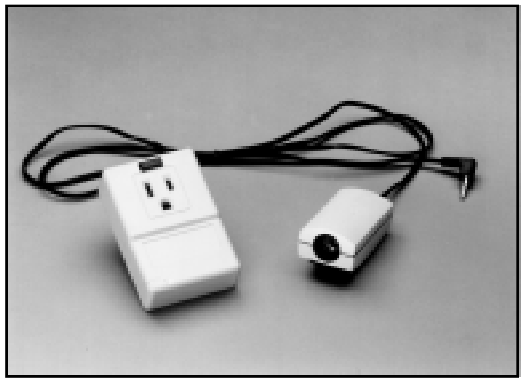
Passive infrared/ultrasonic. Most dual-technology occupancy sensors combine passive infrared and ultrasonic sensors in one product. They switch lamps on when both sensors detect motion. The device keeps the lamps on if either sensor detects motion, and turns them off, after a delay, if neither sensor detects motion. Because both sensors must detect motion before turning on lamps, dual technology products reduce the likelihood of lamps turning on due to false triggering (lamps turning on because of motion that is not caused by an occupant). Because only one sensor has to detect motion to keep lamps on, these products reduce the likelihood of lamps turning off while a space is occupied.

Passive infrared/microphonic. In addition to passive infrared/ultrasonic sensors, NLPIP also received information on a dual-technology occupancy sensor that combines passive infrared technology with a microphone. This hybrid occupancy sensor responds to sounds made by occupants, as well as motion. It switches lamps on when the infrared sensor detects motion and turns lamps off, after a delay, only if the infrared sensor detects no motion and the microphone detects no sound. For example, the sound of a person typing can keep the occupancy sensor from turning off the lamps, even though the motion involved in typing is very slight. The sensitivity of the microphone can be adjusted for different background noise levels. This dual-technology occupancy sensor is less expensive than infrared/ultrasonic occupancy sensors and, unlike many infrared occupancy sensors, can be effective in partitioned offices. However, the performance of this product has not been documented.

Application Considerations

The most suitable applications for occupancy sensors are in spaces where occupancy is infrequent or unpredictable, such as many offices, warehouses, conference rooms, classrooms, hallways, service corridors, lavatories, storage closets, or copy rooms. In areas where occupancy is

Controlling Task Lights and Desktop Equipment with Occupancy Sensors



MYTECH's CUBi-U30 Workspace Sensor

In addition to occupancy sensors designed to control general lighting systems, some products are available to control the "plug load" in an individual workstation. These devices can control not only task lights but also monitors, printers, radios, and other small electrical appliances. For example, Watt Stopper's ISOLe´ and MYTECH's CUBi-U30 are passive infrared sensors that control a device plugged into a single electrical outlet or several devices plugged into a power strip.

Hearing Aid Interference from Ultrasonic Sensors

The frequencies commonly used by ultrasonic occupancy sensors are 25, 27, 32 and 40 kHz. Physical plant engineers at California State University at Northridge received complaints of hearing aid interference at 25 and 27 kHz (Witter 1996). They subsequently recommended using only ultrasonic occupancy sensors with frequencies of 32 kHz and above. For similar reasons, New York City has set a minimum limit of 35 kHz in its ultrasonic occupancy sensor specification (Energy Investment Inc., 1996).

Manufacturers of ultrasonic occupancy sensors are aware of the possibility of hearing aid interference. Many are now either using higher frequencies exclusively or offering products at either higher or lower frequencies.

regimented and predictable, such as a factory floor, a time clock might be a more cost-effective lighting control solution.

Types of Motion

A primary consideration when selecting an occupancy sensor is the magnitude of motion required by the occupancy sensor for detection. For example, in hallways, an occupancy sensor needs only to be sensitive enough to detect a person walking. But in a data-entry office, an occupancy sensor must detect motions that are much smaller, such as typing.

NLPIP defines whole body motion as a *large* motion, arm motion as a *medium* motion, and hand motion as a *small* motion. Using these definitions, walking is a large motion, reaching for the telephone a medium motion, and typing a small motion.

Mounting Locations

The layout of the space should be considered carefully when selecting occupancy sensors. The optimum mounting location depends on the shape of the room, the expected locations of the occupants, potential obstacles such as desks, file cabinets, doors and partitions, and potential sources of extraneous motion, such as fluttering curtains or movement in adjacent hallways. Most occupancy sensors are ceiling-mounted or wall-mounted at the height of the typical light switch (42–48 inches). Some manufacturers also make units for mounting in the corner of a room or hallway or on the wall near the ceiling.

Wall. Wall-mounted occupancy sensors often replace standard manual switches or wall dimmers and are relatively easy to install in retrofit projects. Wall-switch replacement occupancy sensors are usually passive infrared sensors and require a clear line-of-sight to detect motion.

Wall-mounted sensors, usually mounted somewhat higher than switch-replacement sensors, can be either passive infrared or ultrasonic. The mounting height of these sensors, usually at eight feet or higher, reduces the risk of tampering that may occur with wall-switch replacement sensors.

Ceiling. Most ceiling-mounted occupancy sensors are surface-mounted; however, some are recessed into the ceiling. Ceiling-mounted passive infrared and ultrasonic occupancy sensors for corridor applications are available with multiple unidirectional detectors or transmitters aimed in different directions for mounting at corridor intersections. Occupancy sensors for corridor applications generally have long, narrow coverage patterns.

Corner. Corner-mounted passive infrared occupancy sensors have 90° vertical fields of view. The round and elliptical coverage patterns common among passive infrared occupancy sensors designed for mounting in the center of the ceiling can leave “dead spots” in the corners of a rectangular or square room if the coverage area does not entirely cover the room. If increasing the sensitivity of the sensor (if possible) does not reduce the dead spots, adding corner-mounted passive infrared occupancy sensors can be effective if occupant motion often occurs near the corners of the room. The only other alternative is to replace the ceiling-mounted sensor with one with a larger coverage area.

Manual Control Options

Occupancy sensors are generally used because they provide automatic control of lighting systems; they turn lamps on when they detect movement, turn them off when they do not detect movement. In many applications, fully automatic control of the lighting system may be desirable, and many of the occupancy sensors available today provide this type of operation. However, many other applications may be better served by occupancy sensors with some manual control options.

Manual “on” control. Some occupancy sensors provide the occupant with the option of turning the lamps on manually; others require the occupant to turn the lamps on manually. These products eliminate the potential for the lamps coming on when the room is unoccupied. Furthermore, an occupant may choose not to turn the lamps on if there is adequate daylight.

Manual “off” control. Some occupancy sensors provide the occupant with the option of turning the lamps off manually. These products are useful for applications where it may be desirable to have the lamps off, even though the room is occupied. Examples include conference rooms and lecture halls where audiovisual presentations occur.

Override controls. In some situations, it may be desirable to disable the automatic functions of an occupancy sensor. These override functions usually require a special tool and may require the removal of the face plate. Once set in override mode, the sensor must be reset to resume the automatic functions.

Occupancy sensors have a variety of possible automatic, manual, and override functions. In many cases, switching between automatic and manual functions is very simple and easily accomplished by the occupant. Because of the many variations in combining automatic, manual, and override functions, NLPIP encourages specifiers to contact the manufacturers of the products they are considering to determine the options available.

System Configurations

Control modules. Wall-mounted occupancy sensors that replace standard wall switches are wired directly to the lighting system and use contacts within the occupancy sensor to switch the lighting load, as do some ceiling-mounted occupancy sensors. However, most other occupancy sensors require a separate control module that contains a relay to switch the lighting load. Control modules can be expensive to install because they require additional wiring and, because the modules usually are located in the ceiling, the installer must work on a ladder. However, systems with separate control modules offer the option of connecting many modules to one occupancy sensor, or the ability to connect many occupancy sensors to one load for increased coverage area. Some types of occupancy sensors can also be connected to a building automation system through the control module.

Photosensors. Occupancy sensors can be wired in series with photosensors that switch lamps on and off depending on available light. Using this combination, the lamps will not be automatically turned on if sufficient daylight is available even if the space is occupied.

Special photosensors are available that can be used with dimming electronic ballasts to control fluorescent lamp output over a continuous range. These photosensors can also be used in conjunction with occupancy sensors. See *Specifier Reports: Dimming Electronic Ballasts* for more information about dimming fluorescent lighting systems.

Some occupancy sensors include a built-in photosensor. When these products detect motion, they turn on lamps only when the illuminance is below a preset level. Once the lamps are on, these products will keep them on as long as motion is detected, even if daylight increases.

The columns in Tables 2–4 on pp. 16–29 labeled ‘Daylight Sensor Availability’ indicate either a built-in or added photosensor is available, or no photosensor is or can be attached.

Building automation systems. Occupancy sensors interface with a building automation system through a special type of control module that contains a microprocessor and a relay that is separate from the load switching relay. Table 5 on pp. 30–31 shows control modules that are designed to work with a building automation system in the column labeled master / slave option. *Lighting Answers: Controlling Lighting with Building Automation Systems* addresses questions about integrating occupancy sensors into the building automation system.

Electrical Requirements

Capacity. The relays used by most control modules and wall-switch replacement occupancy sensors are rated for a maximum load of 20 amperes (A). Some products also have a minimum load requirement, which is typically less than the power required to operate one two-lamp fluorescent luminaire. Large loads can require multiple control modules. Load capacities vary depending on whether the load is resistive (such as incandescent lighting) or inductive (such as fluorescent lighting). Maximum load capacities listed in Tables 2a , 2b, 3a, 3b, and 5 are reported in watts for fluorescent lighting loads. Minimum load requirement and maximum load capacity are not reported for ceiling-mounted occupancy sensors because these sensors use a control module that dictates the limits.

Inrush current. Electronic ballasts use solid-state circuitry that can briefly draw a very high current when starting the lamps. For some electronic ballasts, this inrush current can exceed the 20 A rating of the relay for either a wall-mounted occupancy sensor or a control module, possibly destroying the relay. Inrush current is additive: if several electronic ballasts are connected to one control module, their combined inrush current can exceed the relay's rating. Most ballast manufacturers will provide their inrush current rating upon request; this rating should not exceed the maximum current rating for the occupancy sensor or the control module. Some occupancy sensors have a special circuit that delays switching the relay until the voltage cycle is at zero (called zero-crossing switching), thereby eliminating potential damage from inrush current.

Light Loggers

Some occupancy sensor manufacturers and several other companies make monitoring devices for monitoring occupancy and lighting use. These monitoring devices, sometimes called light loggers, contain both an occupancy sensor and a photosensor. Mounted within or near a lamp, they log the number of hours that a space is occupied and the number of hours that the lamp is on. Subtracting the former from the latter estimates the number of hours of "wasted light," hours during which the room was lighted, but unoccupied. More advanced loggers automatically calculate and print out occupancy/light usage profiles.

