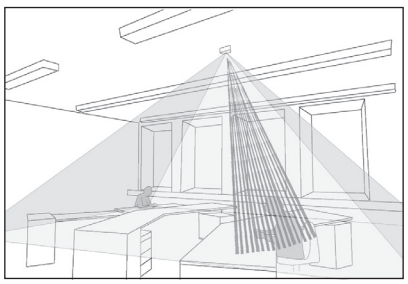
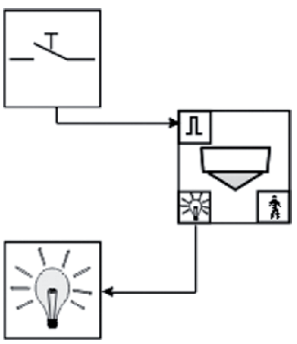
thebenHTS

Technology
Presence Detectors

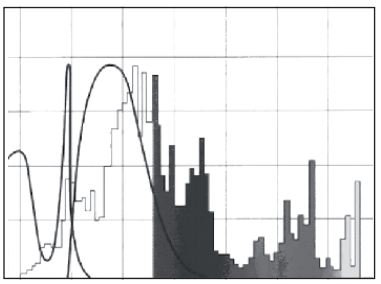
Presence Detection



Configurations



Light Measurement



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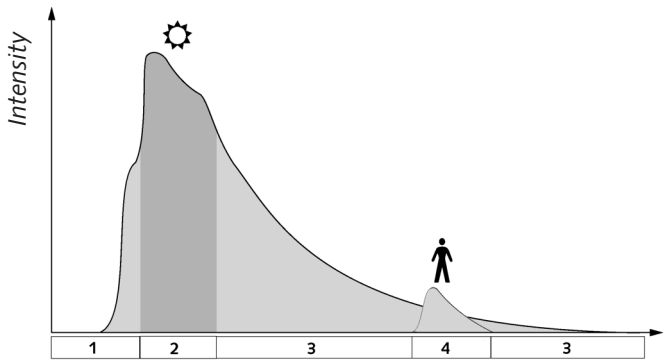
1. Presence Detection

1.1. Passive Infrared Technology



Schematic representation of the spectrum of sunlight

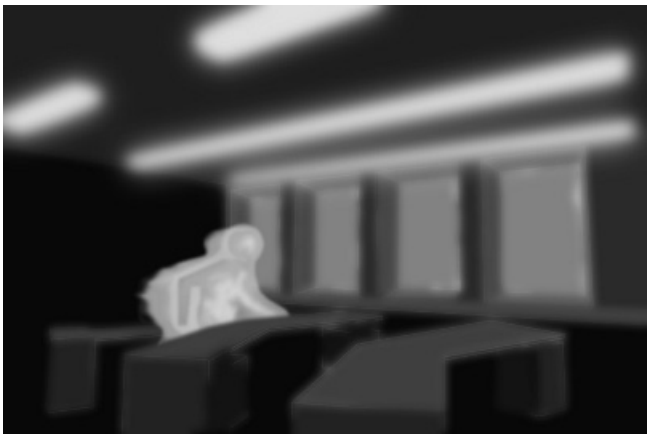
Range 1: short wavelength UV, invisible ultraviolet
Range 2: visible light
Range 3: long wavelength thermal radiation (IR)
Range 4: infrared range for presence detection (7-14 µm)

PIR stands for "Passive Infrared". Infrared radiation, also known as heat radiation or thermal radiation, is a form of electromagnetic wave.

Every object, including the human body, emits thermal radiation according to its temperature. This infrared radiation is invisible to the human eye.

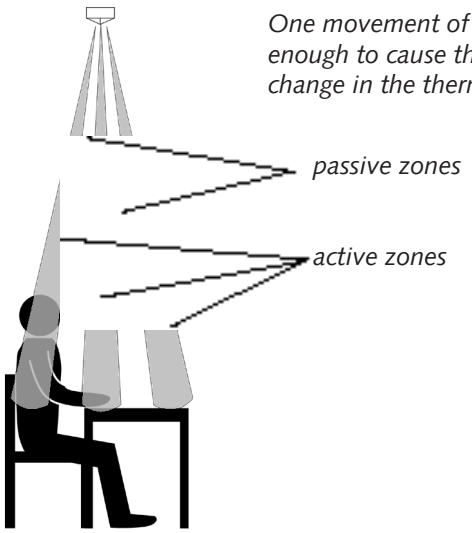
The thermal radiation from the human body falls in the infrared range and can be detected by passive infrared sensors. These sensors do not emit radiation in any way. They only "receive" and are appropriately called "Passive IR sensors".

1.2 Operating principle of Passive Infrared Detectors



Infrared image of a person at work. Warmer surfaces are depicted in lighter colours, colder ones in darker colours.

Human beings emit thermal radiation. Heat diagrams show the temperature distribution over the body surface in the infrared part of the spectrum. Furniture (e.g. desks) emits less heat, and warm fluorescent lights correspondingly more.



One movement of the hand is enough to cause the necessary change in the thermal radiation.

Passive infrared detectors respond only to changes in thermal radiation. To do this they use a dense checkerboard grid pattern of active and passive zones. One movement of the hand is sufficient to recognise that someone is present.

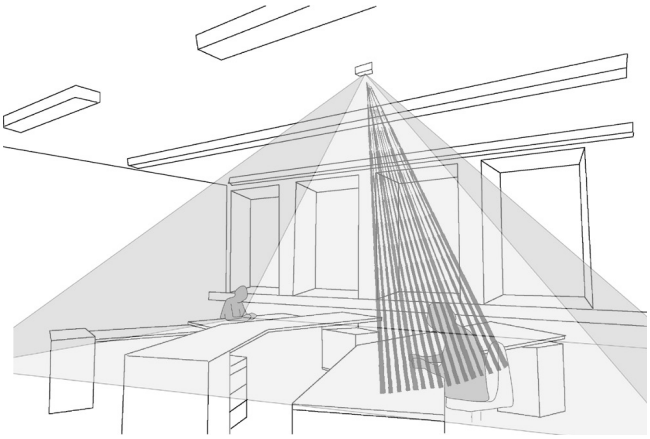
Passive infrared detectors have sensors which only react to changes in the thermal radiation. As long as the thermal radiation is constant they do not generate signals. In order to be able to react to movement, motion detectors use an optical system of lenses and mirrors to divide the whole detection area into a checkerboard grid pattern of active and passive zones.