Some occupancy sensor manufacturers offer the use of light loggers free to potential customers. Telephone numbers for several light logger manufacturers are listed below.

Manufacturers of Occupancy Monitoring Devices (Light Loggers)

Electronic Product Design	(503) 741-0778
The Fleming Group	(510) 275-9185
Heath	(616) 925-2943
MYTECH	(512) 450-1100
North Fork Retrofit	(516) 477-2922
Pacific Science and Technology	(503) 388-4774
The Watt Stopper	(408) 988-5331
Xenergy	(617) 273-5700

Economic Considerations

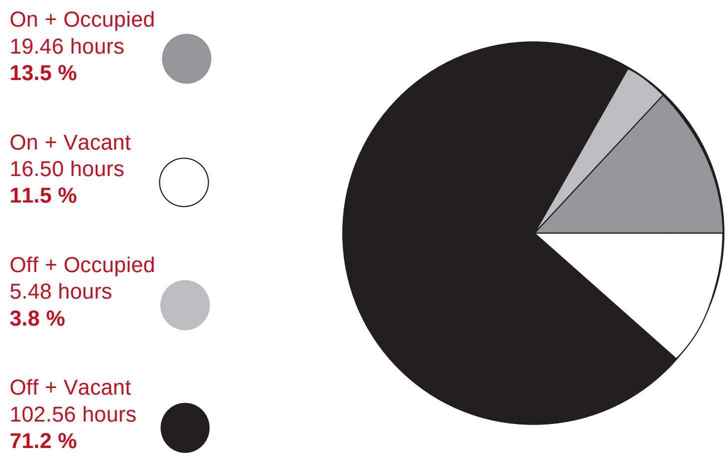
NLPIP collected price information from occupancy sensor manufacturers; the results are shown in Tables 2–4 on pp. 16–29. Uninstalled occupancy sensor prices ranged from $46–$390, compared to less than $2 for a standard wall switch and switch plate. To justify this additional investment, users need to estimate the expected energy savings from the use of the occupancy sensors. Doing so requires determining the amount of time that lighting systems are left on when spaces are unoccupied. To do this, patterns of occupancy and lighting use must be monitored simultaneously. Some occupancy sensor manufacturers rent or lend occupancy monitoring devices to prospective clients to help them determine their potential savings. (See sidebar "Light Loggers".) Rea and Jaekel (1987) describe a number of other methods for monitoring occupancy and patterns of lighting use. The energy saving estimates can be used with the product cost information to conduct life cycle cost or payback analyses.

For example, consider a private office with a fluorescent lighting system that has active power of 500 watts (W) (or 0.5 kW). If the lamps are in use for 3000 hours (h) per year, the annual use is 1500 kilowatt hours (kWh), and if the energy cost per kWh is $0.10, the yearly energy cost is $150. If a monitoring device or a series of observations reveals that for 25 percent of the time, the space is unoccupied with lights left on, an occupancy sensor will yield $37.50 in annual energy savings (this assumes no time delay).

In addition to energy implications, occupancy sensors can also affect fluorescent lamp life. Occupancy sensors are likely to increase the frequency of switching of fluorescent lamps, which may shorten their lamp life. Lamp life ratings of fluorescent lamps are based on a 3 h lamp operating cycle. When the lamps are started more frequently, their operating life is reduced. However, occupancy sensors can actually decrease lamp replacement costs while reducing lamp life. Lamps may not have to be replaced as frequently because occupancy sensors will turn the lamps off, spreading the remaining lamp life over a longer period of time.

Sample Output from The Watt Stopper's Light Logger, Intelitimer Pro.

Lighting/Occupancy Summary



Lighting Statistics

Total ON time: 35.96 hours

Average ON period: 1.28 hours
Shortest ON period: 0.03 hours
Longest ON period: 7.09 hours

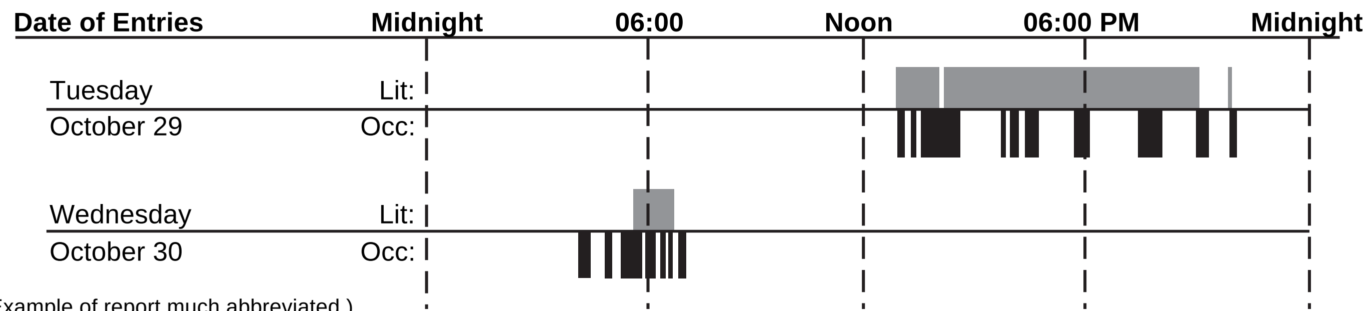
Total ON/OFF cycles: 28
ON/OFF cycles/day: 4.7

Occupancy Statistics

Total Occupancy: 24.94 hours

Average occupancy period: 0.24 hours
Shortest occupancy period: 0.08 hours
Longest occupancy period: 1.01 hours

Total occupancy cycles: 103
Occupancy cycles/day: 17.2



(Example of report much abbreviated.)

(Used by permission)

Performance Evaluations

Manufacturer-Supplied Data

NLPIP identified occupancy sensor manufacturers by attending industry trade shows and consulting trade magazines. NLPIP invited all identified manufacturers to participate in this project. Those who responded were asked to provide performance data for wall-switch replacement occupancy sensors, ceiling-mounted occupancy sensors, and control modules. Eighteen manufacturers submitted information for more than 200 products. The data collected from the manufacturers are presented in Tables 2–5 on pp. 16–31.

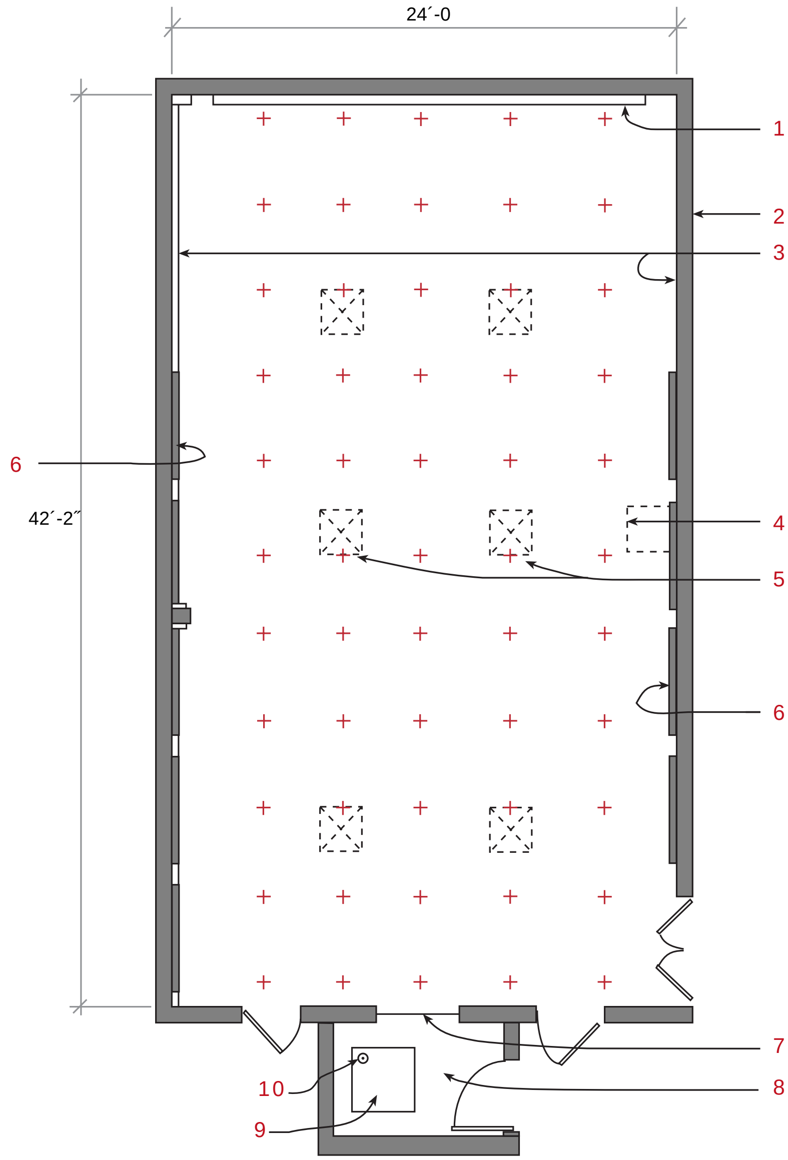
The Product Samples

NLPIP selected two applications for testing to represent typical new construction and retrofit lighting installations: an open-plan office and a private office, respectively. For the open-plan office, NLPIP tested only ceiling-mounted occupancy sensors with recommended mounting locations at or near the center of the room. In the private office, NLPIP tested only wall-switch replacement occupancy sensors.

The open-plan office test room was a 1012 ft^2 (94 m^2) classroom. The private office test room was a 126 ft^2 (11.7 m^2) office. Both rooms had ceiling heights of 9 ft (2.7 m). The plans of the two test rooms are shown in Figures 2 and 3 on pp. 10 and 11.

For both applications, NLPIP reviewed manufacturers' literature and selected products that had rated coverage areas greater than the test room area, but not greater than 2,000 ft^2 for the open-plan application and 500 ft^2 for the private office.

Figure 2. Plan View of the Open-plan Office Test Room



1 4´ tall chalkboard (mounted) @ 3´-0˝ above finished floor
2 Concrete block wall
3 Fabric covered wall
4 Return air grille
5 Supply air diffusers
6 Padded fabric-covered acoustic panels
7 1´ tall opening @ 62˝ above finished floor
8 Control room
9 Computer
10 Lamp for experimental note-taking in the dark

Ceiling hgt = 9´-9˝

+ = test location

NLPIP sent these selections and descriptions of the test rooms to manufacturers, who then revised the list of selected products and submitted samples and their recommended mounting locations. For the open-plan office, some manufacturers recommended using more than one occupancy sensor. In total, NLPIP tested 12 different occupancy sensors in the open-plan office and 12 in the private office (one of the sensors tested has been discontinued and therefore is not reported).

NLPIP Test Methods

NLPIP researchers performed all product testing at the Lighting Research Center's laboratory in Watervliet, New York. In both test rooms, NLPIP designed a grid of test points on the floor as shown in Figures 2 and 3 on pp. 10 and 11. In the open-plan office, NLPIP installed occupancy sensors at the ceiling locations specified by manufacturers. In the private office, NLPIP installed each occupancy sensor at the wall switch location, at a height of 4 ft (1.2 m), which was within the mounting height recommended by all manufacturers. In general, NLPIP set the occupancy sensors at a time delay of twice the manufacturer-reported minimum. Exceptions were those with minimum time delays of less than 15 s. In these cases, NLPIP set the time delay for 30 s. One product had only two settings: 20 s and 4 min, and NLPIP used the 20 s setting for testing.

The sensitivity setting for each sensor with an adjustable setting was set to maximum, with two exceptions. Two of the ultrasonic sensors kept the lights on in the test room at their maximum sensitivity setting even when the room was unoccupied. For these two products, the sensitivity was adjusted until the lights switched off in the unoccupied room.

For the open-office testing, the room's HVAC system was turned off for testing the ultrasonic occupancy sensors since these products can be affected by the HVAC system. Since passive infrared products can be affected by variations in room temperature, the HVAC was left on for testing these products to ensure stable room temperature.

Some products had integral photosensors; the photosensors were disabled prior to testing.

NLPIP tested each sensor's response using a robot to simulate human arm motion (see Figures 4–7 on pp. 11–12, and the sidebar "Human Arm Emulation" on p. 12). NLPIP used a robot to ensure consistent motions for all tests. Each sensor was connected to the input power supply for at least five minutes before testing began. NLPIP then performed the following actions at each test point:

- positioned the robot arm with the shoulder joint directly over the test point;
- pointed the arm toward the location of the occupancy sensor;
- initiated the robot's horizontal arm motion from an adjacent room, with the lamps turned on;
- allowed the motion to continue for 30 s longer than the sensor's time-delay setting;
- recorded whether the occupancy sensor kept the lamps on or turned the lamps off;
- repeated the process for vertical arm motion and rotational wrist motion;
- repeated the three motions at every test point.

NLPIP categorized occupancy sensors that maintained detection of the wrist motion as sensitive to small body motion at that location. If an occupancy sensor maintained detection of either the horizontal or vertical arm motion, NLPIP categorized the occupancy sensor as sensitive to medium-sized body motion at that location.

Summary of Results

Table 6 on pp. 34–35 shows the results of NLPIP's evaluations of occupancy sensors in the open-plan office application. For each occupancy sensor, NLPIP determined which test locations (grid points) were within the manufacturer-reported coverage area for a 9 ft mounting height. NLPIP then calculated the percentage of test locations, within the reported coverage area, at which the occupancy sensors detected motion. For every occupancy sensor, the points within the room at which the occupancy sensor detected medium-size body motion are also shown graphically, as is the portion of the test room within the manufacturer-reported coverage area (pp. 36–39).

For the open-office application, the percentage of test locations within the

Figure 3. Plan View of the Private Office Test Room

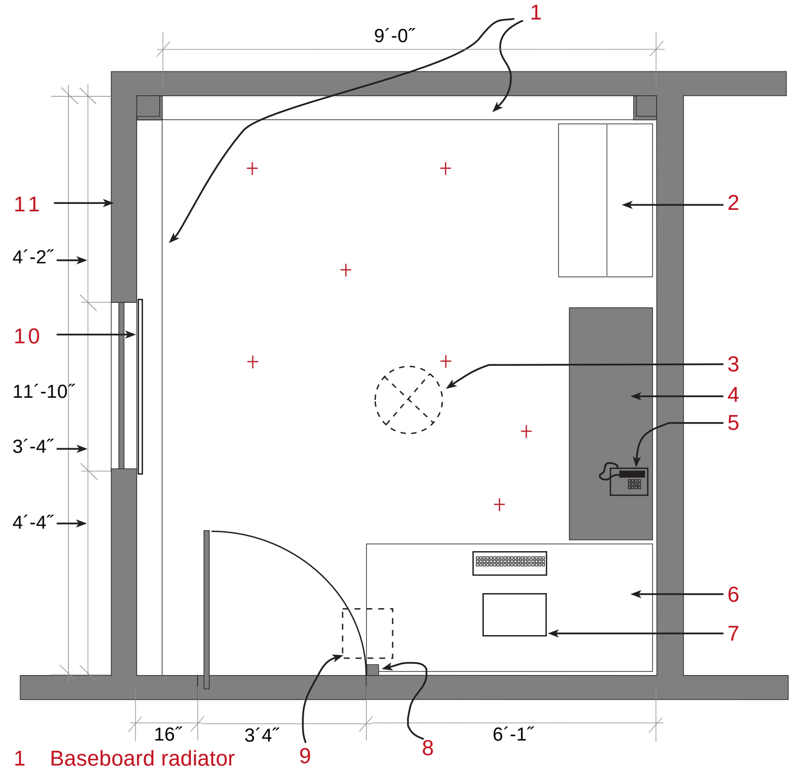
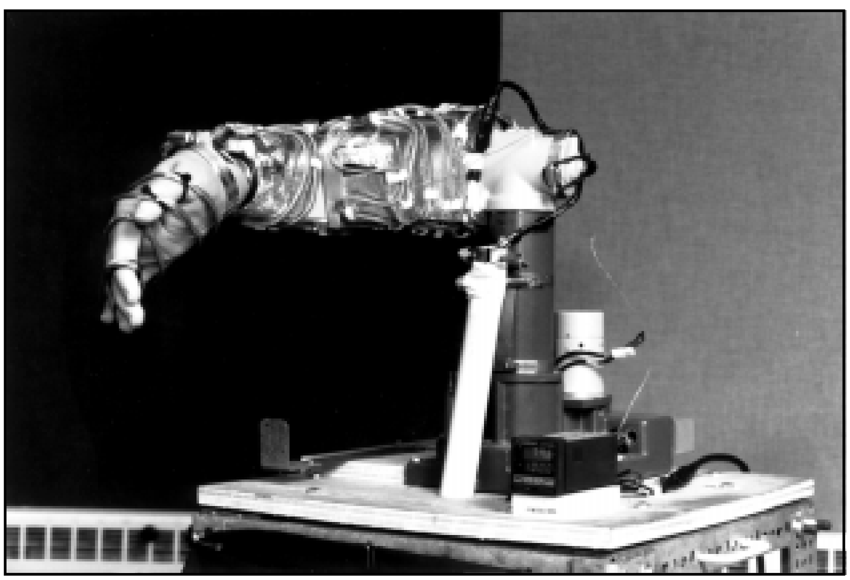


Figure 4. The Robot Arm Used in NLPIP's Evaluations



Human Arm Emulation

NLPIP consulted Architectural Graphic Standards, 1988 in designing the robot arm. The length of the robot arm from the shoulder to the tip of the fingers was approximately 23 in., approximately the dimension of the arm of a small female. The shoulder height was set at 37 in. above the floor to approximate the shoulder height of a person seated at a workstation. The arm was heated using electrical resistance heating to a constant temperature of 95°F (35°C), the average surface temperature of a human arm at rest.

reported coverage areas at which medium-sized motion was detected by ceiling-mounted passive infrared occupancy sensors ranged from 17–76 percent, with a median of 35 percent. For the ceiling-mounted ultrasonic occupancy sensors, the percentage detected ranged from 58–100 percent, with a median of 98 percent. For infrared occupancy sensors, the orientation of the lens affects whether or not the test locations are near the boundaries between the segments in the field of view; altering the position of the occupancy sensor could change the results.

NLPIP's testing of small motion in the open office application confirmed that ultrasonic occupancy sensors detected small motion more consistently over a large area than infrared occupancy sensors did. However, NLPIP did not report manufacturer-specific results for small motion detection in the open-office application, because, in repeated tests of the same product, NLPIP found a large variation (50 percent) in the results for detection of small motion by ultrasonic occupancy sensors in this application.

For the private office application, NLPIP tested only wall-switch replacement occupancy sensors. All of the wall-switch replacement products tested in this category were passive infrared occupancy sensors. Table 7 on p. 34 shows the results of NLPIP's evaluations. All 11 of the occupancy sensors tested and reported detected medium body motion at all seven test points in the office. Three of the occupancy sensors detected small body motion at all seven test points, one occupancy sensor detected small motion at five points, one occupancy sensor detected small motion at one point, and six of the occupancy sensors failed to detect small motion at any point. A repeated test showed no variation for either motion type.

Figure 5. The Robot Arm Motion Used to Simulate Rotational Wrist Motion

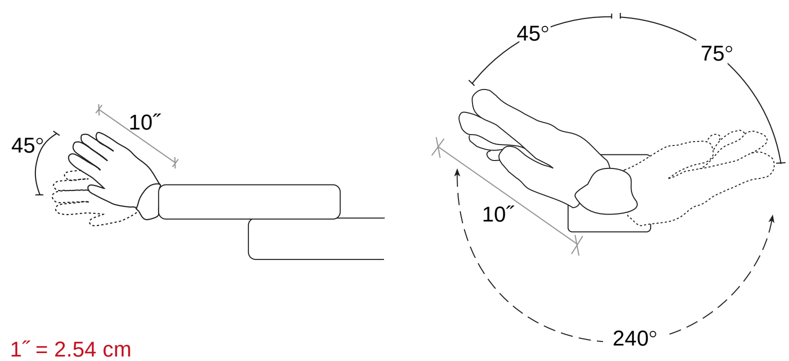


Figure 6. The Robot Arm Motion Used to Simulate Horizontal Arm Motion

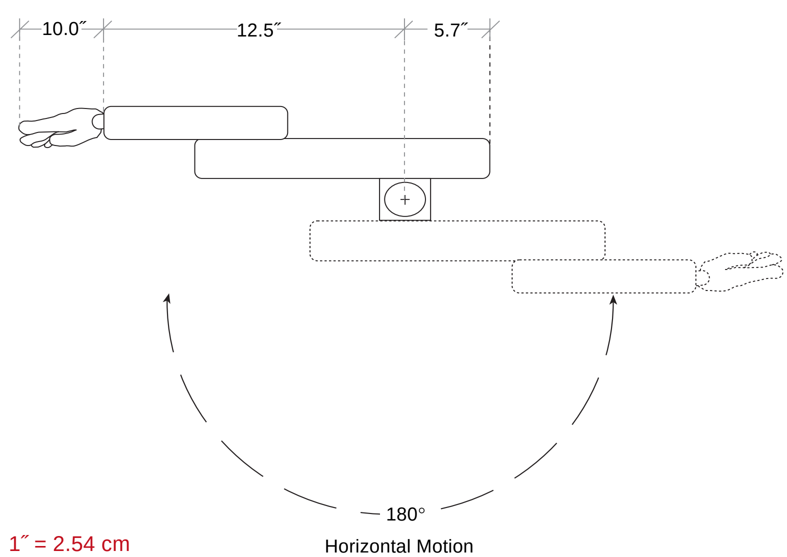
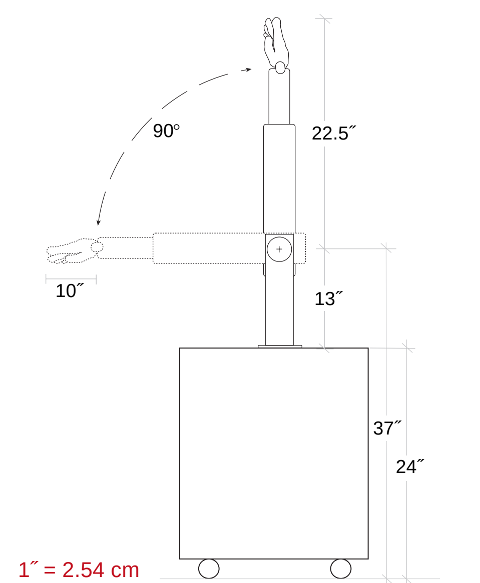


Figure 7. The Robot Arm Motion Used to Simulate Vertical Arm Motion



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Data Table Terms and Definitions

Definitions

The following data tables present product information supplied by manufacturers (Tables 2–5 on pp. 16–30) and data collected by NLPIP researchers (Tables 6 and 7 on pp. 34). Most of the performance characteristics listed in these tables are discussed previously in this report, but the column headings are included and defined here.