Any person within the sensor's detection area is fully or partially registered by several active zones.

Normally the thermal image of the background changes very slowly and smoothly, while human beings cause more sudden changes in the thermal image. Thus the presence of persons may be detected reliably through slight changes in the heat absorption.

These changes in the thermal radiation generate an electric signal in the sensor, which is then processed in order to control lighting or other electrical devices such as HVAC systems, blinds, etc. according to occupancy.

1.3 The Passive Infrared Presence Detector

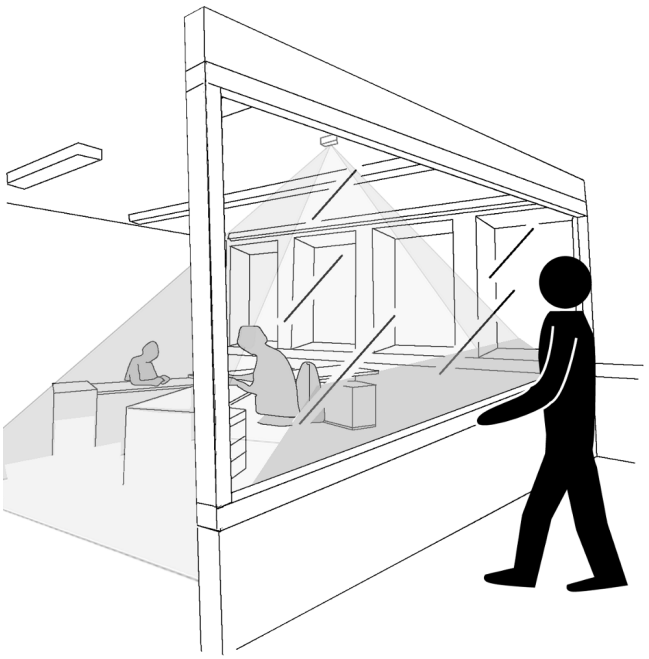


Over 100 zones detect the slightest movement in the detection area.

Presence Detection

While motion detectors only react to rather large movements, Theben HTS presence detectors can even detect seated persons reliably. This is achieved by optimisation of all the presence detector's components. The operating principle basically corresponds to that of passive infrared motion detectors.

The large number of active zones, their homogenous distribution and the high detection sensitivity enable the presence detector to register the slightest movements perfectly and to react to minimal changes in the thermal image. In addition Theben HTS presence detectors possess a large number of other features which distinguish them from conventional motion detectors.

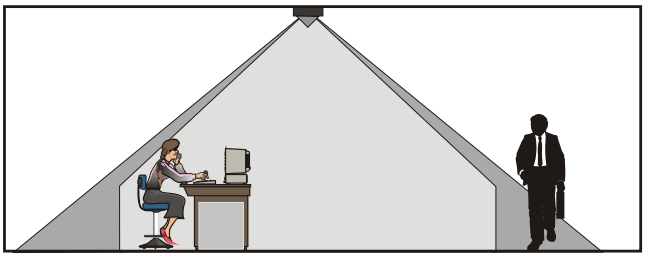


In order to detect the presence of persons reliably the detector needs a clear view. Seated persons must be completely within the detection area. Walls and windows restrict the detection area. (This is a schematic simplified representation)

Requirements for reliable detection of persons

Presence detectors need a clear view of the persons they are monitoring. Thermal radiation cannot penetrate walls or doors and even glass partitions act as barriers.

1.4 Selecting the most appropriate detection characteristic

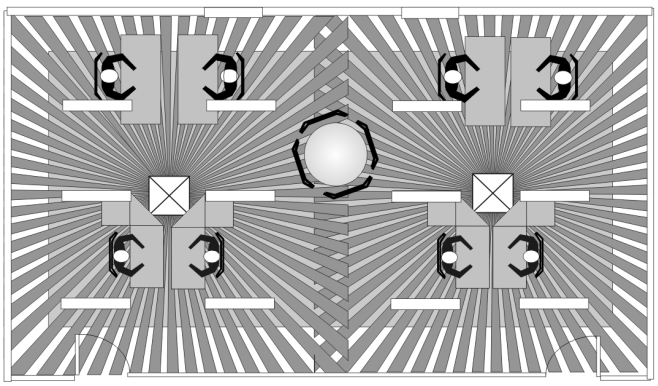


Presence detectors for ceiling mounting are characterised by an evenly high detection sensitivity. They are particularly suitable for persons working in a seated position.

Consideration must be given to room utilisation for effective planning of presence detectors. A different detection characteristic may be more suitable depending on the particular use. We make a distinction between two application areas: "working rooms" for seated persons and "transfer areas" for walking persons.

Ceiling-mounted presence detectors with a detection range of 360° have distinct advantages for the detection of seated persons:

- *clear view of persons (hand movement) is ensured*
- *the detection sensitivity is evenly high throughout the detection area*
- *the distance between persons and detector is limited*



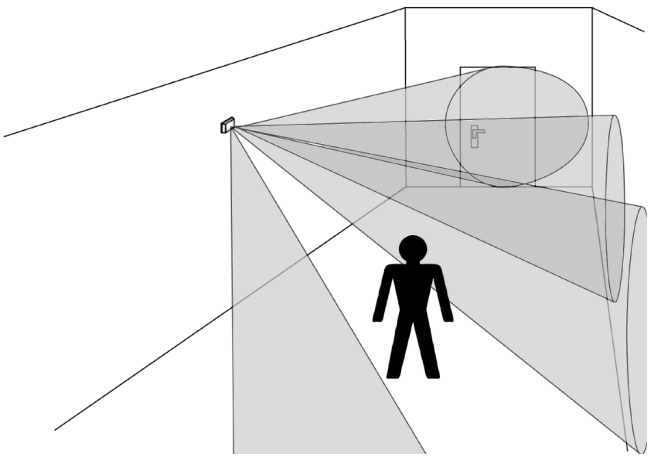
The square detection area ensures comprehensive room coverage with clearly defined detection boundaries. The detection areas of a number of detectors can be arranged with no gaps (see picture) ensuring reliable and simple project planning.