Approximate cost. The unit cost for an occupancy sensor, as reported by manufacturers. Cost may vary for different quantities.

Certification. Indicates the specific certification of products by Underwriters Laboratories (UL) and the Canadian Standards Association (CSA). Several manufacturers listed their products as Canadian Underwriters Laboratory (CUL) certified; NLPIP footnotes those products accordingly.

Daylight sensor availability. Indicates whether the sensor has a photosensor either as an integrated or as an optional component (yes) or if the occupancy sensor has no provision for a photosensor (no). See p. 7.

Dimmer compatible. Indicates whether or not the sensor could be connected to a dimmer.

Electronic ballast compatible. Indicates whether or not the sensor can be connected to an electronic ballast.

Field of view. For wall-mounted occupancy sensors, a horizontal field of view is given. For ceiling-mounted occupancy sensors, the solid angle of the cone-shaped coverage area is reported. See p. 3.

Load capacity. The maximum total power that can be connected to the occupancy sensor.

Minimum load requirement. The minimum power required for the occupancy sensor to operate properly.

Recommended mounting height. The height recommended by the manufacturer for mounting the occupancy sensor.

Sensitivity adjustment. Indicates whether there is no sensitivity adjustment (none), a continuous adjustment, or a discrete adjustment. For those products with a discrete adjustment, the number of incremental steps on the adjustment is shown.

Time delay range. The range of time that may be set for the interval between the last detected motion and the turning off of the lamps.

Ultrasonic frequency. The frequency at which an ultrasonic sensor operates.

Warranty period. The warranty period reported by manufacturers is listed. Contact manufacturers for specific details of warranty coverage.

List of Tables

Table 1. Manufacturer-Supplied Information: Telephone and Fax Numbers for Customer Inquiries

Manufacturer	Telephone	Fax
Bryant Electric, Inc	(203) 876-3600	(203) 876-3675
Douglas Lighting Controls	(604) 873-2797	(604) 873-6939
Honeywell	(612) 951-2907	(612) 951-3465
Hubbell, Inc.	(203) 882-4800	(203) 882-4849
Leviton Manufacturing Company	(718) 229-4040	(800) U FAX LEV
Lightolier Controls	(972) 840-1640	(972) 271-4077
Lithonia Lighting	(770) 987-4400	(770) 987-1002
Mytech	(512) 450-1100	(512) 450-1215
Pass & Seymour/legrand	(315) 468-6211	(315) 468-6296
RAB Electric Manufacturing	(201) 784-8600	(201) 784-0077
Sensor Switch, Inc.	(203) 265-2842	(203) 269-9621
Steinel America, Inc.	(800) 852-4343	(612) 888-5132
Technology Design Center, Inc.	(610) 539-4210	(610) 539-5921
Tork	(914) 664-3542	(914) 664-5052
Universal Energy Control, Inc.	(510) 337-1000	(510) 337-1100
Visonic Ltd.	(800) 243-0833 or (800) 223-0020	(860) 242-8094
The Watt Stopper, Inc.	(408) 988-5331	(408) 988-5373

NLPIP also invited Heath Company, Novitas, Inc., and LVS, Inc. to participate; these companies declined.

Telephone and fax numbers are current as of April 1997.

Table 2a. Manufacturer-Supplied Information: Features of Wall-Switch Replacement Passive Infrared Occupancy Sensors (Products marked with ✜ were tested by NLPIP)

Manufacturer	Trade Name		Catalog Number	Maximum Coverage Area (ft^2)	Field of View (horiz × vert.)	Sensitivity Adjustment
Bryant Electric, Inc.	Motion Switch		MSFL-1200I(W)	1200	180° × 7°	none
			MSWS - 1277	1200	170° × 7°	none
Honeywell, Inc.	Honeywell		EL 7650B 1000	2700	50´ straight ahead × 30´ on either side[b]	none
			EL 7650B 1018	2700	50´ straight ahead × 30´on either side[b]	none
Hubbell, Inc.	H-MOSS wall switch		WSS 1200	1200	180° × 7°	none
Leviton Manufacturing Company	Decora	✜	6775	2500	180° × 2°	none
Lightolier Controls	INSIGHT	✜	IS2-600VA	750	170° × 10°	none
			IHS2-1000VA	750	170° × 10°	none
			IS3-600VA	750	170° × 10°	none
			IHS3-1000VA	750	170° × 10°	none
			IS2-1KVA-277	750	170° × 10°	none
			IHS2-2KVA-277	750	170° × 10°	none
			IS3-1KVA-277	750	170° × 10°	none
			IHS3-2KVA-277	750	170° × 10°	none
Lithonia Lighting	Litronic		LIRW	1000	180° × 30°	continuous
Mytech	LowPro2	✜	LP - 2	900L[a, b] 300S	170° × 4°	none
Pass & Seymour/legrand			WS 3000	900	180° × 10°	continuous
RAB Electric Manufacturing	Light Alert	✜	LOS 300	300	180° × 5°	none
			LOS 900	1500	180° × 5°	continuous
			LOS 1000	1000	180° × 5°	continuous

NA - not applicable
NS - not supplied by manufacturer
[a]L= large (walking) motion, S= small (hand/wrist) motion
[b]Format as supplied by manufacturer.
[c]This product is CUL listed.

Time Delay Range	Minimum Load Requirement (W)	Load Capacity (W)		Electronic Ballast Compatible	Dimmer Compatible	Certification		Warranty (yrs.)	Approximate Retail Cost (US$)
		120V	277V			UL	CSA		
1–20 min	0	1500	1500	Y	N	Y	Y	2	50.00
30 sec - 20 min	0	1200	1200	Y	N	Y	N	2	55.00
45 sec - 15 min	25 (120 V) 55 (277 V)	600	1200	Y	N	Y	Y	3	NS
45 sec - 15 min	25 (120 V) 55 (277 V)	600	1200	Y	N	Y	Y	3	NS
1–20 min	0	1500	1500	Y	N	Y	N	life	64.00
30 sec - 30 min	40	1200	2400	Y	Y	Y	Y	5	76.00
2–15 min	70	800	NA	Y	N	Y	N	3	103.00
2–15 min	70	1000	NA	Y	N	Y	N	3	153.00
2–15 min	15	600	NA	Y	N	Y	N	3	93.00
2–15 min	25	1000	NA	Y	N	Y	N	3	133.00
2–15 min	150	NA	1000	Y	N	Y	N	3	129.00
2–15 min	150	NA	2000	Y	N	Y	N	3	198.00
2–15 min	50	NA	1000	Y	N	Y	N	3	114.00
2–15 min	50	NA	2000	Y	N	Y	N	3	174.00
30 sec - 30 min	50	800	1200	Y	N	Y	N	3	NS
1–20 min.	0	600	1200	Y	Y	Y	Y	5	49.00
30 sec - 30 min	0	NS	NS	Y	N	Y	N[c]	life	NS
20 sec - 15 min	25	900	NA	N	N	N	N[c]	1	NS
9–11 min	25	800	1800	Y	Y	Y	N[c]	1	NS
30 sec - 30 min	0	800	1500	Y	Y	Y	N[c]	1	NS

Table 2a (continued). Manufacturer-Supplied Information: Features of Wall-Switch Replacement Passive Infrared Occupancy Sensors (Products marked with ✜ were tested by NLPIP)

Manufacturer	Trade Name		Catalog Number	Maximum Coverage Area (ft^2)	Field of View (horiz × vert.)	Sensitivity Adjustment
Sensor Switch, Inc.		✜	WSD	400	170° × 10°	none
			WS-170D	1000	170° × 5°	none
			WS-120-TW	2000	180° × 90°	none
			WS-120-TW-2P	2000	180° × 90°	none
			WS-170D-2P	1000	170° × 5°	none
			WSD-RR7	400	170° × 10°	none
Tork	Tork		PS 51D-120	1000	180° × 30°	continuous
			PS 51D-277	1000	180° × 30°	continuous
Universal Energy Control, Inc.	UNENCO	✜	IWS 120-277V	900	180° × 30°	none
			IWS-ZP	900	180° × 30°	none
			IWS-ZP-M	900	180° × 30°	none
			SOM-500-A	800	180° × 60°	none
		✜	SOM-1000-A Series B	1000	180° × 50°	none
			SOM-1000-A-2 Series B	1000	180° × 50°	none
			SOM-1000-A-2-LD Series B	1000	180° × 50°	none
		✜	SOM-1200-2-HD	2200	180° × 40°	none
Visonic Ltd	SRN-2000ET	✜	SRN-2000ET	16635	100° × 23°	continuous
The Watt Stopper, Inc.	Watt Stopper	✜	WA-100	300L[a, b] 150S	180° × 8.6°	discrete 2
		✜	WI-200	1000L[a, b] 300S	180° × 30°	discrete 2
			WM 120/277	900L[a, b] 300S	180° × 8.6°	continuous
			WS-R7P	900L[a, b] 300S	180° × 8.6°	continuous
			WS-120/277	900L[a, b] 300S	180° × 8.6°	continuous

NA - not applicable
NS - not supplied by manufacturer
[a]L= large (walking) motion, S= small (hand/wrist) motion
[b]Format as supplied by manufacturer.
[c]This product is CUL listed.