Square detection area covering 360°

The ideal detection area for a ceiling-mounted presence detector is square. The square detection area ensures maximum dependability and greatly simplifies the positioning of the detectors because:

- *the detection area reflects the shape of the room, ensuring comprehensive coverage.*
- *the detection area is clearly defined, presence detection can be restricted to a single room or part of a room.*
- *in order to cover larger areas, several detection areas can be arranged together seamlessly.*

Please note that seated persons must be completely in the detection area. The sitting area is reduced in relation to the walking area. The size of the detection area is directly related to the mounting height.



Les personnes peuvent se trouver momentanément hors des zones de détection (schéma simplifié).

Detection of walking persons (transfer areas).

Wall-mounted presence detectors with a detection area of 180° or ceiling-mounted models with extensive detection zones are suitable for the detection of walking persons.

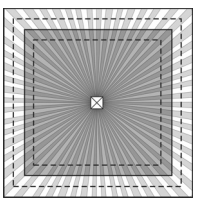
- *the detection zones are less dense but possess a greater range*
- *the detection zones are horizontal in the room, i.e. the detection area is broad and has no sharp boundary.*
- *the sensitivity decreases with increasing distance from the detector*
- *persons crossing a detection zone will even be detected at a great distance while the sensitivity is reduced for persons directly approaching the detector.*

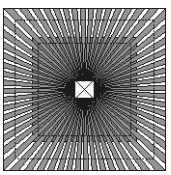
The following factors must be taken into account when positioning the detectors:

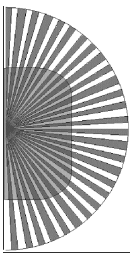
- *persons may also be outside of the detection area for short times*
- *access points (doors) must be completely within the detection area*
- *sitting persons are only detected in the immediate vicinity*

Comparison of detection characteristics

In principle, every room is suitable for the use of presence detectors. Due consideration must be given to the spatial aspects as well as the usage of the rooms. The following table shows the criteria for choosing the appropriate model for the intended location.

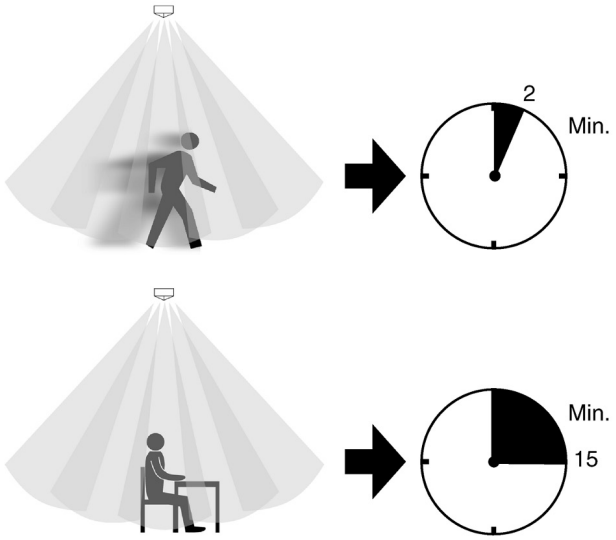






Model ranges ECO-IR 360, compact office, PräsenzLight 360	Model ranges ECO-IR 180, PräsenzLight 180
Ceiling mounting (360°) with square detection area	*Wall mounting (180°) with extended detection area*
Primarily intended for seated persons	*Primarily intended for walking persons*
Extended detection area for walking persons	*Reduced detection area for seated persons*
Range depends on mounting height	*Wide (unrestricted) range*
Square detection area with clear boundary	*Detection area has no boundary*
High, even detection sensitivity completely covering the entire detection area	*Varying sensitivity within the detection area, decreasing sensitivity at increasing distance from the detector*
	Larger movements required at larger distance from the detector

1.5 Adaptive switch-off delay time



The adaptive switch-off delay time ensures maximum energy savings with maximum user convenience. The switching behaviour adapts itself perfectly to the specific situation. This feature effectively prevents irritating false switching.

People can sometimes keep so still that even highly sensitive presence detectors cannot detect any movement. In order to detect the occupancy of a room, the presence detector has to "bridge" the time between 2 movements. Every movement resets the switch-off delay – the internal clock – to zero. As long as the time limit has not been reached, the room is regarded as occupied.

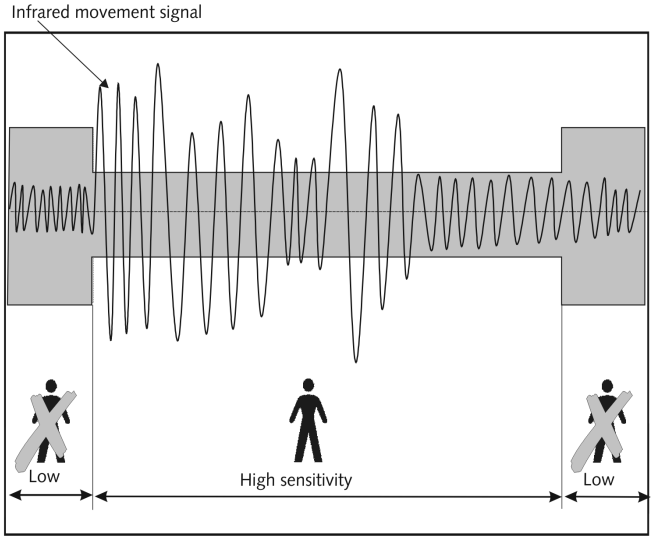
The duration of the switch-off delay is continuously optimised, that is to say it adapts automatically to the different usage conditions in the room.

In places with much coming and going, e.g. corridors, the light is switched off as soon as possible in order to reduce unnecessary utilisation. On the other hand, in an office with infrequent, irregular movements the switch-off delay is extended, which prevents frequent switching.

The switch-off delay time can increase to a maximum of 15 minutes. The minimum set switch-off delay time represents a lower limit which is not reduced even by adaptive behaviour. If very short or very long switch-off delay times are selected (< 2 min. or > 15 min.) the adaptive behaviour is deactivated and the set switch-off delay time remains unchanged.

This adaptive (self-learning) feature prevents irritating false switching and ensures maximum energy saving with the greatest user comfort. In this way the users' varying needs are catered for optimally.

1.6 Detection sensitivity



In order to prevent false responses the sensitivity of the presence detector is reduced when no one is present. The increased sensitivity when the area is occupied ensures extremely reliable presence detection.

Sensitivity adaptation

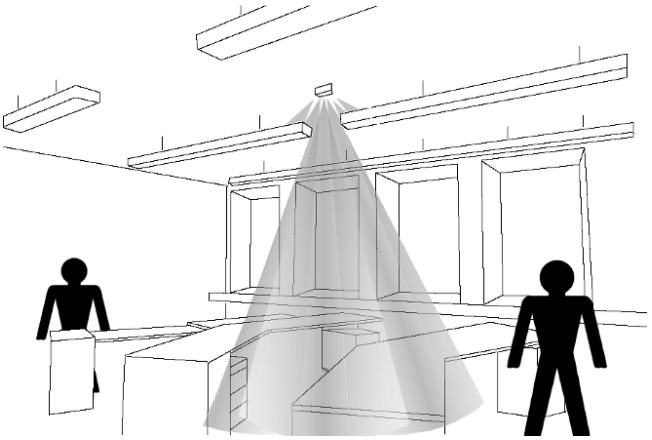
The task of a presence detector is to reliably detect the slightest movements of persons and at the same time to suppress interfering heat sources. To deal with this, Theben HTS presence detectors are equipped with sensitivity adaptation. If a room is occupied, the detector switches to high sensitivity in order to detect the slightest movements of those present. If on the other hand the room is unoccupied, the presence detector operates with reduced sensitivity. In this way Theben HTS presence detectors combine the highest possible detection sensitivity with effective interference suppression.

Room surveillance

Whereas for energy control the emphasis of presence detection is on recognising the presence of persons based on the most minute movements, when it comes to security applications greater importance is attached to the avoidance of false alarms. To this end, with certain Theben HTS presence detectors it is possible to reduce the sensitivity. The detector then only responds to clear movement signals and can indicate the presence of persons with the utmost reliability.

Please note: Theben HTS presence detectors are not alarm detectors.

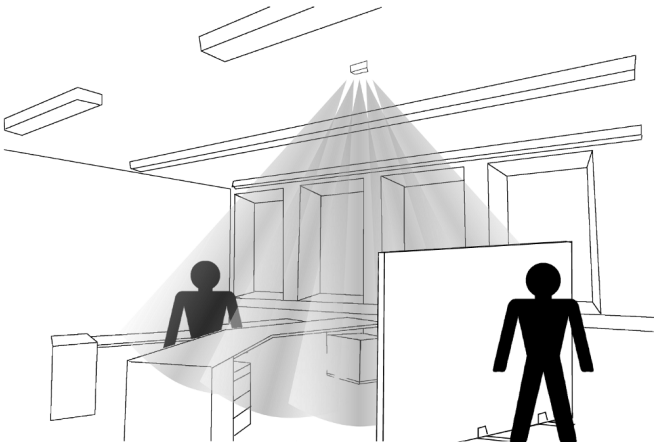
1.7 Sources of interference



Normally, the switching behaviour is defined by the persons within the detection area.
In exceptional cases the switching may be undesirably influenced by other factors. Such sources of interference should therefore be eliminated during the planning or, at the latest, before the installation.

Restricted detector view

- *Suspended lamps may screen the detector's view if mounted in its immediate neighbourhood.*
- *Partition walls, shelves or big plants can reduce the detection area.*



Suspended lamps, furniture and plants restrict the detection area.

Apparent movement

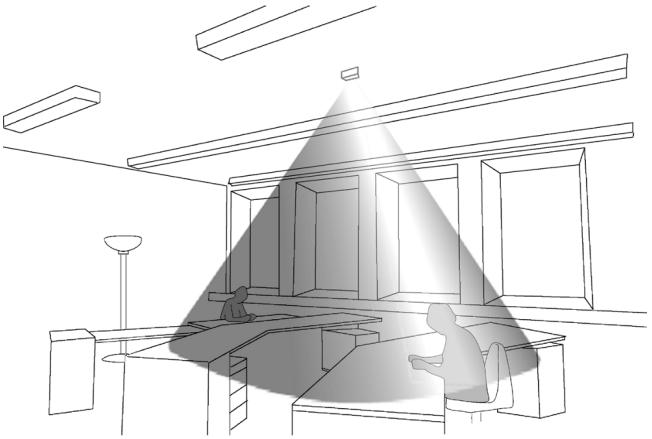
- *Rapid changes of temperature in the detector's vicinity caused by heaters, ventilators, etc, cutting in and out, may simulate movement if the air flow is directed towards the sensor's lens or towards nearby objects within the detection area.*
- *Lights switching on and off near the detector (e.g. incandescent or halogen lights at a distance of < 1 m) may simulate movement.*
- *Moving objects such as machines, robots, swaying posters etc. may simulate movement signals.*

Slowly warming up objects do not cause interference. They do not influence the detector's switching behaviour.

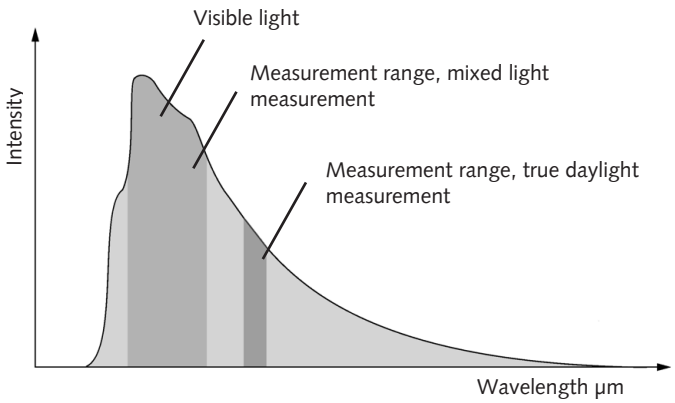
- *Radiators (lateral distance to pipes and radiators >0.5 m)*
- *Computing equipment (computers, printers, monitors)*
- *Ventilation systems, as long as no warm air is blown directly towards the detector*
- *Sunny surfaces*

2. Measuring Light Intensity

2.1 Measuring Light Intensity by Movement and Presence Detectors



Theben HTS presence detectors are equipped with a brightness measurement facility which is permanently active. It is able to switch lighting on and off at any time, depending on daylight and occupancy (light measurement cone for a ceiling-mounted detector).