Time Delay Range	Minimum Load Requirement (W)	Load Capacity (W)		Electronic Ballast Compatible	Dimmer Compatible	Certification		Warranty (yrs.)	Approximate Retail Cost (US$)
		120V	277V			UL	CSA		
30 sec - 20 min	0	600	1200	Y	Y	Y	Y	5	48.00
30 sec - 20 min	0	1500	1500	Y	Y	Y	Y	5	70.00
30 sec - 20 min	0	600	1200	Y	Y	Y	Y	5	77.00
30 sec - 20 min	0	1200	2400	Y	Y	Y	Y	5	98.00
30 sec - 20 min	0	3000	3000	Y	Y	Y	Y	5	91.00
30 sec - 20 min	0	NS	NS	Y	Y	Y	Y	5	74.00
30 sec - 15 min	0	1000	NA	Y	N	Y	N	2	123.00
30 sec - 15 min	0	NA	1800	Y	N	Y	N	2	123.00
30 sec - 30 min	0	1000	1800	Y	Y	Y	N	5	42.00
30 sec - 30 min	0	1000	1800	Y	Y	Y	N	5	42.00
30 sec - 30 min	0	1000	1800	Y	Y	Y	N	5	42.00
30 sec - 30 min	0	1000	1800	Y	Y	Y	N	5	53.00
30 sec - 30 min	0	1000	1800	Y	Y	Y	N	5	54.00
30 sec - 30 min	0	1000	1800	Y	Y	Y	N	5	76.00
30 sec - 30 min	0	1000	1800	Y	Y	Y	N	5	62.00
30 sec - 30 min	0	2000	4000	Y	Y	Y	N	5	117.00
0–20 min	NS	NS	NS	N	Y	Y	N	6	65.00
15 sec - 30 min	0	800	1200	Y	Y	NS	NS	NS	58.00
15 sec - 30 min	0	800	1200	Y	Y	Y	Y	5	65.00
3 sec - 30 min	0	800	1200	Y	N	Y	Y	5	43.00
30 sec - 30 min	0	NS	NS	N	N	Y	Y	5	49.00
30 sec - 30 min	0	800	1200	Y	Y	Y	Y	5	49.00

Table 2b. Manufacturer-Supplied Information: Features of Ceiling-Mounted Passive Infrared Occupancy Sensors
(Products marked with ✜ were tested by NLPIP)

Manufacturer	Trade Name		Catalog Number	Maximum Coverage Area (ft^2)	Field of View (horiz × vert)	Recommended Mounting Height (ft)	Sensitivity Adjustment[c]
Bryant Electric, Inc.	Motion Switch		MSCM-200	200	360° × 90°	8–12	none
			MSCM-600	600	360° × 110°	8–12	none
		✜	MSCM-600HD	600	360° × 110°	8–12	none
		✜	MSCM-1000DC	1000	360° × 140°	8–12	none
			MSCM-1000AC	1000	360° × 140°	8–12	none
Douglas Lighting Controls			WRM-5101	1600L[a, b] 400S	360° × 115°	8–11	continuous
			WRM-5104	1900L[a, b] 700S	360° × 115°	8–11	continuous
Honeywell, Inc	INFRACON		EL7628A 1007	300	360°[b]	8–12	none
Hubbell, Inc.	HMCIDC	✜	HMC1DC	1250	NS	8–12	none
			HMC2DC	900	NS	8–12	none
Leviton Manufacturing Company		✜	6778	1200	360° × 110°	8	none
			6788	1300	360° × 110°	8	none
			16786	1300	360° × 110°	8	none
Lightolier Control	Insight	✜	OS-C	450	360°[b]	8–12	continuous
Lithonia Lighting	Litronic		LIRC	1500	120° × 30°	9–30	continuous
Mytech			LPC-600	900L[a, b] 300S	360° × 110°	8–12	none
	Omni		Omni-IR	1600L[a, b] 500S	360° × 138°	8–12	none
Pass & Seymour/legrand	Switchplan		CS 1001	400	360° × 110°	8–17	none
RAB Electric Manufacturing	LightAlert		LOS2400	2500	360°[b]	20	continuous
			LOS2400RC	2500	360°[b]	20	continuous
Sensor Switch, Inc.			CM-600	600	360° × 90°	up to 34	none
			CM-600-D	1000	360° × 120°	up to 14	none
			CM-600-RR7	600	360° × 120°	up to 34	none
			CM-MOT	600	360° × 120°	up to 34	none
			CMR-600	600	360° × 80°	up to 34	none
			CMR-600-D	1000	360° × 120°	up to 14	none
Steinel			ISI40	1680	140° × 8°	8–15	continuous
Tork	Tork		PC 10A	700	360° × 180°	9–20	continuous
			PC 10AT	700	360° × 180°	9–20	continuous
			PC 10AT2	700	360° × 180°	9–20	continuous
			PC 20A	2100	360° × 180°	9–11	continuous

NA - not applicable
NS - not supplied by manufacturer
[a]L= large (walking) motion, S= small (hand/wrist) motion
[b]Format as supplied by manufacturer.
[c]Number following discrete indicates the number of levels for sensitivity adjustment.
[d]Time delay in control module.

Time Delay Range	Control Module Required	Electronic Ballast Compatible	Daylight Sensor Availability	Certification		Warranty (yrs)	Approximate Retail Cost (US$)
				UL	CSA		
30 sec - 20 min	Y	Y	N	N	N	2	58.00
30 sec - 20 min	Y	Y	N	N	N	2	65.00
30 sec - 20 min	Y	Y	N	N	N	2	70.00
1 min - 30 min	Y	Y	Y	Y	N	2	58.00
10 sec	N	Y	N	Y	N	2	50.00
30 sec - 30 min	Y	N	Y	NS	NS	1	125.00
30 sec - 30 min	Y	N	N	NS	NS	1	125.00
12 min	Y	Y	N	Y	Y	2	NS
30 sec - 30 min[d]	Y	Y	N	Y	Y	life	80.00
30 sec - 30 min[d]	Y	Y	N	N	N	life	80.00
30 sec - 30 min	Y	Y	Y	Y	Y	5	101.00
10 sec - 20 min	Y	Y	N	Y	Y	5	40.00
15 sec - 20 min	N	Y	Y	Y	Y	5	100.00
20 sec - 30 min	Y	Y	Y	Y	N	3	60.00
15 sec - 30 min	Y	Y	N	Y	N	3	NS
30 sec - 22 min	Y	Y	N	N	N	5	80.00
8 sec - 30 min	Y	Y	Y	N	N	5	60.00
15 sec - 25 min	Y	Y	N	Y	Y	life	NS
10 min - 15 min	N	Y	N	Y	N	1	NS
10 min - 15 min	Y	Y	N	Y	N	1	NS
30 sec - 20 min	Y	Y	N	Y	Y	5	63.00
30 sec - 20 min	Y	Y	N	Y	Y	5	63.00
30 sec - 20 min	N	Y	N	Y	Y	5	72.00
30 sec - 20 min	N	Y	N	Y	Y	5	70.00
30 sec - 20 min	N	Y	N	Y	Y	5	74.00
30 sec - 20 min	N	Y	N	Y	Y	5	74.00
10 sec - 15 min	N	Y	Y	Y	Y	life	58.00
30 sec - 15 min	Y	Y	N	N	N	2	154.00
30 sec - 15 min	Y	Y	N	N	N	2	164.00
30 sec - 15 min	Y	Y	N	N	N	2	164.00
30 sec - 15 min	Y	Y	N	N	N	2	195.00

Table 2b (continued). Manufacturer-Supplied Information: Features of Ceiling-Mounted Passive Infrared Occupancy Sensors (Products marked with ✜ were tested by NLPIP)

Manufacturer	Trade Name		Catalog Number	Maximum Coverage Area (ft^2)	Field of View (horiz × vert)	Recommended Mounting Height (ft)	Sensitivity Adjustment[c]
Universal Energy Control, Inc.	UNENCO		PIR-500-P	500	360° × 120°	8–11	none
			PIR-1000-H	1200	360° × 150°	8–11	none
			PIR-1000-P Series B	1000	360° × 120°	8–11	none
			PIR-1000-H-P	1200	360° × 150°	8–11	none
			PIR-1000-QTI Series B	1000	360° × 120°	8–11	none
			PIR-1000-EMS Series B	1000	360° × 120°	8–11	none
			PIR-2000-P	2000	360° × 138°	8–11	none
		✜	PIR-2000-QTI	2000	360° × 138°	8–11	none
			PIR-2000-EMS	2000	360° × 138°	8–11	none
			MODEL DT	200	180° × 90°	8–11	none
			MODEL DT-D	28	360° × 60°	8–9	none
Visonic Inc.	DISC ET	✜	DISC ET	1000	360° × 112°	8–12	none
The Watt Stopper, Inc.	Watt Stopper		CB-100	1200L	101° × 77°	8–12	discrete 4
			CI-12	1200L[a, b] 300S	360° × 140°	8–12	discrete 2
			CI-12-1	500L[a, b] 300S	360° × 113°	8–12	discrete 2
			CI-24	1200L[a, b] 300S	360° × 140°	8–12	discrete 2
			CI-24-1	500L[a, b] 300S	360° × 113°	8–12	discrete 2
			CI-100	1200	101° × 77°	8–12	continuous
			CI-105	1200	101° × 77°	8–12	continuous
			CI-200	1200L[a, b] 300S	360° × 140°	8–12	discrete 4
			CI-200-1	500L[a, b] 300S	360° × 113°	8–12	discrete 4
			CI-205	1200L[a, b] 300S	360° × 118°	8–12	discrete 4
			CI-205-1	500L[a, b] 300S	360° × 113°	8–12	discrete 4
			WPIR	300L[a, b] 150S	170° × 80°	8–12	continuous

NA - not applicable
NS - not supplied by manufacturer
[a]L= large (walking) motion, S= small (hand/wrist) motion
[b]Format as supplied by manufacturer.
[c]Number following discrete indicates the number of levels for sensitivity adjustment.
[d]Time delay in control module.