Theben HTS presence detectors can perform two types of light measurement. The true daylight measurement suppresses artificial light with spectral filters and measures the daylight in the near infrared region.

The mixed light measurement computes the sum of the artificial light and daylight and automatically determines the installed light intensity.

In this way both measurements are able to determine the proportion of daylight in the room even in the presence of artificial light.

Light measurement by motion detectors

A demand oriented lighting control system must not only detect a person's presence but also be able to judge the room's brightness. Conventional motion detectors frequently only have very limited light measurement capabilities. When the brightness level is insufficient, the lighting is switched on. However, the light measurement is then interfered with by its own artificial light and is therefore deactivated. This means that the light does not automatically switch off even in bright daylight, but only after the person has left the room. At this point the light measurement is reactivated. This process is satisfactory in transfer zones but unsatisfactory in continuously occupied rooms.

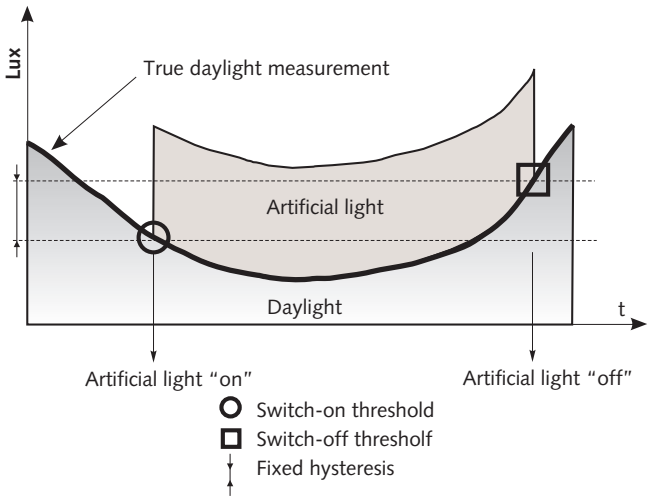
Light measurement by presence detectors

A presence detector requires a light measurement which is continuously active. Not only does it have to switch on artificial light when the daylight is insufficient, it must also switch off the lighting again when the daylight level is sufficient. That may sound simple but in reality the detector must also be able to determine – with artificial light switched on – whether there will still be sufficient daylight once the artificial light is switched off. For this purpose Theben HTS presence detectors use two different methods, "true daylight measurement" and "mixed light measurement".

In both cases the light measurement is carried out in the viewing direction of the unit and determines the brightness value in the room. The brightness measurement carried out from the ceiling may be different from the measured brightness on the working surface. It is affected by the room shape, the arrangement of the windows, the reflective properties of the room and furniture, etc., and therefore does not correspond to the DIN measurement for brightness at the workplace.

The response to changes in the incident daylight is delayed in order to avoid unnecessary switching on and off in response to passing clouds, for example. The light measurement guarantees reliable switching at intensities between approx. 50 lux and 1500 lux.

2.2 True daylight measurement



The true daylight measurement is based on a spectral filtration which suppresses the artificial light and calculates the daylight in the room.
This enables the presence detector to switch the lighting on and off at any time, depending on the brightness.

True daylight measurement by Theben HTS

Daylight consists not only of visible light but also of ultraviolet and infrared components. The true daylight measurement suppresses the visible light through spectral filtration and only assesses the components in the near infrared range which is very close to the visible range. In this way the artificial light becomes invisible and does not affect the daylight measurement. The presence detector is able to continuously determine whether the daylight level is sufficient in order to switch off the artificial light.

Suitability of true daylight measurement

The advantage of true daylight measurement is that artificial light falling directly on the detector has virtually no effect on the light measurement. Whereas in the case of indirect lighting, conventional light sensors are very restricted in where they can be positioned, with true daylight measurement it is only necessary to ensure that the brightness at the detector's mounting location does not exceed the desired light intensity.

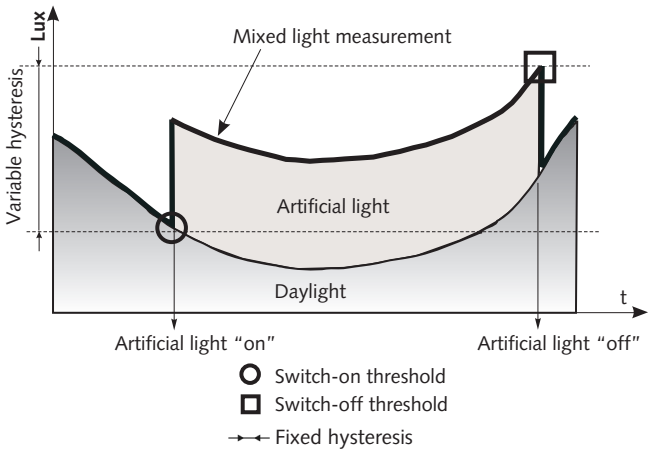
The precondition is that all lamps only emit visible light and do not contain any spectral components in the near infrared range. Fluorescent lamps / compact energy saving lamps are particularly suited for this purpose. Heat sources such as incandescent and halogen lamps falsify the measurement because they shine into the daylight measurement window. True daylight measurement is also ideal for use in combination with manually switched working lights.

Heat-shielding glass can affect the spectral measurement of daylight; the switching value must be set correspondingly lower.

True daylight measurement is unsuitable for constant light control.

Suitable lamps for true daylight measurement	Unsuitable lamps for true daylight measurement
Fluorescent lamps (FL)	*Incandescent, halogen lamps*
Compact energy-saving lamps	*High presure discharge lamps such as:* *- Sodium discharge lamps (SDL)* *- Mercury discharge lamps (MDL)* *- Halogen-metal-oxide discharge lamps (HMODL)*

2.3 Mixed light measurement



The mixed light measurement measures the sum of artificial light and daylight. It automatically determines the artificial light intensity and from it calculates the actual daylight. This enables the presence detector to switch the lighting at any time, depending on the brightness.

Mixed light measurement by Theben HTS

Whereas the true daylight measurement suppresses artificial light by filtration, the mixed light measurement measures the daylight and artificial light components equally. In order to switch off the artificial light at the correct moment as the daylight level increases, the presence detector has to know the proportion of artificial light. It learns this value automatically by continuously analysing all light switching operations in a room. This enables it to calculate the actual daylight intensity at any time from the measured overall brightness.

Suitability for switching lighting

The advantage of mixed light measurement is that it works with any light source. Where there is incident artificial light on the detector, care should be taken that the brightness at the mounting location does not exceed the desired lighting intensity in the room.

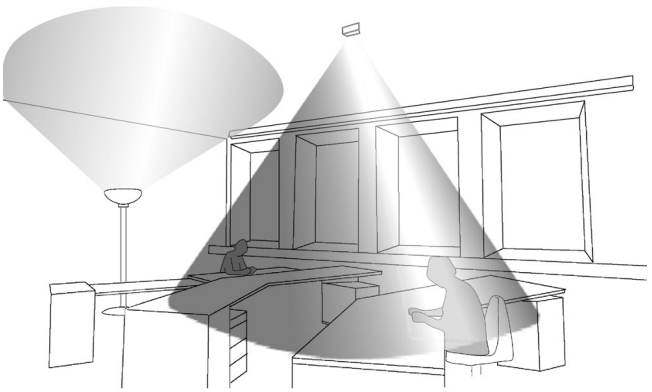
Suitability for constant light control

Mixed light measurement is a prerequisite for constant light control as the sum of artificial light and daylight is important. There are strict limitations on the positioning of the detector. Direct artificial light on the detector must be avoided at all costs. Manually switched working lights also affect the control behaviour.

2.4 Comparison of true daylight measurement with mixed light measurement

True daylight measurement	Mixed light measurement
Principle: spectral filtration, artificial light is suppressed	*Principle: determination of the installed artificial light power*
Permanently active, daylight intensity also known with artificial light switched on	*Permanently active, daylight intensity also known with artificial light switched on*
Also suitable for use in continuously occupied rooms	*Also suitable for use in continuously occupied rooms*
Suitable for fluorescent lamps / compact energy saving lamps, unsuitable for incandescent and halogen lamps	*Suitable for all light sources*
Unsuitable for constant light regulation	*Suitable for constant light regulation*
Suitable for indirect lighting, virtually unaffected by incident artificial light and manually switched work lighting	*Unsuitable for indirect lighting, manually switched work lighting affects the light measurement*

2.5 Choice of mounting location

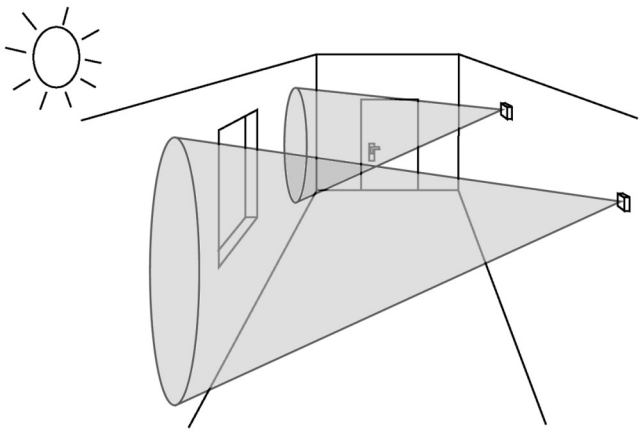


Interference by lamps

- *The daylight measurement determines the brightness value for the room, which is not necessarily equivalent to the work surface brightness. For this reason the detectors should not be located in extreme lighting conditions.*

- *When mounted near lamps with a high indirect component, the artificial light intensity at the position of the detector must not exceed the desired brightness of the room. The remedy is to increase the distance between the light cone and the detector.*

- *In the case of conventional parallel circuit operation of several detectors (no master-slave operation) choose locations with comparable daylight brightness (corridors!)*



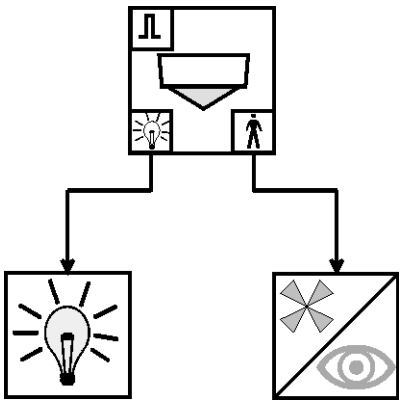
Light measurement cone (wall-mounted detector)

- *In the case of master-slave parallel circuit operation the master must be positioned in a representative point for the entire detection area. Bright mounting locations with plenty of daylight are preferable. (corridors!)*

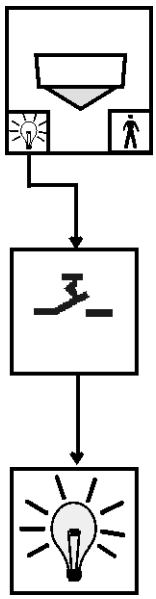
- *Direct sunlight should be prevented from reaching the detector.*

3. Configurations

3.1 Manual control



Presence detector without push-button



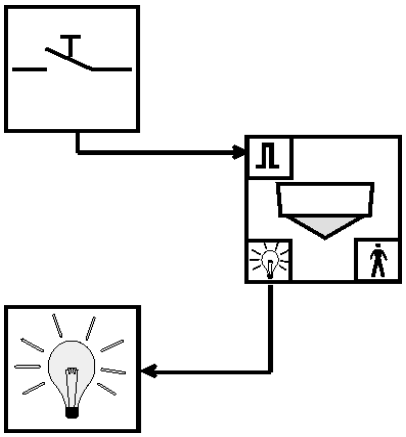
Presence detector with switch connected in series

Presence detector without control input

The simplest variant of a demand-oriented lighting control is a presence detector without additional manual control. The light is switched on automatically when persons are present and the daylight is inadequate, and switched off again when no one is present or the daylight is adequate.