Time Delay Range	Control Module Required	Electronic Ballast Compatible	Daylight Sensor Availability	Certification		Warranty (yrs)	Approximate Retail Cost (US$)
				UL	CSA		
30 sec - 30 min	N	Y	N	Y	N	5	60.00
30 sec - 30 min	Y	Y	N	Y	N	5	72.00
30 sec - 30 min	N	Y	N	Y	N	5	80.00
30 sec - 30 min	N	Y	N	Y	N	5	89.00
30 sec - 30 min	Y	Y	N	Y	N	5	65.00
30 sec - 30 min	Y	Y	N	Y	N	5	69.00
30 sec - 30 min	N	Y	N	Y	N	5	95.00
30 sec - 30 min	Y	Y	N	Y	N	5	80.00
30 sec - 30 min	Y	Y	N	Y	N	5	85.00
3 min - 15 min	Y	Y	Y	Y	N	5	57.00
none	N	Y	Y	Y	N	5	57.00
3 sec - 12 min	Y	N	N	Y	N	6	65.00
15 sec - 10 min	Y	Y	NS	Y	Y	5	125.00
30 sec - 30 min	N	NS	N	Y	Y	5	56.00
30 sec - 30 min	N	NS	N	Y	Y	5	56.00
30 sec - 30 min	N	NS	N	Y	Y	5	56.00
30 sec - 30 min	N	NS	N	Y	Y	5	56.00
15 sec - 30 min	Y	Y	Y	Y	Y	5	81.00
15 sec - 30 min	Y	Y	N	Y	Y	5	63.00
15 sec - 30 min	Y	Y	Y	Y	Y	5	81.00
15 sec - 30 min	Y	Y	Y	Y	Y	5	81.00
15 sec - 30 min	Y	Y	N	Y	Y	5	63.00
15 sec - 30 min	Y	Y	N	Y	Y	5	63.00
30 sec - 30 min	Y	Y	N	Y	Y	5	55.00

Table 3a. Manufacturer-Supplied Information: Features of Wall-Switch Replacement Ultrasonic Occupancy Sensors

Manufacturer	Trade Name	Catalog Number	Maximum Coverage Area (ft^2)	Field of View (horiz × vert)	Sensitivity Adjustment	Time Delay Range
Mytech	Rest Room Supra-Sensor	RRSST8	600L[a] 300S	180° × 180°	continuous	8 sec - 32 min
	Supra-Sensor	SST8	800L[a] 300S	180° × 180°	continuous	8 sec - 32 min
Tork	Tork	SC 20	2000	NS	continuous	30 sec - 15 min

[a]L= large (walking) motion, S= small (hand/wrist) motion

Minimum Load Requirement (W)	Load Capacity (W)		Electronic Ballast Compatible	Dimmer Compatible	Ultrasonic Frequency (kHz)	Certification		Warranty (yrs.)	Approximate Retail Cost (US$)
	120V	277V				UL	CSA		
40 (120 V), 90 (270 V)	740	1400	Y	N	32	Y	Y	5	91.00
40 (120 V), 90 (270 V)	740	1400	Y	N	32	Y	Y	5	91.00
0	NS	NS	Y	N	25	N	N	2	195.00

Table 3b. Manufacturer-Supplied Information: Features of Ceiling-Mounted Ultrasonic Occupancy Sensors
(Products marked with ✜ were tested by NLPIP)

Manufacturer	Trade Name		Catalog Number	Maximum Coverage Area (ft^2)	Field of View (horiz × vert)	Recommended Mounting Height (ft)	Sensitivity Adjustment[c]
Honeywell, Inc.	Honeywell		EL7611A1003	1000	NS	8–12	discrete 10
		✜	EL7612A1001	2000	NS	8–12	discrete 10
Leviton Manufacturing Company			6878-1W	1000	180° × 360°	8	continuous
			6878-2W	2000	360° × 360°	8	continuous
Lithonia Lighting			LUS 1000	1000	360° × 180°	9	continuous
Mytech	Omnisensor		MAS 350SF	350L[a] 250S	180°[b]	9	continuous
			MAS 700SF	700L[a] 500S	180°[b]	9	continuous
			LAS 1000SF	1000L[a] 800S	180°[b]	9	continuous
			LAS 1800SF	1800L[a] 1400S	360°[b]	9	continuous
		✜	LAS 2200SF	2200L[a] 1300S	270°[b]	9	continuous
			LAS 3300SF	3300L[a] 1300S	90°[b]	9	continuous
	Omni		DT-360	2200L[a] 1100S	360° × 180°	9	continuous
			DT-180	1100L[a] 550S	180° × 180°	9	continuous
			US-360	2200L[a] 1100S	360° × 180°	9	continuous
			US-180	1100L[a] 550S	180° × 180°	9	continuous
Pass & Seymour/legrand			US1001	500	NS	10	continuous
Technology Design Center, Inc.	Lights out		LO550	500	NS	8–10	continuous
			LO1000	1000	NS	8–10	none
			LO2000	2000	NS	8–10	continuous
Universal Energy Control, Inc.	UNENCO		C-500-800-EMS	800	360° × 180°	8–12	continuous
			C-500-800-QTI	800	360° × 180°	8–12	continuous
			C-500-800-SC	800	360° × 180°	8–12	continuous
			C-500-1000 HP	1500	360° × 180°	7–21	continuous
			C-500-1000-H-QTI	1500	360° × 180°	7–21	continuous
			C-500-2000-P	2000	360° × 180°	7–21	continuous
		✜	C-500-2000-QTI	2000	360° × 180°	7–21	continuous
			C-600-R-QTI	600	360° × 180°	8–12	continuous
			C-800-1500-EMS	1500	360° × 180°	8–12	continuous
		✜	C-800-1500-QTI	1500	360° × 180°	8–12	continuous
The Watt Stopper Inc.	Watt Stopper		W-500A	500L[a]	360° × 180°	8–12	continuous
			W-550A	500L[a]	360° × 180°	8–12	continuous
		✜	W-1000A	1000L[a]	360° × 180°	8–12	continuous
			W-1050A	1000L[a]	360° × 180°	8–12	continuous
			W-2000A	2000L[a]	360° × 180°	8–12	continuous
			W-2050A	2000L[a]	360° × 180°	8–12	continuous

NA - not applicable
NS - not supplied by manufacturer
[a]L= large (walking) motion, S= small (hand/wrist) motion
[b]Format as supplied by manufacturer.
[c]Number following discrete indicates the number of levels for sensitivity adjustment.
[d]This product is CUL listed.

Time Delay Range	Control Module Required	Electronic Ballast Compatible	Daylight Sensor Availability	Ultrasonic Frequency (kHz)	Certification UL	Certification CSA	Warranty (yrs)	Approximate Retail Cost (US$)
15 sec - 15 min	Y	Y	N	25	Y	Y	3	NS
15 sec - 15 min	Y	Y	N	25	Y	Y	3	NS
30 sec - 30 min	Y	Y	Y	32.768 ± 0.005	Y	Y	5	102.00
30 sec - 30 min	Y	Y	Y	32.768 ± 0.005	Y	Y	5	120.00
10 sec - 30 min	Y	Y	N	25	Y	N	3	NS
8 sec - 32 min	Y	Y	Y	25, 32	N	N	5	75.00
8 sec - 32 min	Y	Y	Y	25, 32	N	N	5	85.00
8 sec - 32 min	Y	Y	Y	25, 32	N	N	5	93.00
8 sec - 32 min	Y	Y	Y	25, 32	N	N	5	112.00
8 sec - 32 min	Y	Y	Y	25, 32	N	N	5	112.00
8 sec - 32 min	Y	Y	Y	25, 32	N	N	5	129.00
8 sec - 30 min	Y	Y	Y	25, 32, 40	NA	NA	5	NS
8 sec - 30 min	Y	Y	Y	25, 32, 40	NA	NA	5	NS
8 sec - 30 min	Y	Y	Y	25, 32, 40	NA	NA	5	90.00
8 sec - 30 min	Y	Y	Y	25, 32, 40	NA	NA	5	85.00
15 sec - 15 min	Y	Y	N	NS	Y	N[d]	lifetime	NS
5–15 min	Y	Y	N	NS	N	N	5	75.00
5–8 min	Y	Y	N	NS	N	N	3	88.00
5–15 min	Y	Y	N	NS	N	N	3	113.00
30 sec - 30 min	Y	Y	N	32.7	y	N	5	61.00
30 sec - 30 min	Y	Y	N	32.7	Y	N	5	56.00
30 sec - 30 min	N	Y	N	32.7	Y	N	5	70.00
30 sec - 30 min	N	Y	N	32.7	Y	N	5	109.00
30 sec - 30 min	Y	Y	N	32.7	Y	N	5	101.00
30 sec - 30 min	N	Y	N	32.7	Y	N	5	107.00
30 sec - 30 min	Y	Y	N	32.7	Y	N	5	93.00
30 sec - 30 min	Y	Y	N	32.7	Y	N	5	68.00
30 sec - 30 min	Y	Y	N	32.7	Y	N	5	74.00
30 sec - 30 min	Y	Y	N	32.7	Y	N	5	70.00
15 sec - 15 min	Y	Y	N	25	Y	Y	5	73.00
15 sec - 15 min	Y	Y	N	25	Y	Y	5	85.00
15 sec - 15 min	Y	Y	N	25	Y	Y	5	88.00
15 sec - 15 min	Y	Y	N	25	Y	Y	5	100.00
15 sec - 15 min	Y	Y	N	25	Y	Y	5	103.00
15 sec - 15 min	Y	Y	N	25	Y	Y	5	115.00

Table 4. Manufacturer-Supplied Information: Dual-Technology Occupancy Sensors

Manufacturer	Trade Name	Catalog Number	Maximum Coverage Area (ft^2)	Field of View (horiz × vert.)	Recommended Mounting Height (ft)	Sensitivity Adjustment
Sensor Switch, Inc. (PIR-Microphonic)		PDT-CM[c]	2000	360° × 145°	up to 12	none
		CMR-PDT[c]	2000	360° × 145°	up to 12	none
		PDT-WV[c]	2000	180° × 90°	up to 10	none
		WSH-120-TW[w]	2000	180° × 90°	up to 10	none
		WSH-120-TW-2P[w]	2000	180° × 90°	up to 10	none
Universal Energy Control, Inc. (PIR-Ultrasonic)	UNENCO	CUI-500-2000-QTI[c]	2000	360° × 138°	8–12	continuous
		CUI-500-2000-SC[c]	2000	360° × 138°	8–12	continuous
The Watt Stopper, Inc. (PIR-Ultrasonic)	Watt Stopper	DT-100L[w2]	1200L[a]	360° × 180°	8–12	continuous

NA - not applicable
NS - not supplied by manufacturer
[a]L= large (walking) motion, S= small (hand/wrist) motion

Product ratings apply when mounted at these heights.
[c]Ceiling-mounted at 8–12 ft.
[w]Wall-mounted at 7–8 ft.
[w2]Wall-mounted at 10 ft.

Time Delay Range	Control Module Required	Electronic Ballast Compatible	Daylight Sensor Availability	Ultrasonic Frequency (kHz)	Certification		Warranty (yrs)	Approximate Retail Cost (US$)
					UL	CSA		
30 sec - 20 min	Y	Y	N	NS	Y	Y	5	70.00
30 sec - 20 min	N	Y	N	NS	Y	Y	5	84.00
30 sec - 20 min	Y	Y	N	NS	Y	Y	5	77.00
30 sec - 20 min	N	Y	N	NS	Y	Y	5	98.00
30 sec - 20 min	N	Y	N	NS	Y	Y	5	119.00
30 sec - 30 min	Y	Y	N	NS	Y	N	5	117.00
30 sec - 30 min	N	Y	N	NS	Y	N	5	142.00
15 sec - 15 min	Y	Y	Y	40	Y	Y	5	138.00

Table 5. Manufacturer-Supplied Information: Features of Control Modules

Manufacturer	Trade Name	Catalog Number	Transformer Secondary Voltage (V dc)	Maximum Number of Sensors
Bryant Electric, Inc.	Motion Switch	CM 120/277	12	15
		CP 120/277	15	25
Douglas Lighting Controls	Douglas	WR-6221	24 (AC)	25
		WR-6161	24 (AC)	25
Honeywell, Inc.	Honeywell Infracon	EL7630A	15	4
	Honeywell	EL7621A 120	12	3
		EL7621A 277	12	3
Hubbell, Inc.		HMC	12	15
Leviton Manufacturing Company		6779	12	10
		6773-CBX	12	7
		6774-CBX	12	7
		6783-120	NA	NA
		6783-277	NA	NA
		6789	12	6
Lightolier Controls	Insight Systems	OSPS-10A	12	12
		OSPS-20A 120	12	12
		OSPS-20A-277	12	12
Lithonia Lighting	LITRONIC	LPCS	24	4
Mytech	Power Control Station	PCS-24	24 (AC)	10
	Slave Relay	SL-20 A	0	NA
	Transformer	T-40VA	24 (AC)	20
	Mini-Power Pack	MP-120	24	3
	Mini-Power Pack	MP-227	24	3
	Mini- PowerSlave	MP-S (Slave)	NA	NA

NA - not applicable
NS - not supplied by manufacturer
[a]NLPIP requested watts, manufacturer supplied amps.
[b]Listed as CUL.

Number of Circuits Controlled	Load Capacity (W) (per circuit)		Master/Slave Configurable	Certification		Warranty (yrs)	Approximate Cost (US$)
	120 V	277 V		UL	CSA		
1	1800	3000	Y	Y	Y	2	75.00
1	2500	3000	Y	Y	N	2	78.00
1	20 Amps[a]	20 Amps[a]	Y	Y	Y	1	25.00
1	20 Amps[a]	20 Amps[a]	Y	Y	Y	1	40.00
1	1500	2500	N	Y	Y	2	NS
1	20 Amps[a]	20 Amps[a]	N	Y	Y	3	NS
1	20 Amps[a]	20 Amps[a]	N	Y	Y	3	NS
1	1800	3000	NS	Y	Y	NS	56.00
1	2400	4800	N	Y	N	5	82.00
1	1800	NA	N	Y	N	5	46.00
1	NA	2700	N	Y	N	5	46.00
1	800	NA	N	Y	N	5	54.00
1	NA	2800	N	Y	N	5	46.00
4	NS	NS	N	Y	N	5	43.00
1	1200	2200	N	Y	N	3	120.00
1	1900	NA	N	Y	N	3	195.00
1	NA	4400	N	Y	N	3	195.00
1	16 Amps[a]	16 Amps[a]	Y	Y	N	3	NS
1	2400	2400	Y	Y	N	5	29.00
1	2400	2400	Y	Y	N	5	21.00
1	NA	NA	Y	Y	N	5	23.00
1	2400	NA	Y	Y	N	5	24.00
1	NA	2400	Y	Y	N	5	24.00
1	2400	2400	Y	Y	N	5	20.00

Table 5 (continued). Manufacturer-Supplied Information: Features of Control Modules

Manufacturer	Trade Name	Catalog Number	Transformer Secondary Voltage (V dc)	Maximum Number of Sensors
Pass & Seymour/legrand	Switchplan	PWP120	24	4
		PWP277	24	4
Sensor Switch, Inc.		CU-20	15	15
		CU-20-2P	15	15
		AR-20	15	15
Technology Design Center, Inc.	Lights Out	LOI-612	24	3
		LOI-627	24	3
		LOI-6NT-2RI	24	NA
		LOI-612-32RI	24	8
		LOI-627-32RI	24	8
Tork	Tork	TRP 1	24	4
		TRP 2	24	4
		TRP 5	24	4
VISONIC		TRV120	12	2
Universal Energy Control, Inc.	UNENCO	211-1	24	4
		212-1	24	4
		213-1	24	4
		HDPP-120V	24	4
		HDPP-277V	24	4
		SRP-1-A	NA	none
The Watt Stopper, Inc	Watt Stopper	A120E-P	24	8
		A277E-P	24	8
		C120E	24	8
		C277E	24	8
		A120C-P	24	8
		A277C-P	24	8

NA - not applicable
NS - not supplied by manufacturer
[a]NLPIP requested Watts, manufacturer supplied Amps.
[b]Listed as CUL.

Number of Circuits Controlled	Load Capacity (W) (per circuit)		Master/Slave Configurable	Certification		Warranty (yrs)	Approximate Cost (US$)
	120 V	277 V		UL	CSA		
1	20	—	Y	Y	N[b]	lifetime	NS
1	—	20	Y	Y	N[b]	lifetime	NS
1	2400	5540	Y	Y	Y	5	63.00
2	2400	5540	Y	Y	Y	5	84.00
1	2400	5540	Y	Y	Y	5	34.00
1	20 Amps[a]	20 Amps[a]	N	Y	N	3	27.00
1	20 Amps[a]	20 Amps[a]	N	Y	N	3	29.00
2	20 Amps[a]	20 Amps[a]	N	Y	N	3	34.00
2	20 Amps[a]	NA	N	Y	N	3	46.00
2	NA	20 Amps[a]	N	Y	N	3	48.00
1	20 Amps[a]	NA	Y	Y	N	2	43.00
1	20 Amps[a]	20 Amps[a]	Y	Y	N	2	43.00
1	20 Amps[a]	NA	Y	Y	N	2	43.00
1	20 Amps[a]	20 Amps[a]	N	Y	N	NS	33.00
1	2400	4500	Y	Y	N	5	23.00
1	2400	4500	Y	Y	N	5	23.00
1	2400	4500	Y	Y	N	5	23.00
1	2400	5000	Y	Y	N	5	26.00
1	2400	5000	Y	Y	N	5	26.00
1	1000	1800	Y	Y	N	5	18.00
1	20 Amps[a]	—	Y	Y	Y	5	23.00
1	—	20 Amps[a]	Y	Y	Y	5	23.00
2	20 Amps[a]	—	Y	Y	Y	5	NS
2	—	20 Amps[a]	Y	Y	Y	5	NS
1	8 Amps[a]	—	Y	Y	Y	5	23.00
1	—	6 Amps[a]	Y	Y	Y	5	23.00

Table 6. Summary of NLPIP Performance Evaluations: Ceiling-Mounted Occupancy Sensors in an Open Office Application

Manufacturer	Trade Name	Catalog Number	Sensitivity Setting	Manufacturer-Reported Coverage Area (ft^2)[a]	Number of Test Locations Within Coverage Area
Passive Infrared Occupancy Sensors					
Bryant Electric, Inc.	Motion Switch	MSCM-600HD	none	480	31
	Motion Switch	MSCM1000-DC	none	823	41
Hubbell, Inc.[b]		HMC1DC	none	823	41
Leviton Manufacturing Company		6778	none	1300	55
Lightolier Controls	INSIGHT	OS-C	max	400	25
Universal Energy Control, Inc.	UNENCO	PIR-2000-QTI	none	2000	55
Visonic Ltd.	DISC ET	DISC ET	none	575	35
Ultrasonic Occupancy Sensors					
Honeywell, Inc.[c]	Honeywell	EL7612 A 1001	8 (of 10)[c]	2000[d]	55
Mytech	Omnisensor	LAS 2200SF	Max	2112	55
Universal Energy Control, Inc.	UNENCO	C-500-2000-QTI	Max	2394[d]	55
	UNENCO	C-800-1500-QTI	Max	1600	55
The Watt Stopper, Inc.[c]	Watt Stopper	W-1000A	5 (of 10)[c]	1000[d]	55

[a]Coverage areas are for 9 ft. mounting height unless otherwise indicated.
[b]Manufacturer recommended using two sensors in this application, thus results are for two sensors. See the plotted data for sensor locations.
[c]In order to start testing with the lamps off, NLPIP had to decrease the sensitivity.
[d]Coverage area is for 10 ft. mounting height.

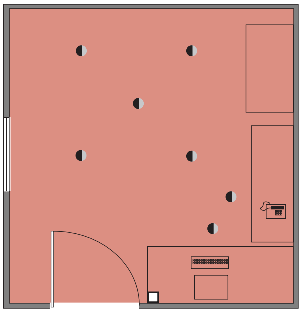
Table 7. Summary of NLPIP Performance Evaluations: Wall-Switch Replacement Passive Infrared Occupancy Sensors in a Private Office Application

				NLPIP Measured Data: No. of Test Locations (Out of 7) Where Motion Was Detected	
Manufacturer	Trade Name	Catalog Number	Manufacturer-Reported Coverage Area (ft^2)	Medium-Sized (Arm) Motion Detection	Small-Sized (Hand/Wrist) Motion Detection
Leviton Manufacturing Company	Decora	6775-W	2700	7	0
Lightolier Controls	INSIGHT	IS2-600VA-W	750	7	7
Mytech	LowPro2	LP-2-IVORY	960	7	0
RAB Electric Manufacturing	Light Alert	LOS 300	300	7	0
Sensor Switch, Inc.		WSD-I	800	7	0
Universal Energy Control, Inc.	UNENCO	IWS 120-277V	960	7	0
	UNENCO	SOM-1000-A (Series B)	1000	7	0
	UNENCO	SOM-1200-2-HD	1200	7	1
Visonic Ltd.	SRN-2000ET	SRN-2000ET	12,000	7	7
The Watt Stopper, Inc.	Watt Stopper	WI-200	1000	7	7
	Watt Stopper	WS-120/277	900	7	5

NLPIP Measured Data	
Medium-Sized (Arm) Motion Detection	
No. of Test Locations (Out of 55) Where Motion Was Detected	% of Coverage Area Where Motion Was Detected
11	35%
7	17%
10	24%
17	31%
19	76%
24	44%
24	69%
54	98%
55	100%
50	91%
32	58%
55	100%

Table 8. NLPIP-Measured Data: Passive Infrared Occupancy Sensors for Wall-Switch Replacement[a]

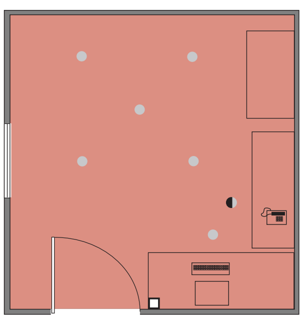
(HVAC on for all measurements)