This only offers limited possibilities for manual intervention: if a switch is connected in series the user can manually switch off the lighting. It is not possible to switch on manually without release by the detector.
This solution may be appropriate in certain applications, e.g. open-plan offices, in enclosed spaces or transfer zones, that is to say where switching is primarily on presence and brightness plays a subordinate role.
Light, however, is a highly subjective experience. The same lighting situation is perceived in a different way depending on the work being carried out at the time, the current daylight situation and not least the personal mood.

A presence detection control without a manual override facility has extremely critical requirements with regard to the optimum adjustment of the switching values and fails to take into account the perception of the user at the time. In order to respond to this need to override the settings on an individual basis, the combination of presence detector and manual control is an obvious choice.



Presence detector with control input for push button

Presence detector with control input

Theben HTS presence detectors with control input can be extended by means of push buttons. They provide the simplest means for the user to manually intervene in the control and to switch the lighting in accordance with individual requirements. Various operating modes offer an ideal solution for a wide range of applications.

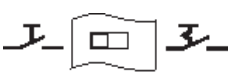
3.2 Different types of switching behaviour

Fully or semi-automatic operation

The lighting control can be either fully automatic for greater convenience or semi-automatic for greater saving. In the fully automatic operating mode the lighting switches on and off automatically, depending on presence and brightness. The user can manually switch the lighting at any time by means of the push button. This results in a temporary interruption of the automatic switching.
In the semi-automatic operating mode the lighting only switches off automatically. Switching on is carried out manually. Artificial light must be switched on with the push button. Although this solution is less convenient, it does result in greater energy saving and encourages environmentally aware energy usage. Manual control by means of push buttons is possible at any time.

Push button function room-corridor

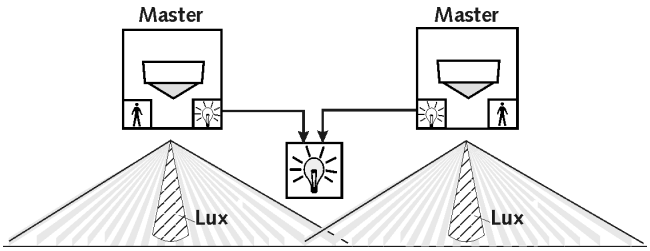
In working areas, push buttons are used to switch the lighting on and off at any time. In transfer zones, however, it may be preferable to prevent manual switching off. Especially in dark areas it should not be possible to simply switch off the light manually. With the "corridor" setting it is only possible to use the push button to switch on, the detector becomes an intelligent automatic stairwell system which only switches off if no one else is present.



Switches instead of push buttons

Presence detectors are frequently installed when refurbishing lighting systems. In order to keep refurbishment costs as low as possible, a number of presence detectors offer the facility to benefit from the full flexibility of manual control with the existing switches.

3.3 Parallel circuit operation



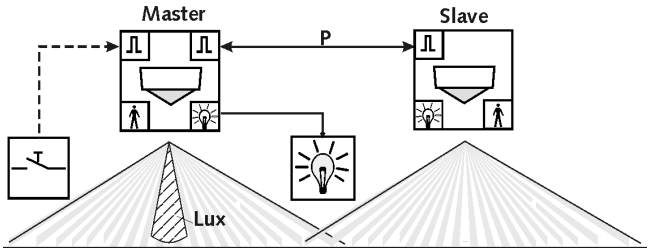
Conventional parallel circuit operation. Each detector determines presence and brightness individually. The switching behaviour is not uniform.

Conventional parallel circuit operation

If the detection area of a single detector is insufficient to control a larger room based on presence, a number of detectors can be connected in parallel.
The simplest type of parallel circuit operation is obtained by direct parallel connection of the switched contacts.

- *Each detector records presence and brightness in its own area*
- *Settings such as switch-off delay times and brightness switching levels are carried out individually for each detector.*
- *The detectors switch the load together*

The advantage for lighting control is that each detector optimises the switching behaviour in its own area. As soon as the ambient brightness is too low at one detector, the lighting switches on. This advantage can also become a disadvantage: carrying out all settings on every single unit calls for a greater setting-up time. In addition, the switching behaviour of the individual units is never consistent because the distribution of daylight in the room changes continuously over the course of the day.



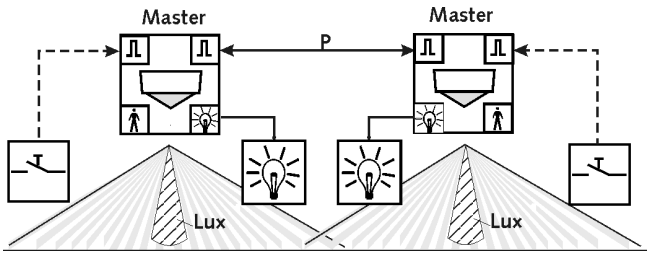
Master-slave parallel circuit operation. All detectors determine presence together. The brightness measurement is only performed by the master. This results in reduced setting-up time and uniform switching behaviour.

Master-slave parallel circuit operation

Some models are equipped with a P terminal which enables master-slave or master-master parallel circuit operation. In the case of master-slave operation, one detector is employed as the master. This detector also ensures that the lighting switches in a uniform manner.

- *Only the master switches the lighting*
- *The light measurement is carried out by the master*
- *All detectors swap presence information with one another*
- *The essential potentiometers and DIP switches are only set at the master*

The advantage for lighting control is that the settings only have to be made at the master. Its environment becomes the reference point for the brightness measurement in the room. As soon as the brightness around the master falls below an acceptable level, the lighting switches on when receiving the next movement signal.



Master-master parallel circuit operation. Although the detectors jointly detect presence, the brightness measurement on the other hand is carried out by each master individually. This results in a separate lighting group with its own push button control for each master.

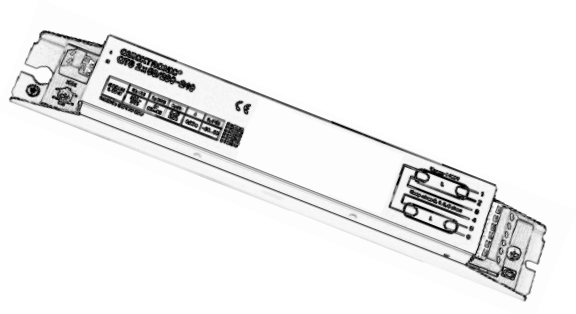
Master-master parallel circuit operation

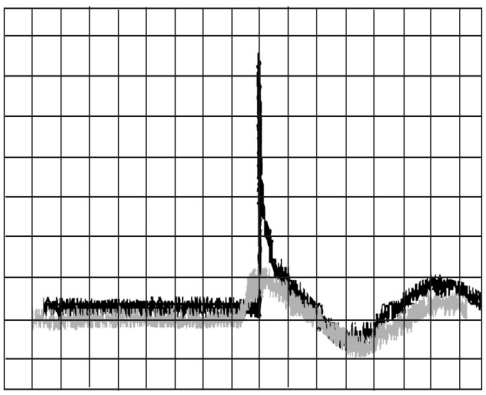
If a larger room is to be switched according to different brightness criteria yet with common presence detection, master-master parallel circuit operation can be used to divide it up into various zones with accompanying lighting groups. In this case one detector is employed as the master for each lighting group. This detector will switch the lighting group according to its own brightness measurement. Presence detection, on the other hand, is performed by all detectors working together.

- *Each master switches one lighting group*
- *All masters swap presence information between themselves*
- *The light measurement takes place in each lighting group by its designated master*
- *The essential potentiometer and DIP switches are set on all masters*
- *In addition, further detectors can be incorporated as slaves. They merely supply presence information from their area.*

If areas with similar daylight incidence are put together as a common lighting group, the result is a demand-related control which assesses the daylight in the optimum way and exhibits smooth switching behaviour through common presence detection.

3.4 Load switching





Peak loads when switching electronic ballasts result in excessive stresses on electrical installations. Presence detectors with inrush current limitation are able to switch a large number of electronic ballasts directly without additional relays.

Direct switching of loads

Theben HTS presence detectors are designed so as to be able to switch different loads directly. They combine sensors and actuators in a single unit and enable demand-oriented controls without additional components. This results in direct wiring and a space-saving installation.

Diverse loads

Different specification contacts are used for the different application areas of lighting control, room surveillance and HVAC control. Please see the specification in the product data sheets.

The switching contact for lighting control is mainly suited to capacitive, inductive and electronic ballasts (see below). The operation of dimmers and electronic low-voltage transformers is possible, provided these are designed for operation with switched phase.
Generally speaking, all loads must be reactionless and correctly suppressed.

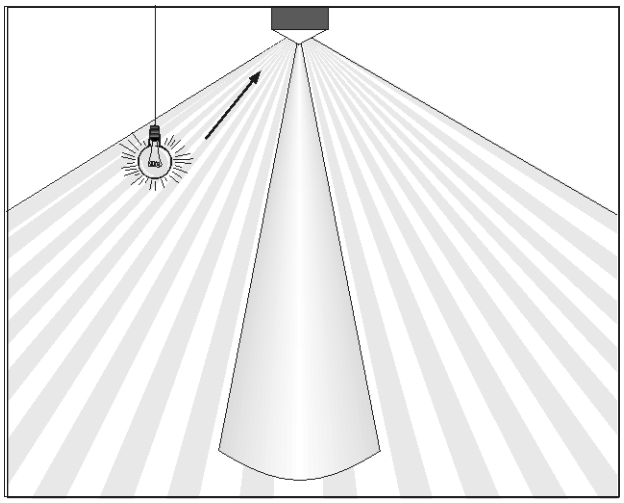
Electronic ballasts

Special consideration must be given to switching electronic ballasts. They may cause high peak loads when switched on, overstress switching contacts and shorten working life. Theben HTS presence detectors are generally provided with robust switching contacts, which are not merely designed to handle the nominal load but have also been tested for peak loads. The maximum number of electronic ballasts is specified in each case. If the load to be switched exceeds the specification, an external relay must be connected in series.

Inrush current limitation for electronic ballasts

Specialised models are provided with an active protection circuit that drastically reduces peak loads. This means that a large number of electronic ballasts can be switched without the need for additional relays, wiring remains simple and inexpensive. The protection circuit protects contacts and electronic ballasts and ensures a long working life.

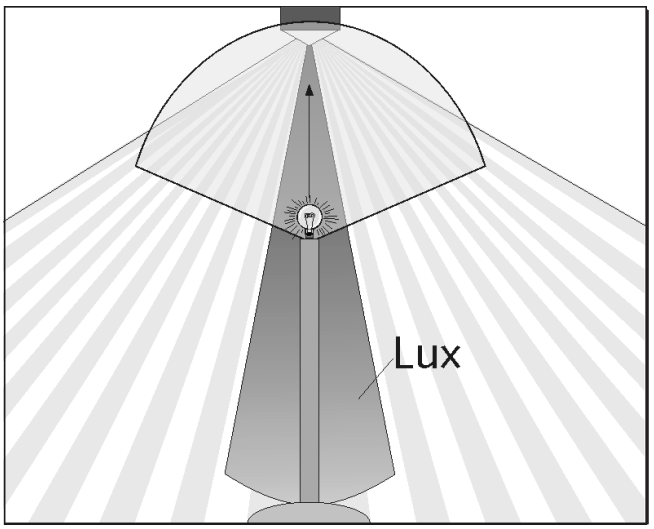
3.5 Interference caused by switched loads



Heat emitters (halogen/ incandescent lamps) within the presence detection area of the detector may simulate movement.

Simulated movement

Heat sources such as halogen and incandescent lamps must not be situated close to the presence detection area of a detector. Switching off the light will result in a change to the thermal image. Strong signals will be interpreted as movement by the presence detector and the light switched off and on again in an unoccupied room. Heat sources outside the detection area may also simulate movement if the heat radiation falls directly on the detector from a short distance (see section 1.7 Sources of interference / presence detection).



Artificial light in the light measuring area of the detector may interfere with the brightness measurement.

Effect on light measurement

If artificial light from the switched lighting falls directly on the detector's light sensor this will affect the brightness measurement during switching procedures. In particular, true daylight measurement will be affected by heat emitters such as halogen and incandescent lamps. This may result in cyclical switching of the lighting by the detector even at night (see section Choice of mounting location / light measurement).