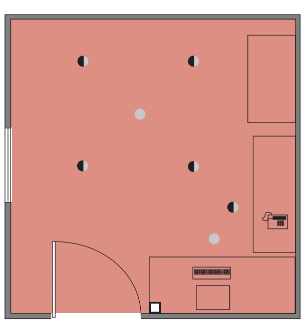
Manufacturer	The Watt Stopper
Trade Name	Watt Stopper
Catalog Number	WI-200
Reported Coverage Area	1,000 ft^2
Time Delay	2 min

Manufacturer	Visonic LTD.
Trade Name	SRN-2000ET
Catalog Number	SRN-2000ET with lens no. 15
Reported Coverage Area	16,635 ft^2
Time Delay	42 sec

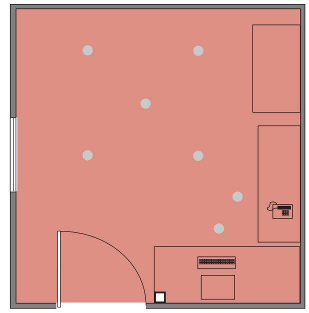
Manufacturer	Lightolier Controls
Trade Name	INSIGHT
Catalog Number	IS2-600VA-W
Reported Coverage Area	750 ft^2
Time Delay	4 min



Manufacturer	Universal Energy Control, Inc.
Trade Name	UNENCO
Catalog Number	SOM-1200-2-HD 120-277V
Reported Coverage Area	2,200 ft^2
Time Delay	5 min 45 sec



Manufacturer	The Watt Stopper, Inc.
Trade Name	Watt Stopper
Catalog Number	WS-120/277
Reported Coverage Area	900 ft^2
Time Delay	1 min



Manufacturer	Leviton Manufacturing Co.
Trade Name	Decora
Catalog Number	6,775-W
Reported Coverage Area	2,500 ft^2
Time Delay	30 sec

Manufacturer	Mytech
Trade Name	LowPro2
Catalog Number	LP-2-IVORY
Reported Coverage Area	900 ft^2
Time Delay	1 min

Manufacturer	RAB Electric Manufacturing
Trade Name	Light Alert
Catalog Number	LOS 300
Reported Coverage Area	300 ft^2
Time Delay	40 sec

Manufacturer	Sensor Switch, Inc.
Trade Name	Sensor Switch
Catalog Number	WSD-1
Reported Coverage Area	400 ft^2
Time Delay	1 min

Manufacturer	Universal Energy Control, Inc.
Trade Name	UNENCO
Catalog Number	IWS 120-277V
Reported Coverage Area	900 ft^2
Time Delay	1 min

Manufacturer	Universal Energy Control, Inc.
Trade Name	UNENCO
Catalog Number	SOM-1000-A (Series B)
Reported Coverage Area	1,000 ft^2
Time Delay	1 min

[a] Room dimensions as reported on p. 11

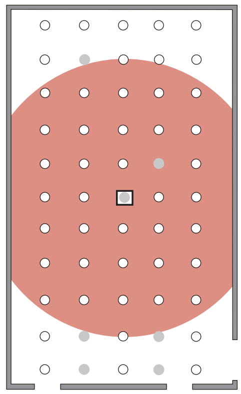
□ Wall-switch replacement passive infrared sensor

● Detected medium-sized motion only

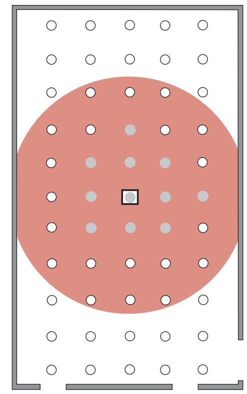
◐ Detected both medium- and small-sized motions

■ Manufacturer-reported coverage area

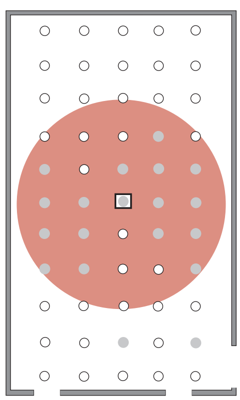
Table 9. NLPIP-Measured Data: Ceiling-Mounted Passive Infrared Occupancy Sensors[a]
(HVAC on for all measurements)



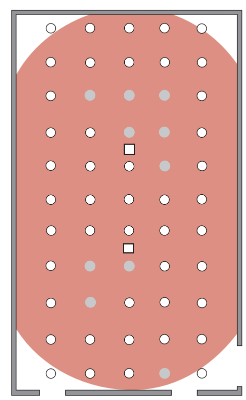
Manufacturer	Bryant Electric, Inc.
Trade Name	Motion Switch
Catalog Number	MSCM1000-DC
Calculated Coverage Area	800 ft^2 @ 9 ft
Sensitivity	NA
Time Delay	58 sec



Manufacturer	Bryant Electric, Inc.
Trade Name	Motion Switch
Catalog Number	MSCM-600HD
Calculated Coverage Area	480 ft^2 @ 9 ft
Sensitivity	NA
Time Delay	1 min



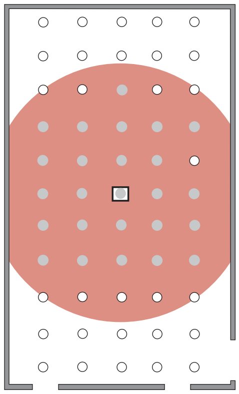
Manufacturer	Lightolier Controls
Trade Name	Insight
Catalog Number	OS-C
Calculated Coverage Area	400 ft^2 @ 9 ft
Sensitivity	Maximum
Time Delay	20 sec



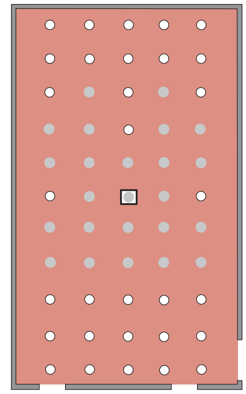
Manufacturer	Hubbell
Trade Name	H-MOSS
Catalog Number	HMC1DC
Calculated Coverage Area	823 ft^2 @ 9 ft
Sensitivity	NA
Time Delay	1 min

[a] Room dimensions as reported on p.10
☐ Passive infrared occupancy sensor
● Detected medium-sized motion
○ No motion detected
■ Manufacturer-reported coverage area

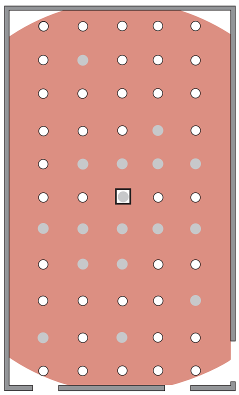
Table 9 (continued). NLPIP-Measured Data: Ceiling-Mounted Passive Infrared Occupancy Sensors
(HVAC on for all measurements)



Manufacturer	Visonic Ltd.
Trade Name	DISC ET
Catalog Number	DISC ET
Calculated Coverage Area	575 ft^2 @ 9 ft
Sensitivity	NA
Time Delay	32 sec



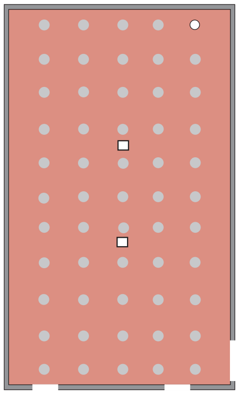
Manufacturer	Universal Energy Control, Inc.
Trade Name	UNENCO
Catalog Number	PIR-2,000-QTI
Calculated Coverage Area	2,000 ft^2 @ 9 ft
Sensitivity	NA
Time Delay	55 sec



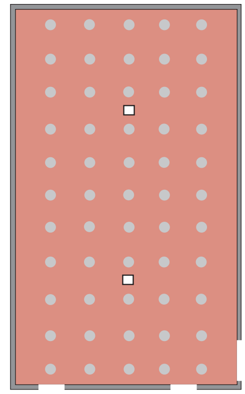
Manufacturer	Leviton Manufacturing Company
Trade Name	NA
Catalog Number	6778
Calculated Coverage Area	1,600 ft^2 @ 9 ft
Sensitivity	NA
Time Delay	55 sec

[a] Room dimensions as reported on p. 10
☐ Passive infrared occupancy sensor
● Detected medium-sized motion
○ No motion detected
■ Manufacturer-reported coverage area

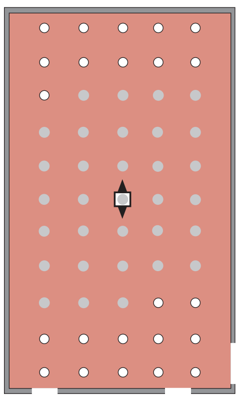
Table 10. NLPIP-Measured Data: Ceiling-Mounted Ultrasonic Occupancy Sensors[a]
(HVAC off for all measurements)



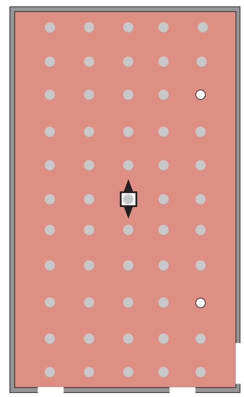
Manufacturer	Honeywell, Inc.
Trade Name	Honeywell
Catalog Number	EL7612 A 1001
Reported Coverage Area	2,000 ft^2 @ 9 ft
Sensitivity	Maximum
Time Delay	49 sec



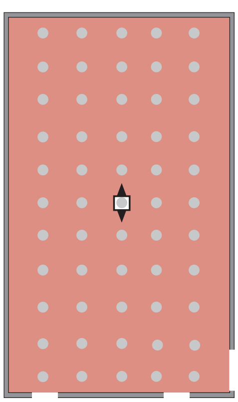
Manufacturer	The Watt Stopper, Inc.
Trade Name	Watt Stopper
Catalog Number	W-1000A
Reported Coverage Area	1,000 ft^2 @ 9 ft
Sensitivity	Maximum
Time Delay	50 sec



Manufacturer	Universal Energy Control, Inc.
Trade Name	UNENCO
Catalog Number	C-800-1500 QTI
Reported Coverage Area	1,500 ft^2
Sensitivity	Maximum
Time Delay	55 sec



Manufacturer	Universal Energy Control, Inc.
Trade Name	UNENCO
Catalog Number	C-500-2000 QTI
Reported Coverage Area	2,000 ft^2 @ 9 ft
Sensitivity	Maximum
Time Delay	59 sec



Manufacturer	Mytech
Trade Name	Omnisensor
Catalog Number	LAS 2,200
Reported Coverage Area	2,200 ft^2 @ 9 ft
Sensitivity	Maximum
Time Delay	33 sec

a Room dimensions as reported on p. 10

Ultrasonic occupancy sensor
Arrows indicate transmitter orientation

Detected medium-sized motion

No motion detected

Manufacturer-reported coverage area

NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

Specifier Reports

Occupancy Sensors

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